Christian and Latter-day Saint Thinkers and Leaders on Natural Theology, Final Causes, Teleological Arguments, Anthropic Principles, Arguments from Design, or Intelligent Design

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Discovery Institute Staff

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I believe I shall be endorsed by the highest scientific authorities when I say that they acknowledge the existence of a master intelligence that organizes, sustains and controls the universe
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Elder Brigham H. Roberts
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The great minds of the world today now teach there is a God; He does live; They teach that he is a great mathematician
Conference Report, October 1960

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Elder Legrand Richards
By unwavering mathematical law, we can prove that our universe was designed and executed by a great engineering intelligence
Conference Report, April 1961

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Elder Bernard P. Brockbank
God created the universe with all of its profound greatness and blessings
Conference Address

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Elder Alma Sonne,
Testimony Of Nature Strong & Convincing Regarding Existence Of Overruling Providence
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Elder Marion G. Romney
First Proof: Orderliness Of Universe
Conference Report, October 1967, Afternoon Meeting, p.134

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Can a man who thinks that life came about by chance on a globe that was made by accident have any overlying purpose to guide him?

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Conference Address

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God created the universe with all of its profound greatness and blessings
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Ensign (CR), December 1971

1976
Frank B. Salisbury, Ph.D. LDS Scientist
Creation
Book (Introduction by Henry Eyring Sr., LDS Scientist)

May 1978
Elder Gordon B. Hinckley, Council of the Twelve
All of beauty in the earth bears the fingerprint of the Master Creator
Ensign Article

1979
Freeman Dysan
Disturbing the Universe
Book

1983
Paul Davies
God and the new physics
Book, Simon & Schuster Paperbacks

1983
Henry Eyring Sr.
Reflections of a Scientist
Book

November 1985
Don Lind, LDS Astronaut
The Heavens Declare the Glory of God,
Conference Address

November 1986
Elder Ted E. Brewerton
Now another evidence of God: speaking of the planets and orbs, the Lord says, Any man who hath seen any or the least of these hath seen God moving in his majesty and power

Conference Address

November 1987
Elder Neal A. Maxwell, Quorum of the Twelve Apostles
Yet Thou Art There
Conference Address

1988
Freeman Dyson, Physicist and Philosopher of Science
Infinite in All Directions
Harper and Rowe Book and Gifford Lectures in 1985

May 1988
Elder M. Russell Ballard, Quorum of the Twelve
How Important It Is For Every Human Soul To See And Appreciate The Glory And Grandeur Of God In Everything About Us
Conference Address

1988
LaMar Garrard, BYU Religion Dept.
Korihor the Anti-Christ
Kent P. Jackson, ed., Studies in Scripture, Vol. 8: Alma 30 to Moroni (Alma 30)

February 1990
Richard Bushman, professor of history, Columbia University
How did the Prophet Joseph Smith respond to skepticism in his time? And what can we learn from him about how to respond to modern-day skeptics?
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January 1991
Jonathan Wells
Darwinism and the Argument to Design
Dialogue & Alliance 4, no. 4

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Paul Davies
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Simon & Schuster Paperbacks

1995
Paul Davies, Ph.D., Physicist, Arizona State University
Templeton Prize Address

1995
Henry B. Eyring, Jr., C.E.S.
Christ and the Creation
Henry B. Eyring, ed., On Becoming a Disciple Scholar (Book)

1996
The Explanatory Power of Design
DNA and the Origin of Information
Stephen C. Meyer, Historian And Philosopher Of Science

Article

I996
Atheism and Theism
J.J. C. Smart (Atheist) and J.J. Haldane (Theist)
Book

1996
Daniel Peterson, Ph.D.
Intelligent Design and Evolution
FARMS Review of Books

1998
Nature's Destiny - How the Laws of Biology Reveal Purpose in the Universe
Michael J. Denton
Book, The Free Press

1998
David Clark, Editor and Contributor
Of Heaven and Earth: Reconciling Scientific Thought with LDS Theology
Book

2000
David Conway, Christian Philosopher
The Rediscovery of Wisdom
Book, St. Martin's Press

April 2000
Elder Russell M. Nelson Of the Quorum of the Twelve Apostles
The Creation
Conference Address

January 2001
Edward L. Hart
A Conversation about Poetry (Beauties of Nature)
Casualene Meyer
BYU Studies v40, Number 1--2001

2004
G. Tanzella-Nitti Pontifical University of the Holy Cross, Rome Faculty of Theology E-mail: tanzella@usc.urbe.it
The Two Books Prior To The Scientific Revolution

January 2004
William A. Dembski, Ph.D. Associate Research Professor in the Conceptual Foundations of Science, Baylor University
Intelligent Design: Yesterday's Orthodoxy, Today's Heresy

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Mark J. Nielsen
The Wonder of the Creation

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Stephen C. Meyer
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Paper at Discovery Institute

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Book by IntraVarsity Press

2005
Dyson Freeman, Physicist
Almost As Though The Universe Knew We Were Coming
Templeton Prize Address

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John Polkinghorne, Physicist and Theologian
Beyond Darwin
Article

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Jeff Lindsey, LDS Blogger
Tuesday, May 03, 2005
Intelligent Design: Not Just a Matter of Faith

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Elder Douglas L. Callister
Our God Is God
Brigham Young University–Idaho Devotional

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Paul Davies
A Mariner Book, Houghton Mifflin Company

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Frank B. Salisbury
A review of "Evolution and Mormonism: A Quest for Understanding" by Trent D. Stephens, D. Jeffrey Meldrum, with Forrest B. Peterson
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Frank B. Salisbury

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June 2006
Frank B. Salisbury, Ph.D.
The Case for Divine Design: Cells, Complexity, and Creation
Book

March 2006 (From an April 1988 general conference address)
The Message: The Handiwork of God
M. Russell Ballard, Quorum of the Twelve Apostles
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John C. Polkinghorne, Physicist and Theologian
Natural Theology
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2007
Anthony Flew, Former Atheist and Now Deist
There is a God – How the World's Most Notorious Atheist Changed His Mind
Book

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Stephen C. Meyer, Ph.D. Historian and Philosopher of Science
Intelligent Design: The Origin of Biological Information and the Higher Taxonomic Categories

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John Barrow, Simon Morris, Stephen Freeland, Charles Harper, Jr., Editors
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Book, Cambridge University Press

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James L. Farmer
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Douglas L. Callister
Our God Truly Is God
Ensign, Jan 2008, 64–68

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By Orson Scott Card
Intelligent Conversation
Article in The Rhinoceros Times, Greensboro, NC

2009
Robin Collins, Christian Philosopher
Chapter 4 - The Teleological Argument: An Exploration of the Fine-Tuning of the Universe
Chapter in book "The Blackwell Companion to Natural Theology" Edited by William Lane Craig and J. P. Moreland

2009
We can look up at the sky at night and have an idea of what Alma meant. There are millions of stars and planets all in perfect order. They did not get there by chance. We can see the work of God in the heavens and on the earth. The many beautiful plants, the many kinds of animals, the mountains, the rivers, the clouds that bring us rain and snow—all these testify to us that there is a God.
Gospel Principles Manual

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Justin Hart
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Meridian Magazine

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God, Science, and Intelligent Design
By Daniel C. Peterson
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Michael De Groote
Intelligent design and the new atheism: Evolution has limits (Address by Michael Behe at BYU)
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Robert D. Hales, Quorum of the Twelve Apostles
Seeking to Know God, Our Heavenly Father, and His Son, Jesus Christ
Ensign Magazine

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Steve P
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By Common Consent Blog

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The Teleological Argument and the Anthropic Principle
William Lane Craig, Biola University / Talbott School of Theology

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Jerry Fodor and Massimo Piattelli-Palmarini (Non-LDS Atheistic Philosophers of Science)
What Darwin Got Wrong
Book (Farrar, Straus and Giroux)

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Creationism and Intelligent Design: Scientific and Theological Difficulties
David H. Bailey

April 2010
James Le Fanu, Historian of Science
Why Us? – How Science Discovered the Mystery of Ourselves
Book

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Edward Feser, Department of Philosophy Pasadena City College Pasadena, California
Teleology - A Shopper's Guide
Philosophia Christi Vol. 12, No. 1 (2010)

SOURCE DOCUMENTS

2009
Discovery Institute Staff
Design In The Bible & The Church Fathers

The idea that human beings can observe signs of intelligent design in nature reaches back to the foundations of both science and civilization. In the Greco-Roman tradition, Plato and Cicero both espoused early versions of intelligent design. In the history of science, most scientists until the latter part of the nineteenth century accepted some form of intelligent design, including Alfred Russel Wallace, the co-discoverer with Charles Darwin of the theory of evolution by natural selection. In the Judeo-Christian tradition, meanwhile, the idea that design can be observed in nature can be found not only in the Bible but among Jewish philosophers such as Philo and in the writings of the Early Church Fathers. This sourcebook contains a collection of some of the main texts on design from both the Bible and the writings of the early church.

Passages From The Bible About Design In Nature
Both the Jewish and Christian scriptures teach that the natural world reflects God's design, and that this design can be clearly discerned in nature. Below are some of the key passages.

Proverbs 8:1-3, 22-35 [NKJV]
Does not wisdom cry out,
And understanding lift up her voice?

She takes her stand on the top of the high hill,
Beside the way, where the paths meet.

She cries out by the gates, at the entry of the city,
At the entrance of the doors...

The LORD possessed me at the beginning of His way,
Before His works of old.

I have been established from everlasting,
From the beginning, before there was ever an earth.

When there were no depths I was brought forth,
When there were no fountains abounding with water.

Before the mountains were settled,
Before the hills, I was brought forth;

While as yet He had not made the earth or the fields,
Or the primal dust of the world.

When He prepared the heavens, I was there,
When He drew a circle on the face of the

When He established the clouds above,
When He strengthened the fountains of the deep,

When He assigned to the sea its limit,
So that the waters would not transgress His command,
When He marked out the foundations of the earth,
Then I was beside Him as a master craftsman;

And I was daily His delight,
Rejoicing always before Him,

Rejoicing in His inhabited world,
And my delight was with the sons of men.

Now therefore, listen to me, my children,
For blessed are those who keep my ways.

Hear instruction and be wise,
And do not disdain it.

Blessed is the man who listens to me,
Watching daily at my gates,

Waiting at the posts of my doors.
For whoever finds me finds life,

And obtains favor from the LORD.
And obtains favor from the LORD;

But he who sins against me wrongs his own soul;
All those who hate me love death."

JOB 38-42 [NIV]
Chapter 38
Then the LORD answered Job out of the storm. He said:
Who is this that darkens my counsel with words without knowledge?

Brace yourself like a man;
I will question you, and you shall answer me.

Where were you when I laid the earth's foundation?
Tell me, if you understand.

Who marked off its dimensions? Surely you know!
Who stretched a measuring line across it?

On what were its footings set,
or who laid its cornerstone—

while the morning stars sang together
and all the angels shouted for joy?

Who shut up the sea behind doors
when it burst forth from the womb,

when I made the clouds its garment
and wrapped it in thick darkness,

when I fixed limits for it
and set its doors and bars in place,

when I said, ‘This far you may come and no farther;
here is where your proud waves halt’?

Have you ever given orders to the morning,
or shown the dawn its place,

that it might take the earth by the edges
and shake the wicked out of it?

The earth takes shape like clay under a seal;
its features stand out like those of a garment.

The wicked are denied their light,
and their upraised arm is broken.

Have you journeyed to the springs of the sea
or walked in the recesses of the deep?

Have the gates of death been shown to you?
Have you seen the gates of the shadow of death?

Have you comprehended the vast expanses of the earth?
Tell me, if you know all this.

“What is the way to the abode of light?
And where does darkness reside?

Can you take them to their places?
Do you know the paths to their dwellings?

Surely you know, for you were already born!
You have lived so many years!

“Have you entered the storehouses of the snow
or seen the storehouses of the hail,

which I reserve for times of trouble,
for days of war and battle?

What is the way to the place where the lightning is dispersed,
or the place where the east winds are scattered over the earth?

Who cuts a channel for the torrents of rain,
and a path for the thunderstorm,

to water a land where no man lives,
a desert with no one in it,

to satisfy a desolate wasteland
and make it sprout with grass?

Does the rain have a father?
Who fathers the drops of dew?

From whose womb comes the ice?
Who gives birth to the frost from the heavens

when the waters become hard as stone,
when the surface of the deep is frozen?

“Can you bind the beautiful Pleiades?
Can you loose the cords of Orion?

Can you bring forth the constellations in their seasons
or lead out the Bear with its cubs?

Do you know the laws of the heavens?
Can you set up God’s dominion over the earth?

“Can you raise your voice to the clouds
and cover yourself with a flood of water?

Do you send the lightning bolts on their way?
Do they report to you, ‘Here we are’?

Who endowed the heart with wisdom
or gave understanding to the mind?

Who has the wisdom to count the clouds?
Who can tip over the water jars of the heavens

when the dust becomes hard
and the clods of earth stick together?

“Do you hunt the prey for the lioness

and satisfy the hunger of the lions

when they crouch in their dens
or lie in wait in a thicket?

Who provides food for the raven
when its young cry out to God
and wander about for lack of food?

Chapter 39
"Do you know when the mountain goats give birth?
Do you watch when the doe bears her fawn?

Do you count the months till they bear?
Do you know the time they give birth?

They crouch down and bring forth their young;
their labor pains are ended.

Their young thrive and grow strong in the wilds;
they leave and do not return.

"Who let the wild donkey go free?
Who untied his ropes?

I gave him the wasteland as his home,
the salt flats as his habitat.

He laughs at the commotion in the town;
he does not hear a driver's shout.

He ranges the hills for his pasture
and searches for any green thing.

"Will the wild ox consent to serve you?
Will he stay by your manger at night?

Can you hold him to the furrow with a harness?
Will he till the valleys behind you?

Will you rely on him for his great strength?
Will you leave your heavy work to him?

Can you trust him to bring in your grain
and gather it to your threshing floor?

"The wings of the ostrich flap joyfully,
but they cannot compare with the pinions and feathers of the stork.

She lays her eggs on the ground
and lets them warm in the sand,

unmindful that a foot may crush them,
that some wild animal may trample them.

She treats her young harshly, as if they were not hers;
she cares not that her labor was in vain,

for God did not endow her with wisdom
or give her a share of good sense.

Yet when she spreads her feathers to run,
she laughs at horse and rider.

“Do you give the horse his strength
or clothe his neck with a flowing mane?

Do you make him leap like a locust, s
triking terror with his proud snorting?

He paws fiercely, rejoicing in his strength,
and charges into the fray.

He laughs at fear, afraid of nothing;
he does not shy away from the sword.

The quiver rattles against his side,
along with the flashing spear and lance.

In frenzied excitement he eats up the ground;
he cannot stand still when the trumpet sounds.

At the blast of the trumpet he snorts, ‘Aha!’
He catches the scent of battle from afar,
the shout of commanders and the battle cry.

“Does the hawk take flight by your wisdom
and spread his wings toward the south?

Does the eagle soar at your command
and build his nest on high?

He dwells on a cliff and stays there at night;
a rocky crag is his stronghold.

From there he seeks out his food;
his eyes detect it from afar.

His young ones feast on blood,
and where the slain are, there is he.”

Chapter 40
The LORD said to Job:

“Will the one who contends with the Almighty correct him?
Let him who accuses God answer him!”

Then Job answered the LORD:

“I am unworthy—how can I reply to you?
I put my hand over my mouth.

I spoke once, but I have no answer—
twice, but I will say no more.”

Then the LORD spoke to Job out of the storm:

“Brace yourself like a man;
I will question you,
and you shall answer me.

“Would you discredit my justice?
Would you condemn me to justify yourself?

Do you have an arm like God's,
and can your voice thunder like his?

Then adorn yourself with glory and splendor,
and clothe yourself in honor and majesty.

Unleash the fury of your wrath,
look at every proud man and bring him low,

look at every proud man and humble him,
crush the wicked where they stand.

Bury them all in the dust together;
shroud their faces in the grave.

Then I myself will admit to you
that your own right hand can save you.

“Look at the behemoth,
which I made along with you
and which feeds on grass like an ox.

What strength he has in his loins,
what power in the muscles of his belly!

His tail sways like a cedar;
the sinews of his thighs are close-knit.

His bones are tubes of bronze,
his limbs like rods of iron.

He ranks first among the works of God,

yet his Maker can approach him with his sword.

The hills bring him their produce,
and all the wild animals play nearby.

Under the lotus plants he lies,
hidden among the reeds in the marsh.

The lotuses conceal him in their shadow;
the poplars by the stream surround him.

When the river rages, he is not alarmed;
he is secure, though the Jordan should surge against his mouth.

Can anyone capture him by the eyes,
or trap him and pierce his nose?

Chapter 41

"Can you pull in the leviathan with a fishhook
or tie down his tongue with a rope?

Can you put a cord through his nose
or pierce his jaw with a hook?

Will he keep begging you for mercy?
Will he speak to you with gentle words?

Will he make an agreement with you
for you to take him as your slave for life?

Can you make a pet of him like a bird
or put him on a leash for your girls?

Will traders barter for him?
Will they divide him up among the merchants?

Can you fill his hide with harpoons
or his head with fishing spears?

If you lay a hand on him,
you will remember the struggle and never do it again!

Any hope of subduing him is false;
the mere sight of him is overpowering.

No one is fierce enough to rouse him.
Who then is able to stand against me?

Who has a claim against me that I must pay?
Everything under heaven belongs to me.

"I will not fail to speak of his limbs,

his strength and his graceful form.

Who can strip off his outer coat?
Who would approach him with a bridle?

Who dares open the doors of his mouth,
ringed about with his fearsome teeth?

His back has rows of shields
tightly sealed together;

each is so close to the next
that no air can pass between.

They are joined fast to one another;
they cling together and cannot be parted.

His snorting throws out flashes of light;
his eyes are like the rays of dawn.

Firebrands stream from his mouth;
sparks of fire shoot out.

Smoke pours from his nostrils
as from a boiling pot over a fire of reeds.

His breath sets coals ablaze,
and flames dart from his mouth.

Strength resides in his neck;
dismay goes before him.

The folds of his flesh are tightly joined;
they are firm and immovable.

His chest is hard as rock,
hard as a lower millstone.

When he rises up, the mighty are terrified;
they retreat before his thrashing.

The sword that reaches him has no effect,
nor does the spear or the dart or the javelin.

Iron he treats like straw
and bronze like rotten wood.

Arrows do not make him flee;
slingstones are like chaff to him.

A club seems to him but a piece of straw;
he laughs at the rattling of the lance.

His undersides are jagged potsherds,
leaving a trail in the mud like a threshing sledge.

He makes the depths churn like a boiling caldron
and stirs up the sea like a pot of ointment.

Behind him he leaves a glistening wake;
one would think the deep had white hair.

Nothing on earth is his equal—
a creature without fear.

He looks down on all that are haughty;
he is king over all that are proud."

Job 42
Then Job replied to the LORD:

"I know that you can do all things;
no plan of yours can be thwarted.

You asked, 'Who is this
that obscures my counsel without knowledge?'

Surely I spoke of things I did not understand,
things too wonderful for me to know.

"You said, 'Listen now, and I will speak;
I will question you, and you shall answer me.'

My ears had heard of you
but now my eyes have seen you.

Therefore I despise myself
and repent in dust and ashes."

Psalm 19: 1-6 [Niv]
The heavens declare the glory of God;
the skies proclaim the work of his hands.
Day after day they pour forth speech;
night after night they display knowledge.
There is no speech or language
where their voice is not heard.
Their voice goes out into all the earth,
their words to the ends of the world.
In the heavens he has pitched a tent for the sun,
which is like a bridegroom coming forth from his pavilion,
like a champion rejoicing to run his course.
It rises at one end of the heavens
and makes its circuit to the other;
nothing is hidden from its heat.

Matthew 5:44-45, 48 [NIV]
But I tell you: Love your enemies and pray for those who persecute you, that you may be sons of your Father in heaven. He causes his sun to rise on the evil and the good, and sends rain on the righteous and the unrighteous. Be perfect, therefore, as your heavenly Father is perfect.

Matthew 6:26-30 [NKJV]
Look at the birds of the air, for they neither sow nor reap nor gather into barns; yet your heavenly Father feeds them. Are you not of more value than they? Which of you by worrying can add one cubit to his stature? "So why do you worry about clothing? Consider the lilies of the field, how they grow: they neither toil nor spin; and yet I say to you that even Solomon in all his glory was not arrayed like one of these. Now if God so clothes the grass of the field, which today is, and tomorrow is thrown into the oven, will He not much more clothe you, O you of little faith?"

Acts 14:8-18 [Niv]
In Lystra there sat a man crippled in his feet, who was lame from birth and had never walked.

He listened to Paul as he was speaking. Paul looked directly at him, saw that he had faith to be healed

and called out, "Stand up on your feet!" At that, the man jumped up and began to walk.

When the crowd saw what Paul had done, they shouted in the Lycaonian language, "The gods have come down to us in human form!"

Barnabas they called Zeus, and Paul they called Hermes because he was the chief speaker.

The priest of Zeus, whose temple was just outside the city, brought bulls and wreaths to the city gates because he and the crowd wanted to offer sacrifices to them.

But when the apostles Barnabas and Paul heard of this, they tore their clothes and rushed out into the crowd, shouting:

"Men, why are you doing this? We too are only men, human like you. We are bringing you good news, telling you to turn from these worthless things to the living God, who made heaven and earth and sea and everything in them.

In the past, he let all nations go their own way.

Yet he has not left himself without testimony: He has shown kindness by giving you rain from heaven and crops in their seasons; he provides you with plenty of food and fills your hearts with joy."

Even with these words, they had difficulty keeping the crowd from sacrificing to them.

Romans 1:19-21 [NKJV]
Because what may be known of God is manifest in them, for God has shown it to them. For since the creation of the world His invisible attributes are clearly seen, being understood by the things that are made, even His eternal power and Godhead, so that they are without excuse, falls on evil as well as good?

Passages From Jewish Thinkers About Design In Nature

Below are selected passages from Jewish writers outside the Bible who raise the issue of design in nature.

Wisdom Of Solomon 13:1-9 [NAB]
The Wisdom of Solomon was likely authored at least a century before the birth of Jesus by a Jew living in Alexandria.

For all men were by nature foolish who were in ignorance of God, and who from the good things seen did not succeed in knowing him who is, and from studying the works did not discern the artisan;

But either fire, or wind, or the swift air, or the circuit of the stars, or the mighty water, or the luminaries of heaven, the governors of the world, they considered gods.

Now if out of joy in their beauty they thought them gods, let them know how far more excellent is the Lord than these; for the original source of beauty fashioned them.

Or if they were struck by their might and energy, let them from these things realize how much more powerful is he who made them.

For from the greatness and the beauty of created things their original author, by analogy, is seen.

But yet, for these the blame is less; For they indeed have gone astray perhaps, though they seek God and wish to find him.

For they search busily among his works, but are distracted by what they see, because the things seen are fair.

But again, not even these are pardonable.

For if they so far succeeded in knowledge that they could speculate about the world, how did they not more quickly find its LORD?

Philo Of Alexandria, On The Creation
Philo of Alexandria was an influential Jewish thinker and writer who lived from around 20 BC to 50 AD. He wrote an important commentary on the creation account in Genesis. This selection is from On the Creation, I.7-11.

Some men, admiring the world itself rather than the Creator of the world, have represented it as existing without any maker, and eternal; and as impiously as falsely have represented God as existing in a state of complete inactivity, while it would have been right on the other hand to marvel at the might of God as the creator and father of all, and to admire the world in a degree not exceeding the bounds of moderation.

But Moses, who had early reached the very summits of philosophy, and who had learnt from the oracles of God the most numerous and important of the principles of nature, was well aware that it is indispensable that in all existing things there must be an active cause, and a passive subject; and that the active cause is the intellect of the universe... while the passive subject is something inanimate and incapable of motion by any intrinsic power of its own, but having been set in motion, and fashioned, and endowed with life by the intellect, became transformed into that most perfect work, this world.

And those who describe it as being uncreated, do, without being aware of it, cut off the most useful and necessary of all the qualities which tend to produce piety, namely, providence: for reason proves that the father and creator has a care for that which has been created; for a father is anxious for the life of his children, and a workman aims at the duration of his works, and employs every device imaginable to ward off everything that is pernicious or injurious, and is desirous by every means in his power to provide everything which is useful or profitable for them.

But with regard to that which has not been created, there is no feeling of interest as if it were his own in the breast of him who has not created it. It is then a pernicious doctrine, and one for which no one should contend, to establish a system in this world, such as anarchy is in a city, so that it should have no superintendant, or regulator, or judge, by whom everything must be managed and governed.

Josephus, Against Apion (Book II)
Josephus (37-c. 100 AD) was an influential Jewish historian and apologist in the first century, AD. He eventually became a Roman citizen.

The first command is concerning God, and affirms that God contains all things, and is a Being every way perfect and happy, self-sufficient, and supplying all other beings; the beginning, the middle, and the end of all things. He is manifest in his works and benefits, and more conspicuous than any other being whatsoever; but as to his form and magnitude, he is most obscure. All materials, let them be ever so costly, are unworthy to compose an image for him, and all arts are unartful to express the notion we ought to have of him. We can neither see nor think of any thing like him, nor is it agreeable to piety to form a resemblance of him. We see his works, the light, the heaven, the earth, the sun and the moon, the waters, the generations of animals, the productions of fruits. These things hath God made, not with hands, nor with labor, nor as wanting the assistance of any to cooperate with him; but as his will resolved they should be made and be good also, they were made and became good immediately. All men ought to follow this Being, and to worship him in the exercise of virtue; for this way of worship of God is the most holy of all others.

Passages From The Early Church Fathers About Design In Nature
Below are some of the most important passages from the writings of the Early Church Fathers that discuss how God's design can be clearly discerned in nature. These selections come from The Early Church Fathers collection edited by Philip Schaff et. al.

Theophilus, Theophilus To Autolycus (Book I)
Theophilus (c. 115-188 AD) was Bishop of Antioch.

Chapter IV.—Attributes of God.
And He is without beginning, because He is unbegotten; and He is unchangeable, because He is immortal. And he is called God [Theos] on account of His having placed [tetheikenai] all things on security afforded by Himself; and on account of [theein], for theein means running, and moving, and being active, and nourishing, and foreseeing, and governing, and making all things alive. But he is Lord, because He rules over the universe; Father, because he is before all things; Fashioner and Maker, because He is creator and maker of the universe; the Highest, because of His being above all; and Almighty, because He Himself rules and embraces all. For the heights of heaven, and the depths of the abysses, and the ends of the earth, are in His hand, and there is no place of His rest. For the heavens are His work, the earth is His creation, the sea is His handiwork; man is His formation and His image; sun, moon, and stars are His elements, made for signs, and seasons, and days, and years, that they may serve and be slaves to man; and all things God has made out of

things that were not into things that are, in order that through His works His greatness may be known and understood.

Chapter V.—The Invisible God Perceived Through His Works.
For as the soul in man is not seen, being invisible to men, but is perceived through the motion of the body, so God cannot indeed be seen by human eyes, but is beheld and perceived through His providence and works. For, in like manner, as any person, when he sees a ship on the sea rigged and in sail, and making for the harbor, will no doubt infer that there is a pilot in her who is steering her; so we must perceive that God is the governor [pilot] of the whole universe, though He be not visible to the eyes of the flesh, since He is incomprehensible. For if a man cannot look upon the sun, though it be a very small heavenly body, on account of its exceeding heat and power, how shall not a mortal man be much more unable to face the glory of God, which is unutterable? For as the pomegranate, with the rind containing it, has within it many cells and compartments which are separated by tissues, and has also many seeds dwelling in it, so the whole creation is contained by the spirit of God, and the containing spirit is along with the creation contained by the hand of God. As, therefore, the seed of the pomegranate, dwelling inside, cannot see what is outside the rind, itself being within; so neither can man, who along with the whole creation is enclosed by the hand of God, behold God. Then again, an earthly king is believed to exist, even though he be not seen by all; for he is recognized by his laws and ordinances, and authorities, and forces, and statues; and are you unwilling that God should be recognized by His works and mighty deeds?

Chapter VI.—God is Known by His Works.
Consider, O man, His works,—the timely rotation of the seasons, and the changes of temperature; the regular march of the stars; the well-ordered course of days and nights, and months, and years; the various beauty of seeds, and plants, and fruits; and the divers species of quadrupeds, and birds, and reptiles, and fishes, both of the rivers and of the sea; or consider the instinct implanted in these animals to beget and rear offspring, not for their own profit, but for the use of man; and the providence with which God provides nourishment for all flesh, or the subjection in which He has ordained that all things subserve mankind. Consider, too, the flowing of sweet fountains and never-failing rivers, and the seasonable supply of dews, and showers, and rains; the manifold movement of the heavenly bodies, the morning star rising and heralding the approach of the perfect luminary; and the constellation of Pleiades, and Orion, and Arcturus, and the orbit of the other stars that circle through the heavens, all of which the manifold wisdom of God has called by names of their own. He is God alone who made light out of darkness, and brought forth light from His treasures, and formed the chambers of the south wind, and the treasure-houses of the deep, and the bounds of the seas, and the treasuries of snows and hailstorms, collecting the waters in the storehouses of the deep, and the darkness in His treasures, and bringing forth the sweet, and desirable, and pleasant light out of His treasures; “who causeth the vapors to ascend from the ends of the earth: He maketh lightnings for the rain;” who sends forth His thunder to terrify, and foretells by the lightning the peal of the thunder, that no soul may faint with the sudden shock; and who so moderates the violence of the lightning as it flashes out of heaven, that it does not consume the earth; for, if the lightning were allowed all its power, it would burn up the earth; and were the thunder allowed all its power, it would overthrow all the works that are therein.

Athenagoras, A Plea For The Christians
Athenagoras of Athens (c. 133-190 AD) was a Christian philosopher and apologist.

Chapter XV.—The Christians Distinguish God from Matter.
For as is the potter and the clay (matter being the clay, and the artist the potter), so is God, the Framer of the world, and matter, which is subservient to Him for the purposes of His art. But as the clay cannot become vessels of itself without art, so neither did matter, which is capable of taking all forms, receive, apart from God the Framer, distinction and shape and order. And as we do not

hold the pottery of more worth than him who made it, nor the vessels of glass and gold than him who wrought them; but if there is anything about them elegant in art we praise the artificer, and it is he who reaps the glory of the vessels: even so with matter and God—the glory and honour of the orderly arrangement of the world belongs of right not to matter, but to God, the Framer of matter. So that, if we were to regard the various forms of matter as gods, we should seem to be without any sense of the true God, because we should be putting the things which are dissoluble and perishable on a level with that which is eternal.

Irenaeus, Against Heresies (Book I)
Irenaeus (c. 130-200) was Bishop of Lyons.

Chapter IX.—There is but one Creator of the world, God the Father: this the constant belief of the Church.
That God is the Creator of the world is accepted even by those very persons who in many ways speak against Him, and yet acknowledge Him, styling Him the Creator...—all men, in fact, consenting to this truth: the ancients on their part preserving with special care, from the tradition of the first-formed man, this persuasion, while they celebrate the praises of one God, the Maker of heaven and earth; others, again, after them, being reminded of this fact by the prophets of God, while the very heathen learned it from creation itself. For even creation reveals Him who formed it, and the very work made suggests Him who made it, and the world manifests Him who ordered it. The Universal Church, moreover, through the whole world, has received this tradition from the apostles.

Dionysius, The Books On Nature (Part II)
Dionysius (200-265 AD) was Bishop of Alexandria.

I. In Opposition to Those of the School of Epicurus Who Deny the Existence of a Providence, and Refer the Constitution of the Universe to Atomic Bodies.
Is the universe one coherent whole, as it seems to be in our own judgment, as well as in that of the wisest of the Greek philosophers, such as Plato and Pythagoras, and the Stoics and Heraclitus? or is it a duality, as some may possibly have conjectured? or is it indeed something manifold and infinite, as has been the opinion of certain others who, with a variety of mad speculations and fanciful usages of terms, have sought to divide and resolve the essential matter of the universe, and lay down the position that it is infinite and unoriginated, and without the sway of Providence? For there are those who, giving the name of atoms to certain imperishable and most minute bodies which are supposed to be infinite in number, and positing also the existence of a certain vacant space of an unlimited vastness, allege that these atoms, as they are borne along casually in the void, and clash all fortuitously against each other in an unregulated whirl, and become commingled one with another in a multitude of forms, enter into combination with each other, and thus gradually form this world and all objects in it; yea, more, that they construct infinite worlds. This was the opinion of Epicurus and Democritus; only they differed in one point, in so far as the former supposed these atoms to be all most minute and consequently imperceptible, while Democritus held that there were also some among them of a very large size. But they both hold that such atoms do exist, and that they are so called on account of their indissoluble consistency. There are some, again, who give the name of atoms to certain bodies which are indivisible into parts, while they are themselves parts of the universe, out of which in their undivided state all things are made up, and into which they are dissolved again. And the allegation is, that Diodorus was the person who gave them their names as bodies indivisible into parts. But it is also said that Heraclides attached another name to them, and called them “weights;” and from him the physician Asclepiades also derived that name.

II. A Refutation of This Dogma on the Ground of Familiar Human Analogies.

How, shall we bear with these men who assert that all those wise, and consequently also noble, constructions (in the universe) are only the works of common chance? those objects, I mean, of which each taken by itself as it is made, and the whole system collectively, were seen to be good by Him by whose command they came into existence. For, as it is said, “God saw everything that He had made, and, behold, it was very good.” But truly these men do not reflect on the analogies even of small familiar things which might come under their observation at any time, and from which they might learn that no object of any utility, and fitted to be serviceable, is made without design or by mere chance, but is wrought by skill of hand, and is contrived so as to meet its proper use. And when the object falls out of service and becomes useless, then it also begins to break up indeterminately, and to decompose and dissipate its materials in every casual and unregulated way, just as the wisdom by which it was skillfully constructed at first no longer controls and maintains it.

For a cloak, for example, cannot be made without the weaver, as if the warp could be set aright and the woof could be entwined with it by their own spontaneous action; while, on the other hand, if it is once worn out, its tattered rags are flung aside. Again, when a house or a city is built, it does not take on its stones, as if some of them placed themselves spontaneously upon the foundations, and others lifted themselves up on the several layers, but the builder carefully disposes the skillfully prepared stones in their proper positions; while if the structure happens once to give way, the stones are separated and cast down and scattered about. And so, too, when a ship is built, the keel does not lay itself, neither does the mast erect itself in the centre, nor do all the other timbers take up their positions casually and by their own motion. Nor, again, do the so-called hundred beams in the wain fit themselves spontaneously to the vacant spaces they severally light on. But the carpenter in both cases puts the materials together in the right way and at the right time. And if the ship goes to sea and is wrecked, or if the wain drives along on land and is shattered, their timbers are broken up and cast abroad anywhere,—those of the former by the waves, and those of the latter by the violence of the impetus.

In like manner, then, we might with all propriety say also to these men, that those atoms of theirs, which remain idle and unmanipulated and useless, are introduced vainly. Let them, accordingly, seek for themselves to see into what is beyond the reach of sight, and conceive what is beyond the range of conception; unlike him who in these terms confesses to God that things like these had been shown him only by God Himself: “Mine eyes did see Thy work, being till then imperfect.” But when they assert now that all those things of grace and beauty, which they declare to be textures finely wrought out of atoms, are fabricated spontaneously by these bodies without either wisdom or perception in them, who can endure to hear them talk in such terms of those unregulated atoms, than which even the spider, that plies its proper craft of itself, is gifted with more sagacity?

III. A Refutation on the Ground of the Constitution of the Universe.

Or who can bear to hear it maintained, that this mighty habitation, which is constituted of heaven and earth, and which is called “Cosmos” on account of the magnitude and the plenitude of the wisdom which has been brought to bear upon it, has been established in all its order and beauty by those atoms which hold their course devoid of order and beauty, and that that same state of disorder has grown into this true Cosmos, Order? Or who can believe that those regular movements and courses are the products of a certain unregulated impetus? Or who can allow that the perfect concord subsisting among the celestial bodies derives its harmony from instruments destitute both of concord and harmony? Or, again, if there is but one and the same substance in all things, and if there is the same incorruptible nature in all,—the only elements of difference being, as they aver, size and figure,—how comes it that there are some bodies divine and perfect, and eternal, as they would phrase it, or lasting, as some one may prefer to express it; and among these some that are visible and others that are invisible,—the visible including such as sun, and moon, and stars, and earth, and water; and the invisible including gods, and demons, and spirits? For the existence of such they cannot possibly deny however desirous to do so.

And again, there are other objects that are long-lived, both animals and plants. As to animals, there are, for example, among birds, as they say, the eagle, the raven, and the phoenix; and among creatures living on land, there are the stag, and the elephant, and the dragon; and among aquatic creatures there are the whales, and such like monsters of the deep. And as to trees, there are the palm, and the oak, and the persea; and among trees, too, there are some that are evergreens, of which kind fourteen have been reckoned up by some one; and there are others that only bloom for a certain season, and then shed their leaves. And there are other objects, again—which indeed constitute the vast mass of all which either grow or are begotten—that have an early death and a brief life. And among these is man himself, as a certain holy scripture says of him: "Man that is born of woman is of few days." Well, but I suppose they will reply that the varying conjunctions of the atoms account fully for differences so great in the matter of duration. For it is maintained that there are some things that are compressed together by them, and firmly interlaced, so that they become closely compacted bodies, and consequently exceedingly hard to break up; while there are others in which more or less the conjunction of the atoms is of a looser and weaker nature, so that either quickly or after some time they separate themselves from their orderly constitution. And, again, there are some bodies made up of atoms of a definite kind and a certain common figure, while there are others made up of diverse atoms diversely disposed.

But who, then, is the sagacious discriminator, that brings certain atoms into collocation, and separates others; and marshals some in such wise as to form the sun, and others in such a way as to originate the moon, and adapts all in natural fitness, and in accordance with the proper constitution of each star? For surely neither would those solar atoms, with their peculiar size and kind, and with their special mode of collocation, ever have reduced themselves so as to effect the production of a moon; nor, on the other hand, would the conjunctions of these lunar atoms ever have developed into a sun. And as certainly neither would Arcturus, resplendent as he is, ever boast his having the atoms possessed by Lucifer, nor would the Pleiades glory in being constituted of those of Orion. For well has Paul expressed the distinction when he says: "There is one glory of the sun, and another glory of the moon, and another glory of the stars: for one star differeth from another star in glory."

And if the coalition effected among them has been an unintelligent one, as is the case with soulless objects, then they must needs have had some sagacious artificer; and if their union has been one without the determination of will, and only of necessity, as is the case with irrational objects, then some skilful leader must have brought them together and taken them under his
charge. And if they have linked themselves together spontaneously, for a spontaneous work, then some admirable architect must have apportioned their work for them, and assumed the superintendence among them; or there must have been one to do with them as the general does who loves order and discipline, and who does not leave his army in an irregular condition, or suffer all things to go on confusedly, but marshals the cavalry in their proper succession, and disposes the heavy-armed infantry in their due array, and the javelin-men by themselves, and the archers separately, and the slingers in like manner, and sets each force in its appropriate position, in order that all those equipped in the same way may engage together...

But inconsiderate men do not see even things that are apparent, and certainly they are far from being cognisant of things that are unapparent. For they do not seem even to have any notion of those regulated risings and settings of the heavenly bodies,—those of the sun, with all their wondrous glory, no less than those of the others; nor do they appear to make due application of the aids furnished through these to men, such as the day that rises clear for man's work, and the night that overshadows earth for man's rest. "For man," it is said, "goeth forth unto his work, and to his labour, until the evening." Neither do they consider that other revolution, by which the sun makes out for us determinate times, and convenient seasons, and regular successions, directed by those

atoms of which it consists. But even though men like these—and miserable men they are, however they may believe themselves to be righteous—may choose not to admit it, there is a mighty Lord that made the sun, and gave it the impetus for its course by His words. O ye blind ones, do these atoms of yours bring you the winter season and the rains, in order that the earth may yield food for you, and for all creatures living on it? Do they introduce summertime, too, in order that ye may gather their fruits from the trees for your enjoyment? And why, then, do ye not worship these atoms, and offer sacrifices to them as the guardians of earth's fruits? Thankless surely are ye, in not setting solemnly apart for them even the most scanty first-fruits of that abundant bounty which ye receive from them.

Moreover, those stars which form a community so multitudinous and various, which these erratic and ever self-dispersing atoms have constituted, have marked off by a kind of covenant the tracts for their several possessions, portioning these out like colonies and governments, but without the presidency of any founder or house-master; and with pledged fealty and in peace they respect the laws of vicinity with their neighbors, and abstain from passing beyond the boundaries which they received at the outset, just as if they enjoyed the legislative administration of true princes in the atoms. Nevertheless these atoms exercise no rule. For how could these, that are themselves nothing, do that? But listen to the divine oracles: "The works of the Lord are in judgment; from the beginning, and from His making of them, He disposed the parts thereof. He garnished His works for ever, and their principles unto their generations."

What phalanx ever traversed the plain in such perfect order, no trooper outmarching the others, or falling out of rank, or obstructing the course, or suffering himself to be distanced by his comrades in the array, as is the case with that steady advance in regular file, as it were, and with close-set shields, which is presented by this serried and unbroken and undisturbed and unobstructed progress of the hosts of the stars? Albeit by side inclinations and flank movements certain of their revolutions become less clear. Yet, however that may be, they assuredly always keep their appointed periods, and again bear onward determinately to the positions from which they have severally risen, as if they made that their deliberate study. Wherefore let these notable anatomizers of atoms, these dividers of the indivisible, these compounders of the uncompoundable, these adepts in the apprehension of the infinite, tell us whence comes this circular march and course of the heavenly bodies, in which it is not any single combination of atoms that merely chances all unexpectedly to swing itself round in this way; but it is one vast circular choir that moves thus, ever equally and concordantly, and whirls in these orbits. And whence comes it that this mighty multitude of fellow-travelers, all unmarshalled by any captain, all ungifted with any determination of will, and all unendowed with any knowledge of each other, have nevertheless held their course in perfect harmony? Surely, well has the prophet ranked this matter among things which are impossible and undemonstrable,—namely, that two strangers should walk together. For he says, "Shall two come to the same lodging unless they know each other?"

IV. A Refutation of the Same on the Grounds of the Human Constitution.

Further, those men understand neither themselves nor what is proper to themselves. For if any of the leaders in this impious doctrine only considered what manner of person he is himself, and whence he comes, he would surely be led to a wise decision, like one who has obtained understanding of himself, and would say, not to these atoms, but to his Father and Maker, "Thy hands have made me and fashioned me." And he would take up, too, this wonderful account of his formation as it has been given by one of old: "Hast Thou not poured me out as milk, and curdled me as cheese? Thou hast clothed me with skin and flesh, and hast fenced me with bones and sinews. Thou hast granted me life and favor, and Thy visitation hath preserved my spirit."

For of what quantity and of what origin were the atoms which the father of Epicurus gave forth from himself when he begat Epicurus? And how, when they were received within his mother's

womb, did they coalesce, and take form and figure? and how were they put in motion and made to increase? And how did that little seed of generation draw together the many atoms that were to constitute Epicurus, and change some of them into skin and flesh for a covering, and make bone of others for erectness and strength, and form sinews of others for compact contexture? And how did it frame and adapt the many other members and parts—heart and bowels, and organs of sense, some within and some without—by which the body is made a thing of life?

For of all these things there is not one either idle or useless: not even the meanest of them— the hair, or the nails, or such like—is so; but all have their service to do, and all their contribution to make, some of them to the soundness of bodily constitution, and others of them to beauty of appearance. For Providence cares not only for the useful, but also for the seasonable and beautiful. Thus the hair is a kind of protection and covering for the whole head, and the beard is a seemly ornament for the philosopher. It was Providence, then, that formed the constitution of the whole body of man, in all its necessary parts, and imposed on all its members their due connection with each other, and measured out for them their liberal supplies from the universal resources. And the most prominent of these show clearly, even to the uninstructed, by the proof of personal experience, the value and service attaching to them: the head, for example, in the position of supremacy, and the senses set like a guard about the brain, as the ruler in the citadel; and the advancing eyes, and the reporting ears; and the taste which, as it were, is the tribute- gatherer; and the smell, which tracks and searches out its objects: and the touch, which manipulates all put under it.

Hence we shall only run over in a summary way, at present, some few of the works of an all- wise Providence; and after a little we shall, if God grant it, go over them more minutely, when we direct our discourse toward one who has the repute of greater learning. So, then, we have the ministry of the hands, by which all kinds of works are wrought, and all skilful professions practised, and which have all their various faculties furnished them, with a view to the discharge of one common function; and we have the shoulders, with their capacity for bearing burdens; and the fingers, with their power of grasping; and the elbows, with their faculty of bending, by which they can turn inwardly, upon the body, or take an outward inclination, so as to be able either to draw objects toward the body, or to thrust them away from it. We have also the service of the feet, by which the whole terrestrial creation is made to come under our power, the earth itself is traversed thereby, the sea is made navigable, the rivers are crossed, and intercourse is established for all with all things. The belly, too, is the storehouse of meats, with all its parts arranged in their proper collocations, so that it apportions for itself the right measure of aliment, and ejects what is over and above that.

And so is it with all the other things by which manifestly the due administration of the constitution of man is wisely secured. Of all these, the intelligent and the unintelligent alike enjoy the same use; but they have not the same comprehension of them. For there are some who refer this whole economy to a power which they conceive to be a true divinity, and which they apprehend as at once the highest intelligence in all things, and the best benefactor to themselves, believing that this economy is all the work of a wisdom and a might which are superior to every other, and in themselves truly divine. And there are others who aimlessly attribute this whole structure of most marvelous beauty to chance and fortuitous coincidence. And in addition to these, there are also certain physicians, who, having made a more effective examination into all these things, and having investigated with utmost accuracy the disposition of the inward parts in especial, have been struck with astonishment at the results of their inquiry, and have been led to deify nature itself. The notions of these men we shall review afterwards, as far as we may be able, though we may only touch the surface of the subject.

Meantime, to deal with this matter generally and summarily, let me ask who constructed this whole tabernacle of ours, so lofty, erect, graceful, sensitive, mobile, active, and apt for all things? Was it, as they say, the irrational multitude of atoms?

Nay, these, by their conjunctions, could not mould even an image of clay, neither could they hew and polish a statue of stone; nor could they cast and finish an idol of silver or gold; but arts and handicrafts calculated for such operations have been discovered by men who fabricate these objects. And if, even in these, representations and models cannot be made without the aid of wisdom, how can the genuine and original patterns of these copies have come into existence spontaneously? And whence have come the soul, and the intelligence, and the reason, which are born with the philosopher? Has he gathered these from those atoms which are destitute alike of soul, and intelligence, and reason? and has each of these atoms inspired him with some appropriate conception and notion? And are we to suppose that the wisdom of man was made up by these atoms, as the myth of Hesiod tells us that Pandora was fashioned by the gods? Then shall the Greeks have, to give up speaking of the various species of poetry, and music, and astronomy, and geometry, and all the other arts and sciences, as the inventions and instructions of the gods, and shall have to allow that these atoms are the only muses with skill and wisdom for all subjects. For this theogony, constructed of atoms by Epicurus, is indeed something extraneous to the infinite worlds of order, and finds its refuge in the infinite disorder.

Lactantius, The Divine Institutes (Book I)
Known as the "Christian Cicero," Lactantius (c. 240-320 AD) was a professor of rhetoric who converted to Christianity. He influenced Emperor Constantine 's policy of religious toleration as well as becoming tutor to Constantine 's son.

Chapter II
For there is no one so uncivilized, and of such an uncultivated disposition, who, when he raises his eyes to heaven, although he knows not by the providence of what God all this visible universe is governed, does not understand from the very magnitude of the objects, from their motion, arrangement, constancy, usefulness, beauty, and temperament, that there is some providence, and that that which exists with wonderful method must have been prepared by some greater intelligence.

Chapter IX
But now the conclusion, with which Tully [Cicero] finished the sentiment, is much more absurd. "But if matter," he says, "was not made by God, the earth indeed, and water, and air, and fire, were not made by God." How skillfully he avoided the danger! For he stated the former point as though it required no proof, whereas it was much more uncertain than that on account of which the statement was made. If matter, he says, was not made by God, the world was not made by God. He preferred to draw a false inference from that which is false, than a true one from that which is true. And though uncertain things ought to be proved from those which are certain, he drew a proof from an uncertainty, to overthrow that which was certain. For, that the world was made by divine providence (not to mention Trismegistus, who proclaims this; not to mention the verses of the Sibyls, who make the same announcement; not to mention the prophets, who with one impulse and with harmonious voice bear witness that the world was made, and that it was the workmanship of God), even the philosophers almost universally agree; for this is the opinion of the Pythagoreans, the Stoics, and the Peripatetics, who are the chief of every sect. In short, from those first seven wise men, even to Socrates and Plato, it was held as an acknowledged and undoubted fact; until many ages afterwards the crazy Epicurus lived, who alone ventured to deny that which is most evident, doubtless through the desire of discovering novelties, that he might found a sect in his own name. And because he could find out nothing new, that he might still appear to disagree with the others, he wished to overthrow old opinions. But in this all the philosophers who snarled around

him, refuted him. It is more certain, therefore, that the world was arranged by providence, than that matter was collected by providence. Wherefore he ought not to have supposed that the world was not made by divine providence, because its matter was not made by divine providence; but because the world was made by divine providence, he ought to have concluded that matter also was made by the Deity. For it is more credible that matter was made by God, because He is all-powerful, than that the world was not made by God, because nothing can be made without mind, intelligence, and design...

If you had been brought up in a well-built and ornamented house, and had never seen a workshop, would you have supposed that that house was not built by man, because you did not know how it was built? You would assuredly ask the same question about the house which you now ask about the world—by what hands, with what implements, man had contrived such great works; and especially if you should see large stones, immense blocks, vast columns, the whole work lofty and elevated, would not these things appear to you to exceed the measure of human strength, because you would not know that these things were made not so much by strength as by skill and ingenuity?

But if man, in whom nothing is perfect, nevertheless effects more by skill than his feeble strength would permit, what reason is there why it should appear to you incredible, when it is alleged that the world was made by God, in whom, since He is perfect, wisdom can have no limit, and strength no measure?

6. Athanasius, Contra Gentes (Part Iii)
Athanasius (c. 296-373) was Archbishop of Alexandria.

§35. Creation a revelation of God; especially in the order and harmony pervading the whole.

1. For God, being good and loving to mankind, and caring for the souls made by Him,—since He is by nature invisible and incomprehensible, having His being beyond all created existence, for which reason the race of mankind was likely to miss the way to the knowledge of Him, since they are made out of nothing while He is unmade,—for this cause God by His own Word gave the Universe the Order it has, in order that since He is by nature invisible, men might be enabled to know Him at any rate by His works. For often the artist even when not seen is known by his works.

2. And as they tell of Phidias the Sculptor that his works of art by their symmetry and by the proportion of their parts betray Phidias to those who see them although he is not there, so by the order of the Universe one ought to perceive God its maker and artificer, even though He be not seen with the bodily eyes. For God did not take His stand upon His invisible nature (let none plead that as an excuse) and leave Himself utterly unknown to men; but as I said above, He so ordered Creation that although He is by nature invisible He may yet be known by His works.

3. And I say this not on my own authority, but on the strength of what I learned from men who have spoken of God, among them Paul, who thus writes to the Romans: “for the invisible things of Him since the creation of the world are clearly seen, being understood by the things that are made;” while to the Lycaonians he speaks out and says: “We also are men of like passions with you, and bring you good tidings, to turn from these vain things unto a Living God, Who made the heaven and the earth and the sea, and all that in them is, Who in the generations gone by suffered all nations to walk in their own ways. And yet He left not Himself without witness, in that He did good, and gave you from heaven rains and fruitful seasons, filling your hearts with food and gladness.”

4. For who that sees the circle of heaven and the course of the sun and the moon, and the positions and movements of the other stars, as they take place in opposite and different directions, while yet in their difference all with one accord observe a consistent order, can resist the conclusion that

these are not ordered by themselves, but have a maker distinct from themselves who orders them? or who that sees the sun rising by day and the moon shining by night, and waning and waxing without variation exactly according to the same number of days, and some of the stars running their courses and with orbits various and manifold, while others move without wandering, can fail to perceive that they certainly have a creator to guide them?

§36. This the more striking, if we consider the opposing forces out of which this order is produced.

1. Who that sees things of opposite nature combined, and in concordant harmony, as for example fire mingled with cold, and dry with wet, and that not in mutual conflict, but making up a single body, as it were homogeneous, can resist the inference that there is One external to these things that has united them? Who that sees winter giving place to spring and spring to summer and summer to autumn, and that these things contrary by nature (for the one chills, the other burns, the one nourishes, the other destroys), yet all make up a balanced result beneficial to mankind,—can fail to perceive that there is One higher than they, Who balances and guides them all, even if he see Him not?

2. Who that sees the clouds supported in air, and the weight of the waters bound up in the clouds, can but perceive Him that binds them up and has ordered these things so? Or who that sees the earth, heaviest of all things by nature, fixed upon the waters, and remaining unmoved upon what is by nature mobile, will fail to understand that there is One that has made and ordered it, even God? Who that sees the earth bringing forth fruits in due season, and the rains from heaven, and the flow of rivers, and springing up of wells, and the birth of animals from unlike parents, and that these things take place not at all times but at determinate seasons,—and in general, among things mutually unlike and contrary, the balanced and uniform order to which they conform,—can resist the inference that there is one Power which orders and administers them, ordaining things well as it thinks fit?

4. For left to themselves they could not subsist or ever be able to appear, on account of their mutual contrariety of nature. For water is by nature heavy, and tends to flow downwards, while the clouds are light and belong to the class of things which tend to soar and mount upwards. And yet we see water, heavy as it is, borne aloft in the clouds. And again, earth is very heavy, while water on the other hand is relatively light; and yet the heavier is supported upon the lighter, and the earth does not sink, but remains immoveable. And male and female are not the same, while yet they unite in one, and the result is the generation from both of an animal like them. And to cut the matter short, cold is opposite to heat, and wet fights with dry, and yet they come together and are not at variance, but they agree, and produce as their result a single body, and the birth of everything...

§38. The Unity of God shewn by the Harmony of the order of Nature.

1. Since then, there is everywhere not disorder but order, proportion and not disproportion, not disarray but arrangement, and that in an order perfectly harmonious, we needs must infer and be led to perceive the Master that put together and compacted all things, and produced harmony in them. For though He be not seen with the eyes, yet from the order and harmony of things contrary it is possible to perceive their Ruler, Arranger, and King.

2. For in like manner as if we saw a city, consisting of many and diverse people, great and small, rich and poor, old and young, male and female, in an orderly condition, and its inhabitants, while different from one another, yet at unity among themselves, and not the rich set against the poor, the great against the small, nor the young against the old, but all at peace in the enjoyment of equal rights,—if we saw this, the inference surely follows that the presence of a ruler enforces

concord, even if we do not see him; (for disorder is a sign of absence of rule, while order shews the governing authority: for when we see the mutual harmony of the members in the body, that the eye does not strive with the hearing, nor is the hand at variance with the foot, but that each accomplishes its service without variance, we perceive from this that certainly there is a soul in the body that governs these members, though we see it not); so in the order and harmony of the Universe, we needs must perceive God the governor of it all, and that He is one and not many.

3. So then this order of its arrangement, and the concordant harmony of all things, shews that the Word, its Ruler and Governor, is not many, but One. For if there were more than one Ruler of Creation, such an universal order would not be maintained, but all things would fall into confusion because of their plurality, each one biasing the whole to his own will, and striving with the other. For just as we said that polytheism was atheism, so it follows that the rule of more than one is the rule of none. For each one would cancel the rule of the other, and none would appear ruler, but there would be anarchy everywhere. But where no ruler is, there disorder follows of course.

4. And conversely, the single order and concord of the many and diverse shews that the ruler too is one. For just as though one were to hear from a distance a lyre, composed of many diverse strings, and marvel at the concord of its symphony, in that its sound is composed neither of low notes exclusively, nor high nor intermediate only, but all combine their sounds in equal balance,—and would not fail to perceive from this that the lyre was not playing itself, nor even being struck by more persons than one, but that there was one musician, even if he did not see him, who by his skill combined the sound of each string into the tuneful symphony; so, the order of the whole universe being perfectly harmonious, and there being no strife of the higher against the lower or the lower against the higher, and all things making up one order, it is consistent to think that the Ruler and King of all Creation is one and not many, Who by His own light illumines and gives movement to all.

§47. Necessity of a return to the Word if our corrupt nature is to be restored.

1. Who then, who can declare the Father by number, so as to discover the powers of His Word? For like as He is the Father's Word and Wisdom, so too condescending to created things, He becomes, to impart the knowledge and apprehension of Him that begot Him, His very Brightness and very Life, and the Door, and the Shepherd, and the Way, and King and Governor, and Saviour over all, and Light, and Giver of Life, and Providence over all. Having then such a Son begotten of Himself, good, and Creator, the Father did not hide Him out of the sight of His creatures, but even day by day reveals Him to all by means of the organisation and life of all things, which is His work.

2. But in and through Him He reveals Himself also, as the Saviour says: "I in the Father and the Father in Me:" so that it follows that the Word is in Him that begat Him, and that He that is begotten lives eternally with the Father. But this being so, and nothing being outside Him, but both heaven and earth and all that in them is being dependent on Him, yet men in their folly have set aside the knowledge and service of Him, and honoured things that are not instead of things that are: and instead of the real and true God deified things that were not, "serving the creature rather than the Creator," thus involving themselves in foolishness and impiety.

3. For it is just as if one were to admire the works more than the workman, and being awestruck at the public works in the city, were to make light of their builder, or as if one were to praise a musical instrument but to despise the man who made and tuned it. Foolish and sadly disabled in eyesight! For how else had they known the building, or ship, or lyre, had not the shipbuilder made it, the architect built it, or the musician fashioned it?

4. As then he that reasons in such a way is mad, and beyond all madness, even so affected in mind, I think, are those who do not recognise God or worship His Word, our Lord Jesus Christ the Saviour

of all, through Whom the Father orders, and 30holds together all things, and exercises providence over the Universe; having faith and piety towards Whom, my Christ-loving friend, be of good cheer and of good hope, because immortality and the kingdom of heaven is the fruit of faith and devotion towards Him, if only the soul be adorned according to His laws. For just as for them who walk after His example, the prize is life everlasting, so for those who walk the opposite way, and not that of virtue, there is great shame, and peril without pardon in the day of judgment, because although they knew the way of truth their acts were contrary to their knowledge.

Chrysostom, Homilies On Romans (Homily 3)
Archbishop of Constantinople at the beginning of the fifth century, John Chrysostom (347?-407 AD) is known as the greatest of the Greek church fathers.

Ver. 19. "Because that which may be known of God is manifest in them, for God hath showed it unto them."
But this glory they invested stocks and stones with. As then he which is entrusted with the goods of the king, and is ordered to spend them upon the king's glory, if he waste these upon robbers, and harlots, and witches, and make these splendid out of the king's stores, he is punished as having done the kingdom the greatest wrong. Thus they also who after having received the knowledge of God and of His glory, invested idols therewith, "held the truth in unrighteousness," and, at least as far as was in their power, dealt unrighteously by the knowledge, by not using it upon fitting objects. Now, has what was said become clear to you, or must one make it still clearer? Perhaps it were needful to say somewhat more. What then is it which is here said? The knowledge of Himself God placed in men from the beginning. But this knowledge they invested stocks and stones with, and so dealt unrighteously to the truth, as far at least as they might. For it abideth unchanged, having its own glory immutable. "And whence is it plain that He placed in them this knowledge, O Paul?" "Because," saith he, "that which may be known of Him is manifest in them." This, however, is an assertion, not a proof. But do thou make it good, and show me that the knowledge of God was plain to them, and that they willingly turned aside. Whence was it plain then? did He send them a voice from above? By no means. But what was able to draw them to Him more than a voice, that He did, by putting before them the Creation, so that both wise, and unlearned, and Scythian, and barbarian, having through sight learned the beauty of the things which were seen, might mount up to God. Wherefore he says,

Ver. 20. "For the invisible things of Him from the Creation of the world are clearly seen, being understood by the things which are made."
Which also the prophet said, "The heavens declare the glory of God." (Ps. xix. 1.) For what will the Greeks (i.e. Heathen) say in that day? That "we were ignorant of Thee?" Did ye then not hear the heaven sending forth a voice by the sight, while the well-ordered harmony of all things spake out more clearly than a trumpet? Did ye not see the hours of night and day abiding unmoved continually, the goodly order of winter, spring, and the other seasons remaining both sure and unmoved, the tractableness (eugnomosunen) of the sea amid all its turbulence and waves? All things abiding in order and by their beauty and their grandeur, preaching aloud of the Creator? For all these things and more than these doth Paul sum up in saying, "The invisible things of Him from the creation of the world are clearly seen, being understood by the things which are made, even His eternal Power and Godhead; so that they are without excuse."

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The Patristic Understanding Of Creation - An Anthology of Writings from the Church Fathers on Creation and Design
Source Book by Leader of Intelligent Design

Athenagoras (125-190)
A Plea for the Christians

Chapter IV — The Christians are Not Atheists, But Acknowledge Only One God
As regards, first of all, the allegation that we are atheists — for I will meet the charges one by one, that we may not be ridiculed for having no answer to give to those who make them — with reason did the Athenians adjudge Diagoras guilty of atheism, in that he not only divulged the Orphic doctrine, and published the mysteries of Eleusis and of the Cabin, and chopped up the wooden statue of Hercules to boil his turnips, but openly declared that there was no God at all. But to us, who distinguish God from matter, and teach that matter is one thing and God another, and that they are separated by a wide interval (for that the Deity is uncreated and eternal, to be beheld by the understanding and reason alone, while matter is created and perishable), is it not absurd to apply the name of atheism?

If our sentiments were like those of Diagoras, while we have such incentives to piety — in the established order, the universal harmony, the magnitude, the colour, the form, the arrangement of the world — with reason might our reputation for impiety, as well as the cause of our being thus harassed, be charged on ourselves. But, since our doctrine acknowledges one God, the Maker of this universe, who is Himself uncreated (for that which is does not come to be, but that which is not) but has made all things by the Logos which is from Him, we are treated unreasonably in both respects, in that we are both defamed and persecuted.

Chapter VI — Opinions of the Philosophers as to the One God
Philolaus, too, when he says that all things are included in God as in a stronghold, teaches that He is one, and that He is superior to matter. Lysis and Opsimus thus define God: the one says that He is an ineffable number, the other that He is the excess of the greatest number beyond that which comes nearest to it. So that since ten is the greatest number according to the Pythagoreans, being the Tetractys, and containing all the arithmetic and harmonic principles, and the Nine stands next to it, God is a unit — that is, one. For the greatest number exceeds the next least by one.

Then there are Plato and Aristotle — not that I am about to go through all that the philosophers have said about God, as if I wished to exhibit a complete summary of their opinions; for I know that, as you excel all men in intelligence and in the power of your rule, in the same proportion do you surpass them all in an accurate acquaintance with all learning, cultivating as you do each several branch with more success than even those who have devoted themselves exclusively to any one. But, in as much as it is impossible to demonstrate without the citation of names that we are not alone in confining the notion of God to unity, I have ventured on an enumeration of opinions.

Plato, then, says, "To find out the Maker and Father of this universe is difficult; and, when found, it is impossible to declare Him to all," conceiving of one uncreated and eternal God. And if he recognises others as well, such as the sun, moon, and stars, yet he recognises them as created: "gods, offspring of gods, of whom I am the Maker, and the Father of works which are indissoluble apart from my will; but whatever is compounded can be dissolved." If, therefore, Plato is not an atheist for conceiving of one uncreated God, the Framer of the universe, neither are we atheists who acknowledge and firmly hold that He is God who has framed all things by the Logos, and holds them in being by His Spirit.

Aristotle, again, and his followers, recognising the existence of one whom they regard as a sort of compound living creature, speak of God as consisting of soul and body, thinking His body to be the etherial space and the planetary stars and the sphere of the fixed stars, moving in circles; but His

soul, the reason which presides over the motion of the body, itself not subject to motion, but becoming the cause of motion to the other.

The Stoics also, although by the appellations they employ to suit the changes of matter, which they say is permeated by the Spirit of God, they multiply the Deity in name, yet in reality they consider God to be one. For, if God is an artistic fire advancing methodically to the production of the several things in the world, embracing in Himself all the seminal principles by which each thing is produced in accordance with fate, and if His Spirit pervades the whole world, then God is one according to them, being named Zeus in respect of the fervid part of matter, and Hera in respect of the air, and called by other names in respect of that particular part of matter which He pervades.

Chapter VIII — Absurdities of Polytheism

As regards, then, the doctrine that there was from the beginning one God, the Maker of this universe, consider it in this wise, that you may be acquainted with the argumentative grounds also of our faith. If there were from the beginning two or more gods, they were either in one and the same place, or each of them separately in his own. In one and the same place they could not be. For, if they are gods, they are not alike; but because they are uncreated they are unlike: for

created things are like their patterns; but the uncreated are unlike, being neither produced from any one, nor formed after the pattern of any one. Hand and eye and foot are parts of one body, making up together one man: is God in this sense one? And indeed Socrates was compounded and divided into parts, just because he was created and perishable; but God is uncreated, and, impassible, and indivisible — does not, therefore, consist of parts.

But if, on the contrary, each of them exists separately, since He that made the world is above the things created, and about the things He has made and set in order, where can the other or the rest be? For if the world, being made spherical, is confined within the circles of heaven, and the Creator of the world is above the things created, managing that by His providential care of these, what place is there for the second god, or for the other gods? For he is not in the world, because it belongs to the other; nor about the world, for God the Maker of the world is above it. But if he is neither in the world nor about the world (for all that surrounds it is occupied by this one), where is he? Is he above the world and [the first] God? In another world, or about another? But if he is in another or about another, then he is not about us, for he does not govern the world; nor is his power great, for he exists in a circumscribed space. But if he is neither in another world (for all things are filled by the other), nor about another (for all things are occupied by the other), he clearly does not exist at all, for there is no place in which he can be.

Or what does he do, seeing there is another to whom the world belongs, and he is above the Maker of the world, and yet is neither in the world nor about the world? Is there, then, some other place where he can stand? But God, and what belongs to God, are above him. And what, too, shall be the place, seeing that the other fills the regions which are above the world? Perhaps he exerts a providential care? [By no means.] And yet, unless he does so, he has done nothing. If, then, he neither does anything nor exercises providential care, and if there is not another place in which he is, then this Being of whom we speak is the one God from the beginning, and the sole Maker of the world.

Chapter X — The Christians Worship the Father, Son, and Holy Ghost

That we are not atheists, therefore, seeing that we acknowledge one God, uncreated, eternal, invisible, impassible, incomprehensible, illimitable, who is apprehended by the understanding only and the reason, who is encompassed by light, and beauty, and spirit, and power ineffable, by whom the universe has been created through His Logos, and set in order, and is kept in being — I have sufficiently demonstrated. [I say "His Logos"], for we acknowledge also a Son of God. Nor let any

one think it ridiculous that God should have a Son. For though the poets, in their fictions, represent the gods as no better than men, our mode of thinking is not the same as theirs, concerning either God the Father or the Son.

But the Son of God is the Logos of the Father, in idea and in operation; for after the pattern of Him and by Him were all things made, the Father and the Son being one. And, the Son being in the Father and the Father in the Son, in oneness and power of spirit, the understanding and reason (nous kia logos) of the Father is the Son of God. But if, in your surpassing intelligence, it occurs to you to inquire what is meant by the Son, I will state briefly that He is the first product of the Father, not as having been brought into existence (for from the beginning, God, who is the eternal mind [nous], had the Logos in Himself, being from eternity instinct with Logos [logikos]; but in as much as He came forth to be the idea and energizing power of all material things, which lay like a nature without attributes, and an inactive earth, the grosser particles being mixed up with the lighter.

The prophetic Spirit also agrees with our statements. "The Lord," it says, "made me, the beginning of His ways to His works." The Holy Spirit Himself also, which operates in the prophets, we assert to be an effluence of God, flowing from Him, and returning back again like a beam of the sun. Who, then, would not be astonished to hear men who speak of God the Father, and of God the Son, and of the Holy Spirit, and who declare both their power in union and their distinction in order, called atheists? Nor is our teaching in what relates to the divine nature confined to these points; but we recognise also a multitude of angels and ministers, whom God the Maker and Framer of the world distributed and appointed to their several posts by His Logos, to occupy themselves about the elements, and the heavens, and the world, and the things in it, and the goodly ordering of them all.

Chapter XIII — Why the Christians Do Not Offer Sacrifices

But, as most of those who charge us with atheism, and that because they have not even the dreamiest conception of what God is, and are doltish and utterly unacquainted with natural and divine things, and such as measure piety by the rule of sacrifices, charges us with not acknowledging the same gods as the cities, be pleased to attend to the following considerations, O emperors, on both points. And first, as to our not sacrificing: the Framer and Father of this universe does not need blood, nor the odour of burnt offerings, nor the fragrance of flowers and incense, for as much as He is Himself perfect fragrance, needing nothing either within or without; but the noblest sacrifice to Him is for us to know who stretched out and vaulted the heavens, and fixed the earth in its place like a centre, who gathered the water into seas and divided the light from the darkness, who adorned the sky with stars and made the earth to bring forth seed of every kind, who made animals and fashioned man. When, holding God to be this Framer of all things, who preserves them in being and superintends them all by knowledge and administrative skill, we "lift up holy hands" to Him, what need has He further of a hecatomb?...

Chapter XV — The Christians Distinguish God from Matter

But grant that they acknowledge the same. What then? Because the multitude, who cannot distinguish between matter and God, or see how great is the interval which lies between them, pray to idols made of matter, are we therefore, who do distinguish and separate the uncreated and the created, that which is and that which is not, that which is apprehended by the understanding and that which is perceived by the senses, and who give the fitting name to each of them — are we to come and worship images?

If, indeed, matter and God are the same, two names for one thing, then certainly, in not regarding stocks and stones, gold and silver, as gods, we are guilty of impiety. But if they are at the greatest possible remove from one another — as far asunder as the artist and the materials of his art — why

are we called to account? For as is the potter and the clay (matter being the clay, and the artist the potter), so is God, the Framer of the world, and matter, which is subservient to Him for the purposes of His art.

But as the clay cannot become vessels of itself without art, so neither did matter, which is capable of taking all forms, receive, apart from God the Framer, distinction and shape and order. And as we do not hold the pottery of more worth than him who made it, nor the vessels or glass and gold than him who wrought them; but if there is anything about them elegant in art we praise the artificer, and it is he who reaps the glory of the vessels: even so with matter and God — the glory and honour of the orderly arrangement of the world belongs of right not to matter, but to God, the Framer of matter. So that, if we were to regard the various forms of matter as gods, we should seem to be without any sense of the true God, because we should be putting the things which are dissoluble and perishable on a level with that which is eternal.

Chapter XVI — The Christians Do Not Worship the Universe

Beautiful without doubt is the world, excelling, as well in its magnitude as in the arrangement of its parts, both those in the oblique circle and those about the north, and also in its spherical form. Yet it is not this, but its Artificer, that we must worship. For when any of your subjects come to you, they do not neglect to pay their homage to you, their rulers and lords, from whom they will obtain whatever they need, and address themselves to the magnificence of your palace; but, if they chance to come upon the royal residence, they bestow a passing glance of admiration on its beautiful structure: but it is to you yourselves that they show honour, as being "all in all." You sovereigns, indeed, rear and adorn your palaces for yourselves; but the world was not created because God needed it; for God is Himself everything to Himself — light unapproachable, a perfect world, spirit, power, reason.

If, therefore, the world is an instrument in tune, and moving in well-measured time, I adore the Being who gave its harmony, and strikes its notes, and sings the accordant strain, and not the instrument. For at the musical contests the adjudicators do not pass by the lute players and crown the lutes. Whether, then, as Plato says, the world be a product of divine art, I admire its beauty, and adore the Artificer; or whether it be His essence and body, as the Peripatetics affirm, we do not neglect to adore God, who is the cause of the motion of the body, and descend "to the poor and weak elements," adoring in the impassible air (as they term it), passible matter; or, if any one apprehends the several parts of the world to be powers of God, we do not approach and do homage to the powers, but their Maker and Lord.

I do not ask of matter what it has not to give, nor passing God by do I pay homage to the elements, which can do nothing more than what they were bidden; for, although they are beautiful to look upon, by reason of the art of their Framer, yet they still have the nature of matter. And to this view Plato also bears testimony; "for," says he, "that which is called heaven and earth has received many blessings from the Father, but yet partakes of body; hence it cannot possibly be free from' change." If, therefore, while I admire the heavens and the elements in respect of their art, I do not worship them as gods, knowing that the law of dissolution is upon them, how can I call those objects gods of which I know the makers to be men? Attend, I beg, to a few words on this subject.

Chapter XIX — The Philosophers Agree with the Poets Respecting the Gods

Such was the beginning of the existence both of their gods and of the universe. Now what are we to make of this? For each of those things to which divinity is ascribed is conceived of as having existed from the first. For, if they have come into being, having previously had no existence, as those say who treat of the gods, they do not exist. For, a thing is either uncreated and eternal, or created and perishable. Nor do I think one thing and the philosophers another. "What is that which always is, and has no origin; or what is that which has been originated, yet never is?"

Discoursing of the intelligible and the sensible, Plato teaches that that which always is, the intelligible, is unoriginated, but that which is not, the sensible, is originated, beginning to be and ceasing to exist. In like manner, the Stoics also say that all things will be burnt up and will again exist, the world receiving another beginning. But if, although there is, according to them, a twofold cause, one active and governing, namely providence, the other passive and changeable, namely matter, it is nevertheless impossible for the world, even though under the care of Providence, to remain in the same state, because it is created — how can the constitution of these gods remain, who are not self-existent, but have been originated? And in what are the gods superior to matter, since they derive their constitution from water? But not even water, according to them, is the beginning of all things.

From simple and homogeneous elements what could be constituted? Moreover, matter requires an artificer, and the artificer requires matter. For how could figures be made without matter or an artificer? Neither, again, is it reasonable that matter should be older than God; for the efficient cause must of necessity exist before the things that are made.

Chapter XXV — The Poets and Philosophers Have Denied a Divine Providence

These angels, then, who have fallen from heaven, and haunt the air and the earth, and are no longer able to rise to heavenly things, and the souls of the giants, which are the demons who wander about the world, perform actions similar, the one (that is, the demons) to the natures they have received, the other (that is, the angels) to the appetites they have indulged. But the prince of matter, as may be seen merely from what transpires, exercises a control and management contrary to the good that is in God:

"Ofttimes this anxious thought has crossed my mind,
Whether 'tis chance or deity that rules
The small affairs of men; and, spite of hope
As well as justice, drives to exile some
Stripped of all means of life, while others still
Continue to enjoy prosperity."

Prosperity and adversity, contrary to hope and justice, made it impossible for Euripides to say to whom belongs the administration of earthly affairs, which is of such a kind that one might say of it:

"How then, while seeing these things, can we say There is a race of gods, or yield to laws?"

The same thing led Aristotle to say that the things below the heaven are not under the care of Providence, although the eternal providence of God concerns itself equally with us below:

"The earth, let willingness move her or not,
Must herbs produce, and thus sustain my flocks,"

and addresses itself to the deserving individually, according to truth and not according to opinion; and all other things, according to the general constitution of nature, are provided for by the law of reason.

But because the demoniac movements and operations proceeding from the adverse spirit produce these disorderly sallies, and moreover move men, some in one way and some in another, as individuals and as nations, separately and in common, in accordance with the tendency of matter on the one hand, and of the affinity for divine things on the other, from within and from without — some who are of no mean reputation have therefore thought that this universe is constituted

without any definite order, and is driven hither and thither by an irrational chance.

But they do not understand, that of those things which belong to the constitution of the whole world there is nothing out of order or neglected, but that each one of them has been produced by reason, and that, therefore, they do not transgress the order prescribed to them; and that man himself, too, so far as He that made him is concerned, is well ordered, both by his original nature, which has one common character for all, and by the constitution of his body, which does not transgress the law imposed upon it, and by the termination of his life, which remains equal and common to all alike; but that, according to the character peculiar to himself and the operation of the ruling prince and of the demons his followers, he is impelled and moved in this direction or in that, notwithstanding that all possess in common the same original constitution of mind.

one; for the men themselves knew what they were saying, as did also their disciples, and those again succeeded these. And, in the next place, if either the Mother or her seed knew and proclaimed those things which were of the truth (and the Father is truth), then on their theory the Saviour spoke falsely when He said, "No one knoweth the Father but the Son," unless indeed they maintain that their seed or Mother is No-one.

Chapter XXV — God is Not to Be Sought After by Means of Letters, Syllables, and Numbers; Necessity of Humility in Such Investigations

1. If any one, however, say in reply to these things, What then? Is it a meaningless and accidental thing, that the positions of names, and the election of the apostles, and the working of the Lord, and the arrangement of created things, are what they are? — we answer them: Certainly not; but with great wisdom and diligence, all things have clearly been made by God, fitted and prepared [for their special purposes]; and His word formed both things ancient and those belonging to the latest times; and men ought not to connect those things with the number thirty, but to harmonize them with what actually exists, or with fight reason.

Nor should they seek to prosecute inquiries respecting God by means of numbers, syllables, and letters. For this is an uncertain mode of proceeding, on account of their varied and diverse systems, and because every sort of hypothesis may at the present day be, in like manner, devised by any one; so that they can derive arguments against the truth from these very theories, inasmuch as they may be turned in many different directions. But, on the contrary, they ought to adapt the numbers themselves, and those things which have been formed, to the true theory lying before them. For system does not spring out of numbers, but numbers from a system; nor does God derive His being from things made, but things made from God. For all things originate from one and the same God.

2. But since created things are various and numerous, they are indeed well fitted and adapted to the whole creation; yet, when viewed individually, are mutually opposite and inharmonious, just as the sound of the lyre, which consists of many and opposite notes, gives rise to one unbroken melody, through means of the interval which separates each one from the others. The lover of truth therefore ought not to be deceived by the interval between each note, nor should he imagine that one was due to one artist and author, and another to another, nor that one person fitted the treble, another the bass, and yet another the tenor strings; but he should hold that one and the same person [formed the whole], so as to prove the judgment, goodness, and skill exhibited in the whole work and [specimen of] wisdom.

Those, too, who listen to the melody, ought to praise and extol the artist, to admire the tension of some notes, to attend to the softness of others, to catch the sound of others between both these extremes, and to consider the special character of others, so as to inquire at what each one aims, and what is the cause of their variety, never failing to apply our rule, neither giving up the [one]

artist, nor casting off faith in the one God who formed all things, nor blaspheming our Creator.

3. If, however, any one do not discover the cause of all those things which become objects of investigation, let him reflect that man is infinitely inferior to God; that he has received grace only in part, and is not yet equal or similar to his Maker; and, moreover, that he cannot have experience or form a conception of all things like God; but in the same proportion as he who was formed but today, and received the beginning of his creation, is inferior to Him who is un-created, and who is always the same, in that proportion is he, as respects knowledge and the faculty of investigating the causes of all things, inferior to Him who made him. For thou, O man, art not an untreated being, nor didst thou always co-exist with God, as did His own Word; but now, through His pre-eminent goodness, receiving the beginning of thy creation, thou dost gradually learn from the Word the dispensations of God who made thee.

4. Preserve therefore the proper order of thy knowledge, and do not, as being ignorant of things really good, seek to rise above God Himself, for He cannot be surpassed; nor do thou seek after any one above the Creator, for thou wilt not discover such, For thy Former cannot be contained within limits; nor, although thou shouldst measure all this [universe], and pass through all His creation, and consider it in all its depth, and height, and length, wouldst thou be able to conceive of any other above the Father Himself. For thou wilt not be able to think Him fully out, but, indulging in trains of reflection opposed to thy nature, thou wilt prove thyself foolish; and if thou persevere in such a course, thou wilt fall into utter madness, whilst thou deemest thyself loftier and greater than thy Creator, and imaginest that thou canst penetrate beyond His dominions.

Chapter XXVI — "Knowledge Puffeth Up, But Love Edifieth"

1. It is therefore better and more profitable to belong to the simple and unlettered class, and by means of love to attain to nearness to God, than, by imagining ourselves learned and skilful, to be found [among those who are] blasphemous against their own God, inasmuch as they conjure up another God as the Father. And for this reason Paul exclaimed, "Knowledge puffeth up, but love edifieth:" not that he meant to inveigh against a true knowledge of God, for in that case he would have accused himself; but, because he knew that some, puffed up by the pretence of knowledge, fall away from the love of God, and imagine that they themselves are perfect, for this reason that they set forth an imperfect Creator, with the view of putting an end to the pride which they feel on account of knowledge of this kind, he says, "Knowledge puffeth up, but love edifieth."

Now there can be no greater conceit than this, that any one should imagine he is better and more perfect than He who made and fashioned him, and imparted to him the breath of life, and commanded this very thing into existence. It is therefore better, as I have said, that one should have no knowledge whatever of any one reason why a single thing in creation has been made, but should believe in God, and continue in His love, than that, puffed up through knowledge of this kind, he should fall away from that love which is the life of man; and that he should search after no other knowledge except [the knowledge of] Jesus Christ the Son of God, who was crucified for us, than that by subtle questions and hair-splitting expressions he should fall into impiety.

2. For how would it be, if any one, gradually elated by attempts of the kind referred to, should, because the Lord said that "even the hairs of your head are all numbered," set about inquiring into the number of hairs on each one's head, and endeavour to search out the reason on account of which one man has so many, and another so many, since all have not an equal number, but many thousands upon thousands are to be found with still varying numbers, on this account that some have larger and others smaller heads, some have bushy heads of hair, others thin, and others scarcely any hair at all — and then those who imagine that they have discovered the number of the hairs, should endeavour to apply that for the commendation of their own sect which they have conceived?

Or again, if any one should, because of this expression which occurs in the Gospel, "Are not two sparrows sold for a farthing? and not one of them falls to the ground without the will of your Father," take occasion to reckon up the number of sparrows caught daily, whether over all the world or in some particular district, and to make inquiry as to the reason of so many having been captured yesterday, so many the day before, and so many again on this day, and should then join on the number of sparrows to his [particular] hypothesis, would he not in that case mislead himself altogether, and drive into absolute insanity those that agreed with him, since men are always eager in such matters to be thought to have discovered something more extraordinary than their masters?

3. But if any one should ask us whether every number of all the things which have been made, and which are made, is known to God, and whether every one of these [numbers] has, according to His providence, received that special amount which it contains; and on our agreeing that such is the case, and acknowledging that not one of the things which have been, or are, or shall be made, escapes the knowledge of God, but that through His providence every one of them has obtained its nature, and rank, and number, and special quantity, and that nothing whatever either has been or is produced in vain or accidentally, but with exceeding suitability [to the purpose intended], and in the exercise of transcendent knowledge, and that it was an admirable and truly divine intellect which could both distinguish and bring forth the proper causes of such a system: if, [I say,] any one, on obtaining our adherence and consent to this, should proceed to reckon up the sand and pebbles of the earth, yea also the waves of the sea and the stars of heaven, and should endeavour to think out the causes of the number which he imagines himself to have discovered, would not his labour be in vain, and would not such a man be justly declared mad, and destitute of reason, by all possessed of common sense?

And the more he occupied himself beyond others in questions of this kind, and the more he imagines himself to find out beyond others, styling them unskilful, ignorant, and animal beings, because they do not enter into his so useless labour, the more is he [in reality] insane, foolish, struck as it were with a thunderbolt, since indeed he does in no one point own himself inferior to God; but, by the knowledge which he imagines himself to have discovered, he changes God Himself, and exalts his own opinion above the greatness of the Creator.

Chapter XXVII — Proper Mode of Interpreting Parables and Obscure Passages of Scripture

1. A sound mind, and one which does not expose its possessor to danger, and is devoted to piety and the love of truth, will eagerly meditate upon those things which God has placed within the power of mankind, and has subjected to our knowledge, and will make advancement in [acquaintance with] them, rendering the knowledge of them easy to him by means of daily study. These things are such as fall [plainly] under our observation, and are clearly and unambiguously in express terms set forth in the Sacred Scriptures. And therefore the parables ought not to be adapted to ambiguous expressions. For, if this be not done, both he who explains them will do so without danger, and the parables will receive a like interpretation from all, and the body of truth remains entire, with a harmonious adaptation of its members, and without any collision [of its several parts]. But to apply expressions which are not clear or evident to interpretations of the parables, such as every one discovers for himself as inclination leads him, [is absurd.] For in this way no one will possess the rule of truth; but in accordance with the number of persons who explain the parables will be found the various systems of truth, in mutual opposition to each other, and setting forth antagonistic doctrines, like the questions current among the Gentile philosophers.

2. According to this course of procedure, therefore, man would always be inquiring but never finding, because he has rejected the very method of discovery. And when the Bridegroom comes, he who has his lamp untrimmed, and not burning with the brightness of a steady light, is classed among those who obscure the interpretations of the parables, forsaking Him who by His plain

announcements freely imparts gifts to all who come to Him, and is excluded from His marriage chamber.

Since, therefore, the entire Scriptures, the prophets, and the Gospels, can be clearly, unambiguously, and harmoniously understood by all, although all do not believe them; and since they proclaim that one only God, to the exclusion of all others, formed all things by His word, whether visible or invisible, heavenly or earthly, in the water or under the earth, as I have shown from the very words of Scripture; and since the very system of creation to which we belong testifies, by what falls under our notice, that one Being made and governs it — those persons will seem truly foolish who blind their eyes to such a clear demonstration, and will not behold the light of the announcement [made to them]; but they put fetters upon themselves, and every one of them imagines, by means of their obscure interpretations of the parables, that he has found out a God of his own. For that there is nothing whatever openly, expressly, and without controversy said in any part of Scripture respecting the Father conceived of by those who hold a contrary opinion, they themselves testify, when they maintain that the Saviour privately taught these same things not to all, but to certain only of His disciples who could comprehend them, and who understood what was intended by Him through means of arguments, enigmas, and parables. They come, [in fine,] to this, that they maintain there is one Being who is proclaimed as God, and another as Father, He who is set forth as such through means of parables and enigmas.

3. But since parables admit of many interpretations, what lover of truth will not acknowledge, that for them to assert God is to be searched out from these, while they desert what is certain, indubitable, and true, is the part of men who eagerly throw themselves into danger, and act as if destitute of reason? And is not such a course of conduct not to build one's house upon a rock which is firm, strong, and placed in an open position, but upon the shifting sand? Hence the overthrow of such a building is a matter of ease.

Chapter XXVIII — Perfect Knowledge Cannot Be Attained in the Present Life: Many Questions Must Be Submissively Left in the Hands of God

1. Having therefore the truth itself as our rule and the testimony concerning God set clearly before us, we ought not, by running after numerous and diverse answers to questions, to cast away the firm and true knowledge of God. But it is much more suitable that we, directing our inquiries after this fashion, should exercise ourselves in the investigation of the mystery and administration of the living God, and should increase in the love of Him who has done, and still does, so great things for us; but never should fall from the belief by which it is most clearly proclaimed that this Being alone is truly God and Father, who both formed this world, fashioned man, and bestowed the faculty of increase on His own creation, and called him upwards from lesser things to those greater ones which are in His own presence, just as He brings an infant which has been conceived in the womb into the light of the sun, and lays up wheat in the barn after He has given it full strength on the stalk. But it is one and the same Creator who both fashioned the womb and created the sun; and one and the same Lord who both reared the stalk of corn, increased and multiplied the wheat, and prepared the barn.

2. If, however, we cannot discover explanations of all those things in Scripture which are made the subject of investigation, yet let us not on that account seek after any other God besides Him who really exists. For this is the very greatest impiety. We should leave things of that nature to God who created us, being most properly assured that the Scriptures are indeed perfect, since they were spoken by the Word of God and His Spirit; but we, inasmuch as we are inferior to, and later in existence than, the Word of God and His Spirit, are on that very account destitute of the knowledge of His mysteries. And there is no cause for wonder if this is the case with us as respects things spiritual and heavenly, and such as require to be made known to us by revelation, since many even of those things which lie at our very feet (I mean such as belong to this world, which we handle, and

see, and are in close contact with) transcend out knowledge, so that even these we must leave to God.

For it is fitting that He should excel all [in knowledge]. For how stands the case, for instance, if we endeavour to explain the cause of the rising of the Nile? We may say a great deal, plausible or otherwise, on the subject; but what is true, sure, and incontrovertible regarding it, belongs only to God. Then, again, the dwelling-place of birds — of those, I mean, which come to us in spring, but fly away again on the approach of autumn — though it is a matter connected with this world, escapes our knowledge. What explanation, again, can we give of the flow and ebb of the ocean, although every one admits there must be a certain cause [for these phenomena]? Or what can we say as to the nature of those things which lie beyond it? What, moreover, can we say as to the formation of rain, lightning, thunder, gatherings of clouds, vapours, the bursting forth of winds, and such like things; of tell as to the storehouses of snow, hail, and other like things? [What do we know respecting] the conditions requisite for the preparation of clouds, or what is the real nature of the vapours in the sky? What as to the reason why the moon waxes and wanes, or what as to the cause of the difference of nature among various waters, metals, stones, and such like things? On all these points we may indeed say a great deal while we search into their causes, but God alone who made them can declare the truth regarding them.

3. If, therefore, even with respect to creation, there are some things [the knowledge of] Which belongs only to God, and others which come with in the range of our own knowledge, what ground is there for complaint, if, in regard to those things which we investigate in the Scriptures (which are throughout spiritual), we are able by the grace of God to explain some of them, while we must leave others in the hands of God, and that not only in the present world, but also in that which is to come, so that God should for ever teach, and man should for ever learn the things taught him by God? As the apostle has said on this point, that, when other things have been done away, then these three, "faith, hope, and charity, shall endure."

For faith, which has respect to our Master, endures unchangeably, assuring us that there is but one true God, and that we should truly love Him for ever, seeing that He alone is our Father; while we hope ever to be receiving more and more from God, and to learn from Him, because He is good, and possesses boundless riches, a kingdom without end, and instruction that can never be exhausted. If, therefore, according to the rule which I have stated, we leave some questions in the hands of God, we shall both preserve our faith uninjured, and shall continue without danger; and all Scripture, which has been given to us by God, shall be found by us perfectly consistent; and the parables shall harmonize with those passages which are perfectly plain; and those statements the meaning of which is clear, shall serve to explain the parables; and through the many diversified utterances [of Scripture] there shall be heard one harmonious melody in us, praising in hymns that God who created all things.

If, for instance, any one asks, "What was God doing before He made the world?" we reply that the answer to such a question lies with God Himself. For that this world was formed perfect by God, receiving a beginning in time, the Scriptures teach us; but no Scripture reveals to us what God was employed about before this event. The answer therefore to that question remains with God, and it is not proper for us to aim at bringing forward foolish, rash, and blasphemous suppositions [in reply to it]; so, as by one's imagining that he has discovered the origin of matter, he should in reality set aside God Himself who made all things.

4. For consider, all ye who invent such opinions, since the Father Himself is alone called God, who has a real existence, but whom ye style the Demiurge; since, moreover, the Scriptures acknowledge Him alone as God; and yet again, since the Lord confesses Him alone as His own Father, and knows no other, as I shall show from His very words — when ye style this very Being the fruit of defect,

and the offspring of ignorance, and describe Him as being ignorant of those things which are above Him, with the various other allegations which you make regarding Him — consider the terrible blasphemy [ye are thus guilty of] against Him who truly is God. Ye seem to affirm gravely and honestly enough that ye believe in God; but then, as ye are utterly unable to reveal any other God, ye declare this very Being in whom ye profess to believe, the fruit of defect and the offspring of ignorance.

Now this blindness and foolish talking flow to you from the fact that ye reserve nothing for God, but ye wish to proclaim the nativity and production both of God Himself, of His Ennoea, of His Logos, and Life, and Christ; and ye form the idea of these from no other than a mere human experience; not understanding, as I said before, that it is possible, in the case of man, who is a compound being, to speak in this way of the mind of man and the thought of man; and to say that thought (ennoea) springs from mind (sensus), intention (enthymesis) again from thought, and word (logos) from intention (but which logos? for there is among the Greeks one logos which is the principle that thinks, and another which is the instrument by means of which thought is expressed); and [to say] that a man sometimes is at rest and silent, while at other times he speaks and is active.

But since God is all mind, all reason, all active spirit, all light, and always exists one and the same, as it is both beneficial for us to think of God, and as we learn regarding Him from the Scriptures, such feelings and divisions [of operation] cannot fittingly be ascribed to Him. For our tongue, as being carnal, is not sufficient to minister to the rapidity of the human mind, inasmuch as that is of a spiritual nature, for which reason our word is restrained within us, and is not at once expressed as it has been conceived by the mind, but is uttered by successive efforts, just as the tongue is able to serve it.

5. But God being all Mind, and all Logos, both speaks exactly what He thinks, and thinks exactly what He speaks. For His thought is Logos, and Logos is Mind, and Mind comprehending all things is the Father Himself. He, therefore, who speaks of the mind of God, and ascribes to it a special origin of its own, declares Him a compound Being, as if God were one thing, and the original Mind another. So, again, with respect to Logos, when one attributes to him the third place of production from the Father; on which supposition he is ignorant of His greatness; and thus Logos has been far separated from God. As for the prophet, he declares respecting Him, "Who shall describe His generation?" But ye pretend to set forth His generation from the Father, and ye transfer the production of the word of men which takes place by means of a tongue to the Word of God, and thus are righteously exposed by your own selves as knowing neither things human nor divine.

6. But, beyond reason inflated [with your own wisdom], ye presumptuously maintain that ye are acquainted with the unspeakable mysteries of God; while even the Lord, the very Son of God, allowed that the Father alone knows the very day and hour of judgment, when He plainly declares, "But of that day and that hour knoweth no man, neither the Son, but the Father only." If, then, the Son was not ashamed to ascribe the knowledge of that day to the Father only, but declared what was true regarding the matter, neither let us be ashamed to reserve for God those greater questions which may occur to us. For no man is superior to his master.

If any one, therefore, says to us, "How then was the Son produced by the Father?" we reply to him, that no man understands that production, or generation, or calling, or revelation, or by whatever name one may describe His generation, which is in fact altogether indescribable. Neither Valentinus, nor Marcion, nor Saturninus, nor Basilides, nor angels, nor archangels, nor principalities, nor powers [possess this knowledge], but the Father only who begat, and the Son who was begotten. Since therefore His generation is unspeakable, those who strive to set forth generations and productions cannot be in their right mind, inasmuch as they undertake to describe things which are indescribable. For that a word is uttered at the bidding of thought and mind, all men indeed

well understand.

Those, therefore, who have excogitated [the theory of] emissions have not discovered anything great, or revealed any abstruse mystery, when they have simply transferred what all understand to the only-begotten Word of God; and while they style Him unspeakable and unnameable, they nevertheless set forth the production and formation of His first generation, as if they themselves had assisted at His birth, thus assimilating Him to the word of mankind formed by emissions.

7. But we shall not be wrong if we affirm the same thing also concerning the substance of matter, that God produced it. For we have learned from the Scriptures that God holds the supremacy over all things. But whence or in what way He produced it, neither has Scripture anywhere declared; nor does it become us to conjecture, so as, in accordance with our own opinions, to form endless conjectures concerning God, but we should leave such knowledge in the hands of God Himself.

In like manner, also, we must leave the cause why, while all things were made by God, certain of His creatures sinned and revolted from a state of submission to God, and others, indeed the great majority, persevered, and do still persevere, in [willing] subjection to Him who formed them, and also of what nature those are who sinned, and of what nature those who persevere — [we must, I say, leave the cause of these things] to God and His Word, to whom alone He said,

"Sit at my right hand, until I make Thine enemies Thy footstool." But as for us, we still dwell upon the earth, and have not yet sat down upon His throne. For although the Spirit of the Saviour that is in Him "searcheth all things, even the deep things of God," yet as to us "there are diversities of gifts, differences of administrations, and diversities of operations;" and we, while upon the earth, as Paul also declares, "know in part, and prophesy in part."

Since, therefore, we know but in part, we ought to leave all sorts of [difficult] questions in the hands of Him who in some measure, [and that only,] bestows grace on us. That eternal fire, [for instance,] is prepared for sinners, both the Lord has plainly declared, and the rest of the Scriptures demonstrate. And that God foreknew that this would happen, the Scriptures do in like manner demonstrate, since He prepared eternal fire from the beginning for those who were [afterwards] to transgress [His commandments]; but the cause itself of the nature of such transgressors neither has any Scripture informed us, nor has an apostle told us, nor has the Lord taught us.

It becomes us, therefore, to leave the knowledge of this matter to God, even as the Lord does of the day and hour [of judgment], and not to rush to such an extreme of danger, that we will leave nothing in the hands of God, even though we have received only a measure of grace [from Him in this world]. But when we investigate points which are above us, and with respect to which we cannot reach satisfaction, [it is absurd] that we should display such an extreme of presumption as to lay open God, and things which are not yet discovered, as if already we had found out, by the vain talk about emissions, God Himself, the Creator of all things, and to assert that He derived His substance from apostasy and ignorance, so as to frame an impious hypothesis in opposition to God.

8. Moreover, they possess no proof of their system, which has but recently been invented by them, sometimes resting upon certain numbers, sometimes on syllables, and sometimes, again, on names; and there are occasions, too, when, by means of those letters which are contained in letters, by parables not properly interpreted, or by certain [baseless] conjectures, they strive to establish that fabulous account which they have devised. For if any one should inquire the reason why the Father, who has fellowship with the Son in all things, has been declared by the Lord alone to know the hour and the day [of judgment], he will find at present no more suitable, or becoming, or safe reason than this (since, indeed, the Lord is the only true Master), that we may learn through Him that the Father is above all things. For "the Father," says He, "is greater than I."

The Father, therefore, has been declared by our Lord to excel with respect to knowledge; for this reason, that we, too, as long as we are connected with the scheme of things in this world, should leave perfect knowledge, and such questions [as have been mentioned], to God, and should not by any chance, while we seek to investigate the sublime nature of the Father, fall into the danger of starting the question whether there is another God above God.

9. But if any lover of strife contradict what I have said, and also what the apostle affirms, that "we know in part, and prophesy in part," and imagine that he has acquired not a partial, but a universal, knowledge of all that exists — being such an one as Valentinus, or Ptolemaeus, or Basilides, or any other of those who maintain that they have searched out the deep things of God — let him not (arraying himself in vainglory) boast that he has acquired greater knowledge than others with respect to those things which are invisible, or cannot be placed under our observation; but let him, by making diligent inquiry, and obtaining information from the Father, tell us the reasons (which we know not) of those things which are in this world — as, for instance, the number of hairs on his own head, and the sparrows which are captured day by day, and such other points with which we are not previously acquainted — so that we may credit him also with respect to more important points.

But if those who are perfect do not yet understand the very things in their hands, and at their feet, and before their eyes, and on the earth, and especially the rule followed with respect to the hairs of their head, how can we believe them regarding things spiritual, and super-celestial, and those which, with a vain confidence, they assert to be above God? So much, then, I have said concerning numbers, and names, and syllables, and questions respecting such things as are above our comprehension, and concerning their improper expositions of the parables: [I add no more on these points,] since thou thyself mayest enlarge upon them.

Irenæus (140AD-201AD)
Against Heresies
Book IV

Chapter XIV — If God Demands Obedience from Man, If He Formed Man, Called Him and Placed Him Under Laws, It Was Merely for Man's Welfare; Not that God Stood in Need of Man, But that He Graciously Conferred Upon Man His Favours in Every Possible Manner

1. In the beginning, therefore, did God form Adam, not as if He stood in need of man, but that He might have [some one] upon whom to confer His benefits. For not alone antecedently to Adam, but also before all creation, the Word glorified His Father, remaining in Him; and was Himself glorified by the Father, as He did Himself declare, "Father, glorify Thou Me with the glory which I had with Thee before the world was." Nor did He stand in need of our service when He ordered us to follow Him; but He thus bestowed salvation upon ourselves. For to follow the Saviour is to be a partaker of salvation, and to follow light is to receive light.

2. Thus it was, too, that God formed man at the first, because of His munificence; but chose the patriarchs for the sake of their salvation; and prepared a people beforehand, teaching the headstrong to follow God; and raised up prophets upon earth, accustoming man to bear His Spirit [within him], and to hold communion with God: He Himself, indeed, having need of nothing, but granting communion with Himself to those who stood in need of it, and sketching out, like an architect, the plan of salvation to those that pleased Him...

ol89]8 XX — That One God Formed All Things in the World, by Means of the Word and the Holy

Spirit: and that Although He is to Us in This Life Invisible and Incomprehensible, Nevertheless He is Not Unknown; Inasmuch as His Works Do Declare Him, and His Word Has Shown that in Many Modes He May Be Seen and Known

1. As regards His greatness, therefore, it is not possible to know God, for it is impossible that the Father can be measured; but as regards His love (for this it is which leads us to God by His Word), when we obey Him, we do always learn that there is so great a God,

Theophilus of Antioch (163AD-182AD)
To Autolycus, Book I

Chapter IV — Attributes of God
And He is without beginning, because He is unbegotten; and He is unchangeable, because He is immortal. And he is called God [Theos] on account of His having placed [tethekeinai] all things on security afforded by Himself; and on account of [theein], for theein means running, and moving, and being active, and nourishing, and foreseeing, and governing, and making all things alive. But he is Lord, because He rules over the universe; Father, because he is before all things; Fashioner and Maker, because He is creator and maker of the universe; the Highest, because of His being above all; and Almighty, because He Himself rules and embraces all. For the heights of heaven, and the depths of the abysses, and the ends of the earth, are in His hand, and there is no place of His rest. For the heavens are His work, the earth is His creation, the sea is His handiwork; man is His formation and His image; sun, moon, and stars are His elements, made for signs, and seasons, and days, and years, that they may serve and be slaves to man; and all things God has made out of things that were not into things that are, in order that through His works His greatness may be known and understood.

Chapter V — The Invisible God Perceived Through His Works
For as the soul in man is not seen, being invisible to men, but is perceived through the motion of the body, so God cannot indeed be seen by human eyes, but is beheld and perceived through His providence and works. For, in like manner, as any person, when he sees a ship on the sea rigged and in sail, and making for the harbour, will no doubt infer that there is a pilot in her who is steering her; so we must perceive that God is the governor [pilot] of the whole universe, though He be not visible to the eyes of the flesh, since He is incomprehensible. For if a man cannot look upon the sun, though it be a very small heavenly body, on account of its exceeding heat and power, how shall not a mortal man be much more unable to face the glory of God, which is unutterable? For as the pomegranate, with the rind containing it, has within it many cells and compartments which are separated by tissues, and has also many seeds dwelling in it, so the whole creation is contained by the spirit of God, and the containing spirit is along with the creation contained by the hand of God. As, therefore, the seed of the pomegranate, dwelling inside, cannot see what is outside the rind, itself being within; so neither can man, who along with the whole creation is enclosed by the hand of God, behold God. Then again, an earthly king is believed to exist, even though he be not seen by all; for he is recognised by his laws and ordinances, and authorities, and forces, and statues; and are you unwilling that God should be recognised by His works and mighty deeds?

Chapter VI — God is Known by His Works
Consider, O man, His works — the timely rotation of the seasons, and the changes of temperature; the regular march of the stars; the well-ordered course of days and nights, and months, and years; the various beauty of seeds, and plants, and fruits; and the divers species of quadrupeds, and birds, and reptiles, and fishes, both of the rivers and of the sea; or consider the instinct implanted in these animals to beget and rear offspring, not for their own profit, but for the use of man; and the providence with which God provides nourishment for all flesh, or the subjection in which He has

ordained that all things sub-serve mankind. Consider, too, the flowing of sweet fountains and never-failing rivers, and the seasonable supply of dews, and showers, and rains; the manifold movement of the heavenly bodies, the morning star rising and heralding the approach of the perfect luminary; and the constellation of Pleiades, and Orion, and Arcturus, and the orbit of the other stars that circle through the heavens, all of which the manifold wisdom of God has called by names of their own.

He is God alone who made light out of darkness, and brought forth light from His treasures, and formed the chambers of the south wind, and the treasure houses of the deep, and the bounds of the seas, and the treasuries of snows and hail storms, collecting the waters in the storehouses of the deep, and the darkness in His treasures, and bringing forth the sweet, and desirable, and pleasant light out of His treasures; "who causeth the vapours to ascend from the ends of the earth: He maketh lightnings for the rain;" who sends forth His thunder to terrify, and foretells by the lightning the peal of the thunder, that no soul may faint with the sudden shock; and who so moderates the violence of the lightning as it flashes out of heaven, that it does not consume the earth; for, if the lightning were allowed all its power, it would burn up the earth; and were the thunder allowed all its power, it would overthrow all the works that are therein.

Theophilus To Autolycus, Book II

Chapter X — The World Created by God Through the Word

And first, they taught us with one consent that God made all things out of nothing; for nothing was coeval with God: but He being His own place, and wanting nothing, and existing before the ages, willed to make man by whom He might be known; for him, therefore, He prepared the world. For he that is created is also needy; but he that is untreated stands in need of nothing. God, then, having His own Word internal within His own bowels, begat Him, emitting Him along with His own wisdom before all things. He had this Word as a helper in the things that were created by Him, and by Him He made all things. He is called "governing principle" [archç], because He rules, and is Lord of all things fashioned by Him. He, then, being Spirit of God, and governing principle, and wisdom, and power of the highest, came down upon the prophets, and through them spoke of the creation of the world and of all other things. For the prophets were not when the world came into existence, but the wisdom of God which was in Him, and His holy Word which was always present with Him.

Wherefore He speaks thus by the prophet Solomon: "When He prepared the heavens I was there, and when He appointed the foundations of the earth I was by Him as one brought up with Him." And Moses, who lived many years before Solomon, or, rather, the Word of God by him as by an instrument, says, "In the beginning God created the heaven and the earth." first he named the "beginning," and "creation," then he thus introduced God; for not lightly and on slight occasion is it right to name God. For the divine wisdom foreknew that some would trifle and name a multitude of gods that do not exist.

In order, therefore, that the living God might be known by His works, and that [it might be known that] by His Word God created the heavens and the earth, and all that is therein, he said, "In the beginning God created the heavens and the earth." Then having spoken of their creation, he explains to us: "And the earth was without form, and void, and darkness was upon the face of the deep; and the Spirit of God moved upon the water." This, sacred Scripture teaches at the outset, to show that matter, from which God made and fashioned the world, was in some manner created, being produced by God.

Chapter XI — The Six Days' Work Described

Now, the beginning of the creation is light; since light manifests the things that are created.

Wherefore it is said: "And God said, Let light be, and light was; and God saw the light, that it was good," manifestly made good for man. [Theophilus goes on to quote the rest of Genesis 1, deleted here.]

Chapter XII — The Glory of the Six Days' Work

Of this six days' work no man can give a worthy explanation and description of all its parts, not though he had ten thousand tongues and ten thousand mouths; nay, though he were to live ten thousand years, sojourning in this life, not even so could he utter anything worthy of these things, on account of the exceeding greatness and riches of the wisdom of God which there is in the six days' work above narrated. Many writers indeed have imitated [the narration], and essayed to give an explanation of these things; yet, though they thence derived some suggestions, both concerning the creation of the world and the nature of man, they have emitted no slightest spark of truth. And the utterances of the philosophers, and writers, and poets have an appearance of trustworthiness, on account of the beauty of their diction; but their discourse is proved to be foolish and idle, because the multitude of their nonsensical frivolities is very great; and not a stray morsel of truth is found in them.

For even if any truth seems to have been uttered by them, it has a mixture of error. And as a deleterious drug, when mixed with honey or wine, or some other thing, makes the whole [mixture] hurtful and profitless; so also eloquence is in their case found to be labour in vain; yea, rather an injurious thing to those who credit it. Moreover, [they spoke] concerning the seventh day, which all men acknowledge; but the most know not that what among the Hebrews is called the "Sabbath," is translated into Greek the "Seventh" (ebdomas), a name which is adopted by every nation, although they know not the reason of the appellation. And as for what the poet Hesiod says of Erebus being produced from chaos, as well as the earth and love which lords it over his [Hesiod's] gods and men, his dictum is shown to be idle and frigid, and quite foreign to the truth. For it is not meet that God be conquered by pleasure; since even men of temperance abstain from all base pleasure and wicked lust.

Chapter XIII — Remarks on the Creation of the World

Moreover, his [Hesiod's] human, and mean, and very weak conception, so far as regards God, is discovered in his beginning to relate the creation of all things from the earthly things here below. For man, being below, begins to build from the earth, and cannot in order make the roof, unless he has first laid the foundation. But the power of God is shown in this, that, first of all, He creates out of nothing, according to His will, the things that are made. "For the things which are impossible with men are possible with God." Wherefore, also, the prophet mentioned that the creation of the heavens first of all took place, as a kind of roof, saying: "At the first God created the heavens" — that is, that by means of the "first" principle the heavens were made, as we have already shown. And by "earth" he means the ground and foundation, as by "the deep" he means the multitude of waters; and "darkness" he speaks of, on account of the heaven which God made coveting the waters and the earth like a lid.

And by the Spirit which is borne above the waters, he means that which God gave for animating the creation, as he gave life to man, mixing what is fine with what is fine. For the Spirit is fine, and the water is fine, that the Spirit may nourish the water, and the water penetrating everywhere along with the Spirit, may nourish creation. For the Spirit being one, and holding the place of light, was between the water and the heaven, in order that the darkness might not in any way communicate with the heaven, which was nearer God, before God said, "Let there be light." The heaven, therefore, being like a dome-shaped covering, comprehended matter which was like a clod. And so another prophet, Isaiah by name, spoke in these words: "It is God who made the heavens as a vault, and stretched them as a tent to dwell in." The command, then, of God, that is, His Word, shining as a lamp in an enclosed chamber, lit up all that was under heaven, when He had made light apart

from the world. And the light God called Day, and the darkness Night. Since man would not have been able to call the light Day, or the darkness Night, nor, indeed, to have given names to the other things, had not he received the nomenclature from God, who made the things themselves.

In the very beginning, therefore, of the history and genesis of the world, the holy Scripture spoke not concerning this firmament [which we see], but concerning another heaven, which is to us invisible, after which this heaven which we see has been called "firmament," and to which half the water was taken up that it might serve for rains, and showers, and dews to mankind. And half the water was left on earth for rivers, and fountains, and seas. The water, then, covering all the earth, and specially its hollow places, God, through His Word, next caused the waters to be collected into one collection, and the dry land to become visible, which formerly had been invisible. The earth thus becoming visible, was yet without form. God therefore formed and adorned it with all kinds of herbs, and seeds and plants.

Chapter XV — Of the Fourth Day

On the fourth day the luminaries were made; because God, who possesses foreknowledge, knew the follies of the vain philosophers, that they were going to say, that the things which grow on the earth are produced from the heavenly bodies, so as to exclude God. In order, therefore, that the truth might be obvious, the plants and seeds were produced prior to the heavenly bodies, for what is posterior cannot produce that which is prior.

And these contain the pattern and type of a great mystery. For the sun is a type of God, and the moon of man. And as the sun far surpasses the moon in power and glory, so far does God surpass man. And as the sun remains ever full, never becoming less, so does God always abide perfect, being full of all power, and understanding, and wisdom, and immortality, and all good. But the moon wanes monthly, and in a manner dies, being a type of man; then it is born again, and is crescent, for a pattern of the future resurrection.

In like manner also the three days which were before the luminaries, are types of the Trinity, of God, and His Word, and His wisdom. And the fourth is the type of man, who needs light, that so there may be God, the Word, wisdom, man. Wherefore also on the fourth day the lights were made. The disposition of the stars, too, contains a type of the arrangement and order of the righteous and pious, and of those who keep the law and commandments of God. For the brilliant and bright stars are an imitation of the prophets, and therefore they remain fixed, not declining, nor passing from place to place. And those which hold the second place in brightness, are types of the people of the righteous. And those, again, which change their position, and flee from place to place, which also are called planets, they too are a type of the men who have wandered from God, abandoning His law and commandments.

Chapter XVI — Of the Fifth Day

On the fifth day the living creatures which proceed from the waters were produced, through: which also is revealed the manifold wisdom of God in these things; for who could count their multitude and very various kinds? Moreover, the things proceeding from the waters were blessed by God, that this also might be a sign of men's being destined to receive repentance and remission of sins, through the water and laver of regeneration — as many as come to the truth, and are born again, and receive blessing from God. But the monsters of the deep and the birds of prey are a similitude of covetous men and transgressors. For as the fish and the fowls are of one nature — some indeed abide in their natural state, and do no harm to those weaker than themselves, but keep the law of God, and eat of the seeds of the earth; others of them, again, transgress the law of God, and eat flesh, and injure those weaker than themselves: thus, too, the righteous, keeping the law of God, bite and injure none, but live holily and righteously. But robbers, and murderers, and godless persons are like monsters of the deep, and wild beasts, and birds of prey; for they virtually devour

those weaker than themselves. The race, then, of fishes and of creeping things, though partaking of God's blessing, received no very distinguishing property.

Chapter XVII — Of the Sixth Day

And on the sixth day, God having made the quadrupeds, and wild beasts, and the land reptiles, pronounced no blessing upon them, reserving His blessing for man, whom He was about to create on the sixth day. The quadrupeds, too, and wild beasts, were made for a type of some men, who neither know nor worship God, but mind earthly things, and repent not. For those who turn from their iniquities and live righteously, in spirit fly upwards like birds, and mind the things that are above, and are well-pleasing to the will of God. But those who do not know nor worship God, are like birds which have wings, but cannot fly nor soar to the high things of God. Thus, too, though such persons are called men, yet being pressed down with sins, they mind grovelling and earthly things.

And the animals are named wild beasts [thçria], from their being hunted [thçreuesthai], not as if they had been made evil or venomous from the first — for nothing was made evil by God, but all things good, yea, very good — but the sin in which man was concerned brought evil upon them. For when man transgressed, they also transgressed with him. For as, if the master of the house himself acts rightly, the domestics also of necessity conduct themselves well; but if the master sins, the servants also sin with him; so in like manner it came to pass, that in the case of man's sin, he being master, all that was subject to him sinned with him. When, therefore, man again shall have made his way back to his natural condition, and no longer does evil, those also shall be restored to their original gentleness.

Chapter XVIII — The Creation of Man

But as to what relates to the creation of man, his own creation cannot be explained by man, though it is a succinct account of it which holy Scripture gives. For when God said, "Let Us make man in Our image, after Our likeness," He first intimates the dignity of man. For God having made all things by His Word, and having reckoned them all mere by-works, reckons the creation of man to be the only work worthy of His own hands.

Moreover, God is found, as if needing help, to say, "Let Us make man in Our image, after Our likeness." But to no one else than to His own Word and wisdom did He say, "Let Us make." And when He had made and blessed him, that he might increase and replenish the earth, He put all things under his dominion, and at his service; and He appointed from the first that he should find nutriment from the fruits of the earth, and from seeds, and herbs, and acorns, having at the same time appointed that the animals be of habits similar to man's, that they also might eat of an the seeds of the earth.

Chapter XIX — Man is Placed in Paradise

God having thus completed the heavens, and the earth, and the sea, and all that are in them, on the sixth day, rested on the seventh day from all His works which He made. Then holy Scripture gives a summary in these words: "This is the book of the generation of the heavens and the earth, when they were created, in the day that the Lord made the heavens and the earth, and every green thing of the field, before it was made, and every herb of the field before it grew. For God had not caused it to rain upon the earth, and there was not a man to till the ground." By this He signifies to us, that the whole earth was at that time watered by a divine fountain, and had no need that man should till it; but the earth produced all things spontaneously by the command of God, that man might not be wearied by tilling it. But that the creation of man might be made plain, so that there should not seem to be an insoluble problem existing among men, since God had said, "Let Us make man; "and since His creation was not yet plainly related, Scripture teaches us, saying: "And a fountain went up out of the earth, and watered the face of the whole earth; and God made man of

the dust of the earth, and breathed into his face the breath of life, and man became a living soul. Whence also by most persons the soul is called immortal. And after the formation of man, God chose out for him a region among the places of the East, excellent for light, brilliant with a very bright atmosphere, [abundant] in the finest plants; and in this He placed man.

Chapter XX — The Scriptural Account of Paradise
Scripture thus relates the words of the sacred history: [Theophilus quotes the rest of Genesis 2, here omitted].

Chapter XXI — Of the Fall of Man
[Theophilus quotes Genesis 3 regarding temptation, fall, and curse, here omitted.]

Chapter XXII — Why God is Said to Have Walked
You will say, then, to me: "You said that God ought not to be contained in a place, and how do you now say that He walked in Paradise? "Hear what I say. The God and Father, indeed, of all cannot be contained, and is not found in a place, for there is no place of His rest; but His Word, through whom He made all things, being His power and His wisdom, assuming the person of the Father and Lord of all, went to the garden in the person of God, and conversed with Adam. For the divine writing itself teaches us that Adam said that he had heard the voice. But what else is this voice but the Word of God, who is also His Son? Not as the poets and writers of myths talk of the sons of gods begotten from intercourse [with women], but as truth expounds, the Word, that always exists, residing within the heart of God. For before anything came into being He had Him as a counsellor, being His own mind and thought. But when God wished to make all that He determined on, He begot this Word, uttered, the firstborn of all creation, not Himself being emptied of the Word [Reason], but having begotten Reason, and always conversing with His Reason. And hence the holy writings teach us, and all the spirit-bearing [inspired] men, one of whom, John, says, "In the beginning was the Word, and the Word was with God," showing that at first God was alone, and the Word in Him. Then he says, "The Word was God; all things came into existence through Him; and apart from Him not one thing came into existence." The Word, then, being God, and being naturally produced from God, whenever the Father of the universe wills, He sends Him to any place; and He, coming, is both heard and seen, being sent by Him, and is found in a place.

Chapter XXIV — The Beauty of Paradise
[concerning Paradise deleted till this point] And God having placed man in Paradise, as has been said, to till and keep it, commanded him to eat of all the trees — manifestly of the tree of life also; but only of the tree of knowledge He commanded him not to taste. And God transferred him from the earth, out of which he had been produced, into Paradise, giving him means of advancement, in order that, maturing and becoming perfect, and being even declared a god, he might thus ascend into heaven in possession of immortality. For man had been made a middle nature, neither wholly mortal, nor altogether immortal, but capable of either; so also the place, Paradise, was made in respect of beauty intermediate between earth and heaven. And by the expression, "till it," no other kind of labour is implied than the observance of God's command, lest, disobeying, he should destroy himself, as indeed he did destroy himself, by sin.

Chapter XXV — God Was Justified in Forbidding Man to Eat of the Tree of Knowledge
The tree of knowledge itself was good, and its fruit was good. For it was not the tree, as some think, but the disobedience, which had death in it. For there was nothing else in the fruit than only knowledge; but knowledge is good when one uses it discreetly. But Adam, being yet an infant in age, was on this account as yet unable to receive knowledge worthily. For now, also, when a child is born it is not at once able to eat bread, but is nourished first with milk, and then, with the increment of years, it advances to solid food. Thus, too, would it have been with Adam; for not as one who grudged him, as some suppose, did God command him not to eat of knowledge. But He

wished also to make proof of him, whether he was submissive to His commandment. And at the same time He wished man, infant as he was, to remain for some time longer simple and sincere. For this is holy, not only with God, but also with men, that in simplicity and guilelessness subjection be yielded to parents. But if it is right that children be subject to parents, how much more to the God and Father of all things? Besides, it is unseemly that children in infancy be wise beyond their years; for as in stature one increases in an orderly progress, so also in wisdom.

But as when a law has commanded abstinence from anything, and some one has not obeyed, it is obviously not the law which causes punishment, but the disobedience and transgression — for a father sometimes enjoins on his own child abstinence from certain things, and when he does not obey the paternal order, he is flogged and punished on account of the disobedience; and in this case the actions themselves are not the [cause of] stripes, but the disobedience procures punishment for him who disobeys — so also for the first man, disobedience procured his expulsion from Paradise. Not, therefore, as if there were any evil in the tree of knowledge; but from his disobedience did man draw, as from a fountain, labour, pain, grief, and at last fall a prey to death.

Chapter XXVII — The Nature of Man

But some one will say to us, Was man made by nature mortal? Certainly not. Was he, then, immortal? Neither do we affirm this. But one will say, Was he, then, nothing? Not even this hits the mark. He was by nature neither mortal nor immortal. For if He had made him immortal from the beginning, He would have made him God. Again, if He had made him mortal, God would seem to be the cause of his death. Neither, then, immortal nor yet mortal did He make him, but, as we have said above, capable of both; so that if he should incline to the things of immortality, keeping the commandment of God, he should receive as reward from Him immortality, and should become God; but if, on the other hand, he should turn to the things of death, disobeying God, he should himself be the cause of death to himself.

For God made man free, and with power over himself. That, then, which man brought upon himself through carelessness and disobedience, this God now vouchsafes to him as a gift through His own philanthropy and pity, when men obey Him. For as man, disobeying, drew death upon himself; so, obeying the will of God, he who desires is able to procure for himself life everlasting. For God has given us a law and holy commandments; and every one who keeps these can be saved, and, obtaining the resurrection, can inherit incorruption.

Chapter XXVIII — Why Eve Was Formed of Adam's Rib

And Adam having been cast out of Paradise, in this condition knew Eve his wife, whom God had formed into a wife for him out of his rib. And this He did, not as if He were unable to make his wife separately, but God foreknew that man would call upon a number of gods. And having this prescience, and knowing that through the serpent error would introduce a number of gods which had no existence — for there being but one God, even then error was striving to disseminate a multitude of gods, saying, "Ye shall be as gods;" — lest, then, it should be supposed that one God made the man and another the woman, therefore He made them both; and God made the woman together with the man, not only that thus the mystery of God's sole government might be exhibited, but also that their mutual affection might be greater.

Therefore said Adam to Eve, "This is now bone of my bones, and flesh of my flesh." And besides, he prophesied, saying, "For this cause shall a man leave his father and his mother, and shall cleave unto his wife; and they two shall be one flesh; "which also itself has its fulfilment in ourselves. For who that marries lawfully does not despise mother and father, and his whole family connection, and all his household, cleaving to and becoming one with his own wife, fondly preferring her? So that often, for the sake of their wives, some submit even to death. This Eve, on account of her having been in the beginning deceived by the serpent, and become the author of sin, the wicked

demon, who also is called Satan, who then spoke to her through the serpent, and who works even to this day in those men that are possessed by him, invokes as Eve. And he is called "demon" and "dragon," on account of his [apodedrakenai] revolting from God. For at first he was an angel. And concerning his history there is a great deal to be said; wherefore I at present omit the relation of it, for I have also given an account of him in another place.

Origen of Alexandria (185AD-254AD)
De Principiis, Book II

Chapter I — On the World
1. Although all the discussions in the preceding book have had reference to the world and its arrangements, it now seems to follow that we should specially re-discuss a few points respecting the world itself, i.e., its beginning and end, or those dispensations of Divine Providence which have taken place between the beginning and the end, or those events which are supposed to have occurred before the creation of the world, or are to take place after the end.

In this investigation, the first point which clearly appears is, that the world in all its diversified and varying conditions is composed not only of rational and diviner natures, and of a diversity of bodies, but of dumb animals, wild and tame beasts, of birds, and of all things which live in the waters; then, secondly, of places, i.e., of the heaven or heavens, and of the earth or water, as well as of the air, which is intermediate, and which they term æther, and of everything which proceeds from the earth or is born in it. Seeing, then, there is so great a variety in the world, and so great a diversity among rational beings themselves, on account of which every other variety and diversity also is supposed to have come into existence, what other cause than this ought to be assigned for the existence of the world, especially if we have regard to that end by means of which it was shown in the preceding book that all things are to be restored to their original condition? And if this should seem to be logically stated, what other cause, as we have already said, are we to imagine for so great a diversity in the world, save the diversity and variety in the movements and declensions of those who fell from that primeval unity and harmony in which they were at first created by God, and who, being driven from that state of goodness, and drawn in various directions by the harassing influence of different motives and desires, have changed, according to their different tendencies, the single and undivided goodness of their nature into minds of various sorts?

2. But God, by the ineffable skill of His wisdom, transforming and restoring all things, in whatever manner they are made, to some useful aim, and to the common advantage of all, recalls those very creatures which differed so much from each other in mental conformation to one agreement of labour and purpose; so that, although they are under the influence of different motives, they nevertheless complete the fulness and perfection of one world, and the very variety of minds tends to one end of perfection. For it is one power which grasps and holds together all the diversity of the world, and leads the different movements towards one work, lest so immense an undertaking as that of the world should be dissolved by the dissensions of souls. And for this reason we think that God, the Father of all things, in order to ensure the salvation of all His creatures through the ineffable plan of His word and wisdom, so arranged each of these, that every spirit, whether soul or rational existence, however called, should not be compelled by force, against the liberty of his own will, to any other course than that to which the motives of his own mind led him (lest by so doing the power of exercising free will should seem to be taken away, which certainly would produce a change in the nature of the being itself); and that the varying purposes of these would be suitably and usefully adapted to the harmony of one world, by some of them requiring help, and others being able to give it, and others again being the cause of struggle and contest to those who are making progress, amongst whom their diligence would be deemed more worthy of approval, and the place of rank obtained after victory be held with greater certainty, which should be established by

the difficulties of the contest.

3. Although the whole world is arranged into offices of different kinds, its condition, nevertheless, is not to be supposed as one of internal discrepancies and discordances; but as our one body is provided with many members, and is held together by one soul, so I am of opinion that the whole world also ought to be regarded as some huge and immense animal, which is kept together by the power and reason of God as by one soul. This also, I think, is indicated in sacred Scripture by the declaration of the prophet, "Do not I fill heaven and earth? saith the Lord;" and again, "The heaven is My throne, and the earth is My footstool;" and by the Saviour's words, when He says that we are to swear "neither by heaven, for it is God's throne; nor by the earth, for it is His footstool:" To the same effect also are the words of Paul, in his address to the Athenians, when he says, "In Him we live, and move, and have our being." For how do we live, and move, and have our being in God, except by His comprehending and holding together the whole world by His power? And how is heaven the throne of God, and the earth His footstool, as the Saviour Himself declares, save by His power filling all things both in heaven and earth, according to the Lord's own words? And that God, the Father of all things, fills and holds together the world with the fulness of His power, according to those passages which we have quoted, no one, I think, will have any difficulty in admitting.

And now, since the course of the preceding discussion has shown that the different movements of rational beings, and their varying opinions, have brought about the diversity that is in the world, we must see whether it may not be appropriate that this world should have a termination like its beginning. For there is no doubt that its end must be sought amid much diversity and variety; which variety, being found to exist in the termination of the world, will again furnish ground and occasion for the diversities of the other world which is to succeed the present.

4. If now, in the course of our discussion, it has been ascertained that these things are so, it seems to follow that we next consider the nature of corporeal being, seeing the diversity in the world cannot exist without bodies. It is evident from the nature of things themselves, that bodily nature admits of diversity and variety of change, so that it is capable of undergoing all possible transformations, as, e.g., the conversion of wood into fire, of fire into smoke, of smoke into air, of oil into fire. Does not food itself, whether of man or of animals, exhibit the same ground of change? For whatever we take as food, is converted into the substance of our body. But how water is changed into earth or into air, and air again into fire, or fire into air, or air into water, although not difficult to explain, yet on the present occasion it is enough merely to mention them, as our object is to discuss the nature of bodily matter.

By matter, therefore, we understand that which is placed under bodies, viz., that by which, through the bestowing and implanting of qualities, bodies exist; and we mention four qualities — heat, cold, dryness, humidity. These four qualities being implanted in the hu1ç, or matter (for matter is found to exist in its own nature without those qualities before mentioned), produce the different kinds of bodies. Although this matter is, as we have said above, according to its own proper nature without qualities, it is never found to exist without a quality. And I cannot understand how so many distinguished men have been of opinion that this matter, which is so great, and possesses such properties as to enable it to be sufficient for all the bodies in the world which God willed to exist, and to be the attendant and slave of the Creator for whatever forms and species He wished in all things, receiving into itself whatever qualities He desired to bestow upon it, was uncreated, i.e., not formed by God Himself, who is the Creator of all things, but that its nature and power were the result of chance. And I am astonished that they should find fault with those who deny either God's creative power or His providential administration of the world, and accuse them of impiety for thinking that so great a work as the world could exist without an architect or overseer; while they themselves incur a similar charge of impiety in saying that matter is un-created, and co-eternal with the uncreated God.

According to this view, then, if we suppose for the sake of argument that matter did not exist, as these maintain, saying that God could not create anything when nothing existed, without doubt He would have been idle, not having matter on which to operate, which matter they say was furnished Him not by His own arrangement, but by accident; and they think that this, which was discovered by chance, was able to suffice Him for an undertaking of so vast an extent, and for the manifestation of the power of His might, and by admitting the plan of all His wisdom, might be distinguished and formed into a world. Now this appears to me to be very absurd, and to be the opinion of those men who are altogether ignorant of the power and intelligence of un-crested nature.

But that we may see the nature of things a little more clearly, let it be granted that for a little time matter did not exist, and that God, when nothing formerly existed, caused those things to come into existence which He desired, why are we to suppose that God would create matter either better or greater, or of another kind, than that which He did produce from His own power and wisdom, in order that that might exist which formerly did not? Would He create a worse and inferior matter, or one the same as that which they call uncreated? Now I think it will very easily appear to any one, that neither a better nor inferior matter could have assumed the forms and species of the world, if it had not been such as that which actually did assume them.

And does it not then seem impious to call that uncreated, which, if believed to be formed by God, would doubtless be found to be such as that which they call uncreated?

5. But that we may believe on the authority of holy Scripture that such is the case, hear how in the book of Maccabees, where the mother of seven martyrs exhorts her son to endure torture, this truth is confirmed; for she says, "I ask of thee, my son, to look at the heaven and the earth, and at all things which are in them, and beholding these, to know that God made all these things when they did not exist." In the book of the Shepherd also, in the first commandment, he speaks as follows: "first of all believe that there is one God who created and arranged all things, and made all things to come into existence, and out of a state of nothingness." Perhaps also the expression in the Psalms has reference to this: "He spake, and they were made; He commanded, and they were created." For the words, "He spake, and they were made," appear to show that the substance of those things which exist is meant; while the others, "He commanded, and they were created," seem spoken of the qualities by which the substance itself has been moulded.

Chapter II — On the Perpetuity of Bodily Nature

1. On this topic some are wont to inquire whether, as the Father generates an uncreated Son, and brings forth a Holy Spirit, not as if He had no previous existence, but because the Father is the origin and source of the Son or Holy Spirit, and no anteriority or posteriority can be understood as existing in them; so also a similar kind of union or relationship can be understood as subsisting between rational natures and bodily matter. And that this point may be more fully and thoroughly examined, the commencement of the discussion is generally directed to the inquiry whether this very bodily nature, which bears the lives and contains the movements of spiritual and rational minds, will be equally eternal with them, or will altogether perish and be destroyed. And that the question may be determined with greater precision, we have, in the first place, to inquire if it is possible for rational natures to remain altogether incorporeal after they have reached the summit of holiness and happiness (which seems to me a most difficult and almost impossible attainment), or whether they must always of necessity be united to bodies. If, then, any one could show a reason why it was possible for them to dispense wholly with bodies, it will appear to follow, that as a bodily nature, created out of nothing after intervals of time, was produced when it did not exist, so also it must cease to be when the purposes which it served had no longer an existence.

2. If, however, it is impossible for this point to be at all maintained, viz., that any other nature than the Father, Son, and Holy Spirit can live without a body, the necessity of logical reasoning compels us to understand that rational natures were indeed created at the beginning, but that material substance was separated from them only in thought and understanding, and appears to have been formed for them, or after them, and that they never have lived nor do live without it; for an incorporeal life will rightly be considered a prerogative of the Trinity alone.

As we have remarked above, therefore, that material substance of this world, possessing a nature admitting of all possible transformations, is, when dragged down to beings of a lower order, moulded into the crasser and more solid condition of a body, so as to distinguish those visible and varying forms of the world; but when it becomes the servant of more perfect and more blessed beings, it shines in the splendour of celestial bodies, and adorns either the angels of God or the sons of the resurrection with the clothing of a spiritual body, out of all which will be filled up the diverse and varying state of the one world. But if any one should desire to discuss these matters more fully, it will be necessary, with all reverence and fear of God, to examine the sacred Scriptures with greater attention and diligence, to ascertain whether the secret and hidden sense within them may perhaps reveal anything regarding these matters; and something may be discovered in their abstruse and mysterious language, through the demonstration of the Holy Spirit to those who are worthy, after many testimonies have been collected on this very point.

Chapter III — On the Beginning of the World, and Its Causes

1. The next subject of inquiry is, whether there was any other world before the one which now exists; and if so, whether it was such as the present, or somewhat different, or inferior; or whether there was no world at all, but something like that which we understand will be after the end of all things, when the kingdom shall be delivered up to God, even the Father; which nevertheless may have been the end of another world — of that, namely, after which this world took its beginning; and whether the various lapses of intellectual natures provoked God to produce this diverse and varying condition of the world. This point also, I think, must be investigated in a similar way, viz., whether after this world there will be any (system of) preservation and amendment, severe indeed, and attended with much pain to those who were unwilling to obey the word of God, but a process through which, by means of instruction and rational training, those may arrive at a fuller understanding of the truth who have devoted themselves in the present life to these pursuits, and who, after having had their minds purified, have advanced onwards so as to become capable of attaining divine wisdom; and after this the end of all things will immediately follow, and there will be again, for the correction and improvement of those who stand in need of it, another world, either resembling that which now exists, or better than it, or greatly inferior; and how long that world, whatever it be that is to come after this, shall continue; and if there will be a time when no world shall anywhere exist, or if there has been a time when there was no world at all; or if there have been, or will be several; or if it shall ever come to pass that there will be one resembling another, like it in every respect, and indistinguishable from it.

2. That it may appear more clearly, then, whether bodily matter can exist during intervals of time, and whether, as it did not exist before it was made, so it may again be resolved into non-existence, let us see, first of all, whether it is possible for any one to live without a body. For if one person can live without a body, all things also may dispense with them; seeing our former treatise has shown that all things tend towards one end.

Now, if all things may exist without bodies, there will undoubtedly be no bodily substance, seeing there will be no use for it. But how shall we understand the words of the apostle in those passages, in which, discussing the resurrection of the dead, he says, "This corruptible must put on incorruption, and this mortal must put on immortality. When this corruptible shall have put on incorruption, and this mortal shall have put on immortality, then shall be brought to pass the saying

which is written, Death is swallowed up in victory!

Where, O death, is thy victory? O death, thy sting has been swallowed up: the sting of death is sin, and the strength of sin is the law." Some such meaning, then, as this, seems to be suggested by the apostle. For can the expression which he employs, "this corruptible," and "this mortal," with the gesture, as it were, of one who touches or points out, apply to anything else than to bodily matter?

This matter of the body, then, which is now corruptible shall put on incorruption when a perfect soul, and one furnished with the marks of incorruption, shall have begun to inhabit it. And do not be surprised if we speak of a perfect soul as the clothing of the body (which, on account of the Word of God and His wisdom, is now named incorruption), when Jesus Christ Himself, who is the Lord and Creator of the soul, is said to be the clothing of the saints, according to the language of the apostle, "Put ye on the Lord Jesus Christ." As Christ, then, is the clothing of the soul, so for a kind of reason sufficiently intelligible is the soul said to be the clothing of the body, seeing it is an ornament to it, covering and concealing its mortal nature. The expression, then, "This corruptible must put on incorruption," is as if the apostle had said, "This corruptible nature of the body must receive the clothing of incorruption — a soul possessing in itself incorruptibitity," because it has been clothed with Christ, who is the Wisdom and Word of God.

But when this body, which at some future period we shall possess in a more glorious state, shall have become a partaker of life, it will then, in addition to being immortal, become also incorruptible. For whatever is mortal is necessarily also corruptible; but whatever is corruptible cannot also be said to be mortal. We say of a stone or a piece of wood that it is corruptible, but we do not say that it follows that it is also mortal. But as the body partakes of life, then because life may be, and is, separated from it, we consequently name it mortal, and according to another sense also we speak of it as corruptible. The holy apostle therefore, with remarkable insight, referring to the general first cause of bodily matter, of which (matter), whatever be the qualities with which it is endowed (now indeed carnal, but by and by more refined and pure, which are termed spiritual), the soul makes constant use, says, "This corruptible must put on incorruption." And in the second place, looking to the special cause of the body, he says, "This mortal must put on immortality."

Now, what else will incorruption and immortality be, save the wisdom, and the word, and the righteousness of God, which mould; and clothe, and adorn the soul? And hence it happens that it is said, "The corruptible will put on incorruption, and the mortal immortality." For although we may now make great proficiency, yet as we only know in part, and prophesy in part, and see through a glass, darkly, those very things which we seem to understand, this corruptible does not yet put on incorruption, nor is this mortal yet clothed with immorality; and as this training of ours in the body is protracted doubtless to a longer period, up to the time, viz., when those very bodies of ours with which we are enveloped may, on account of the word of God, and His wisdom and perfect righteousness, earn incorruptibility and immortality, therefore is it said, "This corruptible must put on incorruption, and this mortal must put on immortality."

3. But, nevertheless, those who think that rational creatures can at any time lead an existence out of the body, may here raise such questions as the following. If it is true that this corruptible shall put on incorruption, and this mortal put on immortality, and that death is swallowed up at the end; this shows that nothing else than a material nature is to be destroyed, on which death could operate, while the mental acumen of those who are in the body seems to be blunted by the nature of corporeal matter.

If, however, they are out of the body, then they will altogether escape the annoyance arising from a disturbance of that kind. But as they will not be able immediately to escape all bodily clothing, they are just to be considered as inhabiting more refined and purer bodies, which possess the

property of being no longer overcome by death, or of being wounded by its sting; so that at last, by the gradual disappearance of the material nature, death is both swallowed up, and even at the end exterminated, and all its sting completely blunted by the divine grace which the soul has been rendered capable of receiving, and has thus deserved to obtain incorruptibility and immortality. And then it will be deservedly said by all, "O death, where is thy victory? O death, where is thy sting? The sting of death is sin."

If these conclusions, then, seem to hold good, it follows that we must believe our condition at some future time to be incorporeal; and if this is admitted, and all are said to be subjected to Christ, this (incorporeity) also must necessarily be bestowed on all to whom the subjection to Christ extends; since all who are subject to Christ will be in the end subject to God the Father, to whom Christ is said to deliver up the kingdom; and thus it appears that then also the need of bodies will cease. And if it ceases, bodily matter returns to nothing, as formerly also it did not exist.

Now let us see what can be said in answer to those who make these assertions. For it will appear to be a necessary consequence that, if bodily nature be annihilated, it must be again restored and created; since it seems a possible thing that rational natures, from whom the faculty of free will is never taken away, may be again subjected to movements of some kind, through the special act of the Lord Himself, lest perhaps, if they were always to occupy a condition that was unchangeable, they should be ignorant that it is by the grace of God and not by their own merit that they have been placed in that final state of happiness; and these movements will undoubtedly again be attended by variety and diversity of bodies, by which the world is always adorned; nor will it ever be composed (of anything) save of variety and diversity — an effect which cannot be produced without a bodily matter.

4. And now I do not understand by what proofs they can maintain their position, who assert that worlds sometimes come into existence which are not dissimilar to each other, but in all respects equal. For if there is said to be a world similar in all respects (to the present), then it will come to pass that Adam and Eve will do the same things which they did before: there will be a second time the same deluge, and the same Moses will again lead a nation numbering nearly six hundred thousand out of Egypt; Judas will also a second time betray the Lord; Paul will a second time keep the garments of those who stoned Stephen; and everything which has been done in this life will be said to be repeated — a state of things which I think cannot be established by any reasoning, if souls are actuated by freedom of will, and maintain either their advance or retrogression according to the power of their will.

For souls are not driven on in a cycle which returns after many ages to the same round, so as either to do or desire this or that; but at whatever point the freedom of their own will aims, thither do they direct the course of their actions. For what these persons say is much the same as if one were to assert that if a medimnus of grain were to be poured out on the ground, the fall of the grain would be on the second occasion identically the same as on the first, so that every individual grain would lie for the second time close beside that grain where it had been thrown before, and so the medimnus would be scattered in the same order, and with the same marks as formerly; which certainly is an impossible result with the countless grains of a medimnus, even if they were to be poured out without ceasing for many ages.

So therefore it seems to me impossible for a world to be restored for the second time, with the same order and with the same amount of births, and deaths, and actions; but that a diversity of worlds may exist with changes of no unimportant kind, so that the state of another world may be for some unmistakeable reasons better (than this), and for others worse, and for others again intermediate. But what may be the number or measure of this I confess myself ignorant, although, if any one can tell it, I would gladly learn.

5. But this world, which is itself called an age, is said to be the conclusion of many ages. Now the holy apostle teaches that in that age which preceded this, Christ did not suffer, nor even in the age which preceded that again; and I know not that I am able to enumerate the number of anterior ages in which He did not suffer. I will show, however, from what statements of Paul I have arrived at this understanding. He says, "But now once in the consummation of ages, He was manifested to take away sin by the sacrifice of Himself." For He says that He was once made a victim, and in the consummation of ages was manifested to take away sin. Now that after this age, which is said to be formed for the consummation of other ages, there will he other ages again to follow, we have clearly learned from Paul himself, who says, "That in the ages to come He might show the exceeding riches of His grace in His kindness towards us." He has not said, "in the age to come," nor "in the two ages to come," whence I infer that by his language many ages are indicated.

Now if there is something greater than ages, so that among created beings certain ages may be understood, but among other beings which exceed and surpass visible creatures, (ages still greater), which perhaps will be the case at the restitution of all things, when the whole universe will come to a perfect termination), perhaps that period in which the consummation of all things will take place is to be understood as something more than an age. But here the authority of holy Scripture moves me, which says, "For an age and more." Now this word "more" undoubtedly means something greater than an age; and see if that expression of the Saviour, "I will that where I am, these also may be with Me; and as I and Thou are one, these also may be one in Us," may not seem to convey something more than an age and ages, perhaps even more than ages of ages — that period, viz., when all things are now no longer in an age, but when God is in all.

6. Having discussed these points regarding the nature of the world to the best of our ability, it does not seem out of place to inquire what is the meaning of the term world, which in holy Scripture is shown frequently to have different significations. For what we call in Latin mundus, is termed in Greek kosmos, and kosmos signifies not only a world, but also an ornament. finally, in Isaiah, where the language of reproof is directed to the chief daughters of Sion, and where he says, "Instead of an ornament of a golden head, thou wilt have baldness on account of thy works," he employs the same term to denote ornament as to denote the world, viz., kosmos. For the plan of the world is said to be contained in the clothing of the high priest, as we find in the Wisdom of Solomon, where he says, "For in the long garment was the whole world." That earth of ours, with its inhabitants, is also termed the world, as when Scripture says, "The whole world lieth in wickedness."

Clement indeed, a disciple of the apostles, makes mention of those whom the Greeks called antichthones, and other parts of the earth, to which no one of our people can approach, nor can any one of those who are there cross over to us, which he also termed worlds, saying, "The ocean is impassable to men; and those are words which are on the other side of it, which are governed by these same arrangements of the ruling God." That universe which is bounded by heaven and earth is also called a world, as Paul declares: "For the fashion of this world will pass away." Our Lord and Saviour also points out a certain other world besides this visible one, which it would indeed be difficult to describe and make known. He says, "I am not of this world." For, as if He were of a certain other world, He says, "I am not of this world."

Now, of this world we have said beforehand, that the explanation was difficult; and for this reason, that there might not be afforded to any an occasion of entertaining the supposition that we maintain the existence of certain images which the Greeks call "ideas:" for it is certainly alien to our (writers) to speak of an incorporeal world existing in the imagination alone, or in the fleeting world of thoughts; and how they can assert either that the Saviour comes from thence, or that the saints will go thither, I do not see. There is no doubt, however, that something more illustrious and excellent than this present world is pointed out by the Saviour, at which He incites and encourages

believers to aim. But whether that world to which He desires to allude be far separated and divided from this either by situation, or nature, or glory; or whether it be superior in glory and quality, but confined within the limits of this world (which seems to me more probable), is nevertheless uncertain, and in my opinion an unsuitable subject for human thought.

But from what Clement seems to indicate when he says, "The ocean is impassable to men, and those worlds which are behind it," speaking in the plural number of the worlds which are behind it, which he intimates are administered and governed by the same providence of the Most High God, he appears to throw out to us some germs of that view by which the whole universe of existing things, celestial and super-celestial, earthly and infernal, is generally called one perfect world, within which, or by which, other worlds, if any there are, must be supposed to be contained. For which reason he wished the globe of the sun or moon, and of the other bodies called planets, to be each termed worlds. Nay, even that pre-eminent globe itself which they call the non-wandering (aplanç), they nevertheless desire to have properly called world. Finally, they summon the book of Baruch the prophet to bear witness to this assertion, because in it the seven worlds or heavens are more clearly pointed out.

Nevertheless, above that sphere which they call non-wandering (aplanç), they will have another sphere to exist, which they say, exactly as our heaven contains all things which are under it, comprehends by its immense size and indescribable extent the spaces of all the spheres together within its more magnificent circumference; so that all things are within it, as this earth of ours is under heaven. And this also is believed to be called in the holy Scriptures the good land, and the land of the living, having its own heaven, which is higher, and in which the names of the saints are said to be written, or to have been written, by the Saviour; by which heaven that earth is confined and shut in, which the Saviour in the Gospel promises to the meek and merciful. For they would have this earth of ours, which formerly was named "Dry," to have derived its appellation from the name of that earth, as this heaven also was named firmament from the title of that heaven. But we have treated at greater length of such opinions in the place where we had to inquire into the meaning of the declaration, that in the beginning "God made the heavens and the earth." For another heaven and another earth are shown to exist besides that "firmament" which is said to have been made after the second day, or that "dry land" which was afterwards called "earth."

Certainly, what some say of this world, that it is corruptible because it was made, and yet is not corrupted, because the will of God, who made it and holds it together lest corruption should rule over it, is stronger and more powerful than corruption, may more correctly be supposed of that world which we have called above a "non-wandering "sphere, since by the will of God it is not at all subject to corruption, for the reason that it has not admired any causes of corruption, seeing it is the world of the saints and of the thoroughly purified, and not of the wicked, like that world of ours.

We must see, moreover, lest perhaps it is with reference to this that the apostle says, "While we look not at the things which are seen, but at the things which are not seen; for the things which are seen are temporal, but the things which are unseen are eternal. For we know that if our earthly house of this tabernacle were dissolved, we have a building of God, an house not made with hands, eternal in the heavens." And when he says elsewhere, "Because I shall see the heavens, the works of Thy fingers," and when God said, regarding all things visible, by the mouth of His prophet, "My hand has formed all these things," He declares that that eternal house in the heavens which He promises to His saints was not made with hands, pointing out, doubtless, the difference of creation in things which are seen and in those which are not seen. For the same thing is not to be understood by the expressions, "those things which are not seen," and "those things which are invisible." For those things which are invisible are not only not seen, but do not even possess the property of visibility, being what the Greeks call asômata, i.e., incorporeal; whereas those of which Paul says, "They are

not seen," possess indeed the property of being seen, but, as he explains, are not yet beheld by those to whom they are promised.

Origen of Alexandria
Contra Celsum, Book I

Chapter XIX
After these statements, Celsus, from a secret desire to cast discredit upon the Mosaic account of the creation, which teaches that the world is not yet ten thousand years old, but very much under that, while concealing his wish, intimates his agreement with those who hold that the world is uncreated. For, maintaining that there have been, from all eternity, many conflagrations and many deluges, and that the flood which lately took place in the time of Deucalion is comparatively modern, he clearly demonstrates to those who are able to understand him, that, in his opinion, the world was uncreated. But let this assailant of the Christian faith tell us by what arguments he was compelled to accept the statement that there have been many conflagrations and many cataclysms, and that the flood which occurred in the time of Deucalion, and the conflagration in that of Phaethon, were more recent than any others. And if he should put forward the dialogues of Plato (as evidence) on these subjects, we shall say to him that it is allowable for us also to believe that there resided in the pure and pious soul of Moses, who ascended above all created things, and united himself to the Creator of the universe, and who made known divine things with far greater clearness than Plato, or those other wise men (who lived) among the Greeks and Romans, a spirit which was divine. And if he demands of us our reasons for such a belief, let him first give grounds for his own unsupported assertions, and then we shall show that this view of ours is the correct one.

Chapter XX
And yet, against his will, Celsus is entangled into testifying that the world is comparatively modern, and not yet ten thousand years old, when he says that the Greeks consider those things as ancient, because, owing to the deluges and conflagrations, they have not beheld or received any memorials of older events. But let Celsus have, as his authorities for the myth regarding the conflagrations and inundations, those persons who, in his opinion, are the most learned of the Egyptians, traces of whose wisdom are to be found in the worship of irrational animals, and in arguments which prove that such a worship of God is in conformity with reason, and of a secret and mysterious character. The Egyptians, then, when they boastfully give their own account of the divinity of animals, are to be considered wise; but if any Jew, who has signified his adherence to the law and the lawgiver, refer everything to the Creator of the universe, and the only God, he is, in the opinion of Celsus and those like him, deemed inferior to him who degrades the Divinity not only to the level of rational and mortal animals, but even to that of irrational also! — a view which goes far beyond the mythical doctrine of transmigration, according to which the soul falls down from the summit of heaven, and enters into the body of brute beasts, both tame and savage! And if the Egyptians related fables of this kind, they are believed to convey a philosophical meaning by their enigmas and mysteries; but if Moses compose and leave behind him histories and laws for an entire nation, they are to be considered as empty fables, the language of which admits of no allegorical meaning!

Lactantius (ca. 240AD – ca. 320AD)
The Divine Institutes

Book II

Chapter IX — Of the Devil, the World, God, Providence, Man, and His Wisdom
I will therefore set forth the method of all these things, that difficult and obscure subjects may be

more easily understood; and I will bring to light all these deceptions of the pretended deity, led by which men have departed very far from the way of truth. But I will retrace the matter far back from its source; that if any, unacquainted with the truth and ignorant, shall apply himself to the reading of this book, he may be instructed, and may understand what can in truth be "the source and origin of these evils; "and having received light, may perceive his own errors and those of the whole human race.

Since God was possessed of the greatest foresight for planning, and of the greatest skill for carrying out in action, before He commenced this business of the world — inasmuch as there was in Him, and always is, the fountain of full and most complete goodness — in order that goodness might spring as a stream from Him, and might flow forth afar, He produced a Spirit like to Himself, who might be endowed with the perfections of God the Father. But how He willed that, I will endeavour to show in the fourth book.

Then He made another being, in whom the disposition of the divine origin did not remain. Therefore he was infected with his own envy as with poison, and passed from good to evil; and at his own will, which had been given to him by God unfettered, he acquired for himself a contrary name. From which it appears that the source of all evils is envy. For he envied his predecessor, who through his stedfastness is acceptable and dear to God the Father. This being, who from good became evil by his own act, is called by the Greeks diabolus: we call him accuser, because he reports to God the faults to which he himself entices us.

God, therefore, when He began the fabric of the world, set over the whole work that first and greatest Son, and used Him at the same time as a counsellor and artificer, in planning, arranging, and accomplishing, since He is complete both in knowledge, and judgment, and power; concerning whom I now speak more sparingly, because in another place both His excellence, and His name, and His nature must be related by us.

Let no one inquire of what materials God made these works so great and wonderful: for He made all things out of nothing. Nor are the poets to be listened to, who say that in the beginning was a chaos, that is, a confusion of matter and the elements; but that God afterwards divided all that mass, and having separated each object from the confused heap, and arranged them in order, He constructed and adorned the world.

Now it is easy to reply to these persons, who do not understand the power of God: for they believe that He can produce nothing, except out of materials already existing and prepared; in which error philosophers also were involved. For Cicero, while discussing the nature of the gods, thus speaks: "first of all, therefore, it is not probable that the matter from which all things arose was made by divine providence, but that it has, and has had, a force and nature of its own. As therefore the builder, when he is about to erect any building, does not himself make the materials, but uses those which are already prepared, and the statuary also uses the wax; so that divine providence ought to have had materials at hand, not of its own production, but already prepared for use. But if matter was not made by God, then neither was the earth, and water, and air, and fire, made by God."

Oh, how many faults there are in these ten lines first, that he who in almost all his other disputations and books was a maintainer of the divine providence, and who used very acute arguments in assailing those who denied the existence of a providence, now himself, as a traitor or deserter, endeavoured to take away providence; in whose case, if you wish to oppose him, neither consideration nor labour is required: it is only necessary to remind him of his own words. For it will be impossible for Cicero to be more strongly refuted by any one than by Cicero himself.

But let us make this concession to the custom and practice of the Academics, that men are permitted to speak with great freedom, and to entertain what sentiments they may wish. Let us examine the sentiments themselves. It is not probable, he says, that matter was made by God. By what arguments do you prove this? For you gave no reason for its being improbable. Therefore, on the contrary, it appears to me exceedingly probable; nor does it appear so without reason, when I reflect that there is something more in God, whom you verily reduce to the weakness of man, to whom you allow nothing else but the mere workmanship.

In what respect, then, will that divine power differ from man, if God also, as man does, stands in need of the assistance of another? But He does stand in need of it, if He can construct nothing unless He is furnished with materials by another. But if this is the case, it is plain that His power is imperfect, and he who prepared the material must be judged more powerful. By what name, therefore, shall he be called who excels God in power? — since it is greater to make that which is one's own, than to arrange those things which are anther's. But if it is impossible that anything should be more powerful than God, who must necessarily be of perfect strength, power, and intelligence, it follows that He who made the things which are composed of matter, made matter also. For it was neither possible nor befitting that anything should exist without the exercise of God's power, or against His will.

But it is probable, he says, that matter has, and always has had, a force and nature of its own. What force could it have, without any one to give it? What nature, without any one to produce it? If it had force, it took that force from some one. But from whom could it take it, unless it were from God? Moreover, if it had a nature, which plainly is so called from being produced, it must have been produced. But from whom could it have derived its existence, except God? For nature, from which you say that all things had their origin, if it has no understanding, can make nothing. But if it has the power of producing and making, then it has understanding, and must be God. For that force can be called by no other name, in which there is both the foresight to plan, and the skill and power to carry into effect.

Therefore Seneca, the most intelligent of all the Stoics, says better, who saw "that nature was nothing else but God." Therefore he says, "Shall we not praise God, who possesses natural excellence?" For He did not learn it from any one. Yes, truly, we will praise Him; for although it is natural to Him, He gave it to Himself, since God Himself is nature. When, therefore, you assign the origin of all things to nature, and take it from God, you are in the same difficulty — "You pay your debt by borrowing, Geta." For while simply changing the name, you clearly admit that it was made by the same person by whom you deny that it was made.

There follows a most senseless comparison. "As the builder," he says, "when he is about to erect any building, does not himself make the materials, but uses those which are already prepared, and the statuary also the wax; so that divine providence ought to have had materials at hand, not of its own production, but already prepared for use." Nay rather it ought not; for God will have less power if He makes from materials already provided, which is the part of man.

The builder will erect nothing without wood, for he cannot make the wood itself; and not to be able to do this is the part of human weakness. But God Himself makes the materials for Himself, because He has the power. For to have the power is the property of God; for if He is not able, He is not God. Man produces his works out of that which already exists, because through his mortality he is weak, and through his weakness his power is limited and moderate; but God produces His works out of that which has no existence, because through His eternity He is strong, and through His strength His power is immense, which has no end or limit, like the life of the Maker Himself.

What wonder, then, if God, when He was about to make the world, first prepared the material

from which to make it, and prepared it out of that which had no existence? Because it is impossible for God to borrow anything from another source, inasmuch as all things are in Himself and from Himself. For if there is anything before Him, and if anything has been made, but not by Him, He will therefore lose both the power and the name of God. But it may be said matter was never made, like God, who out of matter made this world.

In that case, it follows that two eternal principles are established, and those indeed opposed to one another, which cannot happen without discord and destruction. For those things which have a contrary force and method must of necessity come into collision. In this manner it will be impossible that both should be eternal, if they are opposed to one another, because one must overpower the other. Therefore the nature of that which is eternal cannot be otherwise than simple, so that all things descended from that source as from a fountain. Therefore either God proceeded from matter, or matter from God. Which of these is more true, is easily understood. For of these two, one is endued with sensibility, the other is insensible. The power of making anything cannot exist, except in that which has sensibility, intelligence, reflection, and the power of motion. Nor can anything be begun, or made, or completed, unless it shall have been foreseen by reason how it shall be made before it exists, and how it shall endure after it has been made. In short, he only makes anything who has the will to make it, and hands to complete that which he has willed. But that which is insensible always lies inactive and torpid; nothing can originate in that source where there is no voluntary motion. For if every animal is possessed of reason, it is certain that it cannot be produced from that which is destitute of reason, nor can that which is not present in the original source be received from any other quarter.

Nor, however, let it disturb any one, that certain animals appear to be born from the earth. For the earth does not give birth to these of itself, but the Spirit of God, without which nothing is produced. Therefore God did not arise from matter, because a being endued with sensibility can never spring from one that is insensible, a wise one from one that is irrational, one that is incapable of suffering from one that can suffer, an incorporeal being from a corporeal one; but matter is rather from God. For whatever consists of a body solid, and capable of being handled, admits of an external force. That which admits of force is capable of dissolution; that which is dissolved perishes; that which perishes must necessarily have had an origin; that which had an origin had a source from which it originated, that is, some maker, who is intelligent, foreseeing, and skilled in making.

There is one assuredly, and that no other than God. And since He is possessed of sensibility, intelligence, providence, power, and vigour, He is able to create and make both animated and inanimate objects, because He has the means of making everything. But matter cannot always have existed, for if it had existed it would be incapable of change. For that which always was, does not cease always to be; and that which had no beginning must of necessity be without an end. Moreover, it is easier for that which had a beginning to be without an end, than for that which had no beginning to have an end.

Therefore if matter was not made, nothing can be made from it. But if nothing can be made from it, then matter itself can have no existence. For matter is that out of which something is made. But everything out of which anything is made, inasmuch as it has received the hand of the artificer, is destroyed, and begins to be some other thing. Therefore, since matter had an end, at the time when the world was made out of it, it also had a beginning. For that which is destroyed was previously built up; that which is loosened was previously bound up; that which is brought to an end was begun.

If, then, it is inferred from its change and end, that matter had a beginning, from whom could that beginning have been, except from God? God, therefore, is the only being who was not made; and

therefore He can destroy other things, but He Himself cannot be destroyed. That which was in Him will always be permanent, because He has not been produced or sprung from any other source; nor does His birth depend on any other object, which being changed may cause His dissolution. He is of Himself, as we said in the first book; and therefore He is such as He willed that He should be, incapable of suffering, unchangeable, incorruptible, blessed, and eternal.

But now the conclusion, with which Tully finished the sentiment, is much more absurd. "But if matter," he says, "was not made by God, the earth indeed, and water, and air, and fire, were not made by God." How skilfully he avoided the danger! For he stated the former point as though it required no proof, whereas it was much more uncertain than that on account of which the statement was made.

If matter, he says, was not made by God, the world was not made by God. He preferred to draw a false inference from that which is false, than a true one from that which is true. And though uncertain things ought to be proved from those which are certain, he drew a proof from an uncertainty, to overthrow that which was certain. For, that the world was made by divine providence (not to mention Trismegistus, who proclaims this; not to mention the verses of the Sibyls, who make the same announcement; not to mention the prophets, who with one impulse and with harmonious voice, bear witness that the world was made, and that it was the workmanship of God), even the philosophers almost universally agree; for this is the opinion of the Pythagoreans, the Stoics, and the Peripatetics, who are the chief of every sect.

In short, from those first seven wise men, even to Socrates and Plato, it was held as an acknowledged and undoubted fact; until many ages afterwards the crazy Epicurus lived, who alone ventured to deny that which is most evident, doubtless through the desire of discovering novelties, that he might found a sect in his own name. And because he could find out nothing new, that he might still appear to disagree with the others, he wished to overthrow old opinions. But in this all the philosophers who snarled around him, refuted him.

It is more certain, therefore, that the world was arranged by providence, than that matter was collected by providence. Wherefore he ought not to have supposed that the world was not made by divine providence, because its matter was not made by divine providence; but because the world was made by divine providence, he ought to have concluded that matter also was made by the Deity. For it is more credible that matter was made by God, because He is all-powerful, than that the world was not made by God, because nothing can be made without mind, intelligence, and design.

But this is not the fault of Cicero, but of the sect. For when he had undertaken a disputation, by which he might take away the nature of the gods, respecting which philosophers prated, in his ignorance of the truth he imagined that the Deity must altogether be taken away. He was able therefore to take away the gods, for they had no existence. But when he attempted to overthrow the divine providence, which is in the one God, because he had begun to strive against the truth, his arguments failed, and he necessarily fell into this pitfall, from which he was unable to withdraw himself. Here, then, I hold him firmly fixed; I hold him fastened to the spot, since Lucilius, who disputed on the other side, was silent.

Here, then, is the turning-point; on this everything depends. Let Cotta disentangle himself, if he can, from this difficulty; let him bring forward arguments by which he may prove that matter has always existed, which no providence made. Let him show how anything ponderous and heavy either could exist without an author or could be changed, and how that which always was ceased to be, so that that which never was might begin to be. And if he shall prove these things, then, and not till then, will I admit that the world itself was not established by divine providence, and yet in making

this admission I shall hold him fast by another snare. For he will turn round again to the same point, to which he will be unwilling to return, so as to say that both the matter of which the world consists, and the world which consists of matter, existed by nature; though I contend that nature itself is God. For no one can make wonderful things, that is, things existing with the greatest order, except one who has intelligence, foresight, and power. And thus it will come to be seen that God made all things, and that nothing at all can exist which did not derive its origin from God.

But the same, as often as he follows the Epicureans, and does not admit that the world was made by God, is wont to inquire by what hands by what machines, by what levers, by what contrivance, He made this work of such magnitude. He might see, if he could have lived at that time in which God made it. But, that man might not look into the works of God, He was unwilling to bring him into this world until all things were completed. But he could not be brought in: for how could he exist while the heaven above was being built, and the foundations of the earth beneath were being laid; when humid things, perchance, either benumbed with excessive stiffness were becoming congealed, or seethed with fiery heat and rendered solid were growing hard? Or how could he live when the sun was not yet established, and neither corn nor animals were produced? Therefore it was necessary that man should be last made, when the finishing hand had now been applied to the world and to all other things.

Finally, the sacred writings teach that man was the last work of God, and that he was brought into this world as into a house prepared and made ready; for all things were made on his account. The poets also acknowledge the same. Ovid, having described the completion of the world, and the formation of the other animals, added: "An animal more sacred than these, and more capacious of a lofty mind, was yet wanting, and which might exercise dominion over the rest. Man was produced."

So impious must we think it to search into those things which God wished to be kept secret! But his inquiries were not made through a desire of hearing or learning, but of refuting; for he was confident that no one could assert that. As though, in truth, it were to be supposed that these things were not made by God, because it cannot be plainly seen in what manner they were created!

If you had been brought up in a well-built and ornamented house, and had never seen a workshop, would you have supposed that that house was not built by man, because you did not know how it was built? You would assuredly ask the same question about the house which you now ask about the world — by what hands, with what implements, man had contrived such great works; and especially if you should see large stones, immense blocks, vast columns, the whole work lofty and elevated, would not these things appear to you to exceed the measure of human strength, because you would not know that these things were made not so much by strength as by skill and ingenuity?

But if man, in whom nothing is perfect, nevertheless effects more by skill than his feeble strength would permit, what reason is there why it should appear to you incredible, when it is alleged that the world was made by God, in whom, since He is perfect, wisdom can have no limit, and strength no measure? His works are seen by the eyes; but how He made them is not seen even by the mind, because, as Hermes says, the mortal cannot draw nigh to (that is, approach nearer, and follow up with the understanding) the immortal, the temporal to the eternal, the corruptible to the incorruptible. And on this account the earthly animal is as yet incapable of perceiving heavenly things, because it is shut in and held as it were in custody by the body, so that it cannot discern all things with free and unrestrained perception. Let him know, therefore, how foolishly he acts, who inquires into things which are indescribable. For this is to pass the limits of one's own condition, and not to understand how far it is permitted man to approach.

In short, when God revealed the truth to man, He wished us only to know those things which it

concerned man to know for the attainment of life; but as to the things which related to a profane and eager curiosity He was silent, that they might be secret. Why, then, do you inquire into things which you cannot know, and if you knew them you would not be happier. It is perfect wisdom in man, if he knows that there is but one God, and that all things were made by Him.

Chapter X — Of the World, and Its Parts, the Elements and Seasons

Now, having refitted those who entertain false sentiments respecting the world and God its Maker, let us return to the divine workmanship of the world, concerning which we are informed in the sacred writings of our holy religion. Therefore, first of all, God made the heaven, and suspended it on high, that it might be the seat of God Himself, the Creator. Then He founded the earth, and placed it under the heaven, as a dwelling place for man, with the other races of animals. He willed that it should be surrounded and held together by water. But He adorned and filled His own dwelling place with bright lights; He decked it with the sun, and the shining orb of the moon, and with the glittering signs of the twinkling stars; but He placed on the earth the darkness, which is contrary to these. For of itself the earth contains no light, unless it receives it from the heaven, in which He placed perpetual light, and the gods above, and eternal life; and, on the contrary, He placed on the earth darkness, and the inhabitants of the lower regions, and death. For these things are as far removed from the former ones, as evil things are from good, and vices from virtues.

He also established two parts of the earth itself opposite to one another, and of a different character — namely, the east and the west; and of these the east is assigned to God, because He Himself is the fountain of light, and the enlightener of all things, and because He makes us rise to eternal life. But the west is ascribed to that disturbed and depraved mind, because it conceals the light, because it always brings on darkness, and because it makes men die and perish in their sins. For as light belongs to the east, and the whole course of life depends upon the light, so darkness belongs to the west: but death and destruction are contained in darkness.

Then He measured out in the same way the other parts — namely, the south and the north, which parts are closely united with the two former. For that which is more glowing with the warmth of the sun, is nearest to and closely united with the east; but that which is torpid with colds and perpetual ice belongs to the same division as the extreme west. For as darkness is opposed to light, so is cold to heat. As, therefore, heat is nearest to light, so is the south to the east; and as cold is nearest to darkness, so is the northern region to the west.

And He assigned to each of these parts its own time — namely, the spring to the east, the summer to the southern region, the autumn belongs to the west, and the winter to the north. In these two parts also, the southern and the northern, is contained a figure of life and death, because life consists in heat, death in cold. And as heat arises from fire, so does cold from water.

And according to the division of these parts He also made day and night, to complete by alternate succession with each other the courses and perpetual revolutions of time, which we call years. The day, which the first east supplies, must belong to God, as all things do, which are of a better character. But the night, which the extreme west brings on, belongs, indeed, to him whom we have said to be the rival of God.

And even in the making of these God had regard to the future; for He made them so, that a representation of true religion and of false superstitions might be shown from these. For as the sun, which rises daily, although it is but one — from which Cicero would have it appear that it was called Sol, because the stars are obscured, and it alone is seen — yet, since it is a true light, and of perfect fulness, and of most powerful heat, and enlightens all things with the brightest splendour; so God, although He is one only, is possessed of perfect majesty, and might, and splendour.

But night, which we say is assigned to that depraved adversary of God, shows by a resemblance the many and various superstitions which belong to him. For although innumerable stars appear to glitter and shine, yet, because they are not full and solid lights, and send forth no heat, nor overpower the darkness by their multitude, therefore these two things are found to be of chief importance, which have power differing from and opposed to one another — heat and moisture, which God wonderfully designed for the support and production of all things.

For since the power of God consists in heat and fire, if He had not tempered its ardour and force by mingling matter of moisture and cold, nothing could have been born or have existed, but whatever had begun to exist must immediately have been destroyed by conflagration. From which also some philosophers and poets said that the world was made up of a discordant concord; but they did not thoroughly understand the matter. Heraclitus said that all things were produced from fire Thales of Miletus from water. Each saw something of the truth, and yet each was in error: for if one element only had existed, water could not have been produced from fire, nor, on the other hand, could fire from water; but it is more true that all things were produced from a mingling of the two.

Fire, indeed, cannot be mixed with water, because they are opposed to each other; and if they came into collision, the one which proved superior must destroy the other. But their substances may be mingled. The substance of fire is heat; of water, moisture. Rightly therefore does Ovid say: "For when moisture and heat have become mingled, they conceive, and all things arise from these two. And though fire is at variance with water, moist vapour produces all things, and discordant concord is adapted to production."...

...But from what source or in what manner God lighted up or caused to flow these two principal elements, fire and water, He who made them alone can know.

Chapter XI — Of Living Creatures, of Man; Prometheus, Deucalion, the Parcae

Therefore, having finished the world, He commanded that animals of various kinds and of dissimilar forms should be created, both great and smaller. And they were made in pairs, that is, one of each sex; from the offspring of which both the air and the earth and the seas were filled. And God gave nourishment to all these by their kinds from the earth, that they might be of service to men: some, for instance, were for food, others for clothing; but those which are of great strength He gave, that they might assist in cultivating the earth, whence they were called beasts of burthen.

And thus, when all things had been settled with a wonderful arrangement, He determined to prepare for Himself an eternal kingdom, and to create innumerable souls, on whom He might bestow immortality. Then He made for Himself a figure endowed with perception and intelligence, that is, after the likeness of His own image, than which nothing can be more perfect: He formed man out of the dust of the ground, from which he was called man, because He was made from the earth.

Finally, Plato says that the human form was godlike; as does the Sibyl, who says — "Thou art my image, O man, possessed of right reason." The poets also have not given a different account respecting this formation of man, however they may have corrupted it; for they said that man was made by Prometheus from clay. They were not mistaken in the matter itself, but in the name of the artificer. For they had never come into contact with a line of the truth; but the things which were handed down by the oracles of the prophets, and contained in the sacred book of God; those things collected from fables and obscure opinion, and distorted, as the truth is wont to be corrupted by the multitude when spread abroad by various conversations, everyone adding something to that which he had heard — those things beginning, it is evident that it will at some time have an end. For that cannot, as a whole, be immortal, which consists of mortals.

For as we all die individually, it is possible that, by some calamity, all may perish simultaneously: either through the unproductiveness of the earth, which sometimes happens in particular cases; or through the general spread of pestilence, which often desolates separate cities and countries; or by the conflagration of the world, as is said to have happened in the case of Phaethon; or by a deluge, as is reported in the time of Deucalion, when the whole race was destroyed with the exception of one man. And if this deluge happened by chance, it might assuredly have happened that he who was the only survivor should perish. But if he was reserved by the will of divine providence, as it cannot be denied, to recruit mankind, it is evident that the life and the destruction of the human race are in the power of God.

And if it is possible for it to die altogether, because it dies in parts, it is evident that it had an origin at some time; and as the liability to decay bespeaks a beginning, so also it gives proof of an end. And if these things are true, Aristotle will be unable to maintain that the world also itself had no beginning. But if Plato and Epicurus extort this from Aristotle, yet Plato and Aristotle, who thought that the world would be everlasting, will, notwithstanding their eloquence, be deprived of this also by Epicurus, because it follows, that, as it had a beginning, it must also have an end. But we will speak of these things at greater length in the last book. Now let us revert to the origin of man.

Chapter XII — That Animals Were Not Produced Spontaneously, But by a Divine Arrangement, of Which God Would Have Given Us the Knowledge, If It Were Advantageous for Us to Know It

They say that at certain changes of the heaven, and motions of the stars, there existed a kind of maturity for the production of animals; and thus that the new earth, retaining the productive seed, brought forth of itself certain vessels after the likeness of wombs, respecting which Lucretius says — "Wombs grew attached to the earth by roots;" and that these, when they had become mature, being rent by the compulsion of nature, produced tender animals; afterwards, that the earth itself abounded with a kind of moisture which resembled milk, and that animals were supported by this nourishment. How, then, were they able to endure or avoid the force of the cold or of heat, or to be born at all, since the sun would scorch them or the cold contract them? But, they say, at the beginning of the world there was no winter nor summer, but a perpetual spring of an equable temperature. Why, then, do we see that none of these things now happens? Because, they say, it was necessary that it should once happen, that animals might be born; but after they began to exist, and the power of generation was given to them, the earth ceased to bring forth, and the condition of time was changed.

Oh, how easy it is to refute falsehoods! In the first place, nothing can exist in this world which does not continue permanent, as it began. For neither were the sire and moon and stars then uncreated; nor having been created, were they without their motions; nor did that divine government, which manages and rules their courses, fail to begin its exercise together with them. In the next place, if it is as they say, there must of necessity be a providence, and they fall into that very condition which they especially avoid. For while the animals were yet unborn, it is plain that some one provided that they should be born, that the world might not appear gloomy with waste and desolation. But, that they might be produced from the earth without the office of parents, provision must have been made with great judgment; and in the next place, that the moisture condensed from the earth might be formed into the various figures of bodies; and also that, having received from the vessels with which they were covered the power of life and sensation, they might be poured forth, as it were, from the womb of mothers, is a wonderful and indescribable provision.

But let us suppose that this also happened by chance; the circumstances which follow assuredly cannot be by chance — that the earth should at once flow with milk, and that the temperature of the atmosphere should be equable. And if these things plainly happened, that the newly born animals might have nourishment, or be free from danger, it must be that some one provided these

things by some divine counsel.

But who is able to make this provision except God? Let us, however, see whether the circumstance itself which they assert could have taken place, that men should be born from the earth. If any one considers during how long a time and in what manner an infant is reared, he will assuredly understand that those earth-born children could not possibly have been reared without some one to bring them up. For they must have lain for many months cast forth, until their sinews were strengthened, so that they had power to move themselves and to change their place, which can scarcely happen within the space of one year. Now see whether an infant could have lain through many months in the same manner and in the same place where it was cast forth, without dying, overwhelmed and corrupted by that moisture of the earth which it supplied for the sake of nourishment, and by the excrements of its own body mixed together. Therefore it is impossible but that it was reared by some one; unless, indeed, all animals are born not in a tender condition, but grown up: and it never came into their mind to say this.

Therefore the whole of that method is impossible and vain; if that can be called method by which it is attempted that there shall be no method. For he who says that all things are produced of their own accord, and attributes nothing to divine providence, he assuredly does not assert, but overthrows method. But if nothing can be done or produced without design, it is plain that there is a divine providence, to which that which is called design peculiarly belongs.

Therefore God, the Contriver of all things, made man. And even Cicero, though ignorant of the sacred writings, saw this, who in his treatise on the Laws, in the first book, handed down the same thing as the prophets; and I add his words: "This animal, foreseeing, sagacious, various, acute, gifted with memory, full of method and design, which we call man, was produced by the supreme Deity under remarkable circumstances; for this alone of so many kinds and natures of animals, partakes of judgment and reflection, when all other animals are destitute of them." Do you see that the man, although far removed from the knowledge of the truth, yet, inasmuch as he held the image of wisdom, understood that man could not be produced except by God?

But, however, there is need of divine testimony, lest that of man should be insufficient. The Sibyl testifies that man is the work of God: "He who is the only God being the invincible Creator, He Himself fixed the figure of the form of men, He Himself mixed the nature of all belonging to the generation of life." The sacred writings contain statements to the same effect. Therefore God discharged the office of a true father. He Himself formed the body; He Himself infused the soul with which we breathe. Whatever we are, it is altogether His work. In what manner He effected this He would have taught us, if it were right for us to know; as He taught us other things, which have conveyed to us the knowledge both of ancient error and of true light.

Lactantius
Divine Institutes

Book VII

Chapter I — Of the World, and Those Who are About to Believe, and Those Who are Not; And in This the Censure of the Faithless
It is well: the foundations are laid, as the illustrious orator says. But we have not only laid the foundations, which might be firth and suitable for the support of the work; but we have raised the entire edifice, with great and strong buildings, almost to the summit. There remains, a matter which is much easier, either to cover or adorn it; without which, however, the former works are both useless and displeasing. For of what avail is it, either to be freed from false religions or to understand the true one? Of what avail, either to see the vanity of false wisdom, or to know what is

true? Of what avail is it, I say, to defend that heavenly justice? Of what avail to hold the worship of God with great difficulties, which is the greatest virtue, unless the divine reward of everlasting blessedness attends it? Of which subject we must speak in this book, lest all that is gone before should appear vain and unprofitable: if we should leave this, on account of which they were undertaken, in uncertainty, lest any one should by chance think that such great labours are undertaken in vain; while he distrusts their heavenly reward, which God has appointed for him who shall have despised the present sweet enjoyments of earth in comparison of solitary and unrewarded virtue. Let us satisfy this part of our subject also, both by the testimonies of the sacred writings and also by probable arguments, that it may be equally manifest that future things are to be preferred to those which are present; heavenly things to earthly: and eternal things to those which are temporal: since the rewards of vices are temporal, those of virtues are eternal.

I will therefore set forth the system of the world, that it may easily be understood both when and how it was made by God; which Plato, who discoursed about the making of the world, could neither know nor explain, inasmuch as he was ignorant of the heavenly mystery, which is not learned except by the teaching of prophets and God; and therefore he said that it was created for eternity. Whereas the case is far different, since whatever is of a solid and heavy body, as it received a beginning at some time, so it must needs have an end. For Aristotle, when he did not see how so great a magnitude of things could perish, and wished to escape this objection, said that the world always had existed, and always would exist. He did not at all see, that whatever material thing exists must at some time have had a beginning, and that nothing can exist at all unless it bad a beginning. For when we see that earth, and water, and fire perish, are consumed, and extinguished, which are clearly parts of the world, it is understood that that is altogether mortal the members of which are mortal.

Thus it comes to pass, that whatever is liable to destruction must have been produced. But everything which comes within the sight of the eyes must of necessity be material, and capable of dissolution. Therefore Epicurus alone, following the authority of Democritus, spoke truly in this matter, who said that it had a beginning at some time, and that it would at some time perish. Nor, however, was he able to assign any reason, either through what causes or at what time this work of such magnitude should be destroyed. But since God has revealed this to us, and we do not arrive at it by conjectures, but by instruction from heaven, we will carefully teach it, that it may at length be evident to those who are desirous of the truth, that the philosophers did not see nor comprehend the truth; but that they had so slight a knowledge of it, that they by no means perceived from what source that fragrance of wisdom, which was so pleasant and agreeable, breathed upon them.

In the meantime, I think it necessary to admonish those who are about to read this, that depraved and vicious minds, since the acuteness of their mind is blunted by earthly passions, which weigh down all the perceptions and render them weak, will either altogether fail to understand these things which we relate, or, even if they shall understand them, they will dissemble and be unwilling for them to be true: because they are drawn away by vices, and they knowingly favour their own evils, by the pleasantness of which they are captivated, and they desert the way of virtue, by the bitterness of which they are offended. For they who are inflamed with avarice and a certain insatiable thirst for riches — because, when they have sold or squandered the things in which they delight, they are unable to live in a simple style — undoubtedly prefer that by which they are compelled to renounce their eager desires.

Also, they who, urged on by the incitements of lusts, as the poet says, "Rush into madness and fire," say that we bring forward things plainly incredible; because the precepts about self-restraint wound their ears, which restrain them from their pleasures, to which they have given up their soul, together with their body. But those who, swollen with ambition or inflamed with the love of power,

have bestowed all their efforts on the acquisition of honours, will not, even if we should bear the sun himself in our hands, believe that teaching which commands them to despise all power and honour, and to live in humility, and in such humility that they may be able to receive an injury, and if they have received one, be unwilling to return it.

These are the men who cry out in any way against the truth with closed eyes. But they who are or shall be of sound mind, that is, not so immersed in vices as to be incurable, will both believe these things, and will readily approach them; and whatever things we say, they will appear to them open, and plain, and simple, and that which is chiefly necessary, true and unassailable...

Chapter II — Of the Error of the Philosophers, and of the Divine Wisdom, and of the Golden Age
Now let us instruct those who are ignorant of the truth. It has been so determined by the arrangement of the Most High God, that this unrighteous age, having run the course of its appointed times, should come to an end; and all wickedness being immediately extinguished, and the souls of the righteous being recalled to a happy life, a quiet, tranquil, peaceful, in short, golden age, as the poets call it, should flourish, under the rule of God Himself. This was especially the cause of all the errors of the philosophers, that they did not comprehend the system of the world, which comprises the whole of wisdom. But it cannot be comprehended by our own perception and innate intelligence, which they wished to do by themselves without a teacher.

Therefore they fell into various and ofttimes contradictory opinions, out of which they had no way of escape, "And they remained fixed in the same mire," as the comic writer says, since their conclusion does not correspond with their assumptions; inasmuch as they had assumed things to be true which could not be affirmed, and proved without the knowledge of the truth and of heavenly things. And this knowledge, as I have often said already, cannot exist in a man unless it is derived from the teaching of God. For if a man is able to understand divine things, he will be able also to perform them; for to understand is, as it were, to follow in their track.

But he is not able to do the things which God does, because he is clothed with a mortal body; therefore he cannot even understand those things which God does. And whether this is possible is easy for every one to measure, from the immensity of the divine actions and works. For if you will contemplate the world, with all the things which it contains, you will assuredly understand how much the work of God surpasses the works of men. Thus, as great as is the difference between divine and human works, so great must be the distance between the wisdom of God and man. For because God is incorruptible and immortal, and therefore perfect because He is everlasting, His wisdom also is perfect, as He Himself is; nor can anything oppose it, because God Himself is subject to nothing.

But because man is subject to passion, his wisdom also is subject to error; and as many things hinder the life of man, so that it cannot be perpetual, so also his wisdom must be hindered by many things: so that it is not perfect in entirely perceiving the truth. Therefore there is no human wisdom, if it strives by itself to attain to the conception and knowledge of the truth; inasmuch as the mind of man, being bound up with a frail body, and enclosed in a dark abode, is neither able to wander at large, nor clearly to perceive the truth, the knowledge of which belongs to the divine nature. For His works are known to God alone. But man cannot attain this knowledge by reflection or disputation, but by learning and hearing from Him who alone is able to know and to teach. Therefore Marcus Tullius, borrowing from Plato the sentiment of Socrates, who said that the time had come for himself to depart from life, but that they before whom he was pleading his cause were still alive, says: Which is better is known to the immortal gods; but I think that no man knows. Wherefore all the sects of philosophers must be far removed from the truth, because they who established them were men; nor can those things have any foundation or firmness which are unsupported by any utterances of divine voices.

Chapter III — Of Nature, and of the World; And a Censure of the Stoics and Epicureans

And since we are speaking of the errors of philosophers, the Stoics divide nature into two parts — the one which effects, the other which affords itself tractable for action. They say that in the former is contained all the power of perception, in the latter the material, and that the one cannot act without the other. How can that which handles and that which is handled be one and the same thing? If any one should say that the potter is the same as the clay, or that the clay is the same as the potter, would he not plainly appear to be mad? But these men comprehend under the one name of nature two things which are most widely different, God and the world, the Maker and the work; and say that the one can do nothing without the other, as though God were mixed up in nature with the world.

For sometimes they so mix them together, that God Himself is the mind of the world, and that the world is the body of God; as though the world and God began to exist at the same time, and God did not Himself make the world. And they themselves also confess this at other times, when they say that it was made for the sake of men, and that God could, if He willed it, exist without the world, inasmuch as God is the divine and eternal mind, separate and free from a body. And since they were unable to understand His power and majesty, they mixed Him with the world, that is, with His own work. Whence is that saying of Virgil: "A spirit whose celestial flame Glows in each member of the frame, And stirs the mighty whole."

What, then, becomes of their own saying, that the world was both made and is governed by the divine providence? For if He made the world, it follows that He existed without the world; if He governs it, it is plain that it is not as the mind governs the body, but as a master rules the house, as a pilot the ship, as a charioteer the chariot. Nor, however, are they mixed with those things which they govern. For if all these things which we see are members of God, then God is rendered insensible by them, since the members are without sensibility, and mortal, since we see that the members are mortal.

I can enumerate how often lands shaken by sudden motions have either opened or sunk down precipitously; how often cities and islands have been overwhelmed by waves, and gone into the deep; marshes have inundated fruitful plains, rivers and pools have been dried up; mountains also have either fallen precipitously, or have been levelled with plains. Many districts, and the foundations of many mountains, are laid waste by latent and internal fire. And this is not enough, if God does not spare His own members, unless it is permitted man also to have some power over the body of God. Seas are built up, mountains are cut down, and the innermost bowels of the earth are dug out to draw forth riches. Why, should I say that we cannot even plough without lacerating the divine body? So that we are at once wicked and impious in doing violence to the members of God. Does God, then, suffer His body to be harassed, and endure to weaken Himself, or permit this to be done by man? Unless by chance that divine intelligence which is mixed with the world, and with all parts of the world, abandoned the first outer aspect of the earth, and plunged itself into the lowest depths, that it might be sensible of no pain from continual laceration.

But if this is trifling and absurd, then they themselves were as devoid of intelligence as those are who have not perceived that the divine spirit is everywhere diffused, and that all things are held together by it, not however in such a manner that God, who is incorruptible, should Himself be mixed with heavy and corruptible elements. Therefore that is more correct which they derived from Plato, that the world was made by God, and is also governed by His providence. It was therefore befitting that Plato, and those who held the same opinion, should teach and explain what was the cause, what the reason, for the contriving of so great a work; why or for the sake of whom He made it.

But the Stoics also say the world was made for the sake of men, I hear. But Epicurus is ignorant on what account or who made men themselves. For Lucretius, when he said that the world was not made by the gods, thus spoke: "To say, again, that for the sake of men they have willed to set in order the glorious nature of the world" — then he introduced: "Is sheer folly. For what advantage can our gratitude bestow on immortal and blessed beings, that for our, sake they should take in hand to administer aught?" And with good reason. For they brought forward no reason why the human race was created or established by God.

It is our business to set forth the mystery of the world and man, of which they, being destitute, were able neither to reach nor see the shrine of truth. Therefore, as I said a little before, when they had assumed that which was true, that is, that the world was made by God, and was made for the sake of men, yet, since their argument failed them in the consequences, they were unable to defend that which they had assumed. In fine, Plato, that he might not make the work of God weak and subject to ruin, said that it would remain for ever. If it was made for the sake of men, and so made as to be eternal, why then are not they on whose account it was made eternal? If they are mortal on account of whom it was made, it must also itself be mortal and subject to dissolution, for it is not of more value than those for whose sake it was made. But if his argument were consistent, he would understand that it must perish because it was made, and that nothing can remain for ever except that which cannot be touched.

But he who says that it was not made for the sake of men has no argument. For if he says that the Creator contrived these works of such magnitude on His own account, why then were we produced? Why do we enjoy the world itself? What means the creation of the human race, and of the other living creatures? Why do we intercept the advantages of others? Why, in short, do we grow, decrease, and perish? What reason is implied in our production itself? What in our perpetual succession? Doubtless God wished us to be seen, and to frame, as it were, impressions with various representations of Himself, with which He might delight Himself. Nevertheless, if it were so, He would esteem living creatures as His care, and especially man, to whose command He made all things subject.

But with regard to those who say that the world always existed: I omit that point, that itself cannot exist without some beginning, from which they are unable to extricate themselves; but I say this, if the world always existed, it can have no systematic arrangement. For what could arrangement have effected in that which never had a beginning? For before anything is done or arranged, there is need of counsel that it may be determined how it should be done; nor can anything be done without the foresight of a settled plan. Therefore the plan precedes every work. Therefore that which has not been made has no plan. But the world has a plan by which it both exists and is governed; therefore also it was made: if it was made, it will also be destroyed. Let them therefore assign a reason, I if they can, why it was either made in the beginning or will hereafter be destroyed.

And because Epicurus or Democritus was unable to teach this, he said that it was produced of its own accord, the seeds coming together in all directions; and that when these are again resolved, discord and destruction will follow. Therefore he perverted that which he had correctly seen, and by his ignorance of system entirely overthrew the whole system, and reduced the world, and all things which are done in it, to the likeness of a most trifling dream, if no plan exists in human affairs.

But since the world and all its parts, as we see, are governed by a wonderful plan; since the framing of the heaven, and the course of the stars and of the heavenly bodies, which is harmonious even in variety itself, the constant and wonderful arrangement of the seasons, the varied fruitfulness of the lands, the level plains, the defences and heapings up of mountains, the verdure

and productiveness of the woods, the most salubrious bursting forth of fountains, the seasonable overflowings of rivers, the rich and abundant flowing in of the sea, the opposite and useful breathing of the winds, and all things, are fixed with the greatest regularity: who is so blind as to think that they were made without a cause, in which a wonderful disposition of most provident arrangement shines forth? If, therefore, nothing at all exists nor is done without a cause; if the providence of the Supreme God is manifest from the disposition of things, His excellency from their greatness, and His power from their government: therefore they are dull and mad who have said that there is no providence. I should not disapprove if they denied the existence of gods with this object, that they might affirm the existence of one; but when they did it with this intent, that they might say that there is none, he who does not think that they were senseless is himself senseless.

Chapter IV — That All Things Were Created for Some Use, Even Those Things Which Appear Evil; On What Account Man Enjoys Reason in So Frail a Body

But we have spoken sufficiently on the subject of providence in the first book. For if it has any existence, as appears from the wonderful nature of its works, it must be that the same providence created man and the other animals. Let us therefore see what reason there was for the creation of the human race, since it is evident, as the Stoics say, that the world was made for the sake of men, although they make no slight error in this very matter, in saying it was not made for the sake of man, but of men. For the naming of one individual comprehends the whole human race. But this arises from the fact that they are ignorant that one man only was made by God, and they think that men were produced in all lands and fields like mushrooms. But Hermes was not ignorant that man was both made by God and after the likeness of God.

But I return to my subject. There is nothing, as I imagine, which was made on its own account; but whatever is made at all must necessarily be made for some purpose. For who is there either so senseless or so unconcerned as to attempt to do anything at random, from which he expects no utility, no advantage? He who builds a house does not build it merely for this purpose, that it may be a house, but that it may be inhabited. He who builds a ship does not bestow his labour on this account, only that the ship may be visible, but that men may sail in it. Likewise he who designs and forms any vessel does not do it on this account, that he may only appear to have done it, but that the vessel when made may contain something necessary for use. In like manner, other things, whatever are made, are plainly not made superfluously, but for some useful purposes.

It is plain, therefore, that the world was made by God, not on account of the world itself; for since it is without sensibility, it neither needs the warmth of the sun, or light, or the breath of the winds, or the moisture of showers, or the nourishment of fruits. But it cannot even be said that God made the world for His own sake, since He can exist without the world, as He did before it was made; and God Himself does not make use of all those things which are contained in it, and which are produced. It is evident, therefore, that the world was constructed for the sake of living beings, since living beings enjoy those things of which it consists; and that these may live and exist, all things necessary for them are supplied at fixed times. Again, that the other living beings were made for the sake of man, is plain from this, that they are subservient to man, and were given for his protection and service; since, whether they are of the earth or of the water, they do not perceive the system of the world as man does.

We must here reply to the philosophers, and especially to Cicero, who says: "Why should God, when He made all things on our account, make so large a quantity of snakes and vipers? Why should He scatter so many pernicious things by land and by sea?" A very wide subject for discussion, but it must be briefly touched upon, as in passing. Since man is formed of different and opposing elements, soul and body, that is, heaven and earth, that which is slight and that which is perceptible to the senses, that which is eternal and that which is temporal, that which has sensibility and that which is senseless, that which is endued with light and that which is dark,

reason itself and necessity require that both good and evil things should be set before man — good things which he may use, and evil things which he may guard against and avoid.

For wisdom has been given to him on this account, that, knowing the nature of good and evil things, he may exercise the force of his reason in seeking the good and avoiding the evil. For because wisdom was not given to the other animals, they were both defended with natural clothing and were armed; but in the place of all these He gave to man that which was most excellent, reason only. Therefore He formed him naked and unarmed, that wisdom might be both his defence and covering. He placed his defence and ornament not without, but within not in the body, but in the heart. Unless, therefore, there were evils which he might guard against, and which he might distinguish from good and useful things, wisdom was not necessary for him. Therefore let Marcus Tullius know that reason was either given to man that he might take fishes on account of his own use, and avoid snakes and vipers for the sake of his own safety; or that good and evil things were set before him on this account, because he had received wisdom, the whole force of which is occupied in distinguishing things good and evil.

Great, therefore, and right, and admirable is the force, and reason, and power of man, for whose sake God made the world itself and all things, as many as exist, and gave him so much honour that He set him over all things, since he alone could admire the works of God. Most excellently, therefore, does our Asclepiades, in discussing the providence of the Supreme God in that book which he wrote to me, say: "And on this account any one may with good reason think that the divine providence gave the place nearest to itself to him who was able to understand its arrangement. For that is the sun: who so beholds it as to understand why it is the sun, and what amount of influence it has upon the other parts of the system? This is the heaven, who looks up to it? This is the earth, who inhabits it? This is the sea, who sails upon it? This is fire, who makes use of it?" Therefore the Supreme God did not arrange these things on account of Himself, because He stands in need of nothing, but on account of man, who might fitly make use of them.

Chapter V — Of the Creation of Man, and of the Arrangement of the World, and of the Chief Good

Let us now assign the reason why He made man himself. For if the philosophers had known this, they would either have maintained those things which they had found to be true, or would not have fallen into the greatest errors. For this is the chief thing; this is the point on which everything turns. And if any one does not possess this, the truth altogether glides away from him. It is this, in short, which causes them to be inconsistent with reason; for if this had shone upon them, if they had known all the mystery of man, the Academy would never have been in entire opposition to their disputations, and to all philosophy. As, therefore, God did not make the world for His own sake, because He does not stand in need of its advantages, but for the sake of man, who has the use of it, so also He made man himself for His own sake.

What advantage is there to God in man, says Epicurus, that He should make him for His own sake? Truly, that there might be one who might understand His works; who might be able both to admire with his understanding, and to express with his voice, the foresight displayed in their arrangement, the order of their creation, the power exerted in their completion. And the sum of all these things is, that he should worship God. For he who understands these things worships Him; he follows Him with due veneration as the Maker of all things, He as his true Father, who measures the excellence of His majesty according to the invention, the commencement, and completion of His works. What more evident argument can be brought forward that God both made the world for the sake of man, and man for His own sake, than that he alone of all living creatures has been so formed that his eyes are directed towards heaven, his face looking towards God, his countenance is in fellowship with his Parent, so that God appears, as it were, with outstretched hand to have raised man from the ground, and to have elevated him to the contemplation of Himself. "What, then," he says, "does

the worship paid by man confer on God, who is blessed, and in want of nothing? Or if He gave such honour to man as to create the world for his sake, to furnish him with wisdom, to make him lord of all things living, and to love him as a son, why did He make him subject to death and decay? Why did He expose the object of His love to all evils? When it was befitting that man should be happy, as though closely connected with God, and everlasting as He is, to the worship and contemplation of whom he was formed."

Although we have taught these things for the most part in a scattered manner in the former books, nevertheless, since the subject now specially requires it, because we have undertaken to discuss the subject of a happy life, these things are to be explained by us more carefully and fully, that the arrangement made by God, and His work and will, may be known. Though He was always able by His own immortal Spirit to produce innumerable souls, as He produced the angels, to whom there exists immortality without any danger and fear of evils, yet He devised an unspeakable work, in what manner He might create an infinite multitude of souls, which being at first united with frail and feeble bodies, He might place in the midst between good and evil, that He might set virtue before them composed as they were of both natures; that they might not attain to immortality by a delicate and easy course of life, but might arrive at that unspeakable reward of eternal life with the utmost difficulty and great labours.

Therefore, that He might clothe them with limbs which were heavy and liable to injury, since they were unable to exist in the middle void, the weight and gravity of the body sinking downwards, He determined that an abode and dwelling place should first be built for them. And thus with unspeakable energy and power He contrived the surpassing works of the world; and having suspended the light elements on high, and depressed the heavy ones to the depths below, He strengthened the heavenly things, and established the earthly. It is not necessary at present to follow out each point separately, since we discussed them all together in the second book.

Therefore He placed in the heaven lights, whose regularity, and brightness, and motion, were most suitably proportioned to the advantage of living beings. Moreover, He gave to the earth, which He designed as their dwelling place, fruitfulness for bringing forth and producing various things, that by the abundance of fruits and green herbs it might supply nourishment according to the nature and requirements of each kind. Then, when He had completed all things which belonged to the condition of the world, He formed man from the earth itself, which He prepared for him from the beginning as a habitation; that is, He clothed and covered his spirit with an earthly body, that, being compacted of different and opposing materials, he might be susceptible of good and evil; and as the earth itself is fruitful for the bringing forth of grain, so the body of man, which was taken from the earth, received the power of producing offspring, that, inasmuch as he was formed of a fragile substance, and could not exist for ever, when the space of his temporal life was past, he might depart, and by a perpetual succession renew that which he bore, which was frail and feeble.

Why, then, did He make him frail and mortal, when He had built the world for his sake? First of all, that an infinite number of living beings might be produced, and that He might fill all the earth with a multitude; in the next place, that He might set before man virtue, that is, endurance of evils and labours, by which he might be able to gain the reward of immortality. For since man consists of two parts, body and soul, of which the one is earthly, the other heavenly, two lives have been assigned to man: the one temporal, which is appointed for the body; the other everlasting, which belongs to the soul. We received the former at our birth we attain to the latter by striving, that immortality might not exist to man without any difficulty. That earthly one is as the body, and therefore has an end; but this heavenly one is as the soul, and therefore has no limit. We received the first when we were ignorant of it, this second knowingly; for it is given to virtue, not to nature, because God wished that we should procure life for ourselves in life.

For this reason He has given us this present life, that we may either lose that true and eternal life by our vices, or win it by virtue. The chief good is not contained in this bodily life, since, as it was given to us by divine necessity, so it will again be destroyed by divine necessity. Thus that which has an end does not contain the chief good. But the chief good is contained in that spiritual life which we acquire by ourselves, because it cannot contain evil, or have an end; to which subject nature and the system of the body afford an argument. For other animals incline towards the ground, because they are earthly, and are incapable of immortality, which is from heaven; but man is upright and looks towards heaven, because immortality is proposed to him; which, however, does not come, unless it is given to man by God. For otherwise there would be no difference between the just and the unjust, since every man who is born would become immortal. Immortality, then, is not the consequence of nature, but the reward and recompense of virtue.

Lastly, man does not immediately upon his birth walk upright, but at first on all fours, because the nature of his body and of this present life is common to us with the dumb animals; afterwards, when his strength is confirmed, he raises himself, and his tongue is loosened so that he speaks plainly, and he ceases to be a dumb animal. And this argument teaches that man is born mortal; but that he afterwards becomes immortal, when he begins to live in conformity with the will of God, that is, to follow righteousness, which is comprised in the worship of God, since God raised man to a view of the heaven and of Himself. And this takes place when man, purified in the heavenly laver, lays aside his infancy together with all the pollution of his past life, and having received an increase of divine vigour, becomes a perfect and complete man.

Therefore, because God has set forth virtue before man, although the soul and the body are connected together, yet they are contrary, and oppose one another. The things which are good for the soul are evil to the body, that is, the avoiding of riches, the prohibiting of pleasures, the contempt of pain and death. In like manner, the things which are good for the body are evil to the soul, that is, desire and lust, by which riches are desired, and the enjoyments of various pleasures, by which the soul is weakened and destroyed. Therefore it is necessary, that the just and wise man should be engaged in all evils, since fortitude is victorious over evils; but the unjust in riches, in honours, in power. For these goods relate to the body, and are earthly; and these men also lead an earthly life, nor are they able to attain to immortality because they have given themselves up to pleasures which are the enemies of virtue.

Therefore this temporal life ought to be subject to that eternal life, as the body is to the soul. Whoever, then, prefers the life of the soul must despise the life of the body; nor will he in any other way be able to strive after that which is highest, unless he shall have despised the things which are lowest. But he who shall have embraced the life of the body, and shall have turned his desires downwards to the earth, is unable to attain to that higher life. But he who prefers to live well for eternity, will live badly for a time, and will be subjected to all troubles and labours as long as he shall be on earth, that he may have divine and heavenly consolation. And he who shall prefer to live well for a time, will live ill to eternity; for he will be condemned by the sentence of God to eternal punishment, be cause he has preferred earthly to heavenly goods.

On this account, therefore, God seeks to be worshipped, and to be honoured by man as a Father, that he may have virtue and wisdom, which alone produce' immortality. For because no other but Himself is able to confer that immortality, since He alone possesses it, He will grant to the piety of the man, with which he has honoured God, this reward, to be blessed to all eternity, and to be for ever in the presence of God and in the society of God.

Athanasius of Alexandria (c. 293AD – 373AD)
Contra Gentes

Part III

35. Creation a Revelation of God; Especially in the Order an Harmony Pervading the Whole

1. For God, being good and loving to mankind, and caring for th souls made by Him — since He is by nature in visible and incom prehensible, having His being beyond all created existence, for whic reason the race of mankind was likely to miss the way to th knowledge of Him, she they are made out of nothing while He i unmade — for this cause God by His own Word gave the Universe the Order it has, in order that since He is by nature invisible, men might be enabled to know Him at any rate by His works. For often the artist even when not seen is known by his works.

2. And as they tell of Phidias the Sculptor that his works of art b their symmetry and by the proportion of their parts betray Phidias I those who see them although he is not there, so by the order of th Universe one ought to perceive God its maker and artificer, eve though He be not seen with the bodily eyes. For God did not take H: stand upon His invisible nature (let none plead that as an excuse) an leave Himself utterly unknown to men; but as I said above, He s ordered Creation that although He is by nature invisible He may yet be known by His works. —

3. And I say this not on my own authority, but on the strength what I learned from them who have spoken of God, among them Pau who thus writes to the Romans: "for the invisible things of Him since the creation of the world are clearly seen, being understood by the things that are made;" while to the Lycaonians he speaks out an says: "We also are men of like passions with you, and bring you goc tidings, to turn from these vain things unto a Living God, Who mac the heaven and the earth and the sea, and all that in them is, Who i the generations gone by suffered all nations to walk in their ow ways. And yet He left not Himself without witness, in that lie di good, and gave you from heaven rains and fruitful seasons, finir your hearts with food and gladness."

4. For who that sees the circle of heaven and the course of the su and the moon, and the positions and movements of the other stars, g they take place in opposite and different directions, while yet in the difference all with one accord observe a consistent order, can resist the conclusion that these are not ordered by themselves, but have a maker distinct from themselves who orders them? Or who that sees the sun rising by day and the moon shining by night, and waning and waxing without variation exactly according to the same number of days, and some of the stars running their courses and with orbits various and manifold, while others move without wandering, can fail to perceive that they certainly have a creator to guide them?

36. This the More Striking, If We Consider the Opposing Forces Out 'of Which This Order is Produced

1. Who that sees things of opposite nature combined, and in concordant harmony, as, for example, fire mingled with cold, and dry with wet, and that not in mutual conflict, but making up a single body, as it were homogeneous, can resist the inference that there is One external to these things that has united them? Who that sees winter giving place to spring and spring to summer and summer to autumn, and that these things contrary by nature (for the one chills, the other burns, the one nourishes the other destroys), yet all make up a balanced result beneficial to mankind — can fail to perceive that there is One higher than they, Who balances and guides them all, even if he see Him not?

2. Who that sees the clouds supported in air, and the weight of the waters bound up in the clouds, can but perceive Him that binds them up and has ordered these things so? Or who that sees the earth, heaviest of all things by nature, fixed upon the waters, and remaining unmoved upon what is by nature mobile, will fail to understand that there is One that has made and ordered it, even God? Who that sees the earth bringing forth fruits in due season, and the rains from heaven, and the flow

of rivers, and springing up of wells, and the birth of animals from unlike parents, and that these things take place not at all times but at determinate seasons — and in general, among things mutually unlike and contrary, the balanced and uniform order to which they conform — can resist the inference that there is one Power which orders and administers them, ordaining things well as it thinks fit?

4. For left to themselves they could not subsist or ever be able to appear, on account of their mutual contrariety of nature. For water is by nature heavy, and tends to flow downwards, while the clouds are light and belong to the class of things which tend to soar and mount upwards. And yet we see water, heavy as it is, borne aloft in the clouds. And again, earth is very heavy, while water on the other hand is relatively light; and yet the heavier is supported upon the lighter, and the earth does not sink, but remains immoveable. And male and female are not the same, while yet they unite in one, and the result is the generation from both of an animal like them. And to cut the matter short, cold is opposite to heat, and wet fights with dry, and yet they come together and are not at variance, but they agree, and produce as their result a single body, and the birth of everything.

37. The Same Subject Continued

1. Things then of conflicting and opposite nature would not have reconciled themselves, were there not One higher and Lord over them to unite them, to Whom the elements themselves yield obedience as slaves that obey a master. And instead of each having regard to its own nature and fighting with its neighbour, they recognise the Lord Who has united them, and are at concord one with another, being by nature opposed, but at amity by the will of Him that guides them.

2. For if their mingling into one were not due to a higher authority, how could the heavy mingle and combine with the light, the wet with the dry, the round with the straight, fire with cold, or sea with earth, or the sun with the moon, or the stars with the heaven, and the air with the clouds, the nature of each being dissimilar to that of the other? For there would be great strife among them, the one burning, the other giving cold; the heavy dragging downwards, the light in the contrary direction and upwards; the sun giving light while the air diffused darkness: yes, even the stars would have been at discord with one another, since some have their position above, others beneath, and night would have refused to make way for day, but would have persisted in remaining to fight and strive against it.

3. But if this were so, we should consequently see not an ordered universe, but disorder, not arrangement but anarchy, not a system, but everything out of system, not proportion but disproportion. For in the general strife and conflict either all things would be destroyed, or the Prevailing principle alone would appear. And even the latter would $hew the disorder of the whole, for left alone, and deprived of the help of the others, it would throw the whole out of gears just as, if a single hand and foot were left alone, that would not preserve the body in its integrity.

4. For what sort of a universe would it be, if only the sun appeared, or only the moon went her course, or there were only night, or always day? Or what sort of harmony would it be, again, if the heaven existed alone without the stars, or the stars without the heaven? Or what benefit would there be if there were only sea, or if the earth were there alone without waters and without the other parts of creation? Or how could man, or any animal, have appeared upon earth, if the elements were mutually at strife, or if there were one that prevailed, and that one insufficient for the composition of bodies. For nothing in the world could have been composed of heat, or cold, or wet, or dry, alone, but all would have been without arrangement or combination. But not even the one element which appeared to prevail would have been able to subsist without the assistance of the rest: for that is how each subsists now.

38. The Unity of God Shewn by the Harmony of the Order of Nature

1. Since then, there is everywhere not disorder but order, proportion and not disproportion, not disarray but arrangement, and that in an order perfectly harmonious, we needs must infer and be led to perceive the Master that put together and compacted all things, and produced harmony in them. For though He be not seen with the eyes, yet from the order and harmony of things contrary it is possible to perceive their Ruler, Arranger, and King.

2. For in like manner as if we saw a city, consisting of many and diverse people, great and small, rich and poor, old and young, male and female, in an orderly condition, and its inhabitants, while different from one another, yet at unity among themselves, and not the rich set against the poor, the great against the small, nor the young against the old, but all at peace in the enjoyment of equal rights — if we saw this, the inference surely follows that the presence of a ruler enforces concord, even if we do not see him; (for disorder is a sign of absence of rule, while order shews the governing authority: for when we see the mutual harmony of the members in the body, that the eye does not strive with the hearing, nor is the hand at variance with the foot, but that each accomplishes its service without variance, we perceive from this that certainly there is a soul in the body that governs these members, though we see it not); so in the order and harmony of the Universe, we needs must perceive God the governor of it all, and that He is one and not many.

3. So then this order of its arrangement, and the concordant harmony of all things, shews that the Word, its Ruler and Governor, is not many, but One. For if there were more than one Ruler of Creation, such an universal order would not be maintained, but all things would fall into confusion because of their plurality, each one biasing the whole to his own will, and striving with the other. For just as we said that polytheism was atheism, so it follows that the rule of more than one is the rule of none. For each one would cancel the rule of the other, and none would appear ruler, but there would be anarchy everywhere. But where no ruler is, there disorder follows of course.

4. And conversely, the single order and concord of the many and diverse shews that the ruler too is one. For just as though one were to hear from a distance a lyre, composed of many diverse strings, and marvel at the concord of its symphony, in that its sound is composed neither of low notes exclusively, nor high nor intermediate only, but all combine their sounds in equal balance — and would not fail to perceive from this that the lyre was not playing itself, nor even being struck by more persons than one, but that there was one musician, even if he did not see him, who by his skill combined the sound of each string into the tuneful symphony; so, the order of the whole universe being perfectly harmonious, and there being no strife of the higher against the lower or the lower against the higher, and all things making up one order, it is consistent to think that the Ruler and King of all Creation is one and not many, Who by His own light illumines and gives movement to all.

39. Impossibility of a Plurality of Gods

1. For we must not think there is more than one ruler and maker of Creation: but it belongs to correct and true religion to believe that its Artificer is one, while Creation herself dearly points to this. For the fact that there is one Universe only and not more is a conclusive proof that its Maker is one. For if there were a plurality of gods, there would necessarily be also more universes than one. For neither were it

because the Universe that has been made is one, it is necessary believe that its Maker also is one.

40. The Rationality and Order of the Universe Proves that the Work of the Reason or Word of God

1. Who then might this Maker be? for this is a point most nece to make plain, lest, from ignorance with regard to him, a man s suppose the wrong maker, and fall once more into the sam godless

error, but I think no one is really in doubt about it. For argument has proved that the gods of the poets are no gods, an convicted of error those that deify creation, and in general has s that the idolatry of the heathen is godlessness and impiety, it si follows from the elimination of these that the true religion is wi and that the God we worship and preach is the only true One, R Lord of Creation and Maker of all existence.

2. Who then is this, save the Father of Christ, most holy above all created existence, Who like an excellent pilot, by Hi: Wisdom and His own Word, our Lord and Saviour Christ, steers preserves and orders all things, and does as seems to Him best that is best which has been done, and which we see taking place, that is what He wills; and this a man can hardly refuse to believe,

3. For if the movement of creation were irrational, an, universe were borne along without plan, a man might fairly disbe what we say. But if it subsist in reason and wisdom and skill, E perfectly ordered throughout, it follows that He that is over it an ordered it is none other than the [reason or] Word of God.

4. But by Word I mean, not that which is involved and inher all things created, which some are wont to call the seminal princ which is without soul and has no power of reason or thought, but works by external art, according to the skill of him that applies nor such a word as belongs to rational beings and which consi syllables, and has the air as its vehicle of expression — but I mean living and powerful Word of the good God, the God of the Uni the very Word which is God, Who while different from things th made, and from all Creation, is the One own Word of the good F Who by His own providence ordered and illumines this Universe reasonable for more than one God to make a single universe, nor for the one universe to be made by more than one, because of the absurdities which would result from this.

2. Firstly, if the one universe were made by a plurality of gods, that would mean weakness on the part of those who made it, because many contributed to a single result; which would be a strong proof of the imperfect creative skill of each. For if one were sufficient, the many would not supplement each other's deficiency. But to say that there is any deficiency in God is not only impious, but even beyond all sacrilege. For even among men one would not call a workman perfect if he were unable to finish his work, a single piece, by himself and without the aid of several others.

3. But if, although each one was able to accomplish the whole, yet all worked at it in order to claim a share in the result, we have the laughable conclusion that each worked for reputation, lest he should be suspected of inability. But, once more, it is most grotesque to ascribe vainglory to gods.

4. Again, if each one were sufficient for the creation of the whole, what need of more than one one being self-sufficient for the universe? Moreover it would be evidently impious and grotesque, to make the thing created one, while the creators were many and different, it being a maxim of science that what is one and complete is higher than things that are diverse.

5. And this you must know, that if the universe had been made by a plurality of gods, its movements would be diverse and inconsistent. For having regard to each one of its makers, its movements would be correspondingly different. But such difference again, as was said before, would involve disarray and general disorder; for not even a ship will sail aright if she be steered by many, unless one pilot hold the tiller, nor will a lyre struck by many produce a tuneful sound, unless there be one artist who strikes it.

6. Creation, then, being one, and the Universe one, and its order one, we must perceive that its King and Artificer also is one. For this is why the Artificer Himself made the whole universe one,

lest by the coexistence of more than one a plurality of makers should be supposed; but that as the work is one, its Maker also may be believed to be One. Nor does it follow from the unity of the Maker that the Universe must be one, for God might have made others as well. But

5. For being the good Word of the Good Father He produced the order of all things, combining one with another things contrary, and reducing them to one harmonious order. He being the Power of God and Wisdom of God causes the heaven to revolve, and has suspended the earth, and made it fast, though resting upon nothing, by His own nod. Illumined by Him, the sun gives light to the world, and the moon has her measured period of shining. By reason of Him the water is suspended in the clouds; the rains shower upon the earth, and the sea is kept within bounds, while the earth bears grasses and is clothed with all manner of plants.

6. And if a man were incredulously to ask, as regards what we are saying, if there be a Word of God at all, such an one would indeed be mad to doubt concerning the Word of God, but yet demonstration is possible from what is seen, because all things subsist by the Word and Wisdom of God, nor would any created thing have had a fixed existence had it not been made by reason, and that reason the Word of God, as we have said.

41. The Presence of the Word in Nature Necessary, Not Only for Its Original Creation, But Also for Its Permanence

1. But though He is Word, He is not, as we said, after the likeness of human words, composed of syllables; but He is the unchanging Image of His own Father. For men, composed of parts and made out of nothing, have their discourse composite and divisible. But God possesses true existence and is not composite, wherefore His Word also has true Existence and is not composite, but is the one and only-begotten God, Who proceeds in His goodness from the Father as from a good Fountain, and orders all things and holds them together.

2. But the reason why the Word, the Word of God, has united Himself with created things is truly wonderful, and teaches us that the present order of things is none otherwise than is fitting. For the nature of created things, inasmuch as it is brought into being out of nothing, is of a fleeting sort, and weak and mortal, if composed of itself only. But the God of all is good and exceeding noble by nature — and therefore is kind. For one that is good can grudge nothing: for which reason he does not grudge even existence, but desires all to exist, as objects for His loving-kindness.

3. Seeing then all created nature, as far as its own laws were concerned, to be fleeting and subject to dissolution, lest it should come to this and lest the Universe should be broken up again into nothingness, for this cause He made all things by His own eternal Word, and gave substantive existence to Creation, and moreover did not leave it to be tossed in a tempest in the course of its own nature, lest it should run the risk of once more dropping out of existence; but, because He is good He guides and settles the whole Creation by His own Word, Who is Himself also God, that by the governance and providence and ordering action of the Word, Creation may have light, and be enabled to abide alway securely. For it partakes of the Word Who derives true existence from the Father, and is helped by Him so as to exist, lest that should come to it which would have come but for the maintenance of it by the Word — namely, dissolution — "for He is the Image of the invisible God, the first-born of all Creation, for through Him and in Him all things consist, things visible and things invisible, and He is the Head of the Church" as the ministers of truth teach in their holy writings.

42. This Function of the Word Described at Length

1. The holy Word of the Father, then, almighty and all-perfect, uniting with the universe and having everywhere unfolded His own powers, and having illumined all, both things seen and things invisible, holds them together and binds them to Himself, having left nothing void of His own

power, but on the contrary quickening and sustaining all things everywhere, each severally and all collectively; while He mingles in one the principles of all sensible existence, heat namely and cold and wet and dry, and causes them not to conflict, but to make up one concordant harmony.

2. By reason of Him and His power, fire does not fight with cold nor wet with dry, but principles mutually opposed, as if friendly and brotherly combine together, and give life to the things we see, and form the principles by which bodies exist.. Obeying Him, even God the Word, things on earth have life and things in the heaven have their order. By reason of Him all the sea, and the great ocean, move within their proper bounds, while, as we said above, the dry land grows grasses and is clothed with all manner of diverse plants. And, not to spend time in the enumeration of particulars, where the truth is obVious, there is nothing that is and takes place but has been made and stands by Him and through Him, as also the Divine says, "In the beginning was the Word, and the Word was with God, and the Word was God; all things were made by Him, and without Him was not anything made."

3. For just as though some musician, having tuned a lyre, and by his art adjusted the high notes to the low, and the intermediate notes to the rest, were to produce a single tune as the result, so also the Wisdom of God, handling the Universe as a lyre, and adjusting things in the air to things on the earth, and things in the heaven to things in the air, and combining parts into wholes and moving them all by His beck and will, produces well and fittingly, as the result, the unity of the universe and of its order, Himself remaining unmoved with the Father while He moves all things by His organising action, as seems good for each to His own Father.

4. For what is surprising in His godhead is this, that by one and the same act of will He moves all things simultaneously, and not at intervals, but all collectively, both straight and curved, things above and beneath and intermediate, wet, cold, warm, seen and invisible, and orders them according to their several nature. For simultaneously at His single nod what is straight moves as straight, what is curved also, and what is intermediate, follows its own movement; what is warm receives warmth, what is dry dryness, and all things according to their several nature are quickened and organised by Him, and He produces as the result a marvellous and truly divine harmony.

43. Three Similes to Illustrate the Word's Relation to the Universe

1. And for so great a matter to be understood by an example, let what we are describing be compared to a great chorus. As then the chorus is composed of different people, children, women again, and old men, and those who are still young, and, when one, namely the conductor, gives the sign, each utters sound according to his nature and power, the man as a man, the child as a child, the old man as an old man, and the young man as a young man, while all make up a single harmony.

2. Or as our soul at one time moves our several senses according to the proper function of each, so that when some one object is present all alike are put in motion, and the eye sees, the ear hears, the hand touches, the smell takes in odour, and the palate tastes — and often the other parts of the body act too, as for instance if the feet walk.

3. Or, to make our meaning plain by yet a third example, it is a though a very great city were built, and administered under the presence of the ruler and king who has built it; for when he is preset and gives orders, and has his eye upon everything, all obey; some busy themselves with agriculture, others hasten for water to the aqueducts, another goes forth to procure provisions — one goes t senate, another enters the assembly, the judge goes to the bench, an the magistrate to his court. The workman likewise settles to his craft the sailor goes down to the sea, the carpenter to his workshop, the physician to his treatment, the architect to his building; and while on is going to the country, another is returning from the country, an while some walk about the town others are going out of the town an returning to it again: but all this is going on and is organised by the presence of

the one Ruler, and by his management.

4. In like manner then we must conceive of the whole of Creation even though the example be inadequate, yet with an enlarged idem For with the single impulse of a nod as it were of the Word of Go(all things simultaneously fall into order, and each discharge their proper functions, and a single order is made up by them all together.

44. The Similes Applied to the Whole Universe, Seen an, Unseen

1. For by a nod and by the power of the Divine Word of the Father that governs and presides over all, the heaven revolves, the star move, the sun shines, the moon goes her circuit, and the air receive the sun's light and the nether his heat, and the winds blow: the mountains are reared on high, the sea is rough with waves, and the living things in it grow the earth abides fixed, and bears fruit, and man is formed and lives and dies again, and all things whatever have their life and movement; fire burns, water cools, fountains spring out, rivers flow, seasons and hours come round, rains descend, clouds are filled, hail is formed, snow and ice congeal, birds fly, creeping thing go along, water animals swim, the sea is navigated, the earth is sow and grows crops in due season, plants grow, and some are young, some ripening, others in their growth become old and decay, and while some things are vanishing others are being engendered and are coming to light.

2. But all these things, and more, which for their number we cannot mention, the worker of wonders and marvels, the Word of God, giving light and life, moves and orders by His own nod, making the universe one. Nor does He leave out of Himself even the invisible powers; for including these also in the universe inasmuch as he is their maker also, He holds them together and quickens them by His nod and by His providence. And there can be no excuse for disbelieving this.

3. For as by His own providence bodies grow and the rational soul moves, and possesses life and thought, and this requires little proof, for we see what takes place — so again the same Word of God with one simple nod by His own power moves and holds together both the visible universe and the invisible powers, allotting to each its proper function, so that the divine powers move in a diviner way, while visible things move as they are seen to do. But Himself being over all, both Governor and King and organising power, He does all for the glory and knowledge of His own Father, so that almost by the very works that He brings to pass He teaches us and says, `By the greatness and beauty of the creatures proportionably the maker of them is seen."

45. Conclusion — Doctrine of Scripture on the Subject of Part I

1. For just as by looking up to the heaven and seeing its order and the light of the stars, it is possible to infer the Word Who ordered these things, so by beholding the Word of God, one needs must behold also God His Father, proceeding from Whom He is rightly called His Father's Interpreter and Messenger.

2. And this one may see from our own experience; for if when a word proceeds from men we infer that the mind is its source, and, by thinking about the word, see with our reason the mind which it reveals, by far greater evidence and incomparably more, seeing the power of the Word, we receive a knowledge also of His good Father, as the Saviour Himself says, "He that hath seen Me hath seen the Father." But this all inspired Scripture also teaches more plainly and with more authority, so that we in our turn write boldly to you as we do, and you, if you refer to them, will be able to verify what we say.

3. For an argument when confirmed by higher authority is irresistibly proved. From the first then the divine Word firmly taught the Jewish people about the abolition of idols when it said: "Thou shalt not make to thyself a graven image, nor the likeness of anything that is in the heaven above or in the earth beneath." But the cause of their abolition another writer declares, saying: "The idols

of the heathen are silver and gold, the works of men's hands: a mouth have they and will not speak, eyes have they. and will not see, ears have they and will not: hear, noses have they and will not smell, hands have they and will not handle, feet have they and will not walk." Nor has it passed over in silence the doctrine of creation; but, knowing well its beauty, lest any attending solely to this beauty should worship things as if they were gods, instead of God's works, it teaches men firmly beforehand when it says: "And do not when thou lookest up with thine eyes and seest the sun and moon and all the host of heaven, go astray and worship them, which the Lord thy God hath given to all nations under heaven." But He gave them, not to be their gods, but that by their agency the Gentiles should know, as we have said, God the Maker of them all.

4. For the people of the Jews of old had abundant teaching, in that they had the knowledge of God not only from the works of Creation, but also from the divine Scriptures. And in general to draw men away from the error and irrational imagination of idols, He saith: "Thou shalt have none other gods but Me." Not as if there were other gods does He forbid them to have them, but lest any, turning from the true God, should begin to make himself gods of what were not, such as those who in the poets and writers are called gods, though they are none. And the language itself shews that they are no Gods, when it says, "Thou shalt have none other gods," which refers only to the future. But what is referred to the future does not exist at the time of speaking.

46. Doctrine of Scripture on the Subject of Part 3

1. Has then the divine teaching, which abolished the godlessness of the heathen or the idols, passed over in silence, and left the race of mankind to go entirely unprovided with the knowledge of God? Not so: rather it anticipates their understanding when it says: "Hear, O Israel, the Lord thy God is one God;" and again, "Thou shalt love the Lord thy God with all thy heart and with all thy strength;" and again, "Thou shalt worship the Lord thy God, and Him only shalt thou serve, and shalt cleave to Him."

2. But that the providence and ordering power of the Word also, over all and toward all, is attested by all inspired Scripture, this passage suffices to confirm our argument, where men who speak of God say: "Thou hast laid the foundation of the earth and it abideth. The day continueth according to Thine ordinance." And again: "Sing to our God upon the harp, that covereth the heaven with clouds, that prepareth rain for the earth, that bringeth forth grass upon the mountains, and green herb for the service of man, and giveth food to the cattle."

3. But by whom does He give it, save by Him through Whom all things were made? For the providence over all things belongs naturally to Him by Whom they were made; and who is this save the Word of God, concerning Whom in another psalm he says: `By the Word of the Lord were the heavens made, and all the host of them by the Breath of His mouth." For He tells us that all things were made in Him and through Him.

4. Wherefore He also persuades us and says , "He spake and they were made, He commanded and they were created;" as the illustrious Moses also at the beginning of his account of Creation confirms what we say by his narrative, saying: and God said, "let us make man in our image and after our likeness:" for also when He was carrying out the creation of the heaven and earth and all things, the Father said to Him, "Let the heaven be made," and "let the waters be gathered together and let the dry land appear," and "let the earth bring forth herb" and "every green thing:" so that one must convict Jews also of not genuinely attending to the Scriptures.

5. For one might ask them to whom was God speaking, to use the imperative mood? If He were commanding and addressing the things He was creating, the utterance would be redundant, for they were not yet in being, but were about to be made; but no one speaks to what does not exist, nor addresses to what is not yet made a command to be made. For if God were giving a command

to the things that were to be, He must have said, `Be modal, heaven, and be made, earth, and come forth, green herb, and be created, O man." But in fact He did not do so; but He gives the command thus: "Let us make man," and "let the green herb come forth." By which God is proved to be speaking about them to some one at hand: it follows then that some one was with Him to Whom He spoke when He made all things.

6. Who then could it be, save His Word? For to whom could God be said to speak, except His Word? Or who was with Him when He made all created Existence, except His Wisdom, which says: "When He was making the heaven and the earth I was present with Him?" But in the mention of heaven and earth, all created things in heaven and earth are included as well.

7. But being present with Him as His Wisdom and His Word, looking at the Father He fashioned the Universe, and organised it and gave it order; and, as He is the power of the Father, He gave all things strength to be, as the Saviour says: "What things soever I see the Father doing, I also do in like manner." And His holy disciples teach that all things were made "through Him and unto Him."

8. And, being the good Offspring of Him that is good, and true Son, He is the Father's Power and Wisdom and Word, not being so by participation, nor as if these qualities were imparted to Him from without, as they are to those who partake of Him and are made wise by Him, and receive power and reason in Him; but He is the very Wisdom, very Word, and very own Power of the Father, very Light, very Truth, very Righteousness, very Virtue, and in truth His express Image, and Brightness, and Resemblance. And to sum all up, He is the wholly perfect Fruit of the Father, and is alone the Son, and unchanging Image of the Father.

47. Necessity of a Return to the Word If Our Corrupt Nature is to Be Restored

Who then, who can declare the Father by number, so as to discover the powers of His Word? For like as He is the Father's Word and Wisdom, so too condescending to created things, He becomes, to impart the knowledge and apprehension of Him that begot Him, His very Brightness and very Life, and the Door, and the Shepherd, and the Way, and King and Governor, and Saviour over all, and Light, and Giver of Life, and Providence over all. Having then such a Son begotten of Himself, good, and Creator, the Father did not hide Him out of thé sight of His creatures, but even day by day reveals Him to all by means of the organisation and life of all things, which is His work.

2. But in and through Him He reveals Himself also, as the Saviour says: "I in the Father and the Father in Me:" so that it follows that the Word is in Him that begat Him, and that He that is begotten lives eternally with the Father. But this being so, and nothing being outside Him, but both heaven and earth and all that in them is being dependent on Him, yet men in their folly have set aside the knowledge and service of Him, and honoured things that are not instead of things that are: and instead of the real and true God deified things that were not, "serving the creature rather than the Creator," thus involving themselves in foolishness and impiety.

3. For it is just as if one were to admire the works more than the workman, and being awestruck at the public works in the city, were to make light of their builder, or as if one were to praise a musical instrument but to despise the man who made and tuned it. Foolish and sadly disabled in eyesight! For how else had they known the building, or ship, or lyre, had not the shipbuilder made it, the architect built it, or the musician fashioned it?

4. As then he that reasons in such a way is mad, and beyond all madness, even so affected in mind, I think, are those who do not recognise God or worship His Word, our Lord Jesus Christ the Saviour of all, through Whom the Father orders, and holds together all things, and exercises providence over the Universe; having faith and piety towards Whom, my Christ-loving friend, be of good cheer and of good hope, because immortality and the kingdom of heaven is the fruit of faith and devotion

towards Him, if only the soul be adorned according to His laws. For just as for them who walk after His example, the prize is life everlasting, so for those who walk the opposite way, and not that of virtue, there is great shame, and peril without pardon in the day of judgment, because although they knew the way of truth their acts were contrary to their knowledge.

Athanasius of Alexandria
On the Incarnation of the Word

II. Erroneous Views of Creation Rejected — (1) Epicurean (Fortuitous Generation) But Diversity of Bodies and Parts Argues a Creating Intellect; (2) Platonists (Pre-Existent Matter) But This Subjects God to Human Limitations, Making Him Not a Creator But a Mechanic; (3) Gnostics (an Alien Demiurge) Rejected from Scripture

1. Of the making of the universe and the creation of all things many have taken different views, and each man has laid down the law just as he pleased. For some say that all things have come into being of themselves, and in a chance fashion; as, for example, the Epicureans, who tell us in their self-contempt, that universal providence does not exist speaking right in the face of obvious fact and experience.

2. For if, as they say, everything has had its beginning of itself, and independently of purpose, it would follow that everything had come into mere being, so as to be alike and not distinct. For it would follow in virtue of the unity of body that everything must be sun or moon, and in the case of men it would follow that the whole must be hand, or eye, or foot. But as it is this is not so. On the contrary, we see a distinction of sun, moon, and earth; and again, in the case of human bodies, of foot, hand, and head. Now, such separate arrangement as this tells us not of their having come into being of themselves, but shews that a cause preceded them; from which cause it is possible to apprehend God also as the Maker and Orderer of all.

3. But others, including Plato, who is in such repute among the Greeks, argue that God has made the world out of matter previously existing and without beginning. For God could have made nothing had not the material existed already; just as the wood must exist ready at hand for the carpenter, to enable him to work at all.

4. But in so saying they know not that they are investing God with weakness. For if He is not Himself the cause of the material, but makes things only of previously existing material, He proves to be weak, because unable to produce anything He makes without the material; just as it is without doubt a weakness of the carpenter not to be able to make anything required without his timber. For, ex hypothesi, had not the material existed, God would not have made anything. And how could He in that case be called Maker and Artificer, if He owes His ability to make to some other source — namely, to the material? So that if this be so, God will be on their theory a Mechanic only, and not a Creator out of nothing; if, that is, He works at existing material, but is not Himself the cause of the material. For He could not in any sense be called Creator unless He is Creator of the material of which the things created have in their turn been made.

5. But the sectaries imagine to themselves a different artificer of all things, other than the Father of our Lord Jesus Christ, in deep blindness even as to the words they use.

6. For whereas the Lord says to the Jews: "Have ye not read that from the beginning He which created them made them male and female, and said, For this cause shall a man leave his father and mother, and shall cleave to his wife, and they twain shall become one flesh?" and then, referring to the Creator, says, "What, therefore, God hath joined together let not man put

asunder:" how come these men to assert that the creation is independent of the Father? Or if, in the words of John, who says, making no exception, "All things were made by Him," and "without Him was not anything made," how could the artificer be another, distinct from the Father of Christ?

III. The True Doctrine — Creation Out of Nothing, of God's Lavish Bounty of Being; Man Created Above the Rest, But Incapable of Independent Perseverance; Hence the Exceptional and Supra-Natural Gift of Being in God's Image, with the Promise of Bliss Conditionally Upon His Perseverance in Grace

1. Thus do they vainly speculate. But the godly teaching and the faith according to Christ brands their foolish language as godlessness. For it knows that it was not spontaneously, because forethought is not absent; nor of existing matter, because God is not weak; but that out of nothing, and without its having any previous existence, God made the universe to exist through His word, as He says firstly through Moses: "In the beginning God created the heaven and the earth;" secondly, in the most edifying book of the Shepherd, "first of all believe that God is one, which created and framed all things, and made them to exist out of nothing."

2. To which also Paul refers when he says, `By faith we understand that the worlds have been framed by the Word of God, so that what is seen hath not been made out of things which do appear."

3. For God is good, or rather is essentially the source of goodness: nor could one that is good be niggardly of anything: whence, grudging existence to none, He has made all things out of nothing by His own Word, Jesus Christ our Lord. And among these, having taken especial pity, above all things on earth, upon the race of men, and having perceived its inability, by virtue of the condition of its origin, to continue in one stay, He gave them a further gift, and He did not barely create man, as He did all the irrational creatures on the earth, but made them after His own image, giving them a portion even of the power of His own Word; so that having as it were a kind of reflexion of the Word, and being made rational, they might be able to abide ever in blessedness, living the true life which belongs to the saints in paradise.

4. But knowing once more how the will of man could sway to either side, in anticipation He secured the grace given them by a law and by the spot where He placed them. For He brought them into His own garden, and gave them a law: so that, if they kept the grace and remained good, they might still keep the life in paradise without sorrow or pain or care besides having the promise of incorruption in heaven; but that if they transgressed and turned back, and became evil, they might know that they were incurring that corruption in death which was theirs by nature: no longer to live in paradise, but cast out of it from that time forth to die and to abide in death and in corruption.

5. Now this is that of which Holy Writ also gives warning, saying in the Person of God: "Of every tree that is in the garden, eating thou shalt eat: but of the tree of the knowledge of good and evil, ye shall not eat of it, but on the day that ye eat, dying ye shall die." But by "dying ye shall die," what else could be meant than not dying merely, but also abiding ever in the corruption of death?

IV. Our Creation and God's Incarnation Most Intimately Connected; As by the Ward Man Was Called from Non-Existence into Being, and Further Received the Grace of a Divine Life, So by the One Fault Which Forfeited that Life They Again Incurred Corruption and Untold Sin and Misery filled the World

1. You are wondering, perhaps, for what possible reason, having proposed to speak of the Incarnation of the Word, we are at present treating of the origin of mankind. But this, too, properly belongs to the aim of our treatise.

2. For in speaking of the appearance of the Saviour amongst us, we must needs speak also of the

origin of men, that you may know that the reason of His coming down was because of us, and that our transgression called forth the loving-kindness of the Word, that the Lord should both make haste to help us and appear among men.

3. For of His becoming Incarnate we were the object, and for our salvation He dealt so lovingly as to appear and be born even in a human body.

4. Thus, then, God has made man, and willed that he should abide in incorruption; but men, having despised and rejected the contemplation of God, and devised and contrived evil for themselves (as was said in the former treatise), received the condemnation of death with which they had been threatened; and from thenceforth no longer remained as they were made, but were being corrupted according to their devices; and death had the mastery over them as king. For transgression of the commandment was turning them back to their natural state, so that just as they have had their being out of nothing, so also, as might be expected, they might look for corruption into nothing in the course of time.

5. For if, out of a former normal state of nonexistence, they were called into being by the Presence and loving-kindness of the Word, it followed naturally that when men were bereft of the knowledge of God and were turned back to what was not (for what is evil is not, but what is good is), they should, since they derive their being from God who IS, be everlastingly bereft even of being; in other words, that they should be disintegrated and abide in death and corruption.

6. For man is by nature mortal, inasmuch as he is made out of what is not; but by reason of his likeness to Him that is (and if he still preserved this likeness by keeping Him in his knowledge) he would stay his natural corruption, and remain incorrupt; as Wisdom says: "The taking heed to His laws is the assurance of immortality;" but being incorrupt, he would live henceforth as God, to which I suppose the divine Scripture refers, when it says: "I have said ye are gods, and ye are all sons of the most Highest; but ye die like men, and fall as one of the princes."

V. For God has not only made us out of nothing; but He gave us freely, by the Grace of the Word, a life in correspondence with God;

1. But men, having rejected things eternal, and, by counsel of the devil, turned to the things of corruption, became the cause of their own corruption in death, being, as I said before, by nature corruptible, but destined, by the grace following from partaking of the Word, to have escaped their natural state, had they remained good

2. For because of the Word dwelling with them, even their natural corruption did not come near them, as Wisdom also says: "God made man for incorruption, and as an image of His own eternity; but by envy of the devil death came into the world." But when this was come to pass, men began to die, while corruption thence — forward prevailed against them, gaining even more than its natural power over the whole race, inasmuch as it had, owing to the transgression of the commandment, the threat of the Deity as a further advantage against them...

XII. For Though Man Was Created in Grace, God, Foreseeing His Forgetfulness, Provided Also the Works of Creation to Remind Man of Him; Yet Further, He Ordained a Law and Prophets, Whose Ministry Was Meant for All the World; Yet Men Heeded Only Their Own Lusts

1. For whereas the grace of the Divine Image was in itself sufficient to make known God the Word, and through Him the Father; still God, knowing the weakness of men, made provision even for their carelessness: so that if they cared not to know God of themselves, they might be enabled through the works of creation to avoid ignorance of the Maker.

2. But since men's carelessness, by little and little, descends to lower things, God made provision, once more, even for this weakness of theirs, by sending a law, and prophets, men such as they knew, so that even if they were not ready to look up to heaven and know their Creator, they might have their instruction from those near at hand. For men are able to learn from men more directly about higher things.

3. So it was open to them, by looking into the height of heaven, and perceiving the harmony of creation, to know its Ruler, the Word of the Father, Who, by His own providence over all things makes known the Father to all, and to this end moves all things, that through Him all may know God.

4. Or, if this were too much for them, it was possible for them to meet at least the holy men, and through them to learn of God, the Maker of all things, the Father of Christ; and that the worship of idols is godlessness, and full of all impiety.

5. Or it was open to them, by knowing the law even, to cease from all lawlessness and live a virtuous life. For neither was the law for the Jews alone, nor were the Prophets sent for them only, but, though sent to the Jews and persecuted by the Jews, they were for all the world a holy school of the knowledge of God and the conduct of the soul.

6. God's goodness then and loving-kindness being so great — men nevertheless, overcome by the pleasures of the moment and by the illusions and deceits sent by demons, did not raise their heads toward the truth, but loaded themselves the more with evils and sins, so as no longer to seem rational, but from their ways to be reckoned void of reason.

XLI. Answer to the Greeks — Do they recognise the Logos? If He manifests Himself in the organism of the Universe, why not in one Body? For a human body is part of the same whole

We come now to the unbelief of the Gentiles; and this is indeed a matter for complete astonishment, for they laugh at that which is no fit subject for mockery, yet fail to see the shame and ridiculousness of their own idols. But the arguments on our side do not lack weight, so we will confute them too on reasonable grounds, chiefly from what we ourselves also see.

First of all, what is there in our belief that is unfitting or ridiculous? Is it only that we say that the Word has been manifested in a body? Well, if they themselves really love the truth, they will agree with us that this involved no unfittingness at all. If they deny that there is a Word of God at all, that will be extraordinary, for then they will be ridiculing what they do not know. But suppose they confess that there is a Word of God, that He is the Governor of all things, that in Him the Father wrought the creation, that by His providence the whole receives light and life and being, and that He is King over all, so that He is known by means of the works of His providence, and through Him the Father. Suppose they confess all this, what then? Are they not unknowingly turning the ridicule against themselves?

The Greek philosophers say that the universe is a great body, and they say truly, for we perceive the universe and its parts with our senses. But if the Word of God is in the universe, which is a body, and has entered into it in its every part, what is there surprising or unfitting in our saying that He has entered also into human nature? If it were unfitting for Him to have embodied Himself at all, then it would be unfitting for Him to have entered into the universe, and to be giving light and movement by His providence to all things in it, because the universe, as we have seen, is itself a body. But if it is right and fitting for Him to enter into the universe and to reveal Himself through it, then, because humanity is part of the universe along with the rest, it is no less fitting for Him to appear in a human body, and to enlighten and to work through that. And surely if it were wrong for a part of the universe to have been used to reveal His Divinity to men, it would be much more

wrong that He should be so revealed by the whole!

XLII. His union to the body is based upon His relation to Creation as a whole; He used a human body, since to man it was that He wished to reveal Himself

Take a parallel case. A man's personality actuates and quickens his whole body. If anyone said it was unsuitable for the man's power to be in the toe, he would be thought silly, because, while granting that a man penetrates and actuates the whole of his body, he denied his presence in the part. Similarly, no one who admits the presence of the Word of God in the universe as a whole should think it unsuitable for a single human body to be by Him actuated and enlightened.

But is it, perhaps, because humanity is a thing created and brought into being out of non-existence that they regard as unfitting the manifestation of the Savior in our nature? If so, it is high time that they spurned Him from creation too; for it, too, has been brought out of non-being into being by the Word. But if, on the other hand, although creation is a thing that has been made, it is not unsuitable for the Word to be present in it, then neither is it unsuitable for Him to be in man.

Man is a part of the creation, as I said before; and the reasoning which applies to one applies to the other. All things derive from the Word their light and movement and life, as the Gentile authors themselves say, "In Him we live and move and have our being." Very well then. That being so, it is by no means unbecoming that the Word should dwell in man. So if, as we say, the Word has used that in which He is as the means of His self-manifestation, what is there ridiculous in that? He could not have used it had He not been present in it; but we have already admitted that He is present both in the whole and in the parts. What, then, is there incredible in His manifesting Himself through that in which He is?

By His own power He enters completely into each and all, and orders them throughout ungrudgingly; and, had He so willed, He could have revealed Himself and His Father by means of sun or moon or sky or earth or fire or water. Had He done so, no one could rightly have accused Him of acting unbecomingly, for He sustains in one whole all things at once, being present and invisibly revealed not only in the whole, but also in each particular part. This being so, and since, moreover, He has willed to reveal Himself through men, who are part of the whole, there can be nothing ridiculous in His using a human body to manifest the truth and knowledge of the Father.

Does not the mind of man pervade his entire being, and yet find expression through one part only, namely the tongue? Does anybody say on that account that Mind has degraded itself? Of course not. Very well, then, no more is it degrading for the Word, Who pervades all things, to have appeared in a human body. For, as I said before, if it were unfitting for Him thus to indwell the part, it would be equally so for Him to exist within the whole.

XLIII. He came in human rather than in any nobler form, because (1) He came to save, not to impress; (2) man alone of creatures had sinned, As men would not recognise His works in the Universe, He came and worked among them as Man; in the sphere to which they had limited themselves.

Some may then ask, why did He not manifest Himself by means of other and nobler parts of creation, and use some nobler instrument, such as sun or moon or stars or fire or air, instead of mere man? The answer is this. The Lord did not come to make a display. He came to heal and to teach suffering men. For one who wanted to make a display the thing would have been just to appear and dazzle the beholders. But for Him Who came to heal and to teach the way was not merely to dwell here, but to put Himself at the disposal of those who needed Him, and to be manifested according as they could bear it, not vitiating the value of the Divine appearing by exceeding their capacity to receive it.

Moreover, nothing in creation had erred from the path of God's purpose for it, save only man. Sun, moon, heaven, stars, water, air, none of these had swerved from their order, but, knowing the Word as their Maker and their King, remained as they were made. Men alone having rejected what is good, have invented nothings instead of the truth, and have ascribed the honor due to God and the knowledge concerning Him to demons and men in the form of stones. Obviously the Divine goodness could not overlook so grave a matter as this. But men could not recognize Him as ordering and ruling creation as a whole. So what does He do? He takes to Himself for instrument a part of the whole, namely a human body, and enters into that. Thus He ensured that men should recognize Him in the part who could not do so in the whole, and that those who could not lift their eyes to His unseen power might recognize and behold Him in the likeness of themselves. For, being men, they would naturally learn to know His Father more quickly and directly by means of a body that corresponded to their own and by the Divine works done through it; for by comparing His works with their own they would judge His to be not human but Divine.

And if, as they say, it were unsuitable for the Word to reveal Himself through bodily acts, it would be equally so for Him to do so through the works of the universe. His being in creation does not mean that He shares its nature; on the contrary, all created things partake of His power. Similarly, though He used the body as His instrument, He shared nothing of its defect, but rather sanctified it by His indwelling. Does not even Plato, of whom the Greeks think so much, say that the Author of the Universe, seeing it storm-tossed and in danger of sinking into the state of dissolution, takes his seat at the helm of the Life-force of the universe, and comes to the rescue and puts everything right? What, then, is there incredible in our saying that, mankind having gone astray, the Word descended upon it and was manifest as man, so that by His intrinsic goodness and His steersmanship He might save it from the storm?

XLIV. As God made man by a word, why not restore him by a word? But (1) creation out of nothing is different than reparation of what already exists; (2) Man was there with a definite need, calling for a definite remedy; Death was ingrained in man's nature: He then must wind life closely to human nature; Therefore the Word became Incarnate that He might meet and conquer death in His usurped territory (Simile of straw and asbestos)

It may be, however, that, though shamed into agreeing that this objection is void, the Greeks will want to raise another. They will say that, if God wanted to instruct and save mankind, He might have done so, not by His Word's assumption of a body, but, even as He at first created them, by the mere signification of His will. The reasonable reply to that is that the circumstances in the two cases are quite different.

In the beginning, nothing as yet existed at all; all that was needed, therefore, in order to bring all things into being, was that His will to do so should be signified. But once man was in existence, and things that were, not things that were not, demanded to be healed, it followed as a matter of course that the Healer and Savior should align Himself with those things that existed already, in order to heal the existing evil. For that reason, therefore, He was made man, and used the body as His human instrument. If this were not the fitting way, and He willed to use an instrument at all, how otherwise was the Word to come? And whence could He take His instrument, save from among those already in existence and needing His Godhead through One like themselves? It was not things non-existent that needed salvation, for which a bare creative word might have sufficed, but man — man already in existence and already in process of corruption and ruin. It was natural and right, therefore, for the Word to use a human instrument and by that means unfold Himself to all.

You must know, moreover, that the corruption which had set in was not external to the body but established within it. The need, therefore, was that life should cleave to it in corruption's place, so that, just as death was brought into being in the body, life also might be engendered in it. If death

had been exterior to the body, life might fittingly have been the same. But if death was within the body, woven into its very substance and dominating it as though completely one with it, the need was for Life to be woven into it instead, so that the body by thus enduing itself with life might cast corruption off.

Suppose the Word had come outside the body instead of in it, He would, of course, have defeated death, because death is powerless against the Life. But the corruption inherent in the body would have remained in it none the less. Naturally, therefore, the Savior assumed a body for Himself, in order that the body, being interwoven as it were with life, should no longer remain a mortal thing, in thrall to death, but as endued with immortality and risen from death, should thenceforth remain immortal. For once having put on corruption, it could not rise, unless it put on life instead; and besides this, death of its very nature could not appear otherwise than in a body. Therefore He put on a body, so that in the body He might find death and blot it out. And, indeed, how could the Lord have been proved to be the Life at all, had He not endued with life that which was subject to death?

Take an illustration. Stubble is a substance naturally destructible by fire; and it still remains stubble, fearing the menace of fire which has the natural property of consuming it, even if fire is kept away from it, so that it is not actually burnt. But suppose that, instead of merely keeping the fire from it somebody soaks the stubble with a quantity of asbestos, the substance which is said to be the antidote to fire. Then the stubble no longer fears the fire, because it has put on that which fire cannot touch, and therefore it is safe. It is just the same with regard to the body and death. Had death been kept from it by a mere command, it would still have remained mortal and corruptible, according to its nature. To prevent this, it put on the incorporeal Word of God, and therefore fears neither death nor corruption any more, for it is clad with Life as with a garment and in it corruption is clean done away.

XLV. Thus once again every part of creation manifests the glory of God; Nature, the witness to her Creator, yields (by miracles) a second testimony to God Incarnate; The witness of Nature, perverted by man's sin, was thus forced back to truth; If these reasons suffice not, let the Greeks look at facts

The Word of God thus acted consistently in assuming a body and using a human instrument to vitalize the body. He was consistent in working through man to reveal Himself everywhere, as well as through the other parts of His creation, so that nothing was left void of His Divinity and knowledge. For I take up now the point I made before, namely that the Savior did this in order that He might fill all things everywhere with the knowledge of Himself, just as they are already filled with His presence, even as the Divine Scripture says, "The whole universe was filled with the knowledge of the Lord."

If a man looks up to heaven he sees there His ordering; but if he cannot look so high as heaven, but only so far as men, through His works he sees His power, incomparable with human might, and learns from them that He alone among men is God the Word. Or, if a man has gone astray among demons and is in fear of them, he may see this Man drive them out and judge therefrom that He is indeed their Master. Again, if a man has been immersed in the element of water and thinks that it is God — as indeed the Egyptians do worship water — he may see its very nature changed by Him and learn that the Lord is Creator of all. And if a man has gone down even to Hades, and stands awestruck before the heroes who have descended thither, regarding them as gods, still he may see the fact of Christ's resurrection and His victory over death, and reason from it that, of all these, He alone is very Lord and God.

For the Lord touched all parts of creation, and freed and undeceived them all from every deceit. As St. Paul says, "Having put off from Himself the principalities and the powers, He triumphed on the

cross," so that no one could possibly be any longer deceived, but everywhere might find the very Word of God. For thus man, enclosed on every side by the works of creation and everywhere — in heaven, in Hades, in men and on the earth, beholding the unfolded Godhead of the Word, is no longer deceived concerning God, but worships Christ alone, and through Him rightly knows the Father.

On these grounds, then, of reason and of principle, we will fairly silence the Gentiles in their turn. But if they think these arguments insufficient to confute them, we will go on in the next chapter to prove our point from facts.

LIV. The Word Incarnate, as is the case with the Invisible God, is known to us by His works; By them we recognise his deifying mission; Let us be content to enumerate a few of them, leaving their dazzling plentitude to him who will behold

As, then, he who desires to see God Who by nature is invisible and not to be beheld, may yet perceive and know Him through His works, so too let him who does not see Christ with his understanding at least consider Him in His bodily works and test whether they be of man or God. If they be of man, then let him scoff; but if they be of God, let him not mock at things which are no fit subject for scorn, but rather let him recognize the fact and marvel that things divine have been revealed to us by such humble means, that through death deathlessness has been made known to us, and through the Incarnation of the Word the Mind whence all things proceed has been declared, and its Agent and Ordainer, the Word of God Himself.

He, indeed, assumed humanity that we might become God. He manifested Himself by means of a body in order that we might perceive the Mind of the unseen Father. He endured shame from men that we might inherit immortality. He Himself was unhurt by this, for He is impassable and incorruptible; but by His own impassability He kept and healed the suffering men on whose account He thus endured. In short, such and so many are the Savior's achievements that follow from His Incarnation, that to try to number them is like gazing at the open sea and trying to count the waves. One cannot see all the waves with one's eyes, for when one tries to do so those that are following on baffle one's senses. Even so, when one wants to take in all the achievements of Christ in the body, one cannot do so, even by reckoning them up, for the things that transcend one's thought are always more than those one thinks that one has grasped.

As we cannot speak adequately about even a part of His work, therefore, it will be better for us not to speak about it as a whole. So we will mention but one thing more, and then leave the whole for you to marvel at. For, indeed, everything about it is marvelous, and wherever a man turns his gaze he sees the Godhead of the Word and is smitten with awe.

Athanasius of Alexandria
Contra Arianos

Discourse II

Chapter XXII. Text Explained; Sixthly, the context of Proverbs 8:22-30; It is right to interpret the passage by the Regulafidei; `Founded' is used in contrast to superstructure; and it implies, as in the case of stones in building, previous existence; `Before the world' signifies the divine intention and purpose; Recurrence to Proverbs 8:22, and application of it to created Wisdom as seen in the works; The Son reveals the Father, first by the works, then by the Incarnation

78. Now the Only-begotten and very Wisdom of God is Creator and Framer of all things; for `in Wisdom hast Thou made them all,' he says, and `the earth is full of Thy creation.' But that what came into being might not only be, but be good, it pleased God that His own Wisdom should

condescend to the creatures, so as to introduce an impress and semblance of Its Image on all in common and on each, that what was made might be manifestly wise works and worthy of God . For as of the Son of God, considered as the Word, our word is an image, so of the same Son considered as Wisdom is the wisdom which is implanted in us an image; in which wisdom we, having the power of knowledge and thought, become recipients of the All-framing Wisdom; and through It we are able to know Its Father. `For he who hath the Son,' saith He, `hath the Father also;' and `he that receiveth Me, receiveth Him that sent Me.'

Such an impress then of Wisdom being created in us, and being in all the works, with reason does the true and framing Wisdom take to Itself what belongs to its own impress, and say, `The Lord created me for His works;' for what the wisdom in us says, that the Lord Himself speaks as if it were His own; and, whereas He is not Himself created, being Creator, yet because of the image of Him created in the works, He says this as if of Himself. And as the Lord Himself has said, `He that receiveth you, receiveth Me,' because His impress is in us, so, though He be not among the creatures, yet because His image and impress is created in the works, He says, as if in His own person, `The Lord created me a beginning of His ways for His works.'

And therefore has this impress of Wisdom in the works been brought into being, that, as I said before, the world might recognise in it its own Creator the Word, and through Him the Father. And this is what Paul said, `Because that which may be known of God is manifest in them, for God has shewed it unto them: for the invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made.' But if so, the Word is not a creature in essence; but the wisdom which is in us and so called, is spoken of in this passage in the Proverbs.

79. But if this too fails to persuade them [the Arians, ed.], let them tell us themselves, whether there is any wisdom in the creatures or not? If not how is it that the Apostle complains, `For after that in the Wisdom of God the world by wisdom knew not God?' Or how is it if there is no wisdom, that a `multitude of wise men' are found in Scripture? For `a wise man feareth and departeth from evil;' and `through wisdom is a house builded;' and the Preacher says, `A man's wisdom maketh his face to shine;' and he blames those who are headstrong thus, `Say not thou, what is the cause that the former days were better than these? For thou dost not inquire in wisdom concerning this.'

But if, as the Son of Sirach says, `He poured her out upon all His works; she is with all flesh according to His gift, and He hath given her to them that love Him,' and this outpouring is a note, not of the Essence of the Very Wisdom and Only-begotten, but of that wisdom which is imaged in the world, how is it incredible that the All-framing and true Wisdom Itself, whose impress is the wisdom and knowledge poured out in the world, should say, as I have already explained, as if of Itself, `The Lord created me for His works?' For the wisdom in the world is not creative, but is that which is created in the works, according to which `the heavens declare the glory of God, and the firmament sheweth His handywork.' This if men have within them, they will acknowledge the true Wisdom of God; and will know that they are made really after God's Image.

And, as some son of a king, when the father wished to build a city, might cause his own name to be printed upon each of the works that were rising, both to give security to them of the works remaining, by reason of the show of his name on everything, and also to make them remember him and his father from the name, and having finished the city might be asked concerning it, how it was made, and then would answer, `It is made securely, for according to the will of my father, I am imaged in each work, for my name was made in the works;' but saying this, he does not signify that his own essence is created, but the impress of himself by means of his name; in the same manner, to apply the illustration, to those who admire the wisdom in the creatures, the true Wisdom makes answer, `The Lord created me for the works,' for my impress is in them; and I have thus condescended for the framing of all things.

80. Moreover, that the Son should be speaking of the impress that is within us as if it were Himself, should not startle any one, considering (for we must not shrink from repetition) that, when Saul was persecuting the Church, in which was His impress and image, He said, as if He were Himself under persecution, `Saul, why persecutest thou Me?' Therefore (as has been said), as, supposing the impress itself of Wisdom which is in the works had said, `The Lord created me for the works,' no one would have been startled, so, if He, the True and Framing Wisdom, the Only-begotten Word of God, should use what belongs to His image as about Himself, namely, `The Lord created me for the works,' let no one, overlooking the wisdom created in the world and in the works, think that `He created' is said of the Substance of the Very Wisdom, lest, diluting the wine with water, he be judged a defrauder of the truth.

For It is Creative and Framer; but Its impress is created in the works, as the copy of the image. And He says, `Beginning of ways,' since such wisdom becomes a sort of beginning, and, as it were, rudiments of the knowledge of God; for a man entering, as it were, upon this way first, and keeping it in the fear of God (as Solomon says, `The fear of the Lord is the beginning of wisdom'), then advancing upwards in his thoughts and perceiving the Framing Wisdom which is in the creation, will perceive in It also Its Father, as the Lord Himself has said, `He that hath seen Me, hath seen the Father,' and as John writes, `He who acknowledgeth the Son, hath the Father also.' And He says, `Before the world He founded me,' since in Its impress the works remain settled and eternal. Then, lest any, hearing concerning the wisdom thus created in the works, should think the true Wisdom, God's Son, to be by nature a creature, He has found it necessary to add, `Before the mountains, and before the earth, and before the waters, and before all hills He begets me,' that in saying, `before every creature' (for He includes all the creation under these heads), He may shew that He is not created together with the works according to Essence. For if He was created `for the works,' yet is before them, it follows that He is in being before He was created. He is not then a creature by nature and essence, but as He Himself has added, an Offspring. But in what differs a creature from an offspring, and how it is distinct by nature, has been shewn in what has gone before.

81. But since He proceeds to say, `When He prepared the heaven, I was present with Him,' we ought to know that He says not this as if without Wisdom the Father prepared the heaven or the clouds above (for there is no room to doubt that all things are created in Wisdom, and without It was made not even one thing); but this is what He says, `All things took place in Me and through Me, and when there was need that Wisdom should be created in the works, in My Essence indeed I was with the Father, but by a condescension to things originate, I was disposing over the works My own impress, so that the whole world as being in one body, might not be at variance but in concord with itself.'

All those then who with an upright understanding, according to the wisdom given unto them, come to contemplate the creatures, are able to say for themselves, `By Thy appointment all things continue;' but they who make light of this must be told, `Professing themselves to be wise, they became fools;' for `that which may be known of God is manifest in them; for God has revealed it unto them; for the invisible things of Him from the creation of the world are clearly seen, being perceived by the things that are made, even His eternal Power and Godhead, so that they are without excuse. Because that when they knew God, they glorified Him not as God, but served the creature more than the Creator of all, who is blessed for ever. Amen.' And they will surely be shamed at hearing, `For, after that in the wisdom of God (in the mode we have explained above), the world by wisdom knew not God, it pleased God by the foolishness of the preaching to save them that believe.' For no longer, as in the former times, God has willed to be known by an image and shadow of wisdom, that namely which is in the creatures, but He has made the true Wisdom Itself to take flesh, and to become man, and to undergo the death of the cross; that by the faith in Him, henceforth all that believe may obtain salvation.

However, it is the same Wisdom of God, which through Its own Image in the creatures (whence also It is said to be created), first manifested Itself, and through Itself Its own Father; and afterwards, being Itself the Word, has `become flesh,' as John says, and after abolishing death and saving our race, still more revealed Himself and through Him His own Father, saying, `Grant unto them that they may know Thee the only true God, and Jesus Christ whom Thou hast sent.'

82. Hence the whole earth is filled with the knowledge of Him; for the knowledge of Father through Son and of Son from Father is one and the same, and the Father delights in Him, and in the same joy the Son rejoices in the Father, saying, `I was by Him, daily His delight, rejoicing always before Him.' And this again proves that the Son is not foreign, but proper to the Father's Essence. For behold, not because of us has He come to be, as the irreligious men say, nor is He out of nothing (for not from without did God procure for Himself a cause of rejoicing), but the words denote what is His own and like.

When then was it, when the Father rejoiced not? But if He ever rejoiced, He was ever, in whom He rejoiced. And in whom does the Father rejoice, except as seeing Himself in His own Image, which is His Word? And though in sons of men also He had delight, on finishing the world, as it is written in these same Proverbs, yet this too has a consistent sense. For even thus He had delight, not because joy was added to Him, but again on seeing the works made after His own Image; so that even this rejoicing of God is on account of His Image. And how too has the Son delight, except as seeing Himself in the Father? For this is the same as saying, `He that hath seen Me, hath seen the Father,' and `I am in the Father and the Father in Me.' Vain then is your vaunt as is on all sides shewn, O Christ's enemies, and vainly did ye parade and circulate everywhere your text, `The Lord created me a beginning of His ways,' perverting its sense, and publishing, not Solomon's meaning, but your own comment. For behold your sense is proved to be but a fantasy; but the passage in the Proverbs, as well as all that is above said, proves that the Son is not a creature in nature and essence, but the proper Offspring of the Father, true Wisdom and Word, by whom `all things were made,' and 'without Him was made not one thing.'

Ephrem the Syrian (ca. 306AD – 373AD)
Commentary on Genesis

Section I
I. In the beginning God created the heavens and the earth, that is, the substance of the heavens and the substance of the earth. So let no one think that there is anything allegorical in the works of the six days. No one can rightly say that the things that pertain to these days were symbolic, nor can one say that they were meaningless names or that other things were symbolized for us by their names. Rather, let us know in just what manner heaven and earth were created in the beginning. They were truly heaven and earth. There was no other thing signified by the names "heaven" and "earth." The rest of the works and things made that followed were not meaningless significations either, for the substances of their natures correspond to what their names signify.

2. In the beginning God created heaven and earth. At this point these comprised the only things that had been made, for there was nothing else created along with heaven and earth. Even the elements that were created on that day had not yet been created. If the elements had been created along with heaven and earth, Moses would have said so. But he did not, lest he give the names of the elements precedence over their substances. Therefore, it is evident that heaven and earth came to be from nothing because neither water nor wind had yet been created, nor had fire, light or darkness been given their natures, for they were younger than heaven and earth. These things were created things that came after heaven and earth and they were not self-subsistent

beings for they did not exist before [heaven and earth].

3. After this [Moses] spoke not of the things that were above the firmament, but rather of those things that were between the firmament and the earth which is within [the womb] [Moses] wrote about [the things within the firmament] for us, although he did not write about everything for us, for he did not record for us the day on which the spiritual beings were created.

(2) [Moses] then goes on to write that the earth was tohu and bohu, that is, void and desolation. This is to show that even the void and desolation were older than the elements. I am not saying that the void and desolation were something. Rather [I am saying] that the earth, which does exist, was known [to exist] in something which does not exist, for the earth existed alone without any other thing.

4. After [Moses] spoke about the creation of heaven and earth and showed that the waste and desolation preceded the elements that were created by the length of that moment that followed [their creation], he turned to write about those elements saying, Darkness was upon the face of the abyss. For the abyss of waters was created at that time. But how was it created on the day on which it was created? Even though it was created on this day and at this moment, Moses does not tell us here how it was created. For now, we should accept the creation of the abyss as it is written, while we wait to learn from Moses how it was created.

(2) As for the darkness that was upon the face of the abyss, some posit that it was a cloud of heaven. Now, if the firmament had been created on the first day they would speak rightly. If the upper heavens were similar to the firmament, then there would have been a thick darkness between the two heavens, for the light had not been created nor affixed there to dissipate the darkness by its rays. But if the place between the two heavens is light as Ezekiel (Ez 1:1, 22), Paul (Acts 9:3; 22:6; 26:13), and Stephen (Acts 7:55-56) bear witness, then how could the heavens, which had dissipated the darkness with their lights, spread darkness over the abyss?

5. Because everything that was created was created in those six days, whether it was written down that it was created or not, the clouds must also have been created on the first day, just as fire was created along with wind, although Moses did not write about the fire as he did about the wind. Thus, the clouds were created along with the abyss although Moses did not write that the clouds were created along with the abyss, just as he did not record the creation of fire along with that of the wind when he wrote about the creation of the wind.

(2) It was necessary that everything be known to have its beginning in those six days. The clouds were surely created along with the abyss, for how many times were these brought forth from the abyss? Elijah saw a cloud rising up out of the sea. Solomon also said, By his knowledge the depths broke forth and the clouds sprinkled down dew. It was not only because of their substance that they should have been created at this point, but they were created on that first night because they also rendered service on that first night. Just as the clouds covered Egypt for three days and three nights, clouds were spread over all of Creation on the first night and on the first day. If the clouds had been dispersed, light would not have been required on the first day because the brightness of the upper heavens would have been sufficient to fill the place of the light that was created on the first day.

6. After one night and one day were completed, the firmament was created on the second evening and henceforth its shadow rendered service for all subsequent nights. Therefore, heaven and earth were created on the evening of the first night. Along with the abyss that was created, there were also created those clouds which, when they were spread out, brought about the requisite night. After their shadow had served for twelve hours, light was created beneath them and the light

dispersed their shadow that had been spread over the waters all night.

7. After Moses spoke of the darkness that was spread over the face of the abyss, he then said, the wind of God was hovering over the face of the waters. Because Moses called it the wind of God, and said it was hovering, some posit that this is the Holy Spirit and, because of what is written here, associate it with the activity of creation. Nevertheless, the faithful do not make this connection, for these things cannot be so related. Rather, by those things that are truly said about it, they associate it with that element, just as, on the basis of the names employed, they cannot posit the Spirit as maker, for it is said that an evil spirit of God consumed Saul.

(2) It is indeed said that it was hovering, but what came forth from the waters on the first day when [the wind] was hovering over the waters? If on the day that it was written that it was hovering over the waters nothing came out of the waters, and then on the fifth day when the waters brought forth reptiles and birds, it was not written that the wind was hovering, how then can anyone say that this wind took part in the activity of creation? For, although Scripture said it was hovering, it did not say that anything came out of the waters on the day that it was hovering.

(3) Just as through the service of the clouds, that is, the shadow of the first night, we infer the creation of the clouds that came to be on the first day, so too through the service of the wind, which is its breeze, Moses wished to make known to us the creation [of the wind]. For just as clouds do not exist without a shadow, neither does wind exist without a breeze. It is in their service then that we infer those things that are not otherwise made apparent to us. Therefore that wind was blowing because it was created for this purpose. After it blew and manifested its creation through its service on the first night, it once again became calm on the first day just as the clouds were once again dispersed on the first day.

8. After [Moses] spoke of heaven and earth, of the darkness, the abyss and the wind that came to be at the beginning of the first night, he then turned to speak about the light that came to be at dawn of the first day. At the end of the twelve hours of that night, the light was created between the clouds and the waters and it chased away the shadow of the clouds that were overshadowing the waters and making them dark. For Nisan was the first month; in it the number of the hours of day and night were equal.

(2) The light remained a length of twelve hours so that each day might also obtain its [own] hours just as the darkness had obtained a measured length of time. Although the light and the clouds were created in the twinkling of an eye, the day and the night of the first day were each completed m twelve hours.

(3) The light then was like a bright mist over the face of the earth. Whether it was like the dawn or like the pillar that gave light to the people in the wilderness, it is obvious that it would have been unable to chase away the darkness that was spread over the face of everything, unless it had spread out completely over everything, either by its substance or by its brightness. The light was released so that it might spread over everything without being fastened down. It dispersed the darkness that was over everything although it did not move. It was only when [the light] went away and when it came that it moved, for when [the light] went away the rule was given to the night and at [the light's] coming there would be an end to [the night's] rule.

9. After the brightness [of the light] rendered its service for three days, lest, like nothing, it return to nothing, God bore clear witness that the light was very good Although God did not [actually] say that the works that preceded the light were very good, He did [in fact] say it about them, for although He did not say it of them in the beginning when only these things had come into existence out of nothing, He did say it of them after everything else had come into existence; for [Moses]

included all that had been made together with all that was created in six days, when he said on the sixth day: God saw everything that he had made, and behold, it was very good.

(2) Because that first light was indeed created good, it rendered its service by its brightness for three days and it also served, as we say, for the conception and the birth of everything that the earth brought forth on the third day. The sun was in the firmament in order to ripen whatever had sprouted under that first light. It is said that from this light, now diffused, and from fire, which were both created on the first day, the sun, which was in the firmament, was fashioned, while the moon and the stars also came to be from that same first light.

(3) Just as the sun, which rules the day by the fact that it gives light to the earth, actually causes the fruits of the earth to ripen, so too does the moon, which rules the night and tempers the strength of the night by its brightness, also bring forth, according to its first nature, fruits and vegetation. For Moses speaks in his blessings of the yield which the moon brought forth (Dent 33:14), along with the other things on account of which the light was created, although they say that, for the sake of the things that were to come forth, the light was created on the first day. After the earth brought forth everything during the course of the third day, then [the moon] came to be in the manner of the light on the fourth day, so that through the moon, as well as through the light, all fruit would have its beginning, and then through the sun all vegetation would become ripe.

10. Thus, through light and water the earth brought forth everything. While God is able to bring forth everything from the earth without these things, it was His will to show that there was nothing created on earth that was not created for the purpose of mankind or for his service... [on saltiness of waters has been cut].

12. Just as the gathering of the waters did not precede that word which said, "Let the waters be gathered and let the dry land appear," neither did the seas exist until that moment when God called the gathering of water "seas." When they received their name they were changed. In their [new] place the [waters] attained that saltiness that had not been theirs [even] outside of their [old] place. For [their place] became deep at that very moment when [God] said, "Let the waters be gathered into one place." Then either the land [under] the sea was brought down below the [level of the] earth to receive within it its own waters along with the waters that were above the entire earth, or the waters swallowed each other so that the place might be sufficient for them, or the place of the sea shook and it became a great depth and the waters quickly hastened into that basin. Although the will of God had gathered these waters when the earth was created, a gate was opened for them to be gathered into one place. Just as in the gathering of the first and second waters there was found no gathering place because there was no place from which they might go out, so now do these waters come down with all the rains and showers and are gathered into seas along paths and roads which had been prepared for them on the first day.

14. Heaven, earth, fire, wind, and water were created from nothing as Scripture bears witness, whereas the light, which came to be on the first day along with the rest of the things that came to be afterwards, came to be from something. For when these other things came to be from nothing, [Moses] said, God created heaven and earth. Although it is not written that fire, water, and wind were created, neither is it said that they were made. Therefore, they came to be from nothing just as heaven and earth came to be from nothing.

15. After God began to make [things] from something, Moses wrote, God said, "Let there be light, " and so on. Although Moses did say, God created the great serpents, nevertheless `let the waters swarm with swarming things" had been [said] prior to that. Therefore those five created things were created from nothing and everything else was made from those [five] things that came to be

from nothing.

(2) Fire was also created on the first day, although it is not written down that it was created. Since [fire] had no existence in and of itself but existed in something else, it was created together with that thing in which it came to be. It is not possible that a thing which does not exist of itself can precede that thing which is the cause of its existence. That [fire] is in the earth, nature bears witness, but that it was not created together with the earth, Scripture affirms, when it said, In the beginning God created heaven and earth. Fire too, then, since it does not exist of itself, will remain in the earth, even if the earth and the waters have been commanded at every moment to bring forth fire from their wombs along with the waters and the wind and the clouds.

16. Darkness, too, is neither a self-subsistent being nor a created thing; it is a shadow, as Scripture makes clear. It was created neither before heaven nor after the clouds, for it was with the clouds and was brought forth from the clouds. [Darkness] also exists in another [thing], for it has no substance of its own. When that in which it exists vanishes, the darkness likewise vanishes with it. For whatever comes to an end along with another thing when it vanishes is without its own existence, because that other thing is the cause of its existence.

(2) So, how could darkness, whose existence is due to the clouds and to the firmament and not to the first light or to the sun, exist of itself? It is [a thing] which one thing brings forth by its cover and another destroys by its brightness. If one thing creates it and causes it to become something while another thing turns it back into nothing, how can it be a self-subsistent being? The clouds and the firmament, which were created at the beginning, bring it forth and the light that was created on the first day brings it to an end. If one created thing can create something and another created thing can destroy it — for subsequent to that, one thing can bring it into visibility at any moment — and another, at that very moment that it itself returns to nothing, turns it back into nothing, it is under the compulsion of that [one thing] which causes it to begin and [that other thing] that causes it to go away. If created things cause it to come into existence and also cause it to vanish then it is a [sic] created from created things. [The darkness then] is but a shadow of the firmament and it vanishes in the presence of another thing, as it disappears before the sun. Some teachings posit that this [darkness], which is at all times subject to created things, is an adversary of creatures, and they make that thing which has no substance of its own a self-existent being.

17. After [Moses] spoke of those things that came to be on the first day, he began to write about those things that came to be on the second day, saying, And God said, "Let there be afirmament between the waters and let it separate the waters below the firmament from the waters above the firmament." The firmament between the waters was pressed together from the waters. It was of the same measure as the waters that were spread out over the surface of the earth. Then if, in its origin, [the firmament] was above the earth (for the earth, water, and fire were beneath it, while water, wind, and darkness were above it), how do others posit that this [firmament], which is enveloped like an embryo in the uterus within the womb, is the womb of everything created between everything?

(2) For if the firmament had been created between everything, light, darkness, and wind, which were above the firmament when it was created, would have been confined above the firmament. If the creation [of the firmament] had occurred at night, the darkness and wind would also have remained there together with the waters which remained there. But if the creation [of the firmament] had occurred in the day, the light and the wind also would have remained there along with the waters. And if they had remained there then the [wind, water, and lights] that are here would be different things. When, then, could they have been created? But if they did not remain there, how did those elements that were above [the firmament] when they were created move down below it?

18. The firmament was created on the evening of the second night, just as the heavens came to be on the evening of the first night. But when the firmament came into existence, the covering of clouds that had served for a night and a day in the place of the firmament dissipated. Because [the firmament] had been created between the light and the darkness, no darkness remained above it, for the shadow of the clouds was dispelled when the clouds themselves were dispelled. Nor did any of this light remain there, for its alotted measure of time had come to an end and so it sank into the waters that were beneath [the firmament].

(2) The wind could not have remained there either because it did not even exist there. For, it was on the first night that [Moses] said it hovered and not on the second night. If the firmament had been created on the first night when [the wind] was blowing there could then be some debate. But, since it is not written that [the wind] was blowing when the firmament was created, who would say that the wind was there when Scripture does not say so?

19. After the wind hovered on the first day, manifested its service by its blowing and returned to its stillness, then the firmament came to be. It is evident, therefore, that [the wind] neither remained above nor descended below, for how can one seek in any position or place for something whose very substance only exists at the moment of its service and whose service comes to an end when it ceases to blow? The wind underwent three things on the day of its creation: it was created from nothing, it blew in and through something, and it reverted to being hidden in its stillness.

20. After the wind had undergone these three things, the firmament was created on the evening of the second day. There was then nothing that rose along with it, because there was nothing that remained above it. It made a separation between the waters that it was commanded to separate, but not between the light, the wind, or darkness, for this had not been commanded.

(2) There was no light, therefore, on the first night. On the night of the second and third day, it sank into the waters beneath the firmament and rose up as we said [above]. But on the fourth day, when the waters were gathered into one place, they say that [the firmament] was formed and that the sun, the moon, and the stars were formed from [the firmament] and from fire, and there were places set apart for the lights. Therefore, the moon would rise in the west of the firmament, the sun in the east, and at that same moment, the stars were dispersed in orderly fashion throughout the entire firmament.

(3) Although God said that the light which came to be on the first day was very good, He did not say this about the firmament which came to be on the second day, because the firmament had not yet been finished, neither in its structure nor in its adornment. The Creator delayed until the lights came to be so that when [the firmament] was adorned with the sun and the moon and the stars, and the strength of the darkness that was weakened by the lights that shone from it, He would then say of [the firmament], included with the rest [of creation], that it was very good.

21. After [Moses] spoke of the firmament that came to be on the second day, he then turned to write about the gathering of the waters and about the grass and the trees that the earth brought forth on the third day, saying, And God said, "Let the waters under the heavens be gathered together into one place, and let the dry land appear." From the fact that He said, "Let the waters be gathered into one place," it is evident that it is the earth that supports the seas and that the abysses beneath the earth do not stand on nothing. Although the waters, by the word of God, were gathered in the night, the surface of the earth still became dry in the twinkling of an eye.

22. After these two things had occurred, God commanded the earth to bring forth at dawn grass and herbs of every kind and all the various fruit-bearing trees. Although the grasses were only a

moment old at their creation, they appeared as if they were months old. Likewise, the trees, although only a day old when they sprouted forth, were nevertheless like [trees] years old as they were fully grown and fruits were already budding on their branches.

(2) The grass that would be required as food for the animals who were to be created two days later was [thus] made ready. And the new corn that would be food for Adam and his descendants, who would be thrown out of Paradise four days later, was [thus] prepared.

23. After [Moses] spoke about the gathering of the waters and about the sprouting of the vegetation on the earth on the third day, he turned to write about the lights that were created in the firmament, saying, And God said, "Let there be lights in the firmament of the heavens to separate the day from the night, " that is, "one to rule over the day and the other [to rule] over the night. "

(2) That [God] said, "Let them be for signs," [refers to] measures of time, and `let them be for seasons," clearly indicates summer and winter. "Let them be for days, " are measured by the rising and setting of the sun, and "let them be for years," are comprised of the daily cycles of the sun and the monthly cycles of the moon.

(3) Indeed [Moses] said, God made the two great lights, the greater light to rule the day, and the lesser light to rule the night; and [He made] the stars. Although all that was done before the fourth day was begun in the evening, the works on the fourth day were fashioned at dawn. Because the third day had been completed, in that [Moses] said, It was evening and it was morning; day three, God did not create the two lights in the evening lest night be changed into day and morning be given priority over evening.

24. Because the days followed the same order in which the first day was created, the night of the fourth day, like that of the other days, preceded its day. And if its evening preceded its dawn, the lights were not created in the evening, but rather at dawn. But to say that one of them was created in the evening and the other at dawn cannot be allowed for Moses said, "Let there be lights," and God made the two great lights. If they were great when they were created and they were created at dawn, then the sun would have stood in the east and the moon opposite it in the west. The sun would have been set very low because it was created in the place where it set out over the earth, whereas the moon would have been set higher because it was created in the place where it stands on the fifteenth day. Indeed, at the moment the sun appears over the earth, the lights see each other and the moon sinks. From the position of the moon, from its size and from the light it produced, it is clear, then, that it was fifteen days old when it was created.

25. Just as the trees, the vegetation, the animals, the birds, and even mankind were old, so also were they young. They were old according to the appearance of their limbs and their substances, yet they were young because of the hour and moment of their creation. Likewise, the moon was both old and young. It was young, for it was but a moment old, but was also old, for it was full as it is on the fifteenth day.

(2) If the moon had been created a day old or even two, it would have given no light; because of its proximity to the sun, it would not even have been visible. If it had been created about four days old, although it might have been visible, it would still not have given any light. This would have rendered false the verse God created the two great lights, as well as He said, "Let there be lights in heaven to give light upon the earth. " Therefore, the moon had to be fifteen days old. The sun, although it was only one day old, was nevertheless four days old, for it is according to the sun that each day is counted and will be reckoned. Accordingly, those eleven days, by which the moon was older than the sun, that were added to the moon at that first moment are also added to it each year, for these [days] are used in the lunar reckoning.

(3) There was nothing lacking in that year for Adam and his descendants, for any deficiency in the measure of the moon had been filled in when the moon was created. Thus, Adam and his descendants learned from this year that, henceforth, eleven days were to be added to every year. Clearly then, it was not the Chaldean who arranged the seasons and the years; these things had been arranged before [the creation of] Adam.

26. After Moses spoke about the lights that came to be in the firmament, he turned to write about the swarming things, the birds, and the serpents that were created from the waters on the fifth day, saying, And God said, "Let the waters cause living things to swarm, and let the birds fly above the earth." And God created the great serpents and every living creature with which the waters swarmed according to their kind.

(2) When the waters were gathered, which had been ordered on the second day, there appeared rivers as well as springs, lakes, and ponds. At the word of God these waters dispersed throughout Creation and brought forth swarming things and fish from within them; the serpents were created in the abysses and the birds soared in flocks out of the waves into the air.

(3) As for the great serpents that were created, although the Prophets said that Leviathan dwelt in the sea, Job said that the Behemoth dwelt on dry land. David too, speaking of this beast, said that on a thousand mountains is Behemoth's pasture land, that is, his place of repose. Perhaps it was after they were created that their places were separated so that Leviathan should dwell in the sea and Behemoth on dry land.

27. After [Moses] spoke about the creation of the swarming things and of the birds and the sea serpents on the fifth day, he turned to write about the creeping things and the animals and the beasts that were created on the sixth day, saying, And God said, "Let the earth bring forth living creatures according to their kinds: cattle and reptiles and beasts. " Although the entire earth was swarming with swarming things, nevertheless the cattle and the beasts were set along the border of Paradise so that they might dwell near Adam.

(2) Therefore, the entire earth stirred with creeping things as had been commanded. [The earth] also brought forth the beasts of the field as companions to the wild beasts, and it brought forth as many beasts as would be suitable for the service of that one who, on that very day, was to transgress the commandment of his Lord.

28. After [Moses] spoke about the reptiles, the beasts and the cattle that were created on the sixth day, he turned to write about the creation of that man who was fashioned on the sixth day, saying, "And God said... " But to whom was God speaking? Here, as in every place where He creates, it is clear that he was speaking to His Son. The Evangelist said about Him that everything came to be through Him and without Him not one thing came to be. Paul, too, confirms this when he said, In Him all things were created, in heaven and on earth, all that is visible and all that is invisible.

29. And God said, "Let us make man in our image. " According to what has been the rule until now, namely, if it pleases God He will make it known to us, Moses explains in what way we are the image of God, when he said "Let them have dominion over the fish of the sea, and over the birds, and over the cattle, and over all the earth." It is the dominion that Adam received over the earth and over all that is in it that constitutes the likeness of God who has dominion over the heavenly things and the earthly things.

(2) Then [Moses] said, male and female He created them, to make known that Eve was inside Adam, in the rib that was drawn out from him. Although she was not in his mind she was in his

body, and she was not only in his body with him, but she was also in soul and spirit with him, for God added nothing to that rib that He took out except the structure and the adornment. If everything that was suitable for Eve, who came to be from the rib, was complete in and from that rib, it is rightly said that male and female Ile created them.

30. And God blessed them and said to them, `Be fruitful and multiply, and fill the earth and subdue it; and have dominion over the fish of the sea, over the birds and over every animal that crawls upon the earth." They were blessed on this earth, as if this dwelling place had been prepared for them before they sinned. Although they had not yet sinned, [God] knew that they were about to sin.

(2) Be fruitful and multiply and fill, not Paradise, but the earth, and have dominion over the fish of the sea and the birds and over all the beasts. But how was Adam to rule over the fish of the sea unless he were to be in proximity to the sea? And how was he to rule over the birds that fly throughout every region unless his descendants were to dwell in every region? And how was Adam to rule over every beast of the earth unless his offspring were to inhabit the entire earth?

31. Although Adam was created and was blessed to rule over the earth and over everything that was created and blessed therein, God had indeed made him to dwell within Paradise. God truly manifested His foreknowledge in His blessing and manifested His grace in the place where He set Adam to dwell. Lest it be said that Paradise was not created for [Adam's] sake, [God] set him there in Paradise to dwell. And lest it be said that God did not know that Adam would sin, He blessed him on this earth. And everything with which God blessed Adam preceded the transgression of the commandment, lest by the transgression of him who had been blessed, the blessings of Him who gave the blessings be withheld and the world be turned back into nothing on account of the folly of that one for whose sake everything had been created.

(2) Therefore, God did not bless Adam in Paradise, because that place and all that is in it is blessed. But God blessed him on the earth first so that by that blessing with which [His] grace blessed beforehand, the curse of the earth, which was about to be cursed by [His] justice, might [thus] be diminished. But even though the blessing was one of promise, in that it was fulfilled after his expulsion from Paradise, His grace, nevertheless, was of actuality, for on that same day, [God] set [Adam] in the garden to dwell, clothed him with glory, and made him ruler over all the trees of Paradise.

32. After Moses spoke about the reptiles, the cattle and the beasts, about mankind and about their blessing on the sixth day, he turned to write about God's rest that took place on the seventh day saying, Thus heaven and earth were finished, and all their host. And God rested on the seventh day from all His work which He had done.

(2) From what toil did God rest? For the creatures that came to be on the first day came to be by implication, except for the light which came to be through His word. And the rest of the works which came to be afterwards came to be through His word. What toil is there for us when we speak one word, that there should be toil for God due to the one word a day that He spoke? If Moses, who divided the sea by his word and his rod, did not tire and Joshua, son of Nun, who restrained the luminaries by his word, did not tire, then what toil could there have been for God when He created the sea and the luminaries by [His] word?

33. It was not because He rested on [that day] that God, who does not weary, blessed and sanctified the seventh day, nor because He was to give it to that people, who did not understand that since they were freed from their servitude, they were to give rest to their servants and maidservants. He gave it to them so that, even if they had to be coerced, they would rest. For it

was given to them in order to depict by a temporal rest, which He gave to a temporal people, the mystery of the true rest which will be given to the eternal people in the eternal world.

(2) Also because a full week as required, God exalted by His word that seventh day which His works had not exalted so that, because of the honor accorded that day, it might be united to its cornpanions, and that the reckoning of the week, which is required for the service of the world, might be completed.

Section II

1. After Moses spoke of the sabbath rest, of how God blessed and sanctified this day, he returned to the account of how the Creation was first fashioned, briefly passing over those things of which he had already spoken, while recounting in detail those things that he had left out. He then began to write about the creation account a second time, saying, These are the generations of heaven and earth when they were created. In the day that God made heaven and earth, when no tree of the field existed and no vegetation had sprouted — for God had not brought down rain upon the earth and Adam was not there to till the earth; but a spring rose up and watered the whole face of the earth.

2. Understand, O hearer, that although the days of creation were finished and [God] had blessed the Sabbath day which was sanctified and he had completed [his account], Moses still returned to tell the story of the beginning of Creation even after the days of creation had been finished.

(2) These are the generations of heaven and earth, that is, this is the account of the fashioning of heaven and earth on the day when the Lord made heaven and earth for as yet no tree of the field existed and no vegetation had sprouted. Even if these things were not actually created on the first day — for they had been made on the third day — still [Moses] did not rashly introduce, on the first day, the report of those things that were created on the third day.

3. For [Moses] said, no trees existed and no vegetation had sprouted — for the Lord had not brought down rain upon the earth; but a spring rose up out of the earth and watered the whole face of the earth. Because everything that has been born and will be born from the earth [will be] through the conjunction of water and earth, [Moses] undertook to show that no tree nor vegetation had been created along with the earth, because the rain had not yet come down. But after the great spring rose up from the great abyss and watered the whole face of the earth, and after the waters had been gathered together on the third day, then the earth brought forth all the vegetation.

(2) These waters, then, over which the darkness had been spread on the first day are the same ones that rose up from the spring and, in the blink of an eye, covered the entire earth. This was also the [same spring] that was opened in the days of Noah and that covered the surface of all the mountains on the earth. This spring did not rise up from below the earth but out of the earth, for [Moses] said, the spring rose up not from below the earth but, out of the earth. The earth itself, which bears these waters in its womb, bears witness that these waters were not prior to the earth.

(3) The spring then rose up out of the earth, as Scripture says, and watered the whole face of the earth. Thus [the earth] produced trees, grasses, and plants. It was not that God was unable to bring forth everything from the earth in any other way. Rather, it was His will that [the earth] should bring forth by means of water. [God] began the creation [of the vegetation] this way right from the beginning so that this procedure would be perpetuated until the end of time.

4. After [Moses] spoke about those things that had been omitted and that had not been recounted on the first day, he turned to write about how Adam was fashioned saying, Adam was not there to

till the earth. Obviously, Adam did not exist in the days that preceded the sixth day, since he was created on the sixth day. Then, on the sixth day the Lord formed Adam from the dust of the earth and blew into his nostrils the breath of life; and Adam became a living being. Even though the beasts, the cattle, and the birds were equal [to Adam] in their ability to procreate and in that they had life, God still gave honor to Adam in many ways: first, in that it was said, God formed him with His own hands and breathed life into him; God then set him as ruler over Paradise and over all that is outside of Paradise; God clothed Adam in glory; and God gave him reason and thought so that he might perceive the majesty [of God].

5. After Moses spoke of how Adam was so gloriously fashioned, he turned to write about Paradise and Adam's entry therein saying, The Lord had previously planted Paradise in Eden and there He Placed Adam whom He had fashioned.

(2) Eden is the land of Paradise and [Moses] said previously because God had [already] planted it on the third day. He explains this by saying, the Lord caused every tree that is pleasant to the sight and good for food to sprout forth from the earth. And to show that he was talking about Paradise, [Moses] said, and the tree of life was in the midst of Paradise, and the tree of the knowledge of good and evil.

7. After [Moses] spoke about Paradise and the rivers that were divided outside of it, he turned to speak about Adam's entry into Paradise and about the law that was laid down for him saying, The Lord God took Adam and put him in the Paradise of Eden to till it and to guard it.

(2) But with what did Adam till the garden since he had no tools for tilling? How could he have tilled it since he was not capable of tilling it by himself? What did he have to till since there were no thorns or briars there? Moreover, how could he have guarded it as he could not possibly encompass it? And from what did he guard it since there were no thieves to enter it? Indeed, the fence that was erected after the transgression of the commandment bears witness that as long as Adam kept the commandment, no guard was required.

(3) Adam had nothing to guard then except the law that had been set down for him. Nor was any other "tilling" entrusted to him except to fulfill the commandment that had been commanded him. But if [someone were to say that Adam] had or would have these two things [to perform] along with the commandment, I would not oppose this [interpretation].

8. After he spoke about Adam's entry into Paradise and why he had been put there, [Moses] turned to write about the law that was set down for him, saying, and the Lord God commanded Adam, saying, "You may eat of every tree that is in Paradise; out of the tree of the knowledge of good and evil you shall not eat, for on the day that you eat of it you shall surely die."

(2) This commandment was an easy one, for God gave to Adam all of Paradise and withheld from him only one tree. If a single tree were sufficient to provide nourishment for someone and many were withheld, [that single tree] would offer relief from the torment [of hunger] by providing nourishment for one's hunger. But if God gave Adam many trees instead of a single one which would have been sufficient for him, any transgression would be due not to any constraint but to disdain.

(3) [God] withheld from Adam a single tree and set death around it, so that if Adam would not keep the law out of love for the One who had set down the law, then at least the fear of death that was set around the tree would frighten him away from overstepping the law.

9. After he spoke about Adam's entry into Paradise and about the law that had been set down for him, Moses turned to write about the names that [Adam] gave to the animals saying, the Lord

formed out of the ground every beast of the field and every bird of the sky and brought them to Adam to see what he would call them.

(2) They were not really formed, for the earth brought forth the animals and the water the birds. When he said, "He formed," [Moses] wished to make known that every animal, reptile, beast, and bird comes into being from the conjunction of earth and water.

(3) That [Moses] said, He brought them to Adam, is so that God might make known the wisdom of Adam and the harmony that existed between the animals and Adam before he transgressed the commandment. The animals came to Adam as to a loving shepherd. Without fear they passed before him in orderly fashion, by kinds and by species. They were neither afraid of him nor were they afraid of each other. A species of predatory animals would pass by with a species of animal that is preyed upon following safely right behind.

10. Adam thus began his rule over the earth when he became lord over all on that day according to the blessing he was given. The word of the Creator came to pass in actuality and His blessing was indeed fulfilled on the same day that he was made ruler over everything, even though he would soon rebel against the Lord of everything. For God gave Adam not only rule over everything, which had been promised to him, but He also allowed him to bestow names [on the animals], which had not been promised to him. If then God did for Adam even more than he had expected, how could God have deprived Adam of these things unless Adam had sinned?

(2) For someone to give a few names to be remembered is not a great thing, but it is too large and too great a thing for any human being to bestow thousands of names in a single moment, without repeating any. It is possible for someone to bestow many names on many kinds of insects, animals, beasts, and birds, but never to name one kind by the name of another belongs either to God or to someone to whom it has been granted by God.

(3) If God did indeed give Adam ruling authority, make him a participant in creation, clothe him with glory, and give him a garden, what else should God have done that Adam heed the commandment but did not do?

11. After he spoke of the formation of the animals and of the names they received, [Moses] turned to write of Adam's sleep and of the rib that was taken from him and made into a woman, saying, But for Adam there was not found a helper like him. Moses called Eve helper because even though Adam had helpers among the beasts and animals he still required one like him of his own kind. Inside, Eve was very diligent; she was also attentive to the sheep and cattle, the herds, and droves which were in the fields. She would also help Adam with the buildings, pens, and with any other task that Adam was capable of doing. The animals, even though they were subservient, were not able to help him with these things. For this reason God made for Adam a helper who would be solicitous for everything for which he was [solicitous] and who would indeed help him in many things.

12. And the Lord cast sleep upon Adam and he slept. God took one of his ribs and closed up its place with flesh. And the Lord fashioned the rib which He had taken from Adam into a woman and brought her to Adam. That man, awake, anointed with splendor, and who did not yet know sleep, fell on the earth naked and slept. It is likely that Adam saw in his dream what was done to him as if he were awake. After Adam's rib had been taken out in the twinkling of an eye, God closed up the flesh in its place in the blink of an eyelash. After the extracted rib had been fashioned with all sorts of beautiful things to adorn it, God then brought her to Adam, who was both one and two. He was one in that he was Adam and he was two because he had been created male and female.

13. After he spoke of Adam's sleep, of the rib that had been taken out, and of the woman who had been fashioned from it and brought to [Adam], [Moses] wrote that Adam said, "This time she is bone of my bones and flesh of my flesh. This one shall be called woman because she was taken out of man. "

(2) This time — that is, this one who came after the animals was not like them for they were from the earth, but this one is bone of my bones and flesh of my flesh. Adam said this either as a prophecy or because he had seen it and knew it from the vision in his dream, as we just said above.

(3) Just as each animal had received from Adam the name of its species on that day, Adam did not call the rib that was fashioned [into the woman] Eve, by her own name but named her woman, the name that was set down for all her kind. Then [Adam] said, Let the man leave his father and his mother and cling to his wife so that they might be joined and the two might become one without division as they were from the beginning.

14. After these things Moses said, The two of them were naked and were not ashamed. That they were not ashamed does not mean that they did not know what shame was. If they were children, as [the pagans] say, [Moses] would neither have said, They were naked and were not ashamed, nor, Adam and his wife, if they had not been young adults. The names that Adam bestowed should be sufficient to convince us of [the level of] his wisdom. And the fact that [Moses] said, he will till it and keep it, should make known to us Adam's strength. The law that was set for them testifies to their full maturity and their transgression of the commandment should bear witness to their arrogance.

(2) It was because of the glory with which they were clothed that they were not ashamed. It was when this glory was stripped from them after they had transgressed the commandment that they were ashamed because they were naked. The two of them then hastened to cover themselves with leaves — not their entire bodies but only their shameful members.

Cyril of Jerusalem (ca. 313AD – 386AD)
Catechetical Lectures

Lecture II — On Repentance and Remission of Sins, and Concerning the Adversary
1. A fearful things is sin, and the sorest disease of the soul is transgression, secretly cutting its sinews, and becoming also the cause of eternal fire; an evil of a man's own choosing, and offspring of the will. For that we sin of our own free will the Prophet says plainly in a certain place: Yet I planted thee a fruitful vine, wholly true: how art thou turned to bitterness, (and become) the strange vine? (Jer 2:21) The planting was good, the fruit coming from the will is evil; and therefore the planter is blameless, but the vine shall be burnt with fire; since it was planted for good, and bore fruit unto evil of its own will. For God, according to the Preacher, made man upright, and they have themselves sought out many inventions. (Ecc 7:29) For we are His workmanship, says the Apostle, created unto good works, which God afore prepared, that we should walk in them. (Eph 2:10) So then the Creator, being good, created for good works; but the creature turned of its own free will to wickedness. Sin then is, as we have said, a fearful evil, but not incurable; fearful for him who clings to it, but easy of cure for him who by repentance puts it from him. For suppose that a man is holding fire in his hand; as long as he holds fast the live coal he is sure to be burned, but should he put away the coal, he would have cast away the flame also with it. If however anyone thinks that he is not being burned when sinning, to him the Scripture saith, Shall a man wrap up fire in his bosom, and not burn his clothes? (Prov 6:27) For sin burns the sinews of the soul, and breaks the spiritual bones of the mind, and darkens the light of the heart.

Lecture IV — On the Ten Points of Doctrine
4....There is then One Only God, the Maker both of souls and bodies: One the creator of heaven and earth, the Maker of Angels and Archangels: of many the Creator, but of One only the Father before all ages — of One only, His Only-begotten Son, our Lord Jesus Christ, by Whom He made all things visible and invisible. (John 1:3)

5. This Father of our Lord Jesus Christ is not circumscribed in any place, nor is He less than the heaven; but the heavens are the works of His fingers (Ps 8:3), and the whole earth is held in His grasp (Is 11:12): He is in all things and around all. Think not that the sun is brighter than He, or equal to Him: for He who at first formed the sun must needs be incomparably greater and brighter. He foreknoweth the things that shall be, and is mightier than all, knowing all things and doing as He will; not being subject to any necessary sequence of events, nor to nativity, nor chance, nor fate; in all things perfect, and equally possessing every absolute form of virtue, neither diminishing nor increasing, but in mode and conditions ever the same; who hath prepared punishment for sinners, and a crown for the righteous.

6. Seeing then that many have gone stray in divers ways from the One God, some having deified the sun, that when the sun sets they may abide in the night season without God; others the moon, to have no God by day; others the other parts of the world; others the arts; others their various kinds of food; others their pleasures; while some, made after women, have set up on high an image of a naked woman, and called it Aphrodite, and worshipped their own lust in a visible form; and others dazzled by the brightness of gold have deified it and the other kinds of matter — whereas if one lay as a first foundation in his heart the doctrine of the unity of God, and trust to Him, he roots out at once the whole crop of the evils of idolatry and of the error of the heretics: lay though, therefore, this first doctrine of religion as a foundation in thy soul by faith.

Lecture VI
9. One He is, everywhere present, beholding all things, perceiving all things, creating all things through Christ: For all things were made by Him, and without Him was not anything made (John 1:3)...

Lecture IX — On the Words, Maker of Heaven and Earth, and of All Things Visible and Invisible
Job XXXVIII. 2-3, "Who is this that hideth counsel from Me, and keepeth words in his heart, and thinketh to hide them from Me?"

1. To look upon God with eyes of flesh is impossible: for the incorporeal cannot be subject to bodily sight: and the Only begotten Son of God Himself hath testified, saying, No man hath seen God at any time. For if according to that which is written in Ezekiel any one should understand that Ezekiel saw Him, yet what saith the Scripture? He saw the likeness of the glory of the Lord; not the Lord Himself, but the likeness of His glory, not the glory itself, as it really is. And when he saw merely the likeness of the glory, and not the glory itself, he fell to the earth from fear. Now if the sight of the likeness of the glory brought fear and distress upon the prophets, any one who should attempt to behold God Himself would to a certainty lose his life, according to the saying, No man shall see My face and live. For this cause God of His great loving-kindness spread out the heaven as a veil of His proper Godhead, that we should not perish. The word is not mine, but the Prophet's. If Thou shalt rend the heavens, trembling will take hold of the mountains at sight of Thee, and they will flow down. And why dost thou wonder that Ezekiel fell down on seeing the likeness of the glory? when Daniel at the sight of Gabriel, though but a servant of God, straightway shuddered and fell on his face, and, prophet as he was, dared not answer him, until the Angel transformed himself into the likeness of a son of man. Now if the appearing of Gabriel wrought trembling in the Prophets, had God Himself been seen as He is, would not all have perished?

2. The Divine Nature then it is impossible to see with eyes of flesh: but from the works, which are Divine, it is possible to attain to some conception of His power, according to Solomon, who says, For by the greatness and beauty of the creatures proportionably the Maker of them is seen. He said not that from the creatures the Maker is seen, but added proportionably. For God appears the greater to every man in proportion as he has grasped a larger survey of the creatures: and when his heart is uplifted by that larger survey, he gains withal a greater conception of God.

4. These things I say to you because of the following context of the Creed, and because we say, We Believe in One God, the Father Almighty, Maker of Heaven and Earth, and of All Things Visible and Invisible; in order that we may remember that the Father of our Lord Jesus Christ is the same as He that made the heaven and the earth, and that we may make ourselves safe against the wrong paths of the godless heretics, who have dared to speak evil of the All-wise Artificer of all this world, men who see with eyes of flesh, but have the eyes of their understanding blinded.

5. For what fault have they to find with the vast creation of God? — they, who ought to have been struck with amazement on beholding the vaultings of the heavens: they, who ought to have worshipped Him who reared the sky as a dome, who out of the fluid nature of the waters formed the stable substance of the heaven. For God said, Let there be a firmament in the midst of the water. God spake once for all, and it stands fast, and falls not. The heaven is water, and the orbs therein, sun, moon, and stars are of fire: and how do the orbs of fire run their course in the water? But if any one disputes this because of the opposite natures of fire and water, let him remember the fire which in the time of Moses in Egypt flamed amid the hail, and observe the all-wise workmanship of God. For since there was need of water, because the earth was to be tilled, He made the heaven above of water that when the region of the earth should need watering by showers, the heaven might from its nature be ready for this purpose.

6. But what? Is there not cause to wonder when one looks at the constitution of the sun? For being to the sight as it were a small body he contains a mighty power; appearing from the East, and sending forth his light unto the West: whose rising at dawn the Psalmist described, saying: And he cometh forth out of his chamber as a bridegroom. He was describing the brightness and moderation of his state on first becoming visible unto men: for when he rides at high noon, we often flee from his blaze: but at his rising he is welcome to all as a bridegroom to look on.

Observe also his arrangement (or rather not his, but the arrangement of Him who by an ordinance determined his course), how in summer he rises higher and makes the days longer, giving men good time for their works: but in winter contracts his course, that the period of cold may be increased, and that the nights becoming longer may contribute to men's rest, and contribute also to the fruitfulness of the products of the earth. See also how the days alternately respond each to other in due order, in summer increasing, and in winter diminishing; but in spring and autumn granting equal intervals one to another. And the nights again complete the like courses; so that the Psalmist also says of them, Day unto day uttereth speech, and night unto night proclaimeth knowledge. For to the heretics who have no ears, they all but cry aloud, and by their good order say, that there is none other God save the Creator who hath set them their bounds, and laid out the order of the Universe.

10. What should have been the effect of these wonders? Should the Creator have been blasphemed? Or worshipped rather? And so far I have said noticing of the unseen works of His wisdom. Observe, I pray you, the spring, and the flowers of every kind in all their likeness still diverse one from another; the deepest crimson of the rose, and the purest whiteness of the lily: for these spring from the same rain and the same earth, and who makes them to differ? Who fashions them? Observe, pray, the exact care: from the one substance of the tree there is part for shelter, and part for diverse fruits: and the Artificer is One.

Of the same vine part is for burning, and part for shoots, and part for leaves, and part for tendrils, and part for clusters.

Admire also the great thickness of the knots which run round the reed, as the Artificer hath made them. From one and the same earth come forth creeping things, and wild beasts, and cattle, and trees, and food; and gold, and silver, and brass, and iron, and stone. The nature of the waters is but one, yet from it comes the substance of fishes and of birds; whereby as the former swim in the waters, so the birds fly in the air.

11. This great and wide sea, therein are things creeping innumerable. Who can describe the beauty of the fishes that are therein? Who can describe the greatness of the whales, and the nature of its amphibious animals, how they live both on dry land and in the waters? Who can tell the depth and the breadth of the sea, or the force of its enormous waves? Yet it stays at its bounds, because of Him who said, Hitherto shalt thou come, and no further, but within thyself shall thy waves be broken. Which sea also clearly shews the word of the command imposed upon it, since after it has run up, it leaves upon the beach a visible line made by the waves, shewing, as it were, to those who see it, that it has not passed its appointed bounds.

13. Who among men knows even the names of all wild beasts? Or who can accurately discern the physiology of each? But if of the wild beasts we know not even the mere names, how shall we comprehend the Maker of them? God's command was but one, which said, Let the earth bring forth wild beasts, and cattle, and creeping things, after their kinds and from one earth, by one command, have sprung diverse natures, the gentle sheep and the carnivorous lion, and various instincts of irrational animals, bearing resemblance to the various characters of men; the fox to manifest the craft that is in men, and the snake the venomous treachery of friends, and the neighing horse the wantonness of young men, and the laborious ant, to arouse the sluggish and the dull...

14. Is not then the Artificer worthy the rather to be glorified? For what? If thou knowest not the nature of all things, do the things that have been made forthwith become useless? Canst thou know the efficacy of all herbs? Or canst thou learn all the benefit which proceeds from every animal? Ere now even from venomous adders have come antidotes for the preservation of men. But thou wilt say to me, "The snake is terrible." Fear thou the Lord, and it shall not be able to hurt thee. "A scorpion stings." Fear the Lord, and it shall not sting thee. "A lion is bloodthirsty." Fear thou the Lord, and he shall lie down beside thee, as by Daniel. But truly wonderful also is the action of the animals: how some, as the scorpion, have the sharpness in a sting; and others have their power in their teeth; and others do battle with their claws; while the basilisk's power is his gaze. So then from this varied workmanship understand the Creator's power.

15. But these things perhaps thou knowest not: thou wouldest have nothing in common with the creatures which are without thee. Enter now into thyself, and from thine own nature consider its Artificer. What is there to find fault with in the framing of thy body? Be master of thyself, and nothing evil shall proceed from any of thy members. Adam was at first without clothing in Paradise with Eve, but it was not because of his members that he deserved to be cast out. The members then are not the cause of sin, but they who use their members amiss; and the Maker thereof is wise. Who prepared the recesses of the womb for child-bearing? Who gave life to the lifeless thing within it? Who knitted us with sinews and bones, and clothed us with skin and flesh, and, as soon as the child was born, brought streams of milk out of the breasts? How grows the babe into a boy, and the boy into a youth, and then into a man; and, still the same, passes again into an old man, while no one notices the exact change from day to day? Of the food, how is one part changed into blood, and another separated for excretion, and another part changed into flesh? Who gives to the heart

its unceasing motion? Who wisely guarded the tenderness of the eyes with the fence of the eyelids? For as to the complicated and wonderful contrivance of the eyes, the voluminous books of the physicians hardly give us explanation. Who distributes the one breath to the whole body? Thou seest, O man, the Artificer, thou seest the wise Creator.

16. These points my discourse has now treated at large, having left out many, yea, ten thousand other things, and especially things incorporeal and invisible, that thou mayest abhor those who blaspheme the wise and good Artificer, and from what is spoken and read, and whatever thou canst thyself discover or conceive, from the greatness and beauty of the creatures mayest proportionably see the maker of them, and bending the knee with godly reverence to the Maker of the worlds, the worlds, I mean, of sense and thought, both visible and invisible, thou mayest with a grateful and holy tongue, with unwearied lips and heart, praise God and say, How wonderful are Thy works, O Lord; in wisdom hast Thou made them all. For to Thee belongeth honour, and glory, and majesty, both now and throughout all ages. Amen.

Lecture XI — On the Words, the Only-Begotten Son of God, Begotten of the Father Very God Before All Ages, by Whom All Things Were Made

21. We believe then "In one Lord Jesus Christ, the Only-begotten Son of God, begotten of His Father very God before all worlds, by whom all things were made." For whether they be thrones, or dominions, or principalities, or powers, all things were made through Him (Col 1:16), and of things created none is exempted from His authority. Silenced be every heresy which brings in different creators and makers of the world; silenced the tongue which blasphemes the Christ the Son of God; let them be silenced who say that the sun is the Christ, for He is the sun's Creator, not the sun which we see. Silenced be they who say that the world is the workmanship of Angels, who wish to steal away the dignity of the Only-begotten. For whether visible or invisible, whether thrones or dominions, or anything that is named, all things were made by Christ. He reigns over the things which have been made by Him, not having seized another's spoils, but reigning over His own workmanship, even as the Evangelist John has said, All things were made by Him, and without Him was not anything made. All things were made by Him, the Father working by the Son.

22....For, as I have said, Angels did not create the world, but the Only-begotten Son, begotten, as I have said, before all ages, By whom all things were made, nothing having been excepted from His creation. And let this suffice to have been spoken by us so far, by the grace of Christ.

23. But let us now recur to our profession of the Faith, and so for the present finish our discourse. Christ made all things... Not that the Father wanted strength to created the works Himself, but because He willed that the Son should reign over His own workmanship, God Himself giving Him the design of the the things to be made...

24. Christ then is the Only-begotten Son of God, and Maker of the world. For He was in the world, and the world was made by Him (John 1:10).. .And not only of the things which are seen but also of the things which are not seen, is Christ the Maker at the Father's bidding...

Lecture XII — On the words Incarnate, and Made Man

29. These are excellent suggestions of the narratives: but the Jews still contradict, and do not yield to the statements concerning the rod, unless they may be persuaded by similar strange and supernatural births. Question them, therefore, in this way: of whom in the beginning was Eve begotten? What mother conceived her the motherless? But the Scripture saith that she was born out of Adam's side. Is Eve then born out of a man's side without a mother, and is a child not to be born without a father, of a virgin's womb? This debt of gratitude was due to men from womankind: for Eve was begotten of Adam, and not conceived of a mother, but as it were brought forth of man alone. Mary, therefore, paid the debt, of gratitude, when not by man but of herself alone in an

immaculate way shy conceived of the Holy Ghost by the power of God.

30. But let us take what is yet a greater wonder than this. For that of bodies bodies should be conceived, even if wonderful, is nevertheless possible: but that the dust of the earth should become a man, this is more wonderful. That clay moulded together should assume the coats and splendours of the eyes, this is more wonderful. That out of dust of uniform appearance should be produced both the firmness of bones, and the softness of lungs, and other different kinds of members, this is wonderful. That clay should be animated and travel round the world self moved, and should build houses, this is wonderful. That clay should teach, and talk, and act as carpenter, and as king, this is wonderful. Whence, then, O ye most ignorant Jews, was Adam made? Did not God take dust from the earth, and fashion this wonderful frame? Is then clay changed into an eye, and cannot a virgin bear a son. Does that which for men is more impossible take place, and is that which is possible never to occur?

Gregory Nazianzen (c. 329AD – 389AD)
Orations

Oration XXVIII — The Second Theological Oration
VI. Now our very eyes and the Law of Nature teach us that God exists and that He is the Efficient and Maintaining Cause of all things: our eyes, because they fall on visible objects and see them in beautiful stability and progress, immovably moving and revolving if I may so say; natural Law, because through these visible things and their order, it reasons back to their Author. For how could this Universe have come into being or been put together, unless God had called it into existence and held it together? For every one who sees a beautifully made lute, and considers the skill with which it has been fitted together and arranged, or who hears its melody, would think of none but the lute-maker, or the lute-player, and would recur to him in mind, though he might not know him by sight. And thus to us also is manifested That which made and moves and preserves all created things, even though He be not comprehended by the mind. And very wanting in sense is he who will not willingly go thus far in following natural proofs...

XVI....But reason receiving us in our desire for God, and in our sense of the impossibility of being without a leader and guide, and then making us apply ourselves to things visible and meeting with the things which have been since the beginning, doth not stay its course even here. For it was not the part of Wisdom to grant the sovereignty to things which are, as observation tells us, of equal rank. But these then it leads to that which is above these, and by which being is given to these. For what is it which ordered things in heaven and things in earth, and those which pass through air, and those which live in water; or other things which were before these, heaven and earth, air and water? Who mingled these, and who distributed them? What is it that each has in common with the other, and their mutual dependence and agreement? For I commend the man, though he was a heathen, who said, What gave movement to these, and drives their ceaseless and unhindered motion? Is it not the Artificer of them Who implanted reason in them all, in accordance with which the Universe is moved and controlled? Is it not He who made them and brought them into being? For we cannot attribute such a power to the Accidental. For, suppose that its existence is accidental, to what will you let us ascribe its order? And if you like we will grant you this: to what then will you ascribe its preservation and protection in accordance with the terms of its first creation. Do these belong to the Accidental, or to something else? Surely not to the Accidental. And what can this Something Else be but God? Thus reason that proceeds from God, that is implanted in all from the beginning and is the first law in us, and is bound up in all, leads us up to God through visible things. Let us begin again, and reason this out.

XXII....How is it that species are permanent, and are different in their characteristics, although

there are so many that their individual marks cannot be described?...

XXVI....How is it that the earth stands solid and unswerving? On what is it supported? What is it that props it up, and on what does that rest? For indeed even reason has nothing to lean upon, but only the Will of God... Is this not the clearest proof of the majestic working of God?

Oration XXIX — The Third Theological Oration; On the Son
XI. They do not however assert this, for these qualities are common also to other beings. But God's Essence is that which belongs to God alone, and is proper to Him. But they, who consider matter and form to be unbegotten, would not allow that to be unbegotten is the property of God alone (for we must cast away even further the darkness of the Manichaeans. But suppose that it is the property of God alone. What of Adam? Was he not alone the direct creature of God? Yes, you will say. Was he then the only human being? By no means. And why, but because humanity does not consist in direct creation? For that which is begotten is also human. Just so neither is He Who is Unbegotten alone God, though He alone is Father. But grant that He Who is Begotten is God; for He is of God, as you must allow, even though you cling to your Unbegotten. Then how do you describe the Essence of God? Not by declaring what it is, but by rejecting what it is not. For your word signifies that He is not begotten; it does not present to you what is the real nature or condition of that which has no generation.

What then is the Essence of God? It is for your infatuation to define this, since you are so anxious about His Generation too; but to us it will be a very great thing, if ever, even in the future, we learn this, when this darkness and dullness is done away for us, as He has promised Who cannot lie. This then may be the thought and hope of those who are purifying themselves with a view to this. Thus much we for our part will be bold to say, that if it is a great thing for the Father to be Unoriginate, it is no less a thing for the Son to have been Begotten of such a Father. For not only would He share the glory of the Unoriginate, since he is of the Unoriginate, but he has the added glory of His Generation, a thing so great and august in the eyes of all those who are not altogether grovelling and material in mind.

Oration XXXVIII — On Theophany, or Birthday of Christ
IX. But since this movement of self-contemplation alone could not satisfy Goodness, but Good must be poured out and go forth beyond Itself to multiply the objects of Its beneficence, for this was essential to the highest Goodness, He first conceived the Heavenly and Angelic Powers. And this conception was a work fulfilled by His Word, and perfected by His Spirit. And so the secondary Splendours came into being, as the Minsters of the Primary Splendour; whether we are to conceive of them as intelligent Spirits, or as fire of an immaterial and incorruptible kind, or as some other nature approaching this as near as may be...

X. Thus, then, and for these reasons, He gave being to the world of thought, as far as I can reason upon these matters, and estimate great things in my own poor language. Then when His first creation was in good order, He conceives a second world, material and visible; and this a system and compound of earth and sky, and all that is in the midst of them — an admirable creation indeed, when we look at the fair form of every part, but yet more worthy of admiration when we consider the harmony and the unison of the whole, and how each part fits in with every other, in fair order, and all with the whole, tending to the perfect completion of the world as a Unit. This was to shew that He could call into being, not only a Nature akin to Himself, but also one altogether alien to Himself. For akin to Deity are those natures which are intellectual, and only to be comprehended by mind; but all of which sense can take cognisance are utterly alien to It; and of these the furthest removed are all those which are entirely destitute of soul and of power of motion. But perhaps some one of those who are too festive and impetuous may say, What has all this to do with us? Spur your horse to the goal. Talk to us about the Festival, and the reasons for

our being here today. Yes, this is what I am about to do, although I have begun at a somewhat previous point, being compelled to do so by love, and by the needs of my argument.

XI. Mind, then, and sense, thus distinguished from each other, had remained within their own boundaries, and bore in themselves the magnificence of the Creator-Word, silent praisers and thrilling heralds of His mighty work. Not yet was there any mingling of both, nor any mixtures of these opposites, tokens of a greater Wisdom and Generosity in the creation of natures; nor as yet were the whole riches of Goodness made known. Now the Creator-Word, determining to exhibit this, and to produce a single living being out of both — the visible and the invisible creations, I mean — fashions Man; and taking a body from already existing matter, and placing in it a Breath taken from Himself which the Word knew to be an intelligent soul and the Image of God, as a sort of second world. He placed him, great in littleness on the earth; a new Angel, a mingled worshipper, fully initiated into the visible creation, but only partially into the intellectual; King of all upon earth, but subject to the King above; earthly and heavenly; temporal and yet immortal; visible and yet intellectual; half-way between greatness and lowliness; in one person combining spirit and flesh; spirit, because of the favour bestowed on him; flesh, because of the height to which he had been raised; the one that he might continue to live and praise his Benefactor, the other that he might suffer, and by suffering be put in remembrance, and corrected if he became proud of his greatness. A living creature trained here, and then moved elsewhere; and, to complete the mystery, deified by its inclination to God. For to this, I think, tends that Light of Truth which we here possess but in measure, that we should both see and experience the Splendour of God, which is worthy of Him Who made us, and will remake us again after a loftier fashion.

XII. This being He placed in Paradise, whatever the Paradise may have been, having honoured him with the gift of Free Will (in order that God might belong to him as the result of his choice, no less than to Him who had implanted the seeds of it), to till the immortal plants, by which is meant perhaps the Divine Conceptions, both the simpler and the more perfect; naked in his simplicity and inartificial life, and without any covering or screen; for it was fitting that he who was from the beginning should be such. Also He gave him a Law, as a material for his Free Will to act upon. This Law was a Commandment as to what plants he might partake of, and which one he might not touch. This latter was the Tree of Knowledge; not, however, because it was evil from the beginning when planted; nor was it forbidden because God grudged it to us. ..Let not the enemies of God wag their tongues in that direction, or imitate the Serpent...But it would have been good if partaken of at the proper time, for the tree was, according to my theory, Contemplation, upon which it is only safe for those who have reached maturity of habit to enter; but which is not good for those who are still somewhat simple and greedy in their habit; just as solid food is not good for those who are yet tender, and have need of milk. But when through the Devil's malice and the woman's caprice, to which she succumbed as the more tender, and which she brought to bear upon the man, as she was the more apt to persuade, alas for my weakness! (for that of my first father was mine), he forgot the Commandment which had been given to him; he yielded to the baleful fruit; and for his sin he was banished, at once from the Tree of Life, and from Paradise, and from God; and put on the coats of skins. ..that is, perhaps, the coarser flesh, both mortal and contradictory. This was the first thing that he learnt — his own shame; and he hid himself from God. Yet here too he makes a gain, namely death, and the cutting off of sin, in order that evil may not be immortal. Thus his punishment is changed into a mercy; for it is in mercy, I am persuaded, that God inflicts punishment.

Oration XXXIX — On the Holy Lights

XII. For to us there is but One God, the Father, of Whom are all things, and One Lord Jesus Christ, by Whom are all things; and One Holy Ghost, in Whom are all things; yet these words, of, by, in, whom, do not denote a difference of nature (for if this were the case, the three prepositions, or the order of the three names would never be altered), but they characterize the personalities of a

nature which is one and unconfused. And this is proved by the fact that They are again collected into one, if you will read — not carelessly — this other passage of the same Apostle, "Of Him and through Him and to Him are all things; to Him be glory forever, Amen." The Father is Father, and is Unoriginate, for He is of no one; the Son is Son, and is not un-originate, for He is of the Father. But if you take the word Origin in a temporal sense, He too is Unoriginate, for He is the Maker of Time, and is not subject to Time. The Holy Ghost is truly Spirit, coming forth from the Father indeed, but not after the manner of the Son, for it is not by Generation but by Procession (since I must coin a word for the sake of clearness); for neither did the Father cease to be Un-begotten because of His begetting something, nor the Son to be begotten because He is of the Unbegotten (how could that be?), nor is the Spirit changed into Father or Son because He proceeds, or because He is God — though the ungodly do not believe it. For Personality is unchangeable; else how could Personality remain, if it were changeable, and could be removed from one to another? But they who make "Unbegotten" and "Begotten" natures of equivocal gods would perhaps make Adam and Seth differ in nature, since the former was not born of flesh (for he was created), but the latter was born of Adam and Eve. There is then One God in Three, and These Three are One, as we have said.

Basil of Caesarea or Saint Basil the Great,(330AD – 379AD)
Hexcemeron

Homily I — In the Beginning God Made the Heaven and the Earth
1. It is right that any one beginning to narrate the formation of the world should begin with the good order which reigns in visible things. I am about to speak of the creation of heaven and earth, which was not spontaneous, as some have imagined, but drew its origin from God. What ear is worthy to hear such a tale? How earnestly the soul should prepare itself to receive such high lessons! How pure it should be from carnal affections, how unclouded by worldly disquietudes, how active and ardent in its researches, how eager to find in its surroundings an idea of God which may be worthy of Him!...

2. "In the beginning God created the heaven and the earth." I stop struck with admiration at this thought. What shall I first say? Where shall I begin my story? Shall I show forth the vanity of the Gentiles? Shall I exalt the truth of our faith? The philosophers of Greece have made much ado to explain nature, and not one of their systems has remained firm and unshaken, each being overturned by its successor. It is vain to refute them; they are sufficient in themselves to destroy one another. Those who were too ignorant to rise to a knowledge of a God, could not allow that an intelligent cause presided at the birth of the Universe; a primary error that involved them in sad consequences.

Some had recourse to material principles and attributed the origin of the Universe to the elements of the world. Others imagined that atoms, and indivisible bodies, molecules and ducts, form, by their union, the nature of the visible world. Atoms reuniting or separating, produce births and deaths and the most durable bodies only owe their consistency to the strength of their mutual adhesion: a true spider's web woven by these writers who give to heaven, to earth, and to sea so weak an origin and so little consistency! It is because they knew not how to say "In the beginning God created the heaven and the earth." Deceived by their inherent atheism it appeared to them that nothing governed or ruled the universe, and that was all was given up to chance.

To guard us against this error the writer on the creation, from the very first words, enlightens our understanding with the name of God; "In the beginning God created." What a glorious order! He first establishes a beginning, so that it might not be supposed that the world never had a beginning. Then be adds "Created" to show that which was made was a very small part of the power of the Creator. In the same way that the potter, after having made with equal pains a great number of

vessels, has not exhausted either his art or his talent; thus the Maker of the Universe, whose creative power, far from being bounded by one world, could extend to the infinite, needed only the impulse of His will to bring the immensities of the visible world into being. If then the world has a beginning, and if it has been created, enquire who gave it this beginning, and who was the Creator: or rather, in the fear that human reasonings may make you wander from the truth, Moses has anticipated enquiry by engraving in our hearts, as a seal and a safeguard, the awful name of God: "In the beginning God created" — It is He, beneficent Nature, Goodness without measure, a worthy object of love for all beings endowed with reason, the beauty the most to be desired, the origin of all that exists, the source of life, intellectual light, impenetrable wisdom, it is He who "in the beginning created heaven and earth."

3. Do not then imagine, O man! that the visible world is without a beginning; and because the celestial bodies move in a circular course, and it is difficult for our senses to define the point where the circle begins, do not believe that bodies impelled by a circular movement are, from their nature, without a beginning. Without doubt the circle (I mean the plane figure described by a single line) is beyond our perception, and it is impossible for us to find out where it begins or where it ends; but we ought not on this account to believe it to be without a beginning. Although we are not sensible of it, it really begins at some point where the draughtsman has begun to draw it at a certain radius from the centre. Thus seeing that figures which move in a circle always return upon themselves, without for a single instant interrupting the regularity of their course, do not vainly imagine to yourselves that the world has neither beginning nor end. "For the fashion of this world passeth away" and "Heaven and earth shall pass away."

The dogmas of the end, and of the renewing of the world, are announced beforehand in these short words put at the head of the inspired history. "In the beginning God made." That which was begun in time is condemned to come to an end in time. If there has been a beginning do not doubt of the end. Of what use then are geometry — the calculations of arithmetic — the study of solids and far-famed astronomy, this laborious vanity, if those who pursue them imagine that this visible world is co-eternal with the Creator of all things, with God Himself; if they attribute to this limited world, which has a material body, the same glory as to the incomprehensible and invisible nature; if they cannot conceive that a whole, of which the parts are subject to corruption and change, must of necessity end by itself submitting to the fate of its parts? But they have become "vain in their imaginations and their foolish heart was darkened. Professing themselves to be wise, they became fools." Some have affirmed that heaven co-exists with God from all eternity; others that it is God Himself without beginning or end, and the cause of the particular arrangement of all things.

4. One day, doubtless, their terrible condemnation will be the greater for all this worldly wisdom, since, seeing so clearly into vain sciences, they have wilfully shut their eyes to the knowledge of the truth. These men who measure the distances of the stars and describe them, both those of the North, always shining brilliantly in our view, and those of the southern pole visible to the inhabitants of the South, but unknown to us; who divide the Northern zone and the circle of the Zodiac into an infinity of parts, who observe with exactitude the course of the stars, their fixed places, their declensions, their return and the time that each takes to make its revolution; these men, I say, have discovered all except one thing: the fact that God is the Creator of the universe, and the just Judge who rewards all the actions of life according to their merit. They have not known how to raise themselves to the idea of the consummation of all things, the consequence of the doctrine of judgment, and to see that the world must change if souls pass from this life to a new life. In reality, as the nature of the present life presents an affinity to this world, so in the future life our souls will enjoy a lot conformable to their new condition. But they are so far from applying these truths, that they do but laugh when we announce to them the end of all things and the regeneration of the age. Since the beginning naturally precedes that which is derived from it, the writer, of necessity, when speaking to us of things which had their origin in time, puts at the

head of his narrative these words — "In the beginning God created."

5. It appears, indeed, that even before this world an order of things existed of which our mind can form an idea, but of which we can say nothing, because it is too lofty a subject for men who are but beginners and are still babes in knowledge. The birth of the world was preceded by a condition of things suitable for the exercise of supernatural powers, outstripping the limits of time, eternal and infinite. The Creator and Demiurge of the universe perfected His works in it, spiritual light for the happiness of all who love the Lord, intellectual and invisible natures, all the orderly arrangement of pure intelligences who are beyond the reach of our mind and of whom we cannot even discover the names. They fill the essence of this invisible world, as Paul teaches us. "For by him were all things created that are in heaven, and that are in earth, visible and invisible whether they be thrones or dominions or principalities or powers" or virtues or hosts of angels or the dignities of archangels.

To this world at last it was necessary to add a new world, both a school and training place where the souls of men should be taught and a home for beings destined to be born and to die. Thus was created, of a nature analogous to that of this world and the animals and plants which live thereon, the succession of time, for ever pressing on and passing away and never stopping in its course. Is not this the nature of time, where the past is no more, the future does not exist, and the present escapes before being recognised? And such also is the nature of the creature which lives in time — condemned to grow or to perish without rest and without certain stability. It is therefore fit that the bodies of animals and plants, obliged to follow a sort of current, and carried away by the motion which leads them to birth or to death, should live in the midst of surroundings whose nature is in accord with beings subject to change. Thus the writer who wisely tells us of the birth of the Universe does not fail to put these words at the head of the narrative. "In the beginning God created;" that is to say, in the beginning of time. Therefore, if he makes the world appear in the beginning, it is not a proof that its birth has preceded that of all other things that were made. He only wishes to tell us that, after the invisible and intellectual world, the visible world, the world of the senses, began to exist...

6. Such being the different senses of the word beginning, see if we have not all the meanings here. You may know the epoch when the formation of this world began, if, ascending into the past, you endeavour to discover the first day. You will thus find what was the first movement of time; then that the creation of the heavens and of the earth were like the foundation and the groundwork, and afterwards that an intelligent reason, as the word beginning indicates, presided in the order of visible things. You will finally discover that the world was not conceived by chance and without reason, but for an useful end and for the great advantage of all beings, since it is really the school where reasonable souls exercise themselves, the training ground where they learn to know God; since by the sight of visible and sensible things the mind is led, as by a hand, to the contemplation of invisible things. "For," as the Apostle says, "the invisible things of him from the creation of the world are clearly seen, being understood by the things that are made." Perhaps these words "In the beginning God created" signify the rapid and imperceptible moment of creation.

The beginning, in effect, is indivisible and instantaneous. The beginning of the road is not yet the road, and that of the house is not yet the house; so the beginning of time is not yet time and not even the least particle of it. If some objector tell us that the beginning is a time, he ought then, as he knows well, to submit it to the division of time — a beginning, a middle and an end. Now it is ridiculous to imagine a beginning of a beginning. Further, if we divide the beginning into two, we make two instead of one, or rather make several, we really make an infinity, for all that which is divided is divisible to the infinite. Thus then, if it is said, "In the beginning God created," it is to teach us that at the will of God the world arose in less than an instant, and it is to convey this meaning more clearly that other interpreters have said: "God made summarily" that is to say all at

once and in a moment. But enough concerning the beginning, if only to put a few points out of many.

7. Among arts, some have in view production, some practice, others theory. The object of the last is the exercise of thought, that of the second, the motion of the body. Should it cease, all stops; nothing more is to be seen. Thus dancing and music have nothing behind; they have no object but themselves. In creative arts on the contrary the work lasts after the operation. Such is architecture — such are the arts which work in wood and brass and weaving, all those indeed which, even when the artisan has disappeared, serve to show an industrious intelligence and to cause the architect, the worker in brass or the weaver, to be admired on account of his work. Thus, then, to show that the world is a work of art displayed for the beholding of all people; to make them know Him who created it, Moses does not use another word. "In the beginning," he says "God created." He does not say "God worked," "God formed," but" God created."

Among those who have imagined that the world co-existed with God from all eternity, many have denied that it was created by God, but say that it exists spontaneously, as the shadow of this power. God, they say, is the cause of it, but an involuntary cause, as the body is the cause of the shadow and the flame is the cause of the brightness. It is to correct this error that the prophet states, with so much precision, "In the beginning God created." He did not make the thing itself the cause of its existence. Being good, He made it a useful work. Being wise, He made it everything that was most beautiful. Being powerful He made it very great. Moses almost shows us the finger of the supreme artisan taking possession of the substance of the universe, forming the different parts in one perfect accord, and making a harmonious symphony result from the whole...

8. "In the beginning God created the heaven and the earth." If we were to wish to discover the essence of each of the beings which are offered for our contemplation, or come under our senses, we should be drawn away into long digressions, and the solution of the problem would require more words than I possess, to examine fully the matter. To spend time on such points would not prove to be to the edification of the Church. Upon the essence of the heavens we are contented with what Isaiah says, for, in simple language, he gives us sufficient idea of their nature, "The heaven was made like smoke," that is to say, He created a subtle substance, without solidity or density, from which to form the heavens. As to the form of them we also content ourselves with the language of the same prophet, when praising God "that stretcheth out the heavens as a curtain and spreadeth them out as a tent to dwell in." In the same way, as concerns the earth, let us resolve not to torment ourselves by trying to find out its essence, not to tire our reason by seeking for the substance which it conceals...

If I ask you to leave these vain questions, I will not expect you to try and find out the earth's point of support. The mind would reel on beholding its reasonings losing themselves without end. Do you say that the earth reposes on a bed of air? How, then, can this soft substance, without consistency, resist the enormous weight which presses upon it? How is it that it does not slip away in all directions, to avoid the sinking weight, and to spread itself over the mass which overwhelms it? Do you suppose that water is the foundation of the earth? You will then always have to ask yourself how it is that so heavy and opaque a body does not pass through the water; how a mass of such a weight is held up by a nature weaker than itself. Then you must seek a base for the waters, and you will be in much difficulty to say upon what the water itself rests.

9. Do you suppose that a heavier body prevents the earth from falling into the abyss? Then you must consider that this support needs itself a support to prevent it from falling. Can we imagine one? Our reason again demands yet another support, and thus we shall fall into the infinite, always imagining a base for the base which we have already found. And the further we advance in this reasoning the greater force we are obliged to give to this base, so that it may be able to support all the mass

weighing upon it. Put then a limit to your thought, so that your curiosity in investigating the incomprehensible may not incur the reproaches of Job, and you be not asked by him, "Whereupon are the foundations thereof fastened?" If ever you hear in the Psalms, "I bear up the pillars of it;" see in these pillars the power which sustains it. Because what means this other passage, "He hath founded it upon the sea," if not that the water is spread all around the earth? How then can water, the fluid element which flows down every declivity, remain suspended without ever flowing? You do not reflect that the idea of the earth suspended by itself throws your reason into a like but even greater difficulty, since from its nature it is heavier. But let us admit that the earth rests upon itself, or let us say that it rides the waters, we must still remain faithful to thought of true religion and recognise that all is sustained by the Creator's power. Let us then reply to ourselves, and let us reply to those who ask us upon what support this enormous mass rests, "In His hands are the ends of the earth." It is a doctrine as infallible for our own information as profitable for our hearers.

10. There are inquirers into nature who with a great display of words give reasons for the immobility of the earth. Placed, they say, in the middle of the universe and not being able to incline more to one side than the other because its centre is everywhere the same distance from the surface, it necessarily rests upon itself; since a weight which is everywhere equal cannot lean to either side. It is not, they go on, without reason or by chance that the earth occupies the centre of the universe. It is its natural and necessary position.. .Do not then be surprised that the world never falls: it occupies the centre of the universe, its natural place. By necessity it is obliged to remain in its place, unless a movement contrary to nature should displace it. If there is anything in this system which might appear probable to you, keep your admiration for the source of such perfect order, for the wisdom of God. Grand phenomena do not strike us the less when we have discovered something of their wonderful mechanism. Is it otherwise here? At all events let us prefer the simplicity of faith to the demonstrations of reason.

11. We might say the same thing of the heavens. With what a noise of words the sages of this world have discussed their nature! Some have said that heaven is composed of four elements as being tangible and visible, and is made up of earth on account of its power of resistance, with fire because it is striking to the eye, with air and water on account of the mixture. Others have rejected this system as improbable, and introduced into the world, to form the heavens, a fifth element after their own fashioning. There exists, they say, an æthereal body which is neither fire, air, earth, nor water, nor in one word any simple body. These simple bodies have their own natural motion in a straight line, light bodies upwards and heavy bodies downwards; now this motion upwards and downwards is not the same as circular motion; there is the greatest possible difference between straight and circular motion. It therefore follows that bodies whose motion is so various must vary also in their essence. But, it is not even possible to suppose that the heavens should be formed of primitive bodies which we call elements, because the reunion of contrary forces could not produce an even and spontaneous motion, when each of the simple bodies is receiving a different impulse from nature.

Thus it is a labour to maintain composite bodies in continual movement, because it is impossible to put even a single one of their movements in accord and harmony with all those that are in discord; since what is proper to the light particle, is in warfare with that of a heavier one. If we attempt to rise we are stopped by the weight of the terrestrial element; if we throw ourselves down we violate the igneous part of our being in dragging it down contrary to its nature. Now this struggle of the elements effects their dissolution. A body to which violence is done and which is placed in opposition to nature, after a short but energetic resistance, is soon dissolved into as many parts as it had elements, each of the constituent parts returning to its natural place. It is the force of these reasons, say the inventors of the fifth kind of body for the genesis of heaven and the stars, which constrained them to reject the system of their predecessors and to have recourse to their own hypothesis. But yet another fine speaker arises and disperses and destroys this theory to give

predominance to an idea of his own invention.

Do not let us undertake to follow them for fear of falling into like frivolities; let them refute each other, and, without disquieting ourselves about essence, let us say with Moses "God created the heavens and the earth." Let us glorify the supreme Artificer for all that was wisely and skillfully made; by the beauty of visible things let us raise ourselves to Him who is above all beauty; by the grandeur of bodies, sensible and limited in their nature, let us conceive of the infinite Being whose immensity and omnipotence surpass all the efforts of the imagination. Because, although we ignore the nature of created things, the objects which on all sides attract our notice are so marvellous, that the most penetrating mind cannot attain to the knowledge of the least of the phenomena of the world, either to give a suitable explanation of it or to render due praise to the Creator, to Whom belong all glory, all honour and all power world without end. Amen.

Homily II — "The Earth Was Invisible and Unfinished"

1. In the few words which have occupied us this morning we have found such a depth of thought that we despair of penetrating further. If such is the fore court of the sanctuary, if the portico of the temple is so grand and magnificent, if the splendour of its beauty thus dazzles the eyes of the soul, what will be the holy of holies? Who will dare to try to gain access to the innermost shrine? Who will look into its secrets? To gaze into it is indeed forbidden us, and language. is powerless to express what the mind conceives. However, since there are rewards, and most desirable ones, reserved by the just Judge for the intention alone of doing good, do not let us hesitate to continue our researches. Although we may not attain to the truth, if, with the help of the Spirit, we do not fall away from the meaning of Holy Scripture we shall not deserve to be rejected, and, with the help of grace, we shall contribute to the edification of the Church of God.

"The earth," says Holy Scripture, "was invisible and unfinished." The heavens and the earth were created without distinction. How then is it that the heavens are perfect whilst the earth is still unformed and incomplete? In one word, what was the unfinished condition of the earth? And for what reason was it invisible? The fertility of the earth is its perfect finishing; growth of all kinds of plants, the upspringing of tall trees, both productive and sterile, flowers' sweet scents and fair colours, and all that which, a little later, at the voice of God came forth from the earth to beautify her, their universal Mother. As nothing of all this yet existed, Scripture is right in calling the earth "without form." We could also say of the heavens that they were still imperfect and had not received their natural adornment, since at that time they did not shine with the glory of the sun and of the moon and were not crowned by the choirs of the stars. These bodies were not yet created. Thus you will not diverge from the truth in saying that the heavens also were "without form."

The earth was invisible for two reasons: it may be because man, the spectator, did not yet exist, or because being submerged under the waters which overflowed the surface, it could not be seen, since the waters had not yet been gathered together into their own places, where God afterwards collected them, and gave them the name of seas. What is invisible? First of all that which our fleshly eye cannot perceive; our mind, for example; then that which, visible in its nature, is hidden by some body which conceals it, like iron in the depths of the earth. It is in this sense, because it was hidden under the waters, that the earth was still invisible. However, as light did not yet exist, and as the earth lay in darkness, because of the obscurity of the air above it, it should not astonish us that for this reason Scripture calls it "invisible."

2. But the corrupters of the truth, who, incapable of submitting their reason to Holy Scripture, distort at will the meaning of the Holy Scriptures, pretend that these words mean matter. For it is matter, they say, which from its nature is without form and invisible — being by the conditions of its existence without quality and without form and figure. The Artificer submitting it to the working

of His wisdom clothed it with a form, organized it, and thus gave being to the visible world.

If matter is untreated, it has a claim to the same honours as God, since it must be of equal rank with Him. Is this not the summit of wickedness, that an extreme deformity, without quality, without form, shape, ugliness without configuration, to use their own expression, should enjoy the same prerogatives with Him, Who is wisdom, power and beauty itself, the Creator and the Demiurge of the universe? This is not all.

If matter is so great as to be capable of being acted on by the whole wisdom of God, it would in a way raise its hypostasis to an equality with the inaccessible power of God, since it would be able to measure by itself all the extent of the divine intelligence. If it is insufficient for the operations of God, then we fall into a more absurd blasphemy, since we condemn God for not being able, on account of the want of matter, to finish His own works. The poverty of human nature has deceived these reasoners. Each of our crafts is exercised upon some special matter — the art of the smith upon iron, that of the carpenter on wood. In all, there is the subject, the form and the work which results from the form. Matter is taken from without — art gives the form — and the work is composed at the same time of form and of matter.

Such is the idea that they make for themselves of the divine work. The form of the world is due to the wisdom of the supreme Artificer; matter came to the Creator from without; and thus the world results from a double origin. It hits received from outside its matter and its essence, and from God its form and figure. They thus come to deny that the mighty God has presided at the formation of the universe, and pretend that He has only brought a crowning contribution to a common work, that He has only contributed some small portion to the genesis of beings: they are incapable from the debasement of their reasonings of raising their glances to the height of truth.

Here below arts are subsequent to matter — introduced into life by the indispensable need of them. Wool existed before weaving made it supply one of nature's imperfections. Wood existed before carpentering took possession of it, and transformed it each day to supply new wants, and made us see all the advantages derived from it, giving the oar to the sailor, the winnowing fan to the labourer, the lance to the soldier. But God, before all those things which now attract our notice existed, after casting about in His mind and determining to bring into being time which had no being, imagined the world such as it ought to be, and created matter in harmony with the forth which He wished to give it. He assigned to the heavens the nature adapted for the heavens, and gave to the earth an essence in accordance with its form. He formed, as He wished, fire, air and water, and gave to each the essence which the object of its existence required. Finally, He welded all the diverse parts of the universe by links of indissoluble attachment and established between them so perfect a fellowship and harmony that the most distant, in spite of their distance, appeared united in one universal sympathy. Let those men therefore renounce their fabulous imaginations, who, in spite of the weakness of their argument, pretend to measure a power as incomprehensible to man's reason as it is unutterable by man's voice.

3. God created the heavens and the earth, but not only half — He created all the heavens and all the earth, creating the essence with the form. For He is not an inventor of figures, but the Creator even of the essence of beings. Further let them tell us how the efficient power of God could deal with the passive nature of matter, the latter furnishing the matter without form, the former possessing the science of the form without matter, both being in need of each other; the Creator in order to display His art, matter in order to cease to be without form and to receive a form. But let us stop here and return to our subject.

"The earth was invisible and unfinished." In saying "In the beginning God created the heavens and the earth," the sacred writer passed over many things in silence, water, air, fire and the results

from them, which, all forming in reality the true complement of the world, were, without doubt, made at the same time as the universe. By this silence, history wishes to train the activity of our intelligence, giving it a weak point for starting, to impel it to the discovery of the truth. Thus, we are not told of the creation of water; but, as we are told that the earth was invisible, ask yourself what could have covered it, and prevented it from being seen? Fire could not conceal it. Fire brightens all about it, and spreads light rather than darkness around. No more was it air that enveloped the earth. Air by nature is of little density and transparent. It receives all kinds of visible object, and transmits them to the spectators. Only one supposition remains; that which floated on the surface of the earth was water — the fluid essence which had not yet been confined to its own place. Thus the earth was not only invisible; it was still incomplete. Even today excessive damp is a hindrance to the productiveness of the earth. The same cause at the same time prevents it from being seen, and from being complete, for the proper and natural adornment of the earth is its completion: corm waving in the valleys — meadows green with grass and rich with many coloured flowers — fertile glades and hill-tops shaded by forests. Of all this nothing was yet produced; the earth was in travail with it in virtue of the power that she had received from the Creator. But she was waiting for the appointed time and the divine order to bring forth.

4. "Darkness was upon the face of the deep." A new source for fables and most impious imaginations if one distorts the sense of these words at the will of one's fancies. By "darkness" these wicked men do not understand what is meant in reality — air not illumined, the shadow produced by the interposition of a body, or finally a place for some reason deprived of light. For them "darkness" is an evil power, or rather the personification of evil, having his origin in himself in opposition to, and in perpetual struggle with, the goodness of God. If God is light, they say, without any doubt the power which struggles against Him must be darkness, "Darkness" not owing its existence to a foreign origin, but an evil existing by itself. "Darkness" is the enemy of souls, the primary cause of death, the adversary of virtue. The words of the Prophet, they say in their error, show that it exists and that it does not proceed from God. From this what perverse and impious dogmas have been imagined! What grievous wolves, tearing the flock of the Lord, have sprung from these words to cast themselves upon souls! Is it not from hence that have come forth Marcions and Valentini, and the detestable heresy of the Manicheans, which you may without going far wrong call the putrid humour of the churches.

O man, why wander thus from the truth, and imagine for thyself that which will cause thy perdition? The word is simple and within the comprehension of all. "The earth was invisible." Why? Because the "deep" was spread over its surface. What is "the deep"? A mass of water of extreme depth. But we know that we can see many bodies through clear and transparent water. How then was it that no part of the earth appeared through the water? Because the air which surrounded it was still without light and in darkness. The rays of the sun, Penetrating the water, often allow its to see the pebbles which form the bed of the river, but in a dark night it is impossible for our glance to penetrate under the water. Thus, these words "the earth was invisible" are explained by those that follow; "the deep" covered it and itself was in darkness. Thus, the deep is not a multitude of hostile powers, as has been imagined; nor "darkness" an evil sovereign force in enmity with good. In reality two rival principles of equal power, if engaged without ceasing in a war of mutual attacks, will end in self destruction. But if one should gain the mastery it would completely annihilate the conquered. Thus, to maintain the balance in the struggle between good and evil is to represent them as engaged in a war without end and in perpetual destruction, where the opponents are at the same time conquerors and conquered. If good is the stronger, what is there to prevent evil being completely annihilated? But if that be the case, the very utterance of which is impious, I ask myself how it is that they themselves are not filled with horror to think that they have imagined such abominable blasphemies.

It is equally impious to say that evil has its origin from God; because the contrary cannot proceed

from its contrary. Life does not engender death; darkness is not the origin of light; sickness is not the maker of health. In the changes of conditions there are transitions from one condition to the contrary; but in genesis each being proceeds from its like, and not from its contrary. If then evil is neither uncreate nor created by God, from whence comes its nature? Certainly that evil exists, no one living in the world will deny. What shall we say then? Evil is not a living animated essence; it is the condition of the soul opposed to virtue, developed in the careless on account of their falling away from good.

5. Do not then go beyond yourself to seek for evil, and imagine that there is an original nature of wickedness. Each of us, let us acknowledge it, is the first author of his own vice. Among the ordinary events of life, some come naturally, like old age and sickness, others by chance like unforeseen occurrences, of which the origin is beyond ourselves, often sad, sometimes fortunate, as for instance the discovery of a treasure when digging a well, or the meeting of a mad dog when going to the market place. Others depend upon ourselves, such as ruling one's passions, or not putting a bridle on one's pleasures, to be master of our anger, or to raise the hand against him who irritates us, to tell the truth, or to lie, to have a sweet and well-regulated disposition, or to be fierce and swollen and exalted with pride. Here you are the master of your actions. Do not look for the guiding cause beyond yourself, but recognise that evil, rightly so-called, has no other origin than our voluntary falls. If it were involuntary, and did not depend upon ourselves, the laws would not have so much terror for the guilty, and the tribunals would not be so without pity when they condemn wretches according to the measure of their crimes. But enough concerning evil rightly so called. Sickness, poverty, obscurity, death, finally all human afflictions, ought not to be ranked as evils; since we do not count among the greatest boons things which are their opposites. Among these afflictions, some are the effect of nature, others have obviously been for many a source of advantage. Let us then be silent for the moment about these metaphors and allegories, and, simply following without vain curiosity the words of Holy Scripture, let us take from darkness the idea which it gives us.

But reason asks, was darkness created with the world? Is it older than light? Why in spite of its inferiority has it preceded it? Darkness, we reply, did not exist in essence; it is a condition produced in the air by the withdrawal of light. What then is that light which disappeared suddenly from the world, so that darkness should cover the face of the deep? If anything had existed before the formation of this sensible and perishable world, no doubt we conclude it would have been in light. The orders of angels, the heavenly hosts, all intellectual natures named or unnamed, all the ministering spirits, did not live in darkness, but enjoyed a condition fitted for them in light and spiritual joy.

No one will contradict this; least of all he who looks for celestial light as one of the rewards promised to virtues the light which, as Solomon says, is always a light to the righteous, the light which made the Apostle say "Giving thanks unto the Father, which hath made us meet to be partakers of the inheritance of the saints in light." finally, if the condemned are sent into outer darkness evidently those who are made worthy of God's approval, are at rest in heavenly light. When then, according to the order of God, the heaven appeared, enveloping all that its circumference included, a vast and unbroken body separating outer things from those which it enclosed, it necessarily kept the space inside in darkness for want of communication with the outer light. Three things are, indeed, needed to form a shadow, light, a body, a dark place. The shadow of heaven forms the darkness of the world. Understand, I pray you, what I mean, by a simple example; by raising for yourself at mid-day a tent of some compact and impenetrable material, and shutting yourself up in it in sudden darkness. Suppose that original darkness was like this, not subsisting directly by itself, but resulting from some external coasts. If it is said that it rested upon the deep, it is because the extremity of air naturally touches the surface of bodies; and as at that time the water covered everything, we are obliged to say that darkness was upon the face of the

deep.

6. And the Spirit of God was borne upon the face of the waters. Does this spirit mean the diffusion of air? The sacred writer wishes to enumerate to you the elements of the world, to tell you that God created the heavens, the earth, water, and air and that the last was now diffused and in motion; or rather, that which is truer and confirmed by the authority of the ancients, by the Spirit of God, he means the Holy Spirit. It is, as has been remarked, the special name, the name above all others that Scripture delights to give to the Holy Spirit, and always by the spirit of God the Holy Spirit is meant, the Spirit which completes the divine and blessed Trinity. You will find it better therefore to take it in this sense. How then did the Spirit of God move upon the waters? The explanation that I am about to give you is not an original one, but that of a Syrian, who was as ignorant in the wisdom of this world as he was versed in the knowledge of the Truth. He said, then, that the Syriac word was more expressive, and that being more analogous to the Hebrew term it was a nearer approach to the scriptural sense. This is the meaning of the word; by "was borne" the Syrians, he says, understand: it cherished the nature of the waters as one sees a bird cover the eggs with her body and impart to them vital force from her own warmth. Such is, as nearly as possible, the meaning of these words — the Spirit was borne: let us understand, that is, prepared the nature of water to produce living beings: a sufficient proof for those who ask if the Holy Spirit took an active part in the creation of the world.

7. And God said, Let there be light. The first word of God created the nature of light; it made darkness vanish, dispelled gloom, illuminated the world, and gave to all beings at the same time a sweet and gracious aspect. The heavens, until then enveloped in darkness, appeared with that beauty which they still present to our eyes. The air was lighted up, or rather made the light circulate mixed with its substance, and, distributing its splendour rapidly in every direction, so dispersed itself to its extreme limits. Up it sprang to the very tether and heaven. In an instant it lighted up the whole extent of the world, the North and the South, the East and the West. For the tether also is such a subtle substance and so transparent that it needs not the space of a moment for light to pass through it. Just as it carries our sight instantaneously to the object of vision, so without the least interval, with a rapidity that thought cannot conceive, it receives these rays of light in its uttermost limits. With light the tether becomes more pleasing and the waters more limpid. These last, not content with receiving its splendour, return it by the reflection of light and in all directions send forth quivering flashes. The divine word gives every object a more cheerful and a more attractive appearance, just as when men in deep sea pour in oil they make the place about them clear. So, with a single word and in one instant, the Creator of all things gave the boon of light to the world.

Let there be light. The order was itself an operation, and a state of things was brought into being, than which man's mind cannot even imagine a pleasanter one for our enjoyment. It must be well understood that when we speak of the voice, of the word, of the command of God, this divine language does not mean to us a sound which escapes from the organs of speech, a collision of air struck by the tongue; it S a simple sign of the will of God, and, if we give it the form of an order, it is only the better to impress the souls whom we instruct...

8. "And God called the light Day and the darkness he called Night." Since the birth of the sun, the light that it diffuses in the air, when shining on our hemisphere, is day; and the shadow produced by its disappearance is night. But at that time it was not after the movement of the sun, but following this primitive light spread abroad in the air or withdrawn in a measure determined by God, that day came and was followed by night.

"And the evening and the morning were the first day." Evening is then the boundary common to day and night; and in the same way morning constitutes the approach of night to day. It was to give day

the privileges of seniority that Scripture put the end of the first day before that of the first night, because night follows day: for, before the creation of light, the world was not in night, but in darkness. It is the opposite of day which was called night, and it did not receive its name until after day. Thus were created the evening and the morning. Scripture means the space of a day and a night, and afterwards no more says day and night, but calls them both under the name of the more important: a custom which you will find throughout Scripture. Everywhere the measure of time is counted by days, without mention of nights. "The days of our years," says the Psalmist. "Few and evil have the days of the years of my life been," said Jacob, and elsewhere "all the days of my life." Thus under the form of history the law is laid down for what is to follow. And the evening and the morning were one day.

Why does Scripture say "one day the first day"? Before speaking to us of the second, the third, and the fourth days, would it not have been more natural to call that one the first which began the series? If it therefore says "one day," it is from a wish to determine the measure of day and night, and to combine the time that they contain. Now twenty-four hours fill up the space of one day — we mean of a day and of a night; and if, at the time of the solstices, they have not both an equal length, the time marked by Scripture does not the less circumscribe their duration. It is as though it said: twenty-four hours measure the space of a day, or that, in reality a day is the time that the heavens starting from one point take to return there. Thus, every time that, in the revolution of the sun, evening and morning occupy the world, their periodical succession never exceeds the space of one day.

But must we believe in a mysterious reason for this? God who made the nature of time measured it out and determined it by intervals of days; and, wishing to give it a week as a measure, he ordered the week to revolve from period to period upon itself, to count the movement of time, forming the week of one day revolving seven times upon itself: a proper circle begins and ends with itself. Such is also the character of eternity, to revolve upon itself and to end nowhere. If then the beginning of time is called "one day" rather than "the first day," it is because Scripture wishes to establish its relationship with eternity. It was, in reality, fit and natural to call "one" the day whose character is to be one wholly separated and isolated from all the others. If Scripture speaks to us of many ages, saying everywhere, "age of age, and ages of ages," we do not see it enumerate them as first, second, and third. It follows that we are hereby shown not so much limits, ends and succession of ages, as distinctions between various states and modes of action.

"The day of the Lord," Scripture says, "is great and very terrible," and elsewhere "Woe unto you that desire the day of the Lord: to what end is it for you? The day of the Lord is darkness and not light." A day of darkness for those who are worthy of darkness. No; this day without evening, without succession and without end is not unknown to Scripture, and it is the day that the Psalmist calls the eighth day, because it is outside this time of weeks. Thus whether you call it day, or whether you call it eternity, you express the same idea. Give this state the name of day; there are not several, but only one. If you call it eternity still it is unique and not manifold. Thus it is in order that you may carry your thoughts forward towards a future life, that Scripture marks by the word "one" the day which is the type of eternity, the first fruits of days, the contemporary of light, the holy Lord's day honoured by the Resurrection of our Lord. And the evening and the morning were one day."...

Homily III — On the Firmament

1. We have now recounted the works of the first day, or rather of one day. Far be it from me indeed, to take from it the privilege it enjoys of having been for the Creator a day apart, a day which is not counted in the same order as the others. Our discussion yesterday treated of the works of this day, and divided the narrative so as to give you food for your souls in the morning, and joy in the evening. Today we pass on to the wonders of the second day. And here I do not wish to speak of the narrator's talent, but of the grace of Scripture, for the narrative is so naturally told that it

pleases and delights all the friends of truth. It is this charm of truth which the Psalmist expresses so emphatically when he says, "How sweet are thy words unto my taste. yea, sweeter than honey to my mouth." Yesterday then, as far as we were able, we delighted our souls by conversing about the oracles of God, and now today we are met together again on the second day to contemplate the wonders of the second day....

2. And God said "Let there be a firmament in the midst of the waters, and let it divide the waters from the waters." Yesterday we heard God's decree, "Let there be light." Today it is, "Let there be a firmament." There appears to be something more in this. The word is not limited to a simple command. It lays down the reason necessitating the structure of the firmament: it is, it is said, to separate the waters from the waters. And first let us ask how God speaks? Is it in our manner? Does His intelligence receive an impression from objects, and, after having conceived them, make them known by particular signs appropriate to each of them? Has He consequently recourse to the organs of voice to convey His thoughts? Is He obliged to strike the air by the articulate movements of the voice, to unveil the thought hidden in His heart? Would it not seem like an idle fable to say that God should need such a circuitous method to manifest His thoughts? And is it not more conformable with true religion to say, that the divine will and the first impetus of divine intelligence are the Word of God?

It is He whom Scripture vaguely represents, to show us that God has not only wished to create the world, but to create it with the help of a co-operator. Scripture might continue the history as it is begun: In the beginning God created the heaven and the earth; afterwards He created light, then He created the firmament. But, by making God command and speak, the Scripture tacitly shows us Him to Whom this order and these words are addressed. It is not that it grudges us the knowledge of the truth, but that it may kindle our desire by showing us some trace and indication of the mystery. We seize with delight, and carefully keep, the fruit of laborious efforts, whilst a possession easily attained is despised. Such is the road and the course which Scripture follows to lead us to the idea of the Only-begotten. And certainly, God's immaterial nature had no need of the material language of voice, since His very thoughts could be transmitted to His fellow-worker. What need then of speech, for those Who by thought alone could communicate their counsels to each other? Voice was made for hearing, and hearing for voice. Where there is neither air, nor tongue, nor ear, nor that winding canal which carries sounds to the seat of sensation in the head, there is no need for words thoughts of the soul are sufficient to transmit the will. As I said then, this language is only a wise and ingenious contrivance to set our minds seeking the Person to whom the words are addressed.

3. In the second place, does the firmament that is called heaven differ from the firmament that God made in the beginning? Are there two heavens? The philosophers, who discuss heaven, would rather lose their tongues than grant this. There is only one heaven, they pretend; and it is of a nature neither to admit of a second, nor of a third, nor of several others. The essence of the celestial body quite complete constitutes its vast unity. Because, they say, every body which has a circular motion is one and finite. And if this body is used in the construction of the first heaven, there will be nothing left for the creation of a second or a third.

Here we see what those imagine who put under the Creator's hand uncreated matter; a lie that follows from the first fable. But we ask the Greek sages not to mock us before they are agreed among themselves. Because there are among them some who say there are infinite heavens and worlds. When grave demonstrations shall have upset their foolish system, when the laws of geometry shall have established that, according to the nature of heaven, it is impossible that there should be two, we shall only laugh the more at this elaborate scientific trifling. These learned men see not merely one bubble but several bubbles formed by the same cause, and they doubt the power of creative wisdom to bring several heavens into being!

We find, however, if we raise our eyes towards the omnipotence of God, that the strength and grandeur of the heavens differ from the drops of water bubbling on the surface of a fountain. How ridiculous, then, is their argument of impossibility! As for myself, far from not believing in a second, I seek for the third whereon the blessed Paul was found worthy to gaze. And does not the Psalmist in saying "heaven of heavens" give us an idea of their plurality? Is the plurality of heaven stranger than the seven circles through which nearly all the philosophers agree that the seven planets pass — circles which they represent to us as placed in connection with each other like casks fitting the one into the other? These circles, they say, carried away in a direction contrary to that of the world, and striking the rather, make sweet and harmonious sounds, unequalled by the sweetest melody. And if we ask them for the witness of the senses, what do they say? That we, accustomed to this noise from our birth, on account of hearing it always, have lost the sense of it; like then in smithies with their ears incessantly dinned. If I refuted this ingenious frivolity, the untruth of which is evident from the first word, it would seem as though I did not know the value of time and mistrusted the intelligence of such an audience.

But let me leave the vanity of outsiders to those who are without, and return to the theme proper to the Church. If we believe some of those who have preceded us, we have not here the creation of a new heaven, but a new account of the first. The reason they give is, that the earlier narrative briefly described the creation of heaven and earth; while here Scripture relates in greater detail the manner in which each was created. I, however, since Scripture gives to this second heaven another name and its own function, maintain that it is different from the heaven which was made at the beginning; that it is of a stronger nature and of an especial use to the universe.

4. "And God said, let there be a firmament in the midst of the waters, and let it divide the waters front the waters. And God made the firmament, and divided the waters which were under the firmament from the waters which were above the firmament." Before laying hold of the meaning of Scripture let us try to meet objections from other quarters. We are asked how, if the firmament is a spherical body, as it appears to the eye, its convex circumference can contain the water which flows and circulates in higher regions? What shall we answer? One thing only: because the interior of a body presents a perfect concavity it does not necessarily follow that its exterior surface is spherical and smoothly rounded. Look at the stone vaults of baths, and the structure of buildings of cave form; the dome, which forms the interior, does not prevent the roof from having ordinarily a flat surface. Let these unfortunate men cease, then, from tormenting us and themselves about the impossibility of our retaining water in the higher regions.

Now we must say something about the nature of the firmament, and why it received I the order to hold the middle place between the waters. Scripture constantly makes use of the word firmament to express extraordinary strength. "The Lord in firmament and refuge" "I have strengthened the pillars of it" "Praise him in the firmament of his power." The heathen writers thus call a strong body one which is compact and full, to distinguish it from the mathematical body. A mathematical body is a body which exists only in the three dimensions, breadths depth, and height. A firm body, on the contrary, adds resistance to the dimensions. It is the custom of Scripture to call firmament all that is strong and unyielding. It even uses the word to denote the condensation of the air: He, it says, who strengthens the thunder. Scripture means by the strengthening of the thunder, the strength and resistance of the wind, which, enclosed in the hollows of the clouds, produces the noise of thunder when it breaks through with violence.

Here then, according to me, is a firm substance, capable of retaining the fluid and unstable element water; and as, according to the common acceptation, it appears that the firmament owes its origin to water, we must not believe that it resembles frozen water or any other matter produced by the filtration of water; as, for example, rock crystal, which is said to owe its

metamorphosis to excessive congelation, or the transparent stone which forms in mines. This pellucid stone, if one finds it in its natural perfection, without cracks inside, or the least spot of corruption, almost rivals the air in clearness. We cannot compare the firmament to one of these substances. To hold such an opinion about celestial bodies would be childish and foolish; and although everything may be in everything, fire in earth, air in water, and of the other elements the one in the other; although none of those which come under our senses are pure and without mixture, either with the element which serves as a medium for it, or with that which is contrary to it; I, nevertheless, dare not affirm that the firmament was formed of one of these simple substances, or of a mixture of them, for I am taught by Scripture not to allow my imagination to wander too far afield.

But do not let us forget to remark that, after these divine words "let there be a firmament," it is not said "and the firmament was made" but, "and God made the firmament, and divided the waters." Hear, O ye deaf! See, O ye blind! — who, then, is deaf? He who does not hear this startling voice of the Holy Spirit. Who is blind? He who does not see such clear proofs of the Only begotten, "Let there be a • firmament." It is the voice of the primary and principal Cause. "And God made the firmament." Here is a witness to the active and creative Power of God.

5. But let us continue our explanation: "Let it divide the waters from the waters." The mass of waters, which from all directions flowed over the earth, and was suspended in the air, was infinite, so that there was no proportion between it and the other elements. Thus, as it has been already said, the abyss covered the earth. We give the reason for this abundance of water. None of you assuredly will attack our opinion; not even those who have the most cultivated minds, and whose piercing eye can penetrate this perishable and fleeting nature; you will not accuse me of advancing impossible or imaginary theories, nor will you ask me upon what foundation the fluid clement rests. By the same reason which makes them attract the earth, heavier than water, from the extremities of the world to suspend it in the centre, they will grant us without doubt that it is due both to its natural attraction downwards and its general equilibrium, that this immense quantity of water rests motionless upon the earth. Therefore the prodigious mass of waters was spread around the earth; not in proportion with it and infinitely larger, thanks to the foresight of the supreme Artificer, Who, from the beginning, foresaw what was to come, and at the first provided all for the future needs of the world.

But what need was there for this superabundance of water? The essence of fire is necessary for the world, not only in the economy of earthly produce, but for the completion of the universe; for it would be imperfect if the most powerful and the most vital of its elements were lacking. Now fire and water are hostile to and destructive of each other. Fire, if it is the stronger, destroys water, and water, if in greater abundance, destroys fire. As, therefore, it was necessary to avoid an open struggle between these elements, so as not to bring about the dissolution of the universe by the total disappearance of one or the other, the sovereign Disposer created such a quantity of water that in spite of constant diminution from the effects of fire, it could last until the time fixed for the destruction of the world. He who planned all with weight and measure, He who, according to the word of Job, knows the number of the drops of rain, knew how long His work would last, and for how much consumption of fire He ought to allow. This is the reason of the abundance of water at the creation.

Further, there is no one so strange to life as to need to learn the reason why fire is essential to the world. Not only all the arts which support life, the art of weaving, that of shoemaking, of architecture, of agriculture, have need of the help of fire, but the vegetation of trees, the ripening of fruits, the breeding of land and water animals, and their nourishment, all existed from heat from the beginning, and have been since maintained by the action of heat. The creation of heat was then indispensable for the formation and the preservation of beings, and the abundance of waters

was no less so in the presence of the constant and inevitable consumption by fire.

6. Survey creation; you will see the power of heat reigning over all that is born and perishes. On account of it comes all the water spread over the earth, as well as that which is beyond our sight and is dispersed in the depths of the earth. On account of it are abundance of fountains, springs or wells, courses of rivers, both mountain torrents and ever flowing streams, for the storing of moisture in many and various reservoirs... Thus the habitable part of our earth is surrounded by water, linked together by vast seas and irrigated by countless perennial rivers, thanks to the ineffable wisdom of Him Who ordered all to prevent this rival clement to fire from being entirely destroyed.

However, a time will come, when all shall be consumed by fire; as Isaiah says of the God of the universe in these words, "That saith to the deep, Be dry, and I will dry up thy rivers." Reject then the foolish wisdom of this world, and receive with me the more simple but infallible doctrine of truth.

7. Therefore we read: "Let there be a firmament in the midst of the waters, and let it divide the waters from the waters." have said what the word firmament in Scripture means. It is not in reality a firm and solid substance which has weight and resistance; this name would otherwise have better suited the earth. But, as the substance of super-incumbent bodies is light, without consistency, and cannot be grasped by any one of our senses, it is in comparison with these pure and imperceptible substances that the firmament has received its name. Imagine a place fit to divide the moisture, sending it, if pure and filtered, into higher regions, and making it fall, if it is dense and earthy; to the end that by the gradual withdrawal of the moist particles the same temperature may be preserved from the beginning to the end. You do not believe in this prodigious quantity of water; but you do not take into account the prodigious quantity of heat, less considerable no doubt in bulk, but exceedingly powerful nevertheless, if you consider it as destructive of moisture. It attracts surrounding moisture, as the melon shows us, and consumes it as quickly when attracted, as the flame of the lamp draws to it the fuel supplied by the wick and burns it up.

Who doubts that the ether is an ardent fire? If an impassable limit had not been assigned to it by the Creator, what would prevent it from setting on fire and consuming all that is near it, and absorbing sit the moisture from existing things? The aerial waters which veil the heavens with vapours that are sent forth by rivers, fountains, marshes, lakes, and seas, prevent the ether from invading and burning up the universe. Thus we see even this sun, in the summer season, dry up in a moment a damp and marshy country, and make it perfectly arid. What has become of all the water? Let these masters of omniscience tell us. Is it not plain to every one that it has risen in vapour, and has been consumed by the heat of the sun? They say, none the less, that even the sun is without heat. What time they lose in words! And see what proof they lean upon to resist what is perfectly plain. Its colour is white, and neither reddish nor yellow. It is not then fiery by nature, and its heat results, they say, from the velocity of its rotation. What do they gain? That the sun does not seem to absorb moisture?

I do not, however, reject this statement, although it is false, because it helps my argument. I said that the consumption of heat required this prodigious quantity of water. That the sun owes its heat to its nature, or that heat results from its action, makes no difference, provided that it produces the same effects upon the same matter. If you kindle fire by rubbing two pieces of wood together, or if you light them by holding them to a flame, you will have absolutely the same effect. Besides, we see that the great wisdom of Him who governs all, makes the sun travel from one region to another, for fear that, if it remained always in the same place, its excessive heat would destroy the order of the universe. Now it passes into southern regions about the time of the winter solstice, now it returns to the sign of the equinox; from thence it betakes itself to northern regions during

the summer solstice, and keeps up by this imperceptible passage a pleasant temperature throughout all the world.

Let the learned people see if they do not disagree among themselves. The water which the sun consumes is, they say, what prevents the sea from rising and flooding the rivers; the warmth of the sun leaves behind the salts and the bitterness of the waters, and absorbs from them the pure and drinkable particles, thanks to the singular virtue of this planet in attracting all that is light and in allowing to fall, like mud and sediment, all which is thick and earthy. From thence come the bitterness, the salt taste and the power of withering and drying up which are characteristic of the sea. While as is notorious, they hold these views, they shift their ground and say that moisture cannot be lessened by the sun.

8. ...And do not let any one compare with the inquisitive discussions of philosophers upon the heavens, the simple and in-artificial character of the utterances of the Spirit; as the beauty of chaste women surpasses that of a harlot, so our arguments are superior to those of our opponents. They only seek to persuade by forced reasoning. With us truth presents itself naked and without artifice. But why torment ourselves to refute the errors of philosophers, when it is sufficient to produce their mutually contradictory books, and, as quiet spectators, to watch the war? For those thinkers are not less numerous, nor less celebrated, nor more sober in speech in fighting their adversaries, who say that the universe is being consumed by fire, and that from the seeds which remain in the ashes of the burnt world all is being brought to life again. Hence in the world there is destruction and palingenesis to infinity. All, equally far from the truth, find each on their side by-ways which lead them to error.

9. But as far as concerns the separation of the waters I am obliged to contest the opinion of certain writers in the Church who, under the shadow of high and sublime conceptions, have launched out into metaphor, and have only seen in the waters a figure to denote spiritual and incorporeal powers. In the higher regions, above the firmament, dwell the better; in the lower regions, earth and matter are the dwelling place of the malignant. So, say they, God is praised by the waters that are above the heaven, that is to say, by the good powers, the purity of whose soul makes them worthy to sing the praises of God. And the waters which are under the heaven represent the wicked spirits, who from their natural height have fallen into the abyss of evil. Turbulent, seditious, agitated by the tumultuous waves of passion, they have received the name of sea, because of the instability and the inconstancy of their movements.

Let us reject these theories as dreams and old women's tales. Let us understand that by water water is meant; for the dividing of the waters by the firmament let us accept the reason which has been given us. Although, however, waters above the heaven are invited to give glory to the Lord of the Universe, do not let us think of them as intelligent beings; the heavens are not alive because they "declare the glory of God," nor the firmament a sensible being because it "sheweth His handiwork." And if they tell you that the heavens mean contemplative powers, and the firmament active powers which produce good, we admire the theory as ingenious without being able to acknowledge the truth of it. For thus dew, the frost, cold and heat, which in Daniel are ordered to praise the Creator of all things, will be intelligent and invisible natures. But this is only a figure, accepted as such by enlightened minds, to complete the glory of the Creator. Besides, the waters above the heavens, these waters privileged by the virtue which they possess in themselves, are not the only waters to celebrate the praises of God. "Praise the Lord from the earth, ye dragons and all deeps." Thus the singer of the Psalms does not reject the deeps which our inventors of allegories rank in the divisions of evil; he admits them to the universal choir of creation, and the deeps sing in their language a harmonious hymn to the glory of the Creator.

10. "And God saw that it was good." God does not judge of the beauty of His work by the charm of

the eyes, and He does not form the same idea of beauty that we do. What He esteems beautiful is that which presents in its perfection all the fitness of art, and that which tends to the usefulness of its end. He, then, who proposed to Himself a manifest design in His works, approved each one of them, as fulfilling its end in accordance with His creative purpose. A hand, an eye, or any portion of a statue lying apart from the rest, would look beautiful to no one. But if each be restored to its own place, the beauty of proportion, until now almost unperceived, would strike even the most uncultivated. But the artist, before uniting the parts of his work, distinguishes and recognises the beauty of each of them, thinking of the object that he has in view. It is thus that Scripture depicts to us the Supreme Artist, praising each one of His works; soon, when His work is complete, He will accord well deserved praise to the whole together.

Let me here end my discourse on the second day, to allow my industrious hearers to examine what they have just heard. May their memory retain it for the profit of their soul; may they by careful meditation inwardly digest and benefit by what I say. As for those who live by their work, let me allow them to attend all day to their business, so that they may come, with a soul free from anxiety, to the banquet of my discourse in the evening. May God who, after having made such great things, put such weak words in my mouth, grant you the intelligence of His truth, so that you may raise yourselves from visible things to the invisible Being, and that the grandeur and beauty of creatures may give you a just idea of the Creator. For the visible ,things of Him from the creation of the world are clearly seen, and His power and divinity are eternal. Thus earth, air, sky, water, day, night, all visible things, remind us of who is our Benefactor. We shall not therefore give occasion to sin, we shall not give place to the enemy within us, if by unbroken recollection we keep God ever dwelling in our hearts, to Whom be all glory and all adoration, now and for ever, world without end. Amen.

Homily IV — Upon the Gathering Together of the Waters

1....And shall we, whom the Lord, the great worker of marvels, calls to the contemplation of His own works, tire of looking at them, or be slow to hear the words of the Holy Spirit? Shall we not rather stand around the vast and varied workshop of divine creation and, carried back in mind to the times of old, shall we not view all the order of creation? Heaven, poised like a dome, to quote the words of the prophet; earth, this immense mass which rests upon itself; the air around it, of a soft and fluid nature, a true and continual nourishment for all who breathe it, of such tenuity that it yields and opens at the least movement of the body, opposing no resistance to our motions, while, in a moment, it streams back to its place, behind those who cleave it; water, finally, that supplies drink for man, or may be designed for our other needs, and the marvellous gathering together of it into definite places which have been assigned to it: such is the spectacle which the words which I have just read will show you.

2. "And God said, Let the waters under the heaven be gathered together unto one place, and let the dry land appear, and it was so." And the water which was under the heaven gathered together unto one place; "And God called the dry land earth and the gathering together of the waters called He seas." What trouble you have given me in my previous discourses by asking me why the earth was invisible, why all bodies are naturally endued with colour, and why all colour comes under the sense of sight. And, perhaps, my reason did not appear sufficient to you, when I said that the earth, without being naturally invisible, was so to us, because of the mass of water that entirely covered it. Hear then how Scripture explains itself. "Let the waters be gathered together, and let the dry land appear." The veil is lifted and allows the earth, hitherto invisible, to be seen.

Perhaps you will ask me new questions. And first, is it not a law of nature that water flows downwards? Why, then, does Scripture refer this to the fiat of the Creator? As long as water is spread over a level surface, it does not flow; it is immovable. But when it finds any slope, immediately the foremost portion falls, then the one that follows takes its place, and that one is

itself replaced by a third. Thus incessantly they flow, pressing the one on the other, and the rapidity of their course is in proportion to the mass of water that is being carried, and the declivity down which it is borne. If such is the nature of water, it was supererogatory to command it to gather into one place. It was bound, on account of its natural instability, to fall into the most hollow part of the earth and not to stop until the levelling of its surface. We see how there is nothing so level as the surface of water. Besides, they add, how did the waters receive an order to gather into one place, when we see several seas, separated from each other by the greatest distances?

To the first question I reply: Since God's command, you know perfectly well the motion of water; you know that it is unsteady and unstable and fails naturally over declivities and into hollow places. But what was its nature before this command made it take its course? You do not know yourself, and you have heard from no eyewitness. Think, in reality, that a word of God makes the nature, and that this order is for the creature a direction for its future course. There was only one creation of day and night, and since that moment they have incessantly succeeded each other and divided time into equal parts.

3. "Let the waters be gathered together." It was ordered that it should be the natural property of water to flow, and in obedience to this order, the waters are never weary in their course. In speaking thus, I have only in view the flowing property of waters. Some flow of their own accord like springs and rivers, others are collected and stationary. But I speak now of flowing waters. "Let the waters be gathered together unto one place." Have you never thought, when standing near a spring which is sending forth water abundantly, Who makes this water spring from the bowels of the earth? Who forced it up? Where are the store-houses which send it forth? To what place is it hastening? How is it that it is never exhausted here, and never overflows there? All this comes from that first command; it was for the waters a signal for their course.

In all the story of the waters remember this first order, "let the waters be gathered together." To take their assigned places they were obliged to flow, and, once arrived there, to remain in their place and not to go farther. Thus in the language of Ecclesiastes, "All the waters run into the sea; yet the sea is not full." Waters flow in virtue of God's order, and the sea is enclosed in limits according to this first law, "Let the waters be gathered together unto one place." For fear the water should spread beyond its bed, and in its successive invasions cover one by one all countries, and end by flooding the whole earth, it received the order to gather unto one place. Thus we often see the furious sea raising mighty waves to the heaven, and, when once it has touched the shore, break its impetuosity in foam and retire. "Fear ye not me, saith the Lord.. .which have placed the sand for the bound of the sea." A grain of sand, the weakest tiring possible, curbs the violence of the ocean...

I report this fact to make you understand the full force of the command, "Let the waters be gathered unto one place"; that is to say, let there be no other gathering, and, once gathered, let them not disperse.

4. To say that the waters were gathered in one place indicates that previously they were scattered in many places. The mountains, intersected by deep ravines, accumulated water in their valleys, when from every direction the waters betook themselves to the one gathering place. What vast plains, in their extent resembling wide seas, what valleys, what cavities hollowed in many different ways, at that time fu11 of water, must have been emptied by the command of God! But we must not therefore say, that if the water covered the face of the earth, all the basins which have since received the sea were originally full. Where can the gathering of the waters have come from if the basins were already full? These basins, we reply, were only prepared at the moment when the water had to unite in a single mass. At that time the sea which is beyond Gadeira and the vast

ocean, so dreaded by navigators did not exist. But, all of a sudden, God created this vast space, and the mass of waters flowed in...

5. And God said: "Let the waters be gathered together unto one place and let the dry land appear." He did not say let the earth appear, so as not to show itself again without form, mud-like, and in combination with the water, nor yet endued with proper form and virtue. At the same time, lest we should attribute the drying of the earth to the sun, the Creator shows it to us dried before the creation of the sun. Let us follow the thought Scripture gives us. Not only the water which was covering the earth flowed off from it, but all that which had filtered into its depths withdrew in obedience to the irresistible order of the sovereign Master. And it was so. This is quite enough to show that the Creator's voice had effect: however, in several editions, there is added "And the water which was under the heavens gathered itself unto one place and the dry land was seen;" words that other interpreters have not given, and which do not appear conformable to Hebrew usage. In fact, after the assertion, "and it was so," it is superfluous to repeat exactly the same thing. In accurate copies these words are marked with an obelus, which is the sign of rejection...

6. "And God saw that it was good." Scripture does not merely wish to say that a pleasing aspect of the sea presented itself to God. It is not with eyes that the Creator views the beauty of His works. He contemplates them in His ineffable wisdom. A fair sight is the sea all bright in a settled calm; fair too, when, ruffled by a light breeze of wind, its surface shows tints of purple and azure — when, instead of lashing with violence the neighbouring shores, it seems to kiss them with peaceful caresses. However, it is not in this that Scripture makes God find the goodness and charm of the sea. Here it is the purpose of the work which makes the goodness...

Homily V — The Germination of the Earth

1. "And God said Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself." It was deep wisdom that commanded the earth, when it rested after discharging the weight of the waters, first to bring forth grass, then wood as we see it doing still at this time. For the voice that was then heard and this command were as a natural and permanent law for it: it gave fertility and the power to produce fruit for all ages to come; "Let the earth bring forth." The production of vegetables shows first germination. When the germs begin to sprout they form grass; this develops and becomes a plant, which insensibly receives its different articulations, and reaches its maturity in the seed. Thus all things which sprout and are green are developed. "Let the earth bring forth green grass." Let the earth bring forth by itself without having any need of help from without.

Some consider the sun as the source of all productiveness on the earth. It is, they say, the action of the sun's heat which attracts the vital force from the centre of the earth to the surface. The reason why the adornment of the earth was before the sun is the following; that those who worship the sun, as the source of life, may renounce their error. If they be well persuaded that the earth was adorned before the genesis of the sun, they will retract their unbounded admiration for it, because they see grass and plants vegetate before it rose. If then the food for the flocks was prepared, did our race appear less worthy of a like solicitude? He, who provided pasture for horses and cattle, thought before all of your riches and pleasures. If he fed your cattle, it was to provide for all the needs of your life. And what object was there in the bringing forth of grain, if not for your subsistence? Moreover, many grasses and vegetables serve for the food of man.

2. "Let the earth bring forth grass yielding seed after his kind." So that although some kind of grass is of service to animals, even their gain is our gain too, and seeds are especially designed for our use. Such is the true meaning of the words that I have quoted. "Let the earth bring forth grass, the herb yielding seed after his kind." In this manner we can re-establish the order of the words, of which the construction seems faulty in the actual version, and the economy of nature will be

rigorously observed. In fact, first comes germination, then verdure, then the growth of the plant, which alter having attained its full growth arrives at perfection in seed.

...Nothing then is truer than that each plant produces its seed or contains some seminal virtue; this is what is meant by "after its kind." So that the shoot of a reed does not produce an olive tree, but from a reed grows another reed, and from one sort of seed a plant of the same sort always germinates. Thus, all which sprang from the earth, in its first bringing forth, is kept the same to our time, thanks to the constant reproduction of kind.

"Let the earth bring forth." See how, at this short word, at this brief command, the cold and sterile earth travailed and hastened to bring forth its fruit, as it east away its sad and dismal covering to clothe itself in a more brilliant robe, proud of its proper adornment and displaying the infinite variety of plants.

I want creation to penetrate you with so much admiration that everywhere, wherever you may be, the least plant may bring to you the clear remembrance of the Creator. If you see the grass of the fields, think of human nature, and remember the comparison of the wise Isaiah. "All flesh is grass, and all the goodliness thereof is as the flower of the field." Truly the rapid flow of life, the short gratification and pleasure that an instant of happiness gives a man, all wonderfully suit the comparison of the prophet. Today he is vigorous in body, fattened by luxury, and in the prime of life, with complexion fair like the flowers, strong and powerful and of irresistible energy; tomorrow and he will be an object of pity, withered by age or exhausted by sickness. Another shines in all the splendour of a brilliant fortune. and around him are a multitude of flatterers, an escort of false friends on the track of his good graces; a crowd of kinsfolk, but of no true kin; a swarm of servants who crowd after him to provide for his food and for all his needs; and in his comings and goings this innumerable suite, which he drags after him, excites the envy of all whom he meets. To fortune may be added power in the State, honours bestowed by the imperial throne, the government of a province, or the command of armies; a herald who precedes him is crying in a loud voice; lictors right and left also fill his subjects with awe, blows, confiscations, banishments, imprisonments, and all the means by which he strikes intolerable terror into all whom he has to rule. And what then? One night, a fever, a pleurisy, or an inflammation of the lungs, snatches away this man from the midst of men, stripped in a moment of all his stage accessories, and all this, his glory, is proved a mere dream. Therefore the Prophet has compared human glory to the weakest flower.

3. Up to this point, the order in which plants shoot bears witness to their first arrangement. Every herb, every plant proceeds from a germ... A single plant, a blade of grass is sufficient to occupy all your intelligence in the contemplation of the skill which produced it. Why is the wheat stalk better with joints? Are they not like fastenings, which help it to bear easily the weight of the ear, when it is swollen with fruit and bends towards the earth? Thus, whilst oats, which have no weight to bear at the top, are without these supports, nature has provided them for wheat. It has hidden the grain in a case, so that it may not be exposed to birds' pillage, and has furnished it with a rampart of barbs, which, like darts, protect it against the attacks of tiny creatures.

4. What shall I say? What shall I leave unsaid? In the rich treasures of creation it is difficult to select what is most precious; the loss of what is omitted is too severe. "Let the earth bring forth grass;" and instantly, with useful plants, appear noxious plants; with corn, hemlock; with the other nutritious plants, hellebore, monkshood, mandrake and the juice of the poppy. What then? Shall we show no gratitude for so many beneficial gifts, and reproach the Creator for those which may be harmful to our life? And shall we not reflect that all has not been created in view of the wants of our bellies?

The nourishing plants, which are destined for our use, are close at hand, and known by all the

world. But in creation nothing exists without a reason. The blood of the bull is a poison: ought this animal then, whose strength is so serviceable to man, not to have been created, or, if created, to have been bloodless? But you have sense enough in yourself to keep you free from deadly things. What! Sheep and goats know how to turn away from what threatens their life, discerning danger by instinct alone: and you, who have reason and the art of medicine to supply what you need, and the experience of your forebears to tell you to avoid all that is dangerous, you tell me that you find it difficult to keep yourself from poisons! But not a single thing has been created without reason, not a single thing is useless. One Serves as food to some animal; medicine has found in another a relief for one of our maladies... These plants, then, instead of making you accuse the Creator, give you a new subject for gratitude.

5. "Let the earth bring forth grass." What spontaneous provision is Included in these words — that which is present in the root, in the plant itself, and in the fruit, as well as that which our labour and husbandry dd! God did not command the earth immediately to give forth seed and fruit, but to produce germs, to grow green, and to arrive at maturity in the seed; so that this first command teaches nature what she has to do in the course of ages. But, they ask, is it true that the earth produces seed after his kind, when often, after having sown wheat, we gather black grain? This is not a change of kind, but an alteration, a disease of the grain. It has not ceased to be wheat; it is on account of having been burnt that it is black, as one can learn from its name. If a severe frost had burnt it, it would have had another colour and a different flavour. They even pretend that, if it could find suitable earth and moderate temperature, it might return to its first form. Thus, you find nothing in nature contrary to the divine command.

As to the darnel and all those bastard grains which mix themselves with the harvest, the tares of Scripture, far from being a variety of corn, have their own origin and their own kind; image of those who alter the doctrine of the Lord and, not being rightly instructed in the word, but, corrupted by the teaching of the evil one, mix themselves with the sound body of the Church to spread their pernicious errors secretly among purer souls. The Lord thus compares the perfection of those who believe in Him to the growth of seed, "as if a man should cast seed into the ground; and should sleep and rise, night and day, and the seed should spring and grow up, he knoweth not how. For the earth bringeth forth fruit of herself; first the blade, then the ear, after that the full corn in the ear."

"Let the earth bring forth grass." In a moment earth began by germination to obey the laws of the Creator, completed every stage of growth, and brought germs to perfection. The meadows were covered with deep grass, the fertile plains quivered with harvests, and the movement of the corn was like the waving of the sea. Every plant, every herb, the smallest shrub, the least vegetable, arose from the earth in all its luxuriance. There was no failure in this first vegetation: no husbandman's inexperience, no inclemency of the weather, nothing could injure it; then the sentence of condemnation was not fettering the earth's fertility. All this was before the sin which condemned us to eat our bread by the sweat of our brow.

6. "Let the earth," the Creator adds, "bring forth the fruit tree yielding fruit after his kind, whose seed is in itself." At this command every copse was thickly planted; all the trees, fir, cedar, cypress, pine, rose to their greatest height, the shrubs were straightway clothed with thick foliage. The plants called crown-plants, roses, myrtles, laurels, did not exist; in one moment they came into being, each one with its distinctive peculiarities. Most marked differences separated them from other plants, and each one was distinguished by a character of its own. But then the rose was without thorns; since then the thorn has been added to its beauty, to make us feel that sorrow is very near to pleasure, and to remind us of our sin, which condemned the earth to produce thorns and caltrops...

8. Plants reproduce themselves in so many different ways, that we can only touch upon the chief among them. As to fruits themselves, who could review their varieties, their forms, their colours, the peculiar flavour, and the use of each of them?... Nothing has been done without motive, nothing by chance. All shows ineffable wisdom.

9. ..."Let the earth bring forth the fruit tree yielding fruit." Immediately the tops of the mountains were covered with foliage: paradises were artfully laid out, and an infinitude of plants embellished the banks of the rivers. Some were for the adornment of man's table; some to nourish animals with their fruits and their leaves; some to provide medicinal help by giving us their sap, their juice, their chips, their bark or their fruit. In a word, the experience of ages, profiting from every chance, has not been able to discover anything useful, which the penetrating foresight of the Creator did not first perceive and call into existence...

10. "Let the earth bring forth." This short command was in a moment a vast nature, an elaborate system. Swifter than thought it produced the countless qualities of plants. It is this command which, still at this day, is imposed on the earth, and in the course of each year displays all the strength of its power to produce herbs, seeds and trees. Like tops, which after the first impulse, continue their evolutions, turning upon themselves when once fixed in their centre; thus nature, receiving the impulse of this first command, follows without interruption the course of ages, until the consummation of all things. Let us all hasten to attain to it, full of fruit and of good works; and thus, planted in the house of the Lord we shall flourish in the court of our God, in our Lord Jesus Christ, to whom be glory and power for ever and ever. Amen.

Homily VI — The Creation of Luminous Bodies

1. At the shows in the circus the spectator must join in the efforts of the athletes. This the laws of the show indicate, for they prescribe that all should have the head uncovered when present at the stadium. The object of this, in my opinion, is that each one there should not only be a spectator of the athletes, but be, in a certain measure, a true athlete himself. Thus, to investigate the great and prodigious show of creation, to understand supreme and ineffable wisdom, you must bring personal light for the contemplation of the wonders which I spread before your eyes, and help me, according to your power, in this struggle, where you are not so much judges as fellow combatants, for fear lest the truth might escape you, and lest my error might turn to your common prejudice.

Why these words? It is because we propose to study the world as a whole, and to consider the universe, not by the light of worldly wisdom, but by that with which God wills to enlighten His servant, when He speaks to him in person and without enigmas. It is because it is absolutely necessary that all lovers of great and grand shows should bring a mind well prepared to study them. If sometimes, on a bright night, whilst gazing with watchful eyes on the inexpressible beauty of the stars, you have thought of the Creator of all things; if you have asked yourself who it is that has dotted heaven with such flowers, and why visible things are even more useful than beautiful; if sometimes, in the day, you have studied the marvels of light, if you have raised yourself by visible things to the invisible Being, then you are a well prepared auditor, and you can take your place in this august and blessed amphitheatre.

Come in the same way that any one not knowing a town is taken by the hand and led through it; thus I am going to lead you, like strangers, through the mysterious marvels of this great city of the universe. Our first country was in this great city, whence the murderous daemon whose enticements seduced man to slavery expelled us. There you will see man's first origin and his immediate seizure by death, brought forth by sin, the first born of the evil spirit. You will know that you are formed of earth, but the work of God's hands; much weaker than the brute, but ordained to command beings without reason and soul; inferior as regards natural advantages, but, thanks to the privilege of reason, capable of raising yourself to heaven.

If we are penetrated by these truths, we shall know ourselves, we shall know God, we shall adore our Creator, we shall serve our Master, we shall glorify our Father, we shall love our Sustainer, we shall bless our Benefactor, we shall not cease to honour the Prince of present and future life, Who, by the riches that He showers upon us in this world, makes us believe in His promises and uses present good things to strengthen our expectation of the future. Truly, if such are the good things of time, what will be those of eternity? If such is the beauty of visible things, what shall we think of invisible things? If the grandeur of heaven exceeds the measure of human intelligence, what mind shall be able to trace the nature of the everlasting? If the sun, subject to corruption, is so beautiful, so grand, so rapid in its movement, so invariable in its course; if its grandeur is in such perfect harmony with and due proportion to the universe: if, by the beauty of its nature, it shines like a brilliant eye in the middle of creation; if finally, one cannot tire of contemplating it, what will be the beauty of the Sun of Righteousness? If the blind man suffers from not seeing the material sun, what a deprivation is it for the sinner not to enjoy the true light!

2. "And God said, Let there be lights in the firmament of the heaven to give light upon the earth, and to divide the day from the night." Heaven and earth were the first; after them was created light; the day had been distinguished from the night, then had appeared the firmament and the dry element. The water had been gathered into the reservoir assigned to it, the earth displayed its productions, it had caused many kinds of herbs to germinate and it was adorned with all kinds of plants. However, the sun and the moon did not yet exist, in order that those who live in ignorance of God may not consider the sun as the origin and the father of light, or as the maker of all that grows out of the earth. That is why there was a fourth day, and then God said: "Let there be lights in the firmament of the heaven."

When once you have learnt Who spoke, think immediately of the hearer. God said, "Let there be lights.. .and God made two great lights." Who spoke? And Who made? Do you not see a double Person? Everywhere, in mystic language, history is sown with the dogmas of theology.

The motive follows which caused the lights to be created. It was to illuminate the earth. Already light was created; why therefore say that the sun was created to give light? And, first, do not laugh at the strangeness of this expression. We do not follow your nicety about words, and we trouble ourselves but little to give them a harmonious turn. Our writers do not amuse themselves by polishing their periods, and everywhere we prefer clearness of words to sonorous expressions. See then if by this expression "to light up," the sacred writer sufficiently made his thought understood. He has put "to give light" instead of "illumination." Now there is nothing here contradictory to what has been said of light. Then the actual nature of light was produced: now the sun's body is constructed to be a vehicle for that original light. A lamp is not fire. Fire has the property of illuminating, and we have invented the lamp to light us in darkness. In the same way, the luminous bodies have been fashioned as a vehicle for that pure, clear, and immaterial light. The Apostle speaks to us of certain lights which shine in the world without being confounded with the true light of the world, the possession of which made the saints luminaries of the souls which they instructed and drew from the darkness of ignorance. This is why the Creator of all things, made the sun in addition to that glorious light, and placed it shining in the heavens.

7....If the origin of our virtues and of our vices is not in ourselves, but is the fatal consequence of our birth, it is useless for legislators to prescribe for us what we ought to do, and what we ought to avoid; it is useless for judges to honour virtue and to punish vice. The guilt is not in the robber, not in the assassin: it was willed for him; it was impossible for him to hold back his hand, urged to evil by inevitable necessity. Those who laboriously cultivate the arts are the maddest of men. The labourer will make an abundant harvest without sowing seed and without sharpening his sickle. Whether he wishes it or not, the merchant will make his fortune, and will be flooded with riches by

fate. As for us Christians, we shall see our great hopes vanish, since from the moment that man does not act with freedom, there is neither reward for justice, nor punishment for sin. Under the reign of necessity and of fatality there is no place for merit, the first condition of all righteous judgment. But let us stop. You who are sound in yourselves have no need to hear more, and time does not allow us to make attacks without limit against these unhappy men [astrologers].

8. Let its return to the words which follow. "Let them be for signs and for seasons and for days and years." We have spoken about signs. By times, we understand the succession of seasons, winter, spring, summer and autumn, which we see follow each other in so regular a course, thanks to the regularity of the movement of the luminaries...

...I have entered into these details, to show you the grandeur of the luminaries, and to make you see that, in the inspired words, there is not one idle syllable. And yet my sermon has scarcely touched on any important point; there are many other discoveries about the size and distance of the sun and moon to which any one who will make a serious study of their action and of their characteristics may arrive by the aid of reason. Let me then ingenuously make an avowal of my weakness, for fear that you should measure the mighty works of the Creator by my words. The little that I have said ought the rather to make you conjecture the marvels on which I have omitted to dwell. We must not then measure the moon with the eye, but with the reason. Reason, for the discovery of truth, is much surer than the eye...

But enough on the greatness of the sun and moon. May He Who has given us intelligence to recognise in the smallest objects of creation the great wisdom of the Contriver make us find in great bodies a still higher idea of their Creator. However, compared with their Author, the sun and moon are but a fly and an ant. The whole universe cannot give us a right idea of the greatness of God; and it is only by signs, weak and slight in themselves, often by the help of the smallest insects and of the least plants, that we raise ourselves to Him. Content with these words let us offer our thanks, I to Him who has given me the ministry of the Word, you to Him who feeds you with spiritual food; Who, even at this moment, makes you find in my weak voice the strength of barley bread. May He feed you for ever, and in proportion to your faith grant you the manifestation of the Spirit in Jesus Christ our Lord, to whom be glory and power for ever and ever. Amen.

Homily VII — The Creation of Moving Creatures

1. "And God said, Let the waters bring forth abundantly the moving creature that hath life" after their kind, "and fowl that may fly above the earth" after their kind. After the creation of the luminaries the waters are now filled with living beings and its own adornment is given to this part of the world. Earth had received hers from her own plants, the heavens had received the flowers of the stars, and, like two eyes, the great luminaries beautified them in concert. It still retained for the waters to receive their adornment. The command was given, and immediately the rivers and lakes becoming fruitful brought forth their natural broods; the sea travailed with all kinds of swimming creatures; not even in mud and marshes did the water remain idle; it took its part in creation. Everywhere from its ebullition frogs, gnats and flies came forth. For that which we see today is the sign of the past. Thus everywhere the water hastened to obey the Creator's command. Who could count the species which the great and ineffable power of God caused to be suddenly seen living and moving, when this command had empowered the waters to bring forth life? Let the waters bring forth moving creatures that have life. Then for the first time is made a being with life and feeling. For though plants and trees be said to live, seeing that they share the power of being nourished and growing; nevertheless they are neither living beings, nor have they life. To create these last God said, "Let the water produce moving creatures."

Every creature that swims, whether it skims on the surface of the waters, or cleaves the depths, is of the nature of a moving creature, since it drags itself on the body of the water. Certain aquatic

animals have feet and walk; especially amphibia, such as seals, crabs, crocodiles, river horses and frogs; but they are above all gifted with the power of swimming. Thus it is said, Let the waters produce moving creatures. In these few words what species is omitted? Which is not included in the command of the Creator? Do we not see viviparous animals, seals, dolphins, rays and all cartilaginous animals? Do we not see oviparous animals comprising every sort of fish, those which have a skin and those which have scales, those which have fins and those which have not? This command has only required one word, even less than a word, a sign, a motion of the divine will, and it has such a wide sense that it includes all the varieties and all the families of fish. To review them all would be to undertake to count the waves of the ocean or to measure its waters in the hollow of the hand. "Let the waters produce moving creatures." That is to say, those which people the high seas and those which love the shores; those which inhabit the depths and those which attach themselves to rocks; those which are gregarious and those which live dispersed, the cetaceous, the huge, and the tiny. It is from the same power, the same command, that all, small and great receive their existence. "Let the waters bring forth."...

2. "Let the waters bring forth moving creatures after their kind." God caused to be born the firstlings of each species to serve as seeds for nature. Their multitudinous numbers are kept up in subsequent succession, when it is necessary for them to grow and multiply...

3....Instances have, however, been known of migratory fish, who, as if common deliberation transported them into strange regions, all start on their march at a given sign. When the time marked for breeding arrives, they, as if awakened by a common law of nature, migrate from gulf to gulf, directing their course toward the North Sea. And at the epoch of their return you may see all these fish streaming like a torrent across the Propontis towards the Euxine Sea. Who puts them in marching array? Where is the prince's order? Has an edict affixed in the public place indicated to them their day of departure? Who serves them as a guide? See how the divine order embraces all and extends to the smallest object. A fish does not resist God's law, and we men cannot endure His precepts of salvation! Do not despise fish because they are dumb and quite unreasoning; rather fear lest, in your resistance to the disposition of the Creator, you have even less reason than they.

Listen to the fish, who by their actions all but speak and say: it is for the perpetuation of our race that we undertake this long voyage. They have not the gift of reason, but they have the law of nature firmly seated within them, to show them what they have to do. Let us go, they say, to the North Sea. Its water is sweeter than that of the rest of the sea; for the sun does not remain long there, and its rays do not draw up all the drinkable portions. Even sea creatures love fresh water. Thus one often sees them enter into rivers and swim far up them from the sea. This is the reason which makes them prefer the Euxine Sea to other gulfs, as the most fit for breeding and for bringing up their young. When they have obtained their object the whole tribe returns home. Let us hear these dumb creatures tell us the reason. The Northern sea, they say, is shallow and its surface is exposed to the violence of the wind, and it has few shores and retreats. Thus the winds easily agitate it to its bottom and mingle the sands of its bed with its waves. Besides, it is cold in winter, filled as it is from all directions by large rivers. Wherefore after a moderate enjoyment of its waters, during the summer, when the winter comes they hasten to reach warmer depths and places heated by the sun, and after fleeing froth the stormy tracts of the North, they seek a haven in less agitated seas.

5. I myself have seen these marvels, and I have admired the wisdom of God in all things. If beings deprived of reason are capable of thinking and of providing for their own preservation; if a fish knows what it ought to seek and what to shun, what shall we say, who are honoured with reason, instructed by law, encouraged by the promises, made wise by the Spirit, and are nevertheless less reasonable about our own affairs than the fish? They know how to provide for the future, but we renounce our hope of the future and spend our life in brutal indulgence. A fish traverses the extent

of the sea to find what is good for it; what will you say then — you who live in idleness, the mother of all vices? Do not let any one make his ignorance an excuse. There has been implanted in us natural reason which tells us to identify ourselves with good, and to avoid all that is harmful.. .God has foreseen all, He has neglected nothing. His eye, which never sleeps, watches over all. He is present everywhere and gives to each being the means of preservation. If God has not left the sea urchin outside His providence, is He without care for you?

Homily VIII — The Creation of Fowl and Water Animals

1. And God said "Let the earth bring forth the living creature after his kind, cattle and creeping things, and beast of the earth after his kind; and it was so." The command of God advanced step by step and earth thus received her adornment. Yesterday it was said, "Let the waters produce moving things," and today "let the earth bring forth the living creature." Is the earth then alive? And are the mad-minded Manichaeans right in giving it a soul? At these words "Let the earth bring forth," it did not produce a germ contained in it, but He who gave the order at the same time gifted it with the grace and power to bring forth. When the earth had heard this command "Let the earth bring forth grass and the tree yielding fruit," it was not grass that it had hidden in it that it caused to spring forth, it did not bring to the surface a palm tree, an oak, a cypress, hitherto kept back in its depths. It is the word of God which forms the nature of things created. "Let the earth bring forth;" that is to say not that she may bring forth that which she has but that she may acquire that which she lacks, when God gives her the power. Even so now, "Let the earth bring forth the living creature," not the living creature that is contained in herself, but that which the command of God gives her. Further, the Manichaeans contradict themselves, because if the earth has brought forth the life, she has left herself despoiled of life. Their execrable doctrine needs no demonstration...

2. "Let the earth bring forth a living soul." Why did the earth produce a living soul? So that you may make a difference between the soul of cattle and that of man. You will soon learn how the human soul was formed; hear now about the soul of creatures devoid of reason. Since, according to Scripture, "the life of every creature is in the blood," as the blood when thickened changes into flesh, and flesh when corrupted decomposes into earth, so the soul of beasts is naturally an earthy substance. "Let the earth bring forth a living soul." See the affinity of the soul with blood, of blood with flesh, of flesh with earth; and remounting in an inverse sense from the earth to the flesh, from the flesh to the blood, from the blood to the soul, you will find that the soul of beasts is earth. Do not suppose that it is older than the essence of their body, nor that it survives the dissolution of the flesh; avoid the nonsense of those arrogant philosophers who do not blush to liken their soul to that of a dog; who say that they have been formerly themselves women, shrubs, fish. Have they ever been fish? I do not know; but I do not fear to affirm that in their writings they show less sense than fish.

"Let the earth bring forth the living creature." Perhaps many of you ask why there is such a long silence in the middle of the rapid rush of my discourse. The more studious among my auditors will not be ignorant of the reason why words fail me. What! Have I not seen them look at each other, and make signs to make me look at them, and to remind me of what I have passed over? I have forgotten a part of the creation, and that one of the most considerable, and my discourse was almost finished without touching upon it. "Let the waters bring forth abundantly the moving creature that hath life and fowl that may fly above the earth in the open firmament, of heaven." I spoke of fish as long as eventide allowed: today we have passed to the examination of terrestrial animals; between the two, birds have escaped us. We are forgetful like travellers who unmindful of some important object, are obliged, although they be far on their road, to retrace their steps, punished for their negligence by the weariness of the journey. So we have to turn back. That which we have omitted is not to be despised. It is the third part of the animal creation, if indeed there are three kinds of animals, land, winged and water.

"Let the waters" it is said "bring forth abundantly moving creature that hath life and fowl that may fly above the earth in the open firmament of heaven." Why do the waters give birth also to birds? Because there is, so to say, a family link between the creatures that fly and those that swim. In the same way that fish cut the waters, using their fins to carry them forward and their tails to direct their movements round and round and straightforward, so we see birds float in the air by the help of their wings. Both endowed with the property of swimming, their common derivation from the waters has made them of one family.

At the same time no bird is without feet, because finding all its food upon the earth it cannot do without their service. Rapacious birds have pointed claws to enable them to close on their prey; to the rest has been given the indispensable ministry of feet to seek their food and to provide for the other needs of life. There are a few who walk badly, whose feet are neither suitable for walking nor for preying. Among this number are swallows, incapable of walking and seeking their prey, and the birds called swifts who live on little insects carried about by the air. As to the swallow, its flight, which grazes the earth, fulfils the function of feet.

4. What a variety, I have said, in the actions and lives of flying creatures. Some of these unreasoning creatures even have a government, if the feature of government is to make the activity of all the individuals centre in one common end. This may be observed in bees.

They have a common dwelling place; they fly in the air together, they work at the same work together ... The book of Proverbs has given the bee the most honourable and the best praise by calling her wise and industrious. How much activity she exerts in gathering this precious nourishment, by which both kings and men of low degree are brought to health! How great is the art and cunning she displays in the construction of the store houses which are destined to receive the honey! After having spread the wax like a thin membrane, she distributes it in contiguous compartments which, weak though they are, by their number and by their mass, sustain the whole edifice. Each cell in fact holds to the one next to it, and is separated by a thin partition; we thus see two or three galleries of cells built one upon the other. The bee takes care not to make one vast cavity, for fear it might break trader the weight of the liquid, and allow it to escape. See how the discoveries of geometry are mere by-works to the wise bee!

The rows of honey-comb are all hexagonal with equal sides. They do not bear on each other in straight lines, lest the supports should press on empty spaces between and give way; but the angles of the lower hexagons serve as foundations and bases to those which rise above, so as to furnish a sure support to the lower mass, and so that each cell may securely keep the liquid honey.

5. How shall we make an exact review of all the peculiarities of the life of birds?.. .If divine Providence has established these marvellous laws in favour of creatures devoid of reason, it is to induce you to ask for your salvation from God. Is there a wonder which He will not perform for you — you have been made in His image, when for so little a bird, the great, the fearful sea is held in check and is commanded in the midst of winter to be calm.

7. "Let the waters bring forth the moving creatures that have life, and fowl that may fly above the earth in the open firmament of heaven." They received the command to fly above the earth because earth provides them with nourishment. "In the firmament of heaven," that is to say, as we have said before, in that part of the air called Ouranos, heaven, from the word horan, which means to see; called firmament, because the air which extends over our heads, compared to the ether, has greater density, and is thickened by the vapours which exhale from the earth. You have then heaven adorned, earth beautified, the sea peopled with its own creatures, the air filled with birds which scour it in every direction. Studious listener, think of all these creations which God has drawn out of nothing, think of all those which my speech has left out, to avoid tediousness, and not

to exceed my limits; recognise everywhere the wisdom of God; never cease to wonder, and, through, every creature, to glorify the Creator.

...Our God has created nothing unnecessarily and has omitted nothing that is necessary.

8. If we simply read the words of Scripture we find only a few short syllables. "Let the waters bring forth fowl that may fly above the earth in the open firmament of heaven," but if we enquire into the meaning of these words, then the great wonder of the wisdom of the Creator appears. What a difference He has foreseen among winged creatures! How He has divided them by kinds! How He has characterized each one of them by distinct qualities! But the day will not suffice me to recount the wonders of the air. Earth is calling me to describe wild beasts, reptiles and cattle, ready to show us in her turn sights rivalling those of plants, fish, and birds. "Let the earth bring forth the living soul" of domestic animals, of wild beasts, and of reptiles after their kind...

...May He who has filled all with the works of His creation and has left everywhere visible memorials of His wonders, fill your hearts with all spiritual joys in Jesus Christ, our Lord, to whom belong glory and power, world without end. Amen.

Homily IX — The Creation of Terrestrial Animals

1....I know the laws of allegory, though less by myself than from the works of others. There are those truly, who do not admit the common sense of the Scriptures, for whom water is not water, but some other nature, who see in a plant, in a fish, what their fancy wishes, who change the nature of reptiles and of wild beasts to suit their allegories, like the interpreters of dreams who explain visions in sleep to make them serve their own ends. For me grass is grass; plant, fish, wild beast, domestic animal, I take all in the literal sense. "For I am not ashamed of the gospel."

Those who have written about the nature of the universe have discussed at length the shape of the earth. If it be spherical or cylindrical, if it resemble a disc and is equally rounded in all parts, or if it has the forth of a winnowing basket and is hollow in the middle; all these conjectures have been suggested by cosmographers, each one upsetting that of his predecessor. It will not lead me to give less importance to the creation of the universe, that the servant of God, Moses, is silent as to shapes; he has not said that the earth is a hundred and eighty thousand furlongs in circumference; he has not measured into what extent of air its shadow projects itself whilst the sun revolves around it, nor stated how this shadow, casting itself upon the moon, produces eclipses. He has passed over in silence, as useless, all that is unimportant for us.

Shall I then prefer foolish wisdom to the oracles of the Holy Spirit? Shall I not rather exalt Him who, not wishing to fill our minds with these vanities, has regulated all the economy of Scripture in view of the edification and the making perfect of our souls? It is this which those seem to me not to have understood, who, giving themselves up to the distorted meaning of allegory, have undertaken to give a majesty of their own invention to Scripture. It is to believe themselves wiser than the Holy Spirit, and to bring forth their own ideas under a pretext of exegesis. Let us hear Scripture as it has been written.

2. "Let the earth bring forth thee living creature." Behold the word of God pervading creation, beginning even then the efficacy which is seen displayed today, and will be displayed to the end of the world! As a ball, which one pushes, if it meet a declivity, descends, carried by its form and the nature of the ground and does not stop until it has reached a level surface; so nature, once put in motion by the Divine command, traverses creation with an equal step, through birth and death, and keeps up the succession of kinds through resemblance, to the last. Nature always makes a horse succeed to a horse, a lion to a lion, an eagle to an eagle, and preserving each animal by these uninterrupted successions she transmits it to the end of all things. Animals do not see their

peculiarities destroyed or effaced by any length of time; their nature, as though it had been just constituted, follows the course of ages, for ever young.

"Let the earth bring forth the living creature." This command has continued and earth does not cease to obey the Creator. For, if there are creatures which are successively produced by their predecessors, there are others that even today we see born from the earth itself. In wet weather she brings forth grasshoppers and an immense number of insects which fly in the air and have no names because they are so small; she also produces mice and frogs. In the environs of Thebes in Egypt, after abundant rain in hot weather, the country is covered with field mice. We see mud alone produce eels; they do not proceed from an egg, nor in any other manner; it is the earth alone which gives them birth. "Let the earth produce a living creature."

Cattle are terrestrial and bent towards the earth. Man, a celestial growth, rises superior to them as much by the mould of his bodily conformation as by the dignity of his soul. What is the form of quadrupeds? Their head is bent towards the earth and looks towards their belly, and only pursues their belly's good. Thy head, O man! is turned towards heaven; thy eyes look up. When therefore thou degradest thyself by the passions of the flesh, slave of thy belly, and thy lowest parts, thou approachest animals without reason and becomest like one of them. Thou art called' to more noble cares; "seek those things which are above where Christ sitteth." Raise thy soul above the earth; draw from its natural conformation the rule of thy conduct; fix thy conversation in heaven. Thy true country is the heavenly Jerusalem; thy fellow-citizens and thy compatriots are "the first-born which are written in heaven."

3. "Let the earth bring forth the living creature." Thus when the soul of brutes appeared it was not concealed in the earth, but it was born by the command of God. Brutes have one and the same soul of which the common characteristic is absence of reason. But each animal is distinguished by peculiar qualities. The ox is steady, the ass is lazy, the horse has strong passions, the wolf cannot be tamed, the fox is deceitful, the stag timid, the ant industrious, the dog grateful and faithful in his friendships. As each animal was created the distinctive character of his nature appeared in him in due measure...

What language can attain to the marvels of the Creator? What ear could understand them? And what time would be sufficient to relate them? Let us say, then, with the prophet, "O Lord, how manifold are thy works! In wisdom hast thou made them all." [Ps 104] We shall not be able to say in self-justification, that we have learnt useful knowledge in books, since the untaught law of nature makes us choose that which is advantageous to us. Do you know what good you ought to do your neighbour? The good that you expect from him yourself. Do you know what is evil? That which you would not wish another to do to you. Neither botanical researches nor the experience of simples have made animals discover those which are useful to them; but each knows naturally what is salutary and marvellously appropriates what suits its nature.

4. Virtues exist in us also by nature, and the soul has affinity with them not by education, but by nature herself. We do not need lessons to hate illness, but by ourselves we repel what afflicts us, the soul has no need of a master to teach us to avoid vice. Now all vice is a sickness of the soul as virtue is its health. Thus those have defined health well who have called it a regularity in the discharge of natural functions; a definition that can be applied without fear to the good condition of the soul. Thus, without having need of lessons, the soul can attain by herself to what is fit and conformable to nature. Hence it comes that temperance everywhere is praised, justice is in honour, courage admired, and prudence the object of all aims; virtues which concern the soul more than health concerns the body. Children love your parents, and you, "parents provoke not your children to wrath." Does not nature say the same? Paul teaches us nothing new; he only tightens the links of nature. If the lioness loves her cubs, if the she wolf fights to defend her little ones, what

shall man say who is unfaithful to the precept and violates nature herself; or the son who insults the old age of his father; or the father whose second marriage has made him forget his first children?

With animals invincible affection unites parents with children. It is the Creator, God Himself, who substitutes the strength of feeling for reason in them. From whence it comes that a lamb as it bounds from the fold, in the midst of a thousand sheep recognises the colour and the voice of its mother, runs to her, and seeks its own sources of milk. If its mother's udders are dry, it is content, and, without stopping, passes by more abundant ones. And how does the mother recognise it among the many lambs? All have the same voice, the same colour, the same smell, as far at least as regards our sense of smell. Yet there is in these animals a more subtle sense than our perception which makes them recognise their own. The little dog has as yet no teeth, nevertheless he defends himself with his mouth against any one who teases him. The calf has as yet no horns, nevertheless he already knows where his weapons will grow. Here we have evident proof that the instinct of animals is innate, and that in all beings there is nothing disorderly, nothing unforeseen. All bear the marks of the wisdom of the Creator, and show that they have come to life with the means of assuring their preservation.

The dog is not gifted with a share of reason; but with him instinct has the power of reason. The dog has learnt by nature the secret of elaborate inferences, which sages of the world, after long years of study, have hardly been able to disentangle. When the dog is on the track of game, if he sees it divide in different directions, he examines these different paths, and speech alone fails him to announce his reasoning. The creature, he says, is gone here or there or in another direction. It is neither here nor there; it is therefore in the third direction. And thus, neglecting the false tracks, he discovers the true one. What more is done by those who, gravely occupied in demonstrating theories, trace lines upon the dust and reject two propositions to show that the third is the true one?...

5. But let us return to the spectacle of creation. The easiest animals to catch are the most productive. It is on account of this that hares and wild goats produce many little ones, and that wild sheep have twins, for fear lest these species should disappear, consumed by carnivorous animals. Beasts of prey, on the contrary, produce only a few and a lioness with difficulty gives birth to one lion; because, if they say truly, the cub issues from its mother by tearing her with its claws; and vipers are only born by gnawing through the womb, inflicting a proper punishment on their mother. Thus in nature all has been foreseen, all is the object of continual care. If you examine the members even of animals, you will find that the Creator has given them nothing superfluous, that He has omitted nothing that is necessary. To carnivorous animals He has given pointed teeth which their nature requires for their support. Those that are only half furnished with teeth have received several distinct receptacles for their food. As it is not broken up enough in the first, they are gifted with the power of returning it after it has been swallowed, and it does not assimilate until it has been crushed by rumination. The first, second, third, and fourth stomachs of ruminating animals do not remain idle; each one of them fulfils a necessary function. The neck of the camel is long so that it may lower it to its feet and reach the grass on which it feeds.

Bears, lions, tigers, all animals of this sort, have short necks buried in their shoulders; it is because they do not live upon grass and have no need to bend down to the earth; they are carnivorous and eat the animals upon whom they prey.

6. Beasts bear witness to the faith. Hast thou confidence in the Lord? "Thou shalt walk upon the asp and the basilisk and thou shalt trample under feet the lion and the dragon." With faith thou hast the power to walk upon serpents and scorpions. Do you not see that the viper which attached itself to the hand of Paul, whilst he gathered sticks, did not injure him, because it found the saint full of

faith? If you have not faith, do not fear beasts so much as your faithlessness, which renders you susceptible of all corruption. But I see that for a long time you have been asking me for an account of the creation of man, and I think I can hear you all cry in your hearts. We are being taught the nature of our belongings, but we are ignorant of ourselves. Let me then speak of it, since it is necessary, and let me put an end to my hesitation.

In truth the most difficult of sciences is to know one's self. Not only our eye, from which nothing outside us escapes, cannot see itself; but our mind, so piercing to discover the sins of others, is slow to recognise its own faults. Thus my speech, after eagerly investigating what is external to myself, is slow and hesitating in exploring my own nature. Yet the beholding of heaven and earth does not make us know God better than the attentive study of our being does; I am, says the Prophet, fearfully and wonderfully made; that is to say,in observing myself I have known Thy infinite wisdom. And God said "Let us make man." Does not the light of theology shine, in these words, as through windows; and does not the second Person show Himself in a mystical way, without yet manifesting Himself until the great day? Where is the Jew who resisted the truth and pretended that God was speaking to Himself? It is He who spoke, it is said, and it is He who made. "Let there be light and there was light."

But then their words contain a manifest absurdity. Where is the smith, the carpenter, the shoemaker, who, without help and alone before the instruments of his trade, would say to himself; let us make the sword, let us put together the plough, let us make the boot? Does he not perform the work of his craft in silence? Strange folly, to say that any one has seated himself to command himself, to watch over himself, to constrain himself, to hurry himself, with the tones of a master! But the unhappy creatures are not afraid to calumniate the Lord Himself. What will they not say with a tongue so well practised in lying?

Here, however, words stop their mouth; "And God said let us make man." Tell me; is there then only one Person? It is not written "Let man be made," but, "Let us make man." The preaching of theology remains enveloped in shadow before the appearance of him who was to be instructed, but, now, the creation of man is expected, that faith unveils herself and the dogma of truth appears in all its light. "Let us make man." "O enemy of Christ, hear God speaking to His Co-operator, to Him by Whom also He made the worlds, Who upholds all things by the word of His power. But He does not leave the voice of true religion without answer. Thus the Jews, race hostile to truth, when they find themselves pressed, act like beasts enraged against man, who roar at the bars of their cage and show the cruelty and the ferocity of their nature, without being able to assuage their fury. God, they say, addresses Himself to several persons; it is to the angels before Him that He says, "Let us make man."

Jewish fiction! A fable whose frivolity shows whence it has come. To reject one person, they admit many. To reject the Son, they raise servants to the dignity of counsellors; they make of our fellow slaves the agents in our creation. The perfect man attains the dignity of an angel; but what creature can be like the Creator? Listen to the continuation. "In our image." What have you to reply? Is there one image of God and the angels? Father and Son have by absolute necessity the same form, but the form is here understood as becomes the divine, not in bodily shape, but in the proper qualities of Godhead.

Hear also, you who belong to the new concision and who, under the appearance of Christianity, strengthen the error of the Jews. To Whom does He say, "in our image," to whom if it is not to Him who is "the brightness of His glory and the express image of His person," "the image of the invisible God"? It is then to His living image, to Him Who has said "I and my Father are one," "He that hath seen me hath seen the Father," that God says "Let us make man in our image." Where is the unlikeness in these Beings who have only one image? "So God created man," It is not "They made."

Here Scripture avoids the plurality of the Persons. After having enlightened the Jew, it dissipates the error of the Gentiles in putting itself under the shelter of unity, to make you understand that the Son is with the Father, and guarding you from the danger of polytheism. He created him in the image of God. God still shows us His co-operator, because He does not say, in His image, but in the image of God.

If God permits, we will say later in what way man was created in the image of God, and how he shares this resemblance. Today we say but only one word. If there is one image, from whence comes the intolerable blasphemy of pretending that the Son is unlike the Father? What ingratitude! You have yourself received this likeness and you refuse it to your Benefactor! You pretend to keep personally that which is in you a gift of grace, and you do not wish that the Son should keep His natural likeness to Him who begat Him.

But evening, which long ago sent the sun to the west, imposes silence upon me. Here, then, let me be content with what I have said, and put my discourse to bed. I have told you enough up to this point to excite your zeal; with the help of the Holy Spirit I will make for you a deeper investigation into the truths which follow. Retire, then, I beg you, with joy, O Christ-loving congregation, and, instead of sumptuous dishes of various delicacies, adorn and sanctify your tables with the remembrance of my words. May the Anomoean be confounded, the Jew covered with shame, the faithful exultant in the dogmas of truth, and the Lord glorified, the Lord to Whom be glory and power, world without end. Amen.

sanity, would deny it; what necessity is there that against the divine nature we should admit this strange thought?

Having heard of Father and Son from the Truth, we are taught in those two subjects the oneness of their nature; their natural relation to each other expressed by those names indicates that nature; and so do Our Lord's own words. For when He said, "I and My Father are one," He conveys by that confession of a Father exactly the truth that He Himself is not a first cause, at the same time that He asserts by His union with the Father their common nature; so that these words of His secure our faith from the taint of heretical error on either side: for Sabellius has no ground for his confusion of the individuality of each Person, when the Only-begotten has so distinctly marked Himself off from the Father in those words, "I and My Father;" and Arius finds no confirmation of his doctrine of the strangeness of either nature to the other, since this oneness of both cannot admit distinction in nature. For that which is signified in these words by the oneness of Father and Son is nothing else but what belongs to them on the score of their actual being; all the other moral excellences which are to be observed in them as over and above their nature may without error be set down as shared in by all created beings...

John Chrysostom (c. 347AD – 407AD), Archbishop of Constantinople
Homilies on John

Homily V — John 1:3
"All things were made by Him; and without Him was not anything made that was made."

1. Moses in the beginning of the history and writings of the Old Testament speaks to us of the objects of sense, and enumerates them to us at length. For, "In the beginning," he says, "God made the heaven and the earth," and then he adds, that light was created, and a second heaven and the stars, the various kinds of living creatures, and, that we may not delay by going through particulars, everything else. But this Evangelist, cutting all short, includes both these things and the things which are above these in a single sentence; with reason, because they were known to his hearers,

and because he is hastening to a greater subject, and has instituted all his treatise, that he might speak not of the works but of the Creator, and Him who produced them all. And therefore Moses, though he has selected the smaller portion of the creation, (for he has spoken nothing to us concerning the invisible powers), dwells on these things; while John, as hastening to ascend to the Creator Himself, runs by both these things, and those on which Moses was silent, having comprised them in one little saying, "All things were made by Him." And that you may not think that he merely speaks of all the things mentioned by Moses, he adds, that "without Him was not anything made that was made." That is to say, that of created things, not one, whether it be visible or intelligible was brought into being without the power of the Son...

2....What (the Evangelist) says is this, "Without Him was not anything made that was made"; whatever created thing was made, says he, was not made without Him. See you how by this short addition he has rectified all the besetting difficulties; for the saying, that "without Him was not anything made," and then the adding, "which was made," includes things cognizable by the intellect, but excludes the Spirit. For after he had said that "all things were made by Him," and "without Him was not anything made," he needed this addition, lest some one should say, "If all things were made by Him, then the Spirit also was made." "I," he replies, "asserted that whatever was made was made by Him, even though it be invisible, or incorporeal, or in the heavens. For this reason, I did not say absolutely, `all things,' but `whatever was made,' that is, 'created things,' but the Spirit is uncreated."

Do you see the precision of his teaching? He has alluded to the creation of material things, (for concerning these Moses had taught before him), and after bringing us to advance from thence to higher things, I mean the immaterial and the invisible, he excepts the Holy Spirit from all creation. And so Paul, inspired by the same grace, said, "For by Him were all things created." (Col 1:16). Observe too here again the same exactness. For the same Spirit moved this soul also.

That no one should except any created things from the works of God because of their being invisible, nor yet should confound the Comforter with them, after running through the objects of sense which are known to all, he enumerates also things in the heavens, saying, "Whether they be thrones, or dominions, or principalities, or powers"; for the expression "whether" subjoined to each, shows to us nothing else but this, that "by Him all things were made, and without Him was not anything made that was made."

But if you think that the expression "by" is a mark of inferiority, (as making Christ an instrument), hear him say, "Thou, Lord, in the beginning, hast laid the foundation of the earth, and the heavens are the work of Thy hands." (Ps. 102:25). He says of the Son what is said of the Father in His character of Creator; which he would not have said, unless he had deemed of Him as of a Creator, and yet not subservient to any. And if the expression "by Him" is here used, it is put for no other reason but to prevent any one from supposing the Son to be Unbegotten. For that in respect of the title of Creator He is nothing inferior to the Father; hear from Himself, where He saith, "As the Father raiseth up the dead and quickeneth them, even so the Son quickeneth whom He will." (John 5:2 1).

If now in the Old Testament it is said of the Son, "Thou, Lord, in the beginning hast laid the foundation of the earth," His title of Creator is plain. But if you say that the Prophet spoke this of the Father, and that Paul attributed to the Son what was said of the Father, even so the conclusion is the same. For Paul would not have decided that the same expression suited the Son, unless he had been very confident that between Father and Son there was an equality of honor; since it would have been an act of extremest rashness to refer what suited an incomparable Nature to a nature inferior to, and falling short of it. But the Son is not inferior to, nor falls short of, the Essence of the Father; and therefore Paul has not only dared to use these expressions concerning

Him, but also others like them. For the expression "from Whom," which you decide to belong properly to the Father alone, he uses also concerning the Son, when he says, "from which all the body by joints and bands having nourishment ministered, and knit together, increaseth with the increase of God." (Col. 2:19).

3. And he is not content with this only, he stops your mouths in another way also, by applying to the Father the expression "by whom," which you say is a mark of inferiority. For he says, "God is faithful, by whom ye were called unto the fellowship of His Son" (1 Cor. 1:9): and again, `By His will" (1 Cor. 1:1 & c.); and in another place, "For of Him, and through Him, and to Him, are all things." (Rom. 11:26). Neither is the expression "from whom," assigned to the Son only, but also to the Spirit; for the angel said to Joseph, "Fear not to take unto thee Mary thy wife, for that which is conceived in her is of the Holy Ghost." (Matt. 1:20). As also the Prophet does not deem it improper to apply to the Father the expression "in whom," which belongs to the Spirit, when he says, "In God we shall do valiantly." (Ps. 60:12). And Paul, "Making request, if by any means now at length I might have a prosperous journey, in the will of God, to come unto you." (Rom. 1:10). And again he uses it of Christ, saying, "In Christ Jesus." (Rom. 6:11, 23 & c.). In short, we may often and continually find these expressions interchanged; now this would not have taken place, had not the same Essence been in every instance their subject. And that you may not imagine that the words, "All things were made by Him," are in this case used concerning His miracles, (for the other Evangelists have discoursed concerning these;) he farther goes on to say, "He was in the world, and the world was made by Him"; (but not the Spirit, for This is not of the number of created things, but of those above all creation).

Let us now attend to what follows. John having spoken of the work of creation, that "All things were made by Him, and without Him was not anything made that was made," goes on to speak concerning His Providence, where he saith, "In Him was Life." That no one may doubt ' how so many and so great things were "made by Him," he adds, that "In Him was Life." For as with the fountain which is the mother of the great deeps, however much you take away you nothing lessen the fountain; so with the energy of the Only-Begotten, however much you believe has been produced and made by it, it has become no whit the less.

Or, to use a more familiar example, I will instance that of light, which the Apostle himself added immediately, saying, "And the Life was the Light." As then light, however many myriads it may enlighten, suffers no diminution of its own brightness; so also God, before commencing His work and after completing it, remains alike indefectible, nothing diminished, nor wearied by the greatness of the creation. Nay, if need were that ten thousand, or even an infinite number of such worlds be created, He remains the same, sufficient for them all not-merely to produce, but also to control them after their creation. For the word "Life" here refers not merely to the act of creation, but also to the providence (engaged) about the permanence of the things created; it also lays down beforehand the doctrine of the resurrection, and is the beginning of these marvelous good tidings. Since when "life" has come to be with us, the power of death is dissolved; and when "light" has shone upon us, there is no longer darkness, but life ever abides within us, and death cannot overcome it. So that what is asserted of the Father might be asserted absolutely of Him (Christ) also, that "In Him we live and move and have our being." (Col. 1:16, Col 1:17). As Paul has shown when he says, `By Him were all things created," and "by Him all things consist"; for which reason He has been called also "Root" and "Foundation."...

John Chrysostom
Homilies on Romans

Homily III — On Romans 1:18
"For the wrath of God is revealed from Heaven against all ungodliness and unrighteousness of men,

who hold down the truth in unrighteousness. "

Ver. 19 — "Because that which may be known of God is manifest in them, for God hath showed it unto them."

...The knowledge of Himself God placed in men from the beginning. But this knowledge they invested stocks and stones with, and so dealt unrighteously to the truth, as far at least as they might. For it abideth unchanged, having its own glory immutable. "And whence is it plain that He placed in them this knowledge, O Paul?" "Because," saith he, "that which may be known of Him is manifest in them." This, however, is an assertion, not a proof. But do thou make it good, and show me that the knowledge of God was plain to them, and that they willingly turned aside. Whence was it plain then? Did He send them a voice from above? By no means. But what was able to draw them to Him more than a voice, that He did, by putting before them the Creation, so that both wise, and unlearned, and Scythian, and barbarian, having through sight learned the beauty of the things which were seen, might mount up to God. Wherefore he says,

Ver. 20 — "For the invisible things of Him from the Creation of the world are clearly seen, being understood by the things which are made."

Which also the prophet said, "The heavens declare the glory of God." (Ps. 19:1). For what will the Greeks (i.e. Heathen) say in that day? That "we were ignorant of Thee?" Did ye then not hear the heaven sending forth a voice by the sight, while the well-ordered harmony of all things spake out more clearly than a trumpet? Did ye not see the hours of night and day abiding unmoved continually, the goodly order of winter, spring, and the other seasons remaining both sure and unmoved, the tractableness (eugnômosunçn) of the sea amid all its turbulence and waves? All things abiding in order and by their beauty and their grandeur, preaching aloud of the Creator? For all these things and more than these doth Paul sum up in saying, "The invisible things of Him from the creation of the world are clearly seen, being understood by the things which are made, even His eternal Power and Godhead; so that they are without excuse." And yet it is not for this God hath made these things, even if this came of it. For it was not to bereave them of all excuse, that He set before them so great a system of teaching, but that they might come to know Him. But by not having recognized Him they deprived themselves of every excuse...

St. Augustine of Hippo (354AD – 430AD)
City of God

Chapter 10 — Of the Simple and Unchangeable Trinity, Father, Son, and Holy Ghost, One God, in Whom Substance and Quality are Identical
...According to this, then, those things which are essentially and truly divine are called simple, because in them quality and substance are identical, and because they are divine, or wise, or blessed in themselves, and without extraneous supplement. In Holy Scripture, it is true, the Spirit of wisdom is called "manifold" because it contains many things in it; but what it contains it also is, and it being one is all these things. For neither are there many wisdoms, but one, in which are untold and infinite treasures of things intellectual, wherein are all invisible and unchangeable reasons of things visible and changeable which were created by it. For God made nothing unwittingly; not even a human workman can be said to do so. But if He knew all that He made, He made only those things which He had known. Whence flows a very striking but true conclusion, that this world could not be known to us unless it existed, but could not have existed unless it had been known to God.

Chapter 16 — Of the Ranks and Differences of the Creatures, Estimated by Their Utility, or

According to the Natural Gradations of Being

For, among those beings which exist, and which are not of God the Creator's essence, those which have life are ranked above those which have none; those that have the power of generation, or even of desiring, above those which want this faculty. And, among things that have life, the sentient are higher than those which have no sensation, as animals are ranked above trees. And, among the sentient, the intelligent are above those that have not intelligence — men, e.g., above cattle. And, among the intelligent, the immortal such as the angels, above the mortal, such as men. These are the gradations according to the order of nature; but according to the utility each man finds in a thing, there are various standards of value, so that it comes to pass that we prefer some things that have no sensation to some sentient beings. And so strong is this preference, that, had we the power, we would abolish the latter from nature altogether, whether in ignorance of the place they hold in nature, or, though we know it, sacrificing them to our own convenience. Who, e.g., would not rather have bread in his house than mice, gold than fleas? But there is little to wonder at in this, seeing that even when valued by men themselves (whose nature is certainly of the highest dignity), more is often given for a horse than for a slave, for a jewel than for a maid. Thus the reason of one contemplating nature prompts very different judgments from those dictated by the necessity of the needy, or the desire of the voluptuous; for the former considers what value a thing in itself has in the scale of creation, while necessity considers how it meets its need; reason looks for what the mental light will judge to be true, while pleasure looks for what pleasantly titilates the bodily sense. But of such consequence in rational natures is the weight, so to speak, of will and of love, that though in the order of nature angels rank above men, yet, by the scale of justice, good men are of greater value than bad angels.

Chapter 17 — That the Flaw of Wickedness is Not Nature, But Contrary to Nature, and Has Its Origin, Not in the Creator, But in the Will

It is with reference to the nature, then, and not to the wickedness of the devil, that we are to understand these words, "This is the beginning of God's handiwork;" for, without doubt, wickedness can be a flaw or vice only where the nature previously was not vitiated. Vice, too, is so contrary to nature, that it cannot but damage it. And therefore departure from God would be no vice, unless in a nature whose property it was to abide With God. So that even the wicked will is a strong proof of the goodness of the nature. But God, as He is the supremely good Creator of good natures, so is He of evil wills the most just Ruler; so that, while they make an ill use of good natures, He makes a good use even of evil wills. Accordingly, He caused the devil (good by God's creation, wicked by his own will) to be cast down from his high position, and to become the mockery of His angels — that is, He caused his temptations to benefit those whom he wishes to injure by them. And because God, when He created him, was certainly not ignorant of his future malignity, and foresaw the good which He Himself would bring out of his evil, therefore says the psalm, "This leviathan whom Thou hast made to be a sport therein," that we may see that, even while God in His goodness created him good, He yet had already foreseen and arranged how He would make use of him when he became wicked.

Chapter 18 — Of the Beauty of the Universe, Which Becomes, by God's Ordinance, More Brilliant by the Opposition of Contraries

For God would never have created any, I do not say angel, but even man, whose future wickedness He foreknew, unless He had equally known to what uses in behalf of the good He could turn him, thus embellishing, the course of the ages, as it were an exquisite poem set off with antitheses. For what are called antitheses are among the most elegant of the ornaments of speech. They might be called in Latin "oppositions," or, to speak more accurately, "contrapositions;" but this word is not in common use among us, though the Latin, and indeed the languages of all nations, avail themselves of the same ornaments of style. In the Second Epistle to the Corinthians the Apostle Paul also makes a graceful use of antithesis, in that place where he says, `By the armor of righteousness on the right hand and on the left, by honor and dishonor, by evil report and good report: as deceivers,

and yet true; as unknown, and yet well known; as dying, and, behold, we live; as chastened, and not killed; as sorrowful, yet always rejoicing; as poor, yet making many rich; as having nothing, and yet possessing all things." As, then, these oppositions of contraries lend beauty to the language, so the beauty of the course of this world is achieved by the opposition of contraries, arranged, as it were, by an eloquence not of words, but of things. This is quite plainly stated in the Book of Ecclesiasticus, in this way: "Good is set against evil, and life against death: so is the sinner against the godly. So look upon all the works of the Most High, and these are two and two, one against another."

Maximus the Confessor (c. 580AD –662AD)
Ambigua (discussion of difficulties in the writings of St Gregory the Theologian)

Difficulty 10

17 — Contemplation of the Transfiguration of the Lord
... Whence in both cases I think it necessarily follows that anyone who wishes may live an upright and blameless life with God, whether through scriptural understanding in the Spirit, or through the natural contemplation of reality in accordance with the Spirit. So the two laws — both the natural law and the written law — are of equal honour and teach the same things; neither is greater or less than the other, which shows, as is right, that the lover of perfect wisdom may become the one who desires wisdom perfectly.

26 — Contemplation that the one who follows Christ transcends law and nature
For the whole nature of reality is divided into the intelligible and the sensible. There is that which is said to be and is eternal, since it receives the beginning of its being in eternity, and that which is temporal, since it is made in time; there is that which is subject to intellection, and that which is subject to the power of sense-perception. The entities on each side of this division are naturally related to each other through an indissoluble power that binds them together. Manifold is the relation between intellects and what they perceive and between the senses and what they experience. Thus the human being, consisting of both soul and sensible body, by means of its natural relationship of belonging to each division of creation, is both circumscribed and circumscribes: through being, it is circumscribed, and through potency, it circumscribes. So in its two parts it is divided between these things, and it draws these things through their own parts into itself in unity. For the human being is circumscribed by both the intelligible and the sensible, since it is soul and body, and it has the natural capacity of circumscribing them, because it can both think and perceive through the senses. God is simply and indefinably beyond all things, both what circumscribes and what is circumscribed and the nature of those [categories] without which none of these could be, I mean, time and eternity and space, by which the universe is enclosed, since He is completely unrelated to anything. Since all this is so, the one who discerns with sagacity how he ought to love God, the transcendent nature, that is beyond reason and knowledge and any kind of relationship whatever, passes without relation through everything sensible and intelligible and all time and eternity and space. Finally he is supernaturally stripped bare of every energy that operates in accordance with sense or reason or mind, and ineffably and unknowably attains the divine delight that is beyond reason and mind, in the form and fashion that God who gives such grace knows and those who are worthy of receiving this form God understand. He no longer bears about with him anything natural or written, since everything that he could read or know is now utterly transcendent and wrapped in silence.

35 — Contemplation of how God is understood from creation
So therefore when the Saints behold the creation, and its fine order and proportion and the need that each part has of the whole, and how all the perfect parts have been fashioned wisely and with

providence in accordance with reason that fashioned them, and how what has come to be is found to be not otherwise than good beside what now is, and is in need of no addition or subtraction in order to be otherwise good, they are taught from the things he has made that there is one who fashioned them. So, too, when they see the permanence, the order and position of what has come to be, and its manner of being, in accordance with which each being, according to its proper form, is preserved unconfused and without any disorder; and the course of the stars proceeding in the same way with no alteration of any kind, and the circle of the year proceeding in an orderly manner according to the periodic return of the [heavenly bodies] from and to their own place, and the equal yearly proportion of the nights and days, with their mutual increase and decrease, taking place according to a measure that is neither too small nor too great, they understand that behind everything there is providence, and this they acknowledge as God, the fashioner of all.

36 — Contemplation that the world has a beginning
For who, seeing the beauty and greatness of God's creatures, does not immediately understand that He has brought all this into being, as the beginning and source of beings and their maker? In his understanding he returns to Him alone, leaving behind all these things. For though he cannot accomplish the complete transition with his mind, or receive without intermediary the object of his desires which he knows through the mediation of its effects, he can readily put away the error that the world is without beginning, as he reasons truly that everything that moves must certainly begin to move. No motion is without beginning, since it is not without cause. For motion has a beginning, and a cause from which it is called and an end to which it is drawn....

41 — On the dyad and the monad
But it has been shown that from God, who eternally is, everything has come to be completely and wholly from nothing, not partially or incompletely, as proceeding wisely from a source that is infinitely wise and infinitely powerful, and that everything is held together in it, as protected and supported in an all-powerful foundation, and that everything will return to it, as each to its own goal, as the great Denys the Areopagite has said somewhere.

42 — Contemplation of divine providence
Anyone who is convinced that God exercises providence over the things that are, from which he has learnt that he exists, will judge it right and reasonable that he is none other than the guardian of the things that are and cares for them and that he alone is the fashioner of what is. For the permanence of what is, and its order and position and movement and the consonance of the extremities with the middle, the agreement of the parts with the wholes, and the union throughout of the wholes with the parts, and the unblurred distinction of the parts one from another in accordance with the individuating difference of each, and the unconfused union in accordance with the indistinguishable sameness in the wholes, and the combination and distinction of everything with everything else (not to limit myself to particulars), and the eternally preserved succession of everything and each one according to form, so that the logos of each nature is not corrupted by confusion or blurring — all this shows clearly that everything is held together by the providence of the Creator God. For it is not the case that God is good but not beneficent, or beneficent but without providence, and therefore he cares wisely for the things that are and in a way befitting God, so that they are favoured with existence and care.

Providence is, then, according to the God — bearing Fathers, the care that comes from God to the things that are. They also define it thus: providence is the will of God through which everything that is receives suitable direction. If this will is God's, if I may use the very words of my teachers, then it necessarily follows that what happens, happens in accordance with right reason, and so no better disposition could be looked for. One who has chosen to take truth as his guide is therefore led to say that providence is either the one who is truly known to be the Creator or is a power exercised by the Creator of all things. And with animals, if we approach them in a rational way we

shall find a trace of the intelligible in them which is a not unworthy imitation of what is above reason. For if we look at those beings that naturally care for their offspring, we are encouraged to define for ourselves reverently and with godly boldness that God exercises providence in his sovereign uniqueness over all beings, and not over some beings but not others, as some of the adepts of the "outer learning" have it, but of absolutely everything, in accordance with the one and indistinguishable will of goodness, and indeed of both universals and particulars, for we know that if particulars can perish because they are not within the remit of providence and fitting protection, then universals will perish with them (for universals consist of particulars), in this way propounding a rational demonstration that rightly leads by a reasonable retort to the truth. For if universals consist of particulars, then if the particular examples of any logos in accordance with which things exist and consist should perish, then it is quite clear that the corresponding universals will not continue to be. For the parts exist and subsist in the wholes, and the wholes in the parts. No reason can gainsay it. But there are those who are, as it were, unwillingly bound by the truth and betray the power of providence, arguing that it only pervades what is important to them. For they say that only universals are governed by providence, and that particulars are hidden from providence, being led by necessity towards the truth that they are anxious to flee. For if they say that it is because of permanence that universals are worthy of providence, they admit even more strongly that those particulars are worthy, in which the permanence and stability of the universals consist. These are admitted together through the indissoluble natural relationship that they have with each other, and both conserve permanence, nor can one be said to be foreign to the protection of the other, and again if they admit the protection of the one with respect of permanence, they have to grant the other too.

Apart from that there are three ways in which the providence of God is denied. Some say that God does not understand the method of providence, others that he cannot will it, others that he has not the power. But it follows from the common notions that God is good and beyond goodness and eternally wills what is good for everything, and that he is wise and beyond wisdom, or rather the source of all wisdom, and certainly knows everything that is going to happen, and that he is powerful, or rather infinitely powerful, and certainly brings about in a divinely fitting way in everything what is known to him and what he wills for the good and what is fitting. For God is good and wise and powerful, and pervades everything visible and invisible, both universals and particulars, both small and great, indeed everything that possesses existence in any way whatever. He is not diminished by the boundlessness of his goodness and wisdom and power, and conserves everything in accordance with the logos of its being, both in relation to themselves and to others, and in accordance with the indissoluble harmony and permanence that relates everything one to another.

Why then can we not understand that nature itself teaches us clearly about the existence of God's providence over everything? For nature itself gives us no small proof that the knowledge of providence is naturally implanted within us, whenever it prepares us to seek salvation through prayers in sudden emergencies, as if pushing us towards God in an untaught way. For seized by necessity, all unawares, without choice, before we have had a chance to think of anything, as if providence itself led us to itself without any thought, faster than any mental power within ourselves, placing before us the divine help as stronger than anything else. Not that nature leads us to the possession of something unnatural. Whatever happens naturally, even if it is obscure to all, possesses the strong and unconquerable power of the demonstration of the truth. If it is the case that the reason for providence as it affects particulars is incomprehensible to us, as in accordance with the verse, his judgments are unsearchable and his ways past finding out (Rom. 11:33), then in my view they are not right who say that it shows that there is no such providence. For if the difference and variation between different human beings is great and incomprehensible, in ways of life and customs and opinions and choices and desires, in what they know, and their needs and pursuits, and the almost countless thoughts in their minds, and in everything that happens to them

in each day and hour (for this animal, man, is changeable, sharp on occasions and changing with need), it is absolutely necessary that providence, comprehending everything with foresight in the circumscription of its individuality, should be manifest as different and manifold and complex, and should achieve harmony as it extends into the incomprehensibility of the multitudinous, in a way suitable to each individual, whether thing or thought, reaching as far as the least movement of mind or body. If therefore the difference of particulars is incomprehensible, then likewise is the infinite meaning of providence that draws them into harmony, but it should not follow that, since the meaning of particular providence happens to be infinite and unknowable to us, we should make our ignorance a ground for denying the all-wise care for the things that are, but we should receive and hymn all the works of providence, simply and without examination, as divinely fitting and suitable, and believe that what happens happens well, even if the reason is beyond our grasp. And I mean all the works of providence, not what happens by our agency in accordance with our reason, for these arc quite different from the logos of providence. For the manner indicated by the great teacher of the power and grace of the Saints, according to reason and contemplation, is conjectural rather than categorical (for our mind is very far from truth itself), but trying to act hold of what has been said with the reason, and as it were tracking it down, I have done nothing more than make suggestions.

John of Damascus (c. 676AD – 749AD)
An Exact Exposition of the Orthodox Faith

Book II

Chapter I — Concerning won or age
He created the ages Who Himself was before the ages, Whom the divine David thus addresses, "From age to age Thou art." The divine apostle also says, "Through Whom He created the ages."

It must then be understood that the word age has various meanings, for it denotes many things. The life of each man is called an age. Again, a period of a thousand years is called an age. Again, the whole course of the present life is called an age: also the future life, the immortal life after the resurrection, is spoken of as an age. Again, the word age is used to denote, not time nor yet a part of time as measured by the movement and course of the sun, that is to say, composed of days and nights, but the sort of temporal motion and interval that is co-extensive with eternity. For age is to things eternal just what time is to things temporal.

Seven ages of this world are spoken of, that is, from the creation of the heaven and earth till the general consummation and resurrection of men. For there is a partial consummation, viz., the death of each man: but there is also a general and complete consummation, when the general resurrection of men will come to pass. And the eighth age is the age to come.

Before the world was formed, when there was as yet no sun dividing day from night, there was not an age such as could be measured, but there was the sort of temporal motion and interval that is co-extensive with eternity. And in this sense there is but one age, and God is spoken of as aiônios and proaiônios, for the age or on itself is His creation. For God, Who alone is without beginning, is Himself the Creator of all things, whether age or any other existing thing. And when I say God, it is evident that I mean the Father and His Only begotten Son, our Lord, Jesus Christ, and His all-holy Spirit, our one God.

But we speak also of ages of ages, inasmuch as the seven ages of the present world include many ages in the sense of lives of men, and the one age embraces all the ages, and the present and the future are spoken of as age of age. Further, everlasting life and everlasting punishment prove that

the age or neon to come is unending. For time will not be counted by days and nights even after the resurrection, but there will rather be one day with no evening, wherein the Sun of Justice will shine brightly on the just, but for the sinful there will be night profound and limitless. In what way then will the period of one thousand years be counted which, according to Origen, is required for the complete restoration? Of all the ages, therefore, the sole creator is God Who hath also created the universe and Who was before the ages.

Chapter II — Concerning the creation
Since, then, God, Who is good and more than good, did not find satisfaction in self-contemplation, but in His exceeding goodness wished certain things to come into existence which would enjoy His benefits and share in His goodness, He brought all things out of nothing into being and created them, both what is invisible and what is visible. Yea, even man, who is a compound of the visible and the invisible. And it is by thought that He creates, and thought is the basis of the work, the Word filling it and the Spirit perfecting it.

Chapter V — Concerning the visible creation
Our God Himself, Whom we glorify as Three in One, created the heaven and the earth and all that they contain, and brought all things out of nothing into being: some He made out of no pre-existing basis of matter, such as heaven, earth, air, fire, water: and the rest out of these elements that He had created, such as living creatures, plants, seeds. For these are made up of earth, and water, and air, and fire, at the bidding of the Creator.

Chapter VI — Concerning the Heaven
...Others have pictured the heaven as a hemisphere. This idea is suggested by these words of David, the singer of God, Who stretchest out the heavens like a curtain, by which word he clearly means a tent: and by these from the blessed Isaiah, Who hath established the heavens like a vault: and also because when the sun, moon, and stars set they make a circuit round the earth from west to north, and so reach once more the east. Still, whether it is this way or that, all things have been made and established by the divine command, and have the divine will and counsel for a foundation that cannot be moved. For He

Himself spoke and they were made: He Himself commanded and they were created. He hath also established them for ever and ever: He hath made a decree which will not pass...

All things, then, which are brought into existence are subject to corruption according to the law of their nature, and so even the heavens themselves are corruptible. But by the grace of God they are maintained and preserved. Only the Deity, however, is by nature without beginning and without end. Wherefore it has been said, They will perish, but Thou dost endure: nevertheless, the heavens will not be utterly destroyed. For they will wax old and be wound round as a covering, and will be changed, and there will be a new heaven and a new earth...

Chapter VII — Concerning light, fire, the luminaries, sun, moon and stars
Fire is one of the four elements, light and with a greater tendency to ascend than the others. It has the power of burning and also of giving light, and it was made by the Creator on the first day. For the divine Scripture says, "And God said, `Let there be light,' and there was light." Fire is not a different thing from what light is, as some maintain. Others again hold that this fire of the universe is above the air and call it ether. In the beginning, then, that is to say on the first day, God created light, the ornament and glory of the whole visible creation. For take away light and all things remain in undistinguishable darkness, incapable of displaying their native beauty. And God called the light day, but the darkness He called night. Further, darkness is not any essence, but an accident: for it is simply absence of light. The air, indeed, has not light in its essence. It was, then, this very absence of light from the air that God called darkness: and it is not the essence of air that

is darkness, but the absence of light which clearly is rather an accident than an essence. And, indeed, it was not night, but day, that was first named, so that day is first and after that comes night. Night, therefore, follows day. And from the beginning of day till the next day is one complete period of day and night. For the Scripture says, "And the evening and the morning were one day."

When, therefore, in the first three days the light was poured forth and reduced at the divine command, both day and night came to pass.

But on the fourth day God created the great luminary, that is, the sun, to have rule and authority over the day: for it is by it that day is made: for it is day when the sun is above the earth, and the duration of a day is the course of the sun over the earth from its rising till its setting. And He also created the lesser luminaries, that is, the moon and the stars, to have rule and authority over the night, and to give light by night. For it is night when the sun is under the earth, and the duration of night is the course of the sun under the earth from its rising till its setting. The moon, then, and the stars were set to lighten the night: not that they are in the daytime under the earth, for even by day stars are in the heaven over the earth but the sun conceals both the stars and the moon by the greater brilliance of its light and prevents them from being seen.

On these luminaries the Creator bestowed the first-created light: not because He was in need of other light, but that that light might not remain idle. For a luminary is not merely light, but a vessel for containing light...

Now the Greeks declare that all our affairs are controlled by the rising and setting and collision of these stars, viz., the sun and moon: for it is with these matters that astrology has to do. But we hold that we get from them signs of rain and drought, cold and heat, moisture and dryness, and of the various winds, and so forth, but no sign whatever as to our actions. For we have been created with free wills by our Creator and are masters over our own actions. Indeed, if all our actions depend on the courses of the stars, all we do is done of necessity: and necessity precludes either virtue or vice. But if we possess neither virtue nor vice, we do not deserve praise or punishment, and God, too, will turn out to be unjust, since He gives good things to some and afflicts others. Nay, He will no longer continue to guide or provide for His own creatures, if all things are carried and swept along in the grip of necessity. And the faculty of reason will be superfluous to us: for if we are not masters of any of our actions, deliberation is quite superfluous. Reason, indeed, is granted to us solely that we might take counsel, and hence all reason implies freedom of will...

It must be understood, then, that the moon derives its light from the sun; not that God was unable to grant it light of its own, but in order that rhythm and order may be unimpressed upon nature, one part ruling, the other being ruled, and that we might thus be taught to live in community and to share our possessions with one another, and to be under subjection, first to our Maker and Creator, our God and Master, and then also to the rulers set in authority over us by Him: and not to question why this man is ruler and not I myself, but to welcome all that comes from God in a gracious and reasonable spirit.

The sun and the moon, moreover, suffer eclipse, and this demonstrates the folly of those who worship the creature in place of the Creator, and teaches us how changeable and alterable all things are For all things are changeable save God, and whatever is changeable is liable to corruption in accordance with the laws of its own nature.

Now the cause of the eclipse of the sun is that the body of the moon is interposed like a partition-wall and casts a shadow, and prevents the light from being shed down on us: and the extent of the eclipse is proportional to the size of the moon's body that is found to conceal the sun. But do not

marvel that the moon's body is the smaller. For many declare that the sun is many times larger even than the earth, and the holy Fathers say that it is equal to the earth: yet often a small cloud, or even a small hill or a wall quite conceals it.

The eclipse of the moon, on the other hand, is due to the shadow the earth casts on it when it is a fifteen days' moon and the sun and moon happen to be at the opposite poles of the highest circle, the sun being under the earth and the moon above the earth. For the earth casts a shadow and the sun's light is prevented from illuminating the moon, and therefore it is then eclipsed.

It should be understood that the moon was made full by the Creator, that is, a fifteen days' moon: for it was fitting that it should be made complete. But on the fourth day, as we said, the sun was created. Therefore the moon was eleven days in advance of the sun, because from the fourth to the fifteenth day there are eleven days. Hence it happens that in each year the twelve months of the moon contain eleven days fewer than the twelve months of the sun. For the twelve months of the sun contain three hundred and sixty-five and a quarter days, and so because the quarter becomes a whole, in four Years an extra day is completed, which is called bissextile. And that year has three hundred and sixty-six days. The years of the moon, on the other hand, have three hundred and fifty-four days. For the moon wanes from the time of its origin, or renewal, till it is fourteen and three-quarter days' old, and proceeds to wane till the twenty-ninth and a half day, when it is completely void of light. And then when it is once more connected with the sun it is reproduced and renewed, a memorial of our resurrection. Thus in each year the moon gives away eleven days to the sun, and so in three years the intercalary month of the Hebrews arises, and that year comes to consist of thirteen months, owing to the addition of these eleven days.

It is evident that both sun and moon and stars are compound and liable to corruption according to the laws of their various natures. But of their nature we are ignorant. Some, indeed, say that fire when deprived of matter is invisible, and thus, that when it is quenched it vanishes altogether. Others, again, say that when it is quenched it is transformed into air...

Chapter IX — Concerning the waters

Water also is one of the four elements, the most beautiful of God's creations. It is both wet and cold, heavy, and with a tendency to descend, and flows with great readiness. It is this the Holy Scripture has in view when it says, "And darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters." For the deep is nothing else than a huge quantity of water whose limit man cannot comprehend. In the beginning, indeed, the water lay all over the surface of the earth. And first God created the firmament to divide the water above the firmament from the water below the firmament. For in the midst of the sea of waters the firmament was established at the Master's decree. And out of it God bade the firmament arise, and it arose. Now for what reason was it that God placed water above the firmament? It was because of the intense burning heat of the sun and ether. For immediately under the firmament is spread out the ether, and the sun and moon and stars are in the firmament, and so if water had not been put above it the firmament would have been consumed by the heat.

Next, God bade the waters be gathered together into one mass. But when the Scripture speaks of one mass it evidently does not mean that they were gathered together into one place: for immediately it goes on to say, "And the gatherings of the waters He called seas:" but the words signify that the waters were separated off in a body from the earth into distinct groups. Thus the waters were gathered together into their special collections and the dry land was brought to view.

And hence arose the two seas that surround Egypt, for it lies between two seas. These collections contain various seas and mountains, and islands, and promontories, and harbours, and surround various bays and beaches, and coastlands. For the word beach is used when the nature of the tract

is sandy, while coastland signifies that it is rocky and deep close into shore, getting deep all on a sudden. In like manner arose also the sea that lies where the sun rises, the name of which is the Indian Sea: also the northern sea called the Caspian. The lakes also were formed in the same manner...

By the divine decree hollow places are made in the earth, and so into these the waters are gathered. And this is how mountains are formed. God, then, bade the first water produce living breath, since it was to be by water and the Holy Spirit that moved upon the waters in the beginning, that man was to be renewed. For this is what the divine Basilius said: Therefore it produced living creatures, small and big; whales and dragons, fish that swim in the waters, and feathered fowl. The birds form a link between water and earth and air: for they have their origin in the water, they live on the earth and they fly in the air. Water, then, is the most beautiful element and rich in usefulness, and purifies from all filth, and not only from the filth of the body but from that of the soul, if it should have received the grace of the Spirit...

Chapter X — Concerning earth and its products

The earth is one of the four elements, dry, cold, heavy, motionless, brought into being by God, out of nothing on the first day. "For in the beginning," he said, "God created the heaven and the earths:" but the seat and foundation of the earth no man has been able to declare. Some, indeed, hold that its seat is the waters: thus the divine David says, "To Him Who established the earth on the waters." Others place it in the air. Again some other says, "He Who hangeth the earth on nothing." And, again, David, the singer of God, says, as though the representative of God, "I bear up the pillars of it," meaning by "pillars" the force that sustains it. Further, the expression, "He hath founded it upon the seas," shews clearly that the earth is on all hands surrounded with water. But whether we grant that it is established on itself, or on air or on water, or on nothing, we must not turn aside from reverent thought, but must admit that all things are sustained and preserved by the power of the Creator.

In the beginning, then, as the Holy Scripture says, it was hidden beneath the waters, and was unwrought, that is to say, not beautified. But at God's bidding, places to hold the waters appeared, and then the mountains came into existence, and at the divine command the earth received its own proper adornment, and was dressed in all manner of herbs and plants, and on these, by the divine decree, was bestowed the power of growth and nourishment, and of producing seed to generate their like. Moreover, at the bidding of the Creator it produced also all manner of kinds of living creatures, creeping things, and wild beasts, and cattle. All, indeed, are for the seasonable use of man: but of them some are for food, such as stags, sheep, deer, and such like: others for service such as camels, oxen, horses, asses, and such like: and others for enjoyment, such as apes, and among birds, jays and parrots, and such like. Again, amongst plants and herbs some are fruit bearing, others edible, others fragrant and flowery, given to us for our enjoyment, for example, the rose and such like, and others for the healing of disease. For there is not a single animal or plant in which the Creator has not implanted some form of energy capable of being used to satisfy man's needs. For He Who knew all things before they were, saw that in the future man would go forward in the strength of his own will, and would be subject to corruption, and, therefore, He created all things for his seasonable use, alike those in the firmament, and those on the earth, and those in the waters.

Indeed, before the transgression all things were under his power. For God set him as ruler over all things on the earth and in the waters. Even the serpent was accustomed to man, and approached him more readily than it did other living creatures, and held intercourse with him with delightful motions. And hence it was through it that the devil, the prince of evil, made his most wicked suggestion to our first parents. Moreover, the earth of its own accord used to yield fruits, for the benefit of the animals that were obedient to man, and there was neither rain nor tempest on the

earth. But after the transgression, when he was compared with the unintelligent cattle and became like to them, after he had contrived that in him irrational desire should have rule over reasoning mind and had become disobedient to the Master's command, the subject creation rose up against him whom the Creator had appointed to be ruler: and it was appointed for him that he should till with sweat the earth from which he had been taken.

But even now wild beasts are not without their uses, for, by the terror they cause, they bring man to the knowledge of his Creator and lead him to call upon His name. And, further, at the transgression the thorn sprung out of the earth in accordance with the Lord's express declaration and was conjoined with the pleasures of the rose, that it might lead us to remember the transgression on account of which the earth was condemned to bring forth for us thorns and prickles.

That this is the case is made worthy of belief from the fact that their endurance is secured by the word of the Lord, saying, `Be fruitful and multiply, and replenish the earth."

Further, some hold that the earth is in the form of a sphere, others that it is in that of a cone. At all events it is much smaller than the heaven, and suspended almost like a point in its midst. And it will pass away and be changed. But blessed is the man who inherits the earth promised to the meek.

For the earth that is to be the possession of the holy is immortal. Who, then, can fitly marvel at the boundless and incomprehensible wisdom of the Creator? Or who can render sufficient thanks to the Giver of so many blessings?...

Chapter XI — Concerning Paradise

Now when God was about to fashion man out of the visible and invisible creation in His own image and likeness to reign as king and ruler over all the earth and all that it contains, He first made for him, so to speak, a kingdom in which he should live a life of happiness and prosperity. And this is the divine paradise, planted in Eden by the hands of God, a very storehouse of joy and gladness of heart (for "Eden" means luxuriousness)...

In its midst God planted the tree of life and the tree of knowledge. The tree of knowledge was for trial, and proof, and exercise of man's obedience and disobedience: and hence it was named the tree of the knowledge of good and evil, or else it was because to those who partook of it was given power to know their own nature. Now this is a good thing for those who are mature, but an evil thing for the immature and those whose appetites are too strong, being like solid food to tender babes still in need of milk. For our Creator, God, did not intend us to be burdened with care and troubled about many things, nor to take thought about, or make provision for, our own life. But this at length was Adam's fate...

Thus, to my thinking, the divine Paradise is twofold, and the God-inspired Fathers handed down a true message, whether they taught this doctrine or that. Indeed, it is possible to understand by every tree the knowledge of the divine power derived from created things. In the words of the divine Apostle, "For the invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made." But of all these thoughts and speculations the sublimest is that dealing with ourselves, that is, with our own composition. As the divine David says, "The knowledge of Thee from me," that is from my constitution, was made a wonder. But for the reasons we have already mentioned, such knowledge was dangerous for Adam who had been so lately created.

The tree of life too may be understood as that more divine thought that has its origin in the world

of sense, and the ascent through that to the originating and constructive cause of all. And this was the name He gave to every tree, implying fulness and indivisibility, and conveying only participation in what is good. But by the tree of the knowledge of good and evil, we are to understand that sensible and pleasurable food which, sweet though it seems, in reality brings him who partakes of it into communion with evil. For God says, "Of every tree in Paradise thou mayest freely eat." It is, me-thinks, as if God said, "Through all My creations thou art to ascend to Me thy creator, and of all the fruits thou mayest pluck one, that is, Myself who am the true life: let every thing bear for thee the fruit of life, and let participation in Me be the support of your own being. For in this way than wilt be immortal. But of the tree of the knowledge of good and evil, thou shall not eat of it: for in the day that thou eatest thereof thou shall surely die." For sensible food is by nature for the replenishing of that which gradually wastes away and it passes into the drought and perisheth: and he cannot remain incorruptible who partakes of sensible food.

Chapter XII — Concerning Man

In this way, then, God brought into existence mental essence, by which I mean, angels and all the heavenly orders. For these clearly have a mental and incorporeal nature: "incorporeal" I mean in comparison with the denseness of matter. For the Deity alone in reality is immaterial and incorporeal. But further He created in the same way sensible essence, that is heaven and earth and the intermediate region; and so He created both the kind of being that is of His own nature (for the nature that has to do with reason is related to God, and apprehensible by mind alone), and the kind which, inasmuch as it clearly falls under the province of the senses, is separated from Him by the greatest interval. And it was also fit that there should be a mixture of both kinds of being, as a token of still greater wisdom and of the opulence of the Divine expenditure as regards natures, as Gregorius, the expounder of God's being and ways, puts it, and to be a sort of connecting link between the visible and invisible natures. And by the word "fit" I mean, simply that it was an evidence of the Creator's will, for that will is the law and ordinance most meet, and no one will say to his Maker, "Why hast Thou so fashioned me?" For the potter is able at his will to make vessels of various patterns out of his clay, as a proof of his own wisdom.

Now this being the case, He creates with His own hands man of a visible nature and an invisible, after His own image and likeness: on the one hand man's body He formed of earth, and on the other his reasoning and thinking soul He bestowed upon him by His own in-breathing, and this is what we mean by "after His image." For the phrase "after His image" clearly refers to the side of his nature which consists of mind and free will, whereas "after His likeness" means likeness in virtue so far as that is possible.

Further, body and soul were formed at one and the same time, not first the one and then the other, as Origen so senselessly supposes.

God then made man without evil, upright, virtuous, free from pain and care, glorified with every virtue, adorned with all that is good, like a sort of second microcosm within the great world, another angel capable of worship, compound, surveying the visible creation and initiated into the mysteries of the realm of thought, king over the things of earth, but subject to a higher king, of the earth and of the heaven, temporal and eternal, belonging to the realm of sight and to the realm of thought, midway between greatness and lowliness, spirit and flesh: for he is spirit by grace, but flesh by overweening pride: spirit that he may abide and glorify his Benefactor, and flesh that he may suffer, and suffering may be admonished and disciplined when he prides himself in his greatness: here, that is, in the present life, his life is ordered as an animal's, but elsewhere, that is, in the age to come, he is changed and — to complete the mystery — becomes deified by merely inclining himself towards God; becoming deified, in the way of participating in the divine glory and not in that of a change into the divine being.

But God made him by nature sinless, and endowed him with free will. By sinless, I mean not that sin could find no place in him (for that is the case with Deity alone), but that sin is the result of the free volition he enjoys rather than an integral part of his nature; that is to say, he has the power to continue and go forward in the path of goodness, by co-operating with the divine grace, and likewise to turn from good and take to wickedness, for God has conceded this by conferring freedom of will upon him. For there is no virtue in what is the result of mere force.

The soul, accordingly, is a living essence, simple, incorporeal, invisible in its proper nature to bodily eyes, immortal, reasoning and intelligent, formless, making use of an organised body, and being the source of its powers of life, and growth, and sensation, and generation, mind being but its purest part and not in any wise alien to it; (for as the eye to the body, so is the mind to the soul); further it enjoys freedom and volition and energy, and is mutable, that is, it is given to change, because it is created. All these qualities according to nature it has received of the grace of the Creator, of which grace it has received both its being and this particular kind of nature...

Chapter XXV — Concerning what is in our own power, that is, concerning Free will

The first enquiry involved in the consideration of free will, that is, of what is in our own power, is whether anything is in our power: for there are many who deny this. The second is, what are the things that are in our power, and over what things do we have authority? The third is, what is the reason for which God Who created us endued us with free will? So then we shall take up the first question, and firstly we shall prove that of those things which even our opponents grant, some are within our power. And let us proceed thus.

Of all the things that happen, the cause is said to be either God, or necessity, or fate, or nature, or chance, or accident. But God's function has to do with essence and providence: necessity deals with the movement of things that ever keep to the same course: fate with the necessary accomplishment of the things it brings to pass (for fate itself implies necessity): nature with birth, growth, destruction, plants and animals; chance with what is rare and unexpected. For chance is defined as the meeting and concurrence of two causes, originating in choice but bringing to pass something other than what is natural: for example, if a man finds a treasure while digging a ditch: for the man who hid the treasure did not do so that the other might find it, nor did the finder dig with the purpose of finding the treasure: but the former hid it that he might take it away when he wished, and the other's aim was to dig the ditch: whereas something happened quite different from what both had in view. Accident again deals with casual occurrences that take place among lifeless or irrational things, apart from nature and art. This then is their doctrine. Under which, then, of these categories are we to bring what happens through the agency of man, if indeed man is not the cause and beginning of action? For it would not be right to ascribe to God actions that are sometimes base and unjust: nor may we ascribe these to necessity, for they are not such as ever continue the same: nor to fate, for fate implies not possibility only but necessity: nor to nature, for nature's province is animals and plants: nor to chance, for the actions of men are not rare and unexpected: nor to accident, for that is used in reference to the casual occurrences that take place in the world of lifeless and irrational things. We are left then with this fact, that the man who acts and makes is himself the author of his own works, and is a creature endowed with free will.

Further, if man is the author of no action, the faculty of deliberation is quite superfluous for to what purpose could deliberation be put if man is the master of none of his actions? For all deliberation is for the sake of action. But to prove that the fairest and most precious of man's endowments is quite superfluous would be the height of absurdity. If then man deliberates, he deliberates with a view to action. For all deliberation is with a view to and on account of action.

Chapter XXVIII — Concerning what is not in our hands

Of things that are not in our hands some have their beginning or cause in those that are in our power, that is to say, the recompenses of our actions both in the present and in the age to come, but all the rest are dependent on the divine will. For the origin of all things is from God, but their destruction has been introduced by our wickedness for our punishment or benefit. For God did not create death, neither does He take delight in the destruction of living things. But death is the work rather of man, that is, its origin is in Adam's transgression, in like manner as all other punishments. But all other things must be referred to God. For our birth is to be referred to His creative power; and our continuance to His conservative power; and our government and safety to His providential power; and the eternal enjoyment of good things by those who preserve the laws of nature in which we are formed is to be ascribed to His goodness. But since some deny the existence of Providence, let us further devote a few words to the discussion of Providence.

Chapter XXIX — Concerning Providence

Providence, then, is the care that God takes over existing things. And again: Providence is the will of God through which all existing things receive their fitting issue. But if Providence is God's will, according to true reasoning all things that come into being through Providence must necessarily be both most fair and most excellent, and such that they cannot be surpassed. For the same person must of necessity be creator of and provider for what exists: for it is not meet nor fitting that the creator of what exists and the provider should be separate persons. For in that case they would both assuredly be deficient, the one in creating, the other in providing. God therefore is both Creator and Provider, and His creative and preserving and providing power is simply His good-will. For, "Whatsoever the Lord pleased that did He in heaven and in earth," and "no one resisted His will." He willed that all things should be and they were. He wills the universe to be framed and it is framed, and all that He wills comes to pass.

That He provides, and that He provides excellently, one can most readily perceive thus. God alone is good and wise by nature. Since then He is good, He provides: for he who does not provide is not good. For even men and creatures without reason provide for their own offspring according to their nature, and he who does not provide is blamed. Again, since He is wise, He takes the best care over what exists.

When, therefore, we give heed to these things we ought to be filled with wonder at all the works of Providence, and praise them all, and accept them all without enquiry, even though they are in the eyes of many unjust, because the Providence of God is beyond our ken and comprehension, while our reasonings and actions and the future are revealed to His eyes alone. And by "all" I mean those that are not in our hands: for those that are in our power are outside the sphere of Providence and within that of our Free will.

Now the works of Providence are partly according to the goodwill (of God) and partly according to permission. Works of good-will include all those that are undeniably good, while works of permission are. ..[There are various readings here. Perhaps the best is supplied from Nemesius, Ch. 44, which says, "but there are many forms of concession"]. For Providence often permits the just man to encounter misfortune in order that he may reveal to others the virtue that lies concealed within him, as was the case with Job. At other times it allows something strange to be done in order that something great and marvellous might be accomplished through the seemingly-strange act, as when the salvation of men was brought about through the Cross. In another way it allows the pious man to suffer sore trials in order that he may not depart from a right conscience nor lapse into pride on account of the power and grace granted to him, as was the case with Paul.

One man is forsaken for a season with a view to anther's restoration, in order that others when they see his state may be taught a lesson, as in the case of Lazarus and the rich man. For it belongs to our nature to be east down when we see persons in distress. Another is deserted by Providence in

order that another may be glorified, and not for his own sin or that of his parents, just as the man who was blind from his birth ministered to the glory of the Son of Man. Again another is permitted to suffer in order to stir up emulation in the breasts of others, so that others by magnifying the glory of the sufferer may resolutely welcome suffering in the hope of future glory and the desire for future blessings, as in the case of the martyrs. Another is allowed to fall at times into some act of baseness in order that another worse fault may be thus corrected, as for instance when God allows a man who takes pride in his virtue and righteousness to fall away into fornication in order that he may be brought through this fall into the perception of his own weakness and be humbled and approach and make confession to the Lord.

Moreover, it is to be observed that the choice of what is to be done is in our own hands: but the final issue depends, in the one case when our actions are good, on the cooperation of God, Who in His justice brings help according to His foreknowledge to such as choose the good with a right conscience, and, in the other case when our actions are to evil, on the desertion by God, Who again in His justice stands aloof in accordance with His foreknowledge.

Now there are two forms of desertion: for there is desertion in the matters of guidance and training, and there is complete and hopeless desertion. The former has in view the restoration and safety and glory of the sufferer, or the rousing of feelings of emulation and imitation in others, or the glory of God: but the latter is when man, after God has done all that was possible to save him, remains of his own set purpose blind and uncured, or rather incurable, and then he is handed over to utter destruction, as was Judas. May God be gracious to us, and deliver us from such desertion.

Observe further that the ways of God's providence are many, and they cannot be explained in words nor conceived by the mind.

And remember that all the assaults of dark and evil fortune contribute to the salvation of those who receive them with thankfulness, and are assuredly ambassadors of help.

Also one must bear in mind that God's original wish was that all should be saved and come to His Kingdom. For it was not for punishment that He formed us but to share in His goodness, inasmuch as He is a good God. But inasmuch as He is a just God, His will is that sinners should suffer punishment.

The first then is called God's antecedent will and pleasure, and springs from Himself, while the second is called God's consequent will and permission, and has its origin in us. And the latter is two-fold; one part dealing with matters of guidance and training, and having in view our salvation, and the other being hopeless and leading to our utter punishment, as we said above. And this is the case with actions that are not left in our hands.

But of actions that are in our hands the good ones depend on His antecedent goodwill and pleasure, while the wicked ones depend neither on His antecedent nor on His consequent will, but are a concession to free will. For that which is the result of compulsion has neither reason nor virtue in it. God makes provision for all creation and makes all creation the instrument of His help and training, yea often even the demons themselves, as for example in the cases of Job and the swine.

Chapter XXX — Concerning Prescience and Predestination

We ought to understand that while God knows all things beforehand, yet He does not predetermine all things. For He knows beforehand those things that are in our power, but He does not predetermine them. For it is not His will that there should be wickedness nor does He choose to compel virtue. So that predetermination is the work of the divine command based on foreknowledge. But on the other hand God predetermines those things which are not within our power

in accordance with His prescience. For already God in His prescience has prejudged all things in accordance with His goodness and justice.

Bear in mind, too, that virtue is a gift from God implanted in our nature, and that He Himself is the source and cause of all good, and without His co-operation and help we cannot will or do any good thing. But we have it in our power either to abide in virtue and follow God, Who calls us into ways of virtue, or to stray from paths of virtue, which is to dwell in wickedness, and to follow the devil who summons but cannot compel us. For wickedness is nothing else than the withdrawal of goodness, just as darkness is nothing else than the Withdrawal of light. While then we abide in the natural state we abide in virtue, but when we deviate from the natural state, that is from virtue, we come into an unnatural state and dwell in wickedness.

Repentance is the returning from the unnatural into the natural state, from the devil to God, through discipline and effort.

Man then the Creator made male, giving him to share in His own divine grace, and bringing him thus into communion with Himself: and thus it was that he gave in the manner of a prophet the names to living flyings, with authority as though they were given to be his slaves. For having been endowed with reason and mind, and free will after the image of God, he was filly entrusted with dominion over earthly things by the common Creator and Master of all.

But since God in His prescience knew that man would transgress and become liable to destruction, He made from him a female to be a help to him like himself; a help, indeed, for the conservation of the race after the transgression from age to age by generation. For the earliest formation is called `making' and not `generation.' For `making' is the original formation at God's hands, while `generation' is the succession from each Other made necessary by the sentence of death imposed on us on account of the transgression.

This man He placed in Paradise, a home that was alike spiritual and sensible. For he lived in the body on the earth in the realm of sense, while he dwelt in the spirit among the angels, cultivating divine thoughts, and being supported by them: living in naked simplicity a life free from artificiality, and being led up through His creations to the one and only Creator, in Whose contemplation he found joy and gladness.

When therefore He had furnished his nature with free will, He imposed a law on him, not to taste of the tree of knowledge. Concerning this tree, we have said as much as is necessary in the chapter about Paradise, at least as much as it was in our power to say. And with this command He gave the promise that, if he should preserve the dignity of the soul by giving the victory to reason, and acknowledging his Creator and observing His command, he should share eternal blessedness and live to all eternity, proving mightier than death: but if forsooth he should subject the soul to the body, and prefer the delights of the body, comparing himself in ignorance of his true dignity to the senseless beasts, and shaking off His Creator's yoke, and neglecting His divine injunction, he will be liable to death and corruption, and will be compelled to labour throughout a miserable life. For it was no profit to man to obtain incorruption while still untried and unproved, lest he should fall into pride and under the judgment of the devil. For through his incorruption the devil, when he had fallen as the result of his own free choice, was firmly established in wickedness, so that there was no room for repentance and no hope of change: just as, moreover, the angels also, when they had made free choice of virtue became through grace immoveably rooted in goodness.

It was necessary, therefore, that man should first be put to the test (for man untried and unproved would be worth nothing), and being made perfect by the trial through the observance of the command should thus receive incorruption as the prize of his virtue. For being intermediate

between God and matter he was destined, if he kept the command, to be delivered from his natural relation to existing things and to be made one with God's estate, and to be immoveably established in goodness, but, if he transgressed and inclined the rather to what was material, and tore his mind from the Author of his being, I mean God, his fate was to be corruption, and he was to become subject to passion instead of passionless, and mortal instead of immortal, and dependent on connection and unsettled generation. And in his desire for life he would cling to pleasures as though they were necessary to maintain it, and would fearlessly abhor those who sought to deprive him of these, and transfer his desire from God to matter, and his anger from the real enemy of his salvation to his own brethren. The envy of the devil then was the reason of man's fall. For that same demon, so full of envy and with such a hatred of good, would not suffer us to enjoy the pleasures of heaven, when he himself was kept below on account of his arrogance, and hence the false one tempts miserable man with the hope of Godhead, and leading him to as great a height of arrogance as himself, he hurls him down into a pit of destruction just as deep.

From Eastern Orthodox Ecology Site:

Clement of Alexandria (c.150AD - c. 215AD), Earliest Christian Platoniser
The Westminster Collection of Christian Quotations, Martin H. Manser, 2001
The world is the first Bible that God made for the instruction of man.

St. Maximus the Confessor (580 - 662)
"Third Century on Love," The Philokalia, Vol. II, Nr. 46, pg. 90
God, full beyond all fullness, brought creatures into being, not because He had need of anything, but so that they might participate in Him in proportion to their capacity and that He Himself might rejoice in His works, through seeing them joyful and ever filled to overflowing with His inexhaustible gifts.

St. Maximus the Confessor (580 - 662)
Wholeness and Transfiguration, pg. 5
The shining vestments of the transfigured Christ symbolize the fact that when God, the son of Righteousness, reveals Himself to the human soul, then all the "logoi" of things intelligible and sensible in scripture and nature appear as if they were with him.

Man is not a being isolated from the rest of creation. By his very nature, he is bound up with the whole of the universe.... In his way to union with God, man in no way leaves creatures aside, but gathers together in his love the whole cosmos disordered by sin, that it may be transfigured by grace.

St. Maximus the Confessor (580 - 662)
Ambiguum 10, PG 91. 1128-1129a
Creation is a bible whose letters and syllables are the particular aspects of all creatures and whose words are the more universal aspects of creation. Conversely, Scripture is like a cosmos constituted of heaven and earth and things in between; that is, the ethical, the natural, the theological dimension.

St. Maximus the Confessor (580 - 662)
Philokalia, Vol. II, Various Texts on Theology: Third Century, Nr. 6, Faber and Faber, London,

pg. 211
Creation is the accuser of the ungodly. For through its inherent spiritual principles, creation proclaims its Maker; and through the natural laws intrinsic to each individual species it instructs us in virtue. The spiritual principles may be recognized in the unremitting continuance of each individual species, the laws in the consistency of its natural activity. If we do not ponder on these things, we remain ignorant of the cause of created being and we cling to all the passions which are contrary to nature.

Minucius Felix (c. 167 AD – 249 AD)
The Octavius XVII
Man ought to know himself, but this knowledge cannot be attained by him unless first he is willing to acknowledge the entire scope of things, including God Himself. And then, from the constitution and furniture of the world itself, every one endowed with reason holds that it was established by God, and is governed and administered by Him.

Minucius Felix (c. 167 AD – 249 AD)
The Octavius XVIII
God does not care only for the universe, He also cares for all of its parts. ... If on entering a house, you should behold everything refined, well arranged and adorned, you would believe that a master presided over it, and that he was much better and above all those excellent things. So in this house of the world, when you look upon the heaven and the earth, its providence, its ordering, its law, believe that there is a Lord and Parent of the universe far more glorious than the stars themselves, and the parts of the whole world.

Origen (185 - 254) (This is original quote on Scriptures and Nature)
Nature and Scripture offer the same conclusions
Commentary on St John's Gospel, 13,42. (GCS 4,269)

'Lift up your eyes, and see how the fields are already white for harvest' (John 4.35). The Word is in the midst of his disciples. He is asking his hearers to lift up their eyes toward [:]
[1] the fields of the Scriptures and
[2] toward that other field where the Word is present in every creature,
however small, so that they may perceive the whiteness and the brilliant radiance of the light of Truth which is everywhere.

Origen (185 - 254)
Nature and Scripture offer the same conclusions
Quoted by St. Maximus the Confessor, in Charles Upton, Who is the Earth: How to See God in the Natural World, San Rafael, 1997, p. 59.
There is a parallel between nature and Scripture that is so complete, says Origen, that we learn the same things from one source as the other. This he says is true because of a common origin in the Word of God. This explains why "we must necessarily believe that the person who is asking questions of nature and the person who is asking questions of the Scriptures are bound to arrive at the same conclusions."

Origen (185 - 254)
"The Beginning of Creation," Commentary on the Gospel of St. John, Book I:17
There is a beginning in a matter of origin, as might appear in the saying, "In the beginning God made the heaven and the earth" (Genesis 1:1). This meaning, however, appears more plainly in the Book of Job in the passage, "This is the beginning of God's creation, made for His angels to mock at"

(Job 40:19). One would suppose that the heavens and the earth were made first, of all that was made at the creation of the world. But the second passage suggests a better view, namely, that as many beings were framed with a body, the first made of these was the creature called dragon, but called in another passage the great whale (i.e., “leviathan,” in Job 41:1) which the Lord tamed. We must ask about this, whether, when the saints were living a blessed life apart from matter and from any body, the dragon, falling from the pure life, became fit to be bound in matter and in a body, so that the Lord could say, speaking through storm and clouds, "This is the beginning of the creation of God, made for His angels to mock at." It is possible, however, that the dragon is not positively the beginning of the creation of the Lord, but that there were many creatures made with a body for the angels to mock at, and that the dragon was the first of these, while others could subsist in a body without such reproach.

Origen (185 - 254)
De Principiis, Book II:13 (if not already in Dembski section)
The world in all its diversity and varying conditions is composed not only of rational and diviner natures, but of dumb animals, wild and tame beasts, of birds and of all the things which live in the waters.... Seeing there is so great a variety in the world, and so great a diversity among rational beings themselves, what cause ought to be assigned for the existence of the world? But God, by ineffable skill of His wisdom, transforming and restoring all things, recalls those very creatures which differed so much from each other in mental conformation to one agreement of labor and purpose, so that although they are under the influence of different motives, they nevertheless complete the fullness and perfection of one world, and the very variety of minds tends to one end of perfection.

And although the world is arranged into different kinds of offices and conditions, nevertheless the whole world ought to be regarded as some huge and immense animal, which is kept together by the power and reason of God as one soul. This is indicated in sacred scripture by the declaration of the prophet, "Do not I fill heaven and earth? saith the Lord" (Jeremiah 23:24), and again, "The heaven is my throne and the earth is my footstool" (Isaiah 66:1).
Seeing the "bridegroom of the soul" in creation

Origen (185 - 254)
Commentary on the Psalms, ii, as quoted by D. WallaceHadrill, The Greek Patristic View of Nature, Manchester University Press, Manchester, 1968, pg. 114.
There are things in creation hard to understand, or even undiscoverable for human beings. We are not in consequence to condemn the Creator of the universe just because we cannot discover the reason for the creation of scorpions or other venomous beasts. The right thing for a man who is aware of the weakness of our race and who knows it is impossible to understand the reasons of God's design even when most minutely examined, is to ascribe the knowledge of these things to God, who will later on, if we are judged worthy, reveal to us the matters about which we are now reverently in doubt.

Origen (185 - 254)
The divine art of the Creator is hidden in creation
Commentary on Psalm 1, 3 (PG 12, 1081)
The divine art that is manifested in the structure of the world is not only to be seen in the sun, the moon and the stars; it operates also on earth on a reduced scale. The hand of the Lord has not neglected the bodies of the smallest animals – and still less their souls – because each one of them is seen to possess some feature that is personal to it, for instance, the way it protects itself.

Nor has the hand of the Lord neglected the plants of the earth, each of which has some detail bearing the mark of the divine art, whether it be the roots, the leaves, the fruits or the variety of

species. In the same way, in books written under the influence of divine inspiration, Providence imparts to the human race a wisdom that is more than human, sowing in each letter some saving truth in so far as that letter can convey it, marking out thus the path of wisdom. For once it has been granted that the Scriptures have God himself for their author, we must necessarily believe that the person who is asking questions of nature, and the person who is asking questions of the Scriptures, are bound to arrive at the same conclusions.

Origen (185 - 254)
God's invisible nature is perceptible through creation
Commentary on the Song of Songs, 3
The apostle Paul teaches us that God's "invisible nature" has been "clearly perceived in the things that have been made" (Romans 1:20). He shows us that this visible world contains teaching about the invisible world, and that this earth includes "images of celestial realities..." It could even be that God who made the human race "in His own image and likeness" (Genesis 1:27) also gave to other creatures a likeness to certain celestial realities. Perhaps this resemblance is so detailed that even the grain of mustard seed has its counterpart in the kingdom of heaven. If so, by that law of its nature that makes it the smallest of seeds and yet capable of becoming larger than all the others and of sheltering in its branches the birds of the air, it would represent for us not a particular celestial reality, but the kingdom of heaven as a whole.

In this sense it is possible that other seeds of the earth also contain an analogy with celestial objects and are a sign of them. And if that is true for seeds, it must be the same for plants. And if it is true for plants, it cannot be otherwise for animals, birds, reptiles and four-footed beasts.... It may be granted that these creatures, seeds, plants, roots and animals, are undoubtedly at the service of humanity's physical needs. However they include the shape and image of the invisible world, and they also have the task of elevating the soul and guiding it to the contemplation of celestial objects. Perhaps this is what the spokesman of Divine Wisdom means when he expresses himself in the words: "It is he who gave me unerring knowledge of what exists, to know the structure of the world and the activity of the elements; the beginning and end and middle of times, the alternation of the solstices and the changes of the seasons, the cycles of the year and the constellations of the stars, the natures of animals and the tempers of wild beasts, the powers of spirits..., the varieties of plants and the virtues of roots; I learned both what is secret and what is manifest" (Wisdom of Solomon 7:17-21). He shows thus, without any doubt, that everything that is seen is related to something that is hidden. That is to say that each visible reality is a symbol, and it refers to an invisible reality to which it is related.

St. Pachomius (292 - 346)
God's presence fills the earth
The Instructions 25
Do not go from one place to another, saying, "I will find God here or I will find God there." God has said, "I fill the earth, I fill the heavens."
And again He has said, "If you cross over the water, I am with you."
My son, be aware that God is within you, so that you may dwell in his law and commandments.
A prayer for the whole world

The Bohairic Life, pg. 138
Lord, God Almighty, blessed God,
grant us to carry through this service
    my fellowmembers as I have begun,
that we may be worthy of you;
that you may dwell in our bodies,

in our souls, and in our spirits; and
that we may always be perfect in your love,
walking before you according
to your good pleasure.

May we not sin against you,
or put to the test your Holy Spirit
in whose name we have been sealed....
For He makes the sun to shine upon the earth,
enlightening those who carry on their work,
the moon and the stars shine for us by night.
The seasons of fruitfulness,
the rains, the dew, and the winds destined
to make grow the harvests
that have been sown in the field;
All things that are necessary to men and to creatures
have been created by God for man's needs.

St. Augustine (354 AD – 430 AD)
The Book of Nature
Some people, in order to discover God, read books. But there is a great book: the very appearance of created things. Look above you! Look below you! Note it. Read it. God, whom you want to discover, never wrote that book with ink. Instead He set before your eyes the things that He had made. Can you ask for a louder voice than that? Why, heaven and earth shout to you: "God made me!"
De Civit. Dei, Book XVI

St. Patrick (385 - 471)
Tree of Life
The nature of our God

When Patrick was sent to Ireland as a bishop, he was confronted by a Druidic society headed by kings and tribal chieftans. To reply to a question from a Druid's daughter about the nature of the Christian God, Patrick replied, "Our God is the God of all men, the God of Heaven and Earth, of sea and river, of sun and moon and stars, of the lofty mountain and the lowly valley, the God above Heaven, the God in Heaven, the God under Heaven. He has his dwelling round Heaven and Earth and the sea and all that in them is. He inspires all, he quickens all, he rules over all, he sustains all. He lights the light of the sun; he furnishes the light of the light; he has put springs in the dry land and has set stars to minister to the greater lights....

Quoted in St. Patrick, Eerdmans, 1997, pg. 11
God is in all things
He inspires all, He gives life to all, He dominates all, He supports all.
He lights the light of the sun. He furnishes the light of the night.
He has made springs in dry land.
He is the God of heaven and earth, of sea and rivers, of sun, moon and stars,
of the lofty mountain and the lowly valley, the God above heaven,
and in heaven and under heaven.
God of all things

Quoted in St. Patrick, Eerdmans, 1997, pg. 10
Our God is the God of all, the God of heaven and earth, of the sea and of the rivers.
The God of the sun and of the moon and of all the stars;
The God of the lofty mountains and of the lowly valleys.
He has His dwelling around heaven and earth, and sea, and all that in them is.

Dionysius the Areopagite (485? - 535?)
Celestial Hierarchy I:3 (PG 3:121)
For anyone who reflects, the appearances of beauty become the themes of an invisible harmony. Perfumes as they strike our senses represent spiritual illumination. Material lights point to that immaterial light of which they are the images.

Dionysius the Areopagite (485? - 535?)
Divine Names IV:7, in PG 3:701
God is beauty. This beauty is the source of friendship and all mutual understanding.

It is this Beauty... which moves all living things and preserves them while filling them with love and desire for their own particular sort of beauty. ... for it is by its likeness to beauty that everything is defined. Thus true Beauty and Goodness are mixed together because, whatever the force may be that moves living things, it tends always towards Beauty-and-Goodness, and there is nothing that does not have a share in Beauty-and-Goodness. ...

By virtue of this reality, all creatures subsist, united and separate, identical and opposite, alike and unlike, contraries are united and the united elements are not confused.

By virtue of Beauty-and-Goodness, everything is in communion with everything else, each in its own way; creatures love one another without losing themselves in one another, everything is in harmony, parts snugly fit into the whole... one generation succeeds another; spirits, souls and bodies remain at the same time steady and mobile; because for all of them, Beauty-and-Goodness is at once repose and movement, being itself beyond both.

Dionysius the Areopagite (485? - 535?)
Divine Names IV:28 (PG 3:792), as quoted in Olivier Clement, The Roots of Christian Mysticism, New City Press, New York, NY, 1995, p. 218
It is just as false to repeat the commonplace [notion] that it is in matter as such that evil resides. For to speak truly, matter itself also participates in the order, the beauty, and the form [of Good]... How, if it were not so, could Good be produced from something evil? How could that thing be evil when it is impregnated with good? ... If matter is evil, how can one explain its ability to engender and nourish nature? Evil as such engenders and nourishes nothing. It does not produce or preserve anything. If it be objected that matter... leads souls toward evil, how could that be true when many material creatures turn their gaze toward the Good?

St. Peter of Damaskos (1027? - 1107?)

As it is said, “In everything give thanks.” When you see the sky, the earth, the sea, and all things in them, marvel at these things and glorify their Creator

God’s providence embraces the whole universe.... By contemplating the beauty and use of each thing, (one who has acquired the habit of detachment) is filled with love for the Creator. He

surveys all visible things: the sky, the sun, moon, stars and clouds, rain, snow and hail... thunder, lightening, the winds and breezes and the way they change, the seasons, the years...; the four-legged animals, the wild beasts and animals and reptiles, all the birds, the springs and rivers, the many varieties of plants and herbs, both wild and cultivated. He sees in all things the order, the equilibrium, the proportion, the beauty, the rhythm, the union, the harmony, the usefulness, the variety, the motion, the colours, the shapes, the reversion of things to their source, permanence in the midst of corruption. Contemplating thus all created realities, he is filled with wonder.
Philokalia, Vol. III, "The Sixth Stage of Contemplation," trans. by Philip Sherrard, Faber and Faber, London, p. 136-137

St. Symeon the New Theologian (949 - 1022)

The things and possessions that are in the world are common to all, like the light and this air that we breathe, as well as the pasture for the dumb animals on the plains and on the mountains. All these things were made for all in common solely for use and enjoyment; in terms of ownership they belong to no one.

But covetousness, like a tyrant, has intruded into life, so that its slaves and underlings have in various ways divided up that which the Master gave to be common to all. She has enclosed them by fences and made them secure by means of watchtowers, bolts and gates. She has deprived all other men of the enjoyment of the Master's good gifts, shamelessly pretending to own them, contending that she has wronged no one. But this tyrant's underlings and slaves in turn become, each one of them, evil slaves and keepers of the properties and monies entrusted to them. Even if they are moved by the threat of punishments... and take a few or even all of these things to give to those who are in poverty and distress whom they have hitherto ignored, how can they be accounted merciful? Have they fed Christ? Have they done a deed that is worthy of a reward? By no means! I tell you that they owe a debt of penitence to their dying day for all that they so long have kept back and deprived their brothers from using.
Catechesis 9:107116

We awaken in Christ's body as Christ awakens our bodies, and my poor hand is Christ; He enters my foot and is infinitely me. I move my hand, and wonderfuly my hand becomes Christ, becomes all of Him (for God is indivisibly whole, seamless in His Godhood). I move my foot, and at once He appears like a flash of lightning. Do my words seem blasphemous? Then open your heart to Him, and let yourself receive the one who is opening to you so deeply. For if we genuinely love Him, we wake up inside Christ's body where all our body, all over, every most hidden part of it, is realized in joy as Him, and He makes us utterly real, and everything that is hurt, everything that seemed to us dark, harsh, shameful, maimed, ugly, irreparably damaged, is in Him transformed and recognized as whole, as lovely, and radiant in His light. We awaken as the Beloved in every part of our body.
Quoted by Stephen Mitchell, The Enlightened Heart, Harper and Row, Publ., San Francisco, 1989, pg. 3839.

When man again (will) be renewed and become spiritual, incorrupt and immortal, then also the whole creation, which has been subjected by God to man to serve him, (will) be delivered from servitude, (will) be renewed together with him, and become incorrupt, and, as it were, spiritual. All this the All-Merciful God foreordained before the creation of the world.
The Sin of Adam, 69

top
St. Theophan the Recluse (1815 - 1894)

The world, with its concepts, principles and rules, its entire system made into immutable law, lays

a heavy, authoritarian hand on each of its offspring. As a result, no one dares even to think of rebelling against it or renouncing its power. Everyone... adheres to its rules with such timidity. A violation of these rules is considered as a criminal act.

The world is not a person, but its spirit in some way stands firm on the earth, influences us, and holds us as if with bonds. ...

Experience shows how frequently the mind, obscured by worldly ways, becomes sober through contemplation of divine creation....

Visible nature as the temple of God have not only often brought sense and sobriety to indifferent Christians, but have converted even pagans to true worship of God and devotion to Him.

Their power and influence come from the fact that they vividly and perceptibly offer the best, most blissful way of life for a spirit that is wearied, fatigued and tortured by the vanity of the world.
Translated from the Russian

The world, with its concepts, principles and rules, in general its entire system made into immutable law, lays a heavy, authoritarian hand on each of its offspring. As a result, no one dares even to think of rebelling against it or renouncing its power. Everyone... adheres to its rules with such timidity. A violation of these rules is considered as a criminal act. The world is not a person, but its spirit in some way stands firm on the earth, influences us, and holds us as if with bonds....
The Path to Salvation, St. Herman of Alaska Press, Forestville, CA, 1996, pg. 114-115

Tertullian (160 - 230?)
Nature reflects the Resurrection

Gaze now on these examples of divine power. Day dies into night, and is everywhere entombed in shadows. All things grow dull, voiceless, dumb. Everywhere there is quiet and rest. And so we mourn for the lost light. And yet once more, with all its own beauty, its power, its sun, the same and unharmed, it revives for the universal world, slaying night, which is its death, rending asunder its own sepulcher of darkness....
De Resurrectione Carnis I
Renewal as a universal lesson in creation

Now winter and summer roll around in season, and the blessings of spring and autumn with their power and their fruits, while the earth receives from heaven the knowledge of how to clothe the trees after they are stripped bare, the knowledge of how to give color to flowers and spread the herbage over the earth again, and then those same seeds which were parched by the sun display themselves until at last they are consumed. Oh marvelous method of God, which preserves after denuding, which cuts only to restore, which destroys only to retain, which spoils only to renew, and diminishes only to enlarge. Indeed, by this miracle, greater and riper blessings are received than any which were taken away so that destruction becomes increase, and all loss is gain. Let me say again: the condition of all things is renewal. All things when they have departed return to their first condition. Nothing perishes save into salvation. Therefore the whole revolving wheel of existence bears witness to the resurrection of the dead.
De Resurrectione Carnis I
Simplicity and sufficiency

We do not urge that squalor and slovenliness are good things. We merely set forth the limit and bounds and just measure of bodily adornment. You must not overstep the line to which simple and

sufficient dress requires.... Rather cloth yourself with the silk of honesty, the fine linen of righteousness and the purple of chastity.
On the Dress of Women 1
God teaches through creation

Nature is school-mistress, the soul the pupil; and whatever one has taught or the other has learned has come from God – the Teacher of the teacher.
De Testimonio Animae

1986 / Updated in 2009
John D. Barrow and Frank J. Tipler
The Anthropic Cosmological Principle
Chapter from Oxford Paperbacks book which contains a Brief Historical Summary

Chapter 2 - Design Arguments

What had that flower to do with being white,
The wayside blue and innocent heal-all?
What brought the kindred spider to that height,
Then steered the white moth thither in the night?
What but design of darkness to appall?—
If design govern in a thing so small.
Robert Frost

2.1 Historical Prologue

Original ideas are exceedingly rare and the most that philosophers have done in the course of time is to erect a new combination of them.
G. Sarton

The Anthropic Principle is a consequence of our own existence. Since the dawn of recorded history humankind has used the local and global environment to good advantage; the soil and its fruits for food, the heavenly bodies for navigation, and the winds and waves for power. Such beneficiaries might naturally be led to conclude that the world in all its richness and subtlety was contrived for their benefit alone; uniquely designed for them rather than merely fortuitously used by them. From such inclinations and the natural attraction they appear to hold for those seeking meaning and significance in life, simple design arguments grew in a variety of cultures, each fashioned by the knowledge and sophistication of the society around it and nurtured by the religious and scientific beliefs of the day. In the Hebrew Writings that form our Old Testament, we see the idea of providential design as a key feature of the Creation narratives and the epic poetry of the Wisdom and prophetic writings. The idea of a partially anthropocentric universe with teleological aspects is the warp and woof of the Judaeo-Christian world-view that underlies the growth of Western civilization. Another important aspect of our heritage is the growth of science and logic in early Greece, where the early Greeks also generated a detailed teleological view of the world which was, in time, wedded by the Scholastics to the poetic view of the Judaeo-Christian tradition.

Astronomers and physicists who first encounter the collection of results and observations that exist under the collective label of the Anthropic Principle are usually surprised by the novelty of such an anthropocentric approach to Nature. Yet, the Anthropic Principle is just the latest manifestation of

a style of argument that can be traced back to ancient times when philosophy and science were conjoined and `metaphysics' was concerned with the method as well as the meaning of science. In this chapter we shall follow these arguments from ancient to modern times and attempt to display the recurrent polarization of opinion regarding the meaning of the order perceived in the overall constitution of the world and the apparent teleological relationship between living creatures and their habitats. We shall see many fore-shadowings of modern `Anthropic' arguments.

The Strong Anthropic Principle of Carter has strong teleological overtones. It suggests that `observers' must play a key role in (if not be the goal of) the evolution of the Universe. This type of notion was extensively discussed in past centuries and was bound up with the question of evidence for a Deity. The search for supporting circumstantial evidence focussed primarily upon the biological realm. Indeed, to such an extent did organic analogies permeate the ideas of most Greeks that the entire universe was viewed as an organism wherein the constituent parts were constantly adjusting for the benefit of the whole and in which the lesser members were meaningful only through their function as part of the whole. The most notable supporter of such a view, whose ideas were to dominate Western thought for nearly two thousand years, was Aristotle. He was aware that any phenomenon could be associated with various types of cause, among them an `efficient' cause (which is what modern physicists would call a `cause'). But Aristotle did not believe one could claim a true understanding of any natural object or artefact unless one knew also its `final cause'—the end for which it exists. This he believed to be the pre-eminent quality of things. Rival philosophers denied the relevance of such a notion and even Aristotle's pupils occasionally urged moderation in the deployment of final causes as a mode of explanation. It was, unfortunately, apt to produce `laws' of Nature that tell us things are as they are because it is their natural place to be so!

Aristotle's ideas emerge in Western culture through the channel of medieval scholasticism. Scholars like Aquinas realized the power of teleological reasoning as support for an a posteriori `Design Argument' for the existence of a Deity to whom the `guidedness of things' might be attributed.

Broadly speaking, the Greeks viewed the world as an organism, a view based in part upon the analogy between the natural world and human society. The renaissance view which superseded the Greek view was no less analogical but the paradigm had changed from the organic to the mechanical. The new picture of the clockwork 'watch-world' displayed both the religious conviction in a created order for the world and the desire to find a Creator playing the role of the watch-maker. Whereas the teleological view accompanying the organic world-picture supported a general `guidedness of things', the element of design in the mechanical picture was evidenced by the God-given intrinsic properties of things and the regularity of the laws of Nature. This development leads us to draw a distinction between teleological arguments—which argue that because of the laws of causality order must have a consequent purpose, and iological arguments—which argue that order must have a cause, which is planned. Whereas teleological arguments were based upon the notion that things were constructed for either our immediate benefit or some ultimate end, the eutaxiological arguments point just to their co-present, harmonious composition. There is a clear distinction: the intricate construction of a watch can be appreciated without knowing anything of the `end' for which it has been made. This important distinction, and the terminology, was introduced by Hicks79 in 1883.

The growth of design arguments was, of course, accompanied by the efforts of persuasive and eloquent dissenters to discredit the notion of premeditated design in every or any facet of the natural world. Many of these expressions of scepticism have proven to be overwhelmingly compelling in the biological realm where environmental adaption is now seen to play a key role through the mechanism of natural selection. However, when originally proposed they fell largely upon deaf ears in the face of an impressive array of observational data marshalled in support of `design'.

Scientists rarely take philosophers seriously and they did not often do so in these matters either. One of the strengths of the teleological argument for the layperson is its compelling simplicity; for as one nineteenth-century reviewer remarked, `Imagine two men debating in public, one affirming and the other denying that eyes were intended to see with'. Commonsense superficially appears to affirm the teleological view very convincingly. Closer examination reveals that the argument contains all manner of hidden assumptions and associations, not least of which is a confusion between the ideas of purpose and function. The eutaxiological argument so popular with Newton and his disciples, on the other hand, is logically simpler than the teleological one and hides no linguistic subtleties; but to appreciate the existence of the mathematical beauty and harmony it exhibits and verify the examples cited in support of its claims requires considerable scientific knowledge. For this reason the logically simpler, but conceptually more difficult and more interesting, eutaxiological arguments appealed less to the popular mind. The eutaxiological Design Argument is most similar to the Weak Anthropic Principle. Teleological Design Arguments are analogous to the Final Anthropic Principle, and the Strong Anthropic Principle has something in common with both forms of Design Argument. As a rule, teleological arguments go hand in hand with a holistic, synthetic and global world view whilst the eutaxiological approach is wedded to the local and analytic perspective

that typifies modern physics. To those brought up with the modern scientific method and its emphasis upon concepts like verification, experiment, falsification and so forth, it is surprising that science made as much progress as it did when inbred by teleological ideas. Yet it is clear that even the naivest Design Arguments, unlike the philosophical objections to them, were steeped in observations of the natural world. Indeed, Darwin attributes much of his initial interest in the problem of natural adaption to William Paley's meticulous recording of design in the plant and animal kingdoms. There are other striking examples of teleological reasoning producing significant advances in experimental and theoretical science; for example, Harvey's discovery of the human circulatory system, Maupertuis' discovery of the Principle of Least Action and von Baer's discovery of the mammalian ovum.

We shall see that the simpler teleological arguments concerning biological systems were supplanted by Darwin's work, but the system of eutaxiological arguments regarding 'coincidences' in the astronomical make-up of the Universe and in the fortuitous form of the laws of Nature were left unscathed by these developments and it is these arguments that have evolved into the modern Anthropic Principles. But careful thinkers would not jump now so readily to the conclusions of the early seekers after Design. The modern view of Nature stresses its unfinished and changing character. This is the real sense in which our world differs from a watch. An unfinished watch does not work and the discovery of time's role in Nature led to an abandonment of Design arguments based upon omnipresent harmony and perfection in favour of those that concentrated upon current co-present coincidences. The other modern view that we must appreciate is that we have come to realize the difference between the world as it really is ('reality') and our scientific theories about it and models of it. In every aspect our physical theories are approximations to reality, they claim merely to be `realistic' and so we hesitate to draw far-reaching conclusions about the ultimate nature of reality from models which must be, at some level, inaccurate descriptions of reality. Scientists have not always recognized this, and some do not even today. We see good examples of the consequences of this weakness when we look back at the religious fervour with which Newton's equations of motion and gravitation were regarded by those eighteenth-century scientists intent upon demonstrating that God, like Newton, was also a mathematician. Whilst this group were claiming that the constancy and reliability of the laws of Nature witnessed a Creator, another was citing the breakdown of their constancy, or miracles, as the prime evidence for a Deity.

Our treatment of these questions regarding `design' will be largely chronological and our aim is to chart the history of ideas concerning design and teleology and to bring into focus the similarity

between these ancient ideas and the way modern `Anthropic' arguments are framed. The Anthropic Principle, we shall argue, is a consequence of a certain symmetry in the history of ideas. We shall also see that many other contemporary issues that today are tangent to the Anthropic Principles were also associated with Design Arguments of the past. For example, the question of the plurality of worlds and the construction of proofs of the existence of God (or gods), the uniqueness of man in anthropocentric Christian teleology and the logical status of our perceptions of the natural world were all of continual fascination. There is also a detectable and recurrent trend revealed by our study: students of Nature build a model to describe its workings based on observations; if this description is successful the model becomes an article of faith, some aspect of absolute truth comes to be taken as embodied within it. The descriptive model then becomes almost an idol of worship and a proliferation of Design Arguments arise as expressions of a faith that would claim no comparable or superior descriptions could exist (the fate, perhaps, of a 'paradigm' in ancient times). Thus the modern anthropic principles can he seen partly as natural consequences of the fact that current physical theories are extremely successful. This success is itself still a mystery; after all there is no obvious reason why we should find ourselves able to understand the fundamental structure of Nature. It is also, in part, a consequence of the fact that we have found Nature to be constructed upon certain immutable foundation stones, which we call fundamental constants of Nature. As yet, we have no explanation for the precise numerical values taken by these unchanging dimensionless numbers. They are not subject to evolution or selection by any known natural or unnatural mechanism. The fortuitous nature of many of their numerical values is a mystery that cries out for a solution.

The Anthropic Principle is but one direction of inquiry, albeit, as we shall now see, a surprisingly traditional one.

2.2 The Ancients

You all know the argument from design: everything in the world is made just so that we can manage to live in the world, and if the world was ever so little different, we could not manage to live in it. This is the argument from design.
B. Russell

Our inquiry into the Western predecessors of the modern Anthropic Principle begins on the Mediterranean island of Ionia during the sixth century BC within a culture that valued both curiosity and abstraction for their own sakes. Here, a tiny society nurtured some of the first natural philosophers to pose abstract problems completely divorced from any technological, nautical, agricultural or authoritarian stimuli. Their primary goal was to elucidate the primary forms and functions at the root of all natural phenomena. To realize that ambition they had to understand both the nature of man and the structure of his environment.

Anaxagoras of Clazomenae' (500-428 BC) is a pivotal figure, a mediator between the ancient Ionian philosophical tradition and the emergence of the Greek tradition. In 480 BC he migrated to Athens, probably as a member of Xerxes' militia, and there remained for thirty years as the first teacher of philosophy among the Athenians. Eventually, like Socrates, his career there was to end with charges of heresy; but unlike his famous successor he chose to leave, and fleeing to Ionia, worked there for a further twenty-five years.

Unfortunately we possess only fragments of Anaxagoras' writings in their original forme and these seem to be of an introductory and general nature, but later writers provide sufficient commentary for a fragmentary 'identikit' portrait of his ideas to be composed. Both Plato and Aristotle regard him as the first to attribute the evident structural harmony and order in Nature to some form of intelligent design plan rather than the chance concourse of atoms. Since Anaxagoras appears to be

first of the known pre-Socratics to dwell upon the presence of order in Nature, it is perhaps no surprise that he was among the first to attempt to explain this observation by some primary cause. Anaxagoras sought some all-embracing dynamical influence which would provide him with an explanation for the mysterious harmony he saw about him. He believed the Universe and all matter to have always existed, at first a mindless confusion of infinitesimal particles, but destined to become ordered by the influence of a cosmic 'Mind'. This `Mind' (nous) intervened to eradicate the state of primeval chaos by the induction of a vortical motion in space', which first led to a harmonious segregation of natural things and then slowly abated leaving quiescence, harmony and order. The rotation of the heavenly bodies in the solar system remain as the last vestige of the action of cosmic `Mind'. Anaxagoras aims to explain the orderly motion and arrangement of matter by some subtle and fluid entity which exercises a guiding influence upon the Universe like a man's mind controls his body. These ideas are relevant because they signal the first introduction of `Mind' in conjunction and in competition with 'Matter' for the explanation of phenomena; a problem to be much discussed by subsequent generations of philosophers and scientists. Our interest is attracted by this simple feature of his thinking because it forges a link with later Platonic and Aristotelian ideas.

Unfortunately, if the extant writings provide a fair sample, nous appears to have been a rather vaguely defined entity. It is employed to order all things initially, but thereafter plays no direct role in the temporal development of things nor is it ever used to explain the specific order and design displayed by an individual object or organism. Anaxagoras' description places its influence at the boundary of the Universe, its role cosmological and metaphysical,

And what was to be, and what was and is not now, and what is now and what will be—all these mind ordered.4

This initial and purposeful cause contrasts sharply with the metaphysical edifices that were constructed later by Plato and Aristotle. The latter postulated an 'end' (telos), neither personal nor purposefully goal-directed, to which phenomena were magnetically directed. Anaxagoras' lack of a teleological emphasis provokes criticism from Aristotle who highlights what appears to moderns the plain common sense of the Anaxagorean view. The disagreement between Anaxagoras and Aristotle is interesting because it will appear again and again through the centuries, albeit suitably camouflaged by the thought-forms and categories of contemporary thinking.

Now Anaxagoras says that it is due to his possessing hands that man is of all things the most intelligent. But it may be argued that he comes into possession of hands because of his outstanding intelligence. For hands are a tool, and Nature always allots each tool, just as any sensible man would do, to whosoever is able to make use of it

The root of Aristotle's discontent with Anaxagoras is a suspicion that his predecessor was merely advocating a pre-Socratic version of the 'God-of-the-Gaps' methodology in his approach to the natural world. `Mind' appears only as a form of metaphysical mortar to fill the gaps and cracks of ignorance in his otherwise entirely deterministic world model. For, Aristotle claims Anaxagoras uses mind as a theatrical device for his cosmogony; and whenever he is puzzled over the explanation of why something is from necessity, he wheels it in; but in the case of other happenings he makes anything the explanation rather than mind .6

This criticism had in fact been voiced in a disconsolate commentary a little earlier by Socrates, who describes how objections slowly dawned upon him as he read one of Anaxagoras' books in search of ideas on design in the Universe. He recalls the moment of anticlimax vividly,

Well, I heard someone reading once out of a book, by Anaxagoras he said, how mind is really the arranger and cause of all things; I was delighted with this cause, and it seemed to me in a certain way to be correct that mind is the cause of all, and I thought if this is true, mind arranging all things in places as is best. If, therefore, one wishes to find out the cause of anything, how it is generated or perishes or exists, what one ought to find out is how it is best for it to exist or to do or feel everything.... I was glad to think I had found a teacher of the cause of things after my own mind in Anaxagoras.... For I did not believe that when he said all this was ordered by mind, he would bring in any other cause for them that it was best that they should be as they are.... I got his books eagerly.... How high I soared, how low I fell! When as I went on reading I saw the man using mind not at all; and stating no valid cause of the arrangement of all things, but giving airs and ethers and waters as causes, and many other strange things.'

Whilst these earliest notions concerning order and motion were being incubated, a Sicilian contemporary, Empedocles of Agrigentum (492-435 Bc), was developing some radically different ideas about the origin of ordered organic structures and their survival over the course of time. Unlike many of his contemporaries, Empedocles was a keen and careful observer of Nature and despite sporadic delusions of divinity combined this with the general study of magic, poetry and medicine. His key insight was to intertwine the notions of change and temporal evolution with physical processes rather than conceive of them possessing some time-invariant meaning. These evolutionary processes he imagined to be somehow connected with the presence of order and design in Nature. In modern biological parlance we would say that he proposed the mechanism of `normalizing selection'. Initially, creatures of all possible forms and genetic permutations were imagined to exist but over the passage of time only some were able to reproduce and multiply. Gradually the centaurs and half-human monsters eliminate themselves through sterility. He imagines that eventually only the ordered, and therefore `normal,' beings survive. This type of selection only maintains an invariant species against mutant invasion and is really quite distinct from Darwin's idea of natural selection wherein no species is immune to change. Again we learn more of these ideas through Aristotle's condemnation of them; he quotes Empedocles' summary:

On [the earth] many heads sprung up without necks and arms wandered bare and bereft of shoulders. Eyes strayed up and down for want of foreheads .... Shambling creatures with countless hands.... While others, again arose as offspring of men with the heads of oxen, and creatures in whom the nature of women and men was mingled, furnished with sterile parts.8

Parmenides (c.480 BC) the founder of the school of Elea in Southern Italy was one of the earliest logicians. Although he seems to have written in verse, it is of a sufficiently prosaic nature to allow his principal theses to be extracted. He hoped to explain what is `intelligible' and wanted to show it was impossible to make a negative existential judgement. Parmenides claimed that a 'many-worlds' interpretation of nature is necessary because of the non-uniqueness of the subjective element in our perception and understanding of the world. As a corollary to this he maintained that what is inconceivable must actually be impossible—empty space cannot exist! Over two thousand years later these ideas will appear in a new guise in debates concerning the role of the observer in quantum theory and the theory of measurement.9 The more immediate, but no less important consequence of these ideas was the early atomists' abandonment of trust in the senses as a certain and invariant gauge of world structure. In order to avoid this awkward perceptive subjectivity they sought objective reality in imperceptible `atomic' micro-phenomena that they believed to be independent of the observer and absolute in character.

Socrates (470-399 Bc) and his student Plato (427-347 BC) later reacted against this trend towards purely materialistic explanations of natural phenomena and attempted to show that material order not only sprang from `Mind' but was actively sustained by it. Plato argued that because matter cannot induce motion itself, the observed presence of motion is evidence of a mental presence and

Cause underpinning the whole natural world. He also conceived of a particular hierarchical cosmological model exhibiting this doctrine. In the beginning the outer sphere of his hierarchical universe was perturbed into motion by an obliging deity and thereafter remained in ordered motion and displayed a completely invariant structure. In the `Laws' this regular structure is cited as evidence of the gods. For, when asked how one might prove the existence of the gods, Cleinas replies with one of the most explicit early design arguments:

How? In the first place, the earth and the sun, and the stars and the Universe, and the fair order of the seasons, and division of them into years and months, furnishes proofs of their existence.'"

However, this appeal to astronomical phenomena has a slightly hollow ring to it in the light of Socrates' attitude towards all experimental philosophy and astronomy. We see that he was aware of the ability of `physical philosophers' to provide many different but equally plausible explanations of a single observation but has no notion that perhaps further observations might narrow down the number of `conflicting opinions':

With regard to astronomy Socrates considered a knowledge of it desirable to the extent of determining the day of the year or of the month and the hour of the night; but as for learning the course of the stars, [he regards] occupying oneself with the planets or inquiring about their distance from the earth or about their orbits or the causes as a waste of time. He dwelt on the contradictions and conflicting opinions of the physical philosophers ... and, in fine, he held that speculators on the Universe and on the laws of the heavenly bodies were hardly better than madmen."

Plato opposed contemporary ideas that attempted to explain the observed structures and contrivances in Nature as a result of either chance or mechanism, and this opposition was grounded on the evidence for design in the natural world. He preferred a picture of the Universe as an organic and teleologically ordered structure. •

Socrates gives the first clear statement of an anthropocentric design argument with a distinctly eighteenth-century flavour to it when he is reported by Xenophon extolling the human eye as a proof of the wisdom of the gods:

But which seems to you most worthy of admiration Astrodemus? The artist who forms images devoid of motion and intelligence, or who had skill to produce animals that are endued, not only with activity, but understanding? ... But it is evidently apparent that he who at the beginning made man endued him with senses because they were good for him ... Is not that providence, Aristodemus, in a most eminent manner conspicuous, which because the eye of man is delicate in its contexture, hath therefore prepared eyelids like doors, whereby to screen it, which extend themselves whenever it is needful, and again close when sleep approaches? ... Is it not to be admired ... that the mouth through which the food is conveyed should be placed so near the nose and eyes as to prevent the passage unnoticed of whatever is unfit for nourishment? And can't thou still doubt Aristodemus, whether a disposition of parts like this should be the work of chance, or of wisdom and contrivance.12

Another very early commentator on the beneficial and superficially purposeful contrivance of natural things toward our perennial well-being was the Cretan philosopher, Diogenes (400-325 tic). Working about a century after Anaxagoras, he appears to be one of the earliest thinkers who appealed to a teleological principle behind natural phenomena on the basis of their optimal arrangements. In particular, he was impressed by the regular cycle of the seasons,

Such a distribution would not have been possible without Intelligence, that all things should have their measure: winter and summer and night and day and rain and winds and periods of fine weather; other things also, if one will study them closely, will be found to have the best possible arrangement."

He claims that `air' must be this ordering `Intelligence' because `man and the other animals that breathe live by air. .

The earliest opponents of these teleological notions were Democritus (450-? Bc) and Leucippus of Elea (440-? Bc). Leucippus appears as a rather obscure fifth-century figure reputed to have founded the school at Abdera in Thrace where Democritus was born. Again our knowledge of their work derives principally from secondary sources—through Aristotle, Epicurus, and others. Leucippus proposed the early `atomic' theory which was then developed more `scientifically' by Democritus before being tenuously extrapolated into the realm of ethics and philosophy by Epicurus. Their development of the mechanism of causation and an atomic view of the world was entirely ateleological; the only causes admitted were atomic collisions (although later Epicurus and Lucretius were to appeal to a mysterious intrinsic atomic property, `swerve', which enabled atoms to collide). As with Empedocles we see inklings of some parallels with modern evolutionary biology and the `many worlds' interpretation of quantum theory in their writings. Democritus understands the link between life and its local environment and has the notion of an ensemble of planetary systems:

There are worlds infinite in number and different in size. In some there is neither sun nor moon, in others there are more than one sun and moon. The distance between the worlds are unequal, in some directions there are more of them ... Their destruction comes about through collision with one another. Some worlds are destitute of animal and plant life and of all moisture.15

The pre-eminent proponent of a teleological world view amongst the ancients was Aristotle (384-322 Bc) and his commentary on the ideas of others provides a valuable source of information. The Stagirite's teleological view was to become tremendously influential, some would claim out of all proportion to its profundity, because it became amalgamated with the Judaeo-Christian revelation in the Scholastic synthesis. By this indirect route his ideas were able to shape the thought of Western Europe for nearly two thousand years. Unlike Socrates and Plato, Aristotle was not an Athenian. His father was a physician at the court of the Macedonian royal family and his keen observation of and life-long interest in flora and fauna may have derived from early paternal influence. Whilst still a teenager he went to Athens to study as a student of Plato at the Academy. There he worked for twenty years, principally on ethics, mathematics, politics and philosophy, but then left for the coastal region of Asia Minor where he rekindled his interest in observation through studies in zoology and biology. So much did he learn during that period that on his return to Athens he was able to establish a thriving school of botanical and biological investigation which laid the foundations of modern study in these disciplines.

Aristotelian science was based upon presupposition of an `intelligent natural world that functions according to some deliberate design'. Its;supporters were therefore very critical of all those pre-Socratic thinkers 'who regarded the world structure as simply the inevitable residue of:Chance or necessity. Aristotle's own detailed observational studies in botany, biology and zoology led him to take up the organic analogy as the most fruitful description of the world and he regarded it as superior to the mechanistic paradigm.

In his Metaphysics, Aristotle works through the ideas of earlier philosophers and rejects them one by one. He strongly opposes a recurrent idea, held for example by the Atomists, that a thing is explained when one knows what it is made of. For, he argues, its material composition provides us

with its `Material Cause', but to explain it completely we require an understanding of three further `Causes'. A `Formal Cause' must be identified. This relates to the form or pattern intrinsic to the object which prevents it from behaving like another; for example, it distinguishes sculptures from lumps of unformed metal (or at least it did!). Next, the 'Efficient Cause' should be recognized as the agent which produces the object, transferring the mental notion of a statue from the sculptor's mind into solid material bronze; the `Efficient Cause' is what moderns mean when they use the word `cause'. Finally, there exists that `Cause' which Aristotle regarded as the most important: the `Final Cause'—the purpose for which the object exists. Even at this stage it is evident that this multiplicity of causes leads very quickly to metaphysical ideas of supreme initial causes or ultimate final ends.

The common preoccupation with the presence of order in the Universe meant there were many similarities between the cosmologies of Aristotle and Plato. Where Aristotle differed was in his attitude towards initial conditions. He argued that knowledge of the `beginning' is not relevant to our understanding of the present configuration—that initial conditions did not matter—and furthermore, there were reasons for supposing there never was an origin in time—the natural order should be eternal and unchanging. Aristotle's cosmology was the first `steady-state' Universe.

There, the similarity with any modern cosmological model very abruptly ends. Aristotle imagined the Universe to possess a spherical boundary with the earth resting at its centre. Surrounding the earth were a whole series of concentric shells; the three closest to the centre contained water, air and fire respectively. Now, the idea behind this hierarchical structure was to explain why, for example, flames 'naturally' rose whilst other objects, like stones, always fell to the earth. The outer shell of fire was encompassed by a succession of seven solid and crystalline spheres; they carried the Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn and finally the fixed stellar background. This outer stellar sphere was endowed with a dynamical rotation which it communicated to the inner spheres and thereby to the planets themselves.16

Aristotle's guiding principle was that the ultimate meaning of things was to be divined from their `end' (telos) rather than their present configuration—that is, by learning of their final rather than their material causes. This `end' was the most perfect and fitting purpose, ... it belongs to physical science to consider the purpose or end for which a thing subsists. The poet was led to say `An end it has for which it was produced' ... for not that which is last deserves the name of end, but that which is most perfect."

Although, as we saw above, Aristotle credits Anaxagoras for germinating this view, he upbraids him strongly for employing it in so limited and sterile a fashion. In contrast, he energetically develops his own scheme of final causes in combination with the Platonic teleology and uses it to interpret his own detailed observations of Nature. Although he is not often credited for it, he carried through this programme with something of the modern scientific philosophy:

The actual facts are not yet sufficiently made out. Should further research ever discover them, we must yield to their guidance rather than to that of theory; for theories must be abandoned, unless their teachings tally with the indisputable results of observation.18

He is clearly anxious to derive support for his teleological ideas from observational facts and wants to avoid the approach of those of his predecessors who have adopted the methodology of armchair natural philosophers.

From the idea of a `Final Cause' there emerged the Aristotelian idea of an internal perfecting principle or 'entelechy' which directs things toward some terminal point characterized by its unique harmony. In any individual object all its sub-components are united for its greatest benefit and are

coherently organized with this `perfect' end in view. The evidence for such an opinion, he argues, is much more readily obtained from astronomical observations than from biological ones. For, in the former system, the time-scale over which significant changes occur is so much longer:

For order and definiteness are much more plainly manifest in the celestial bodies than in our own frame; while change and chance are characteristic of the perishable things of earth. Yet there are some who, while they allow that every animal exists and was generated by nature, nevertheless hold that the heaven was constructed to be what it is by chance and spontaneity; the heaven, in which not the faintest sign of haphazard or of disorder is discernible! Again whenever there is plainly some final end to which a motion tends, should nothing stand in the way, we always say that such final end is the aim or purpose of the motion and from this it is evident that there must be a something or other really existing, corresponding to what we call by the name of Nature."

Aristotle also displays an objectivity and breadth of view in his discussion of the limitations and conceivable objections to his teleology that was to prove all too rare in the later work of his many followers. He realizes, for example, that development could play an important role in generating organic structures:

In plants, also there is purpose, but it is less distinct; and this shows that plants were produced in the same manner as animals, not by chance, as by the union of Olives upon grape-vines. Similarly, it may be argued, that there should be an accidental generation [or production] of the germs of things; but he who asserts this subverts Nature herself, for Nature produces those things which, being continually moved by a certain principle contained in themselves, arrive at a certain end.20

and that necessity must be considered as an influence upon their development;

We have ... to inquire whether necessity may not also have a share in the matters and it must be admitted that these mutual relations could not from the very beginning have possibly been other than they are.21

On another occasion he recapitulates the anti-teleological position of the atomists in a convincing fashion:

But here a doubt is raised. Why, it is said, may not nature act without having an end, and without seeking the best of things? Jupiter, for instance, does not send rain to develop and nourish the grain, but it rains by a necessary law; for in rising, the vapour must grow cool, and the cooled vapour becoming water must necessarily fall. But if, this phenomenon taking place, the wheat profits by it to germinate and grow, it is a simple accident. And so again, if the grain which someone has put into the barn is destroyed in the consequence of rain, it does not rain apparently in order to rot the grain, and it is a simple accident if it be lost. What hinders us from saying as well, that in nature the bodily organs themselves are subject to the same law and that the teeth, for instance, necessarily grow ... What hinders us from making the same remark for all the organs where there seems to be an end and a special destination 22

Whereas Plato had been interested in order and structural design within the Universe principally as manifestations of its static, permanent and unchangeable nature, Aristotle's view was clearly more dynamic. The Aristotelian world was endowed with a process of temporal evolution acting solely for the sake of the entities finally evolved.

Following the death of Aristotle, peripatetic thinking was dominated for a period of thirty-five years by Tyrtamus of Eresos (372-287 Bc). Now regarded as one of the founders of systematic botanical study, Tyrtamus is better known to us by his nickname `Theophrastus' which he received

from Aristotle because of his stimulating conversation. Like others before him, Theophrastus was struck by a dichotomy in his experience. On the one hand he was conscious of the orderliness of his mental processes whilst on the other he perceived a natural world of enormous complexity. He felt that if some link could be forged between these disjoint areas of experience then light might be shed upon them both.

Despite his long association with Aristotle, first as a fellow student of Plato at the Academy and then as a co-worker at the Lyceum, he was critical of his master's teleological mode of thinking and recognized the strongly subjective elements that were incorporated in its application:

As regards the view that everything has a purpose and nothing is in vain, first of all the definition of purpose is not so easy, as is often said; for where should we begin and where decide to stop? Moreover, it does not seem to be true of various things, some of which are due to chance and others to a certain necessity, as we see in the heavens and in the many phenomena on earth.23

He then goes on to give many examples of natural phenomena, like drought, flood, and famine, which yield no discernible end, interpreting them as casting doubt upon Aristotle's perfecting principle as a useful practical guide into the nature of things. He concludes that natural science will only make sure and sound progress if it moderates24 its appeal to final causes, for

We must try to set a limit to the assigning of final causes. This is the prerequisite for all scientific enquiry into the universe, that is into the conditions of existence of real things, and their relations with one another?'

The contemporary counter to the peripatetic school's teleology was the radical alternative of Epicurus of Samos (341-270 Bc) and his followers. Following in the footsteps of Democritus and Leucippus, these later atomists emphasized the importance of assuming a complete state of statistical disorder at the moment of the World's creation. They claimed this chaotic initial state subsequently evolved by natural forces into an ordered system characterized by regular and steady rotations. They argued that the infinite time allowed for creation makes it inevitable that it should eventually develop into a stable configuration capable of remaining in a constantly ordered state. The Epicureans were, of course, anxious to scotch any notions of supernatural causation or the appeal to any entity who controls or ordains events. Interestingly, no useful scientific structure was erected upon this materialistic foundation because Epicurus had a very low view of mundane scientific investigation. Indeed, he excluded many of its basic tools—logic, mathematics, grammar and history—from his school's curriculum. He was particularly hostile to the study of astronomy because celestial phenomena seemed to him to admit of so many equally consistent and indistinguishable explanations:

First of all then we must not suppose that any other object is to be gained from the knowledge of the phenomena of the sky, whether they are dealt with in connection with other doctrines or independently, than peace of mind and a sure confidence, just as in all other branches of study.25

The most remarkable spokesman for the Epicurean position was the Roman poet Titus Lucretius Carus (99-55 BC). His great poem De Rerum Natura26 aimed to bury all superstitious speculation and philosophical dogma by outlining the vast scope of a purely materialistic doctrine. It reveals an uncanny intuition regarding the future conceptual development of physics and displays such a good knowledge of flora and fauna that one is led to wonder whether Lucretius wrote other prosaic and systematic studies of these subjects which are now lost to us.

Lucretius believed life to have originated at some definite moment in the past by natural processes but that the created beings included 'a host of monsters, grotesque in build and aspect' who were subsequently eliminated by their sterility:

In those days, again, many species must have died out altogether and failed to reproduce their kind. Every species that you now see drawing the breath of the world survived either by cunning or by prowess or by speed. In addition, there are many that survive under human protection because their usefulness has commended them to our care.27

As his poem unfolds the entire materialistic methodology is eloquently restated and the logical difficulty inherent in a teleological approach is forcefully presented to his patron, Memmius: to put it bluntly, he claims that teleologists like Aristotle have simply been putting the cart before the horse:

There is one illusion that you must do your level best to escape—an error to guard against with all your foresight. You must not imagine that the bright orbs of our eyes were created purposely, so that we might be able to look before us ... and helpful hands attached at either side, in order that we might do what is needful to sustain life. To interpret these or any other phenomena on these lines is perversely to turn the truth upside down. In fact, nothing in our bodies was born in order that we might be able to use it, but the thing born creates the use ... The ears were created long before a sound was heard ... They cannot, therefore, have grown for the sake of being used.28

Yet this critical approach ground to a temporary halt with Lucretius whilst the teleological aspect of Aristotle's philosophy he criticized so strongly, being more adaptable to the theistic Islamic and Christian cultures, was to grow in influence and extent.

Another group who inherited some of Aristotle's teleological ideas were the Stoics; a school which was founded by Zeno of Cilium (334-262 Bc) during the fourth century Bc and which took its name from a painted corridor on the north side of the market place in Athens where it was the custom of the school to meet for discussion. Teleological ideas appear in Stoic physics under the guise of 'Providence'. For the Stoics this concept embodied the notion that all was the best; the idea was carefully gauged to temper the harsher Stoic dictum of 'fate' within which was enshrined the absolute rule of causality. They replaced Aristotle's infinitely old, 'steady-state' Universe with one possessing a cyclic recurr ence.29 Their conviction regarding the innate order and rationality of Nature, which became the basis of their ethics, made the Stoics fervent supporters of the cosmological Design Argument in all its forms. Although they rejected the mechanical world-view in favour of a more Aristotelian organic analogy, they nevertheless developed their Design Arguments via the analogy between the workings of the world and familiar mechanical models. The Roman lawyer, orator and popularizer of Greek philosophy, Marcus Cicero, records that: 30

The Stoics, however, most assuredly did consider man to be at the very apex of the hierarchy of beings and felt that the rest of the Universe was geared to his benefit.

Cicero (106-43 Bc) himself devotes much of his famous work De Natura Deorum to arguments for the existence of the gods drawn from the beneficial contrivance of the world. He also signals the start of a tendency for teleological design arguments to be employed to establish not only the existence but also the character traits of a deity or deities. De Natura Deorum describes the conversations between two disciples of Plato, namely Cotta and Cicero; a Stoic, Balbus; and an Epicurean atomist, Velleius. As might be anticipated from our discussion so far, Balbus provides various teleological arguments for the gods' existence and is backed up by the Platonists in the face of Velleius' continuous opposition. For example, Balbus criticizes the Epicurean view that things

could have fallen out so nicely just by chance and reveals a new type of numerical perspective on the likelihood of ordered configurations arising spontaneously:

Can I but wonder here that anyone can persuade himself that certain solid and individual bodies should move by their natural forces and gravitation in such a manner that a world so beautiful adorned should be made by their fortuitous concourse. He who believes this possible may as well believe, that if a great quantity of the one and twenty letters, composed either of gold or any other matter, were thrown upon the ground, they would fall into such order as legibly to form the 'Annals of Ennius'. I doubt whether fortune could make a single verse of them ... Thus if we every way examine the Universe, it is apparent from the greatest reason that the whole is admirably governed by a divine providence for the safety and preservation of all beings."

These arguments were inspired by a lost work of Aristotle (De Philosophia) in which he reportedly argued that

Cicero couples a purely mechanical view of the world with a good anatomical knowledge and even gives the now classic design argument based upon the watch analogy that was used so persistently by Boyle, Niewentyt, Paley and others over fifteen hundred years later: our familiarity with the remarkable aspects of Nature has removed our sense of wonder at them. If we had spent our lives underground and then suddenly came to the surface we would be so struck by the structure of the heavens and the beauty of the Earth that we would be inevitably and `immediately convinced of the existence of the gods and that all these wonders were their handiwork'.32

When we see some example of a mechanism, such as a globe or clock or some such device, do we doubt that it is the creation of a conscious intelligence? So when we see the movement of the heavenly bodies, ... how can we doubt that these too are not only the works of reason but of a reason which is perfect and divine?"

These and many other examples adorn an argument for the `gods' that is eutaxiological rather than teleological in character; that is, it is based upon the presence of discernible order and mutual harmony in Nature rather than the recognition of any conscious or unconscious anthropocentric purposes. It is a type of argument that was to be repeated regularly in future centuries.

Another, whose ideas were later to form the basis of many eighteenth-and nineteenth-century treatises on the `Wisdom of God' as evidenced by anthropocentric teleology, was the Greek physician Galen (131-201). Although Galen was eclectic in his philosophical outlook he clearly favoured the Aristotelian picture as the most natural backdrop for his monotheistic views. He developed the doctrine of Final Causes in a more specific and teleological manner than Cicero, arguing that the purpose of the deity could be ascertained by detailed inspection of his assumed works in Nature. Specifically, his study of the specialized design of the human hand was a classic piece of anatomical analysis that became the basis of Bell's Bridgewater Treatise on the teleological aspects of this organ over sixteen hundred years later, so little were later workers able to add to his insights. Of the human body he writes:

Let us, then, scrutinize this member of our body, and inquire, not simply whether it be in itself useful for all the purposes of life and adapted to an animal endued with the highest intelligence, but whether its entire structure be not such that it could not be improved upon by any conceivable alteration.34

His approach was wholly teleological and maintained that all the bodily processes were divinely and optimally planned in every respect. This anthropocentric tenor also runs through the encyclopaedic

natural history of the Roman, Pliny (23-79), who also usually described nature by drawing on its relation to man:

Nature and earth fill us with admiration ... as we contemplate the great variety of plants and find that they are created for the wants or enjoyments of mankind.35

Despite their great administrative, legal and military skills the Romans produced little in the way of lasting abstract ideas. The most relevant character to our study is perhaps Boethius (470-525) who mediates the transition from Roman to Scholastic thinking. For many years a prominent Roman statesman and philosopher he was to write his influential manual36 The Consolation of Philosophy whilst incarcerated in Pavia gaol awaiting execution. This work is one of the few threads of contact between classical learning and the Dark Ages and is written in an unusual medley of poetry and prose (the author speaks in prose whilst philosophy replies in verse). Boethius' support of the teleological doctrine of Final Causes is clear from the outset of his work where he hails Socrates, Plato and Aristotle as the only true philosophers and sets them in opposition to the spurious Stoic and Epicurean thinkers:

Thinkest thou that this world is governed by haphazard and chance? Or rather doest thou believe that it is ruled by reason?"

His answer ensured that the teleological argument was handed on safely to the emerging civilizations of Northern Europe, for Boethius' book was probably the most widely read scholarly work of the medieval period. It played a major role in shaping the philosophical vocabulary and perspective of those times—it is even fabled that Alfred the Great (849-901) had it translated into Anglo-Saxon. Although the world-view it presents is teleological and anthropocentric through and through, the world model it presumes most definitely is not. Boethius saw and stated that despite the implication of final causes, the astronomical position of man was both infinitesimal and insignificant; a view that would have become familiar to his later pre-Copernican readership:

Thou hast learnt from astronomical proofs that the whole earth compared with the Universe is no greater than a point; that is, compared with the sphere of the heavens, it may be thought of as having no size at all. Then, of this tiny corner, it is only one-quarter that, according to Ptolemy, is habitable to living things. Take away from this quarter the seas, marshes, and other desert places, and the space left for man hardly even deserves the name of infinitesimal.38

This completes the sketch of Greek and Roman origins, showing how the Design and anti-Design arguments began there. (The dates of the principal protagonists are shown in Figure 2.1.) But, these seeds would have fallen on stony ground had it not been for their adoption by the inheritors of an entirely different tradition.

During the next seven hundred years Greek learning was first perpetuated by the Arabic schools who translated many of the early texts. This Eastern influence reached its zenith during the tenth century and through it Aristotelian ideas slowly diffused into the European culture to be moulded into a Christian form by Aquinas as easily as it was fitted into the Muslim perspective of the early Arabic philosophers.

2.3 The Medieval Labyrinth

The human imagination has seldom had before it an object so sublimely
ordered as the medieval cosmos ... it is perhaps ... a shade too ordered. Is there nowhere any vagueness? No under-discovered byways?
C. S. Lewis

What characterizes the Medieval mind most uniquely for the modern spectator is its absolute respect for written authorities. All writers tried to base their works on ancient authority—most notably that of Aristotle. Also, in C. S. Lewis' words,39 `Medieval man was not a dreamer nor a wanderer. He was an organizer, a codifier, a builder of systems. He wanted "a place for everything and everything in the right place." Distinction, definition, tabulation were his delight.' These two powerful traits proved perfect, not only for the preservation of the ancient Design arguments, but for their subsequent elevation to the status of ecclesiastical dogma. The nearest one gets to a parallel of the atomists versus the teleologists is, at first, the division of opinion concerning whether science, religion and metaphysics should be conjoined with the blessing of the Design Argument.

Averroes of Cordova (1126-1198) was a Mohammedan member of the early Hispan-Arabic school of philosophy and medicine 40 who opposed such a scholastic synthesis. He wanted to separate the basis of religion from experimental science and logic because of the pseudo-conflicts he saw inherent in such a union. He still maintains a teleological view but it is only partially anthropocentric, for he feels it is unreasonable to say that all Nature exists solely for the luxury of humankind:

Why did God create more than one sort of vegetable and animal soul? The reason is that the existence of most of these species rests upon the principle of perfection (completeness). Some animals and plants can be seen to exist only for the sake of man, or of one another; but of others this cannot be granted, for example, of the wild animals which are harmful to men.41

Looking to another culture one finds the Jewish rabbi Maimonides (1135-1204), an astronomer, philosopher and physician who, like the Arabs, sought to reconcile Aristotelian philosophy with his own religious heritage. This led to his construction of a Jewish Scholastic system 42 that developed the 'proof of God from contingent being following analogous earlier work by Avicenna (980-1037) and others. Maimonides wrote an apologetic work as a spiritual guide for atheistic philosophers entitled Guide for the Perplexed43 wherein he states an objection to anthropocentric teleology which is based on the enormous size of the Universe:

Consider then how immense is the size of these bodies, and how numerous they are. And if the earth is thus no bigger than a point relative to the sphere of the fixed stars, what must be the ratio of the human species to the created Universe as a whole? And how then can any of us think that these things exist for his sake, and that they are meant to serve his uses?"

By the middle of the thirteenth century the Dominican scholars, Albert the Great and Thomas Aquinas (1225-74) had completed Aristotle's conversion to Christianity. Aquinas, the `angelic doctor', was born after the major rediscovery and translation of many of Aristotle's works into Latin and his own unique contribution was a vast unification of Aristotle's philosophy with the Judaeo-Christian doctrine of the Catholic church. The Scholastic ideal held that the nature of ultimate things was accessible to reason alone without revelation from a divine source. Therefore Scholasticism preserved a strong belief in the intrinsic intelligibility of Nature and in the presence of an underlying rationality in an age full of astrological and magical notions. Ironically, this rationality would in the future backfire against some of the more negative aspects of Scholastic dogma. Specifically, Aquinas uses a teleological design argument for the existence of a unique God as the basis of his famous `Fifth Way' to prove the existence of God and attributes the idea to St. John of Damascene:

The fifth way begins from the guidedness of things. For we observed that some things which lack knowledge, such as natural bodies, work towards an end. This is apparent from the fact they always or most usually work in the same way and move towards what is best. From which it is clear that

they reach their end not by chance but by intention. For these things which do not have knowledge do not tend to an end, except under the direction of someone who knows and understands: the arrow, for example, is shot by the archer. There is therefore, an intelligent personal being by whom everything in nature is ordered to its end.45

His argument does not appeal to any specific pieces of empirical evidence or detailed examples of adaption but to a single aspect of world order—the general trend of natural behaviour.

Alongside Thomist philosophy there began to develop, through a number of eminent Franciscan friars, an approach to science that has a more modern flavour. Roger Bacon (1214-94) was the most far-sighted—and the most persecuted—of the advocates for this new emphasis. His foresight influenced many fields of learning that are today quite distinct. He argued, for example, that the use of original texts in historical and linguistic study was essential for scholarship whilst in the sciences he saw that useful progress could only be made through a combination of mathematical reasoning and experimental investigation. Yet, alongside this new and modernistic philosophy of the scientific method Bacon held what was, for his time, a typical view of final causation and mankind's pre-eminent position within the natural world:

Man, if we look to final causes, may be regarded as the centre of the world; in so much that if man were taken away from the world, the rest would seem to be all astray, without aim or purpose ... and leading to nothing. For the whole world works together in the services of man; and there is nothing from which he does not derive use and fruit ... in so much that all things seem to be going about man's business and not their own.

The strength of his position was that he did not allow such finalistic inclinations to usurp the place of direct observations in the practice of physical science. Final causes were relegated entirely to the metaphysical domain.

Conscious of the ease with which we adopt preconceived and fallacious modes of reasoning, Bacon ear-marked four explicit sources of erroneous deduction; undue regard for established doctrines and authorities, habit, prejudice and the `false conceit of knowledge'. Uncritical adoption of Aristotelian metaphysics in the area of physical science was clearly the paradigm for the first of these pitfalls.

The Scholastics, in addition to introducing the term `final cause' (causa finalis) into philosophy, were also the first to use the appellation `natural theology' (theologia naturalis) which was to prove so popular during the seventeenth and eighteenth centuries. It originates in the work of Raymonde of Sebonde (c. 1400), an obscure scholar who was persuaded to remain in Toulouse as the university professor of medicine, philosophy and theology whilst passing through on a journey to Paris from his home in Barcelona. His book 47 Theologia Naturalis sive Liber Creaturarum was clearly not wholly orthodox because it was placed on the Index in 1595, but the reasons for this are still not altogether clear. It later became influential following its translation by Montaigne in 1569 and was reprinted thereafter in France on several occasions. The author's guiding theme is the kinship of mankind with the natural world and is slightly reminiscent of St. Francis. This unity between man and his environment speaks to him of both design and a unique Designer:

There could not be so great an agreement and likeness between man and the trees, plants and animals, if there were two designers, rulers or artificers in nature; not would the operations of plants and trees be carried on so regularly after the manner of human operations, nor would they all be so much in man's likeness, except that He which guided and directed the operations of these trees and plants were the same Being that gave man understanding and that ordered the operations of trees which are after the manner of works done by understanding, since in trees and plants there

is no reason nor understanding. And of far more strength is the oneness of matter and sameness of life in man, animals, trees and plants an evidence of the oneness of their Maker."

2.4 The Age of Discovery

Inquiry into final causes is sterile, and, like a virgin consecrated to God, produces nothing.
F. Bacon

The developments heralding the birth of what has become known as the Renaissance view of the world have been exhaustively discussed by scholars. With hindsight, Nicholas Copernicus (1473-1543) appears to us a pivotal figure, the last of the Aristotelians and the harbinger of a fully mechanical model of the Universe. What is now equally clear is that his classic,48 De revolutionibus orbium celestium, had negligible influence until the seventeenth century. Few copies of it were sold and even fewer read in the early years after Copernicus' death; other great events, like the Portuguese voyages of discovery, completely overshadowed it. Although Copernicus' world model was new and heliocentric, his world-view was extremely anthropocentric and he appears a little reticent about relinquishing even the physical centrality of Man, but assures us that Man's displacement is really only very slight, given the immense size of the cosmos:

So it is also as to the place of the earth; although it is not at the centre of the world, nevertheless the distance [to that centre] is as nothing in particular when compared to that to the fixed stars.49

It is also interesting that Copernicus uses various tenets of Aristotelian teleology concerning the necessary harmony and order of the Universe to guide him in the construction of a purely mechanical model.

Because,

the handling of final causes mixed with the rest in physical inquiries, hath intercepted the severe and diligent inquiry of all real and physical causes, and given men the occasion to stay upon these satisfactory and specious causes, to the great arrest and prejudice of further discovery. For this I find done not only in Plato, who ever anchoreth upon that shore, but by Aristotle, Galen and others. For to say that ... the clouds are for watering of the earth; or that the solidness of the earth is for the station and mansion of living creatures, and the like, is well enquired and collected in Metaphysic; but in Physic they are impertinent ... the search of the Physical Cause hath been neglected and passed in silence ... Not because those final causes are not true, and worthy to be enquired, being kept within their own province; but because their excursions into the limits of physical causes hath bred a vastness and solitude in that track.'"

In the course of his work Bacon isolated a number of `idols' of natural or man-made origin which could cause us to stumble from the path to sure knowledge. Two are strikingly reminiscent of the snares pointed out by his medieval namesake: Idola Tribus—fallacies generically inherent in human thought, notably the proneness to perceive in Nature a greater degree of order than is actually present, and Idola Theatri—idols constructed around received and venerated systems of thought. The classical design argument has points of contact with each and Bacon's demarcation helps us to trace some of the psychological origins of this argument.

Yet despite the good sense of Bacon's advice, there was amongst his contemporaries a notable Aristotelian; and one whose contribution to science will be remembered after Bacon is long forgotten. William Harvey (1578-1657) made his monumental discovery of the human circulatory

system by employing the very style of reasoning derided by Bacon. Harvey was not an atomist and he regarded the facts uncovered by his studies of embryology as a refutation of any scientific philosophy devoid of purpose. In his final publication59 he claims that `The authority of Aristotle has always had such weight with me that I never think of differing from him considerably'. The way in which this respect for Aristotle was realized in Harvey's work seems to have been in the search for discernible purpose in the workings of living organisms—indeed, the expectation of purposeful activity—rather than any association in his mind with a vast labyrinth of metaphysical ideas about the structure of the World and the living organisms within it. Harvey's discovery of the human circulatory system actually arose as a consequence of his Aristotelian approach: on the one hand he wondered if the motion of human blood might be circular—with all the significance such a geometry would have for Aristotelians—whilst on the other he tried to conceive of how a purposeful designer would have constructed a system of motion. Robert Boyle records 6O a conversation in which he asked Harvey how he had hit upon such an idea as circulation. Harvey replied that when he had noticed how carefully positioned were the valves within the veins so as to allow blood to pass towards the heart but not away from it, he was

...invited to imagine, that so Provident a cause as Nature had not so placed so many values without Design: and no Design seem'd more possible than that, since the Blood could not well, because of the interposing valves, be sent, by the veins to the limbs; it should be sent through the Arteries and return through the veins.

Elsewhere in Harvey's writings," we find even a desire to interpret the internal structure of the body as a form of mini solar system with the heart at the centre along the lines of an Aristotelian cosmology.

These motivations were clearly not the sole reason for Harvey's success. He was also among the first of a new generation of physicians 62 who did not look simply to Galen for their instruction but dissected, examined and recorded, and carried out their own experimental investigations. By his successful synthesis of teleology and experiment Harvey appears as the forerunner of a new type of teleologist, those with a special interest in the observation of the minute intricacy of Nature.

Another illustrious contemporary of Bacon who was deeply concerned with the unverifiable and imprecise nature of the foundations of all types of philosophy was the founder of modern critical philosophy, Rene Descartes (1596-1650). Like Galileo and many other renaissance scientists he was convinced that the primary qualities of the Universe were mathematical in nature. This led him firmly to reject final causation as a useful scientific concept because it was associated with an anthropocentric and subjective view of the world, reflecting little more than our presumption in supposing we could unravel the purposes of God. Things have many ends, Descartes says, but most of these have no interaction with Man at all:

It is not at all probable that all things have been created for us in such a manner that God had no other end in creating them ... Such a supposition would, I think, be very inept in reasoning about physical questions; for we cannot doubt that an infinitude of things exist, or did exist, though they have now ceased to do so, which have never been beheld or comprehended by man, and have never been of any use to him 63

This view was reinforced by his belief that the Universe was infinite.

Descartes's approach to natural philosophy was an attempt to deduce the essence of the world structure from self-evident primary principles solely by the methods of mathematical reasoning. The Cartesian world-view was `Deistic'; that is, it maintained that order was inherent in the

properties of inorganic material and endowed at the moment of creation; thereafter all operates by mechanical causes alone:

God has so wondrously established these laws that even if we suppose that he creates nothing more than I have said [matter and motion], and even if he puts into this no order nor proportion, but makes of it a chaos as confused and perplexed as the poets could describe, they are sufficient to cause the parts of this chaos to unravel themselves, and arrange themselves in so good an order that they shall have the form of a very perfect world 64

Whereas Bacon had banished final causes to the metaphysical world, Descartes wished to exorcise them from this realm as well. Following Francis Bacon's example, he made no attempt to deny that Nature may possess some ultimate end of premeditated design, but claimed that it is simply beyond our ken to identify it; for,

The capacity of our mind is very mediocre, and not to presume too much on ourselves, as it seems we would do were we to persuade ourselves that it is only for our use that God has created all things, or even, indeed, if we pretended to be able to know by the force of our mind what are the ends for which he has created them. 6s

The reason why the concept of teleology has arisen in our minds, Descartes claimed, is due to muddled thinking about the relationship between causes and effects rather than the reality of different types of cause as Aristotle would have it. By contrast the Cartesian approach would 65 `explain effects by causes, and not causes by effects'. Yet Descartes did seem to allow just one final cause; for he believed God has provided Man with a closely correlated body and mind to evade danger—mankind's end was survival.

2.5 Mechanical Worlds

But of this frame, the bearing and the ties, The strong connections, nice dependencies, Gradations just, has thy pervading soul Look'd thro? Or can a part contain the whole?
A. Pope

The seventeenth century saw a gradual change from an organic to a mechanical world picture; the opinion that an entity which generates life must therefore itself be alive steadily receded in the wake of the manifest success that flowed from the mechanistic paradigm. This appears as an important metamorphosis and one which we are apt to skip over, so familiar are we with the comings and goings of the theoretical models in modern physical science. In modern science, models and descriptions of natural phenomena are taken up and discarded solely according to their transient usefulness, whereas for early scientists they represented not just a model but the very essence of the Universe, the `thing in itself'. Because of this attitude the new mechanical perspective brought with it a more interesting and enthusiastic form of eutaxiological argument which found support principally amongst British physicists. Although their arguments were strongly motivated by their theistic outlook, their arguments also grew out of careful observations and an experimental interrogation of the new clockwork world.

It was Robert Boyle (1627-91) who became the most eloquent expositor and spirited supporter 67 of the 'new' design argument. Boyle laid emphasis upon specific examples and coincidences in Nature, claiming them as `curious and excellent tokens and effects of divine artifice'. His cosmological view required the Deity to initiate the primordial motion of atoms and thereafter remain in lawful and beneficent control to `contrive them into the world he designed they should compose'; this establishes why the laws of nature bear the hallmark of design. Yet Boyle's approach was consistently mechanical throughout and, like Descartes, he rejected the Aristotelian world-view,

based as it was upon an organic model of the Universe, along with the concepts of the Schoolmen which he saw, were an obstacle to the progress of science because they `do neither oblige nor conduct a man to deeper searches into the structures of things.'

Despite his admiration for many aspects of Des cartes's work, Boyle disagreed strongly with him regarding his blanket exclusion of final causes, for to do thus would:

throw away an argument, which the experience of all ages chews to have been the most successful [and in some cases the only prevalent one] to establish, among philosophers, the belief and veneration of God 69

Whilst he agreed with Descartes that one could not hope to ascertain all the underlying purposes in Nature, he did not see why some, at least, could not be fathomed. But, unlike Descartes, Boyle felt that a major reason for the existence of the world was its service to man, though he certainly granted it could have other ends as well, for he writes:

And here it may not be amiss to take notice, in relation to the opinion, that the whole material world was made for man, that though the arguments we have used may be more probable than others hitherto proposed, against the Vulgar Opinion, especially as it relates to the celestial region of the world, yet amongst the ends designed in several of his works, especially plants, animals and metals, the usefulness of them were designed chiefly for men, yet God may design several ends in several creatures, which may find other, and more noble uses for several creatures than have yet been discovered.70

Opponents of the Design Argument, like Montaigne, had highlighted the presumption attached to any affirmation of anthropocentric design in Nature; but as a corollary Boyle claimed that, given our fragmentary understanding, it was equally presumptuous of them to deny it.

Another original aspect of Boyle's approach to final causes was his claim that the discovery of features pointing to design in Nature is promoted principally by experimental science and provides a strong motivation for these empirical investigations. It is because of lack of good experimental evidence that Boyle shows so little enthusiasm for arguing for manifest design in the astronomical world. He has serious reservations here, for:

I am apt to fear that men are wont, with greater confidence than evidence, to assign the systematical ends and uses of the celestial bodies, and to conclude them to be made and moved only for the service of the earth and its inhabitants."

Instead, he preferred to find indications of design from the minutiae of flora and fauna, because of their more allegorical nature and the stronger possibility of deciding the purpose of their composite structures.

For there seems more admirable contrivance in the muscles of a man's body, than the celestial orbs; and the eye of a fly seems a more curious piece of work than the body of the sun72

Such deductions were less obvious in the extraterrestrial realm:

I think that, from the ends and uses of the parts of living bodies, the naturalist may draw arguments, provided he do it with due cautions of which I shall speak. That the inanimate bodies here below that proceed not from seminal principles have a more parable texture ... and will not easily warrant ratiocination drawn from their supposed ends."

Like Aristotle before him, Boyle searched for particular examples of micro-engineering in the structure of animals and insects; such examples had, at that time, received a lot of publicity following the publication of Hooke's Micrographia in 1665. The invention of the microscope had, for the first time, allowed people to see the intricacy of the smallest organisms. In no small way this advance gave added momentum to the Design Argument. Boyle's discussions of these matters appeared in 1688 in a work bearing a rather intimidating title:" Disquisition about the Final Causes of Natural Things: wherein is inquired whether and (if at all) with what caution a naturalist should admit them. There he attempted to classify the various ends one could discern in Nature into four categories: the `universal' (divine), the 'cosmical' (which govern the celestial motions), the `animal' ('which are those that the peculiar parts of animals are destinated to, and for the welfare of the animal itself') and `human' (mental and corporeal). Each category provoked Design Arguments but they differed in character and force according to the quality of the evidence available and the impact they made on the imagination.

Following Cicero's employment of the horological analogy of design, Boyle replied to Descartes's claim that final causes are irresolvable, dissipated in a sea of vague possibilities:

Suppose that a peasant entering in broad daylight the gardens of a famous mathematician, finds there one of those curious gnomonic instruments which indicate the position of the sun in the zodiac, its declination from the equator, the day of the month, the length of the day and so on; it would, no doubt, be a great presumption on his part, ignorant alike of mathematical science and of the intentions of the artist, to believe himself capable of discovering all the ends in view of which this machine, so curiously wrought, has been constructed; but when he remarks that it is furnished with an index, with lines and horary numbers, in short, with all that constitutes a sun-dial, and sees successively the shadow of the index mark in succession the hour of the day, there would be in his part as little presumption as error in concluding that this instrument, whatever may be its other uses, is certainly a dial made to tell the time.74

Boyle argues that in many circumstances no ambiguity arises about the object and purpose of natural contrivances. The world is like a mechanism, and like all known mechanisms, is built for a specific purpose that can almost always be elucidated by a thoughtful inspection of its inner workings.

In this contention he was supported by his continental contemporary Gassendi (1592-1655) who also disagreed with Descartes:

You say that it does not seem to you that you could investigate and undertake to discover, without rashness, the ends of God. But although that may be true, if you mean to speak of ends that God has willed to be hidden, still it cannot be the case with those which he has, as it were, exposed to the view of all the world, and which are discovered without much labour.75

The specific influence of the new mechanical world model can be seen in an interesting way: Boyle is so impressed by the correspondence between the internal workings of the world and a timepiece, that he believes behind the world lurks a designer of mechanisms with a measure of human intelligence:

Thus, he who would thoroughly understand the nature of a watch, and not rest satisfy'd with knowing, in general, that a man made it for such uses, but he must, particularly, know of what materials the spring, the wheels, the chain, and the balance are made, he must know the number of the wheels, their magnitude, shape, situation and connexion in the engine, and after what manner one part moves another ... In short, the neglect of efficient causes would render philosophy useless; but the studious search after them will not prejudice the contemplation of final causes.76

The end of his statement reveals his stance: although immediate efficient causes of phenomena were entirely mechanical in Boyle's physics, their ultimate and final causes were seen as entirely supernatural. He hoped that his crusade for such a complementarity in the scientific view of the world would not die with him. To support and perpetuate teleological studies he bequeathed a sum of fifty pounds 'forever, or at least for a considerable number of years' to support a series of public lectures on Natural Theology.

At this time those Protestant scientists who, like Boyle, supported the experimental approach advocated by Bacon were rapidly becoming impatient with the methodological dogmas of the Schoolmen. The lead given by Descartes and Boyle was enthusiastically followed by others who were more colourful in their condemnations as this extract from John Webster's view of Scholastic reasoning rather vividly indicates:

What is it else, but a confused chaos of needless, frivolous, fruitless, trivial, vain, curious, impertinent, knotty, ungodly, irreligious, thorny and hell-hatch'd disputes, altercations, doubts, questions and endless janglings, multiplied and spawned forth even to monstrosity and nauseousness."

The development of the new mechanized physics was to carry with it a design argument based upon the observation of meticulous contrivances in Nature and the conviction of an underlying order of its universal laws. But in biology the organic approach still held sway. An exceptional scientist who remained unconvinced of the mechanical analogy in all its facets was John Ray (1628-1704), the greatest of seventeenth-century English naturalists. In his famous teleological study, The Wisdom of God manifested in the works of Creation,78 he amassed a wealth of observational data to argue that animals were pre-adapted to survive in special environments. His comprehensive work also reviewed both the astronomical and terrestrial sciences and stressed the manner in which Man's welfare is ensured by the special properties of water, fire, air and wind. It was Ray's meticulous botanical and biological observations that led him to reject the mechanical analogy as too simplistic a view of Nature because it gave no insight into the reasons for the enormous differences in scale between intricately constructed organisms and the Universe as a whole. He challenged Boyle's contention that Nature originally possessed all the intrinsic properties necessary for its multivarious outworkings; rather he appealed to a vitalist force to provide for its constant orchestration. He concludes that:

I therefore incline to Dr Cudworth's opinion, that God uses for these effects the subordinate ministry of some inferior plastic nature ...79

The novelty of `Dr. Cudworth's opinion' was the concept he termed `Plastic Nature'80 which possessed a measure of irrational motion independent of the immediate direction of the Deity. This property enabled it to be employed as an explanation for the aberrations as well as the successes of Nature. Even the lack of design could now be attributed to design.

A strong continental opponent of these attempts to introduce some finalistic design principle into physics was Benedict de Spinoza (1632-77). His antagonism toward any deployment of final causes or inferences from supposed design in the world is spelt out in an appendix to his Ethics81 published in the year of his death. Such notions, he claims, have only arisen because of our ignorance of mechanical laws of Nature and our gullibility regarding the prejudices of anthropocentric philosophy. Far from being in a position to determine the causes and effects of most things we tend to react in amazement, thinking that however these things have come out, they cannot but be for our benefit. This is why, he says, everyone who 'strives to comprehend natural things as a philosophere, in place of admiring them as a stupid man, is at once regarded as impious'.

Those who employ finalistic reasoning simply confuse causes with effects because, It remains to be shown that nature does not propose to itself any end in its operations, and that all final causes are nothing but pure fictions of human imagination. I shall have little trouble to demonstrate this; for it has already been firmly established ... I will, however, add a few words in order to accomplish the total ruin of final causes. The first fallacy is that instead of regarding as a cause that which is by nature anterior, it makes the cause posterior ...82

Also, if the doctrine of final causes is correct he argues, then those most perfect things we are seeking as irrefutable evidences of the `perfect principle' must, by definition, lie in the unobservable future, for:

If the things which God immediately produces were made in order to attain an end, it would follow that those which God produces last would be the most perfect of all, the others having been made in order to serve these. 83

Spinoza claims that our deductions of final causes are probably nothing more than mere wish-fulfillment; expressing, not the nature of the real world, but the nature we hope it has:

When we say that the final cause of a house is to provide a dwelling, we mean thereby nothing more than this, that man, having represented to himself the advantages of the domestic life, has had the desire to build a house. Thus, then this final cause is nothing more than the particular desire just mentioned ...84

Such metaphysical and logical objections seemed to carry very little weight on the other side of the English Channel where the greatest scientific genius of his age, Isaac Newton (1642-1727), was giving his support to anthropocentric teleology:

Can it be an accident that all birds, beasts and men have their right side and left side alike-shaped (except in their bowels) and just two eyes and no more, on either side of the face; and just two ears on either side of the head ...? Whence arises this uniformity in all their outward shapes but from the counsel and contrivance of an Author? .. Did blind chance know that there was light, and what was its refraction, and fit the eyes of all creatures after the most curious manner to make use of it? 85

Underlying all Newton's thinking was his deeply-held belief that order was `created by God at first and conserved by him to this Day in the same state and condition'. Our observation of the planetary orbits, he argued, should convince us that their arrangement did not simply `arise out of chaos by the mere laws of Nature, though being once formed it may continue by those laws for many ages'.

Whereas Robert Boyle had been a critic of Cartesian metaphysics, Newton also opposed Cartesian physics and in particular Descartes's vortex theory of celestial motions, which he showed, by employing angular momentum conservation, to be in conflict with Kepler's observed laws of planetary motion. In his last works Newton voices his exasperation at the omission of final causes in the Cartesian explanations, which he clearly felt to be incomplete because they provided no explanation for the economy and special constitution of Nature:

Whence is it that Nature does nothing in vain; and whence arises all that Order and Beauty which we see in the world? To what end are comets ... How come the bodies of animals to be contrived ... For what ends are their several parts? .. . Was the eye contrived without skill in optics? ..."86

The Newtonian theory of the world, so carefully and impressively argued in his Principia, became the foundation for a steady stream of design arguments based upon optical and gravitational phenomena. Indeed Newton remarked that in writing the treatise he had an `eye upon arguments' for belief in a deity and in the introduction to his Opticks he claims that the main business of natural philosophy is to deduce causes from effects until we arrive at the `First Cause'. However, one man became inextricably linked with Newton in the propagation of these teleological interpretations of Newtonian physics; that man's name was Richard Bentley.

Richard Bentley (1662-1742) was a Yorkshireman from humble beginnings who later, principally because of his successful Christian apologetics and classical scholarship, became the Master of Trinity College, Cambridge. Bentley came first into the public eye in 1691, when, while still chaplain to Edward Stillingfleet, the Bishop of Worcester, he was invited to give the inaugural Boyle Lectures on Natural Theology. They were entitled then “Confutation of Atheism from the Origin and Frame of the World: and in giving them he displayed an excellent knowledge and understanding of Newton's mathematical physics, a familiarity known to have been fostered by his close correspondence 88 and dialogue on such matters with Newton himself. Bentley was to argue that design is most clearly witnessed by elegant mathematical laws of a general and invariant character rather than by the specific, but relative, adaptations we see in the animal world. He attempted to construct a eutaxiological design argument based upon our knowledge rather than, as often had been the case, a teleological argument founded upon our ignorance. The cornerstone of his argument, Newton's gravitational theory, derived, for the first time, what we still consider to be one of the fundamental constants of nature: the gravitational constant. It was this underlying universal constant that was responsible for the apparently universal nature of Newton's deductions and explanations in gravitation physics and it led to the belief that there was something absolute about the entire model of the world it gave rise to—a model that was mechanical, like the workings of a watch.

In retrospect it is perhaps predictable that outstanding success in scientific model-building and explanation should lead to an accompanying proliferation of teleological and eutaxiological design arguments. One sees it in the Aristotelian period and in the twentieth-century study of cosmology and elementary particles. Whenever absolute deductions are possible from a theoretical model, and successfully explain what is seen, then some form of absolute credence tends to be attributed to the mathematical model responsible.

Newton's authority was also extensively employed by other apologists, notably Hales, Clarke, Whiston and MacClaurin, all with Newton's blessing according to David Gregory's report:

In Mr. Newton's opinion a good design of a publick speech.. . may be to show that the most simple laws of nature are observed in the structure of a great part of the Universe, that the philosophy ought there to begin, and that Cosmic Qualities are as much easier as they are more Universal than particular ones, and the general contrivance simpler than that of animals, plants .. 89

The result of this enthusiasm and its widespread influence was to make Newton and his followers the principal target of Hume's attack in the 113 Dialogues concerning Natural Religion. In his History of England Hume describes Newton and his achievement in two-edged terms `the greatest and rarest genius that ever rose for the ornament and instruction of the species', but yet 'while Newton seemed to draw off the veil from some of the mysteries of nature, he shewed at the same time the imperfections of the mechanical philosophy; and thereby restored her ultimate secrets to that obscurity in which they ever did and ever will remain'. The statement of the Design Argument used by Hume in his work is in fact that given by Colin MacClaurin (1698-1746) in his book An Account of Sir Isaac Newton's Philosophical Discoveries wherein he remarks

the plain argument for the existence of the Deity, obvious to all and carrying irresistable conviction with it, is from the evident contrivance and fitness of things for one another, which we find throughout the Universe 90

At this point, it is worth pausing to mention a gradual transition that has occurred in the nature of design arguments from the Scholastics to Newton. For the Schoolmen the causa finalis of Nature was God himself; the unmoved mover was Omega as well as Alpha. The future succession of effects must come to an end just as surely as the past procession of causes must have had a beginning and Man, they argued, should use this insight to know God. For Newton and his colleagues the ordered laws of motion themselves appear to be the end of Nature. God exists to uphold and perpetuate them, defending the world system from falling into chaos and irrationality.

The second Boyle lecturer was another Newtonian, Samuel Clarke, but it is not for this that Clarke is chiefly remembered. Rather, it is for his dialogue with another scientist who was not so readily seduced by the Newtonian design arguments. Clarke's formidable opponent was Gottfried Leibniz (1646-1716) and throughout their famous correspondence Clarke was undoubtedly being coached by his compatriot, Newton. Leibniz believed that mechanistic science alone left no room for theocentric purpose. Such a purpose could only be evident through the recognition and incorporation of perfect geometrical principles into physics. In principle, Leibniz argued, there were many possible worlds that were logically self-consistent but the reason for the selection of the existing cosmos was its maximal degree of perfection; it was `the best of all possible worlds'.91 He argued that the use of this principle of perfection was quite essential in physical modelling and 92 `So far from excluding final causes and the consideration of a Being acting with wisdom, it is from this that everything must be deduced in physics'. In conjunction with mechanical explanation the use of final causation and teleology provides a parallel line of analysis and it is to everyone's benefit that they be conjoined.

In order to make use of his `perfecting principle' Leibniz gave examples of laws in Nature that he believed were not metaphysically necessary. For example, the principle of continuity in the motion of physical systems which appears to be generic when one might have anticipated discontinuities ('leaps') to be prevalent a priori:

The hypothesis of leaps cannot be refuted except by the principle of order, by the help of supreme reason, which does everything in the most perfect way."

So, in the beginning God established all things harmoniously and thereafter they maintained their harmony and mutual consistencies even though they were causally disjoint. The maintenance of order in this fashion was proposed by Leibniz as `a new proof of the existence of God, which is one of surprising clearness'; it was an a posteriori argument from an initially established ordering. He is convinced of it because there seems to exist coordination between things that have never been in causal contact with one another (a dilemma known94 to modern cosmologists as the `horizon problem')

This perfect harmony of so many substances which have no communication with each other can only come from a common cause 95

Leibniz' perfect harmony does not necessarily have any anthropocentric bias and because of that it is not surprising that `we find in the world things that are not pleasing to us', we would expect it because `we know that it was not made for us alone'. In this contention Leibniz would have been supported by some Newtonian but the area where disagreement with Clarke, and thereby Newton himself, rested was in the manner of the maintenance of the world order. Clarke was an 'occasionalist' believing that God constantly intervenes to correct aberrations in the order of Nature

just as the watchmaker occasionally finds it necessary to regulate or repair his watch. Leibniz held that such a view implied either that the laws of Nature and creation were in some way imperfect or the Deity was lacking in foresight; he could not believe the world needed repair `otherwise we must say that God bethinks himself again" Clarke retorted that Leibniz had turned the Deity into an absentee landlord and relegated the sphere of divine action to that of a limited initial cause but received the reply that, to the contrary, His dynamic role was the constant maintenance of the world order.

Besides the two scientific giants of the age, there were several other more off-beat contributors to the Design Argument debate; not least the botanist Nehemiah Grew (1641-1712). In his study Cosmologia Sacra he gave not only many ingenious examples of design in crystallography but also an argument from the large scale regularity of Nature to the existence of extraterrestrial planetary systems:

There can be no manner of symmetry in finishing so small a part of the Universal expansion with so noble an apparatus as aforesaid, and letting innumerable and far greater intervals lie waste and void. If then there are many thousands of visible and invisible fixed stars, or suns, there are also as many planetary systems belonging to them, and many more planetary systems belonging to them, and many more planetary worlds."

An unusual continental commentary is provided in the famous drama 98 Le Festin de Pierre by Moliere (1622-73). There, the Design Argument found itself on the lips of a pious valet who says to his unbelieving master:

This world that we see is not a mushroom that has come of itself in a night .. . Can you see the inventions of which the human machine is composed, without admiring the way in which it is arranged, one part within another? ... My reasoning is that there is something wonderful in man, whatever you may say, and which all the savants cannot explain.98

Another famous French author with interesting opinions on final causes, who was also a vehement opponent of Leibniz' entire world-view was Francois-Marie Arouet (1694-1778), better known by his nom-deplume, Voltaire. Voltaire is perhaps most succinctly categorized as an anti-Epicurean, anti-Christian, Newtonian Deist. His opinion of the order of Nature was that `a watch proves a watch-maker, and that a Universe proves a God'. It was unthinkable to him that one could attribute the existence of the human mind to blind chance:

We are intelligent beings, and intelligent beings could not have been formed by a blind, brute, insensible thing ...99

Furthermore, he maintained, the evident presence of intelligence in Nature made it necessary to consider final causes in Nature.

Although he believed that normalizing selection could explain the adaption that animals displayed with respect to their environments it could account neither for their mental faculties nor the intricacy of the design actually engineered within them, and, as for chance as a feasible mechanism he claimed

The disposition of a fly's wings or of the feelers of a snail is sufficient to confound you."

Yet Voltaire was a scathing opponent of anthropocentric design arguments because he felt that our scanty knowledge made the objects and beneficiaries of design indeterminate and inevitably, the subject provided excellent material for his Dictionary article on `Ignorance'. In the same volume he

argues against the synthesis of Final Causes with these anthropocentric delusions on the grounds that things could not have been set up long ago with our present specific and unpredictable day-to-day needs in view:

In order to become certain of the true end for which a cause acts, that effect must be at all times and in all places. There have not been vessels at all times and on all seas: thus it cannot be said that the ocean has been made for vessels. One feels how ridiculous it would be to allege that nature had wrought from the earliest times to adjust itself to our arbitrary inventions, which have all appeared so late; but it is very evident that if noses have not been made for spectacles, they have been made for smelling, and that there have been noses ever since there have been men.'°°

We also recall the caricature of Leibniz and his `best of all possible worlds' philosophy through Dr. Pangloss, the professor of 'metaphysico-theologo-cosmolonigology' in Candide.101

One of Voltaire's co-editors of the Encyclopedie and the author of its mathematical content was D'Alembert (1717-83). He was, like Voltaire, sceptical of the numerous metaphysical bases to mathematical physics. Also interesting is his distinction between the intrinsic laws of nature and the mathematical models we use to represent them. This distinction he develops when discussing the form of the laws of motion:

It seems to me that these thoughts can serve to make us evaluate the demonstrations given by various philosophers of the laws of motion as being in accord with the principle of final causes, that is to say with the designs of the Author of Nature in establishing these laws. Such proofs can be convincing only insofar as they are preceded and supported by direct demonstrations and have been derived from principles which are within our reach; otherwise they could often lead us into error. It is for having followed that path, for having believed that it was the Creator's wisdom to conserve always the same quantity of motion in the Universe, that Descartes was mistaken about the laws of collision. Those who imitate him run the risk of either being deceived like him, or taking for a general principle something that takes place only in special cases, or finally of regarding a purely mathematical consequence of some formula as a fundamental law of nature.102

For modern mathematicians D'Alembert's name is linked with that of his younger contemporary Moreau de Maupertuis (1698-1759) through their important contributions to the variational principles of mechanics. Such variational principles are remarkable quantitative examples of teleological reasoning being directly and predictively employed in mathematical physics and we shall discuss them in a little more detail in Chapter 3.4. Here, we just mention how they enabled Maupertuis to arrive at a quantification of the notion of `the best of all possible worlds': the optimal configuration or state within an ensemble of logically consistent possibilities.

In general, a variational principle indicates how the actual motion or state of a system differs from all of the kinematically possible motions permitted by its constraints. This principle may be differential, giving the difference between the actual and the optimal systems at each instant of time; or, less generally, it may be integral. Integral variational principles establish the difference between the actual motion of a system and all of its kinematically possible motions during a finite time interval. Maupertuis' name is associated with the famous integral principle of variation—the Least Action Principle. Maupertuis used this idea to argue for a system of God-inspired final causes in Nature and claimed that it was a mathematically precise version of Leibniz' doctrine of `the best of all possible worlds'. Formerly, Design Arguments had been implicitly making statements of comparative reference without any other "worlds" being available; the novelty of Maupertuis' Design Argument is that the other worlds do exist. They are the paths with non-stationary action.

Yet, Maupertuis was well aware that the growth of accurate mathematical models of nature had spawned many over-zealous metaphysical extrapolations:

For all ages proofs of the wisdom and power of Him who governs the Universe have been formed by those who applied themselves to the study of it. The greater the progress in physics, the more numerous have these proofs become. Some struck with amazement at the divine tokens which we behold every moment in nature, other through a zeal misnamed religious, have given certain proofs greater weight than they ought to have, and sometimes taken for proof that which was not conclusive.103

and he believed Newton to be the originator of this uncritical approach because,

That great man believed that the movements of the celestial bodies sufficiently demonstrate the existence of Him who governs them; such uniformity must result from the Will of a Supreme Being.104

and other less distinguished authors, Derham, Fabricus and Lesser were chastised for their unimaginative repetition of earlier platitudes,

Almost all the modern authors in physics and natural history have done little else than expand the proofs drawn from the organization of animals and plants, and push them in the details of nature ... A crowd of physicists since Newton have found God in stars, in insects, in plants, and in water; not to mention those who find him in the wrinkles of the rhinoceros' hide ... leave such bagatelles to those who do not perceive their folly.105

The only people with whom he appears to have less sympathy are those who would outlaw Final Causes at the behest of chance and mechanism. His own approach was grounded in a search for general regulatory principles and for physical laws generated by the precise formulation of a Least Action Principle. He argues that the only objective approach to evaluating the tendencies of nature is to dwell on the form of its laws—not its artefacts and organisms,

I review the proofs drawn from the contemplation of nature, and I add a reflection: it is, that those which have the greatest strength have not been sufficiently examined as regards their validity and extent. That the cosmos presents trains of agencies convergent to an end on a thousand occasions, is no proof of intelligence and design ... skill in the extension is not sufficient .. the purpose must be rational ... The organization of animals, the multiplicity and minuteness of the parts of insects, the immensity of celestial bodies, their distances and revolutions are better suited to astonish the mind than to enlighten it ... Let us search for him in the fundamental laws of the cosmos, in those universal principles of order which underlie the whole, rather than in the complicated results of those laws.""

A number of Maupertuis' criticisms were directed specifically at William Derham (1657-1735) the Boyle lecturer for 1711-12, a minor scientist and an enthusiast for the Newtonian world-view. His Boyle Lectures consisted of sixteen sermons delivered at St. Mary-le-Bow Church which appeared in book form a year later under the title Physico-Theology.107 He considered all the usual good fortunes of the world, the suitability of the terrestrial environment, the diurnal and seasonal variations and so on, all from an anthropocentric perspective. Extraordinarily, he pauses to wonder if the eye might have been more efficiently situated on the hand, but upon reflection, considers it safer from injury on the head! Another unusual trend in his argument is an attempt to persuade the reader that many minor disasters, which one might at first sight have found difficult to reconcile with providential design, were actually beneficial in staving off even graver catastrophes! For instance,

To instance the very worst of all things named, viz., the volcanoes ignivomous mountains: although they are some of the most terrible shocks of the globe and dreadful scourges of the sinful inhabitants thereof .. Nay, if the hypothesis of a central fire and waters be true, these outlets seem to be of the greatest use to the peace and quiet of the terraqueous globe in venting the subterraneous heat and vapours, which, if pent up, would make dreadful and dangerous commotions of the earth and waters.108

Later he was to abandon this anthropocentric bias, referring to it as the `old vulgar opinion that all things were made for man'. His more sophisticated teleological outlook was written-up in a later work Astro-Theology. There, in contrast to his earlier work, he realizes the need to consider the role of the heavenly bodies whose motions appear to be of no possible relevance to ourselves. He uses their existence to support a eutaxiological argument by appeal to the manifest design of their orderly motions:

For where we have such manifest strokes of wide order and management, of the observance of mathematical proportions, can we conclude there was anything less than reason, judgement and mathematical skill in the case? Or that this could be effected by any other power but that of an intelligent Being.1O8

Eighteenth-century biologists were beginning to think more carefully about the progressive development of forms but came to widely differing conclusions. The Swiss naturalist Bonnet (1720-93) introduced the term evolution to describe the ontogenetic development of an individual from fetus to adult and argued that the entire inorganic world was similarly preprogrammed. Further this complete determinism was sufficient to explain the match of living things to their local environment. Yet, his French contemporary, the zoologist Buffon (1707-88), believed that no useful information about animal function could be gleaned from the doctrine of Final Causes so commonly employed by the physicists:

Those who believe they can answer these questions by final causes do not perceive that they take the effect for the cause.109

2.6 Critical Developments

The believers in Cosmic Purpose make much of our supposed intelligence but their writings make one doubt it. IfI were granted omnipotence, and millions of years to experiment in, I should not think Man much to boast of as the final result of all my efforts.
Bertrand Russell

Besides Maupertuis, the most original approach to the metaphysical problems at the core of the mechanical world-view issued from the pen of Giovanni Vico (1688-1744), a Neapolitan professor of Jurisprudence.110 In his own time his work was not widely discussed, but retrospectively he is seen, by philosophers of science, as a forerunner of Kant. Vico was interested in refuting the Cartesian dogma that all science required in order to unravel the working of the World was an axiomatic basis for reasoning and a sound mathematical methodology. His approach was to establish a clear distinction between the world as it really is and the world which we create and cognize through the use of mathematical models and physical experiments. He realized that the understanding one has of something created by oneself is of a different nature to that understanding gleaned from simple observation. This distinction means we can never be free from subjectivism. Vico saw that mathematical models appear intelligible and coherent to our minds because our minds alone have made them. All our enquiry is necessarily anthropocentric because we employ man-made tools and human reason in its pursuit. Vico believed the `real' world of

nature, which obeyed knowable but inaccessible rules, differed in kind from our do-it-yourself model of intelligible but manmade laws;

Create the truth which you wish to cognize, and I, in cognizing the truth that you have proposed to one, will 'make' it in such a way that there will be no possibility of my doubting it, since I am the very one who has produced it."

Vico recognized four distinct types of knowledge and warned against abstracting conclusions drawn from information within one category of enquiry into others. One of his categories is Scienze: a priori knowledge of the real nature of things, which one can only possess of artefacts or models we have made. God alone possesses this type of knowledge of everything. Vico himself was a Christian teleologist who believed that we could only know the ultimate ends of Nature by revelation, (which would endow us with the third of his four types of knowledge).111,112 Yet, his ideas provide a natural prologue to the more critical analyses of the Design Argument and the theory of knowledge which were to be developed by David Hume and Immanuel Kant.

In his posthumous publication, the Dialogues Concerning Natural Religion,'" David Hume (1711-76) mounted a sceptical attack on the logical structure of many naive design arguments and indeed also upon the rational basis of any form of scientific enquiry. In the Dialogues, and In other works, Hume calls the Design Argument 'the religious hypothesis' and proceeds to attack its foundation from a variety of directions. Hume's approach was entirely negative; whereas most of his contemporaries accepted the rationality and ordered structure of the world without question, Hume did not. A common-sense view of the world, along with the metaphysical trimmings that had been added to the Newtonian world model, Hume rejected. His Dialogues are analogous to Cicero's De Natura Deorum; the Dialogues describe a debate in which the sceptical Philo umpires and examines the argument between two supporters of different types of `religious hypothesis'. On the one hand there is Demea, representing the school of a priori truth and revelation and on the other Cleanthes, who reasons in a posteriori manner, employing the fashionable synthesis between Final Causes and the mechanical world-view. The views of Newton's supporters114 are voiced through Cleanthes who actually adopts MacClaurin's statement of the Newtonian Design Argument when summarizing his position:

I shall briefly explain how I conceive this matter. Look round this world: Contemplate the whole and every part of it. You will find it to be nothing but one great machine, subdivided into an infinite member of lesser machines.. . All these various machines and even their most minute parts, are adjusted to each other with an accuracy, which ravishes into admiration all men who have ever contemplated them. The curious adapting of means to ends, throughout all nature, resembles exactly, though it much exceeds, the productions of human contrivance 115 of human design, thought, wisdom and intelligence..

The principal objections which Hume allows to surface during the course of the discussion are threefold: Firstly, the Design Argument is unscientific; there can be no causal explanation for the order of Nature because the uniqueness of the world removes all grounds for comparative reference. Secondly; analogical reasoning is so weak and subjective that it could not even provide us with a reasonable conjecture, never mind a definite proof. And finally: all negative evidence has been conveniently neglected. Hume maintains that a dispassionate approach could argue as well for a disorderly cause if it were to concentrate upon the disorderly aspects of the world's structure. His aim is not so much to refute the Design Argument as to show it only raises questions that are undecidable from the evidence available.

Hume's spokesmen question the anthropocentric bias of the Design Argument:

... we are guilty of the grossest, and most narrow partiality, and make ourselves the model of the Universe ... What peculiar privilege has this little agitation of brain which we call thought, that we must thus make it the model of the whole Universe.116

Hume also draws attention to the tautological nature of the deductions from animal structure. For if the harmonious interrelation of organs is a necessary condition for life how could we fail to inhabit a world of harmonious appearances:

It is vain ... to insist upon the uses of the parts in animals or vegetables and their curious adjustments to each other. I would fain know how an animal could subsist, unless its parts were so adjusted?.117

An alternative explanation of order is suggested: perhaps the development of the world is random but has had an infinite amount of time available to it so all possible configurations arise until eventually a stable self-perpetuating form is found:

Let us suppose it [matter] finite. A finite number of particles is only susceptible to finite transpositions. And it must happen in an eternal duration, that every possible order or position must be tried an infinite number of times ... a chaos ensues; till finite though innumerable revolutions produce at last some forms, whose parts and organs are so adjusted as to support the forms amidst a continued succession of matter 118

Despite these counter-arguments Cleanthes' support for the Design Argument was so carefully built up that there has even been scholarly debate as to where Hume's own sympathies really lay.113 Elsewhere Hume119 appears to display a vitalist view, believing matter to possess some intrinsic self-ordering property:

... that order, arrangement, or the adjustment of final causes is not, of itself, any proof of design; but only in so far as it has been experienced to proceed from that principle. For aught we can know a priori matter may contain the source or spring of order originally, within itself, as mind does ... It is only to say, that such is the nature of material objects and that they are originally possessed by a faculty of order and proportion.

Hume's most telling remarks in the Dialogues seek to convince the reader that problems of design simply cannot be meaningfully posed. Our position in the Universe introduces natural limitations upon our powers of generalization: 120

A very small part of this great system, during a very short time is very imperfectly discovered to us: And do we thence pronounce decisively concerning the origin of the whole? ... Let us remember the story of the Indian philosopher and his elephant. It was never more applicable than to the present subject. If the material world rests upon a similar ideal world this ideal world must rest upon some other; and so on, without end. It were better, therefore, never to look beyond the present material world.121

At the conclusion of the dialogue the sceptical Philo admits to `a deeper sense of religion impressed on the mind', for even though the arguments he has heard in support of design are logically unsound they still have considerable psychological impact upon him; they strike him, he says, 'with irresistible force'.

History shows that the Humean tirade against the simple design arguments of the English physicists fell, for the time being, upon deaf ears. There were probably a number of reasons for this. Many English intellectuals, for instance Samuel Johnson122 and Joseph Priestly, felt that Hume was being

merely mischievous or downright frivolous in an attempt to ensure literary fame and he was an isolated and ignored figure in literary circles even during his own lifetime.121 His Dialogues were published posthumously.

More significant hurdles to Hume's acceptance by the scientific community were his eccentric scientific ideas. His unusual theory of causality and the serious suggestion that the Universe may be organic rather than mechanical in nature must have seemed rather naive when held up against the staggering quantitative achievements of the Newtonian system. Those, like Maupertuis, who subscribed to more sophisticated systems of final causation would not have regarded his objections as relevant and some of his arguments could be falsified by detailed scientific examples.123 However, although his objections to the Design Argument were to lie temporarily dormant, they were to prove extremely significant for the future spirit of critical inquiry.

At least one zoologist, Erasmus Darwin (1731-1802), who was Charles Darwin's grandfather, enthusiastically took up Hume's intimations concerning the organic nature of the World. Erasmus Darwin was starting to take the early steps towards an evolutionary theory of animal biology, maintaining that the components of an animal or plant were not designed for the use to which they are currently applied, but rather, have grown to fit that use by a process of gradual improvement. However, in order to maintain his belief in theistic design Darwin had to subsume this evolutionary development within some deeper all-embracing plan—a Universal Teleology, an idea common amongst romantic philosophers of this period:

The late Mr. David Hume ... concludes that the world itself might have been generated, rather than created; that is, it might have been gradually produced from very small beginnings increasing by the activity of its inherent ° principles, rather than by a sudden evolution of the whole by the Almighty fiat—What a magnificent idea of the infinite power to cause the causes of effects, rather than to cause the effects themselves.124

Of the few other thinkers who saw deeper possibilities and challenges to the Design Argument growing from David Hume's work the most famous is Immanuel Kant (1724-1804). He read Hume's Dialogues in a translated manuscript form in 1780 and subsequently acknowledged his debt to him for awaking him `from his dogmatic slumbers'. Kant's early work had attempted to reconcile the mechanical and teleological views of the world contained in the works of Leibniz and Newton. There he displayed a cautious respect for the Design Argument and the way in which it had been deployed to deduce the existence of a Supreme Being as, for example, in Aquinas' Fifth Way.

In our humble opinion this cosmological proof is as old as the reason of man.... In this respect the endeavours of Derham, Nieuwentyt, and many others, though they sometimes betray much vanity in giving all sorts of physical insights or even chimeras a venerable semblance by the signal of religions, do human reason honour.125

Kant's later critical works take up the claims of Hume concerning the impossibility of deriving sure and necessary principles of a universal nature from empirical data. Independently of Vico he recognizes the irreducible subjectivity of our observations and interpretations. In the Critique of Pure Reason Kant summarizes the Design Argument in detail and calls it the 'Physico-Theological Argument': In the world we everywhere find clear signs of an order in accordance with a determinate purpose, carried out with great wisdom; and this in a Universe which is indescribably varied in content and unlimited in extent.

(1) This purposive order is quite alien to the things of the world and only belongs to them contingently; that is to say, the diverse things could not of themselves have co-operated, by so

great a combination of diverse means, to the fulfilment of determinate final purposes, had they not been chosen and designated .. .

(2) There exists, therefore, a sublime and wise cause....

(3) The unity of this cause may be inferred ... with certainty in so far as our

observation suffices for its verification, and beyond these limits with probability in accordance with the principle of analogy.126

He admits great respect for this argument because of its stimulus to scientific enquiry: he realizes that many biological investigations have been motivated by the expectation of purpose in organic structures,

It enlivens the study of nature ... It suggests ends and purposes, where our observation would not have detected them by itself, and extends our knowledge of nature by means of the guiding concept of a special unity, the principle of which is outside Nature ...137

However, Kant then goes on to undermine the logical foundation of any contention that design exists in nature, arguing that we can neither prove nor disprove statements about the real world by pure reason alone. For, in reaching our conclusions we inevitably introduce facts and observations and employ our, possibly erroneous, `practical reason'. It is only with respect to the `practical reason' that the Design Argument can maintain its cogency:

It would therefore be not only extremely sad, but utterly vain to diminish the authority of that proof ... we have nothing to say against the reasonableness and utility of this line of argument, but wish on the contrary to commend and to encourage it, yet we cannot approve of the claims which this proof advances of apodictic certainty.128

Then he explains how this lack of 'certainty' arises by pointing out that all our empirical enquiries into the structure of Nature regard it as an entity which incorporates within itself a system of empirical laws. These laws are unified and naturally adapted to the faculties of our own cognition. The design we perceive must be necessarily mind-imposed and subjective to our innate categories of thought. Although the `things in themselves' are mind-independent, our act of understanding completely creates the categories in terms of which we order them. Inevitably we view the world through rose-coloured spectacles. These self-created categories cannot themselves be ascertained by observation; they are a priori, conditions of the experience we have, like the perception of the space-time continuum. We could not through our experience hope to ascertain the conditions of such experience. Our observation of order and structure in the Universe, he argues, arises inevitably because we have introduced such concepts into our analysis of experience. We must not then proceed to rederive them from it. We can say nothing stronger than that the world is such as to make its perception by our minds in any form but ordered, impossible.

Kant claimed morality as the final end of nature, for when we consider moral beings, he writes:

We have a reason for being warranted to regard the world as a system of final causes. 129

He thought that only through this ethico-teleology could the final cause of the world be discerned; but its nature is disjoint from the arena of 'physico-theological' design arguments because the latter do not concentrate on the character of final ends, only the transient ends that benefit ourselves here and now:

Now I say that no matter how far physico-theology may be pushed it can never disclose to us anything about a final end of creation; for it never even begins to look for a final end.130

Kant's notion of teleology129•188•189 had an enormous influence on the work of German biologists in the first half of the nineteenth century. Like Kant, for the most part these biologists did not regard teleology and mechanism as polar opposites, but rather as explanatory modes complementary to each other. Mechanism was expected to provide a completely accurate picture of life at the chemical level, without the need to invoke `vital forces'. Indeed, Kant and many of the German biologists were strongly committed to the idea that all objects in Nature, be they organic or inorganic, are completely controlled by mechanical physical laws. These scientists had no objection to the idea that living beings are brought into existence by the mechanical action of physical laws. What they objected to was the possibility of constructing a scientific theory, based on mechanism alone, which described that coming into being, and that could completely describe the organization of life. The impossibility of such a scientific theory was not due to non-mechanical processes in Nature, but rather it lay in the inherent limitations of the human mind. In Kant's view, a mechanical explanation, which was equivalent to a causal explanation in Kant's philosophy, could be given only when there is a clear separation between cause and effect. In living beings, causes and effects are inextricably mixed. An effect in a living being cannot be completely understood without describing every reaction in the being: ultimate biological explanations require a special non-mechanical notion of causality—teleology—in which each part is simultaneously cause and effect. Parts related to the whole in this way transcend mechanical causality'. The order and arrangement of the organism is, according to Kant, a fundamental explanatory mode in biological science.

The limitation of explanation in terms of mechanical causality can perhaps be best understood by comparing a living being to a computer. As Michael Polanyi has pointed out190,191 the internal workings of the computer can of course be completely understood in terms of physical laws. What cannot be so explained is the computer's program. To explain the program requires reference to the purpose of the program, that is, to teleology.

Even the evolution of a deterministic Universe cannot be completely understood in terms of the differential equations which govern the evolution. The boundary conditions of the differential equations must also be specified. These boundary conditions are not determined by the laws of physics which are the differential equations. The universal boundary conditions are as fundamental as the physical laws themselves; they must be included in any explanation on a par with the physical laws.

In a biological organism, the analogues of the computer program are the processing and organizational plans coded in the organism's DNA. The German biologists who followed Kant's program—the historian Lenoir has named them the teleomechanists—sought to discover the plan in the over-all organization of the organism. As the physiologist Hermann Lotze put it,

Thus all parts of the animal body in addition to the properties which they possess by virtue of their material composition also have vital properties; that is, mechanical properties which are attributable to them only so long as they are in combination with the other parts ... Life belongs to the whole but it is in the strictest sense a combination of inorganic processes' ... Biological organization is, therefore, nothing other than a particular direction and combination of pure mechanical processes corresponding to a natural purpose. The study of organization can only consist therefore in the investigation of the particular ways in which nature combines those processes and how in contrast to artificial devices she unites a multiplicity of divergent series of phenomena into complex atomic events. 193

The study of biological organization by the teleomechanists led to a number of important discoveries, particularly in embryology, which they studied because the action of an organism's organizational plan is most manifest when the creature is being formed. For example, such studies led to the discovery of the mammalian ovum by the teleomechanist von Baer."

In spite of such scientific feats, by the latter part of the nineteenth century the teleomechanists had been eclipsed by the reductionists, led by Hermann Helmholtz.188 The great weakness of the teleomechanists was their tendency to think of teleology not only as a plan of organization but also as an actual life force, a tendency which Kant warned against. This led them to believe that it was impossible for organisms to change their fundamental plan of organization, that is, to evolve, under the action of inorganic forces. As a consequence, they later opposed Darwin's theory of evolution by natural selection, and as the evidence for such evolution became overwhelming, they ceased to exert an influence on the development of biology.

Kant's important ideas in critical philosophy and the theory of knowledge which grew out of his work were to have little or no effect upon the growing momentum of the Design Argument in England. The first books describing Kant's work began to appear in English from about 1796 onwards but the logical difficulties they highlighted were not taken seriously by allies of William Paley (1743-1805), author of the famous Natural Theology, a work that was to become something of a minor classic in its own time and synonymous with the gospel according to anthropocentric design. 131

Paley had a distinguished early career at Cambridge; the Senior Wrangler in 1763, he was later greatly admired by his students for a lucid and memorable lecturing style but his progressive social views prevented him rising to high office in the Church of England. On reading his work one is struck by the clarity of his explanation, the skill with which he marshalls his material and the naivety with which he uses his biological examples. This last trait actually led some European supporters of the Design Argument to disown him in embarrassment.132 However, because of its lucidity and the widespread support for its conclusions, Natural Theology was for many years a set text at Cambridge and a special edition was even produced with essay questions bound into it for undergraduate study. Charles Darwin was to recall how he `was charmed and convinced by the long line of argumentation' on reading it during his undergraduate years. Where Kant was a model of obscurity Paley is a paragon of literary clarity.

Paley bases his case for design entirely upon the constitution rather than the development of natural things and interprets this constitution in a completely anthropocentric fashion: everywhere in Nature, he claims, we see elements of design and purpose. Design implies a Designer. Therefore Nature is the result of a Designer who is, by implication, God. Paley claims that, wielded in this manner, teleology `has proved a powerful and perhaps indispensible organ of physical discovery' but he expresses a dislike for the notion of 'Final Causes' largely because of its Scholastic undertones:

it were to be wished that the scholastic phrase `final cause' could, without hesitation, be dropped from our philosophical vocabulary and some more unexceptional mode of speaking be substituted instead of it.133

His central argument appears dramatically in the opening lines of his book.

On crossing a heath,.., suppose I had found a watch upon the ground, and it &pull be inquired how the watch happened to be in that place.. . For this reason, and for no other, viz, that, when we come to inspect the watch, we perceive ... that its several parts are framed and put together for a purpose.'

e analogy of the watch-world had been the watchword of many earlier workers. The advantage of the analogy, Paley claims, is that it makes his point regardless of whether one knows the origin of the watch or understands every facet of its machinery. Furthermore, he believed it evaded other well-known objections: even though the world (watch) occasionally malfunctions it would be peculiar not to attribute its mechanism¬ism to contrivance. It would be senseless, he says, to claim it was merely tone of possible combinations of material forms, a result of the laws of metallic nature' or the inevitable consequence of there having `existed in stings a principle of order.' Nothing, he argues, is to be gained

by supposing the watch before us to have been produced from another watch, *at from a former, and so on indefinitely ... A designing mind is neither supplied by this supposition, nor dispensed with.135

The idea that postulating `laws' of Nature gave explanations of design he thought to be a form of mysticism, `a mere substitution of words for reasons, names for causes.' The so-called `laws' of Nature may be, even now, nothing more than a way of codifying observations that have been made. They do not guarantee anything will take place in the future. They do not provide an explanation of the sort Paley required.

Paley continues to consistently and obliviously mix analogies from the organic and mechanical realms; for example, when discussing explanations of order via evolutionary development and summarizing the general nature of his methodology he admits:

The generations of the animal no more account for the contrivance of the eye or near, than, upon the supposition stated ...,the production of a watch by the motion and mechanism of a former watch, would account for the skill and intention evidenced in the watch so produced ... Every observation which was made ... concerning the watch, may be repeated with strict propriety concerning the eye; concerning animals; concerning plants; concerning, indeed all the organlzed parts of the works of Nature.136

This complete faith in the mechanistic analogy, even in the organic realm, convinces Paley that we can infer ultimate causes from local effects because of the string of causal and mechanical connections that will exist between them. He brushes aside the critique of Hume, Spinoza and Descartes regarding the transposition of causes for effects:

'Of a thousand other things,' say the French academicians, `we perceive not the contrivance, because we understand them only by the effects, of which we know not the causes': but we here treat of a machine, all the parts whereof are visible; and which need only be looked upon to discover the reasons of its motion and action ...137

Like Galen, Boyle, Newton and many others before him Paley concentrates upon the internal structure of the human eye as the example of design par excellence; so enamoured is he by the eye's remarkable structure that he exclaims,

Were there no example in the world of contrivance, except that of the eye, it would be alone sufficient to support the conclusion which we draw from it.138

There is much that is humorous in his examples of design: he dwells upon the foresight displayed by the provision of the epiglottis in the human throat; the following passage has been dubbed the `devotional hymn to the epiglottis'! 139

Reflect how frequemly we swallow, how constantly we breathe. In a city feast, for• example, what deglutition, what anhelation! Yet does this little cartilage, the epiglottis, so effectually interpose its office, so securely guard the entrance of the wind-pipe that. . . Not two guests are choked in a century.140

More noteworthy are the passing parries he aims at two alternative explanations of order. In accordance with his whole approach, firmly grounded in observation, (and we note in passing that Paley was keen amateur naturalist]°') he excludes them on the basis of current observations. Concerning the argument that orderly forms were the inevitable result of normalizing selection from an array of randomly constituted organisms, he takes a blinkered approach to fossilized remains and remarks of believers in chance that:

(chance] ... would persuade me to believe ... every organized body which we see, are only so many out of the possible varieties and combinations of being, which the lapse of infinite ages has brought into existence; that the present world is the relic of that variety; millions of other bodily forms and other species having perished, being by the defect of their constitution incapable of preservation, of continuance by generation. Now there is no foundation whatever for this conjecture in anything which we observed in the works of nature; no such experiments are going on at present; no such energy operates ... A countless variety of animals might have existed, which do not exist.'"2

Paley felt that chance was not a mechanism, as many regarded it at that time, but merely a label for 'the ignorance of the observer.' He also,claimed that appeal to some inherent and universal ordering principle in Nature was in conflict with observation:

., a principle of order, acting blindly and without choice, is negatived by the observation, that order is not universal; which it would be, if it issued from a constant and necessary principle ... where order is wanted there we find it; there order is not wanted, i.e. where, if it prevailed, it would be useless, there we to not find it ... No useful purpose would have arisen from moulding rocks and mountains into regular solids, bounding the channel of the ocean by geometrical curves; or form a map of the ocean resembling a table of diagrams in Euclid's Elements, or Simpson's Conic Sections.143

The second half of Paley's Natural Theology is much more interesting p post-Darwinians than the first. Here he moves from the world of zoology and anatomy to consider the laws of motion and gravitation and heir role in astronomy. The first interesting remarks concern the velocity { light:

Because of its enormous value he infers that the mass of the photon needs to be extremely small to be compatible with our existence: light travels from the sun at the rate of twelve millions of miles in a minute ... It fight seem to be a force sufficient to shatter to atoms the hardest bodies. How then is this effect, the consequence of such prodigious velocity, guarded against? a proportionable minuteness of the particles of which light is composed.144

He continues with a discussion of astronomical phenomena, gratefully ~knowledging his debt to Rev. J. Brinkley, Professor of Astronomy at Dublin145 for assistance with many details. He confesses that he feels here to be severe disadvantages as well as advantages in this new line of

ping:

My opinion of astronomy has always been, that it is not the best medium through which to prove the agency of an intelligent Creator; but that, this being proved, it shows, beyond all other sciences, the magnificence of his operations ... but it is so well adapted as some other subjects are

to the purpose of argument. We are destitute of the means of examining the constitution of the heavenly bodies; very simplicity of their appearance is against them.146

In this area Paley feels adrift from the practice of direct observation he values and is also relieved of his principal dialectical device because he 147 'we are cut off from one principal ground of argumentation-

[Nowgy'. Undoubtedly, he also feels a little less confident of his assertions area where he must seek considerable guidance from others. separated from his false analogical guide he proceeds with Brink-help to make a number of insightful observations concerning the ity of the solar system and the form of the law of gravitation. Many ese have been subsequently re-derived in connection with the ion of whether we could, from the fact of our own existence alone, actually deduce that the world possesses precisely three spatial dimensions, (see section 4.8).

Paley also points out that the evolution of the Sun rules out the possibility of an infinite steady-state history without evolutionary change:

it follows, that the sun also himself must be in his progress towards growing cold; which puts an end to the possibility of his having existed, as he is from eternity.148

He goes on to describe the manner in which the terrestrial oblateness and ocean content sensitively determine the local environment and shows how the present topographical circumstances are necessary for our own existence.

The next observations he makes are the most intriguing from a modem perspective: he points out the unique features that are intrinsic to Newton's inverse square law of gravitation. The basis for his comparative study is an imaginary ensemble containing all possible power laws of variation for the gravitational force. The size of the subset of this collection which are consistent with our existence can then be examined in Anthropic fashion:

whilst the possible laws of variation were infinite, the admissible laws, or the laws compatible with the preservation of the system, lie within narrow limits. If the attracting force had varied according to any direct law of the distance, let it have been what it would, great destruction and confusion would have taken place. The direct simple proportion of the distance would, it is true, have produced an ellipse; but the perturbing forces would have acted with so much advantage, as to be continually changing the dimensions of the ellipse, in a manner inconsistent with our terrestrial creation.149

This enables Paley to quantify that formerly rather vague, qualitative notion of the mechanical optimality in the World's structure and laws. Next he considers the fitness of the various possible force laws in connection with the stability of the elliptical planetary orbits which he assumes are a necessary condition of our existence:

Of the inverse laws, if the centripedal force had changed as the cube of the distance, or in any higher proportion ... the consequence would have been, that the planets, if they once began to approach the sun, would have fallen into its body; if they once, though by every so little, increased their distance from the centre, would forever have receded from it ... All direct ratios of the distance are excluded, on account of the danger from perturbing forces; all reciprocal ratios, except what lie beneath the cube of the distance, ... would have been fatal to the repose and order of the system ... the permanency of our ellipse is a question of life and death to our whole sensitive world.149

Having thus narrowed down the form of the force law to an inverse power law he claims that the inverse square is uniquely selected because it allows extended bodies to behave gravitationally as point particles with an equal mass concentrated at the centre of mass of the body, (see section 4.8),

Whilst this law prevails between each particle of matter, the united attraction of a sphere, composed of that matter obeys the same law ... it is a property which belongs to no other law of attraction that is admissible ... excepted attraction varying directly as the distance.150

The possibility of precisely circular orbits are also excluded on the grounds of stability and Paley argues that the selection of a force law which optimally serves `to guard against [perturbations] running to destructive lengths, is perhaps the strongest evidence of care and foresight that can be given.' His case for anthropocentric design rests upon the concurrence in our solar system of the four circumstances required for the stability of the planetary orbits against perturbations of a `periodical or vibrating' nature:

viz, that the force shall be inversely as the square of the distance; the masses of the revolving bodies small, compared with that of the body at the centre; the orbits not much inclined to one another; and their eccentricity little.151

To complete this intriguing collection of mathematical arguments for anthropocentric design Paley makes some remarks similar to those of Newton in his correspondence with Bentley concerning the gravitational stability of the Universe. This provides him with a simple argument for the finite age of the Universe:

If the attraction acts at all distances, there can be only one quiescent centre of gravity in the universe: and all bodies whatever must be approaching this centre, or revolving around it ... if the duration of the world had been long enough to allow of it, all its parts, all the great bodies of which it is composed, must have been gathered together in a heap round this point.152

Despite the naivety of its earlier treatment of some of the human sciences, Paley's widely read work was to play an important role in summarizing and clearly placing before scientists' eyes the simple facts of adaption in the natural world. In order to supersede his teleological thesis another theory would be required to give a convincing explanation for the vast array of detailed examples he catalogues. The lack of a viable and positive alternative may possibly explain the negligible impact that the afore-mentioned metaphysical objections to the Design Argument actually had. Hume offered no such explanations or deductions with clear observational consequences whereas the hypothesis which was to displace the Paleyean branch of teleology—natural selection—did provide a plausible alternate explanation for the very facts upon which the anthropocentric design argument was based. The relevance of Paley's organic examples of `design' was later recognized by Huxley who went so far as to remark that Paley 'proleptically accepted the modern doctrine of evolution'. It is also worth noting that Paley's astronomical examples—which are so similar to modern Anthropic arguments—are clearly of a different and inorganic nature and lie entirely outside the jurisdiction of Darwinian natural selection. Strangely, they have been ignored in subsequent evaluations of his work.

Paley's work opened the floodgates for apologetic treatises on every conceivable aspect of `design', although few of these had anything new to say. The most encyclopaedic and systematic arose at the bequest of the Rev. Francis Egerton, the Eighth Earl of Bridgewater who died in 1829. Egerton charged his executors with the duty of selecting eight eminent scientific authors to demonstrate:

The Power, Wisdom and Goodness of God, as manifested in the Creation; illustrating such work by all reasonable arguments, as for instance, the variety and formation of God's creatures in the animal, vegetable, and mineral Kingdoms; the effect of digestion, and thereby of conversion; the construction of the hand of man, and an infinite variety of other arguments.153

The scholars chosen to carry out this task were Charles Bell, William Buckland, Thomas Chalmers, John Kidd, William Kirby, William Prout, Peter Roget and William Whewell 154 with a later independent contribution by the mathematician Charles Babbage. They were all eminent scholars of their day; several held university lectureships in the sciences and some like the chemist William Prout are now famous for their scientific work—and almost everyone has Roget's Thesaurus on their bookshelves. Despite their varying subject matter the Bridgewater Treatises have two things in common: they were all published in London and all sold out almost at once, subsequently going through many editions. With the exception of Babbage's numerical study, the style of the contributions is reminiscent of earlier eighteenth-century works and marked by a dogmatically anthropocentric bias that may be ascertained from their fairly explicit titles. It has been suggested155 that the whole collection is well summed-up by a sentence in Prout's contribution, `The argument of design is necessarily cumulative; that is to say, is made up of many similar arguments!'

Whereas in England this teleological spirit appears to have been firmly entrenched in the minds of many scientists, evolutionary ideas were beginning to germinate elsewhere. The biologist von Baer (1792-1876) remarked in his 1834 lectures that `only in a very childish view of nature could organic species be regarded as permanent and unchangeable types'. Another articulate critic of teleology who was considering the consequences of an evolutionary perspective was Goethe (1749-1832). A widely gifted man who was responsible for important contributions in anatomy, botany, poetry and philosophy, Goethe tried to introduce an evolutionary perspective into every one of these disciplines. As a student he studied in Leipzig and Strasbourg where his thinking was strongly influenced by the works of Bacon, Spinoza, and Kant. Like Francis Bacon, Goethe detects and rejects that systematic bias in Man's self-image which tempts him to elevate himself relative to the world at large:

Man is naturally disposed to consider himself as the centre and end of creation, and to regard all the beings that surround him as bound to subserve his personal profit ... He cannot imagine that the least blade of grass is not there for him.156

2.7 The Devolution of Design

The apparent uniqueness of the Universe primarily depends upon the fact that we can conceive of so many alternatives to it.
C. Pantin

The seventy-fifth section of Kant's Critique of Judgement bears the title `The conception of an objective finality of nature is a critical principle of reason for the use of the reflective judgement', and in it Kant made a confident claim:

It is ... quite certain that we can never get a sufficiem knowledge of organized beings and their inner possibility, much less get an explanation of them, by looking merely to mechanical principles of nature ... we may confidently assert that it is absurd for me even to entertain any thought of so doing or to hope that maybe another Newton may some day arise, to make intelligible to us even the genesis of but a blade of grass from natural laws that no design has ordered. Such insight we must absolutely deny to mankind.129

When the young Charles Darwin (1809-82) began his theological studies at Christ's College Cambridge, where Paley had been both a student and a fellow, he did not study Kant; but for Darwin the study of Paley's various works was compulsory.157 Many years later Darwin was to recall in his autobiography these early studies:

In order to pass the B.A. examination, it was also necessary to get up Paley's ... Evidences. The logic of this book and, as I may add, of his Natural Theology gave me as much delight as did Euclid. The careful study of these . works, without attempting to learn any part by rote, was the only part of the academical course which, as I then felt and as I still believe, was of the least use to me in the education of my mind. I did not at that time trouble myself about Paley's premises; and taking these on trust, I was charmed and convinced by the long line of argumentation.

Following his monumental development of the theory of natural selection in parallel with Wallace, Darwin remarked on its interaction with the traditional design arguments:

The old argument from design in nature, as given by Paley, which formerly seemed to me so conclusive, fails, now that the law of Natural Selection has been discovered.'"

As he grew older Darwin became more agnostic, especially with regard to the awkward problem of the evolution of intelligence. He considered:

The impossibility of conceiving this immense and wonderful universe, including man ...158 as the result of blind chance or necessity. When thus reflecting I feel compelled to look to a First Cause having an intelligent mind in some degree analogous to that of man and I deserve to be call a Theist. But then arises the doubt, can the mind of man, which has, as I fully believe, been developed from a mind as low as that possessed by the lowest animal, be trusted when it draws such grand conclusions.160

Many have looked to the relegation of Man's special status in relation to the animal world as the principal cause of hostility between Darwinians and those of an orthodox religious persuasion.161 But it appears that the possible demolition of the Design Argument may have been an equally strong motivation for opposition. Charles Hodge made this explicit at the time in his book What is Darwinism:

It is, however, neither evolution nor natural selection which gives Darwinism its peculiar character and importance. It is that Darwin rejects all teleology, or the doctrine of final causes.162

The nineteenth-century philosopher Winston Graham also pointed out that primarily Darwin had launched a successful assault on the Design Argument of the natural theologians:

Now it appears that Darwin has at last enabled the extreme materialist to attempt and carry the design argument, the last and hitherto impregnable fortress behind which natural theology has entrenched herself.163

Ideas of a general evolutionary development had of course been in the wind and were suggested by many previous workers, but it was only Darwin's introduction of the concept of natural selection along with a vast collection of observational evidence that finally displaced the anthropocentric design arguments drawn from biology. The stress laid upon the many precise adaptions visible in Nature by writers like Paley and the Bridgewater authors can be seen to have played an interesting role in this development. Their claims for design were usually based upon a systematic study of biological and botanical observations and, whether or not the Design Argument was regarded as

true, they served to focus the attention of naturalists upon a set of remarkable adapted features.164

The new evolutionary world-view led predictably to a re-evaluation of the teleological interpretation and the conception of a universal teleology that used the process of natural selection to direct events towards a final cause. Most notable amongst the supporters of this view was the American botanist and Calvinist, Asa Gray (1810-88). Gray had been appointed professor of natural science at Harvard in 1842 and through his exchange of ideas 165 with Darwin before the publication of the Origin of Species in 1859 had confirmed its thesis by his own independent botanical studies. His approach to teleology was to use the Darwinian hypothesis as a panacea to solve many of the problems which had formerly been brushed under the carpet by supporters of the Design Argument, for:

Darwinian teleology has the special advantage of accounting for the imperfections and failures as well as for successes. It not only accounts for them, but turns them to practical account ... So the most puzzling things of all to the old-school teleologists are the principles of the Darwinian, ... it would appear that in Darwinian evolution we may have a theory that accords with, if it does not explain, the principal facts, and a teleology that is free from the common objection ... if [a theist] cannot recognize design in Nature because of evolution, he may be ranked with those of whom it was said 'Except ye see signs and wonders ye will not believe.

In a letter to de Candolle in 1863 Gray offered his

... hearty congratulations of Darwin for his striking contributions to teleology ... knowing well that he rejects the idea of design, while all the while he is bringing out the neatest illustrations of it.167

Darwin liked Gray's interpretation of his work, but perhaps only because it helped soothe the public antagonism to his ideas; he remarked in a private letter to Gray that `what you say about Teleology pleases me especially and I do not think anyone else has ever noticed the point'. In the later editions of the Origin he even acknowledges Gray as `a celebrated author and divine' who had:

gradually learnt to see that it is just as noble a conception of the Deity to believe that he created a few original forms capable of self-development into other and needful forms .. .

Another American who recognized the impact of evolution on Design:*es the philosopher and science writer John Fiske (1842-1901), who gave a series of thirty-five lectures on Darwinian evolution at Harvard in 171; they subsequently appeared in revised and expanded book-form as Outlines of Cosmic Philosophy. Fiske was another to realize that it was overthrow of the anthropocentric design arguments by the mechanism natural selection that made Darwin's work so unpopular:

from the dawn of philosophic discussion, Pagan and Christian, Trinitarian and Deist, have appealed with equal confidence to the harmony pervading nature as surest foundation of their faith in an intelligent and beneficient Ruler of the universe. We meet the argument in the familiar writing of Xenophon and Cicero, and it is forcibly and eloquently maintained by Voltaire as well as by Paley, and, with various modifications by Agassiz as well as by the authors of the Bridgewater Treatises. One and all they challenge us to explain, on any other hypothesis than that of creative design, these manifold harmonies, these exquisite adaptions of means to ends, whereof the world is admitted to be full, and which are, especially conspicuous among the phenomena of life ..., in natural selection there has been assigned and adequate cause for the marvellous phenomena of adaption, which has formerly been regarded as clear proofs of beneficent creative contrivance.168

Like Gray, Fiske believed that natural selection did not necessitate the rejection of a teleology that was conceived on a large enough scale. Fiske's development of these ideas was looked upon with approval by his friend Thomas Huxley, to whose memory his subsequent work 169 Through Nature to God was dedicated. Huxley (1825-95) had set himself up as the principal public defender of the evolutionary `faith' in England on Darwin's behalf, but was himself surprisingly sympathetic to the teleological interpretation of evolutionary theory.

Huxley foresaw the demise of natural theology but was at first taken aback by the manner in which the evolutionary hypothesis had received a teleological interpretation from some of his colleagues:

It is singular how one and the same book will impress different minds. That which struck the present writer most forcibly on his first perusal of the Origin of Species was the conviction that teleology, as commonly understood, had received its death-blow at Mr. Darwin's hands.170

Huxley was the first to draw attention to the contribution which the earlier teleological ideas had made in focusing attention upon a number of remarkable organic adaptions. This common interest of teleology and evolution, he said, meant that Darwin

... Has rendered a most remarkable service to philosophic thought by enabling the student of nature to recognize, to the fullest extent, those adaptions to purpose which are so striking in the organic world, and which teleology has done good service in keeping before our minds ... The apparently diverging teachings of the teleologist and of the morphologist are reconciled by the Darwinian hypothesis.

More interesting still is Huxley's recognition of an awkward problem for the idea of natural selection—determinism. He saw that because the mechanistic view of the world must regard the later products of natural selection as a completely determined function of the initial molecular configurations, it reduces to a specification of the initial conditions. Natural selection appeared to offer an 'explanation' that things are as they are only because they were as they were:

There is a wider teleology which is not touched by the doctrine of evolution. This proposition is that the whole world, living and not living, is the result of the mutual interaction, according to definite laws, of the forces possessed by the molecules of which the primitive nebulosity of the universe was composed ... The teleological and mechanical views of nature are not, necessarily, mutually exclusive. On the contrary, the more purely a mechanist the speculator is, the more firmly does he assume a primordial molecular arrangement of which all the phenomena of the universe are the consequences and the more completely is he thereby at the mercy of the teleologist, who can always defy him to disprove that this primordial molecular arrangement was not intended to evolve the actual phenomena of the universe ... Evolution has no more to do with theism than the first book of Euclid has.172

Huxley also speculated that the evolutionary approach to Nature might have a far wider applicability. For, suppose the laws of motion and energy conservation were also just the results of natural selection acting upon a collection of possibilities:

Of simplest matter and definitely operating energy ... it is possible to raise the question whether it may not be the product of evolution from a universe of such matter, in which the manifestations of energy were not definite—in which for example laws of motion held good for some units and not for others, or for some units at one time and not another.173

However, neither Huxley nor any of his colleagues addressed the;astronomical design arguments based upon the co-presence of a number of coincidental features in the solar system dynamics and upon which the stability our environment so delicately hinges. The only debate that took place with physicists concentrated upon other more fundamental problems like reconciling evolutionary development with contemporary views on the age and origin of the earth. In that conflict the most critical opponent of Darwin's theory amongst the ranks of the physicists was Lord Kelvin who argued that the geophysical evidence pointed towards a terrestrial age too brief for natural selection to evolve the observed spectrum of living creatures. This objection against evolution, which at the time Darwin called `the gravest yet advanced' generated an extremely significant debate which we shall present in extended form in Chapter 3 since it led to the first modern prediction derived from an Anthropic Principle. Kelvin's deepest sympathies were with design couched in a suitable form because of the difficulties inherent in making any observational test of the Darwinian evolutionary hypothesis:

The essence of science consists in inferring antecedent conditions and anticipating future evolutions from phenomena which have actually come under observation. In biology the difficulties of successfully acting up to this ideal are prodigious.. . I have always felt that the hypothesis of 'the origin of species through natural selection' does not contain the true theory of evolution ... I feel convinced that the argument of design has been greatly too much lost sight of in recent zoological speculations. 14

As we shall see, Kelvin's opposition was extremely influential because of his pre-eminent position amongst British scientists of his day and the greater respect most scientists had for arguments based upon mathematical physics rather than the purely qualitative hypothesis of natural selection. Another outstanding physicist who contributed to the argument concerning the place of final causes in the evolutionary view was James Clerk Maxwell. Maxwell focused his attention upon molecules, which were then regarded as invariant and fundamental structures. He argued that their time invariance and identical structure proves they could not have developed from some natural process in a statistical fashion. These invariance properties gave them `the stamp of the manufactured article' and signalled a cut-off in the applicability of a principle of natural selection. His address to the British Association in 1873 contains a statement of these ideas:

No theory of evolution can be formed to account for the similarity of molecules, for evolution necessarily implies continuous change, and the molecule is incapable of growth, or decay, of generation or destruction. None of the processes of Nature, since the time when Nature began, have produced the slightest difference in the properties in the operation of any of the causes which we call natural. . . the molecules out of which these systems are built—the foundation stones of the material universe—remain unbroken and unknown.

These are the first glimmerings of a more sophisticated twentieth-century approach to the invariant properties of crucial molecular structures and their relevance to the existence of a life-supporting environment. This approach was later to be developed in a remarkable way by the American biochemist Lawrence Henderson whose work we shall discuss at length in Chapter 3.16

One of Henderson's forerunners both in advocating such a view and as Professor of Chemistry at Harvard was Josiah Cooke. Cooke'" appealed strongly to the form of laws of Nature and the special properties of particular chemical compounds (for example, water) as evidences for order in Nature. However, he keeps these eutaxiological arguments distinct from those which appeal to purposeful design:

We can see that each property of water has been designed for some purpose ... [But] the strength of our argument lies ... in the harmonious working of all the separate details. To me the laws of

nature afford the strongest evidences ... I do not, therefore, regard the constitution of water as some-thing apart from law.. . nor do I believe that this argument from general plan could supply the place of the great argument from design. The last lies at the basis of natural theology.. 178

We have seen that from the very earliest times there have been strong criticisms of attempts to `explain' the structure of inorganic and organic phenomena on the basis of teleological or eutaxiological design arguments. Most antagonistic objectors attempted to show that the principal arguments for design were confused or vacuous whilst sceptical or agnostic commentators held that all such issues were undecidable. Very few of the treatises on natural theology or teleological science ever attempted to deal with these criticisms in a convincing or systematic fashion. One interesting exception, whose work signals the end of the pre-modern approach to the question of final causes, was the French philosopher Paul Janet. His Causes Finales was translated into English 51 in 1878, several years after its publication in France and it provides a careful and moderately critical summary of ideas up to and including the Darwinian `revolution'. Janet's work is characterized by a broad and undogmatic discussion of possible objections to a rightly conceived system of final causation which he defines at the outset in three points:

(I) There is no a priori principle of final causes. The final cause is an induction, a hypothesis, whose probability depends on the number and character of observed phenomena.

(II) The final cause is proved by the existence in fact of certain combinations, such that the accord of these combinations with a final phenomenon independent of them would be a mere chance, and that nature altogether must be explained by an accident.

(III) The relation of finality being once admitted as a law of the universe, the only hypothesis appropriate to our understanding that can account for this law, is that it is derived from an intelligent cause.""

In his second point we see that Janet seeks to exclude any arguments based upon development and concentrates instead upon the simultaneous realization of inorganic configurations. The system is not intended to possess the anthropocentric orientation of Paley of whom he does not approve because,

This anthropocentric doctrine as it has been called, appears to be connected with the geocentric doctrine, that made the earth the centre of the world, and ought to disappear with it.

Janet then attempts to counter a number of criticisms, both ancient and modern, against the accusation that finalists have consistently confused causes for effects. He cites an example of the `chicken and egg problem' in which the effect of reproduction is then the cause of further reproduction and acts to perpetuate and to immortalize the species. Here, the order of causes is manifestly reversed, and whatever Lucretius and Spinoza may say, it is the causes that are the effects.

Janet then proceeds to argue against the claim, which he attributes to Maupertuis, (although Maupertuis merely cites Lucretius), that normalizing selection could have ensured the inevitable survival of ordered beings from random permutations. Like Paley, Janet asserts that there is no observational evidence for such a claim, but he glosses over the significance of the recent fossil finds. The theory of progressive evolutionary development, on the other hand, he cites approvingly as an excellent manifestation of final causes:

The progressive development of forms, far from being opposed to the theory of finality, is eminently favourable to it. What more simple and more rational law could have presided over

creation than that of a progressive evolution, in virtue of which the world must have seen forms, more and more finished, successively appear? 181

Janet hopes to follow Boyle and Leibniz in propounding a doctrine of complementarity where both mechanism and finalism provide different, but equally valid complementary descriptions of the same phenomena, each complete within its own sphere of reference. Janet then continues his discussion with an evaluation of what he terms certain 'contrary facts'; these include the presence of apparently useless or vestigial organs in animals. Interestingly, he discusses them in relation to the Least Action Principle, suggesting that they may be byproducts of the quest for the most economical path of development. He believes that the variational principles have some application in deciding the pathway of evolutionary development:

For that certain pieces of the organism have ceased to serve is no reason why they should entirely disappear. The law of economy is only a particular application of the metaphysical principle of the simplicity of ways, appealed to by Malebranche, or of the mathematical principle of least action, defended by Euler and Maupertuis.182

Janet then turns to discuss the status of final causation in a completely deterministic mechanical system, using Laplace's Nebular Hypothesis as the mechanical paradigm. He points out the logical equivalence of setting initial or final data for the evolution of a completely determined physical system. He also questions the notion of 'chaos' in completely determined systems'" because however a random a system might appear, it should still have evolved deterministically from definite initial conditions and will likewise evolve towards a definite final state:

The primitive nebula was, then already the actual world potentially ... But let it be observed, the nebula is not a chaos; it is a definite form, whence there is to issue later, in virtue of the laws of motion, an ordered world ... If you do not admit anything that guides and directs phenomena, you at the same time admit that they are absolutely undetermined, that is to say, disordered: now how are you to pass from this absolute disorder to any order whatever?'

Janet has turned the argument against the evolutionist and the mechanist. In effect he is saying that determinism means we must suppose the Universe to have possessed very special initial conditions if human life is to result.

There follows a discussion of the pros and cons of evolutionary theories of organic development and the principle of natural selection. Janet argues against the sufficiency of the latter hypothesis on two grounds: first, he claims that although such ideas work in the context of forced breeding experiments—unnatural selection—the probability of a sufficient number of advantageous selections occurring naturally in the real world is extremely small. Secondly, he argues that adaptations tend not to be propagated, but rather are diluted in their offspring and this tends to keep a species invariant.

Janet's final discussions centre around the consequences of various theories of knowledge for his doctrine of final causes. Of particular interest is his discussion of Kant's claim that our knowledge of the world is a property of the observer not the observed. In the course of a lengthy discussion he cites a number of contemporary objections to Kant's thesis from the works of Trendelenburg and Herbart. If ordering is an inevitable selection effect created by our act of perception, why, he asks, do we find some things unintelligible and why do we not see everything as a teleological structure?

How is it ... that the convenience of the arrangement of nature is only made evident in certain cases; that very often this convenience appears doubtful to us; in fine, that nature offers us a

certain mechanical regularity, or even simple facts, of which it is impossible for us to give an account?185

Janet closes his work with a discussion of the final end of Nature. He has already rejected the anthropocentric notion that this end is Man, and now he also rules out the possibility that the Deity might have created all for himself for this would suggest his privation—a contradiction.

Janet then meanders through various lesser possibilities in a style reminiscent of the Scholastics, before concurring with Kant that ethical goals provide the only ultimate meaning for Nature:

If there are no ends in the universe, there are none for man any more than for nature; that there is no reason why the series of causes should be mechanical up to the appearance of man, and become teleological from man upwards. If mechanism reigns in nature, it reigns everywhere, and in ethics as well as in physics ... Morality is, therefore, at once the accomplishment and the ultimate proof of the law of finality.186

Finally, we cannot resist citing our favourite Design Argument which is due to Bernadin de Saint-Pierre 187 which is of a type that distresses Janet very greatly. Indeed, Janet feels that it is a member of a class of examples which `one could believe ... invented to ridicule the theory itself'.

Bernadin claims that:

Dogs are usually of two opposite colours, the one light and the other dark, in order that, wherever they may be in the house, they may be distinguished from the furniture, with the colour of which they might be confounded.

2.8 Design in Non-Western Religion and Philosophy

There was no confidence that the code of Nature's laws could ever be unveiled and read, because there was no assurance that a divine being, even more rational than ourselves, had ever formulated such a code capable of being read.
J. Needham

Recently, the paleontologist Stephen Jay Gould characterized the Anthropic Principle as the latest manifestation of '...that age-old pitfall of Western intellectual life—the representation of raw hope gussied up as rationalized reality'.194 He further warned: 'Always be suspicious of conclusions that. . . follow comforting traditions of Western thought'. '94

Actually, the idea that humanity is important to the cosmos and indeed the idea that the material world was created for man both seem to be present in many cultural traditions; they may even be universal. Although no study of non-Western teleology has ever been done, a cursory search of the anthropological literature shows teleological notions defended in Mayan,195 Zuni (New Mexico Indian), the `Thompson' Indian of the North Pacific coast,197 Iroquois,198 Sumerian,199 Bantu,205 ancient Egyptian,200 Islamic-Persian,201 and Chinese204 traditions.

In the Popal Vuh, the most important surviving work of Mayan literature, it is recorded that the dry Earth and all life thereon was created by the gods for the benefit of mankind:

Let it be thus done. Let the waters retire and cease to obstruct, to the end that earth exist here, that it harden itself and show its surface, to the end that it be sown, and that the light of day shine in the heavens and upon the earth; for we shall receive neither glory nor honour from all that we have created and formed until human beings exist, endowed with sentience.195

In the Zuni Indian creation myth, much of the material world, including the moon, planets, rain, and vegetation, was formed for the benefit of both Mankind and animals, who were viewed as the children of the Creator gods:

Thus, as a man and woman, spake [the Earth-mother and Sky-father], one to the other. 'Behold!' said the Earth-mother as a great terraced bowl appeared at hand and within it water, 'this is as upon me the homes of my tiny children shall be. On the rim of each world-country they wander in, terraced mountains shall stand, making in one region many, whereby country shall be known from country, and within each, place from place. Behold again! said she as she spat on the water and rapidly smote and stirred it with her fingers. Foam formed, gathering about the terraced rim, mounting higher and higher. 'Yea', said she, 'and from my bosom they shall draw nourishment, for in such as this shall they find the substance of life whence we were ourselves sustained, for see!' Then with her warm breath she blew across the terraces; white flecks of the foam broke away, and, floating over the water, were shattered by the cold breath of the Sky-father attending, and forthwith shed downward abundantly fine mist and spray!

`Even so!' said the Sky-father; 'Yet not alone shalt thou helpful be unto our children, for behold!' and he spread his hand abroad with the palm downward and into all the wrinkles and crevices thereof he set the semblance of shining yellow corn grains; in the dark of the early world-dawn they gleamed like sparks of fire, and moved as his hand was moved over the bowl, shining up from and also moving in the depths of the water therein. 'See!' said he, pointing to the seven grains clasped by his thumb and four fingers', by such shall our children be guided; for behold, when the Sun-father is not nigh, and thy terraces are as the dark itself (being all hidden therein), then shall our children be guided by lights.. . Yea! and even as these grains gleam up from the water, so shall seed-grains like to them, yet numberless, spring up from thy bosom when touched by my waters, to nourish our children'. Thus and in other ways many devised they for their offspring.'

The 'Thompson' Indians of the North Pacific coast believed that the parts of the world were formed from five hairs which the Creator pulled from his head. The first two hairs chose to become women, the third the Earth, and the fourth chose to be Fire in grass, trees, and all wood, for the good of man. The fifth became Water, to 'cleanse and make wise' the people. `I will assist all things on earth to maintain life'.

In the Iroquois origin myth the Earth was created primarily for the benefit of mankind by the people of the Sky World. The sky god Sapling created the first man out of red clay, and then made a compact between the Earth people and the people of Sky World:

I have made you master over the Earth and over all that it contains. It will continue to give comfort to my mind. I have planted human beings on the Earth for the purpose that they shall continue my work of creation by beautifying the Earth, by cultivating it and making it more pleasing for the habitation of man.198

Thus the Iroquois believed they had a mandate to change the Earth, in order to make it `more pleasing for the habitation of man'.198 A similar motif appears in some of the Sumerian origin legends. Human beings were created to serve the gods primarily by offering sacrifices and homage, but also by imitating the gods in creating and preserving the cosmic order.'

According to the Boshongo, a Bantu Tribe in central Africa, the Universal Creator Bumba walked among mankind, saying unto them `Behold [the] wonders [of the Earth]. They belong to you.'205

The ancient Egyptian text The Instruction of King Meri-ka-Re (written c. 2000 Bc) records:

Men, the cattle of God, have been well provided for. He [the sun god] made the sky and the earth for their benefit ... He made the air to vivify their nostrils, for they are his images, issued from his flesh. He shines in the sky, he makes plants and animals for them, birds and fish to feed them?

This passage appears to represent the typical Egyptian tradition concerning the origin and purpose of mankind.

Islam is closely related to Christianity, for both are rooted in Judaism and both were influenced by Greek philosophy. Thus it is not surprising to find in Islam certain teleological ideas similar to those in Judaism and Christianity. Teleological concepts are prominent in the works of one of the most outstanding Muslim scientists, the Persian al-Biruni (c.1000 AD). This scholar held that Man's intellect made him God's vice-regent (Khallfat Allah) on earth. Because Man is God's vice-regent, the world is ordered for his benefit, and he is granted power over God's creation.1 In holding such an opinion, al-Biruni is merely following the Qur'an. For example, in Surah (Chapter) 2, ayah (verse) 29 and 30 of the Qur'an, we find the words:

How do you disbelieve in God, seeing ... It is He who created for you all that is... [When He created humankind, the] Lord said to the angels, "I am setting in the Earth a viceroy [Khalfat]". 246

The more abstract teleological ideas are also present in al-B runi's works. In his view, everything in Nature was ordered according to God's plan. As al-Birani put it: `Praise therefore be unto Him who has arranged creation and created everything for the best.... there is no waste or deficiency in His Work' 203 The idea in these passages are strikingly similar to the view of the Christian philosopher Leibniz, who contended that God has created the best of all possible worlds. The same notion of a perfectly ordered cosmos is found in both Christianity and Islam, for both religions have an omnipotent, omniscient, and perfect god who would naturally create a perfect world, a world in which no event or thing would be outside the Divine plan.

More subtle notions of teleology were evolved in Chinese civilization, a civilization which never possessed the concept of a Supreme Deity.204 Like other peoples, the Chinese developed the idea that the Earth was made for Man, but early in their civilized history they were aware of the arguments against this rather naive form of teleology. The following story, taken from the book Lieh Tzu attributed to the semi-legendary Taoist philosopher Lieh Yu-Khou (much of the book probably comes from the third century BC 197) illustrates both:

Mr. Thien, of the State of Chhi, was holding an ancestral banquet in his hall, to which a thousand guests had been invited. As he sat in their midst, many came up to him with presents of fish and game. Eyeing them approvingly, he exclaimed with unction; `How generous is Heaven to man! Heaven makes the five kinds of grain to grow, and brings forth the finny and the feathered tribes, especially for our benefit'. All Mr. Thien's guests applauded this sentiment to the echo, except the twelve-year-old son of a Mr. Pao, who, regardless of seniority, came forward and said; 'It is not as my Lord says. The ten thousand creatures [in the universe] and we ourselves belong to the same category, that of living things, and in this category there is nothing noble and nothing mean. It is only by reason of size, strength or cunning, that one particular species gains mastery over another, or that one feeds upon another. None of them are produced in order to subserve the uses of others. Man catches and eats those that are fit for food, but how [could it be maintained that] Heaven produced them just for him? Mosquitoes and gnats suck [blood through] his skin; tigers and wolves devour his flesh—but we do not therefore assert that Heaven produced man for the benefit of mosquitoes and gnats, or to provide food for tigers and wolves'.206

Needham 206 cites this passage as an indication of the denial of general teleology by the Taoists, but we think it indicates an acceptance of naive teleology by most Chinese. Note that all except the boy agree with the teleological sentiments expressed by Mr. Thien. The criticism of teleology is probably placed in the mouth of a boy by the Taoist author in order to emphasize that the argument against naive teleology should be obvious even to a child.

China had two major indigenous philosophical systems: Taoism and Confucianism. The former was concerned primarily with the order of Nature while the latter concerned itself primarily with the proper ordering of human society. These two branches of Chinese philosophy and Buddhism were partially merged by the Neo-Confucian philosophers in the Sung dynasty (eleventh and twelfth centuries AD). Among these scholars, the most important was Chu Hsi (1131-1200). In Neo-Confucian philosophy, social order was placed in Nature, but Nature took on certain aspects of social order. In the view of Chu Hsi, the vast `pattern' of Nature was normal because it was inevitable that moral values and moral behaviour would appear when the Universe had developed sufficiently far. 208 Nevertheless, this Natural spontaneous moral order was not the result of conscious design:

Someone also asked, `When Heaven brings into being saints and sages, is it only the effect of chance, and not a matter of design?' The philosopher replied, `How could Heaven and Earth say: 'We will now proceed to produce saints and sages? It simply comes about that the required quantities [of matter-energy] meet together in perfect mutual concordance, and thus a saint or a sage is born. And when this happens it looks as if Heaven had done it by design'.209

Chu Hsi's spontaneous ordering principle seems strikingly similar to Leibniz' pre-established harmony. Needham himself considers the emergent moral order in Chu Hsi's work as closely analogous to the Western idea of emergent evolution, defended in particular by Herbert Spencer, Henri Bergson, and Alfred North Whitehead (whose work we shall discuss at length in Chapter 3), wherein the moral order appears at later stages in the Universe's history. We see that a spontaneous ordering principle may or may not be teleological. It can properly be regarded as teleological only if the spontaneous order is generated as a consequence of the purposeful interaction of goal-directed organisms, or if the final state of the ordering process is emphasized over the initial and intermediate states. Otherwise, the spontaneous ordering principle is more properly regarded as eutaxiological.

The concept of spontaneous order has been central in Chinese philosophy from the dawn of Chinese civilization to the twentieth century. The idea probably arose as a result of the close observation of the growth of plants and the non-coercive social organization which develops spontaneously among human beings in primitive farming communities.204 The following passage, by Liu Tsung-Yuan (773-819) a T'ang dynasty naturalist, illustrates both:

One day a customer asked 'Camel-Back' Kuo, a famous market-gardener, how he was so successful in growing plants], to which he replied: `Old Camel-Back cannot make trees live or thrive. He can only let them follow their natural tendencies. In planting trees, be careful to set the root straight, to smooth the earth around them, to use good mould and ram it down well. Then, don't touch them, don't think about them, don't go and look at them, but leave them alone to take care of themselves, and Nature will do the rest. I only avoid trying to make my trees grow. I have no special method of cultivation, no special means for securing luxuriance of growth. I just don't spoil the fruit. I have no way of getting it either early or in abundance. Other gardeners set with bent root, and neglect the mould, heaping up either too much earth or too little. Or else they like their trees too much and become anxious about them, and are for ever running back and forth to see how they are growing; sometimes scratching them to make sure they are still alive, or shaking them to see if they are sufficiently firm in the ground; thus constantly interfering with the natural bias of

the tree, and turning their care and affection into a bane and a curse. I just don't do those things. That's all'.

`Can these principles of yours be applied to government?' asked his listener. 'Ah', replied Camel-Back, 'I only understand market-gardening; government is not my trade. Still, in the village where I live, the officials are constantly issuing all kinds of orders, apparently out of compassion for the people, but really to their injury. Morning and night the underlings come round and say, 'His Honour bids us urge on your ploughing, hasten your planting, supervise your harvest. Do not delay with spinning and weaving. Take care of your children. Rear poultry and pigs. Come together when the drum beats. Be ready when the rattle goes'. Thus we poor people are badgered from morning till night. We haven't a moment to ourselves. How could anyone develop naturally under such conditions? It was this that brought about my deformity. And so it is with those who carry on the gardening business'.

`Thank you', said the listener. 'I simply asked about the management of trees, but I have learnt about the management of men. I will make this known, as a warning to government officials.'210

We have quoted at length a minor T'ang writer, but the same notion of spontaneous order appears over and over again in most Chinese philosophical writing, including the most influential works. For example, the Tao Ti Ching of Lao Tzu (fourth century Bc), the most important of the Taoist books, considers the Tao to be simply a spontaneous ordering principle:

The supreme Tao, how it floods in every direction! This way and that, there is no 'place where it does not go. All things look to it for life, and it refuses none of them; Yet when its work is accomplished it possesses nothing. Clothing and `Nourishing all things, it does not lord it over them. Since it asks for nothing from them It may be classed among things of low estate; But since all things obey it without coercion It may be named supreme. It does not arrogate greatness to itself And so it fulfils its Greatness.211

In this passage, the action of the spontaneous ordering principle of Nature, the Tao, is contrasted with the order brought about by the conscious design of a ruler. The superiority of the order brought about spontaneously by human interaction over the order imposed from above by force is also a central motif in Confucian works. In fact, the early Confucians felt that the Tao of mankind was to be good, or rather to order naturally their relations with each other in mutually beneficial ways. They believed the ideal ruler would govern his people most effectively by his upright example rather than by force, as the following passage from the Analects of Confucius illustrates:

Chi Khang Tzu asked Confucius about the art of ruling. Confucius said, 'Ruling is straightening. If you lead along a straight way, who will dare go by a crooked one?' 212

Chi Khang Tzu asked Confucius about government, saying, `Supposing we liquidated all those people who have not the Tao in order to help those who do have the Tao, what would you think about it?' Confucius replied, 'You are there to rule, not to kill. If you desire what is good, the people will be good. The natural ruler [chuntzu] has the virtue of wind, the people the virtue of grass. The grass must needs bend when the wind blows over it' .2 3

Similar remarks can be found throughout the works of the Confucians, at least through the tenth century AD; (see Chapter 9 of ref. 204 for representative examples). Politically, the Confucians can be regarded as China's native liberals. They were able to prevent the continuation, though not the formation, of a totalitarian state in China: the Chin Empire (second century Bc). The advocates of such a state, the Legalists, were in the end defeated with the overthrow of the Chin and its replacement by the Han dynasty. The Legalists argued that the people should be governed

according to positive law, fa, which were written rules expressing the arbitrary will of the supreme autocrat, while the Confucians, true to their tradition, countered that society should be ordered spontaneously according to evolved good customs, called li. It has been li rather than fa that has been the most significant force governing the day-to-day actions of the Chinese people from the formation of the Han Empire to the founding of the Republic in 1912. Needham argues 214 that such an emphasis on ii, as opposed to fa, made it impossible for the Chinese to develop the concept of natural laws, which in the West, he believes, were originally pictured as decrees from the Supreme Ruler of the Universe, God. However this may be, it would be difficult for the notion of teleology to be developed in Chinese philosophy and applied to the cosmos since cosmic teleology involves planning in some sense by a thinking being.

Nevertheless, there is a deep connection between teleology and spontaneous social order, a connection which has been pointed out by philosophers of the classical liberal tradition,215 of whom Fredrick Hayek is the most distinguished representative in our own time. Hayek received his original university training in Vienna in Law, but spent the first thirty or so years of his career in economics (he was awarded the Nobel prize in economics in 1974) at the University of London. He has concentrated his attention on questions of social organization during the last thirty years. Like the Confucians, Hayek is primarily concerned with spontaneous order in human society. Human language is the most obvious example of such an order. It was not formed by the conscious design of any individual or group of individuals. Rather, it just grew. It is growing and changing now by the daily interactions of countless numbers of human beings. Hayek argues in scores of articles and many books (e.g. refs. 216-22) that the free market is a similar sort of order, an order which is created by the decentralized action of many minds, using far more information than is available or could be available to any one mind, thus generating an order much more complex than any one mind could even imagine. The market order cannot be said to have an overall purpose in the naive sense of the word. As Hayek puts it:

Most important ... is the relation of a spontaneous order to the conception of purpose. Since such an order has not been created by an outside agency, the order as such also can have no purpose, although its existence may be very serviceable to the individuals which move within such order. But in a different sense it may well be said that the order rests on purposive action of its elements, when `purpose' would, of course, mean nothing more than their actions tend to secure the preservation or restoration of that order.217

In effect, the different and often conflicting purposes of the many human beings interacting via the market are woven together into an orderly whole; the entire system evolves in a direction none can foresee, because the knowledge dispersed throughout the system, and sustaining the order, is much greater than any individual can comprehend:

Certainly nobody has yet succeeded in deliberately arranging all the activities that go on in a complex society. If anyone did ever succeed in fully organizing such a society, it would no longer make use of many minds, but would be altogether dependent on one mind; it would certainly not be very complex but extremely Primitive—and so would soon be the mind whose knowledge and will determined everything. The facts which could enter into the design of such an order could be Only those which were known and digested by this mind; and as only he could decide on action and thus gain experience, there would be none of that interplay of many minds in which alone mind can grow.218

Teleology is definitely present, for the human actors all have their own purposes, but it is teleology in the small, not a global teleology. The market system harmonizes these individual purposes, but it has none of its own. The image of the market and its spontaneous order developed by Hayek appears strikingly similar to the picture of spontaneously-ordering human society given by the

Chinese sages in the quotes above. Hayek himself points out that his notion of spontaneous social order is closely analogous to the Greek Kosmos, which originally meant a right order for a community'.219

The precise and subtle relationship between a spontaneously ordered social system and the teleology of the beings who comprise it has recently been worked out by the political scientist Robert Axelrod. He has shown 220 on the basis of game theory that the spontaneous formation of a cooperative social order actually requires a very strong teleology to be acting at the individual level. That is, such an order can form spontaneously only if the future expectations of the individuals in the society are dominant over their immediate expectations in determining their present actions.

The barrier to the spontaneous formation of cooperation in a population of individuals without teleology is illustrated by the famous Prisoner's Dilemma. Two prisoners are in separate gaol cells and not permitted to communicate. Their gaoler urges each to confess, telling each that if he confesses to the crime and his partner does not, then the party that confesses will go free, while the other will get the maximum punishment of five years. If both confess, the confession of each will be worth less, so they both will get three years. If neither confess, then both will be convicted of only a minor charge, and each will get only one year. What action should the prisoners take? Consider the strategy of prisoner A. If the other prisoner B confesses, then A has no choice but to confess also since otherwise he would get five years rather than three. On the other hand, if B does not confess, then it is in the interest of A to confess since then he would go free. Thus, whatever B does, it is in A's interest to confess. Since the same analysis applies to B, we conclude that the best strategy for each to adopt is to confess. But the joint confession results in both getting three years rather than the one year they both would have received if they had cooperated. Nevertheless, it would be against the self-interest of each not to confess, even though both would be better off if neither confesses. The Prisoner's Dilemma is faced by every individual in many, if not every, interaction with other individuals; for it is always in the self-interest of an individual to get something for nothing; it is always in the self-interest of an individual to cheat another in any given interaction even though both might be better off if neither cheated! How then is it possible for cooperation to arise spontaneously in a group of individuals each pursuing his own interests?

Cooperation can arise because in general individuals will interact with a given individual not just once but many times. In the language of game theory, the Prisoner's Dilemma two-person positive-sum game must be replaced with a sequence of such games; the resulting game is termed an iterated Prisoner's Dilemma game. The pay-off matrix for the Prisoner's Dilemma game is to fix ideas, let us choose R = 3, P =1, S = 0, and T = 5. Then as in the example above, it is in the rational interest of both players not to cooperate, even though this means that they receive the pay-off P rather than the pay-off R which they would have both received if they had cooperated. In general, the Prisoner's Dilemma arises when T> R > P> S. with R > (T+S)/2, and both players must choose their strategy before they know what strategy the other chooses.

In the iterated Prisoner's Dilemma, the above game is played many times and the total pay-off is achieved over many games. However, the present value of a future pay-off is not as great as the present value of a present pay-off because a future good is not as valuable as a present good (if one is to receive a thousand pounds, it is better to receive it now rather than ten years from now), and also because there is some chance that the game will halt after a finite number of steps (in real life, interactions eventually will cease because one of the players dies, moves away, or becomes bankrupt). Therefore, the pay-off of each game is discounted relative to the previous game by a discount parameter w, where 0 < w < 1. The expected cumulative pay-off of an infinite number of games is obtained by adding all the expected pay-offs from each game, where the expected pay-off of each game is obtained by multiplying the pay-off of the immediately preceding game by w. For

example, the expected cumulative pay-off accruing to both players if they cooperate in all games would be given by R+Rw+Rw2+Rw3+...= R/(1—w) when the sum is an infinite geometrical progression. Cooperation becomes a possible rational strategy, because although a given player does not know the other's choice on the present game, he does know what the other chose on previous games. He can choose his strategy for the nth game according to what the other player has chosen on the preceding (n - 1) games with him.

The discount parameter w measures the importance of the future. One can prove220.221 that only if w is sufficiently close to 1—i.e., only if the present value of future pay-offs is sufficiently high—is it possible for `nice' strategies (those which have the player cooperate until the other player doesn't cooperate) to be a collectively stable strategy. Axelrod calls a strategy `collectively stable' if, when everyone is using such a strategy, then no one can do better by adopting a different strategy.

In order for a strategy to persist in Nature, it must be collectively stable, for there will always arise by mutation individuals who try different strategies. In an evolutionary context, the collective stability of some cooperative strategies shows that, if a population of individuals using such strategies ever forms, it can persist and grow. Collectively stable strategies are essentially the same as what the evolutionist John Maynard Smith223.224 has called `evolutionarily stable strategies'. Furthermore, Axelrod shows that a population of non-cooperators can be successfully invaded by clusters of cooperators if w is high enough and if the relative frequency with which the cooperators interact with each other rather than with the non-cooperators is sufficiently high. For example, if we have T = 5, R = 3, P = 1, S = 0, and w = 0.9 then a cluster of individuals using the `nice' strategy of `cooperate until the other does not, then don't cooperate for one game, then cooperate until the other does not cooperate again' can successfully invade a population of non-cooperators if only 5 per cent of their interactions are with other members of the cluster. (Individual cooperators cannot invade a population of non-cooperators because the strategy of total non-cooperation is also collectively stable. But a cluster of non-cooperators cannot invade a population of cooperators using a collectively stable strategy.)

These ideas have been applied to the evolution of cooperative behaviour by Axelrod and Hamilton, 22'"2z2 and by Maynard Smith 223,224,225 More speculatively, these results showing the importance of teleology for the formation of order suggest that if one wishes to model the physical cosmos after a biological or social cosmos—this is the idea underlying Wheeler's Participatory Anthropic Principle—then the state of the universe at any given time must be determined not only by the state of the universe an instant before, which is the usual physical assumption, but rather it must be a function of all the preceding states and all the future states.

2.9 Relationship Between The Design Argument and The Cosmological Argument

To someone who could grasp the Universe from a unified standpoint the entire creation would appear as a unique truth and necessity.
J. D'Alembert

The unrest which keeps the never stopping clock of metaphysics going is the thought that the non-existence of the world is just as possible as its existence.
W. James

The cosmological argument is today probably the most often used theological existence proof. It was the main argument used by Father Copleston against Bertrand Russell in their famous BBC debate on the existence of God,226 and there have been several books written recently defending this argument; see refs 227-9. The argument in its most common version is based on two

assumptions: (1) something exists, and (2) there must be a sufficient reason for everything that exists. The argument begins with the claim that the existence of everything in the Universe is merely contingent; that is, it could be otherwise than it is. To use an example of Matson,230 this book could have been as it is except for one extra typo. The book as it is is contingent, since we would think that the number of typos in the book is not a logically necessary feature of the Universe; we would not expect the Universe to be logically inconsistent with the extra typo. Thus by the principle of sufficient reason, there must be a reason why that typo is not there, namely our sharp eyes. But we are also apparently contingent, which means there has to be a reason (or cause) for our own existence. And so it goes for everything in the Universe upon which we are dependent. It is now contended that these other objects—which at this stage in the argument include everything in the Universe—must have a reason (cause) for existence. Since it has been argued that everything in the Universe must be explained in terms of something else, this other reason must be outside the Universe. Furthermore, this transcendental reason must be the final reason, for otherwise the hierarchy of causes would continue without end, and this hierarchy would itself want a reason. In order to avoid the charge that the Final Cause itself needs a cause, the defenders claim it is its own cause. We should emphasize that the hierarchy of `causes' which is referred to in the cosmological argument does not refer to a hierarchy of causes in the sense of a series of causes preceding effects in time. It refers rather to hierarchy of underlying `reasons' for events which are perceived by the human mind. Another example of such a hierarchy is as follows: (first level) our writing of these words has as its physical cause the muscle fibres in our arms, the cells of which (second level) obey the laws of chemistry, the laws of chemistry being derived from (third level) atomic physics, and finally the laws of atomic physics are determined by (fourth level) quantum physics. At present, we are forced to accept quantum physics as a brute fact, but physicists feel in their heart of hearts that there is some reason why the Universe runs according to quantum physics rather than, say, Newtonian physics. (There is a temporal version of the cosmological argument, with 'cause' being followed by `effect' which is another cause, but as this version is easily demolished, no major theologian in the past thousand years has defended it. For instance, Aquinas did not accept the temporal version: he did not believe it was possible to show by reason alone whether or not the Universe had a beginning.)

There are many problems with the non-temporal version of the cosmological argument, which is often called the argument from contingency. We shall focus only on those difficulties which are relevant to the Anthropic Principle; the reader can consult references 231 and 232 for a more complete discussion. One obvious problem with the argument is, why should we accept its minor premise? Why should the principle of sufficient reason be true? The defenders of the cosmological argument feel that the Universe must at bottom be rational, but again, why should it? Antony Flew, who is the most profound of the contemporary critics of theism, points out 231 that not only is the principle of sufficient reason unjustified, but it is actually demonstrably false! Any logical argument must start with some assumptions, and these assumptions must themselves be unjustified. We might of course be able to justify these particular assumptions in the context of another demonstration from which the particular assumptions are deduced, but this just pushes the problem to a higher level; the basic underlying assumptions in the higher level argument are themselves unjustified. At some point we have to just accept some postulates for which we can give no reason why they should be true. Thus the nature of logic itself requires the principle of sufficient reason to be false.233

Nevertheless, by insisting that the Universe is rational—which really means that the Universe has a causal structure which can be ordered by the human mind, and further that the ultimate reason for the existence of the Universe can be understood by human beings—the defenders of the cosmological argument are taking an Anthropic Principle position. In its insistence that there is an actual hierarchy of causes in the Universe which is isomorphic to the pyramid of causes constructed by human beings, the cosmological argument is analogous to the teleological argument, for the

latter argument asserts that the order observed in the Universe is isomorphic to the order produced by human beings when they construct artifacts. In both arguments the mental activities of human beings are used as a model for the Universe as a whole.

The major premise in the cosmological argument is that things exist, and further, that contingent things exist. But Hume in his Dialogues pointed out contingency could be just an illusion of our ignorance:

To a superficial observer so wonderful a regularity [as a complex property of the integers] may be admired as the effect either of chance or design; but a skilled algebraist immediately concludes it to be the work of necessity, and demonstrates that it must forever result from the nature of these numbers. Is it not probable, I (philol ask, that the whole economy of the Universe is conducted by a like necessity, though no human algebra can furnish a key which solves the difficulty? 234

Most defenders of the cosmological argument have dismissed Hume's objection, but many modern cosmologists are coming to the conclusion that there is only one logically possible universe. These modern cosmologists have hubris that Hume's alter-ego, Philo, would have blanched at: some of them believe they have found the key (or rather, keys) which will permit a mathematical description of this single logically possible universe! For example, Hartle and Hawking 235 and Hawking 236 have obtained an expression for the `wave function of the Universe', using path integral techniques. The wave function of the Universe, regarded as a function of three spatial variables and a time variable, is essentially a list of all possible histories, classical and otherwise, through which the universe could have evolved to its present quantum state, which itself includes all logically possible particles and arrangements of particles that could exist in the Universe at the present time. If we accept the Many-Worlds interpretation of quantum mechanics—as Hartle and Hawking do—then all these possibilities actually exist. In other words, the Universe, which is defined as everything that actually exists, is equal to all logically consistent possibilities. What more could there possibly be? Furthermore, there are strong indications that the mathematical structure of quantum mechanics requires that all observationally distinguishable possibilities are actually realized. More precisely, the Universal wave function can be shown to have only isolated zeros, if it is an eigen-state of the energy—the Hartle–Hawking Universal wave function is such an eigen-state—and if the Universal Hamiltonian is a self-adjoint operator..... This means that such a wave function is non-zero almost everywhere on the domain of possibilities. It is impossible to distinguish observationally between a function which is non-zero everywhere and one which is non-zero almost everywhere. If it could be proved that the mathematical structure assumed for quantum mechanics were logically necessary, then we would have a proof that only one unique Universe—the one we live in—is logically possible. The above discussion sounds a bit woolly, but it is possible to make predictions by restricting attention to a few parameters of the domain of possibilities. See Chapter 7 for a detailed analysis, from the point of view of the Many-Worlds interpretation, of a Universal wave function in which the only possibility considered is the radius of the sidereal Universe. As we shall point out in Chapter 3, the mathematician-philosopher A. N. Whitehead was the first to suggest that the problem of contingency might be solved if the actual Universe realized all possibilities: if this were the case, there would be no contingency in the large.

The remainder of the cosmological argument's major premise is the assertion `something exists'. This is a rather unobjectionable postulate, as it wins the assent of realists, idealists, and even solipsists. Nevertheless, the nerve of the cosmological argument lies in creating the suspicion that the entire Universe, even if it is necessarily unique, may want a reason for existence: that is, it suggests we should ask the question, `why is there something rather than nothing?'

This question has an answer only if there is something whose existence is logically necessary, which is to say, that the denial of its existence would be a logical contradiction. This brings us to the

ontological argument for the existence of God, a proof claiming to deduce the existence of God from His definition.

The ontological argument has had a rather mixed reception by theologians and philosophers since its introduction by St. Anselm in 1078 239 Aquinas did not accept it as valid, nor have the vast majority of modern philosophers, but both Descartes and Leibniz did believe it to be valid. As Kant and, more recently, Antony Flew 231 have pointed out, the explicit rejection of the ontological argument puts those theologians who accept the cosmological argument in a difficult position, because the cosmological argument assumes that there is a Final Cause who is Its own reason for existence, and only if the existence of this Final Cause is logically necessary will it be superfluous to find a reason for its existence. At bottom, the cosmological argument presupposes the validity of the ontological argument.

The reason Kant gave for the invalidity of the argument is basically the one which modern philosophers find convincing: existence is not a property, but rather it is a precondition for something to have properties. An example will make this clearer. It certainly makes sense to say `some black lions exist', but the statement `some black lions exist, and some don't' is conceptually meaningless. It is meaningless because although `black' can be a property of lions, `existence' cannot. Modern logicians have constructed a notation that makes it impossible to formulate in the notation existential sentences like `some black lions exist, and some don't', which are grammatically correct in English but conceptually mean ingless. In this notation, `X exists' means `X has an instance'. Another criticism that can be levelled against the ontological argument is that the concept of logical necessity applies to propositions, not to questions of existence.

In our opinion, these criticisms of the ontological argument are correct; it is not possible to deduce the existence of any single being from its definition. But a caveat must be made. If the Universe is by definition the totality of everything that exists, it is a logical impossibility for the entity `God,' whatever He is, to be outside the Universe if in fact He exists. By definition, nothing which exists can be outside the Universe. This is a viewpoint which more and more twentieth-century theologians are coming to hold: they are beginning to adopt a notion of deity which insofar as questions of existence are concerned, is indistinguishable from pantheism." As Paul Tillich succinctly put it, `God is being-itself, not a being'.240 We do not concern ourselves with whether it is appropriate for a theologian defending such a position to call himself a theist, as most of them do. (The atheist George Smith has subjected such theologians to a very witty and scathing criticism on this point in ref. 232.) Rather, we are interested in the truly important implication of this notion of deity, which is that in the context of such a notion, the purpose of the ontological argument is to establish the existence of the Universe, or equivalently, the existence of something, as logically necessary. This is the caveat to the above-mentioned refution of ontological argument which we wish to consider: granted that the existence of no single being is logically necessary, could it nevertheless be true that it would be a logical contradiction for the entire Universe; which is not a being, but all being considered as a whole, not to exist? If the Universe must necessarily exist, then modem logical notation cannot be applied to the single unique case of the ontology of the Universe, but it would be valid in every other situation.

Even philosophical atheists differ as to the validity of the cosmological/ontological argument interpreted in such a way. David Hume, in the persona of Cleanthes, admitted that if the logic of the cosmological argument were sound, then why may not the material universe be the necessarily existent Being, according to this pretended explication of necessity? We dare not affirm that we know all the qualities of matter; and, for aught we can determine, it may contain some qualities which, were they known, would make its non-existence appear as great a contradiction as that twice two is five. 234

Bertrand Russell, on the other hand, thought we had to accept the existence of the Universe as an irreducible brute fact. As he expressed it in his BBC debate with Copleston:

COPLESTON: Then you would agree with Sartre that the universe is what he calls 'gratuitous'?

RUSSELL: Well, the word 'gratuitous' suggests it might be something else; I should say that the universe is just there, and that's all 241

The reason 'something exists' may be necessarily true arises from a close analysis of what the word 'existence' means. An entity X is said to exist if it is possible, at least in principle, to observe it, or to infer it from observation of other entities. If it is claimed that X had, has, and will have no influence whatsoever on anything we can possibly observe, then by definition X does not exist 242 But again by definition, there must exist this ill-defined entity we have termed 'the observer' to act as an arbiter for the existence of everything else, which implies that something—the observer, at least—actually exists. This argument will be immediately recognized as a self-reference argument, a category of arguments to which all the Anthropic Principle arguments belong. To put the argument another way, the phrase 'nothing exists' is logically contradictory because the phrase `X has an instance' (equivalent to 'X exists' in modern logic) means that there is an 'observer' who can, at least in principle, observe X. Thus 'nothing has an instance' would mean that an observer has not observed anything. But the observer has observed himself, or at least he himself exists, which means it is not true that `nothing has an instance.' Cogito ergo sum. Assuming the truth of `nothing has an instance' implies its falsity, which means that it is contradictory and hence false.

We do not defend this self-reference argument: we merely note it because of its Anthropic Principle flavour. The philosopher Charles Hartshorne, who is generally recognized as the most influential defender of the ontological argument in the twentieth century,239 is a pantheist in the sense described above in his ontology, and he believes that 'something exists' is a logically necessary truth?43 For Hartshorne, the phrase, `God exists necessarily' means that the non-existence of the Universe is a logical contradiction. (His critics, e.g. Hick,239 seem unaware of this, and base their refutation of his arguments on another, more traditional concept of deity.) If one does not accept the non-existence of the Universe as logically contradictory, then one is forced into Bertrand Russell's position of regarding the Universe's existence as a brute fact. But if the speculations of some modern cosmologists are correct, there may be only one unique Universe which is logically possible, and the assumption of the Universe's existence is the only assumption we have to make.

In this chapter we have attempted to outline the history of Design Arguments and the philosophical debates surrounding them. In this way we have been able to introduce some of the questions touched upon by the modern Anthropic Principles. At the very least we aim to have shown that the Anthropic Principle is not the new and revolutionary idea that many scientists see it to be. We have argued that the Anthropic Principles are but a modern manifestation of the traditional tendency to frame design arguments around successful mathematical models of Nature. Investigation reveals there to have existed quite distinct teleological and eutaxiological Design Arguments whose divide mirrors the divide between different varieties of Anthropic Principle. We found that both Western and Eastern cultures acquired an interest in the question of design. What characterizes the European interest especially is the use of these arguments to prove the existence of a deity from the apparent purpose or harmonious workings of the machinery of Nature. The surprising persuasiveness of such arguments can be traced to the dramatic success of the Newtonian approach to science to which they were wedded. This led us to consider the famous Cosmological Argument for the existence of God in some detail and discuss its connections with the Anthropic Principles. The blow dealt by Darwin to the traditional design arguments founded upon the existence of environmental adaption revealed two interesting features. On the one hand the early Design

Arguments played a key role in leading Darwin to develop his theory of natural selection but on the other we must recognize that this advance still left untouched most of the design arguments of the day that were framed around non-biological phenomena. It is this class of eutaxiological design argument that has evolved into the more precise examples which motivated the modern Anthropic arguments. One of the most interesting features of the world to emerge from study of biological populations has been the possibility that order can develop spontaneously. Modern ideas concerning the spontaneous generation of order in social systems were discussed together with the relevance of this for the teleological behaviour of their members. This departure prepares the ground for a more detailed investigation of the use of teleological arguments in science and philosophy in the next chapter.

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2. These fragments are listed in ref. 1 along with subsequent citations. They are also listed in G. S. Kirk and J. E. Raven, The presocratic philosophers: a critical history with a selection of texts (Cambridge University Press, 1957). Hereafter we shall reference fragments according to their catalogue number in Kirk and Raven, for example as KR999.
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first from a small area. . . Mind arranged ... this rotation in which we are now rotating, the stars, the sun and the moon'.
4. Anaxagoras, KR504.
5. Aristotle, Parts of animals, 687a7.
6. Aristotle, Metaphysics, 985a18.
7. Plato, Phaedo, 98B7 (KR522). For some further criticism, see Simplicius, Physics 327, 26.
8. Aristotle, De Caelo 2, 300b20. See also KR444151617.
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10. Plato, The Republic, Bk7.
11. Xenophon, Memorabilia, I(1), 10.
12. Xenophon, Memorabilia, IV(3), 5.
13. Diogenes, KR604.
14. KR505.
15. KR564.
16. For a discussion of Aristotle's cosmology see Theories of the universe, ed. M. K. Munitz (I.U. Free Press, Glencoe, 1957).
17. Aristotle, Physics Bk2, §2.
18. Aristotle, cited in On man in the universe (W. Black, NY, 1943) P. xiii.
19. Aristotle, Parts of animals Bkl, 1. There exists at least one example of how these unusual metaphysical ideas, so different from those of modern scientists, could be effective in making predictions. The Alexandrian, Hero (c. 50) was able to deduce the law of optical reflection from the Aristotelian `axiom' that everything strives towards an optimal, perfect end. He interpreted this to mean that light rays should always traverse the shortest path available to them-this was the first use of a variational principle. See § 3.4 for further discussions of Hero's work.
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final causation. This is rather similar to modern approaches to `design'. The Anthropic Principle picks on a large number of remarkable coincidences of Nature for examination but does not aim to use teleological reasoning to explain specific local phenomena.
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38. ibid., BkII, prose vii.
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47. Raymonde, 'Theologia naturalis sive Tiber creaturarum', see C. C. J. Webb, Studies in the history of natural theology (Cambridge University Press, Cambridge, 1915).
48. N. Copernicus, On the revolution of the heavenly spheres, transl. C. G. Wallis, ed. R. M. Hutchins (Encyclopaedia Britannica, London, 1952). See also The nature of scientific discovery: Copernicus symposium, ed. O. Gingerich (Smithsonian, Washington, 1975).
49. ibid., Bk1, Chapter 6.
50. G. Galileo, Dialogue on the Great World Systems (U. Chicago Press, 1953), first publ. 1661.
Si. P. Janet, Final causes, transl. W. Affleck (Clark, Edinburgh, 1878).
52. The quote is taken from p. 154.
53. For an interesting biography of Kepler by a strong admirer of his work see, A. Koestler, The sleepwalkers (Grosset & Dunlap, NY, 1970). The section
on Kepler in this work was previously published as The watershed: a biography of Johannes Kepler (Doubleday, NY, 1960).
54. M. Montaigne, Essays, ii, xii, transl. E. J. Trechmann (Oxford University Press, London, 1927).
55. ibid., ii, xii.

56. The earliest revival of 'atomism' may be N. Hill, Philosophia epicurea (Paris, 1601), who tried to make it theologically respectable by maintaining that the atoms and their motions were initiated by God, see G. McColly, Ann. Sci. 4, 390 (1949). The more familiar atomic revivalist is P. Gassendi, Observations on the tenth book of Diogenes Laertius (Lyon, 1649) and it appears he also took the view that a Deity must make the atoms.
57. F. Bacon, De augmentis scientiarum BkI11, Chapter 5 (1623), and The philosophical works of Francis Bacon, ed. J. M. Robertson (Routledge, London, 1905).
58. ibid., p. 96-7.
59. W. Harvey, Anatomical exercises in the generation of animals (London, 1653), exercise 11.
60. R. Boyle, A disquisition about the final causes of natural things (London, 1688), p. 157.
61. W. Harvey, The motion of the heart and blood. Chapter 8, in Great books of the Western World', ed. R. M. Hutchins (Encyclopaedia Britannica, London, 1952), Vol. 28.
62. The foundation of modern anatomical study began with Vesalius', De humani corporis fabrica (1543, Basilaae; reprint by Culture et Civilization, Brussels, 1964) which contained the results of a large number of dissections and which corrected many accepted dogmas of Galen. It was also the first printed book to contain diagrams. Formerly these were absent from medical treatises, and illustrations were simply reproductions of classical anatomical configurations.
63. R. Descartes, Principles of philosophy, III, 3; The philosophical works of Descartes, ed. and transl. E. S. Haldane and G. R. T. Ross, 2 vols (Cambridge University Press, Cambridge, 1911-12).
64. R. Descartes, Le monde, ed. V. Cousin (F. Levrault, Paris, 1824-6), Chapter
6, p. 249.
65. R. Descartes, Principles of philosophy III, 2, O. cit.
66. ibid., III, 4.
67. The design argument from a mechanical world model was seen also in Cicero and in many early Stoic writings.
68. R. Boyle, from The Christian virtuoso, cited in Anglicanism: the thought and practice of the Church of England, illustrated from the religious literature of the seventeenth century, ed. P. E. More and F. L. Cross (SPCK, London, 1935), p. 235.
69. R. Boyle, A disquisition about the final causes of natural things (London, 1688), p. 522.
70. R. Boulton (ed.) The theological works of the Honourable Robert Boyle (London, 1715), II, p. 235.
71. ibid., II, pp. 211-12.
72. ibid., II, pp. 221, 251. R. Boyle, ref. 69, p. 528.
72. R. Boyle, Letter on final causes, a reply to Descartes cited in Janet, ref. 51, p. 481.
73. P. Gassendi, Objections to the 4th meditation, Vol. II (Amsterdam, 1642), p. 179.
74. R. Boyle, ref. 69, p. 520.
75. J. Webster, Academiarum examen (London, 1654), p. 15.
76. J. Ray, The wisdom of God manifested in the works of creation (London, 1691). This work went through twenty editions between 1691 and 1846.
77. J. Ray, cited in L. E. Hicks, A critique of Design Arguments (Scribner, NY, 1883).
78. R. Cudworth, The intellectual system of the universe, with notes and dissertations of J. L. Moshiem (Thomas Tegg, London, 1845). For further discussion of `Plastic Nature' and Ray's interpretation of it see C. E. Raven, John Ray: naturalist: his life and works (Cambridge University Press, Cambridge, 1950) and C. E. Raven, Organic design: a study of scientific thought from Ray to Paley, 7th Dr. Williams' Library Lecture (Oxford University Press, Oxford, 1953).
79. B. Spinoza, Ethics (see The chief works of Benedict de Spinoza, transl. R. H. Elves, 2 vols, Bohn's Philosophical Library, repr. Dover, NY, 1951), appendix to Part I. The argument of Spinoza against the Design Argument is exactly the same as Cicero's for it-that men from underground would with `stupid amazement' ascribe the regularities of Nature to a Deity.
80. B. Spinoza, ibid.
81. B. Spinoza, ibid.
82. B. Spinoza, ibid.

83. I. Newton, The reasonableness and certainty of the Christian religion (London, 1700) BkII, 18. Elsewhere it appears that, although extremely pious, Newton preferred to allow others to make use of his ideas in support of the Design Argument rather than defend it himself directly. His views here were those of the Protestant orthodoxy of his day. The philosophical influence of his discovery of the universal law of gravity and the first constant of Nature can be seen in William Whiston's work Astronomical principles of religion (London, 1717) which was dedicated to Newton. On p. 131 he writes, `The Universe appears thereby to be evidently One Universe; governed by One Law of Gravity through the whole; and observing the same laws of motion everywhere so that this Unity of God is now for ever established by that more certain knowledge we have of the Universe'.
84. I. Newton, Opticks, 4th edn (London, 1730), query 28.
85. R. Bentley, A confutation of atheism from the Origin and frame of the world (London, 1693).
86. The Newton-Bentley letters are reprinted in I. B. Cohen, Isaac Newton's papers and letters on natural philosophy and related documents (Harvard University Press, Cambridge, Mass., 1958).
87. D. Gregory, cited in H. Guerlac and M. C. Jacob, J. Hut. Ideas 30, 307 (1969).
88. C. MacClaurin, An account of Sir Isaac Newton's philosophical discoveries (London, 1748), p. 405, see also p. 400.
91. G. Leibniz, in The philosophic works of Leibniz, ed. G. M. Duncan (London,
1890). On p. 101 he writes, 'the present state exists because it follows from the nature of God that he should prefer the most perfect'.
92. ibid., p. 36; this was a letter to Boyle.
93. G. Leibniz, in letter to de Voider; C. I. Gerhardt, Die philosophischen Schriften von G. W. Leibniz (Georg. Olms, Berlin, 1960), Vol. 2, p. 193.
94. Parts of the present Universe which have apparently never been in causal contact during its entire past history exhibit the same large-scale density and temperature to within one part in ten thousand, see J. D. Barrow and J. Silk, Scient. Am. (April 1979). The reason for this synchronization is a key problem of modern cosmology, see J. D. Barrow and M. S. Turner, Nature 292, 35 (1981).
95. G. Leibniz, Refutations of Spinoza in ref. 91, p. 176.
96. Second letter to Clarke, ref. 91, pp. 241-2.
97. N. Grew, Cosmologia sacra (London, 1701).
98. J. B. Moliere, Dom Juan, ou, Le festin de Pierre, Act 3, scene 1 (1665), cited in P. Janet, Final causes, see ref. 51, p. 291; a modern edition is ed. W. Howarth (Blackwell, Oxford, 1958).
99. Voltaire, 'Atheist atheism', Philosophical dictionary (1769), transl. and ed. P. Gay, 2 vols (Basic Books, NY, 1955).
100. Article on 'Causes finales' in ref. 99, 1, 271.
101. Voltaire, Candide (Washington Square Press, NY. 1962).
102. J.'D'Alembert, Traite de dynamique: discours preliminaire (1742), transl. Y. Elkane. The particular errors of Descartes he is referring to were his rules of collision, that (1) if two bodies have equal mass and velocity before collision then after any collision they will have the same speeds as before, and (2) if two bodies have different mass then the lighter body is reflected and its velocity becomes equal to that of the larger one. Leibniz showed that these rules contradict the requirement of continuity on approach to the situation where the two masses are equal. This inconsistency was first pointed out by Leibniz in 1692 although it was not published until 1844.
103. P. L. M. Maupertuis, 'Essai de cosmologie' (1751) in Oeuvres, Vol. 4, p. 3 (1768), (Lyon).
104. ibid.
105. ibid.
106. ibid.
107. W. Derham, Physico-Theology (London, 1714).
108. W. Derham, Astro-theology (London, 1795). The titles of both Derham's books have a familiar ring to them. During the eighteenth century countless such works of natural theology were written. The naturalist Lesser wrote a sequence of books entitled Helio-theologie (1744), Testaceo-theologie (1757), 'Insecto-theologie' (1757), whilst Fabricius authored a Theologie de l'eau (1741).

109. G. de Buffon, 'History of animals', (in Natural history, transl. H. D. Symonds, London, 1797), Chapter 1. Buffon also doubted that it could be argued that the entire collection of celestial bodies and motions could be conceived as contrived for the service of humans.
110. For a discussion of his work see I. Berlin, Vico and Herder: two studies in the history of ideas (Hogarth Press, London, 1976).
111. G. Vico, cited in On the study methods of our time (The Library of Liberal Arts, Bobbs-Merrill, NY, 1965).
112. The other categories were 'Conscienze'-the behavioural and everyday information common to all men-then intuition regarding ultimate things, and finally, human psychology.
113. D. Hume, Dialogues concerning natural religion, ed. N. Kemp Smith (Bobbs Merrill, Indiana, 1977). First published in 1779, probably in Edinburgh, but this is not certain. See J. V. Price, Papers Bibliog. Soc. Am. 68, 119 (1974).
114. For some discussion of the relation between Newton's influence and Hume's writings see R. H. Hurlbrutt III, Hume, Newton and the Design Argument (University of Nebraska Press, Lincoln, 1965).
115. Hume, op. cit., Part II.
116. ibid., Part II.
117. ibid., Part VIII.
118. ibid., Part VIII.
119. D. Hume, An enquiry concerning human understanding (London, 1748), § 11. Hume would probably have appeared a 'crank' to the Newtonian because of these outmoded vitalist views.
120. He also draws attention to the fallacy of composition which is latent in the classical argument that if everything in the Universe has a cause then so must the Universe. For example, although every member of a club has a mother it certainly does not follow that every club has a mother! The original argument is based upon a simple confusion between different logical classes. See section 2.9 for further discussion.
121. Ref. 113.
122. Boswell recalls that Johnson once left the room when Hume entered, see J. Boswell, The life of Samuel Johnson (Oxford University Press, London 1953). Johnson was, of course, an ardent admirer of Newton and his work.
123. For example, as any applied mathematician knows, an infinitesimal perturbation (cause) can often have an arbitrarily large effect when a system is unstable. For a discussion of the logical status of the Design Argument following Hume's work see R. G. Swinburne, Philosophy 43, 164 (1968).
124. E. Darwin, Zoonomia, or the laws of organic life, 2 vols (London, 1794). A discussion of his evolutionary ideas can be found in E. Krause, Erasmus Darwin (transl. W. S. Dallas, NY 1880).
125. I. Kant, Der einzig mogliche Beweisgrund zu einer Demonstration des Daseyns Gottes (Konigsberg, J. J. Kanter, 1763) in Werke (Suhrkamp edn, Frankfurt, 1960), Vol. 1, p. 734. No full translation appears to exist. The translation we give is due to Hicks (ref. 79, p. 210) but it is wrongly attributed and referenced by him.
126. I. Kant, Kritik der reinen Vernunft (Riga, 2nd edn, 1787), Critique of pure reason, ed. N. Kemp Smith (Macmillan, London, 1968), p. 521.
127. ibid.
128. ibid.
129. I. Kant, Kritik der Urteilskraft (Berlin and Leibau, 1790), transl. J. C. Meredith, The critique of judgement, ed. R. M. Hutchins (Encyclopaedia Britannica Inc., Chicago, London, Toronto, 1952), § 85.
130. ibid.
131. W. Paley, Natural theology (1802) in The works of William Paley, 7 vols, ed. R. Lynam (London, 1825). Natural theology was so successful that an expanded edition containing notes and further illustrations was published in 1836; Paley's natural theology with illustrative notes, 2 vols, ed. H. Brougham and C. Bell (London, 1836). Paley began work on Natural theology in the 1770's when he

delivered a series of sermons entitled The being of God demonstrated in the works of creation, Works, Vol. 7, pp. 405-44.
132. For example, Paul Janet in ref. 51.
133. Cited in Hicks, ref. 79, p. 232.
134. There has been considerable debate as to the source of Paley's watch story. It is probable that its source was in B. Nieuwentyt's, Religious philosopher, (Vols 1-3), transl. J. Chamberlayne (London, 1719), where it appears in Vol. 1, p. xlvi; however, S. Leslie (History of English thought in the eighteenth century (ed. Harbinger, 1962), first publ. 1876, p. 347) thinks he abstracted it from Abraham Tucker (apparently Paley's favourite author), Light of Nature pursued (London, 1768-1778), 7 vols; i, 523, ii, 83. To confuse things further, Henry Brougham, Discourse of Nature theology, (London, 1835) says Paley's work is chiefly taken from the writings of Derham! Remarkably, Encyclopaedia Britannica articles on 'Nieuwentyt' in the nineteenth century claim that Paley 'appropriated' Nieuwentyt's ideas and arrangement `without anything like honourable acknowledgement'.
135. Natural theology, p. 8-9.
136. ibid., p. 40-5.
137. ibid., p. 30.
138. ibid., p. 60.
139. J. Clive, Scotch reviewers: The Edinburgh review (1802-15) (Faber & Faber, London, 1957), p. 149; cited in D. L. LeMahieu, The mind of William Paley: a philosopher and his age (University of Nebraska Press, Lincoln and London, 1976), p. 74. This book contains further interesting biographical information, as does M. L. Clarke, Paley: evidences for the man (SPCK, London, 1974).
140. Paley, op. cit., p. 152.
141. Ref. 131, Works, Vol. 1, p. 320.
142. Natural theology, p. 52.
143. ibid., p. 58.
144. ibid., p. 317. Today we would say that the fine structure constant, which gives the strength of interactions between matter and light, must be small.
145. Brinkley was probably responsible for almost all the material in Chapter 22 of Natural theology. Like Paley he had been a Senior Wrangler at Cambridge. He became professor at Dublin in 1792 and met Paley shortly afterwards through their mutual friend John Law.
146. Natural theology, p. 318-9. ibid., p. 319.
146. ibid., p. 323. This idea seems to have originated with Buffon and Newton who estimated the age of the Earth using a law of cooling for a metal ball initially at red heat. Paley quotes Buffon's work on p. 339.
147. ibid., p. 332.
148. ibid., p. 333. The other case he mentions, with attraction varying as distance, corresponds to allowing a cosmological constant term in Newtonian gravity.
149. ibid., p. 334-5.
150. ibid., p. 341.
151. see C. C. Gillespie, Genesis and geology (Harper, NY, 1951).
152. The original titles allocated and written under were: T. Chalmers, On the power, wisdom and goodness of God as manifested in the adaption of external nature to the moral and intellectual constitution of Man, 2 vols (London, 1833), eight editions by 1884; J. Kidd, On the adaption of external Nature to the physical condition of Man (London, 1833), seven editions by 1887; W. Whewell, Astronomy and general physics, considered with reference to natural theology (London, 1833), nine editions by 1864; C. Bell, The hand, its mechanism and vital endowments, as evincing design (London, 1833), seven editions by 1865; P. M. Roget, Animal and vegetable physiology, considered with reference to natural theology, 2 vols (London, 1834), five editions by 1870; W. E. Buckland, Geology and mineralogy, considered with reference to natural theology, 2 vols (London, 1836), nine editions by 1860; W. Kirby, On the power, wisdom and goodness of God as manifested in the creation of animals, and in their history, habits and instincts (London, 1835), six editions by

1853; W. Prout, Chemistry, meteorology and the function of digestion (London, 1834), four editions by 1855. The unusual independent addition was that of C. Babbage, The 9th Bridgewater treatise; a fragment, 2nd edn (London, 1838).
153. C. C. Gillespie, ref. 153.
154. J. W. Eckermann, Conversations of Goethe with Eckermann and Soret, transl. K. Oxenford (Bell, London, 1892), Vol. 2, p. 282. See also C. S. Sherrington, Goethe on Nature and on science (Cambridge University Press, Cambridge, 1949).
155. Darwin met Whewell, Sedgewick, and Babbage at Christ's College, Cambridge. All were strong supporters of the Design Argument.
156. C. Darwin, The autobiography of Charles Darwin, ed. N. Barlow (Dover, NY, 1958 [first published 1898]), p. 19.
157. ibid.
158. F. Darwin, The life and letters of Charles Darwin, 3 vols (Appleton, NY, 1897) Vol. 1, p. 282.
159. J. C. Greene, The death of Adam (Iowa State University Press, NY, 1961); J. R. Moore, The post-Darwinian controversies (Cambridge University Press, Cambridge, 1979).
160. C. Hodge, What is Darwinism? (Princeton, NY, 1874), p. 52.
161. W. Graham, The creed of science (London, 1881), p. 319.
162. It would be nice to attribute the discovery of natural selection to this impetus from the Design Argument, but it would not be correct; Darwin
attributed his inspiration to reading T. Malthus, An essay on the principle of population (London, 1798), although his writings show the idea of natural selection was clear to him before he read Malthus; see S. Smith, Adv. Sci. 16, 391 (1960), and R. M. Young, Past & Present 43, 109 (1969).
165. C. R. Darwin, The origin of species (Murray, London, 1859).
166. A. Gray, Darwinian (Appleton, NY, 1876).
167. C. Darwin, Autobiography and selected letters, ed. F. Darwin (Dover, NY, 1958), p. 308.
168. J. Fiske, Outlines of cosmic philosophy (Mifflin, Boston, 1874).
169. J. Fiske, Through Nature to God (Mifflin, Boston, 1899).
170. T. H. Huxley, Lay sermons, addresses and reviews (Appleton, NY, 1871), p. 301. Huxley was commenting on Kolliker's claim that 'Darwin is, in the fullest sense of the word, a teleologist'.
171. T. H. Huxley, Critiques and addresses (Macmillan, London, 1873), p. 305.
172. T. H. Huxley, 'On the reception of the Origin of Species' in Life and letters of Charles Darwin, ref. 160, Vol. 2, p. 179.
173. T. H. Huxley, 'The progress of science', in Method and results (Macmillan, London, 1894), p. 103-4.
174. Lord Kelvin, cited by A. Ellegard in Darwin and the general reader (Goteborg, 1958), p. 562.
175. C. Maxwell, Address of the British Association (1873) in Scientific papers (Cambridge University Press, Cambridge, 1890), Vol. 2, p. 376.
176. L. J. Henderson, The fitness of the environment (Harvard University Press, Mass., 1913) discusses the fitness of various chemical elements for incorporation of living systems. In a later work, The order of Nature (Harvard University Press, Mass., 1917), he discusses the philosophical background to the apparent teleology of chemistry, but study of his unpublished papers shows that his interpretation of chemical `fitness' changed in later life; see Chap. 3, ref. 339.
177. J. P. Cooke, Religion and chemistry (Scriven, NY, 1880), rev. edn. We were unable to locate a copy of the first edition anywhere in the United Kingdom.
178. ibid., p. 161. Cooke's analysis of water provided the basis of several other American publications supporting the Design Argument; P. A. Chadbourne, Lectures on natural theology (Putnam, NY, 1870) has detailed discussion of the advantageous properties of carbon, nitrogen, oxygen and carbonic acid, whilst the later M. Valentine, Natural theology; or rational theism (Griggs, NY, 1885) summarizes Cooke's ideas about chemistry and also has extensive discussion of Darwinian evolution as a system of final causes.
179. Ref. 51, p. 3.
180. ibid., p. 415.

181. ibid., p. 59.
182. ibid., p. 148-9.
183. Only recently has the connection between chaos and determinism been carefully considered by physicists. Behaviour that appears random to us-for example, fluid turbulence-is described by mathematical models that exhibit a very sensitive dependence on initial conditions. These mathematical models are deterministic in principle but not in "practice: in order to
know the state of the system precisely at any future time one must know its initial state exactly. In practice, there always exists some minute error in our knowledge of the initial state, and this error is amplified exponentially in the evolution time of the system, so that very soon we have no idea where the state of the system resides. Laplacian determinism is impossible; see Chapter 3 for further discussion of the meaning of determinism. It is interesting to note that, as early as 1873, Maxwell urged natural philosophers to study 'the singularities and instabilities, rather than the continuities of things.. . [which]. . . may tend to remove that prejudice in favour of determinism which seems to arise from assuming that the physical science of the future is a mere magnified image of the past.' [We are grateful to M. Berry for drawing our attention to this passage]. Maxwell's remarks are unusual, given the prevailing fascination of Victorians for the clockwork predictability of the world legislated by the Newtonian mechanical description.
184. ibid., p. 202.
185. ibid., p. 323-4.
186. ibid., p. 424.
187. ibid., p. 495, from Bernadin de St. Pierre, Etudes de la Nature-Bernadin also makes a memorable statement of what we might call 'natural antiselection'-'wherever fleas are, they jump on white colours. This instinct has been given them, that we may more easily catch them'.
188. T. Lenoir, The strategy of life: teleology and mechanics in nineteenth century biology (Reidel, Dordrecht, 1982).
189. J. D. McFarland, Kant's concept of teleology (University of Edinburgh Press, Edinburgh, 1970), pp. 69-139.
190. M. Polanyi, Science 113, 1308 (1968).
191. M. Polanyi, The tacit dimension (Doubleday, NY, 1966).
192. H. Lotze, 'Lebenskraft', in Handworterbuch der Physiologie, Vol. 1, ed. Rudolph Wagner (Gottingen, 1842).
193. This English translation of Lotze's remarks taken from ref. 188, 170-1.
194. S. J. Gould, Natural History 92 (1983), 34-8.
195. M. Eliade, From primitives to Zen: a thematic source book of the history of religions (Harper & Row, NY, 1967), p. 94.
196. ibid., pp. 131-2.
197. ibid., p. 135.
198. D. Blanchard, unpublished notes, reported by Sol Tax, in Free Inquiry 2 (1982), No. 3, 45.
199. M. Eliade, A history of religious ideas, Vol. 1 (University of Chicago Press, Chicago, 1978), pp. 59-60.
200. M. Eliade, ref. 199, p. 90.
201. S.-H. Nasr, An introduction to Islamic cosmological doctrines (Shambhala, Boulder, 1978), p. 150.
202. Al-Birnni, Alberni India, quoted in ref. 201, p. 123.
203. Al-BirUni, Kitab al-jamahir, quoted in ref. 201, p. 123.
204. J. Needham, Science and civilization in China, Vol. 2 (Cambridge University Press, Cambridge, 1956).
205. M. Eliade, Gods, goddesses, and myths of creation (Harper & Row, NY, 1974), p. 92.
206. Ref. 204, pp. 55-6.
207. Ref. 204, p. 36.
208. Ref. 204, p. 453.

209. Chu Hsi, Chu Tzu Chhüan Shu (Collected works of Chu Hsi), Chapter 43, quoted in ref. 204, p. 489.
210. Liu Tsung-Yuan, quoted in ref. 204, p. 577.
211. Lao Tzu, Tao Ti Ching, Chapter 34, quoted in ref. 204, p. 37.
212. Confucius, Lun Yü (Analects), XII, 17, quoted in ref. 204, p. 10.
213. Confucius, Lun Ye (Analects), XII, 19, quoted in ref. 204, p. 10.
214. Ref. 204, Chapter 18.
215. N. Barry, `The tradition of spontaneous order', Literature of Liberiy 5, (1982) No. 2, pp. 7-58.
216. F. A. Hayek, The constitution of liberty (University of Chicago Press, Chicago, 1960); Individualism and economic order (University of Chicago Press, Chicago, 1948); Studies in philosophy, politics, and economics (Rout-ledge & Kegan Paul, London, 1967); New studies in philosophy, economics, and the history of ideas (Routledge & Kegan Paul, London, 1978); The counter-revolution of science (Liberty Press, Indianapolis, 1979); The road to serfdom (University of Chicago Press, Chicago, 1944).
217. F. A. Hayek, Law, legislation, and liberty, Vol. 1: Rules and order (University of Chicago Press, Chicago, 1973), p. 37.
218. Ref. 217, p. 49.
219. Ref. 217, p. 37.
220. R. Axelrod, The evolution of cooperation (Basic Books, NY, 1984).
221. R. Axelrod, Am. Political Sci. Rev. 75, 306 (1981).
222. R. Axelrod and W. Hamilton, Science 211, 1390 (1981).
223. J. Maynard Smith, J. Theor. Biol. 47, 209 (1974).
224. J. Maynard Smith, Evolution and the theory of games (Cambridge University Press, Cambridge, 1982).
225. R. Dawkins, The selfish gene (Oxford University Press, Oxford, 1976).
226. F. C. Copleston and B. Russell, 'Debate on the existence of God', repr. in The existence of God, ed. J. Hick (Macmillan, NY, 1964).
227. W. L. Rowe, The cosmological argument (Princeton University Press, Princeton, 1975).
228. W. L. Craig, The cosmological argument from Plato to Leibniz (Macmillan, NY, 1980).
229. R. Swinburne, The existence of God (Oxford University Press, Oxford, 1979).
230. W. I. Matson, The existence of God (Cornell University Press, Ithaca, 1965).
231. A. Flew, God and philosophy (Harcourt Brace & World, NY, 1966).
232. G. H. Smith, Atheism: the case against God (Prometheus, Buffalo, 1979).
233. Not every theologian agrees with Flew; see, for example, the discussion in ref. 227.
234. D. Hume, ref. 113, part IX. J. Hartle and S. W. Hawking, Phys. Rev. D 28, 2960 (1983).
235. S. W. Hawking, in Les Houches lectures 1983, ed. C. DeWitt (Addison-Wesley, NY, 1984).
236. L. Landau and E. Lifshitz, Quantum mechanics: non-relativistic theory, 2nd edn (Pergamon Press, London, 1965), p. 60.
237. R. Courant and D. Hilbert, Methods of mathematical physics, Vol. 1 (Interscience, NY, 1953), pp. 451-64.
238. J. Hick, Arguments for the existence of God (Macmillan, London, 1970).
239. P. Tillich, Systematic theology, Vol. 1 (University of Chicago Press, Chicago, 1967), p. 236; quoted in ref. 232, p. 33.
240. Ref. 226, p. 175.
241. Antony Flew used this definition of `existence' to great effect against theism in his classic paper `Theology and falsification', repr. in John Hick's The existence of God, ref. 226. It has also been reprinted in A. Flew and A. MacIntyre, New essays in philosophical theology (Macmillan, NY, 1964), together with commentary by theologians.
242. C. Hartshorne, A natural theology for our time (Open Court, La Salle, 1967), pp. 50, 83. Professor Hartshorne disagrees with our interpretation of his work (private communication to FJT). However, his objections seem to be due to the meaning he gives to the word `Universe', which differs from ours. By `Universe' he means `a particular collection of laws and particles', whereas we

mean 'all collections of laws and particles which ever did, does, or ever will exist'; see also ref. 245 below.
243. As the epigrams to this section suggest, the literature on the logical necessity (or lack of it) of the Universe is immense. Any philosopher worthy of the name discusses it. For recent guides to the literature on the question, the interested reader might consult M. K. Munitz, The mystery of existence: an essay in philosophical cosmology (Appleton-Century-Crofts, NY, 1965); Anna-Teresa Tymieniecka, Why is there something rather than nothing? (Van Gorcum, Amsterdam, 1966); and M. Gardner, Scient. Am. 232 (No. 2, Feb.), 98 (1975). The interested reader is advised to avoid R. Nozick, Philosophical investigations (Harvard University Press, Harvard, 1981).
Some philosophers are fond of arguing that nothing naturally engenders something. For a method of generating the entire real number system from the empty set, see J. H. Conway, On numbers and games (Academic Press, NY, 1976).
245. If the Universe is defined to be the totality of everything that exists, then every believer in God-however one defines God-is a pantheist by definition. The traditional distinctions between theism, deism, pantheism, etc. can be made only if it is possible to distinguish between God and the physical Universe. Most modern, philosophically minded theologians would contend that such a distinction can be made, but that the physical universe is actually a proper subset of God: the physical universe is in God, but God is more than the physical universe. This position was termed panentheism (literally, all-in-God) by the eighteenth-century German philosopher K. C. F. Krause. The philosopher R. C. Whittemore has pointed out (in an unpublished manuscript, The universal as spirit') that most of the philosophers traditionally regarded as pantheists (that is, it has been thought that these men identified God with the physical universe) were actually panentheists. For example, Spinoza asserted in a letter that 'I assert that all things live and move in God ... However, those who think that the Tractatus TheologicoPoliticus rests on this, namely, that God and Nature (by which they mean a certain mass, or corporeal matter) are one and the same, are entirely mistaken' (p. 343 of The correspondence of Spinoza (Letter LXIII), transl. and ed. A. Wolf (Dial Press, NY, 1955). Panentheism is distinguished from theism by saying that the latter contends that God is wholly other than the world. A problem with this distinction is that it is difficult to find a 'theistic' philosopher or theologian who really believes in theism in this sense of the word. For example, mystical Judaism is perhaps best described as panentheistic (G. G. Scholem, Major trends in Jewish mysticism (Thames & Hudson, London, 1955); H. Weiner, Nine and one-half mystics: the Kabbala today (Macmillan, NY, 1969)). Traditional Christianity also claims that not only is God everywhere in the physical universe, but—following St. Paul (Acts 17:27-8)—that everything is also 'in' Him.
The philosophical difficulty which panentheism must overcome is showing that it makes sense to talk about something which is outside (or 'transcendent to') the physical universe. One approach is to say that the organization (= information content) of the universe is distinguishable from and transcendent to the substance of which it is composed. This approach has been defended by Charles Hartshorne, whose work we discuss in Chapter 3. See also his book Omnipotence and other theological mistakes (State University of New York Press, Albany, 1984). The Omega Point theory which we shall develop in Chapter 10 might be considered another approach to panentheism. According to J. Barr, Biblical words for time (SCM Press, London, 1962), pp. 80 and 145, the philology of the Biblical texts does not allow any distinction to be drawn between the ideas of God being eternal in time or eternal in the sense that he is beyond time.
246. A. J. Arberry, The Koran Interpreted (Allen & Unwin, London, 1955), pp. 32-3. According to H. E. Kassis, in A Concordance of the Qur'an (Univ. of California Press, Berkeley, 1983), this English translation of the Qur'an is the best to date. Arberry preferred to call his work an 'interpretation' rather than a 'translation' because of the impossibility of conveying the music of the Arabic Qur'an into English. Our ayah references are those of the Cairo edition of the Arabic Qur'an. It is this edition which has become the standard in the Muslim world.

1150
Peter Lombard, French Bishop & Scholastic Theologean
On The Cognition Of The Creator Through The Creatures, In Which The Vestige Of The Trinity Appears
The Four Books of Sentences - Sententiarum Quatuor Libri

The First Book Of The Sentences On The Unity And Trinity Of God - Liber Primus Sententiarum. De Dei Unitate Et Trinitate

Distinction 3 - Distinctio III.

Latin text taken from Opera Omnia S. Bonaventurae, Ad Claras Aquas, 1882, Vol. 1, pp. 62-66. Notes by the Quaracchi Editors.

Part 1 Chapter 1
On the cognition of the Creator through the creatures, in which the vestige of the Trinity appears - De cognitione Creatoris per creaturas in quibus Trinitatis vestigium apparet.

For the Apostle also says,1 that the invisible (things) of God by the creature of the world through those things which have been made, being understood, are perceived [conspiciuntur] (as are) also His sempiternal virtue and Divinity. By the creature of the world there is understood man « on account of the excellence, by which he excels among the other creatures, and/or on account of the encounter [convenientiam], which he has with every creature ». Therefore man could by the understanding of (his) mind perceive the invisible things of God and/or did also perceive (them) through those things which have been made, that is, through creatures visible and/or2 invisible. For from the two he is helped, that is from nature, which was rational, and from the works wrought [facit] by God, to manifest truth to man. For that reason the Apostle said:3 that God revealed to them, that is while He wrought the works, in which the evidence of the Craftsman [aritificis] glittered to some extent.

Apostolus namque ait,1 quod invisibilia Dei a creatura mundi per ea quae facta sunt intellecta conspiciuntur [conspiciuntur], sempiterna quoque virtus eius et divinitas. Per creaturam mundi intelligitur homo « propter excellentiam, qua excellit inter alias creaturas, vel propter convenientiam, quam habet cum omni creatura ». Homo ergo invisibilia Dei intellectu mentis conspicere potuit vel etiam conspexit per ea quae facta sunt, id est, per creaturas visibiles vel2 invisibiles. A duobus enim iuvabatur, scilicet a natura, quae rationalis erat, et ab operibus a Deo factis, ut manifestaretur homini veritas. Ideo Apostolus dixit:3 quia Deus revelavit illis, scilicet dum fecit opera, in quibus artificis aliquatenus relucet indicium.

For as (St.) Ambrose says:4 « So that God, who is by nature invisible, might also be able to be known by visible (things), He wrought a work, which manifested the Worker by its own visibility, that the uncertain might be known through the certain, and that He might be believed to be the God of all, He who made this, which by man is impossible to be wrought ». Therefore they could cognize or they did cognize, that beyond every creature is He who made those (things), which none of the creatures has the strength [valet] to do and/or destroy.5 Let the creature, howsoever strong [quaecumque vis], approach and let it make such a heaven and such an earth, and I will say, that it is God. But because no creature has the strength [valet] to make such (things), it is established, that He who made them is above every creature; and through this (line of reasoning) the human mind could cognize, that He is God.

Nam sicut ait Ambrosius:4 « Ut Deus, qui natura invisibilis est, etiam a visibilibus posset sciri, opus fecit, quod opificem visibilitate sui manifestavit, ut per certum incertum posset sciri, et ille Deus

omnium esse crederetur, qui hoc fecit, quod ab homine impossibile est fieri ». Potuerunt ergo cognoscere sive cognoverunt, ultra omnem creaturam esse illum qui ea fecit, quae nulla creaturarum facere vel destruere valet.5 Accedat, quaecumque vis, creatura et faciat tale caelum et talem terram, et dicam, quia Deus est. Sed quia nulla creatura talia facere valet, constat, super omnem creaturam esse illum qui ea fecit; ac per hoc, illum esse Deum, humana mens cognoscere potuit.

They could also in another manner cognize and/or they did also cognize the truth of God under the leading of reason.. For as (St.) Augustine says in the Book On the City of God:6 « The highest philosophers saw that no body is God, and for that reason they transcended all other bodies, seeking God (as they did); they also says, that whatever is mutable is not the Most High God and principle of all (things), and for that reason they transcended every soul and the mutable spirits; then they saw, that everything, which is mutable, cannot be except by Him, who incommutably and simply is. Therefore they understood, that He both had made all these (things) and that He could come to be [fieri] from none (of them) ».

Alio etiam modo Dei veritatem ductu rationis cognoscere potuerunt vel etiam cognoverunt. Ut enim Augustinus ait in Libro de Civitate Dei:6 « Viderunt summi philosophi nullum corpus esse Deum, et ideo cuncta corpora trascenderunt, quaerentes Deum; viderunt etiam, quidquid mutabile est non esse summum Deum omniumque principium, et ideo omnem animam mutabilesque spiritus transcenderunt; deinde viderunt, omne, quod mutabile est, non posse esse nisi ab illo, qui incommutabiliter et simpliciter est. Intellexerunt ergo, eum et omnia ista fecisse et a nullo fieri potuisse ».

« They also considered, that whatever is in substances is a body and/or a spirit, and that any spirit is better than a body, but better by far Him who made spirit and body ».

« Consideraverunt etiam, quidquid est in substantiis vel corpus esse vel spiritum, meliusque aliquid spiritum esse quam corpus, sed longe meliorem qui spiritum fecit et corpus ».

« They also understood, that the appearance [species] of a body is sensible and the appearance of a spirit is intelligible, and they preferred the intelligible appearance to the sensible. We call sensibles, what can [queunt] be sensed by the sight or touch of a body, intelligibles, what (can) be understood by the sight [conspectu] of the mind.7 Therefore since in their sight [conspectu] both the body and the human spirit [animus] were more and less apparent [speciosa]; but if they could lack every appearance, they would be entirely nothings [nulla]: they saw that there is a Something, by which those (things) are made apparent, where there is a first and incommutable Appearance, and for that reason incomparable; and that It is the principle of things they did most rightly believe, because It had not been made, and (because) all other (things) had been made from It ». Behold in so many manners the truth of God could be cognized. Therefore though [cum] God is the one and simple essence, which consists of no diversity of parts and/or of accidents, the Apostle says, however, in the plural: the invisible (things) of God, because the truth of God is cognized in very many manners through those (things) which have been made. For from the perpetuity of creatures the eternal Founder is understood; from the magnitude of creatures the Omnipotent One; from (their) order and disposition the Wise One; from (His) governance (of them) the Good One. Moreover all these (things) tend ultimately [pertinent] to manifest the unity of the Deity.

« Intellexerunt etiam, corporis speciem esse sensibilem et spiritus speciem intelligibilem, et intelligibilem speciem sensibili praetulerunt. Sensibilia dicimus, quae visu tactuque corporis sentiri queunt, intelligibilia, quae conspectu mentis intelligi.7 Cum ergo in eorum conspectu et corpus et animus magis minusque speciosa essent; si autem omni specie carere possent, omnino nulla essent:

viderunt esse aliquid, quo illa speciosa facta sunt, ubi est prima et incommutabilis species, ideoque incomparabilis; et illud esse rerum principium rectissime crediderunt, quod factum non esset, et ex quo cuncta facta essent ». Ecce tot modis potuit cognosci veritas Dei. Cum ergo Deus una sit et simplex essentia, quae ex nulla diversitate partium vel accidentium consistit, pluraliter tamen dicit Apostolus: invisibilia Dei, quia pluribus modis cognoscitur veritas Dei per ea quae facta sunt. Ex perpetuitate namque creaturarum intelligitur Conditor aeternus; ex magnitudine creaturarum omnipotens; ex ordine et dispositione sapiens; ex gubernatione bonus. Haec autem omnia ad unitatem Deitatis pertinent monstrandam.

Now there remains to show, whether through those (things) which have been made anything could be regarded a vestige or scanty [exiguum]1 evidence of the Trinity. On this (St.) Augustine in the sixth book On the Trinity says: « It is proper, that perceiving the Creator with (our) intellect [intellectu] through the (things) which have been made, we understand the Trinity. For the vestige of this Trinity appears [apparet] in creatures. For all these (things),3 which have been made by the Divine Art, both show a certain unity in themselves and an outward-appearance [species] and an order. For each of these creators is also some one [unum aliquid], as are the natures of bodies and of souls, and (each) is formed by some species [species], as are the figures and/or qualities of bodies and the doctrines and/or arts of souls, and (each) seeks or holds some order, as are the weights and/or positions [collocationes] of bodies and the loves [amores] and/or delectations of souls; and thus does the vestige of the Trinity shine forth in creatures. For in that Trinity there is a Most High Origin of all things [omnium rerum] and a Most Perfect Beauty [pulcritudo] and a Most Blessed Delectation ». « But the Most High Origin », as (St.) Augustine shows in the book On the True Religion,4 « is understood to be God the Father, from whom are all things [omnia], from whom (is) the Son and the Holy Spirit. The Most Perfect Beauty is understood (to be) the Son, that is the Truth of the Father, dissimilar to Him from no vantage point [nulla ex parte], which5 we venerate with and in the Father Himself [cum ipso et in ipso Patre], which is the Form of all, which has been made from the One and are referred to the One, which all, however, would neither have come to be from the Father through the Son nor would have been safe in their confines [suis finibus], unless God was the most highly Good, who both envies no nature, which6 is good from Him, and grants that the one as much as it wants, the other as much as it can, remain in the Good itself; which goodness is understood (to be) the Holy Spirit, who is the Gift of the Father and the Son. Wherefore it is fitting that the very Gift of God, equally incommutable with the Father and the Son, take care of us [colere] and hold us. And thus through a consideration of creatures we understand the Trinity (to be) of one substance, that is one God the Father, from whom we are, and the Son, through whom we are, and the Holy Spirit, in whom we are, that is the Principle, back to which we run, and the Form which we follow, and the Grace by which we are reconciled: that is God, who said:7 Let there be; and the Word, through which there is made everything, which substantially and naturally is; and the Gift of His benignity, who was pleased that what was wrought by Him through the Word and reconciled to the Author, might not perish ». Behold it has been shown, how among creatures to some extent the image of the Trinity is indicated; for through the contemplation of creatures a sufficient knowledge [notitia] of the Trinity cannot be had nor [vel] could it without the revelation of doctrine and/or of interior inspiration. Whence those ancient philosophers as if through a shadow and from afar saw the truth, deficient (as they were) in the contuition of the Trinity, like [ut] the magi of the Pharaoh at the third sign.8 We, however, are helped to believe invisible things [in fide invisibilium] through those (things), which have been made.

Nunc restat ostendere, utrum per ea quae facta sunt aliquod Trinitatis vestigium vel indicium exiguum1 haberi potuerit. De hoc Augustinus in libro sexto de Trinitate ait: « Oportet, ut Creatorem per ea quae facta sunt intellectu conspicientes, Trinitatem intelligamus. Huius enim Trinitatis vestigium in creaturis apparet. Haec enim omnia,3 quae arte divina facta sunt, et unitatem quandam in se ostendunt et speciem et ordinem. Nam quodque horum creatorum et

unum aliquid est, sicut sunt naturae corporum et animarum, et aliqua specie formatur, sicut sunt figurae vel qualitates corporum ac doctrinae vel artes animarum, et ordinem aliquem petit aut tenet, sicut sunt pondera vel collocationes corporum et amores vel delectationes animarum; et ita in creaturis praelucet vestigium Trinitatis. In illa enim Trinitate summa origo est omnium rerum et perfectissima pulcritudo et beatissima delectatio ». « Summa autem origo, ut Augustinus ostendit in libro de Vera Religione,4 intelligitur Deus Pater, a quo sunt omnia, a quo Filius et Spiritus sanctus. Perfectissima pulcritudo intelligitur Filius, scilicet veritas Patris, nulla ex parte ei dissimilis, quam5 cum ipso et in ipso Patre veneramur, quae forma est omnium, quae ab uno facta sunt et ad unum referuntur, quae tamen omnia nec fierent a Patre per Filium neque suis finibus salva essent, nisi Deus summe bonus esset, qui et nulli naturae, quae6 ab illo bona esset, invidit, et ut in bono ipso maneret, alia quantum vellet, alia quantum posset, dedit; quae bonitas intelligitur Spiritus sanctus, qui est donum Patris et Filii. Quare ipsum donum Dei cum Patre et Filio aeque incommutabile colere et tenere nos convenit. Per considerationem itaque creaturarum unius substantiae Trinitatem intelligimus, scilicet unum Deum Patrem, a quo sumus, et Filium, per quem sumus, et Spiritum sanctum, in quo sumus, scilicet principium, ad quod recurrimus, et formam quam sequimur, et gratiam qua reconciliamur: unum scilicet, quo auctore conditi sumus, et similitudinem eius, per quam ad unitatem reformamur, et pacem, qua Unitati adhaeremus: scilicet Deum, qui dixit:7 fiat; et Verbum, per quod factum est omne, quod substantialiter et naturaliter est; et Donum benignitatis eius, qua placuit quod ab eo per Verbum factum est et reconciliatum est auctori, ut non interiret ». Ecce ostensum est, qualiter in creaturis aliquatenus imago Trinitatis indicatur; non enim per creaturarum contemplationem sufficiens notitia Trinitatis potest haberi vel potuit sine doctrinae vel interioris inspirationis revelatione. Unde illi antiqui philosophi quasi per umbram et de longinquo viderunt veritatem, deficientes in contuitu Trinitatis, ut magi Pharaonis in tertio signo.8 Adiuvamur tamen in fide invisibilium per ea, quae facta sunt.

NOTES (ENGLISH)

1 Rm 1:20; the Vulgate reads: For the invisible (things) of him by the creature . . . [Invisibilia enim ipius a creatura]. The Glossa Ordinaria, which Master (Peter), with a few words varied, now uses, interprets the word by the creature [a creatura] thus: By man through excellence, because he excells among the other creatures, and/or on account of the encounter [convenientiam] which he has with all creatures. [Trans. note: It should be noted that the Latins, neglecting to refer to the Greek original of this passage, understood a creatura [apo ktisews] as by the creature rather than the more literal, and intended, from the act of the creating, i.e. from the foundation]. Then the Vulgate has His virtue [eius virtus] in place of the virtue of Him [virtus eius], which our manuscripts and editions exhibit in complete agreement. [Trans. note: Here For ... also (namque) refers to what has just been said in d. 2, ch.5]

2 Codices C D and E have and [et].

3 A reference to Rm 1:19: What is known of God, has been made manifest unto them. For God has manifested it to them [Quod notus est Dei, manifestum est in illis. Deus enim illis manifestavit]. — The Vatican edition together with the other editions has And therefore [ideoque], against all the codices and editions 1 and 8.

4 In the Epistle to the Romans, ch. 1, v. 19, with a few things changed and omitted by Master (Peter). At the end of this text before it is impossible [impossibile est] the Vatican edition alone superfluously repeats: (St.) Ambrose said [ait Ambrosius].

5 Manuscripts B D and E have can [potest]. Then in the Vatican edition alone there is read: the creature, whatever ones you wish [quaecumque vis creaturae], understanding vis as a form of velle and quaecumque as a neuter plural. Immediately after the same the Vatican edition prefaces earth [terram] with such [talem], having left out the other many things, against the codices and editions 1, 6 and 8.

6 Book VIII, ch.6, with not a few things transposed and omitted. Also, below, the third and fourth reason have been taken from there. A little before this only codex D has they could . . . and they did [potuerunt et] in place of they could . . . and they did also [potuerutn vel etiam].

7 The editions against our codices and Augustine's edition, by putting a period before intelligibles, and adding can [possunt] has Intelligibles, which can [Intelligibilia quae . . . possunt].

NOTES (LATIN):
1 Rom. 1, 20; Vulgata: Invisibilia enim ipsius a creatura . . . Glossa ordinaria, qua Magister, paucis variatis, mox utitur, verbum a creatura sic interpretatur: Ab homine per excellentiam, quia excellit inter alias craturas, vel propter convenientiam, quam habet cum omnibus creaturis. Tum Vulgata eius virtus pro virtus eius, quod nostri mss. et edd. summo consensu exhibent.
2 Codd. C D E et.
3 Respicit ad Rom. 1, 19: Quod notus est Dei, manifestum est in illis. Deus enim illis manifestavit. — Vat. cum aliis edd. ideoque contra omnes codd. et edd. 1, 8.
4 In Epist. ad Rom. c. 1, 19, paucis a Magistro mutatis et omissis. In fine huius textus ante impossible est Vat. sola repetit supervacanee: ait Ambrosius.
5 Mss. B D E potest. Tum in Vat. sola: quaecumque vis creaturae; in textu accipe vis a velle et quaecumque ut neutrum in plurali. Subinde eadem Vat. cum plerisque excusis ante terram praetermittit talem contra codd. et edd. 1, 6, 8.
6 Libr. VIII. c. 6, nonnullis transpositis et omissis. Etiam infra tertia et quarta ratio inde sumtae sunt. Paulo ante solus cod. D potuerunt et pro potuerunt vel etiam.
7 Edd. contra codd. nostros et ed. Augustini, ponendo punctum ante intelligibilia, praemittunt hic possunt.

1224
St Francis of Assisi (1181-1226), French Saint and Founder of Monastic Order
The Canticle of the Creatures
Prayer

Original text in Umbrian Italian dialect:

Altissimu, onnipotente bon Signore,
Tue so le laude, la gloria e l'honore et onne benedictione.

Ad Te solo, Altissimo, se konfano,
et nullu homo ène dignu te mentouare.

Laudato sie, mi Signore cum tucte le Tue creature,
spetialmente messor lo frate Sole,
lo qual è iorno, et allumini noi per lui.
Et ellu è bellu e radiante cum grande splendore:
de Te, Altissimo, porta significatione.

Laudato si, mi Signore, per sora Luna e le stelle:
in celu l'ài formate clarite et pretiose et belle.

Laudato si, mi Signore, per frate Uento
et per aere et nubilo et sereno et onne tempo,
per lo quale, a le Tue creature dài sustentamento.

Laudato si, mi Signore, per sor'Acqua,
la quale è multo utile et humile et pretiosa et casta.

Laudato si, mi Signore, per frate Focu,
per lo quale ennallumini la nocte:
ed ello è bello et iucundo et robustoso et forte.

Laudato si, mi Signore, per sora nostra matre Terra,
la quale ne sustenta et gouerna,
et produce diuersi fructi con coloriti fior et herba.

Laudato si, mi Signore, per quelli ke perdonano per lo Tuo amore
et sostengono infirmitate et tribulatione.

Beati quelli ke 'l sosterranno in pace,
ka da Te, Altissimo, sirano incoronati.

Laudato si mi Signore, per sora nostra Morte corporale,
da la quale nullu homo uiuente pò skappare:
guai a quelli ke morrano ne le peccata mortali;
beati quelli ke trouarà ne le Tue sanctissime uoluntati,
ka la morte secunda no 'l farrà male.

Laudate et benedicete mi Signore et rengratiate
e seruiteli cum grande humilitate.

English Translation:

Most High, all-powerful, all-good Lord,
All praise is Yours, all glory, honor and blessings.
To you alone, Most High, do they belong;
no mortal lips are worthy to pronounce Your Name.

We praise You, Lord, for all Your creatures,
especially for Brother Sun,
who is the day through whom You give us light.
And he is beautiful and radiant with great splendor,
of You Most High, he bears your likeness.

We praise You, Lord, for Sister Moon and the stars,
in the heavens you have made them bright, precious and fair.

We praise You, Lord, for Brothers Wind and Air,
fair and stormy, all weather's moods,
by which You cherish all that You have made.

We praise You, Lord, for Sister Water,
so useful, humble, precious and pure.

We praise You, Lord, for Brother Fire,
through whom You light the night.
He is beautiful, playful, robust, and strong.

We praise You, Lord, for Sister Earth,

who sustains us
with her fruits, colored flowers, and herbs.

We praise You, Lord, for those who pardon,
for love of You bear sickness and trial.
Blessed are those who endure in peace,
by You Most High, they will be crowned.

We praise You, Lord, for Sister Death,
from whom no-one living can escape.
Woe to those who die in their sins!
Blessed are those that She finds doing Your Will.
No second death can do them harm.

We praise and bless You, Lord, and give You thanks,
and serve You in all humility.
(In Jesus' Name, Amen.)

1275
St. Thomas Aquinas (1225 – 1274)
Proofs of God's Existence
Summa Theologica

It seems that God does not exist, for if one of two contrary things were infinite, its opposite would be completely destroyed. By "God," however, we mean some infinite good. Therefore, if God existed evil would not. Evil does exist in the world, however. Therefore God does not exist.

Furthermore, one should not needlessly multiply elements in an explanation. It seems that we can account for everything we see in this world on the assumption that God does not exist. All natural effects can be traced to natural causes, and all contrived effects can be traced to human reason and will. Thus there is no need to suppose that God exists.

But on the contrary God says, "I am who I am" (Ex. 3:14).

Response: It must be said that God's existence can be proved in five ways …

The second way is based on the existence of efficient causality. We see in the world around us that there is an order of efficient causes. Nor is it ever found (in fact it is impossible) that something is its own efficient cause. If it were, it would be prior to itself, which is impossible. Nevertheless, the order of efficient causes cannot proceed to infinity, for in any such order the first is cause of the middle (whether one or many) and the middle of the last. Without the cause, the effect does not follow. Thus, if the first cause did not exist, neither would the middle and last causes in the sequence. If, however, there were an infinite regression of efficient causes, there would be no first efficient cause and therefore no middle causes or final effects, which is obviously not the case. Thus it is necessary to posit some first efficient cause, which everyone calls "God."

The fifth way is based on the governance of things. We see that some things lacking cognition, such as natural bodies, work toward an end, as is seen from the fact hat they always (or at least usually) act the same way and not accidentally, but by design. Things without knowledge tend toward a goal, however, only if they are guided in that direction by some knowing, understanding being, as is

the case with an arrow and archer. Therefore, there is some intelligent being by whom all natural things are ordered to their end, and we call this being "God."

To the second, it must be said that, since nature works according to a determined end through the direction of some superior agent, whatever is done by nature must be traced back to God as its first cause. in the same way, those things which are done intentionally must be traced back to a higher cause which is neither reason nor human will, for these can change and cease to exist and, as we have seen, all such things must be traced back to some first principle which is unchangeable and necessary, as has been shown.

1436
Raymond Sebonde, Professeur De Philosophie, de Médecine, et de Théologie A Toulouse
Livre Des Créatures – De l'échelle De Nature Par Laquell l'homme Monte A La Cognoissance De Soi Et De Son Créateur
Traduit en Francais par Michel Montaigne

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Préface de l'Auteur
La louange & gloire de la tres-haute & tres-glorieuse Trinité, de la vierge Marie, & de toute la cour celeste; au nom de nostre Seigneur Jesus Christ, au proffit & salut de tous les Chrétiens, s'en lui propre ensuit la doctrine du livre des Créatures; or livre de Nature, doctrine de l'homme, & a lui propre en tant qu'il est homme; doctrine convenable, naturelle & utile a tout homme; par laquelle, il est illumine a se cognoistre soi-même, son créateur, & presque tout ce, a quoy il est tenu comme homme; doctrine, contenant la reigle de Nature; par laquelle aussi, un chacun est instruit de ce a quoy il est oblige naturellement tant envers Dieu, qu'envers son prochain; & non seulement instruit, mais essieu & poussee a se faire de soi-même par amour & par une allègre volonté. En outre, cette doctrine apprens a toute homme de voir a l'œil sans difficulté & sans peine la verité autant qu'il est possible a la raison naturelle pour la Cognoissance de Dieu & de soi-même, & de ce de quoi il a besoing pour son salut, & pour parvenir a la vie éternelle: lui donne grand accès a l'intelligence de ce qui est prescrit & commande aux Sainctes escritures, & fait ce que l'entendement humain est délivré de plusieurs doubts & consent hardiment a ce qu'elle contiennent concernant la cognoissance de Dieu, ou de soi-même. En ce livre de descouvrent les anciennes erreur des payens & philosophes Infideles. & par sa doctrine se maintient & se cognoist la foi Catholique; toute secte qui loi est contraire est decossement & convainque faulse & mesangiere. Voila pourquoy en cette décadence & fin du monde, il est besoing de tous les Chestians se roidissant, s'arment, & s'asseurent en cette foi la, contre ceux qui la combattent, pour se garder de être séduit; &, s'il en est besoing, mourrir allaigrement pour elle. Davantage, cette doctrine ouvre a un chacun la voye a l'intelligence des Saints Docteurs, voire elle est incorporée en leurs livres (encore qu'elle n'y paroisse point), comme est un Alphabet en tous écrits. Aussi est-ce l'Alphabet des Docteurs; & comme tel il ne faut premierement apprendre. Par quoy pour l'acheminer aux Sainctes escritures to sera bien d'acquerir cette science comme rudimens de toutes sciences, & pour mieux être résolus, apprends la devrant toute autre chose, autrement a grand peine parviendra tu a la perfection des sciences plus hautes; poser ce que c'est ici la racine, l'origine & les peres fondemens de la doctrine appartenante a l'homme poser son salut. Ainsi quiconque a le salut par esperance, doit premieremens avoir en soi la racine de Salut; & se doit par consequens garnir de cest science, qui est une fontaine de verité salutaire. & cette besoin que personne laisse a la lire, ou apprendre par faut d'autre doctrine. Car elle ne presuppose ny la grammaire, ny la logique, ny autre art liberal, ny la physique, ny la megaphysique, attendu qu'elle est la première, et que c'est elle qui range, qui accommode, & qui dresse les autres a une sainte

fin. A la vrai verité, & a notre profit, parce qu'elle instruit a se connaitre soi-même, pour scavoir pourquoi il a este créé, & par qui il a este oblige.

Or a l'homme ignorant de ces choses, que peuvent servir les autres sciences? Ce n'est que vanité; attendu que les hommes n'en usent que mal, & a leur dommage; veut qu'il ne savent ny ou ils vont, ny d'où ils viennent, ny ou ils sont; Par quoy on leur apprend ici a entendre que c'est que la corruption & défaut de l'homme, sa damnation, & d'où elle lui est venue, a cognoistre l'état auquel il est, celui auquel il estoit en son origine, d'où il est cheu, & combien il est eloiné de si première perfection, de quelle façon il se peut reformer, & les choses nécessaires a ce faire. Par ainsi cette doctrine est commune aux laïcs, aux clercs & a toute manière de gens; & se peut comprendre par cœur, ny en avoir des livres; car depuis que elle est concevez, elle ne se peut oublier. Elle rend l'homme contant, humble, gracieux, obéissant, ennemi du vice & du pêche, amoureux de vertu, sans l'enfler pourtant ou l'enorgueillir pour sa suffisance. Elle ne se sert d'arguments obscur, qui ayant besoing de profond & long discours; car elle n'argumente que pare choses apparente & cogneuse a chacun par expérience, comme par les créatures & par la nature de l'homme; par lequel, & par ce qu'il sait de soi, elle prouve ce qu'elle veut; & principalement par cela, qu'un chacun a essaye en lui-même; aussi n'a elle métier d'une témoin que de l'homme. Au reste elle semble de prime face des prsable & de néant, d'autant qu'elle a des commencement vulgaire & fort bas; mais elle ne laisse pas d'apporter un fruit grand & notable, a scavoir la cognoissance de Dieu & de l'home; & d'autant quelle part de plus bas, d'autant plus monte elle & s'esleve aux choses hautes & célestes. Par ainsi qui se voudra ressentir de son fruit, qu'il se exerce premierement aux petits principes de cette science, sans les dédaigner; car autrement il n'en pourra goutter; non plus qu'un enfant n'apprend a lire sans l'intelligence de l'alphabet, & de chaque character a par soi. Et ne plaigne hardiment sa peine; car il se rendra par cette doctrine en pue de mois scavant & verse en pleusiers choses, pour lesquelles scavoir il conviendroit employer long temps a la lecture de pleusiers livres. Elle n'allègue nulle authorite, ny celle même de la Bible, pour ce que son but est de confirmer ce qui est couche aux Sainctes Escritures, & de jetter les fondemens, sur lesquels nous puissons bastir ce que s'ensuit en icelles l'obscurement. Ainsi quant à nous elle va devant le Vieil & Nouveau Testament. Dieu nous a donne deux livres, celui de la Bible. Celui-la nous fut donne premier, & des l'origine du monde; car chaque créature n'est que comme une lettre, tirée par la main de Dieu. De façon que d'une grande multitude de créatures, comme d'un nombre de lettres, ce livre a este compose; dans lequel l'homme se trouve, & en est la Lettre capital & principal. Or tout Ani que les lettres, & les mots faits des lettres sont une science, en comprenant tout plain de sentences & significations différents, tout ainsi les créatures jointes ensemble & accouple l'une a l'autre emportent diverses propositions & divers sens, & contiennent la science, qui nous est nécessaire avant tout autre. Le second livre ses Sainctes Escritures a este depuis donne a l'homme & ce au défauts du premier; auquel (ainsi aveugle comme il estoit) il ne voit rien; si est-ce que le premier est commun a tout le monde, & non pas le second; car il faut être clerc pour le pouvoir lire. En autre, le livre de nature ne se peut ny falsifier, ny effacer, ne faussement interpréter; par ainsi no le peuvent les hérétiques faussement entendre; & nul en celui la ne devient hérétique; la ou il va tout autrement de celui de la Bible. Se est-ce que l'un & l'autre est parti de même Maistre; & Dieu a battis les créatures comme il a révèle ses escritures. Aussi s'accordent ils tres-bien l'un avec l'autre & n'ont garde de s'entre contredire; quoy que le premier symbolise plus avec notre nature, & que le second soit bien loin au dessus d'elle. Puis que l'homme, tout raisonnable & capable de discipline qu'il estoit, ne se trouvait toutefois a sa naissance garni actuellement de nulle science, & que nulle science ne se peut acquerir sans lire, ou elle soit écrite, il estoit plus que raisonnable (afin que cette capacité d'être scavant ne nous fut pour néant donnée) que la divine intelligence nous fournit de quoy pouvoir, sans Maistre d'école, naturellement, & de nous même nous instruire de la doctrine qui nous est seule nécessaire. A cette cause battit elle ce monde visible & nous le donna comme un livre propre, familier & infaillible, écrit de sa main, ou les créatures sont rangées ainsi que lettres non a notre poste, mais par le saint jugement de Dieu, pour nous apprendre la sapience & la science de notre

salut; laquelle toutefois nul ne peut voir de soi, ny lire en ce grand livre (bien que toujours ouvert & présent a nos yeux) sil n'est éclaire de Dieu & purge de sa macule originelle. D'où il est advenu que anciens philosophes payens, que en ont tire toutes leurs autres science & tout leur scavoir, n'y ont pourtant jamais peu apercevoir & découvrir (aveugles en ce que concernait leu souverain bien) la sapience, qui y est enclose, & la vraie & solide doctrine, qui nous guide a la vie éternelle. Or veut que de l'assemblage des créatures, tout ainsi que d'une bien ordonnée couture de paroles l'engendre la vraie intelligence en celui qui a la suffisance de la concevoir, la façon de traiter ce livre est d'assortir & rapporter les créatures l'une a l'autre, considérant leu poix & signification, pour après en avoir tire la divine sapience qu'elles contiennent, la ficher & empreindre bien avant en nos cœur & en notre âme. Or pour ce que la sacro-sainte Elise Romaine est mère de tous les Chrétiens fidèles, mais tresse de grâce, reigle de foi & de verité, je soumets entièrement à sa correction tout ce que est dit & contenu en ce mien ouvrage.

Chapitre 1 – Les Échelles de la Nature

Par l'inclination naturelle des hommes ils sont continuellement en cherche de la verité & de la certitude; & ne se peuvent assouvinir ne contenter qu'ils ne s'en soit approchez jusques au dernier point de le puissance. Or il y a des degrez en la certitude & en la prevue, qui font les une preuves plus forte, les autres plus foibles, quelque certitude plus grande, quelque autre moindre, L'authorite de la prevue & la force de la certitude s'engendre de la force & authorite des témoin & des témoignages, desquels la verité dépend; & de la vient que d'autant que les témoin se trouvent plus veritables, aparrens & indubitables, d'autant y a le plus de certitude en ce qu'ils preuvent. Et s'ils font tells que leurs témoignages par leur évidence ne puissant tomber en nul doute, tout ce qu'ils vérifieront nous sera tres-certain, tres-evident & tres-manifeste. Aussi d'autant que les témoins sont plus estrangers & plus allongé de la chose, de laquelle on toute, d'autant font-ils moins de foi et de créance; & plus ils font voisins, plus ils aportent avec eux de certitude. Mais il n'y a rien plus familier, plus intérieur & plus propre a chacun, que soi-même a foi; il s'ensuit doc, que tout ce qui est vérifie de quelque chose par elle même & par la nature, reste très bien vérifie. Puis qu nulle chose créée n'est plus voisine * l'homme que 'homme même a soi, tout ce qui se prouvera de lui par lui-même, par la nature & par ce qu'il sait certainement, de tout cela demeurera-il tres-aseure & très eclarci. Car en ce point consiste a plus commode certitude, & la plus assurée créance que se puisse faire, ou tirer de la prevue. Voila pourquoi l'homme & sa nature doivent servir de moyen, d'argument & de temoinage, pour prouver toute chose de l'homme, pour prouver tout ce qui concernes son salut, son heur, sone malheur, son mal & on bien; autrement il n'en sera jamais assez certain. Qu'il commence donc se cognoistre soi-même & sa nature, s'il veut vérifier quelque chose de foi. Mais il est hors de foi, esloigne de foi d'une extrême distance, absent de sa maison propre qu'il ne vis oncques, ignorant sa valeur, meconnaissant soi-même, s'échangeant pour chose de néant, pour une courte joie, pour un leger plaisir, pour le pache. S'il se veut donc reconnaitre, son ancien pris, sa nature, sa beauté première, qu'il revienne a soi et rentre chez soi; & pour ce faire, veut qu'il oublie son domicile, il est nécessaire que par le moyen d'autres chose on le ramène & reconduise chez lui. Il lui faut une échelle pour l'aider a se remonter a soi & a se ravoir. Les pas qu'il fera, les échelons qu'il enjambera, ce seront autant de notices qu'il acquerra de sa nature. Toute connaissance se prend par arguments des choses que nous savons premierement & le mieux, a celles qui nous sont inconnues; & par ce qui nous est évidemment notoire, nous montons a l'intelligence de ce que nous ignorons. Aussi nous entendons premierement les chose plus petites & plus basses, & après les plus grandes & les plus enlevées; d'où il advient que l'homme, comme étant la plus excellent et la plus digne chose de ce monde, connaisse toutes autres chose avant qu'il se connaisse soi-même. Or afin qu'ainsi hors de lui, comme il est, & s'ignorant, il puisse être ramène a soi & instruit de la nature, on lui parfait cette belle université des choses, & des créatures, comme une droicte voie & ferme échelle, ayant des marche tres-asseurees, par ou il puisse arrive a son naturel domicile, & se remonter a la vraie cognoissance de sa nature. Pour cest effet tout y est diversifie par un bel ordre de rangs de tres-juste proportions. Les choses y sont, les unes basse, les autres haute, celles-ci parfaites, celles-la

imparfaite; quelques unes y sont extrêmement viles, & quelques autre a d'un prix inestimable, pour accommoder ses pas & pour l'acheminer contrement jusques a foi, de degre en degre a la mode d'une échelle; de laquelle s'il se veut servir, voici comme il lui en convient fer; voici le train qu'il lui faut tenir pour parvenir a sa cognoissance. Premièrement, qu'il considère la valeur de chaque chose en soi; & puis le générale police de cest univers, distribuee en différents dignitez & diverse ranges de créatures. Cela fait, il lui faudra coopérer l'homme, qui en est la plus noble & première partie, à toutes les autres; & les coopérer en double façon. Tantost regardant en qui il convient, Tantost en quoy il diffère d'avec elles. De cette ressemblance, ou dissemblable s'engendrera en lui l'intelligence qu'il cherche de foi, & qui plus est, celle de Dieu son créature immortel; car par la voye des chose inférieure, il s'acheminera jusques a l'homme; & tout d'un fil il enjambera de l'homme jusques a Dieu. Il est impossible d'arriver par ailleurs à cette double cognoissance. Ce sont deux montees & deux traites, à faire; l'une par la chose, qui est au dessoubs de l'homme jusques a lui, & la seconde de lui jusqu'est a son createur. Quant a la première, il y a un grade diversité & distinction de degrés & choses de ce monde; desquels ferme & immobiles comme ils sont, est bâtie l'échelle de nature. Il nous les faut nombrer & poser chacun à part foi, la generalite être reduite à quatre marches, encore qu'il y ait sous chacune d'elles divers ordres particuliers & diverses espèces.

Ces quatre se rangent ainsi. Tout ce qui est, ou il a l'être seulement sans vie, sans sentiment, sans intelligence, sans jugement, sans libre volonté; ou bien il a l'être & le vivre seulement, & rien du reste, ou bien il est, il vit, il sent, & c'est tout; ou bien il est, il vit, il sent, in entend, & veut a sa liberty. Ainsi ces quatre choses, être, vivre, sentir, & entendre, comprennent tout, & rien n'est au delà. Car sous l'intelligence est aussi loge le jugement, & la liberté de vouloir. Ce premier ordre des choses qui n'ont que l'être, contient une grande multitude d'espèce, lesquelles, bien que pareilles & semblables en cela, reçoivent toutes fois sous cest être seulement, beaucoup de différence; d'autant que l'être de l'un est plus noble que celui de l'autre, & qu'elles ont leur vertus, & leurs opérations plus ou moins excellente. La sont les quatre éléments, chacun garni de sa particulière nature; & se ont des rangs entre eux. La terre est la plus abaissée & de moindre pris, l'eau est plus noble que la terre, l'air encore plus noble que l'eau, & au sevest réserve le dernier honneur. Il les faudra considérer chacun a par soi, tout vulgairement, pour voir ce qu'il a de propre & de particulier. La sont aussi toutes choses qui s'engendrent dans le ventre de la terre, comme les minerus & les métaux, qui son dissemblables en pris. L'argent vif, le plomb, le fer, le cuyure, l'or, l'argent, & l'estaing; l'azur Y est aussi, qui eccede tout metal en valeur; le souphre, le salpêtre, le talgemme, & l'alun; toutes choses de grande efficace. Les pierre en sont, & les pierres précieuse; précieuse, no par leur grande, mais par leurs proprietes singulières, l'effcarboucle, le hiacinthe, l'esmeraude, le crystal & autres. Le ciel est encore en cet ordre, & tous les corps celeste, planètes & etoilles, comme aussi toutes choses fiat par art; car de celles-la nul ne peut avoir que l'être.

La second marche de notre échelle comprend tout choses qui one l'être & le vivre seulement; & dit on qu'elles on vit, d'autant que de soi elles se meuvent contremont, contrebas, devant, derrière, a dextre & a fenêtre; la sont toutes les planes, les arbres & les herbes, qui vivent d'autant qu'elles on ce mouvement par elles-mêmes. Nous les voyons croire en hauteur & en grosseur, & tirer de la terre leur nourriture, pas laquelle continuellement elles s'augmentent, s'entretiennent, engendrent de la semence & du fruit. Ce nourrissement, cette génération & augmentation par leur vertu propre fait que nous leur attribuons la vie, & cela n'est aux éléments que par similitude. Ce range souffre une sous distinction des arbres & des herbes. Les arbres sont plus nobles, les herbes le sont moins. Des arbres in en est un million d'espèces, différente en qualités, en vertu &en estimation; ne plus, ne moins y a-t-il un infini nombre de sortes d'herbes, desquelles l'une n'est pas l'autre, & a chacune sa particulière nature & efficace. En l'ordre troisième loge tout ce qui a être, vie, & sentiment; le sentiment comprend sous soi le voir, l'oyr, le goutter, le flevrer, & le toucher, avec toutes les opérations que nous voyons aux animaux plus

qu'aux plantes. A ce range faut-il attribuer toutes espèces de bestes, soient en terre, en l'air, ou en l'eu. Et voyez combien il y a de façons de bestes terrestres, combien de différence & de diversité, de forme & de valeur entre elles, combien entre les oiseux et les poissons. Tous les animaux sont triplement de partis & diversifiez entr-eux. Les uns n'ont que l'attouchement sans mémoire & sans ouïe; comme toutes ces coquilles, & ces petites bestes qui sont attachées aux arbres & à la racine. Ce premier rang est le plus bas & le plus vil; les autres on l'attouchement et la mémoire, sans l'ouie comme le fourmi. D'autres plus parfaits ont l'attouchement, la mémoire & l'ouie, comme chiens, chevaux & semblables.

D'en trouver une quatrième espèce de tels qui eussent ouie sans mémoire, ils ne se peut faire; parce que tout par tout ou ouie se trouve, la mémoire qu'il la suit, s'y trouve aussi. Les animaux de la première façon, d'autant qu'ils n'ont point de mémoire, n'ont point aussi de prudence; & d'autant qu'ils n'ont point d'oie, sont incapable de tout apprentissage. Davantage, ils font prive du mouvement de lieu a autre, attendu que sans mémoire nul bête ne se peut ainsi mouvoir. Ceux de la second, a cause de la mémoire, ont mouvement de place a place, et si peuvent avoir de la prudence; comme nous disons des fourmis, lors que nous leur voyons faire provision de grain; mais a faute ouie ils sont incapable d'être instruits. Quant a ceux de la troisième, parce qu'ils ont &le souvenir & l'ouïr, ils sont disciplinable en quelque façon; comme les chiens &les oiseaux. Toutes ces trois espèces sont comprises, comme ayans sentiment, sous le tiers général ordre. Il est vrai que la première, pour être plus voisine des plantes, est aussi la moins honorable, la seconde est plus noble pour en être plus eslongnee, & la tierce à même mesure. Voila quant au troisième ordre.

Sous le quatrième sont les choses qui ont être, vivre, sentir, entendre, juge, vouloir& ne vouloir a leur fantaisie, cest a dire le liberal arbitre. Ici sont les hommes, desquels la nature est se accomplie qu'il est impossible d'y se trouver a redire, ne d'y rien ajouter, attendu qu'il n'y a rien en perfection & en dignité au dessus du liberal arbitre, ny rang auquel l'homme puisse monter au delà. Or parce qu'ils sont raisonnables, ils ont aussi l'intelligence, 'a discrétion, le jugement, la ratiocination; font suffisans pour concevoir par expérience & par l'art; sont capables de science & et de doctrine, ce que ne sont pas les autres animaux. Et parce qu'ils ont naturellement le liberal arbitre, ils peuvent vouloir, & ne vouloir pas; consentir & choisir d'eux-mêmes librement & sans contraincte, ce qui defaut aussi aux bestes. Il se traittera ailleurs plus au long de ce quatrième ordre. Ainsi voila notre échelle de nature depeschee avec sa marche, de laquelle le premier effet (fondement de tout le reste de cette doctrine) consiste à la concevoir & planter en nos entendemens, telle que realement elle est.

Chapitre 2 – Comparaison des Hommes avec les Autres Créatures

Apres avoir dit des quatre degrés des chose naturelle, desquels nous sommes instruit indubitablement par nos sens & par l'expérience; il nous faut a cette heure assortir les unes choses aux autres, & l'homme au reste des créatures; pour voir en quoi il est accordant, ou en quoy il diffère des choses qui sont au dessoubs de lui. Par cette comparaison l'homme parviendra a la cognoissance de soi & de Dieu son créateur qui est au dessus.

Voyons donc que premierement en général, & puis en particulier, en quoy il se rapporte aux autres choses. Il se rapporte aux corps insensibles, en ce qu'il a ce qu'ils ont; toutes leurs perfections & en toutes manières. Il a en soi être comme eux; voire il a en soi les éléments mêmes qui en sont, encore que ce fait invisiblement & sous autres forme. Il en est nourri, il loge chez eux, il vit par leur moyen, & ne s'en peut passer un seul moment. Quant aux créatures du second degre, comme plantes, arbres & herbes, il a de commun avec elles l'être, la vie, l'aliment, la génération, & leurs autres conditions. Il vit, se ne le dormir commurist, croit, engendre de même elles. Aussi s'accorde-t-il avec les choses du troisième degre; c'est a scavoir avec les bestes qui ont l'être, le vivre & le sentir; d'autant qu'il a le voir, louir, le goutter, le toucher, le fleurer,, le veiller, le

manger, & de boire, comme elle. Reste donc que tout ce qui est rois marches inférieures est aussi en l'homme. Et qu'a cette cause il a un grande alliance, convenance & amitié avec les autres créatures. Mais il est à poisser, que tout ce qui est distribue diversement entre elles, est en lui tout en un, & assemble. Car il a les quatre degrez; & ne lui en peut être rien ajoute & se n'y a nul degre au dessins des siens en dignité, puis qu'il a l'être, le vivre, le sentir, l'entendre & le liberal arbitre; de quoy les autres n'ont que des parcelles départies a chacun selon son rang.

Chapitre 3 – Qu'il y a un Maître Invisible, qui a Bâti le Monde

Sachons maintenant ce que l'homme peut tirer & conclure de cette comparaison. Puis que ce que les autres ont en pièces, il l'a tout en un, il s'ensuit que quiconque ait ainsi distribue & départi ses biens entre ces créatures, celui-la même, & nulle autre, les a aussi assemblez en un & ami celle en l'homme, accouplant l'être, la vivre, le sentir, l'entendre & le libéral arbitre; & que celui même qui a donne aux chose inférieures ce qu'elles ont, lui a fait aussi pressent de ce qu'il a. Car tout ainsi que l'homme n'a pas donne aux autres créatures l'être, le vivre & le sentir; ainsi ne s'est il pas donne a soi-même l'être, la vie, le sens & l'intelligence. Par quoi une même main a fait & l'un & l'autre; un même architecte a proportionne, limite, & range toutes ces choses. De vrai, pourquoi est-ce que les créatures du premier degre n'not que l'être? Pour quoy sont les éléments privez du vivre & du sentir? Qui leur a taille les morceaux se court? Qui a range les plantes a n'avoir rien que la vie, les bestes a n'avoir que le sentir? Qui a preste la main aux animaux pour se montrer au dessus des plantes, & des herbes, d'un échelon & non plus outre? Qui a compasse leurs pas a cette mesure? Pour quoy ont les hommes, outre ces trois qualités première, le vouloir, le non vouloir & l'intelligence? & celles-ce que les a jointes ensemble, & mise en un, pour en fait le liberal arbitre, absolue perfection & consommation de tout bien? Soit ce l'homme même que les aurait ainsi assemblées pour parfaire son excellence, & s'effleurer bien loin au dessus de toutes autres créatures; ou se ce soit quelque autre? & les autres créatures, se sont elles ainsi rangées, mesurées, & parties; ou si quelqu'un au dessus d'elles l'a fait? Chaque chose s'est el prince ce qu'elle a, ou se d'ailleurs on lui a fait sa part? Il est sans doute impossible qu'elles se soient se justement provenues & proportionnées. Or tout étant ce néanmoins se bien range, advouons hardiment que tel ordre est parti de quelque autre a dessus des éléments; les bestes au dessus des plantes; & qui nous a donne notre avantage. Comme il a voulu que les arbres requissent & se nourrissent, attirant leur aliment de terre pas leurs racines. Tout ainsi a-t-il ordonne que les animaux se nourrissent & s'alimentasse par la bouche. Les animaux ont une plus noble manière de vivre que les plantes, & encore les hommes plus noble que les animaux; mais qui a trouve ces trois différentes modes de se nourrir & de vivre? N'est-ce par le même Maistre & le même arrivant? D'avantage que est-ce qui maintient ce bel ordre? Qui fait que rien ne bouge de sa place, de son état & de son range? Qui a plante ces degrés se firme qu'il se puissent maintenir continuellement sans confusion? Qui conserve la terre, le ciel, et la mer en leur être? N'est-ce pas celui-la même qui les a rangez & donnez? Or fus donc homme, tien hardiment ce que tu as de lui duquel les autres choses ont ce qu-Elles ont. Tu es une pièce de l'ordre des chose, tu fais un corps avec elles, & une hiérarchie; to es donc certainement a celui a qui est tout le reste; to es conserve & gouverne par celui qui gouverne & maintient le reste. Et tout ainsi que les autres créatures ne sont pas a elles-mêmes, mais a celui qui les a engendrée; aussi n'es-tu pas a toi, ainsi a celui a qui elles font, & la terre & l'eau & les éléments ou to habites. Apprend encore que puis que to ne t'es pas donne ce que to as, ne les chose inférieures a toi ne to l'ont donne, ne t'ont fait tel que tu es, que c'est donc quelqu'un qui est plus grand qu toi ne que 'elles. Quelqu'un qui est présents; & d'ailleurs faut-il bien qu'ils soient venus, puisque ny tu ne te les as pas peut fournir ny ne les as eut de toute éternité.

Chapitre 17 – Que Dieu a Cree le Monde par sa Simple Volonté, Non par Aucune Nécessite Naturelle

Sachons maintenant si Dieu a fait le monde par quelque nécessite naturelle, comme nécessairement le feu engendre la chaleur; or si c'a este volontairement, comme l'architecte battit la maison. San doute il l'a fait comme par art, & non par aucune contrainte. Car si l'être de Dieu est une même chose avec son intelligence & sa volonté, certainement sa volonté & son intelligence son les moyens de la création; & aussitôt qu'il a voulu, aussi tôt il a produit ce que bon lui a semble. D'avantage, puis que l'être du monde est hors de l'être de Dieu, & de nature différente a la sienne, il doit avoir estes produit, comme touts autre chose faite par art, qui sont semblablement différents a la nature de l'artisan, & lui est leur essence étrangère. Pour quoy le monde, c'est une artificielle besoin de Dieu produite par art, comme un palais ou une maison; & de même que l'ouvrier forme volontairement son ouvrage, non contraint par aucune nécessite naturelle, de même Dieu a produit le monde, non naturellement, ainsi artificiellement. Et comme l'artisan a la forme, l'image & l'idée être engendrer baissement en sa cervelle avant qu'il le produise, ainsi l'être engendrant, c'est-à-dire Dieu entendant & engendrer le monde, avait nécessairement en soi son idée & sa forme, autrement il est été impossible de le produire. Or par ce que nous avons monstre que Dieu ne peut rien recevoir d'autrui, la forme donc & l'idée du monde estoit en lui de toute éternité. Et se le monde est en Dieu, & que l'être de Dieu soi tres-simple & tres-un, 'être du monde qui est en lui, est donc lui-même, & une même chose avec son être. Et d'autant que dieu est plus parfait & plus digne que l'être du monde qui a este produit de néant, d'autant est plus excellent & plus noble sans comparaison le monde, en le Dieu, u il est éternel, esloigne de tout non être, qu'il n'est en sa propre essence & particulière nature. Au reste l'ouvrier a besoin de matière, en laquelle il mette la forme de son ouvrage, mais Dieu fait tout de néant, & sauf lui toute chose a este par son moyen engendrée de notre être. Tout ainsi que le façon peut produire une infinité de maisons par la maison qu'il a en son imagination, sans que celle la se diminue; ainsi Dieu peut faire un million de mondes, par le moyen &sans l'intérêts de celui qui est en son intelligence, veut mêmement que de rie il produit toutes chose. Attendu qu'il engendre par sa seule volonté, il a crée ce monde sans peine, sans ennui & sans travail; & comme l'artisan, selon le besoing de la maison la battit en la meilleure manière qu'il peut, de même a Dieu établi ce monde parfait en toutes ses commodités, de façon qu'il n'y peut être ajoute ny diminue aucune chose, car il n'y a faute de rien, ny rien de superflu. Or d'autant que l'ouvrier ne fournit point de matière, & lui donne seulement la façon & la forme, sa continuelle présence ne sait nul besoing à maintenir & conserver son ouvrage. Il est tout autrement du monde à l'endroit de son créateur. Car Dieu ayant fourni & de matière & de forme & les ayant produites du rien, son assistance fait incessamment besoin a la conservation de son bâtiment qui peut sans elle subsister une seule minute, & qui tout soudain reviendrait a rien, d'où il est parti, s'il avait esloigne l'œil de son facteur. Voila pourquoy il est nécessaire que toute l'essence do Dieu soit infuse en tout l'être du monde, non enclose pourtant, car elle s'étend au de la. Ainsi ce grand Maistre ouvrier ny endormi ne nonchalant, porte sans cesse, enferme & soutien en sa main, sans peine & par sa seule volonté cette machine, son bel ouvrage; mais bien que sa présence ne puisse pas marquer au monde, d'autant que son e'este est tout par tout, si est-ce que par ce que ce n'est pas par contrainte ou par nécessite naturelle, qu'il le maintient, ainsi par sa simple volonté; il est en lui, quand il lui plaira de le perdre, détruire & anéantir, comme fait du néant. D'avantage si Dieu, ce partait ouvrier, maintient continuellement & conserve ce monde, il la bâtit aussi par conséquent & engendre continuellement, tout ainsi que le soleil ses rayons qu'il fait & refait, se dru, qu'il en continue la lumière; autrement nous en serions incontinent privez, comme nous essayons la nous en son absence. Le monde donc finirait sans toute, s'il n'était regenere incessamment & maintenu par son créateur.

Chapitre 28 – Comparaison de Deux Êtres au Soleil & à la Lune

Ce premier & second être ressemble en beaucoup de sorte au soleil & à la lune. Car tout ainsi que la lune n'a aucune lumière de soi, ainsi l'empreinte toute du soleil; ainsi le monde n'a aucune essence, que celle qui lui est départie par le grand & éternel être; & comme le soleil a la claire continuelle en soi sans que autre créature la lui fournisse, ainsi a Dieu de soi-même son être perpétuel qu'il n'a reçu de personne.

Et tout ainsi que par ce peu de lumière que nous avons la nuit, nous imaginons la lumière du soleil qui est esloigne de nous; de même par l'être du monde que nous connaissons, nous argumentons l'être de Dieu qui nous est cache. D'avantage comme la claire de la lune se perd & s'évanouit en la présence du soleil, ainsi s'obscurcit l'être du monde assorti a l'être de Dieu; & plus nous l'en approchons, plus il s'apetisse; la ou si nous le considérons tout a part la foi, il nous semble grand & merveilleux, comme la lune clarté largement lors qu'elle est esloigner du Soleil. Ces deux êtres servent donc comme de deux lumières a notre entendement; 'une éternelle & perpétuelle, qui et Dieu; l'autre créée & nouvelle, qui est le monde; & les rayons de celle-ci sont les créatures. Or pour la faiblesse & petitesse de la lumière créée, nous la pouvons a notre aise, & sans dommage de notre veut, contempler, tout ainsi que nous faisons la lumière de la lune; Mais la conséquences de celle-ci nous même a la contemplation de Dieu, comme de la brillante & véhémente clarté du soleil, de laquelle, comme nos yeux éblouis, ne peuvent supporter la lueur extrême; ainsi empêche par tendresse des yeux de nos entendements, de pouvoir pendant que nous sommes si bas, contempler vis-à-vis & de droit fil l'éclairante & lumineuse grandeur de l'être de Dieu, il faut que l'être du monde nous serve de passage & de moyen par ou nous puissions conduire & pousser notre veut jusques a ce grand & resplendissant miroir de l'essence de Dieu, & comme d'un ombre, au travers de laquelle ainsi que nous faisons regardant le soleil, nous montions jusques a la haute & divine considération de notre créateur. Voila la double nature des deux êtres, & des deux non-être's depeschee.

Chapitre 36 – Du Libéral Arbitre

Je vis que Dieu nous a donne la liberté de vouloir a notre poste & sans contrainte, c'est a dit le liberal arbitre, & que c'est un si beau & si riche présent, il s'enfuit qu'il l'a en soi. Nous pouvons aussi prouver ceci par son essence intellectuelle; veut que par conséquence nécessaire le liberal arbitre se trouve tout par tout ou est l'intelligence. Or d'autant que le vouloir de Dieu est avant toute autre volonté, il ne peut être attache, ne sures aucun vouloir que le sien même chose, & que son être est tres-accompli invariable & éternel, n'ayant besoin de rien, comme nous avons prouve, sa volonté est donc aussi tres-parfaite, immuable, éternelle & toute-puissante comme son être. On outre attendu que son être set premier, plus noble, meilleur & plus excellent que nulle autre chose, & que Dieu se connait premierement & son essence, il nous faut croire, qu'avant toutes autres choses, il veut son bien et sa perfection de son être; & par conséquent que tout ce qu'il en ait affaire, mais pour se communiquer aux autres hors de soi. Il veut donc soi-même & son bien plus que nulle autre chose, il ne peut ny vouloir, ny faire rien qui loi soit contraire, ny ne peut vouloir n'être pas; ainsi jouissant d'un tres-parfait contentement & entier accomplissement de ses volontés, il a un aise continuel & nourrit en soi une joie éternelle, infiniment esloignee de tristesse.

Chapitre 37 – Par l'Intelligence de Dieu Nous Pouvons Conclure la Grandeur & Perfection de son Vouloir

Nous avons conclus tantôt que l'intelligence de Dieu est actuellement infinie & incapable d'ignorance. Or son vouloir & son entendement étant en lui une même chose, comme nous venons aussi de dire, il est impossible qu'il veuille rien contre raison & contre le sain jugement d'un parfait entendement, duquel la première opération est de concevoir le sens des mots & des paroles. La seconde est de poser par une raison se la chose conçue est vraie ou fausse, juste ou injuste, approuvant & affirmant ce qui est bon & véritable, niant & reprouvant ce qui est au contraire. Voila les deues naturelle & nécessaire opérations de l'entendement, comme nous dirons ailleurs, lesquelles sont en Dieu réglées, & guidées par sa divine raison. Ainsi il ne peut rien vouloir de désordonne ou d'unique, autrement il aurait une volonté différente de son intelligence; ce qui ne peut être. Sa volonté est donc droituriere, juste, tres-ordonee & tres-reglee; mais reglee & ordonnée non par autrui, mais par soi-même; Car c'est elle qui est la règle des règles, règle qui ne se peut tordre, biaiser ny des metir. C'est la vraie & première justice c'est la même vérité, la

même bonté la même sapience. Par quoi il est impossible qu'elle fac rien d'unique & sans ordre; car il ordonne ce mal la a quelque bonne fin.

1436
Raymond Sebonde, Professeur De Philosophie, de Médecine, et de Théologie A Toulouse
Naturalis Sive Liber Creaturarum
Livre de Théologie Naturelle
1827 Publication in Michel de Montaigne, Essai's, Volume 6

Link at Google Book

Extrait De La Théologie Naturelle De Raymond Sebon

Raymond Sebon Ou Sebonde, professeur de philosophie, de médecine et de théologie à Toulouse dans le quinzième siècle, était de Barcelone. Il composa plusieurs ouvrages, dont le plus considérable est celui qui porte le titre de *Theologia naturalis sive liber Creaturarum*. Montaigne, à qui nous devons une traduction de cet ouvrage, s'étonne que la vie de son auteur soit restée dans l'obscurité, et il a tracé de son livre une apologie qui est le plus long chapitre de ses Essais. « Il faut, dit Bayle, que ce livre « ne sente pas les notions d'un auteur vulgaire », et rampant sur la surface des préjugés, puisque » Montaigne en a fait un cas tout particulier. Non seulement l'histoire de cette traduction peut servir à faire connaître Sebon, mais elle jette encore un grand jour sur l'esprit et le caractère de Montaigne; et peut-être aurait-elle dû lui épargner le reproche d'irréligion. Pierre Bunel, dit-il, homme de grande réputation de savoir, en son temps, ayant arrêté quelques jours à Montaigne, en la compagnie de mon père, avec d'autres hommes de sa sorte, lui fait présent, au déloger, d'un livre qui s'intitule: Theologia naturalis, sive liber Creaturarum. Et parce que la langue italienne et espagnole étaient familières à mon père, et que ce livre est battu d'un espagnol barragouiné en terminaisons latines, il espérait qu'avec bien peu d'aide il en pourrait faire son profit, et le lui recommanda comme livre très utile.... Or, quelques fours avant sa mort, mon père ayant de fortune rencontré ce livre sous un tas autres papiers abandonnez, me commanda de le lui mettre en françois. Il fait bon traduire les auteurs comme celui là, où il n'y a guerres que la matière à représenter: mais ceux qui ont donné beaucoup à la grâce et à l'élégance du langage, - ils sont dangereux à entreprendre, nommément t pour les rapporter à un idiome plus faible. C'était une occupation bien étrange et nouvelle pour moi; mais étant de fortune pour lors de loisir, et ne pouvant rien refuser au commandement du meilleur père qui fut oncques, i'en vains à bout, comme je peut: à quoi il prit un singulier plaisir, et donna charge qu'on le fait imprimer; ce qui fut exécuté aurez sa mort ».

Mais si Montaigne entreprit cette traduction par les ordres de son père, ce fut de son propre mouvement qu'il fit cette étonnante apologie, où, selon l'expression de Pascal, il foudroie l'impiété, et où la raison de l'homme est si invinciblement froissée par ses propres armes, qu'on est tenté d'aimer le ministre d'une si grande vengeance (a).

Montaigne, charmé, comme il le dit lui-même, des belles imaginations de. Sebon, de ses conceptions hautaines et comme divines, voulut secourir les nombreux lecteurs de cet ouvrage en répondant aux objections dont il était l'origine: mais, comme il arrive toujours à Montaigne, dès les premières pages du chapitre, il perd de vue son objet; et, cédant aux caprices de sa philosophie, il renverse ce qu'il voulait soutenir, et il relève ce qu'il voulait abattre. Chose étonnante! un livre dont le but est d'établir la vérité de la religion par la seule force du raisonnement, devient l'origine d'un chapitre où l'on ne cesse de gourmander la faiblesse et la vanité de notre chétive raison; un livre où tous les mystères qui ne devraient être présentés qu'à notre foi, sont imprudemment

soumis aux spéculations de l'intelligence humaine qui veut les expliquer, inspire le génie de Montaigne, et le conduit, au contraire, à cette importante pensée, que hors de la foi, il n'y a qu'incertitude!

Nous ne parlerons pas des diverses éditions du Traité de Sebon. Duverdier en connaissait une traduction en fort vieil langage. Celle de Montaigne parut pour la première fois en i 581; elle est précédée d'une épître dédicatoire, pleine de grâce et de naïveté, adressée à monseigneur son père. En lisant ces pages quelquefois si originales, on se demande comment un livre loué par Bayle, admiré et traduit par Montaigne, médité et imité par Leibniz et Pascal, a pu tomber dans un si profond oubli? L'indifférence religieuse, l'un des caractères les plus marquants du siècle, n'explique point cet abandon, puisque l'ouvrage de Sebon, dépouillé des idées purement théologiques, conserve encore un mérite littéraire digne de fixer l'attention et de piquer la curiosité. Dès son début, l'auteur embrasse tout son sujet, et nous instruit de cette doctrine par laquelle l'homme est délivré de plusieurs doutes, et se sent esmen et poussé à faire par amour ce qu'il doit à son prochain et à Dieu:

Cette doctrine est commune à tous les hommes; il ne la faut apprendre par coeur, ni en avoir des livres; car, depuis qu'elle est conçue, elle ne se peut oublier: elle rend humble, gracieux, obéissant, ennemi du vice, amoureux de vertu; elle ne se sert d'arguments obscurs qui aven t besoin de profond et long discours, car elle n'argumente que par choses apparentes; elle prouve ce qu'elle veut, en s'appuyant de ce que chacun sait de soi même: aussi n'a elle métier d'autre témoin que de l'homme.

Après avoir esquissé rapidement le sujet de son ouvrage, Sebon en montre toute la grandeur;

Le livre de la Bible a été depuis donné à l'homme qui cessait quelquefois de lire dans le livre de la Nature. « Si est ce que le premier est commun à tout le monde, et non pas le second: car il faut entre clerc pour le pouvoir lire. En outre, le livre de Nature ne se peule ni falsifier, ni effacer, ni faussement interpréter; là où il va tout autrement de celui de la Bible. Si est ce que l'un et l'autre est parti de même maistre. Aussi s'accordent ils, très bien, et n'ont garde de s'entre contredire: quoi que le premier symbolise plus avec notre nature, et que le second soit bien loin au dessus d'elle.

Il nous semble que cette idée ne serait point indigne du 'grand Bossuet; elle présente un tableau magnifique: le livre dé la Bible servant d'interprétation au livre dé la Nature, et Dieu lui-même prenant soin de nous instruire des secrets de son ouvrage.

Après un semblable début, il est impossible de résister au désir de suivre l'auteur dans les routes qu'il s'est ouvert. On aime à le voir passer alternativement d'un livre,à l'autre, les unissant, les confondant, et puisant dans leurs pages sacrées une force de raison qui a souvent inspiré Pascal, et qu'on ne retrouve point là sans étonnement.. C'est ainsi que par la connaissance de la nature il remonte jusqu'à Dieu, et que par la connaissance de Dieu, il redescend à l'explication de la nature; mais en cherchant la vérité dans les deux livres qu'il nous présente, il a soin de faire remarquer leur ressemblance frappante: Le livre de la Nature, dit-il, nous apprend qu'il faut croire Dieu premièrement, de soi simplement et sans preuve, et le livre de la Bible parle tout de même Telle est la marche de Sebon; et, dans cette immense carrière, Montaigne le suit sans se fatiguer, lui prêtant tour à tour la grâce de son esprit, l'énergie de son langage, et revêtant des imaginations quelquefois bizarres de ces expressions pittoresques qui donnent tant de charme aux Essais.

Nous allons donc essayer de réunir les plus beaux passages dispersés dans ce singulier ouvrage; mais nous écarterons de notre travail les discussions et les explications théologiques, qui n'ont été pour Sebon qu'une occasion de prouver jusqu'à quel point les esprits les plus fermes peut s'égarer.

Le chapitre premier est intitulé: De l'Echelle de mature par laquelle l'homme monte à la connaissance de soi et de son Créateur. Il commence ainsi:

Par l'inclination naturelle des hommes, ils sont continuellement en cherche de l'évidence de la venter et de la certitude; et ne se peuvent assouvir. Ni contenter qu'ils ne s'en soient approchez jusques au dernier point de leur puissance. Or il y a des degrés en la certitude et en la preuve, qui font les unes preuves plus fortes, les autres plus faibles, quelque certitude plus grande, quelque autre moindre. L'autorité de la preuve et la force de la certitude s'engendre de la force et autorité des témoins et des témoignages, desquels la venté dépend; et de là vient que d'autant que les témoins se trouvent plus véritables, appartins et indubitables, d'autant y a il plus de certitude en ce qu'ils peuvent. Et s'ils sont tels que leurs témoignages, par leur évidence, ne puissent tomber en nul doute, tout ce qu'ils vérifieront nous sera très certain, très - évident et très - manifeste. Aussi d'autant que les témoins sont plus étrangers et plus esbignez de la chose de laquelle on doute, d'autant font-ils moins de foi et de créance; et plus ils sont voisins, plus ils apportent avec eux de certitude. Mais il n'y a rien plus familier, plus intérieur et plus propre à chacun, que soi-même à soi: il s'ensuit donc, que tout ce qui est vérifié de quelque chose par elle-même et par sa nature, reste très bien vérifié Puis que nulle chose créée n'est plus voisine à l'homme que l'homme même à soi, tout ce qui se prouvera de lui par lui-même, par sa nature et par ce qu'il sait certainement, de tout cela demeurera-il très assuré et très éclairci Car en ce point consiste la plus commode certitude, et la plus assurée créance qui se puisse faire ou tirer de la preuve. Voilà pourquoi l'homme et sa nature doivent servir de moyen, d'argument et de témoignage, pour prouver toute chose de l'homme, pour prouver tout ce qui concerne son salut, son heur, son malheur, son mal et son bien: autrement, il n'en sera jamais assez certain. Qu'il commence donc à se connaitre soi-même et sa nature, s'il veut vérifier quelque chose de soi. Mais il est hors de soi, esbigné de soi d'une extrême distance, absent de sa maison propre, qu'il ne vidons que, ignorant sa valeur, méconnaissant soi-même, s'es changeant pour chose de néant, pour une courte joie, pour un léger plaisir, pour le péché. S'il se veut donc reconnaître, son ancien pris, sa nature, sa beauté première, qu'il revienne à soi et rentre chez soi: et pour ce faire, veut qu'il a oublié son domicile, il est nécessaire que, par le moyen d'autres choses, on le ramène et reconduise chez lui. Il lui faut une échelle pour l'aider à se remonter à soi et à se ravoir. Les pas qu'il fera, les échelons qu'il enjambera, ce seront autant de notices qu'il acquerra de sa nature. Toute connaissance se prend par argument des choses que nous savons premièrement et le mieux, à celles qui nous sont inconnues: et par ce qui nous est évidemment notoire, nous montons à l'intelligence de ce que nous ignorons. Aussi nous entendons premièrement les choses plus petites et plus basses, et après les plus grandes et les plus élevées: d'où il advient que l'homme, comme étant la plus excellente et la plus digne chose de ce monde, connait toutes .autres choses avant qu'il se conise soi-même Or, afin qu'ainsi hors de lui, comme il est, et s'ignorant, il puisse être ramené à soi et instruit de sa nature, on lui présente ceste belle université des choses et des créatures, comme une droite voie et ferme échelle, ayant des marches très assurées, par où il puisse arriver à son naturel domicile, et se remonter à la vraie connaissance de sa nature; Pour c’est effet, tout y est diversifié par un bel ordre de rangs de tressauter proportion. Les choses sont, les unes basses, les autres hautes, celles-ci parfaites, celles-là imparfaites: quelques unes i sont extrêmement viles, et quelques autres d'un pris inestimable, pour accommoder ses pas et pour l'acheminer contremont jusques à soi, de degré en degré à la mode d'une échelle, de laquelle, s'il se veut servir, voici comme il lui en convient user: voici le train qu'il lui faut tenir pour parvenir à sa connaissance. Premièrement, qu'il considère la valeur de chaque chose en soi; et puis la générale police de cet univers, distribuée en différentes dignités et divers rangs de créatures. Cela fait, il lui faudra comparer l'homme, qui en est la plus noble et première partie, à toutes les autres; et les comparer en double façon. Tantôt regardant en quoi il convient, tantôt en quoi il diffère d'avec elles. De ceste ressemblance ou dissemblable s'engendrera en lui l'intelligence qu'il cherche de soi, et, qui plus est, celle de Dieu son créateur immortel; car, par la voie des choses inférieures, il s'acheminera jusques à l’homme,

et tout d'un fil il enjambera de l'homme jusques à Dieu. Il est impossible d'arriver par ailleurs à ceste double connaissance. Ce sont deux montées et deux traites à faire; l'une par les choses, qui sont au dessous de l'homme jusques à lui, et la seconde de lui jusques à son Créateur. Quant à la première, il i a une grande diversité et distinction de degrés de choses de ce monde, (lesquels, fermes et immobiles comme ils sont, est bas tic échelle (le nature).

On reconnaît dans ce passage l'idée fondamentale de cette fameuse chaîne des êtres dont on a fait honneur à Leibniz. Cette pensée, que rien ne va par saut dans l'univers, -a été l'origine de trop de découvertes pour ne pas la rendre à sou véritable auteur, et l'on ne doit point oublier que c'est sur ce plan, peut-être systématique, que Bonnet composa son plus bel ouvrage: *La Contemplation de la Nature*.

Sebon même, en établissant que « tous les objets de la création sont range et ordonnez de façon qu'ils montent très mesurément de degré en degré, du petit au grand, tirant toujours vers le plus digne »; Sebon, dis-je, e hâte d'arriver à cette conclusion, que le dernier anneau de la chaîne où il suspend tous es êtres, depuis l'insecte jusqu'à l'homme, est soutenu par la main du Créateur. « L'expérience, dit-il, nous apprend que toutes choses visent au profit l'une de l'autre, qu'elles s'entresoutiennent et s'entraident par plaisir mutuel; et que les plus basses servent à celles qui leur sont au dessus. Ainsi font elles un ordre, une police, et, quand tout est dit, une unité ». Voilà Dieu trouvé! Et l'auteur conclut encore de ce, raisonnement que c'est un seul qui ordonne et qui gouverne le monde!

La description de l'échelle des êtres donne à Sebon l'occasion de tracer le tableau des éléments, des plantes et des animaux; et c'est là qu'il établit une division ingénieuse qui semble ne pas avoir été inconnue à Linné:

Tout ce qui est ou il a l'être seulement sans vie, sans sentiment, sans intelligence, sans jugement, sans libre volonté; ou bien il a l'être et le vivre seulement, et rien du reste; ou bien il est, il vit, il sent, et c'est tout; ou bien il est, il vit, il sent, il entend, et veut à sa liberté. Ainsi ces quatre choses, être, vivre, sentir et entendre comprennent tout, et rien n'est au-delà.

C'est ainsi qu'il nous place à la tête de la création; mais comme les qualités qu'il a reconnues dans lés êtres inférieurs appartiennent aussi à l'homme, Sebon trouve dans ce rapport la cause de l'alliance, convenance et amitié qui nous lie aux autres créatures. Idée à la fois ingénieuse et profonde qui lui sert bientôt à unir Dieu aux hommes par un sentiment semblable; car Dieu, ainsi que l'homme, à l'être, le vivre, le sentir, l'entendre et le libéral arbitre. Il doit donc aimer en nous ce qui est en lui, mais ce qui -est en lui sans borne ni mesure.

Cependant Sebon n'en reste pas là, et trois cents pages plus loin, on trouve une nouvelle conclusion du même principe qu'il n'a jamais abandonné. Retournant donc sa pensée, il voit dans la ressemblance de l'homme avec Dieu l'origine de cette maxime admirable de l'Évangile:

Que nous devons aimer jusques à nos ennemis. Chacun' étant tenu d'aimer l'image de Dieu, il nous faut aimer indifféremment nos amis et nos ennemis, ceux qui nous profitent, ceux qui nous nuisent: car ce sont toujours hommes, et par conséquent image et ressemblance de Dieu.

C'est ainsi que Sebon sait donner à un sentiment toute la force d'un raisonnement. Il prouve pour l'esprit ce qui est déjà prouvé pour le coeur; et, frappé de sa découverte, il la renferme en huit lignes, et en forme un chapitre complet que je viens de rapporter, et qui est le 122e.

Certes, cette liaison dans les idées, cette force de conception justifiera Bayle et Montaigne de leur admiration, si cette admiration avait jamais pu être prodiguée. Au reste, comme si la beauté de cette pensée donnait tout à coup un nouvel élan à l'éloquence et au génie de Sebon, il s'écrie:

Or sus donc, homme, tiens hardiment ce que tu as de celui duquel les autres choses ont ce qu'elles ont: tu es une pièce de l'ordre des choses, tu fais un corps avec elles, et une hiérarchie: tu es donc certainement à celui à qui est tout le reste, tu es conservé et gouverné par celui qui gouverne et maintient le reste. Et tout ainsi que les autres créatures ne sont pas à elles mêmes, niais à celui qui les a engendrées: aussi n'es tu pas à toi, ainsi à celui à qui elles sont, et la terre et l'eau et les elle-même on tu habites. Apprends encore que puis que tu ne t'es pas donné ce que tu as, ni les choses inférieures à toi ne te l'ont donné, ni ne t'ont fait tel que tu es, que c'est donc quelqu'un qui est plus grand que toi ni qu'elles.

Un peu plus loin, il voit dans le libre arbitre un don céleste qui nous conduit naturellement à Dieu; car la liberté n'est autre chose que le choix du bien ou du mal; et il serait insensé de ne pas s'attacher au bien, qui est Dieu:

Les hommes sont naturellement tout un, -t de mesure dignité, comme ayans tous également le libéral arbitre: qui est la première et principale pièce de leur entre, qui leur donne un rang à part: et par laquelle seule il diffère d'avec les autres créatures Si donc tant et tant de choses différentes qui sont en ce monde, répondent et servent à une seule nature, à savoir à l'humaine, comme plus excellente qu'elles, et non à plusieurs: combien. Plus est il raisonnable que l'humaine n'en serve qu'une supérieure et maîtresse de toutes, et non diverses? Autrement que serait-ce à dire? Que les natures inférieures et moins dignes visassent à l'unité et à une seule nature comme à la plus digne: et l'humaine, qui est beaucoup plus excellente, et à laquelle les autres cèdent, visant à la diversité et à plusieurs natures, comme plus grandes et maîtrisant? L'ordre des choses ne saurait souffrir, que ce qui est plus bas et moins digne resplendir à ce qui est plus fort, le meilleur et le plus noble: et que le plus haut et le plus digne répondant au pire et au plus faible. Or est-il plus honorable et plus beau sans doute de tirer à l'unité qu'à la diversité, et à un qu'à plusieurs: par ce que viser à l'unité et à l'un, c'est viser à la conservation, à la force, au bien et à. être: mais viser à la diversité et multitude, c'est viser à la division, à la faiblesse, à la ruine, au mal et au non entre. Arrêtons donc qu'il n'i a qu'une seule nature au dessus de l'homme, et qui lui commande.

Mais ce n'est point en vain que Sebon place l'homme à la tête de la création; ce n'est point en vain qu'il reconnaît en nous une intelligence suprême: cette intelligence, il l'interroge, il l'étudie; il s'étonne de la trouver supérieure aux besoins de notre corps; elle va toujours au-delà: souvent même elle lui est plus nuisible qu'utile. Nous réduire à l'instinct, ce serait nous ôter bien des maux, sans nous ôter rien de nécessaire à la vie; mais aussi ce serait nous ôter notre grandeur. Si l'intelligence est supérieure aux besoins du corps, elle a donc un autre but que les choses de la terre. Ce but nous est révélé par la reconnaissance qui nous élève à Dieu, comme elle élève quelquefois les autres créatures à nous: c'est ainsi que, renonçant au secours des sens, Sebon fait de l'intelligence la chaîne qui unit les hommes à leur Créateur. Voici le chapitre 34:

Et par ce qu'il est tout intellectuel, nous n'i pouvons atteindre de notre veux corporelle, d'autant qu'il n'est capable ne de couleur, ne de figure: aussi n'est-il palpable, ni sensible à nul des sens, que nous avons communs avec les bêtes: car la force de ces sens - là corporels, ne s'étant que jusques aux choses et qualités, qui sont aussi corporelles. Ainsi la veux sert à nous découvrir les couleurs, les figures et la lumière: l'ouie à recevoir les sons qui se font en l'air: le fleurer les odeurs: le goutter les saveurs: le toucher nous apprend le chaud et le froid. Or d'autant que Dieu est tout esprit et tout âme, il ne peut être compris, ou appercu que par l'intelligence. Voilà comme de toutes ses créatures, le seul homme peut parvenir à sa connaissance, et lui a Dieu fait présent de ceste grande et particulière partie de l'entendement, afin qu'il le puisse reconnaître.

Sebon cependant ne donne une idée complète de la hauteur de notre intelligence que lorsque, cent pages plus loin, il la montre embrassant à la fois l'immensité et l'éternité: elle connait Dieu, dit-il, et Dieu est ce qui se peut songer de plus grand.....; il est tout ce qu'il vaut mieux d'être que de n'être pas. Pensée sublime, de mesurer la grandeur de notre intelligence .par la grandeur du Dieu qu'elle peut concevoir! Enfin, descendant > encore plus avant dans notre coeur, il trouve dans. Chaque passion, chaque sentiment, chaque pensée de l'homme, un argument contre les incrédules, argument auquel le langage de Montaigne semble donner encore une nouvelle énergie:

Il y a relation, entre le Créateur et l'homme. Attendu que nous sommes capables de louer, glorifier et bénir, Dieu est bénissable, glorifiable et louable. Attendu que nous sommes capables de connaitre les bienfaits, Dieu est bienfaiteur et libéral donneur: et est ouvrier emerveillable attendu que nous nous pouvons émerveiller. Si nous pouvons croire, Dieu est croyable. Si nous sommes aptes à espérer, il nous faut espérer en lui. Si nous sommes prouve de confiance, •Dieu est fiable, et c'est en lui que nous devons mettre notre confiance: il est désirable, veut que nous sommes capables de désirer. Yeu que l'homme est toujours en quête de la sensé, Dieu est véritable. Yeu qu'il désire continuellement le bien, Dieu est très bon. Parce que l'homme est capable d'infiniment demander, Dieu est capable d'infiniment donner. Parce qu'il peut infiniment souhaiter, Dieu peut infiniment assouvir et satisfaire. Parce que nous sommes aptes à bien faire, Dieu est apte à rémunérer; et d'autant que nous pouvons pêcher et faillir, Dieu nous peut punir et châtier.

Sebon revient plusieurs fois à ce raisonnement, et il n'est point inutile de montrer comment il le convertit en argument; il veut prouver que, dans la nature, rien n'est fait sans dessein:

Aux choses visibles répond d'oeil, pour les voir: à celles que il faut ouïr, l'oreille: aux intellectuelles, l'entendement, et ainsi du reste: à fin qu'il n'i ait rien pour néant. Pourquoi ne répondra tout (le mesure aux choses recompensables un recompenseur, aux punissables un punisseur, aux jugeables un juge: et cela à fin que le mérite et le démérite n'ayant pas été frustratoirement produits par nature, qui n'engendre rien sans son effet? Tenons donc certainement qu'il i a quelque payeur, ou châtieur plus grand que nous, auquel l'homme se rapporte pour le regard de ses opérations.

D'où il conclut, à la fin du chapitre, que l'argumentation sera bonne en cette manière: l'homme peut faillir; il i a donc un punisseur: l'homme peut bien faire; il i a donc un récompenseur.

Sebonde vient de prouver que l'homme seul est doué d'intelligence. Voilà, pour me servir de son expression, que le premier huis de la maison est franchi; mais il est nécessaire de donner un guide à cette intelligence. Elle invente, elle imagine, elle crée, et cependant elle ne sait rien, si l'expérience ne l'éclaire; elle ne peut même, sans s'égarer, oublier un moment la plus haute de ses pensées, celle de Dieu. Ainsi de notre grandeur naît la connaissance de Dieu, et de notre faiblesse le besoin de nous adresser à lui. D'où l'on peut rigoureusement conclure la nécessité d'une morale, c'est-à-dire d'une religion. Le chapitre étroit difficile, mais il était important; et Sebon l'a traité avec tant de supériorité, qu'on croit lire les pensées de Pascal:

L'entrée et l'advenue de notre intelligence, c'est la créance et l'affirmation: de façon que nous appelions accepté et reçu, ce qu'elle approuve, et refusé et rejeté, ce qu'elle nie. Il .nous faut donc prendre garde bien soigneusement à l'approbation ou refus que nous avons à faire des premières choses qui s'offrent à notre imagination: puis que par là nous lions et obligeons la liberté de notre entendement, principalement en celles qui touchent le bonheur ou malheur de l'homme; car nous pourrions bien embrasser., au lieu de la venté, la mensonge, et notre mal, et notre ruine;

comme aussi rejeter pour fausse la venté, et notre bien, et notre salut: Pour nous garder de mécompte, il faut apprendre un art d'affermer et de nier, d'avouer et de contredire, qui puisse engendrer en nous une constante résolution et assurance: non un art qui serve à toutes choses qui se proposeront, mais à celles seulement qui nous concernent, entant que nous sommes hommes. Et puis que nous avons bien le soin de nous prouver des sciences qui nous apprennent à lire et écrire, combien plus justement devons nous travailler à acquérir celle qui nous apprend à croire ou à mécroire les choses desquelles dépend notre entière féliciter ou misère. l'entreprends donc de montrer ce qu'il est tenu de croire si évidemment, que celui même qui n'en fera rien, verra toutefois qu'il était obligé par raison et par droit de nature à le faire. Et c'est bien autre chose savoir et entendre son devoir, que de le mettre à exécution; car journellement nous savons assez ce que nous avons là faire, et si n'en faisons riens pourtant: semblablement je pourrai bien apprendre à l'homme ce qu'il doit croire par nécessité naturelle; et si par aventure il n'en croira rien. De vrai, toutefois et quant à que nous donnons des préceptes pour les actions humaines, et que nous entreprenons de refiler les opérations qui appartiennent à l'homme, nous ne pouvons le forcer à nous croire autrement que par raison. Et si nous pouvions i ajuster la contrainte, et l'obliger par nécessité à faire son devoir, nous lui- oserions la liberté de faire au contraire, et le priverions du chois et de son libéral arbitre.

Voilà une maxime qui ne ressemble guère à l'intolérance qu'on a si souvent et quelquefois si injustement reprochée aux théologiens. Pour s'exprimer avec cette franchise, il faut être bien sûr de convaincre par la seule force du raisonnement. Il semble que Sebonde n'ait multiplié les difficultés que pour montrer la richesse de ses ressources. Cependant il ne les montrera que peu à peu; il pressera son lecteur, sans l'accabler, et il ne lui dévoilera toutes les conséquences de ses arguments, que lorsqu'il lui aura ôté tous moyens de s'échapper. La première proposition qu'il établit est si simple, qu'il est impossible de la lui refuser: les hommes doivent travailler à leur bien-être, et repousser ce qui peut le détruire, comme les arbres qui sucent la terre pour leur profit, et en tirent l'humeur qui sert à leur accroissance, non celle qui leur est nuisible.

Ainsi, ajoute Sebonde, l'homme serait dévoyé du train ordinaire de l’univers, s'il employait ses facultés à sa ruine, mal et dommage. Et il s'en suit par nécessité, veux qu'outre les autres animaux, il a l'entendement et la volonté, et que ces pièces là le font homme, qu'il est tenu naturellement d'en user à son profit et avantage; c'est à dire, pour s'acquérir le plus qu'il peut de joie, de liesse, d'espérance, de consolation, de paix, de repos et de confiance; et pour en combattre la tristesse, le malheur, le désespoir et toutes autres choses contraires à son bien. Et d'autant que toutes les forces et moyens, qu'il a comme homme pour acquérir de la perfection. Dignité et noblesse, consistent en son intelligence et volonté, il se doit prendre garde à les bien employer et à s'en aider pour l'homme, non contre l'homme.

C'était sans doute une idée hardie et philosophique, que de fonder la morale sur l'amour de soi, sur l'intérêt de chacun; et cependant c'est dans -ce principe, qui depuis a servi de base à •tant de doctrines absurdes, que Sebonde trouvera des arguments pour nous faire aimer la vertu cette première proposition adoptée, il en conclut que pour travailler à notre bien-être il faut savoir distinguer le bien du mal; puis accepter l'un, et refuser l'autre; car il est impossible que les deux choses soient vraies, et impossible aussi de les croire toutes deux. Partant de cette pensée, il établit que l'homme est tenu -de croire ce qui lui est meilleur, ce qui le conduit à examiner la vérité qu'il nous importe le plus de connaître; il propose donc cet exemple:

On nous demande s'il i â un Dieu, il nous faut soudain imaginer son contraire: il n'i a point de Dieu, et puis assortir ces choses l'une à l'autre, pour voir laquelle d'elles cons• vient plus à l'être et au bien, et laquelle i convient le moins. Or celle là, il i a un Dieu, nous présente une essence infinie, un bien incompréhensible: car Dieu est tout ceci. La contraire, il n'i a point de Dieu, apporte avec soi privation d'un être infini, et d'un infini bien. A ce compte, par leur comparaison, il i a autant à

dire entre elles, qu'il i a entre le bien et le mal. Passant outre, accommodons les à l'homme. La première lui apporte de la fiance, du bien, de la consolation et de l'espérance: La seconde du mal et de la misère: il croira donc et recevra par notre règle de nature, celle qui est et meilleure de soi, et plus profitable pour lui: et refusera celle qui est rejetable d'elle mesure, et qui lui apporterait toutes incommodité: autrement il abuserait de son intelligence, et s'en servirait à son dam: ce qu'il ne peut ni ne doit faire entant qu'il est homme. Mais quel bien pourvoit-il espérer de croire que Dieu ne fut pas? Quel fruit en pourrait-il recueillir? Pourquoi se joindrait-il à la part stérile de tout bien? À quoi faire la logerait-il en son' coeur et en sa foi? Ne lui vaut-il pas mieux attacher sa créance à celle qui est fertile et fructueuse? Car celle-ci, s'il la reçoit bien en bon escient, s'il la plante bien vivement en soi, voyez quelle suite de biens elle lui même. Son intelligence se rend plus noble et plus digne, laissant le non être pour se joindre à l'être, et logeant en soi* l'infinité du bien: elle prend une merveilleuse accroissance de perfection, elle reçoit de cette sainte créance une influence de bonté, et participe à la grandeur et excellence de la chose qu'elle croit: là où si l'homme s'associe avec la part contraire, son entendement se rend dépravé ne visant qu'au non être, au rien et à l'infinité du mal. Pourquoi il est tenu de croire que Dieu est. Toutes les autres créatures le convient à ce faire par leur exemple. Nature mesure le lui commande: et ne peut faillir de l'en croire: car il est certain qu'elle ne ment pas, qu'elle ne nourrit point en soi la fausseté, et que toute obligation naturelle nous pousse à la venté, non à la mensonge. Voilà la manière de convier à la foi les mécréants, d'apprendre à l'homme d'affermer ce qu'il n'entend pas, et de renforcer et roidir nos entendements à croire plus ferme.

Ces arguments sont irrésistibles; et l'on peut douter que Pascal, qui se proposait le même but que Sebonde, eût mieux pensé et mieux écrit. Au reste, ce chapitre est le meilleur du livre. On peut i joindre cependant le chapitre 67, où Sebon établit la: règle de ce que l'homme doit croire ou mécroire. Nous le rapporterons en entier:

La seconde opération de notre entendement, c'est affermer ou nier, croire ou mécroire: car elle va après l'appréhension. Au reste, elle est divisée en deux effets opposites: d'autant que toute proposition -qui se présente à notre imagination en a aussi une autre entièrement répugnante et contraire; et de ces deux, l'une est par nécessité vraie, l'autre fausse: voilà pourquoi c'est, notre office d'en accepter l'une, et refuser l'autre. Et il n'i a point de doute, par ce que - nous venons de dire, que l'homme ne soit tenu d'accepter, d'affermer et de croire celle là, qui lui apporte plus d'utilité, de commodité, de perfection et de dignité, en tant qu'il est homme, par laquelle il peut engendrer en soi du contentement, de la consolation, de l'espérance, de la confiance, de la sûreté, et en éloigner le déplaisir et le désespoir: et par conséquent qu'il doit embrasser celle qui est plus aimable et plus désirable de sa nature, et en laquelle il i a plus d'être et plus de bien: et nier, mécroire et repousser l'opposite et contraire à celle là, comme fausse et ennemie de son profit. Là où s'il fait au rebours, il abuse contre soi même de son entendement, il renverse entièrement la refile générale de nature, il combat et soi même et l'ordre universel des choses: puis que là ois toutes les autre créature inférieure emploient leurs forces et moyens à leur bien et avantage, c'est ci s'en acquiert sa ruine et le désespoir: et à la venté il a son entendement merveilleusement dépravé et corrompu: voire il ne mente point d'être appelé homme, puis qu'il combat l'homme. Or, s'il me dit qu'il n'i a pas d'apparence qu'il croie ce qu'il n'entend pas, et qu'il avoue pour véritable ce de quoi il ne voit pas la raison: veux qu'à ce compte il pourvoit bien prendre la mensonge pour la certitude, je lui respond, que son ignorance ne lui peut servir d'excuse, et que ceste seule intention d'approuver ce qui est à son profit et à son utilité, lui sert d'une suffisante et juste occasion de croire: attendu que ce que nous faisons selon la règle de nature ne nous peut être imputé à faute, et notre intelligence fait son devoir et le profit de soi et de la volonté toutefois et quantes qu'elle consent à ce qui est son grand bien, et à ce qui est entièrement contraire à la ruine de l'homme: voire elle est obligée d'en user ainsi, parce qu'elle ne nous a été donnée que pour notre service et commodité: ainsi il nous doit suffire de nous joindre toujours à la part qui est de notre coste et à notre avantage, bien que nous ne sachions pas comme 'elle P ét. Car s'il nous venait de choisir le

contraire et la privation de notre bien, nous sachions logerions et recevrions chez nous notre ennemi, qui en déplacerait ceux qui font pour nous; nous serions adversaires et traîtres à o nous mêmes, et en bon escient insensé a tres-digne d'être haïs et châtie par toutes les autres créatures. Aussi c'est un signe évident. Que l'homme est possédé par son- ennemi mortel,' quand il ne veut pas croire o ce qui lui et de plus avantageux: par un & ennemi qui trannise sa volonté et son entendement, et qui les tient liez et garrottez » étroitement pour les empêcher de faire leur n devoir, et pour les ranger par contrainte à » employer leurs effets au dommage de leur » maître, à sa ruine contre tout ordre de » nature.

Ces exemples peuvent donner une idée de la difficulté d'extraire un auteur dont tous les raisonnements se lient, dont toutes les pensées .s'enchaînent, de sorte que la dernière page est .une conclusion de la première. Aussi n'avons-nous pas eu la prétention de tracer une analyse complète de cet ouvrage: notre but n'était que d'en recueillir lé traits les plus saillants, les pagé les plus éloquentes. Quant aux théologiens, ils doivent recourir au livre même En entrant dans un pareil sujet, nous risquions de ne point citer assez pour eux, ou de citer trop pour les autres lecteurs; et, dans cette alternative, le mieux était de nous abstenir. Cependant, pour donner à cette notice tout l'intérêt dont elle est susceptible, nous avons cru devoir la terminer par l'extrait des passages les plus piquants répandus dans le Traité de Sebonde; on y reconnaîtra facilement, et sans qu'il soit nécessaire de l'indiquer, l'origine de quelque pensées de Pascal:

Ce n'est pas peu de chose de pouvoir, non pas ouïr lé paroles seulement, mais lé entendre et leurs significations, de pouvoir remâcher et digérer en notre cervelle la diversité des sentences et des propositions, de montrer et d'argumenter de l'une à l'autre, du moindre au plus grand, de pouvoir à la suite des unes imaginations en engendrer et conclure d'autres.

Le corps ne vit ni ne sent de soi même, ainsi le vivre et le sentir sont pièces, qui lui sont ajustées, et qui s'en peuvent éloigner.

Ce sont les actions vertueuse de l'homme qui doivent embellir l'univers; car il n'a pas son libéral arbitre pour ne rien faire, mais pour. ne faire pas mal.

Toute secte qui met le souverain bien sur les choses corporelles, est fausse; car elle est ennemie de l'homme.

Les éléments, les planté et les animaux » ont un être en l'homme: car il est avec les » éléments, il vit avec les planté, et sent avec » les animaux.

L'amitié mutuelle des hommes tourne toute » à leur profit.

A quiconque on donne l'amour, on donne » aussi toute la volonté et tout l'homme: car » l'amour et la volonté se changent, et sont » transfère en la nature et seigneurie de la » chose aimée.

L'amour est la boucle de la nature.

L'eau court naturellement: de mesure va » il à notre volonté; car elle se coule très» aisément vers l'amour de nous, et s'i repose' » sans l'aide d'autrui.

L'amour de nous même dresse une guerre » contre Dieu; elle est lourde et pesante, celle » de Dieu au contraire.

Les hommes, garnis de l'amour de leur » propre volonté, sont hors de toutes les créatures, voire hors d'eux meure: ils se sont: fait leur Dieu, et ne sont plus créatures, " s'étant anéantis et rejette

au rien, en abana donnant leur Créateur.

L'expérience est maîtresse de toute science.

Dieu a créé ce monde sans peine, sans ennui et sans travail, et i a mis la perfection; car il n'i a faute, ni rien de superflu.

Tout ainsi que par le peu de lumière que nous avons la nuit, nous imaginons la lumière du soleil qui est éloignée de nous: de même, par l'être du monde que nous connaissons, nous argumentons l'être de " Dieu qui nous est caché.

Qui aurait commandé à la nature de nous fournir seulement de deux mains, de cinq doigts, de deux jeux? et qui la maintiendrait toujours en ceste règle? Qui a disposé, rangé, mesuré toutes ces choses d'une si belle et constante manière? Qui leur a donné à chacune sa charge et son office particulier? N'est ce pas celui qui nous fait voir ses miracles aux arbres, qui nous les fait aussi venir. en nous mêmes? Par aventure, serait ce. ton père, ô homme! ou ta mère, qui t'aurait façonné lé membres comme tu les as: mais quoi? tu vois bien qu'ils naissent souvent, grossissent et se façonnent, eux ignorants et endormis: voire quelque fois en despote d'eux et contre leur volonté; et quelque fois aussi eux le voulant et le souhaitant, ne les peuvent pourtant engendrer. Reconnais donc, reconnais hardiment par la noble architecture de ton corps l'immense sapience, fines. timable douceur et bénignité de ton Créateur qui a rangé et organisé tes membres d'une telle puissance, prudence et bonté, qu'il t'a fait la plus belle et la plus excellente créature du monde.

Comparez la condition des chrétiens plaine de tant de belles et grandes espérances et de i tant défiance à celle des infidèles. Comparez le repos et l'assurance qui est en notre âme à la turbulente, inconstante et douteuse erreur, qui tourmente et martyrise continuellement les entendements des voies de cette sainte créance, ignorants, douteux et incertains, en ce qui les concerne principalement comme hommes; car indubitablement ils ne s'en peuvent résoudre que par opinion imaginaire, et appuie sur des fondements frêles, sujets à être debater et controverser en mille manières: de façon qu'il ne se présente sans cesse > à leur âme ainsi irrésolue, qu'une horreur et > épouvantement effroyable des, menacé de > Dieu, qu'une peur continuelle de s'être mes> comptée en chose où il allait du bien souverain de l'homme et de son dernier mal: ils " remâchent et reposent incessamment la dise parité de leur condition à la notre, et voient D avec grand despit et désespéré remords de ' leur conscience, comme de notre mécompte (quand il serait possible qu'il i en est) nous ne pouvons encourir nul danger et nulle perte, et n'en pouvons retomber qu'en ce D même état qu'ils espèrent pour eux et qu'ils se proposent: là où le leur les pousse et les a précipite en un abîme de malheur et d'anguisse immortelle.

Or. sus, homme, jette hardiment ta veux bien Loing autour de toi, et contemple si de tant de membres, si de tant de diverses pièces de cet grande machine, il i en a aucune qui ne te serve. Considère comme le soin et la sollicitude de nature ne vise qu'à ton profit, comme elle a asservi tous ses desseins et tous ses effets à ton seul besoin et utilité, de quelle affluence elle te fournis incessamment de toute façon de biens, jusques aux délices mesures et à tes plaisirs. Ce ciel, ceste terre, c’est air, ceste mer et tout ce qui est en eux, est continuellement embéonné pour ton service. Ce branle divers du soleil, ceste constante variété des saisons de l'an ne regarde qu'à ta nécessité. Tu sens bien la grandeur de ce présent, tu ne le saurai nier. Mais pourquoi ne sais-tu soudain qui en a été le donneur? C'est par ce que ce n'est pas une dette qu'on t'ait payée, ainsi un bienfait Parti de la franche libéralité d'autrui. coûte la voix de toute les créature qui te crie: Reçois, mais paie; prends man service, mais reconnais le oui de ces biens, mais rends en grâces. Le ciel te dit: le te fourni de lumière le four, afin que tu veilles; d'ombre la nuit, afin que tu dormes et reposé: pour ta recréation et commodité, je renouvelle les saisons, je te donne la fleurissante douceur du printemps, la chaleur de l'été, la fertilité de l'automne, les froidures de l'hiver. le bi-

garre mes jours, oré les allongeant, ores les accourcissant, ares le les taille moyens, afin que la variété te rende la course du temps moins ennuyeuse, et que ceste diversité te porte de la délectation.

Habitudes de vertu habillent nature et l'embellissent. C'est ainsi que les belles robes servent à ceux qui en sont vertus de quelque marque de grandeur.

Puisque nous sommes tels que nos actions ont du démérite ou du mente, et qu'elles sont punissables ou digne de reconnaissance, il s'ensuit, veut que l'homme n'a de quoi récompenser ou punir ses oeuvres, qu'il i en a quelqu'un au déssus de lui qui le peut faire.: autrement, ceste qualité particulière lui aurait été frustratoirement attribuée: ses actions mesuré seraient de néant et inutiles: voire qui plus est sa création serait entièrement vaine: et par conséquent, attendu qu'il est la principale pièce du monde, que tout répond à lui, qu'il n'i a rien durette qui n'ait été fait pour son service, il s'ensuivrait que l'entier bâtiment de c’est univers serait inutile, et que tout i serait confus et sans ordre. Si est ce que nous touchons au doigt et à d'oeil que les autres natures jusques à l'humaine sont tres-bien rangées. Or ce n'est point l'homme qui les a ainsi ordonnées: il est donc lui même ordonné et répond par nécessité à quelque autre, ou bien il i aurait en l'univers beaucoup de vuide.... Concluons donc que le monde, et tout ce qui est en lui, est fait pour l'homme, qu'au dessous de l'homme nulle chose n'est faite,pour elle même, ni pour son .bien, mais pour le notre, pour servir à notre corps ou à notre âme, pour notre nécessité, ou utilité, ou secours, ou consolation, ou doctrine: d'où il s'ensuit que nous sommes tenus à .Dieu pour .tout son ouvrage d'une très fermée obligation et solennellement écrite en son livre des créatures. C'est elle qui fait le premier neud, et le premier lien d'entre Dieu et nous; et comme les .autres créatures sont jointes, et se rapportent à nous pour être faites à notre contemplation, ainsi sommes nous attachez et joints à Dieu par notre dette et par ceste obligation.

Si Dieu n'est eu le dessein de nous sauver, il eut.. fait -des le premier four tarir notre race, il eut détruit et dissipé la semence des homme.: veux qu'il ne l'a pas détruite, ainsi conservée et augmentée, certainement il en voulait faire quelque chose de bon: or il n'en peut faire rien de meilleur que de les remettre au point pour lequel il les avait ordonnez. Voilà comme les choses apparentes nous découvrent les conseils intérieurs de notre créateur. Si le monde a été un seul moment sans qu'il est quelqu'un qui est être sauvé pendant ce moment-là, le monde était pour néant, ce que la Providence di. vine ne pourrait souffrir; car cela blesserait l'honneur de sa puissance, sapience et bonté, auquel elle vise par toutes ses actions.

Celui qui cherche la gloire battu hors de soi, sur le rien et le guide: il se fait serviteur et valet de l'inanité même.

La tribulation est à l'âme comme un marteau .qui la frappe, et qui en la battant la fourbit et dérouille; c'est la fournaise à recuire " l'âme.

Au jugement dernier, le livre de notre conscience sera lu à haute voix devant toute " la compagnie.

La vertu, le bien, et perfection de la bonté A consiste à choisir, aimer, et vouloir selon raison et selon l'ordre.

Il y a un livre nommé la Bible, qu'on sait et afferme être à Dieu. Regardons et considérons de âpres, si par quelques signes ou marques nous pourrons découvrir son auteur, et juger de quelle main il a été tracé, divine ou humaine, créée ou créatrice. Il nous faut poser la façon et la nature des mots, la manière de son parler, et puis les assortir et comparer au facteur, et à la facture, pour voir auquel des deux elles reviendront et se rapporteront plus convenablement. Premièrement, il i a cela de singulier et de particulier en ce livre, qu'à vérifier ce qu'il dit, il ne se sert d'aucune preuve,

raison ou argument, et s'i dit choses qui semblent bien mériter, pour leur étrangeté et difficulté, qu'on se servit d'argumentation et de raisonnement à le § persuader. Lé autres livres, pour s'insinuer en notre créance, logent en leur premier front les propositions les plus avouées, et témoignées, s'il est possible, par l'expérience de nos sens: Le notre est bien fait d'une autre sorte. Des l'entrée, il nous présente ces mots: Au commencement, Dieu bâtit le ciel et la terre. Voilà un langage de merveilleuse hardiesse; il assure qu'il i a un Dieu, qu'il a bâti le ciel et la terre, que le monde a eu commencement, propositions plutôt contraires qu'approchantes à l'expérience. Aristote, pour nous en prouver seulement la première, l'a employé lé huit livres de sa physique, et les douze de la métaphysique. Quel signe est-ce, que la Bible face sans nulle preuve un principe de chose si inconnues? Qu'est-ce à dire, que ce livre veuille être creux de chose si importante à sa simple parole? Que serait-ce? si ce n'est, que l'auteur qui parle en lui se sent de telle dignité et autorité, que sans témoignage, sans preuve et sans argument, on se doit entièrement reposer à ce qu'il en dit: que son crédit surpasse outre mesure toute preuve et tout témoignage: et qu'un simple mot parti de sa bouche doit avoir plus de persuasion et plus d'efficace que les raisons et arguments de tous les livres du monde.

A ce morceau d'une éloquence si forte et si imposante, Sebonde oppose les preuves qui se lisent dans le livre de Nature, et termine ainsi:

Voilà la merveilleuse ressemblance, et singulier accord de ces deux livras: ils ont même but et même argument, ils contiennent pareille discipline, et une même instruction différent en ce seulement, que l'un se conduit par argumentation et par preuve, et l'autre par résolution et autorité, et que l'un représente plus l'obéissance, l'autre la maîtrise.... Pourquoi arrêtons résolument que c'est un vrai livre de Dieu que le livre du vieil et du nouveau Testament, et que nous i devons ajuster d'autant plus de fiance, que plus il comprend de matières élevé et super naturelles, et que plus il excède les raisons et argumentations humaines, et notre ordinaire suffisance: car c'est un certain signe et témoignage qu'il part d'une divine boutique, non de celle de quelqu'un de nos compagnons. Plus les articles de notre foi chrétienne semblent obscurs et incompréhensibles, plus ils sentent et retirent à la grandeur infinie de leur auteur, et plus ferme en doivent être tenus par nous et embrassez.

Nous terminerons cette notice par une série de pensées qui s'enchaînent, et forment un seul raisonnement. Sebou examine lé bienfaits de Dieu; il veut, par la grandeur de l'obligation, démontrer la nécessité de la reconnaissance. Il prouve qu'il nous est venu deux choses de la part de Diu, son amour et ses présents; et puisant une nouvelle force dans une idée à la fois touchante et gracieuse, il remarque que l'amour a devancé les présents: Car si Dieu ne nous est premièrement aimée, il n'i aurait eu rien de donné, ni rien de reçu: son amour donc a été le premier donné, et par son moyen tout le reste.

Cependant, dit Sebonde, nous sommé contraints et nécessite de recevoir le bien que Dieu nous offre par un besoin si forcé, qu'il est impossible de nous en passer un seul moment. Refusons pour voir, et disons, je n'ai que faire de son air, de sa terre, ni de son Soleil. Que nous chaut-il de ses bénéfices et de ses obligations, je vivrai bien sans cela? Que l'homme brave hardiment ainsi, s'il peut. Considérons donc notre inévitable et continuel besoin des présent de Dieu, et de l'autre part la franche libéralité de laquelle il nous pourvoit journellement et incessamment de ses biens: comme sa bonté ne nous manque jamais, comme il n'est jamais las ni ennuyé de nous bien faire.

Aussi ces bienfaits se renouvellent-ils sans cesse; notre obligation s'accroît chaque jour. Il est impossible de la faire égarer, de l'effacer, changer, corrompre, ou de la mains tenir de faux: Car Dieu qui l'a écrit de sa sainte main s'est servi pour ce faire de papier et d'encre immortels. Il l'a écrite en nous, en notre âme, en notre corps, en chacune créature: et puis l'a conçue éternellement en la liasse du livre de nature: nous et tout le monde en rendons continuellement

témoignage, elle est ouverte, publique et commune à tout chacun: aussi est-ce l'obligation de l'univers et faite à son occasion.

Mais le paiement doit répondre à l'obligation, et comment payer tant de bienfaits? L'homme n'a rien qu'il puisse dire à la venté et proprement sien que l'amour, d'autant qu'il est logé en la volonté, seule maîtresse, règne et empereur, seule ayant commandement et puissance en l'homme. L'amour est donc tout son trésor, et le joie au le plus honorable, le plus précieux, le plus cher, et le plus sien qu'il puisse donner. En fin ai-je trouvé ce que je cherchais, et tout tel que je le cherchais: quelque chose en nous qui ne . fut pas hors de nous, mais en nous, non en notre corps, mais en notre âme: non en toute âme, mais en sa plus noble partie. Or sus, voilà donc l'homme fourni de bonne et loyale monnaie pour satisfaire à sa dette, et contenter ce grand. créancier: mais aussi qu'il la garde, qu'il la message et réserve toute à ce besoin, qu'il se ressouvienne que tout son amour est voué et destiné à cet usage, qu'il le doit tout à Dieu pour la décharge de son obligation. »

Fin De L'extrait De Sebon.

1436
Raymond Of Sebonde, Spanish Theologian and Professor at University of Toulouse
Theologia Naturalis sive Liber Creaturarum (Natural Theology or the Book of Creatures)
Book on Natural Theology described by Michael Montaigne
1915 article is in “Studies In The History Of Natural Theology”
By Clement C. J. Webb

Fellow Of St. Mary Magdalen College, Oxford; And Wilde Lecturer In Natural And Comparative Religion, 1911-1914
Oxford, At The Clarendon Press,1915

Raymond Of Sebonde

The three theologians we have now considered -- Anselm, Abelard, Aquinas -- are all great men, who may fitly be taken as representative of their respective epochs. In Anselm we saw the understanding at peace with a tradition in the exploration of whose contents it has found its own satisfaction. In Abelard we saw the understanding, equipped with a new critical method, continuing this exploration, and, while no longer able to find satisfaction therein so readily, yet not despairing of doing so, even though perhaps at the price of some purging or remodelling of the tradition. This hardihood, we saw, excited a strenuous opposition on the part of those who could not brook any tampering with tradition or uncertainty as to its contents -- an opposition which, while able to impair Abelard's reputation, did not avail to put his new method out of use; so that the substantial victory remained after all with Abelard. With the recovery of the greater Aristotelian treatises and the study of their Arabian interpreters, the discordances which existed between theological and philosophical traditions became apparent. Just as the traditional struggle of Church and State enabled the individual to work out his political emancipation from each by the help of the other, the ultimate intellectual emancipation of the individual was rendered possible by the struggle of the two authoritative traditions. It was only postponed by the sincere efforts of the great schoolmen to accomplish a synthesis, which by the most influential of them all, St. Thomas, was only accomplished at the cost of abandoning such a confidence in the possibility of a complete rational comprehension of the religious tradition as Abelard had shared with Anselm, and by means of an attempt to establish a hard and fast line between the spheres of Reason and of Faith, which brought men far on the way to that paradox of a double truth, by means of which the latter Scholasticism was to confess its intellectual bankruptcy. The importance of my fourth hero, Raymond of Sebonde, may, in comparison with that of my former three, be said to be factitious.

Two facts which may be called without absurdity accidental have given him a prominence in the histories of Natural Theology which on his own account he scarcely deserves: the fact that he gave to his book the title of Theologia Naturalis, and the fact that Montaigne, having been caused by his father to trans- late it in his youth, used it afterwards as a peg on which to hang the longest of his immortal essays.

Raymond of Sebonde was of Barcelona. The name Raymond was common in those parts. Thus it was a favourite name in the sovereign house of the Counts of Toulouse, and it was borne by that singular personage of the thirteenth century, the schoolman-missionary and father of Catalan poetry, Raymond Lull. Of the life of Raymond of Sebonde we know little. He is said to have been a graduate in arts and medicine, and to have been persuaded, as he passed through Toulouse on the way to Paris, to remain there as professor at the University. At Toulouse he died at a date variously given as 1432, 1434, and 1436. His book is called Theologia Naturalis sive Liber Creaturarum: and opened with a Prologue printed in the earliest editions, but placed on the Index in 1595. Gabriel Compayré, the eminent French writer on education, who in 1877 made Raymond the subject of a thesis for his Paris doctorate, says that the embargo was removed under Benedict XIV. But this statement seems to be incorrect.

For the book is included in the Index printed by authority of that Pope in 1744 and still appears in that put forth under Leo XIII in 1896. But, like all books published prior to 1600, it was omitted from the Index issued by the authority of the last-mentioned Pope in 1900. Most accounts of him that are to be found in encyclopaedias and the like state that the ground of the prohibition of Raymond's Prologue was the exclusive position assigned in it to the Bible as the source of revealed truth; but it is difficult, after the perusal of the offending preface, to believe that this can really have been the reason. No doubt in 1595 any excessive emphasis on the superiority of Scripture over the tradition of the Church might have seemed at Rome likely to afford undesirable encouragement to Protestant controversialists. But no such excessive emphasis is to be found in Raymond's Prologue, and I entertain no doubt at all that what brought down ecclesiastical censure upon it was not its language about the Bible, but its language about the other book of God, the book of nature, language which goes near to making the written Word superfluous.

He says in the condemned Prologue:

The knowledge of the book of the creatures or book of Nature is necessary, natural, and fit for every man; by means of it he is enlightened both as to himself and as to his Maker, and as to the whole duty of man as man; and moreover of the rule of nature, whereby every one also is aware of all his natural obligations, whether to God or to his neighbour. And not only will he be enlightened so as to know all this, but he will be moved and roused of his own free will and with gladness to will and to do it and that from the heart. And not only so, but this knowledge teaches every man to recognize indeed without difficulty or toil every truth that man needs to know whether concerning man or concerning God, and all that man needs to know for his salvation and perfection and progress in the way that leads to life eternal. Moreover, by means of this knowledge man comes to know without difficulty whatever is contained in Holy Scripture, and whatever is narrated or commanded therein by means thereof comes to be known infallibly and with great assurance. So that the human understanding may put aside all disputation and with all security and certitude assent to the whole of Holy Scripture, and is given such assurance that it can no longer doubt on any point of that science; and by it can be solved every problem that needs solving, whether concerning God or concerning himself, and that without difficulty. In this book also is contained the knowledge of all the erroneous opinions of the ancient philosophers and of the heathens and unbelievers; and by means of the knowledge thereof the whole Catholic faith is made known and proved to be true, and also every heresy which is opposed to the Catholic faith and proved to be false and mistaken.

And further by this science any man understands easily all the holy doctors, who are thus, we may observe, duly placed side by side with the Bible. 'Thus this knowledge is as it were an alphabet of all duties, which thus should be known first of all like an alphabet. And so every one who wishes to understand all the doctors and the whole of Holy Scripture should possess this knowledge which is the light of all the sciences.

It is the root and origin and foundation of all the sciences which are necessary to man's salvation.' 'It needs the assistance of no other science or art.' 'It is the first of all, and necessary to man and orders all others to a good end and to what is for man truly true and profitable; for this science teaches man to know himself and wherefore he was created and by whom, what is his good and what his evil, what he ought to do, and to what and to whom he is bound, and if a man knows not all this, of what profit are other sciences to him?

Plainly we have here not a glorification of the Bible at the expense of tradition, but an assertion of the pre-eminent importance of natural knowledge, somewhat in the spirit of Roger Bacon (only Raymond is thinking rather of what lies open to every attentive sense, and not of methodical experimental investigation) and quite out of keeping with the spirit of the Thomistic tradition, which had become authoritative in the Roman Church by the time at which Raymond's Prologue was placed, no doubt for this very reason, upon the Index.

We read again:

This science is accessible alike to laymen and to clerks and to every condition of men and can be had in less than a month and without trouble, nor to possess it need one have learned anything by heart or keep any written book, nor can it be forgotten when once obtained.' 'And it makes man cheerful, modest, kind and obedient, and causes him to hate all vices and sins and so love virtue: it puffs not up nor makes proud its possessor. Moreover it proves by means of arguments which none can gainsay, for it proves by means of what is most certain to every man by experience, that is by all the creatures and by the natural qualities of man himself and by man himself, and by what man knows most assuredly of himself by experience, and above all by the inner experience which every man has of himself; and so this science seeks no other witness than a man's own self. At first this science appears very low and worthless, but in the end there cometh of it most noble fruit.' 'And this science alleges no authorities, neither Holy Scripture nor any doctors, nay rather it con- firms Holy Scripture, and by means of it a man believes firmly in the Holy Scripture. And so in the order of our procedure it comes before Holy Scripture; and so there are two books given us of God, to wit the book of the world of creatures or book of nature, and another, which is the book of Holy Scripture.

The book of Scripture is given to man in the second place, and that when the first book was not available, in that man, being blind, could not read in the first book. But yet the first book of creatures is common to all men, while that of Scripture is not common to all men, since only clerks know how to read in it. Moreover the first book cannot be falsified or mutilated or falsely interpreted.' 'One and the same Lord both created the world and revealed the Holy Scripture and therefore they agree together and do not contradict one another. Yet the first is connatural with us, the second supernatural.'

And once more:

In the book of nature a man can study by himself, and without a teacher, the doctrine that he needs. God created this whole visible world for himself and gave it us as his own natural and infallible book, written with the finger of God, wherein the creatures are as it were letters devised,

not by the will of man but by the wisdom of God, to convey to man wisdom and teaching necessary for his salvation. No man indeed can see or read by himself in this book ever open though it be unless he be enlightened by God and purified from original sin; and so none of the ancient heathen philosophers could read this knowledge, because they were blinded so to the knowledge of themselves, although in that book they did read some knowledge, and all which they had they derived thence.

These quotations sufficiently bear out, I think, my contention that the statement about the reason for which the book of Raymond was placed on the Index, which goes on being copied into one book of reference out of another, cannot possibly be true; but that there is a very obvious reason for the censure in Raymond's doctrine of the all-sufficiency of the book of Nature, the constant reiteration of which might well cause to pass unnoticed such a passing reference as that which denies to the unbaptized the power of reading in it all that it contains. Even if this were noticed, it would still be Raymond's teaching that the whole of the knowledge necessary to salvation could (at least by the baptized) be obtained thence without a further revelation.

The considerable extracts I have given from the Prologue may seem to establish this point; but they may also make you wonder what there was in an author so little conspicuous for grace or charm to take the fancy of a great man of letters. And yet, as I have said, Raymond of Sebonde owes great part of his celebrity to the attention paid him by his illustrious apologist, Montaigne. Montaigne himself has told us at the beginning of the Apologie de Raimond Sebonde 1 how Pierre Bunel, an eminent Latinist from Toulouse (where Raymond himself had taught in the early part of the preceding century), after visiting Montaigne's father at his country seat, presented him, on his departure, with a copy of the Theologia Naturalis; he thought his host, who knew Spanish well, would be easily able to read it, since it was written in a sort of Spanish tagged with Latin terminations (d'un espagnol bayyagouiné en termi- naisons latines), and would find profitable for the times, in which the 'novelties of Luther' were beginning to be talked of and to unsettle the foundations of the received creed. At first the elder Montaigne would seem to have made no use of his friend's gift; but 'some days before his death, he accidentally found it under a heap of other papers put aside, and bade' his son 'put it for him into French'. This Michel dutifully did, and his version (which contains, by the way, the suspect Prologue) is still extant. 'It is an easy task', says he, 'to translate such authors as this, where there is scarce any question of rendering aught but the matter; whereas with writers who have paid much attention to grace and elegance of language, it is dangerous to undertake to translate them; one runs the risk of rendering them into a style less vigorous than their own. It was an occupation quite new for me; but chancing to be at leisure, and being unable to refuse obedience to the command of the best father that ever was, I accomplished it as well as I could; and he took a singular pleasure in it and gave order for it to be printed; which was done after his death. I found the author's imaginations fine, the arrangement of his work good and his intention pious.'

Many folk, he tells us, amused themselves with reading this translation, especially ladies; and the object of his Apology for Raymond of Sebonde is to defend it from two chief objections which he found made to it; one that the Christian faith should not be made to depend on human reasonings; and the other that Raymond's reasonings are weak and easily confuted. Of the book itself Montaigne's judgement is this: 'The author's end is bold and courageous; for he undertakes, by human and natural arguments, to establish and defend against the atheists all the articles of the Christian religion; wherein, to say the truth, I found him so firm and so happy, that I do not believe it is possible to do better in the conduct of that argument, and think that none has done so well as he. This work seeming to me too rich and fine to be the work of an author of so little fame and of whom we know nothing but that he was a Spaniard who professed medicine at Toulouse about two hundred years ago, I once asked Adrian Turnebus, who knew everything, what the book could be. He answered that it was a Quintessence extracted from St. Thomas Aquinas; for in truth, the genius

of that great man, so inexhaustibly rich in learning and so wonderful in subtilty, was the only one capable of such imaginations. In any case, whoever be the first author and inventor of the work -- and there is no reason without better grounds to deny the title to Sebonde -- he was a very sufficient man of great and excellent parts.' Doubtless it was this commendation of an author so much read and admired at the beginning of the seventeenth century that made Raymond of Sebonde's fortune at that time, and that led Grotius, for instance, in the first page of his book, On the Truth of the Christian Religion, to excuse himself for attempting a task already so ably performed by Raymond.

The publisher of the 1654 edition, a certain Pierre Compagnon of Lyons, in his dedicatory preface, addressed to the Chancellor Pierre Séguier, refers to Montaigne's esteem as justifying him in his bringing Sebonde again before the world. But Montaigne Apology has really very little to do with its professed theme. Any one who should expect from it to find Raymond laying the foundations of theology (with Mr. Balfour) in a sceptical distrust of human reason would be disappointed; nor indeed, though the general drift of Montaigne's essay might lead to the expectation, does the essayist anywhere attribute to him such a position. Nothing could, indeed, be less sceptical than Raymond's quixotic confidence in the possibility of establishing by the help of the book of Nature all the articles of the Christian faith; and, if the theology may be considered, as Turnebus suggested, in the light of an extract from St. Thomas, there is no trace in the book of Thomas's characteristic line of demarcation between the spheres of Natural and Revealed Theology. Montaigne himself, as we saw, says that it was a book in translating which one had only to consider the matter. Still he speaks with approval of its style, and even of the imagination shown in it; and one may suspect that the fact that it is being written as a continuous treatise, without the scholastic device of advancing objections and solving them, and without a parade of authorities, and so is for most people more readable, because more continuous, than a treatise in regular scholastic form, told in its favour with so thorough a son of the Renaissance as its great apologist.

We have already given some account of Raymond's glorification in his Prologue of the 'book of Nature' or 'of the Creatures' -- a glorification too unqualified, as we saw, for the sensitive representatives of a tradition claiming supernatural authority in the meticulous days of the Counter-Reformation. It remains to call attention to what may be found interesting in the body of the book. It will be seen that Adrian Turnebus was by no means right in supposing it to be an extract from St. Thomas. After the first four Tituli or chapters, Raymond conveniently sums up as follows what he has so far maintained:

From what has been already said we may conclude the nature of the being of the universe: that it is, as it were, a body orderly divided into distinct parts; has made us ascend by four steps to another Being; and has manifested to us this other Being, by which the whole being of the universe was newly brought forth out of nothing. And in the first being we found that there of necessity existed four grades in all: to wit, being, living, feeling, and under- standing or free will. And moreover we found in it that posse (power or capacity), which does not constitute a grade, but is the foundation of all grades and is also included in all the grades. And thus we have found beyond possibility of mistake, that the Maker of the universe has being, feeling, understanding, will and power; and that in him all these are one and the same with his being. And further we found out the conditions, properties and excellences of the divine Being: how it is a Being that is uncreated, original, eternal, unchangeable, incorruptible, and so forth. And between all these properties there is no inequality; because such is God's life, intelligence, will and power, as is his being. But notwithstanding all things agree with God in respect of their being; yet some things are nearer to him than others in respect of life, some in respect of understanding, some in respect of power; of life, in that he lives for ever; of understanding, in that he is wise, prudent, true and the judge of all; of will, in that he is good, gentle, kind, holy, upright, just, gracious; of power, in that he is almighty. So then we first know God to have being, life, perception, understanding, will and power.

And hereby we afterwards know that all other things have agreement with him; and all things are included in his being. Join then one thing with another and compare them together, and you will understand wonderful things concerning him. For example, join understanding with power and will; because his power is as great as his will and his understanding, and vice versa; because they are all one with another and one and the same with his being; and so shalt thou have the best knowledge of God.

There is nothing in this discussion seriously divergent from the doctrine of Thomas Aquinas; but it is not strictly on his lines. Thus Raymond carefully enough expounds the diversity of the being which we ascribe to God from that which we ascribe to the creature: but he does not say with Thomas that esse is not used univocally -- in the same sense -- of God and of other things. Again, his is a different attitude from that of Thomas towards the Averroist (not to say Aristotelian) doctrine of the eternity of the world, though he mentions neither Aver- roes nor Aristotle in connexion with it -- for he avoids, as we have seen, the mention of authorities. For Thomas held that good reasons could be alleged for it and good reasons against it; neither it nor its opposite could be demonstrated to be necessary; and Revelation alone decides the question for us in a negative sense. This, of course, involves the admission that the eternity of the world is not inconsistent with its complete dependence upon God, whose act of creation, calling it into being out of nothing, might have been exercised from all eternity. Raymond, on the other hand, concludes against the eternity of the world without reference to revelation, mainly from the consideration that it would suggest that the world is necessary to God, and was a necessary emanation of his nature, instead of the free work of his goodness. It is true that this is an argument rather from the fitness of things than from irrefragable principles of reason. But still the line taken is different from that of Thomas.

After another nine chapters Raymond calls another halt and gives another generalis epilogatio. He says:

And so, to sum up all that has so far been shown and revealed to us, 1 by the scale of four degrees in nature we can see how by comparing man, who is in the fourth degree, with other things inferior to him, and them with him, and considering the agreement between them we ascended to the recognition of one supreme and infinite nature which is above man.

The chief argument used was that the source of that in which man agreed with the lower creation is surely one, that man certainly does not impart these to the lower creation, and that therefore we must look beyond him for the source of these and higher qualities in himself.

We thus see that perception, and intelligence were other than at the level of nature. We made, therefore, another scale there; and beginning from being went on to other levels and found that in that Supreme Nature which is our God that being and living, perception and intelligence, are all one. Again, we found that being in God was not produced, not received from another, but eternal; and that by that eternal being and nature the whole being of the world and the whole scale of nature was produced, and that out of nothing, and newly. Moreover, by way of this production of the world from nothing which we had already discovered we ascended to one other production of surpassing excellence and eternal; for the supreme joy cannot be in God without the society and reciprocated love of a Being which is of his own nature; and we concluded this to be the derivation of a Being from the very being of God, and thereby we discovered in the divine nature two eternal Persons, and a production of God from God, and that by way of nature.

Again by this production which we have discovered existing in the divine nature we find that there must also necessarily be there another production out of the Divine Being, which is by way of a will and freedom, whereby there proceedeth a third Person in the divine essence. And so, to sum up,

we found by means of the scale of nature four things, to wit the Divine Being, and three productions of the Divine Being himself; and three things produced from God. The first production, we found, is the production of the world out of nothing and outside of God himself; and the second production is that of God from God within himself, from all eternity, by way of nature. The third production is that of God from the divine nature by way of will. And the two latter productions are eternal and without beginning or end, and never cease. There then are three beings produced: to wit the world, the Son, and the Holy Ghost; and one unproduced, to wit the Father. The Son then is of the Father, the Holy Ghost of the Father and of the Son, and of the Father, Son and Holy Ghost as one the world is produced. From all these premises we may conclude a like division wherein are included all things that exist. Everything that exists is either from eternity and from itself; or not from eternity nor from itself: or from eternity, yet not from itself, but from another. In the first member of this division is the Father, in the second the world, in the third the Son and the Holy Ghost. And so by this process we have discovered God three and one, one in essence and three in persons, of whom are all things, in whom are all things, and by whom are all things, who liveth blessed for evermore world without end.

On this summary we have to observe that it certainly does not represent, as Turnebus suggested it did, the views of St. Thomas. The mind is represented as rising from the consideration of the nature of created things not merely to the discovery of the existence and unity of God, but also to that of the Trinity in his nature. The line drawn by Thomas between the spheres of natural and revealed religion is ignored; and we may also observe, although it does not belong to our present business to do more than observe it in passing, that Raymond's presentation of the details of the doctrine of the Trinity is in several respects different from, and cannot be thought to have been especially based upon, its presentation by Thomas. Some of its language reminds us of Anselm's; and we shall see that Raymond accepted the Anselmic definition, if we may so call it, of Deus as id quo nihil majus cogitari potest, 1 a reminiscence of which occurs also in the section of the book of which we have just had Raymond's summary.

The next occasion on which Raymond, following the convenient practice which has already so much assisted us, pauses to sum up is in the 128th chapter, which I will translate as follows:

But now, summing up by way of epilogue all that has gone before in this book, we may note how, beginning with creatures of the lower grade and mounting up from the first step and lower scale of nature, we gradually arrived at the genuine apprehension and knowledge of God, supremely mighty, supremely wise and supremely good. So that the creatures have led us and raised us by an ascent and staircase admirably devised to God the Creator of all things, considered as the one supreme principle and Father and Creator of all things. And then a second time we were enabled by creatures to go yet further and approach more closely to God himself and to his love; since they led us to love God, and showed us that we were supremely bound to him and under an obligation above all other obligations to love him with our whole heart. And thus, so far as in them lay, they joined us in a bond of marriage with God. Then we came down again from that supreme Creator to the creatures themselves, so that from the love of the Creator we descended to the love of all creatures; since in loving God the Creator we love all his creatures, and all things which are his, in so far forth as they are his. And so we love all creatures for his sake. And thus is made our ascent and descent. First an ascent from the creatures to the Creator, then a descent from the Creator to all creatures. For in the first place we loved the creatures because they were fair and good, and because they were serviceable to us, and so we loved them for our own sakes. But in the second place we loved them for their Creator's sake, because they are his and he made them; nay, we love also our own selves because we too are God's. And this love is perfect, good, enduring, excellent and constant, because it proceeds from the Creator who is the most excellent of all beings, the highest and supreme of all, And in this it is plain that love given to God is not wasted or diminished, nay it grows and is infinitely increased and expanded beyond all measure; since in the love of God

are loved also all creatures and all things which belong to God. And so all are loved by one love and by the power of one love, and there is nothing but is loved in virtue of that love. And therefore our love, when it is given to God, is then most high, most general, and most widely extended.

In the section of which this is a summary occur some of the most interesting passages in the book. What really distinguishes Raymond is not any peculiarity of speculation; for his theology and philosophy present little that is characteristic; it is rather a strong sense of the kinship of man with all parts of nature, which may well have charmed Montaigne. Take such a passage as that which I shall now quote:

There could not be so great an agreement and likeness between man and the trees, plants and animals, if there were two designers, rulers or artificers in nature; nor would the operations of plants and trees be carried on so regularly after the manner of human operations, nor would they all be so much in man's likeness, except that he which guided and directed the operations of these trees and plants were the same Being that gave man understanding and that ordered the operations of trees which are after the manner of works done by understanding, since in trees and plants there is no reason nor understanding. And of far more strength is the oneness of matter and sameness of life in man, animals, trees, and plants an evidence of the oneness of their Maker.

He says a little later on:

So then, how much profit and advantage, how many useful meditations may man gather from this comparison of himself with the lower creatures. Let him not then despise them; for he ought to love them and think upon the likeness and brotherhood which he hath to them and to be made humble thereby and to let his soul rub itself as it were against them (fricare animam suam cum eis)'.

One seems to hear an echo of St. Francis here. He goes on:

For they acknowledge him to be wonderful and more excellent than they in many things; because he is set over them in a most excellent rank and dignity. But yet consider that thou too art a creature; nor for all thine excellence canst thou cease to be a creature. Forget not then that thou art of the number of the creatures and canst not separate thyself from their society, because thou agreest with them in much, being made of the same matter by the same Artificer. Exercise thyself therefore in the knowledge of them, because the more thou knowest them the more thou knowest thine own dignity and shalt obtain a greater and surer knowledge of thy Maker. If thou then wouldst know thyself and thy Maker, see that thou first know the creatures, since the nearer thou drawest to the creatures by knowing them, the nearer shalt thou draw to thyself and to thy Maker. And the farther thou dost remove thyself from the creatures, the farther thou removest thyself from thyself and from thy Maker. If then the knowledge of the creatures increase in thee, there shall increase also in thee the know- ledge of thyself and of thy Maker; and if that be diminished, this shalt be diminished likewise, and if that be annihilated, this is annihilated also; and if that abide, this abideth also, since this is born from that.

There is something individual and impressive in this realization of man's kinship with the lower creation, and this confidence that in the knowledge of this lower creation lies the most ready avenue to the knowledge of God. If the former looks back to Francis of Assisi, the latter looks forward to Francis of Verulam. Raymond goes on to say that:

If we may hope much for our knowledge from the realization of our likeness to the beings below us in the scale of creation, we may hope even more from the realization of our difference from them. This is the crown of the knowledge necessary to our salvation; nor is the former knowledge

profitable without the latter. The beings below us act by nature, not by understanding and will; and hence we rank them according to their respective natural capacities; but men by those 'accidents of free will, which are voluntary and intellectual. By these accidentia intellectualia men are distinguished into many ranks and grades; among such accidents he reckons power, jurisdiction, office, science, skill, virtue, wisdom; these are sometimes acquired by men for themselves, sometimes bestowed on them by the bounty of God. They are accidents, for they may be lost without the loss of essential human nature; yet they 'greatly ennoble man and dignify and exalt human nature, and make one man nobler and even far worthier than another; without them human nature would be as it were stripped naked'. It is, perhaps, noticeable that the list of these accidentia include distinctions of rank as well as of moral and intellectual attainment; and it is, of course, quite true that the one sort of distinction as much as the other is distinctively human, and can only exist among beings possessed of reason.

Only in a clear view, Raymond insists, of the prerogatives which he enjoys above the beasts can man hope to know himself aright and find contentment in thankfulness to his Creator. And here Raymond shows himself a thoroughgoing disciple of Anselm, though according to his usual rule, he makes no mention of his name. The Anselmian definition of Deus -- quo nihil majus cogitari potest -- is represented as a 'rule rooted in man's nature', and he deduces thence, following Anselm's procedure in the Proslogion 1, a more positive representation of God as quicquid melius cogitari potest. The so-called Ontological Argument is given just as in Anselm and accepted as the basis of man's knowledge of God, including that of his triune nature. Once more we see how much the omniscient Turnebus was out in his answer to Montaigne's question. Nothing could be more unlike St. Thomas than this assent to Anselm's ontological argument and this inclusion of the triune nature in what can be known of God by pursuing a clue given by the very nature of our thought.

Somewhat later we find another point worthy of remark, namely, an anticipation by Raymond of that curious doctrine of the criterion of truth which nowadays our friends the Pragmatists so often din into our ears. For the rule of affirmation and negation is said to be utility. Man is by nature bound to believe that which is more useful to him, even if he does not understand how it can be. He who will not believe that to be true which is better for himself puts himself as it were in the power of his mortal enemy. This pragmatism, to use the familiar name, is then assigned as the justification of religious faith. The doctrines of God's existence, of his unity, of the generation of the Son of God, of God's omnipotence, wisdom, and goodness, of his veracity and other perfections; of the creation of the world, of the Incarnation, of the resurrection, last judgement, and immortality of the soul, and finally the Christian religion as a whole, are alleged as examples of what we should believe rather than its opposite in each case, because it does us more good than its opposite. For instance,

We should believe that a man has already ascended into heaven, rather than the opposite of this proposition, because from this follows the highest degree of hope, consolation, security and joy for human nature; while to believe the opposite does no good to man at all'. And thus 'whoso believes and affirms the Christian faith can in no wise incur blame from God or from any creature, because he believes what is better for human nature than its opposite; and though the Christian religion were not true, he would be excused before God and all creatures because he affirms and believes the better and more desirable alternative, and that which more conduces to man's good, his advantage, his perfection, in so far as he is a man; and this he is bound to do.

It is, we must note, only what is best for man as man -- as a rational being, as Kant would say -- that Raymond holds one is thus bound to believe rather than the opposed alternative, not what is best for my private interests as this or that individual. Besides this 'pragmatic' argument others, more familiar, are mentioned, but in subordination to it. There is the argument that Christianity is preached everywhere with promises of rewards to believers, penalties for unbelievers; whereas no

such threats or promises are held out for disbelief of it. This argument amounts to very much the same as Pascal's famous wager. The argument from the martyrdoms of Christians, to the like of which, it is asserted, unbelief in Christianity cannot point, is also mentioned.

To these succeeds an argument for the existence of God of greater weight; that from the implication in the very nature of moral distinctions of the existence of a Moral Governor:

A good argument may be thus constructed. Man can sin, therefore there is a God; and similarly man can do well and have merit, therefore there is a God.

The adaptation to man's wants of his earthly environment is also alleged. The service of man by all creatures is a service of man as man, as God's image, not as this or that individual; hence all men should regard themselves as one man and each love his neighbour as himself. Every man is a brother to every creature of God; but in a more especial sense of every other man, created like him in the image of that God.

The following section of the book is not summarized like the preceding ones; we must mention such points in it as seem to be worthy of notice. Not till we have reached the 206th 'title' is there any question of authority. There the divinity of Christ is proved by the difficulty of believing that his claim to be divine would have been suffered by God to be accepted for so long, had it not been true. No one else has made such a claim; Mahomet, for example, did not. Had the claim not been justified, how could it survive the shameful death of him who made it? How explain the exaltation of the Christians who recognize it and the subjection of the Jews who, were it not justified, would but have executed vengeance on God's worst enemy? Lastly, were not Christ's claim to be divine just, he would be the worst of men and the proudest; and how is that reconcilable with the manifest excellence of his moral teaching and his humble obedience even to the death of the cross? The divinity of Christ thus proved, the divine authority of the Bible is proved. It is found to be entirely in harmony with the book of the creatures, differing only in the manner of speech; the one book teaching per modum probationis, the other per modum praecepti et auctoritatis.

It may be observed that had the Congregation of the Index really desired to suppress Raymond's recognition of the supreme authority of the Bible, it would not have been the Prologue but these later chapters on which their censure would have lit. But it would be a delusion to suppose that, when Raymond spoke of the Bible, he was in any way intending to distinguish its teaching from that of the Church; on the other hand he takes for granted that the whole doctrinal system of the Church as he knew it, Papacy, seven Sacraments, nine orders of the ministry, and all the rest, was guaranteed by the authority of the Bible. In no sense is Raymond a forerunner of the Reformation, nor we may be sure was it as savouring of Protestantism that his Prologue fell under the ecclesiastical censure.

A reader of Raymond will find as he proceeds a good deal that is put with a certain freshness and individuality; but nothing in itself original apart from his enthusiasm for the book of Nature and his confidence that the student of that book will find himself led on without a check to the Christian religion in all its full ecclesiastical development. Christianity is for him, not only in its fundamental principles but in its greatest elaboration, a 'republication of the religion of nature'. This position is developed with ingenuity and not without a certain charm, arising from the obvious sincerity and zeal of the writer; but it implies a certain lack in him of an eye for difficulties. We may part with Raymond of Sebonde with a recognition that, while he is an author whom the curious in such literature will find worth reading, he is not a thinker of very high rank, and owes the celebrity of his name less to the actual merits of his book than to the novelty of its title and to the happy accident which gave him so illustrious a translator and apologist as Michel Seigneur de Montaigne.

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Raymond Sebonde
1994 book by Jaume De Puig, Les Sources de la Pensée Philosophique de Raimond Sebond (Ramon Sibiuda)

Chapitre I - Sa Vie

Nous aborderons l'étude biographique du personnage mal connu qui se cache sous le nom de Ramon Sibiuda 1 à partir de deux séries de sources. On se référera d'abord à quelques documents manuscrits connus qui contiennent le peu de données que nous possédons sur sa vie. Ensuite nous analyserons des documents bio-bibliographiques, oeuvre de compilateurs, auteurs de répertoires, ainsi que de dictionnaires et bibliothèques, dune valeur inégale, parfois même déroutante. L'historien ne peut se passer de ce matériel éparpillé et qui ne contient que quelques brins de vérité, mélangée à beaucoup d'idées erronées. En effet, jusqu'ici les archives n'ont pas fourni assez de documents sur Ramon Sibiuda et il faudra, donc, laisser planer d'importants doutes sur le personnage dont nous entreprenons l'étude.

A- Sources Manuscrites
1 • Les plus anciens documents qu'on possède aujourd'hui et où l'on retrouve des renseignements concernant Ramon Sibiuda sont d'origine toulousaine. C'est M. Fournier2 qui commence la série dans la publication de son cartulaire des universités médiévales du Midi de la France. Il s'agit d'une addition aux Statuts du Collège Saint-Raymond, datée le 17 mars 1429. Ce document se trouve dans un cahier du XVIIIème s.3, où l'on avait eu soin de le recopier, plus les Statuts du Collège et quelques-unes des additions postérieures aux Statuts.

Ce document mentionne au début un reverendus in Christo pater et dominus Ramundus Sebiende4 magister in artibus et rector venerabilis universitatis studii tholosani, à propos duquel on dit qu'il visitavit praesens collegium Sancti Raymundi prout et tenebatur ration sui officii rectoriae, prout dicebat, et pro videndo si collegium erat per administratores eiusdem debito modo provisum.

Le document nous place, donc, en plein milieu universitaire de Toulouse, et nous avons affaire à un ecclésiastique maître-ès-arts et recteur en fonctions pendant le deuxième trimestre de l'année académique 1428 -1429.

2 - Ensuite il y a quelques documents que nous avons eu la chance de trouver dans les Archives de la Haute-Garonne et qui s'étaient jusqu'ici dérobés à la poursuite des érudits. Dans le premier, daté le 21 juillet "a nativitate"6, il s'agit de quelques provisions arrêtées par un conseil de douze professeurs présidé par Hugues Amelli, decretorum doctor canonicus sancti Saturnin, qui siège en fonction de locumtenens domini rectoris videlicet domini Ramundi Sibioude. Aucune précision ultérieure ne venant pas compléter la sobriété de cette donnée, nous retiendrons ceci: en 1434, pendant le deuxième trimestre de l'année académique 1433-1434, Ramon Sibiuda est recteur à l'université de Toulouse. Il est dit aussi qu'il est magister in sacra pagina7.

3 - Dans un document de la même année, daté le 6 novembre, et qui nous détaille le nom de dix professeurs toulousains, nous y retrouvons Ramundum Sebioude sacre pagine magister$.

4 - René Gadave avait signalé un document du 12 janvier 1435, où l'on trouve Ramon Sibiuda en fonction de recteur. Il s'agit d'une réquisition adressée au recteur Sibiuda par Raymond Serène, legum doctor ac regens in universitate tholosana, contre l'admission à l'université de Pierre Pigat, docteur-ès-lois, s'il ne paie pas ses dettes. Notre personnage apparaît sous le nom de R. Sebioude rectoris9.

5 - A la suite de ce document, une très courte minute du 24 janvier de la même année constate encore le nom de R. Sebioude rectoris dicti venerabilis studii'°.

6 - Finalement, un document du 8 mars 1435 rapporte le nom de R. Sebioude parmi une liste de quatorze professeurs'1.

Un fait révélateur: lorsque le nom de Ramon Sibiuda apparaît à côté ou parmi des frères mineurs, des prédicateurs, des carmes, des augustins et des chanoines, il n'est jamais assigné à aucun ordre religieux. Nous avons vu, cependant, qu'il a droit a être appelé venerabilis in Christo pater. Nous en tirerons la conséquence qu'il était prêtre séculier.

Une deuxième remarque, concernant la variété des graphies de son nom: nous venons de trouver Sebiende (mais dans un cahier du XVIIIème siècle), Sibioude, et Sebioude.

Troisième remarque: dans le document de 1429 Sibiuda apparaît comme maître-ès-arts, tandis que dès le début de l'année 1434 il est présenté comme sacre pagine magister.

Dernière remarque: Sibiuda a été recteur du Studium toulousain en 1429, en 1434 et en 1435.

7 - Le document toulousain le plus intéressant sur Ramon Sibiuda ne provient pas des Archives; il se trouve dans le ms. 747 de la Bibliothèque Municipale de Toulouse. Dans ce ms. il existe le texte de son oeuvre Scientia libri creaturarum seu nature et de homme. Nous aurons l'occasion de revenir sur ce précieux ms.12. Pour l'instant, nous nous bornerons à étudier son explicit et la note d'une autre main qui a été rajoutée après l'explicit. D'abord, voici l'explicit:

"Et sic explicit liber creaturarum seu nature seu liber de homine propter quem sunt creature alie inchoatus et inceptus in alma vniuersitate uenerabilis studij tholosani Anno domini M° CCCC° XXXIIII° Et completus et terminatus in eadem vniuersitate anno domini M° CCCC° XXXVI° in mense februarij undecima die que fuit dies sabbati Ad laudem et gloriam et honorem sanctissisme trinitatis et gloriosissime uirginis marie matris domini nostri jhesu xti filii dei Et ad vtilitatem omnium xtianorum et omnium hominum quiquidem liber totaliter comictitur correccioni sacrosante romane ecclesie Deo gracias."

Plus loin, d'une autre main et avec une écriture plus fine, on trouve cette note:

"Hic liber est Berengarij Operarij auctoritate regia notarij tholose habitatoris extractus a consimili copia magistri alrici de Rupe eciam notarij ibidem et correctus per ambos iam dictos notarios subscriptos cum originali libro manu reuerendi magistri ramundi sibiude in sacra pagina in artibus et in medicina magistri compilatoris eiusdem scripto fmitus corrigi die mercurij cinerum XIII mensis febroarij Anno ab incarnacione domini millesimo quadringentesimo tricesimo sexto cuiusquidem compillatoris vita functi penultima aprilis eodem anno anima in pave requiescat Amen Al. de Rupe. Beng. Op."

C'est à partir de cela qu'on arrive à dégager quelques données fondamentales. D'après l'explicit, Sibiuda serait l'auteur de ce livre, Scientia libri creaturarum seu nature siue liber de homme, qu'il commença à rédiger en 1434 et a terminé le samedi 11 février 1436. La note ajoutée en bas de l'explicit nous dit qu'il était maître-ès-arts, en médecine et en théologie. En fin, il mourut le 29 avril 1436. Cependant il semble qu'une contradiction apparaît entre les dates de l'explicit et celles de la note des notaires qui le suit. En effet, il ressort de l'explicit que l'onze février 1436 était un samedi. Or, dans la note des notaires le 13 février de la même année serait un mercredi et notamment le mercredi des cendres, et non pas un lundi comme il le faudrait, si la première

indication de l'explicit ne serait pas mauvaise. D'autre part, si on prend en toute rigueur ces dates, nous aurions ceci: Ramon Sibiuda écrit sa Scientia de 1434 jusqu'à l'onze février 1436; or, les deux notaires toulousains se seraient trouvés dans la possibilité d'en extraire deux copies (celle du ms. et la consimilis copia magistri Alrici de Rupe), de corriger celle de Berenguer Operarii avec l'autographe de l'auteur et aussi de terminer leur travail deux jours seulement après que Ramon Sibiuda aurait fmi son oeuvre.

Toutes ces contradictions ne sont qu'apparentes si l'on fait attention aux problèmes de la computation du temps à l'époque13. En effet, avant 1515 l'année civile commençait en France au printemps et l'on datait "ab incarnatione" (c'est ce que nous voyons faire aux deux notaires civils toulousains); tandis que l'Église datait "a nativitate", c'est à dire en computant l'année à partir du solstice d'hiver. Ainsi, dans la note des notaires il faut sous-entendre 1437 au lieu de 1436. Et ce serait une année après la mort de Ramon Sibiuda (+ 29 avril 1436) que les notaires auraient fini la correction du ms. Effectivement, en 1437 le jour de Pâques tomba le 31 mars. Le mercredi des cendres - 47 jours avant Pâques - tomba le 13 février, date des notaires. Etant donné que l'année 1436 fut bissextile, nous retrouverions facilement que le 13 février 1436 était certainement lundi et que l'onze février - date de l'explicit - était samedi. Nous concluons, donc, avec, Reulet'4:

- Ramon Sibiuda a commencé son livre en 1434 et l'a terminé l'onze février 1436.

- Les notaires toulousains Berenguer Operarii et Alrice de Rupe ont terminé la correction de la copie manuscrite que possède la Bibliothèque Municipale de Toulouse le 13 février 1437, une année et deux jours après que l'oeuvre est sortie des mains de son auteur.

- Sibiuda est mort le 29 avril 1436, deux mois et 18 jours après avoir fini sa Scientia libri creaturarum.

- Le manuscrit de Toulouse 747 peut être accepté comme la copie authentique de l'oeuvre de Sibiuda, la reproduction du texte tel que son auteur l'a laissé, tout au moins en ligne de principe, puisque le travail critique pourrait réserver des surprises. Car, si le ms. de Berenguer Operarii a été écrit d'après la copie appartenant à son collègue Alrice de Rupe, il n'en porte pas moins dans les marges des corrections faites à partir du texte autographe. C'est, du moins, ce que s'engagent à affirmer et à souscrire les deux notaires.

8 - Le ms. 595 de la Bibliothèque Municipale de Rouen apporte une donnée très intéressante. Bien qu'il ne soit pas possible de lire son incipit, car le manuscrit est mutilé, nous trouvons dans l'explicit la constatation que Ramon Sibiuda était in decretis liccenciatus:

" Et sic explicit liber creaturarum seu nature seu liber de homme propter quem sunt creature alie Inchoatus et inceptus in alma Uniuersitate uenerabilis studij tholosani per Reuerendum magistrum Ramundum Sibieude in sacra pagina proffessorem nobilissimun et in artibus et medicina magistrum in decretis eciam liccenciatus compositus anno domini millesimo quadringentesimo tricesimo quarto et completus et terminatus in eadem uniuersitate Anno domini millesimo CCCC° tricesimo sexto in mense Februarij undecima die que fuit dies sabbati ad laudem et gloriam et honorera trinitatis et gloriosissime uirginis marie matris domini nostri Ihesu Xti filii Dei et ad utilitatem omnium xtianorum Et omnium hominum Qui quidem liber totaliter comictitur correccioni sacro sancte romane ecclesie Deo gracias".

Il est évident que le copiste du manuscrit Rouen 595 a voulu intercaler le nom et les titres académiques de l'auteur dans le corps même de l'explicit, à côté des circonstances sur la composition du livre qui y sont mentionnées. Avec l'iluminado 97 de la Bibliothèque Nationale de Lisbonne, c'est le seul manuscrit qui ouvre une telle parenthèse dans cet explicit uniformément

transmis par tous les autres mss. qui le rapportent; et il est aussi le seul qui renseigne sur les études et la licence en droit canon de Sibiuda. Aucun document, aucun ms. en dehors de celui-ci ne fait allusion à la circonstance que Ramon Sibiuda était canoniste. Nous retiendrons cette donnée: elle peut s'avérer très suggestive plus loin, lorsque nous étudierons l'oeuvre sebondienne.

9 - Les manuscrits sebondiens qui restent en dehors de ceux dont nous venons de nous occuper n'élargissent pas notre faible connaissance historique de l'auteur de la Scientia libri creaturarum. Six d'entre eux reprennent l'explicit du manuscrit 747 de Toulouse, mais omettent la note des notaires15. Dans les autres cas, les copistes n'ajoutent rien de nouveau16. Ils confirment ce que nous savons déjà par les documents d'archives et par le manuscrit 747 de Toulouse: Sibiuda enseigna à l'université toulousaine, il était maître-ès-arts, docteur en médecine et maître en théologie.

10 - Toutefois nous devons faire une mention spéciale du ms. 3914 de la Herzogliche Bibliothek zu Wolfenbüttel, peut-être très proche des années qui suivirent la mort de Sibiuda17. Il s'agit d'un petit recueil de douze feuilles; les sept premières contiennent des extraits ex libro Raymundi filii Gaufredi qui inscribitur Theologia Naturalis vel creaturarum sine de homine liber. Les feuilles 8 à 10 contiennent Fracii Africi discipuli Bulbonis Albunizar liber quartus de septem herbis septem planetis attributis, secundum prologum "inventus in civitate Troyana in monumento reclusus cum ossibus propriis regis Kyroni". Dans l'explicit de cette partie il y a cette date: Finitus anno domini M CCCC XXXXIX feria secunda post dominicam infra octavam corporis Xti. Feuille n. 12: Ein plattdeutsches und ein lateinisches Recept gegen di Pocken. Nous n'avons pas encore vu ce manuscrit. En ce qui regarde Ramon Sibiuda, il faudrait d'abord identifier ces extraits, qui, d'après l'explicit par lequel ils se terminent, concernent l'ars operationis magistri Raymundi filii Gaufredi. Ce manuscrit mériterait, nous semble-t-il, toute notre attention, s'il devait se confirmer que la date de 1439 était valable pour l'ensemble du recueil; car il serait le seul qui se réfère à l'oeuvre de Sibiuda en la nommant Theologia Naturalis, titre qui n'était censé d'apparaître qu'avec l'édition de Deventer, vers 1480. En ce qui concerne la donnée selon laquelle maître Raymond serait fils de Godefroid, sans la rejeter, nous préférons suspendre notre jugement jusqu'au moment où nous pourrons étudier la pièce. Nous en prenons acte de forme provisoire. Peut-être un jour les recherches dans les archives la confirmeront ou l'invalideront. A présent, pour elle même, elle ne constitue pas un renseignement de première importance.

Pour conclure, nous dirons ceci: Les sources manuscrites connues jusqu'ici permettent d'établir que Ramon Sibiuda se trouve à Toulouse un peu avant 1428. Car nous savons qu'à Toulouse, pour accéder au rectorat du Studium - trimestriel[$ -, il fallait observer un ordre d'antiquité dans chaque faculté19. Maître-ès-arts et recteur en 1429, il aurait dû être incorporé au Studium toulousain à une date antérieure, impossible à signaler pour l'instant. Puis, en 1434, il est professeur de théologie et commence à rédiger sa Scientia libri creaturarum. Redevenu recteur en 1435, il termine son oeuvre le 11 février 1436 et meurt le 29 avril suivant. Il possédait la maîtrise ès-arts, en médecine et en théologie, et il était licencié en droit canon.

B - Sources Imprimees

1 - Le plus ancien document imprimé qui nous renseigne sur Ramon Sibiuda est le témoignage de l'abbé Trithème20:

"Raymundus Sebeide, nation hispanus, vir in divins scripturis studiosus et eruditus, atque in secularibus litteris egregie doctus, artium et medicine doctor insignis; qui docendo et scribendo in gymnasio tholosano magnum eruditionis sue experimentum dedit. Fertur multa preclara scripsisse opuscula, de quibus ego vidi tantum volumen grande, quod in prefata universitate publice legerat, in cuius principio et multa et gloriosa promittit; de quorum veritate nonnulli sibi applaudunt tamquam experti, quod prenotavit Creaturarum sive de homme, lib. I Ad laudem et gloriam.

Questions disputate, lib. I. Cetera me latent. Claruit temporibus Sigismundi Imperatoris et Eugenii pape quanti Anno domini 1430".

En substance, Trithème nous dit que Ramon Sibiuda était espagnol, professeur à Toulouse vers l'année 1430, auteur du Liber Creaturarum et d'un volume de Quaestiones disputatae, qu'il nous signale ne pas avoir vu. Dépouillé de réthorique, son témoignage n'ajoute à ce que nous avons établi par ailleurs, que ces deux nouveautés: l'origine espagnole de Ramon et l'attribution à lui d'un volume de questions disputés. Accepterons-nous le témoignage de Trithème? On ne saurait pas dire, en tout cas, avec Reulet21 et sans preuves à l'appui, que Trithème fait de Sibiuda un espagnol par méprise ou par distraction 22.

Pour le moment, nous croyons que la donnée de Trithème, vraie dans l'essentiel, doit être retenue, quitte à la contraster avec des données ultérieures, si notre enquête nous en fournit d'avantage. En laissant provisoirement de côté la question soulevée par ces Quaestiones disputatae que Trithème met au compte de Sibiuda, nous acceptons sa donnée: il se peut très bien que Ramon Sibiuda soit hispanus.

2- L'abbé de Sponheim a été copié par le lyonnais Symphorien Champier avec une exactitude remarquable23 et, à son tour, celui-ci a inspiré le toulousain Nicolas Bertrand, qui dit:

"Produxit praeterea Tholosa in medicina doctores solemnes et probatos, inter quos hispanus ille cebeyde vir divinarum scripturarum amator, artium et medicinae insignis doctor apud gymnasium tholosanum evasit: atque a tholosanis studiis eruditionis experimentum magnum habuit: qui plurima grandiaque volumina tholose condidit et apud tholosates publice legit: ut testatur Symphorianus medicinae proffessor in suo volumine scribens ad electum regium lugdunensem&

Ce témoignage n'est qu'une amplification de la nouvelle de Trithème puisée dans le livre de Champier. Nicolas Bertrand ne s'est pas soucié de vérifier lui-même ce qu'il affirme sur Sibiuda. En tout cas, nous noterons que c'est dans un livre consacré à l'histoire de Toulouse dans lequel Nicolas Bertrand ne dédaigne pas inclure l'hispanus ille cebeyde. C'est une confirmation de la donnée de Trithème, que Bertrand aurait pu contester s'il en avait eu les moyens.

Gesner puise dans Trithème 25 et Simler résume Gesner26. Mais avec Scaliger les confusions commencent. Celui-ci, en effet, fera une seule et la même personne du dominicain Ramon Marti (s. XIII), auteur du Pugio fidei, et de notre Ramon Sibiuda:

Raymundus Sebon dominicanus eximius philosophus, sed nimis allegoriis indulgens, et non solum ille Pugio fidei ostendit, sed et liber de Theologia Naturali 27.

Ensuite Scaliger trompera Naudé28, mais celui-ci sera corrigé par Maussac29 en ce qui concerne la confusion de Ramon Marti et Ramon Sibiuda; cependant Maussac fera dire à Montaigne que Sibiuda était un juif devenu chrétien; non content avec cela, il en fait lui-même un barcelonais et place sa mort dans l'année 1432:

"Non est Raymundus Sebon auctor Pugionis, nec eo tempore quo (Scaliger) notavit, vixit, nec dominicanus fuit, nec in hebraicis cum Raymundo comparandus. Sciendum est Raymundum Sebonde nec dominicanum nec in Hebraicis aliisque linguis orientalibus valde versatum fuisse, quamvis eum ex Iudaeo christianum nobis repraesentet Michael a Monte toto capite Apologiae (quo pacto etiam Augustinus Iustinianus Martinum nostrum quod in hebraicis contra esse versatissimus auguratur fuisse Iudaeum), sed tantum hispanum et barcinonensem, atque in Academia tholosana medicinae proffessorem, philosophiae sacraeque scientiae eoque gradu illuc insignitum uti omnes extranei et alienigenae ut hispani, angli, scoti, hivernique, germani et helvetii, si se talibus dignos prebeant

honorum apicibus sincere et &tôtacpopwç soient admitti: diemque suum obiisse anno millesimo quadringentesimo trigesimo secundo, ut, refert Trithemius et post eum losias Simlerus Bibliothecae gesnerianae breviator..."30

Réfuté, plus tard, par Scharbau sur la question du judaïsme de Sibiuda31, Maussac sera copié par Altamura32; mais Pierre Bayle mettra en doute l'affirmation selon laquelle Montaigne aurait dit que Ramon Sibiuda était juif devenu chrétien; pourtant, il suivra Maussac en ce qui concerne l'origine barcelonaise de Sibiuda et la date de sa mort: ces deux points n'ont pas attiré son esprit critique33. De notre côté, il nous semble que l'information de Maussac est trop confuse pour que nous nous engagions à la suivre. II ne dit pas d'où a-t-il puisé l'origine barcelonaise de Sibiuda; les sources qu'il cite, expressément, n'ont pas pu le lui dire. Là-dessus, il faudra encore attendre que les archives fassent un jour toute la lumière.

Sur les traces de Maussac, Moréri reprend ses affirmations (espagnol, natif de Barcelone) et il ajoute qu'étant sorti de son pays pour venir enseigner dans l'Université de Paris, il fut arrêté malgré lui par les écoliers de Toulouse, où il mourut en 1432. Or, d'après Altès Escrivà, ce serait l'éditeur Pierre Compagnon, de Lyon, qui en 1648 aurait affirmé:

"Ante ducentos et plures annos parisiensem Clarissimam totius orbis Accademiam adire volens, patrio Hispaniarum solo relicto, tolosae subsistere Scholasticorum ibi degentium precibus coactus, morte praeventus est priusquam votum solverit".

Sans pouvoir maintenant évaluer l'origine lyonnaise de cette notice, il est clair que Moréri a pu la puiser dans l'édition de Compagnon. Lui-même ne s'y engage pas trop: on dit... Par conséquent, en attendant une meilleure confirmation et sans avoir mené des recherches particulières sur l'affirmation de P. Compagnon, nous n'accorderons pas une valeur de première importance à ce qui s'abrite sous le timide on dit de Moréri.

Nous n'allons pas nous attarder sur ce que disent les auteurs de dictionnaires, encyclopédies et catalogues que nous avons consulté. Ils se copient fidèlement les uns aux autres, on ne dépasse en aucun cas le témoignage de Trithème et les faibles additions successives, vraies ou fausses, de Scaliger, Maussac et Moréri. Dès les documents d'archives en passant par les mss., jusqu'au Dictionnaire des Sciences philosophiques35, les progrès sont rares. Tout ce que nous avons appris de nos sources manuscrites est confirmé; en plus, nous n'avons que l'affirmation de Trithème: natione hispanus. Pour le dire avec le mot de Nicolas Antonio, nous ne parvenons pas à sortir Ramon Sibiuda de son statut de personnage obscuri aeque nominis et
Conditionis 36.

3 - Montaigne parle à deux reprises de Ramon Sibiuda. D'abord dans sa traduction du Liber Creaturarum37, dans la lettre-dédicace à son père; puis, dans le chapitre XII du deuxième livre des Essais, la célèbre Apologie de Raymond Sebond. Montaigne est bien plus qu'un compilateur, sa connaissance de l'oeuvre sebondienne n'est pas seulement externe, il l'a traduite en français, il a eu un long commerce avec les idées de son auteur, à qui il s'est efforcé de donner, en le traduisant, "assez de façon et d'entregent pour se présenter en toute bonne compagnie"38. Il pourrait être une bonne source d'information. Mais il ne dit presque rien. Il n'ajoutera aucune donnée nouvelle à ce que nous savons; il semble même savoir bien moins de choses que les auteurs de dictionnaires anciens et modernes.

Pourtant, il n'hésite pas à affirmer quelque chose. Et d'abord dans la lettre-dédicace à son père:

"... j'ay taillé et dressé de ma main à Raymond Sebon, ce grand Theologien et Philosophe Espaignol, un accoustrement à la Françoise"39.

Puis, dans le deuxième livre des Essais, chap. XII:

Cet ouvrage (la Theologia Naturalis') me semblant trop riche et trop beau pour un autheur duquel le nom soit si peu connu, et duquel tout ce que nous sçavons c'est qu'il estoit Espaignol, faisant profession de medecine à Toulouse, il y a environ deux cents ans, je m'enquis autrefois à Adrien (Turnèbe ou Tournebu), qui sçavait toutes choses, que ce pouvoit estre de ce livre; il me respondit qu'il pensoit que ce fut quelque quinte essence tirée de Saint Thomas d'Aquin' d0.

Montaigne, donc, affirme ici que Sibiuda était espagnol, théologien, philosophe et médecin, enseignant à Toulouse. Au début de l'Apologie il expliquait quand, comment et par l'intermédiaire de qui l'oeuvre de Sibiuda était arrivé chez lui:

.. Pierre Bunel, homme de grande réputation de sçavoir en son temps, ayant arresté quelques jours en la compaignie de mon pere avec d'autres hommes de sa sorte, luy fit present, au desloger, d'un livre qui s'intitule Theologia Naturalis sive Creaturarum magistri Raymondi de Sabonde"

Que ce soit à travers Adrien Turnèbe 42, que ce soit à travers Pierre Bunel43, le peu de choses que Montaigne nous dit sur Sibiuda dérive de sources toulousaines. Cela a son importance. Ainsi, nous trouvons que dans les milieux humanistes de Toulouse, vers la moitié du XVIème siècle, il était courant de considérer Ramon Sibiuda comme un espagnol. On n'en savait presque rien, on le situait chronologiquement dune façon imprécise44, mais ce point était acquis: il était espagnol. Il faut avouer, par la suite, que le témoignage de Trithème est confirmé par cette source indépendante, provenant directement de Toulouse, la ville d'où, si le témoignage de l'abbé de Sponheim n'avait pas été vrai, des contre-indications auraient pu facilement venir. La tradition de l'hispanicité de Sibiuda reçoit un nouvel appui de la part des amis de Montaigne.

4 - Les éditions anciennes du Liber Creaturarum 45, si nous mettons à part les différentes façons décrire le nom de son auteur, en développant et en fixant des formes que nous rencontrons déjà dans les mss. les plus tardifs, ne nous renseignent pas sur sa vie. Elles reproduisent, pour la plus part, l'affirmation qui revient si souvent dans les mss.: Sibiuda était maître-ès-arts, en médecine et en théologie; elles mentionnent, aussi, son magistère à Toulouse. C'est tout.

C - Deux Details Autobiographiques Dans Le "Liber Creaturarum"?
Ce que les documents examinés jusqu'ici nous disent sur Sibiuda est si peu, que nous nous sommes tournés du côté de son oeuvre avec l'espoir d'y découvrir quelque détail révélateur sur sa personnalité ou sur des circonstances de sa vie;1'enquête a été négative.

Cependant, il y a deux endroits où l'on se demande si l'auteur n'apparaît pas derrière ses mots. Le premier de ces textes appartient au titre 162 du Liber Creaturarum; dans ce chapitre, Sibiuda illustre comment peut-on se représenter la tristesse qu'éprouveront dans l'au-delà, tous ceux dont la vie morale aura été enraciné dans l'amour de soi. Il commence par ces mots:

"Primo sic: Nam per experienciam videmus quod quando aliquis poterat habere aliquod maximum bonum sibi conuenientissimum per quod esset exaltatus et ditatus et per totam suam vitam completus, ut uerbi gracia, papatum uel cardinalatum uel episcopatum uel aliquod regnum uel ducatum, uel aliquod officium et maxime in patria propria et in loco proprio, et si iste talis perdat tale et tantum bonum per culpam suam et alius habeas... '46.

Nous ne voudrions pas tomber dans les fantaisies, mais il nous semble que la petite remarque et maxime in patria propria et in loco proprio peut connoter, de la part de son auteur, l'expression de quelque chose de personnel. Trithème et Montaigne nous ont dit que Sibiuda était espagnol. Rien

de plus naturel que le professeur éloigné de son pays souligne (maxime) le bonheur spécial que l'on trouve à réussir chez soi. En fait, si l'on regarde de près cette remarque et si l'on veut la référer aux papatum, cardinalatum, episcopatum, regnum uel ducatum qui ont été évoqués, elle apparaîtra sensiblement déplacée. Par contre, elle accompagnerait aisément l'officium, lui aussi évoqué. Faudrait-il en conclure que Sibiuda aurait tenté en vain d'obtenir quelque officium dans son pays et que, ayant échoué, il le quitta pour Toulouse? Le texte ne nous autorise pas à avancer cette hypothèse. D'autre part, on n'a pas encore trop étudié les liens de tout ordre qui rapprochaient les pays de la Couronne d'Aragon et l'ensemble du Languedoc dans le bas moyen-âge. Sibiuda n'a pas été le premier ni le dernier espagnol ayant enseigné à l'Université de Toulouse. La relation entre les deux pays, si proches par la langue, par la culture de vieille souche latine, même par des souvenirs d'histoire politique très précis, était normale et constante dans les deux sens. Il n'y a, donc, rien de particulier dans le fait que Sibiuda, par des circonstances que nous ne connaissons pas, se trouve lié à la vie universitaire de Toulouse au début du XVème siècle. Mais, alors, les mots et maxime in patria propria et in loco proprio ne se laisseraient-ils interpréter comme une allusion au fait que Sibiuda, professeur à Toulouse, n'en est pas, quand même, originaire? Sans prétendre trancher, nous croyons qu'on doit laisser une porte ouverte à cette suggestion.

Le deuxième texte à analyser se trouve dans le titre 234, dans lequel il est question de l'état de justice originelle. Après avoir établi l'immortalité de l'homme dans cette étape, Sibiuda renchérit:

"Item, sicut homo nollet mortem, ita nollet senectutem nec perdere iuuentutem nec pulchritudinem corporalem nec fortitudinem sed semper uellet conseruari in suo uigore, quia maxima miseria est venire ad senectutem"47.

Bien que, parlant en sens absolu, ce texte ne peut pas être considéré comme une référence évidente à quelque circonstance particulière de son auteur, notre attention a été attirée par la présence du verbe venire. Venire ad senectutem c'est une phrase assez normale sous la plume d'un vieux; un jeune homme, même un adulte, va certainement en direction de la vieillesse, mais c'est du point de vue de l'homme âgé que l'on y vient. Voilà un détail tout infime, non dépourvu, cependant, d'importance dans notre cas, étant donné que nous ignorons la date de naissance de maître Ramon. L'auteur du liber Creaturarum serait-il un vieil homme? En réserve d'informations plus exactes, la question reste posée.

D - La Question Du Nom

Jamais, peut-être, le nom d'un philosophe, fut-il médiéval, n'a subi plus de transformations que celui de Sibiuda. Il se transforme d'abord dans les manuscrits, puis, avec les premières éditions, il se latinise, il est adapté par les traducteurs aux diverses langues, toujours sous des formes plus disparates. Nous pensons que ce sont les documents des Archives de la Haute-Garonne et le ms. 747 de Toulouse qui ont gardé le nom authentique de notre auteur. A remarquer, toutefois, qu'entre le ms. 747 et les documents du registre Assolenti que nous avons étudiés auparavant, l'ancienneté de l'écriture revient au ms. En effet, les documents du registre Assolenti dont nous nous servons ne sont que des copies du XVIème siècle de documents plus anciens, tandis que le ms. Toulouse 747 a été terminé en 1437, comme nous avons vu. Nous pensons, donc, qu'il lui revient de donner la règle.

Or, sans aucun doute, il présente la forme Ramundi Sibiude, au génitif, c'est-à-dire, Ramon Sibiuda. Nous avons eu l'opportunité de le vérifier, nous-mêmes, sur place; dans ce beau manuscrit gothique, le nom de l'auteur ne laisse aucune place à l'hésitation. Cette forme est suivie de près par les documents du registre Assolenti; cependant, la forme Sibiuda ne se trouve que dans le premier de la série, daté le 21 juillet 1434, et elle est transcrite Sibioude. Les autres pièces rapportent déjà Sebioude. La diphtongue ou au lieu de la voyelle simple u que nous trouvons dans

le ms. Toulouse 747 ne servirait peut-être pas à conserver le son originel de la diphtongue iu, qu'on prononce iou au sud des Pyrénées? De ce point de vue, la transcription du nom dans le registre Assolenti serait très rigoureuse, puisqu'elle tiendrait à conserver le nom phonétiquement originel. Mais il est aussi incontestable que cette transcription a pu donner naissance à des corruptions telles que S(a)(e)(i)bieude4s et Sebiende49. En tout cas, il est clair qu'entre la forme la plus ancienne du nom et celles déjà évoluées qui apparaîtront bientôt dans les mss., s'interpose la forme Sibioude. Phonétiquement correcte, du point de vue paléographique cette forme est à l'origine des graphies où apparaît le n: S(a)(e)bunde, Sebonde.

La présomption de F. Stegmüller que le ms. Arsenal 747 serait plus ancien que celui de Toulouse ne tient pas. Stegmüller prétend que Ars. 747 aurait été terminé du vivant de Sibiuda, au moins en partie. Il appuie son affirmation sur l'explicit de ce ms.50:

"Nunc uenerandum librum creaturarum seu nature seu librum de homine propter quem sunt creature alie edidit et compilauit uenerabilis doctor in theologia magister Remundus Sebude eciam in septem artibus liberalibus et in medicina solemnis magister perspicuus, cuius uitam sanitatis incolumitate perfouendam perseueret xtus. Amen".

Le même explicit nous est transmis par le ms. Vat. Reg. Lat. 397, daté le 14 octobre 1438. A cette époque, Sibiuda était mort. Comme il serait erroné de prétendre que ce ms. suppose dans son explicit que Sibiuda était toujours vivant, on ne peut pas tirer cette conclusion de l'explicit du ms. Ars. 747, non daté. D'ailleurs, Stegmüller admet que la forme authentique du nom de Ramon était Sibiuda51. S'il tient le ms. de l'Arsenal comme rédigé en tout ou en partie (ihre Vorlage) du vivant de notre philosophe, on ne s'explique pas pourquoi n'a-t-il pas préféré la forme Sebude de ce ms., ainsi que de Vat. Reg. Lat. 397.

Cela dit, nous renoncerons à examiner le processus de transformation du nom dans les mss. et dans les éditions anciennes. Il nous suffit d'avoir signalé la forme la plus sûre du point de vue documentaire. Ajoutons que cette forme précise, Sibiuda, n'est pas du tout inconnue, et notamment comme nom de famille, dans le domaine linguistique catalan52. Mais nous nous abstiendrons d'en extraire des conséquences trop hâtives.

Nous ne saurions, en effet, déduire de cette seule constatation que Sibiuda était originaire de tel ou tel autre endroit, ainsi que s'y hasardent Stegmüller et, à sa suite, PouS3. Ce sont des données que seules les archives nous livreront, peut-être, un jour.

E - La Langue De Ramon Sibiuda

Le latin de Sibiuda a surpris certains de ses lecteurs par sa saletésa, et Montaigne nous parle du "port farouche et maintien barbaresque" de maître Ramon; le latin du Liber Creaturarum est décrit par lui comme "un espagnol baragouiné en terminaisons latines"56. En fait, Sibiuda n'écrit ni mieux ni pire que tant d'autres auteurs du moyen-âge. Cependant, les spécialistes ont bien noté que son latin a une influence marquée des structures linguistiques romanes. A partir du latin sebondien, Reulet a voulu déduire la nationalité française de Ramon; d'après Reulet, il suit "de si près la construction de la phrase française que bien souvent on la dirait calquée sur notre langue"57. Toutefois, outre le fait que pendant le XVème s. la langue française était, dans le Languedoc, "absolument étrangère" et "entendue de peu de personnes, même parmi celles de premier rang"58, Reulet ne tient pas compte du fait que les exemples qu'il offre pour illustrer l'adéquation du latin sebondien au français pourraient aussi être employés pour démontrer la correspondance du style sebondien au style de n'importe quelle des langues romanes. Telle est la critique de fond qu'a faite M. M. Menéndez y Pelayo à la thèse peu fondée de ReuletS9, en remarquant que tous les exemples fournis par lui s'adaptent bien plus au génie de la langue catalane qu'à celui de la française60. Dune

façon générale, il semble, donc, que la langue du Liber Creaturarum ne peut pas orienter de forme sûre en vue d'établir la nationalité de son auteur.

Nous avons, cependant, relevé une expression typique de Sibiuda et qui n'est pas rapportée par Du Cange comme appartenant au latin médiéval, laquelle se retrouve, en revanche, dans des auteurs classiques catalans de la fin du moyen-âge et du XVIème s. C'est l'expression ad oculum, toujours avec des verbes ou des adjectifs qui signifient voir et démontrer. Ainsi, nous lisons dans le Liber Creaturarum:

.. quoniam ad oculum probatur61; ipsae creaturae quae sunt nobis manifestae ad oculum62; hoc ostenditur et probatur clarissime ad oculum sic63; ut auteur ad oculos videamusM; ordo creaturarum quem videmus ad oculum65; et hoc apparet ad oculum66; possumus hoc declarare ad oculum in corpore humano67; possumus cognoscere manifestissimam differentiam et separationem et distinctionem ad oculum inter homines et omnia animalia68... ", etc.

Cette construction, qui n'est pas latine69, revient dans des auteurs catalans contemporains de Sibiuda et même postérieurs; fait révélateur, elle est employée dans leurs écrits toujours et seulement avec des verbes connotant vision ou démonstration. Nous en donnons d'abord trois exemples extraits de textes contemporains de Sibiuda:

Car la millor e pus vertadera demostraci6 que hom pot fer si és com la cosa és demostrada a ull... Perquè nos, volents satisfer al vostre desig, volem mostrar a ull cour la gent de Catalunya fort valerosa és per tot lo mGn nomenada.

E no veus tu a ull que tothom hic mor e no s'hic perdona a edat ne a llinatge, masculi ne femeni, ne a ric ne a pobre?

E deus acf saber que, no contrastant que les sanctes Escriptures daço hajen malt tractat, empero aquells quj pus pregonament nan parlat ens han informats son estats primerament aquell glorios martir monsenyer sent Dionis en lo libre que feu qujs apella de angelical gerarchia, en la quai posa que aço que aqui tracta de la angelical natura ell hac de hom qui a uyll ho uehé, ça es, de monsènyer sent Pau....

La même expression se retrouve sous la plume de Cristofor Despuig, qui écrit en 1557 "Los Col. loquis de la Insigne ciutat de Tortosa", sa patrie:

Si cert y no sols en esta terra mas en quasi tota Espana, que de Castella y altres moites parts envier pers mides de esta gloriosa sauta per a curar de varios mals y especialment de porsellanes, y ab gran rao, perquè vehuen al ull quant grans y quant continuos miracles es Deu servit fer per la intercesio de ella en benefici dels homens lliuranlos de tan lletges malalties.

... y serà as6 per nostres pecats, que no es de creure que altra cosa sia, perquè vegem clarament al ull la posibilitat de la obra, veyem lobrau y perfet principi que te....

La littérature administrative enregistre, elle aussi, cette expression, qui n'a pas survécu dans le catalan moderne avec le même sens qu'elle avait anciennement. Nous en offrons un exemple du milieu du XVème siècle:

"Item en les coses contengudes en lo penultim capitol designat en les dites primeras ordinacions qui vol que los Juheus haian star tots dins lo Call, attès que per los dits honorables jurats es stat vint a ull que los juheus no caben dins lo dit Call, volen e ordonen que los dits Juheus prenguen star e

habitai en algunes cases qui son fora lo dit Call, en lo loch apellat dejus requesen e assats prop e dauant lo portalet del Cali... "75.

Jusqu'à présent nous n'avons pas trouvé l'expression équivalente au catalan a ull dans les langues romanes que nous pouvons lire; et nous avouons que l'expression ad oculum videre, ad oculum demonstrare nous a bien étonné lorsque nous avons lu le Liber Creaturarum, d'abord par sa nouveauté, ensuite parce que Sibiuda en fait un usage abondant. Or, il semble logique de rapprocher ces deux expressions, le catalan a ull et le latin sebondien ad oculum, par un rapport de cause à effet: c'est à la langue catalane littéraire de son temps où Sibiuda emprunte l'expression ad oculum et son jeu sémantique.

La donnée nous paraît assez intéressante, car elle dénoterait que Sibiuda a pu être élevé dans un milieu certainement catalan et culte (une école d'écrivains?). D'autre part, cette donnée n'en confirme pas moins les données précédentes: l'affirmation de Trithème, le témoignage de Montaigne, le nom catalan de Ramon. Ainsi, nous voyons que des éléments tous divers convergent vers le même point: Ramon Sibiuda serait un hispanus, plus exactement, un catalanus. Faute de données définitives, pour l'instant nous devons nous contenter de cette convergence des signes; au terme de notre enquête, donc, nous nous bornerons à conclure:

Ramon Sibiuda, clerc séculier vraisemblablement catalan, maître-ès-arts, en médecine et en théologie, licencié en droit canon, professeur d'arts et de théologie à Toulouse, où il fut recteur du Studium en 1429, en 1434 et en 1435 au moins, est l'auteur de la Scientia libri creaturarum et mourut à Toulouse le 29 avril 1436, peut-être dans un âge avancé. Nous ne savons pas où est-il né, où a-t-il fait ses études, où fut-il reçu maître dans chacune des facultés, où et quand a-t-il fait ses études juridiques; nous ne savons même pas s'il exerça l'enseignement ailleurs qu'à Toulouse et pour combien de temps. Sa vie se déroula, très probablement, dans le cadre politique et culturel sous la Couronne d'Aragon et du Languedoc toulousain, peut-être dès avant même la fin du XIVème s. jusqu'à l'année 1436.

Chapitre III - Son Milieu Historique Et Culturel

Ramon Sibiuda mourut en 1436; rien n'autorise à prendre le risque de fixer une date quelconque pour sa naissance; toutefois, obligés de décrire sommairement le cadre dans lequel sa vie a pu se dérouler, nous allons fixer un terme a quo conventionnel. Nous prenons, donc, en considération les événements qui se sont produits de 1380 à 1436; il nous semble que cette période de cinquante-six ans suffit à encadrer notre personnage et à le situer dans le cours des événements de son temps.

A - Considerations Generales

L'époque de Sibiuda a été dominée par les faits suivants: le grand Schisme (1378-1417), les conciles de Pise (1409), Constance (1414-1418) et Bâle (1431-1449), dans le domaine ecclésiastique; les questions et guerres hussites (1419-1436) dans le cadre de l'Empire; en France, la guerre civile des armagnacs et cabochiens, avec la reprise de la guerre des Cent Ans dans sa dernière période (1415-1453; Jeanne d'Arc est brulée en 1431); en Aragon, s'extingue la maison de Barcelone avec Joan I (1387-1396) et Martf, dit l'Humain (1396-1410), et monte au trone la maison castillane des Trastsmara à partir du Compromis de Casp (1412). C'est la période la plus brillante des lettres catalanes au moyen-âge.

Epoque dure, critique, amenant de grandes transformations et des troubles dans les esprits. Dans le cadre du Languedoc et du Royaume d'Aragon, cette époque a une caractéristique que nous ne pourrions pas passer sous silence ou minimiser: la recrudescence du prophétisme populaire154. Justement dans le prologue de sa Scientia libri creaturarum, s'adressant à son public pour lui recommander l'oeuvre, Sibiuda ne laisse pas de remarquer:

"Et ideo nunc in fine mundi est summe necessaria omni christiano ista scientia infallibilis, ut quilibet sit munitus et solidatus et vertus in fade catholica..."155

La crise religieuse déclenchée par le Grand Schisme n'a pas eu d'autre effet chez Sibiuda que de renforcer sa conviction que le pouvoir temporel doit être subordonné au pouvoir spirituel:

"Considerent moderni principes qualiter predecessores eorum, quorum ipsi sunt successores, fuerunt subiecti et oboedientes potestati spirituali, cogitent qualiter caput potestatis terrenae, scilicet Romanum Imperium fuerat subiectum spirituali potestati per mille annos et ultra..."156.

A la fin du XIVe et au début du XVe siècle, la question juive a pris un caractère grave en Aragon. L'impuissance devant les vagues de la peste noire déboucha vers une recrudescence de la rage anti-juive, et des "pogroms" se sont produits157. Benoît XIII, pour consolider sa position de plus en plus compromise, a eu l'idée de promouvoir la conversion des Juifs par le moyen de disputes solennelles. C'est à ce but qu'il organisa la Dispute de Tortosa, dont l'échec fut total; à la suite de ces faits, les conditions de vie des juifs parmi les chrétiens devinrent de plus en plus difficiles158. Sibiuda s'en fait écho, lorsqu'il tire les conclusions d'une comparaison entre les peuples chrétien, musulman et juif; pour lui, les juifs sont totalement hors de question dans la vie politique et sociale:

"Genus Iudaeorum est in derisum et opprobium et in vituperium omnium hominum totius mundi et in captivitate aliorum populorum et sine capite et sine terra, et tamen alias fuerunt in maxima dignitate et reputatione et per universum mundum et modo est totum per oppositum et in tali statu fuerunt per mille annos et ultra"159.

En revanche, il n'en est pas ainsi pour les musulmans. Il y a dans le Liber Creaturarum une violente polémique anti-musulmane. Nous aurons l'occasion de voir que Sibiuda a des motifs très précis pour s'engager contre les musulmans. Car, sils ne constituaient plus un danger permanent sur le plan militaire, ils entraient en concurrence avec les chrétiens sur le plan idéologique et religieux. En Aragon, lieu classique de la polémique musulmanochrétienne, se posait le problème des chrétiens convertis à la foi de Mahomet, soit pour échapper à la captivité, soit pour des motifs plus complexes. Le cas le plus célèbre d'un chrétien devenu musulman fut celui du frère franciscain Anselm Turmeda - 1355? -1424? 160, converti entre 1386 et 1390, et nommé par la suite à un poste élevé dans la douane de Tunis, par la grâce du souverain Abou el-Abbas Amedl61. Là il se livra à une discrète activité littéraire: Libre de bons amonestaments (1398), Cobles de la divisi6 del regne de Mallorques (1398), Disputa de lAse (1417), des Profecies d'une date incertaine et, peut-être, le Libre de Tres, ouvrage à caractère burlesque162. Dans ces oeuvres, écrites en catalan et pour un publique chrétien, Turmeda étale une idéologie cynique et sceptique. Puis, en 1420, Turmeda, du nom arabe Abdallah al-Tarjouman, rédige en arabe sa Tuhfat-al-adib (ou al-anib) fi al-radd ala ahl al-salib (Présent de l'homme lettré pour réfuter les partisans de la croix), oeuvre de polémique anti-chrétienne qui n'a pas été connue dans la chrétienté avant le XIXe siècle163. L'affaire Turmeda a fait beaucoup de bruit en Catalogne et, par son activité littéraire et prophétiqueiM, il n'a pas cessé d'avoir une certaine influence à l'intérieur de son ancien milieu. Peut-être mort en 1424165, son souvenir resta et le Libre de bons amonestaments est devenu le manuel dans lequel les enfants catalans s'initiaient à la lecture jusqu'au début du XIXe siècle'. Nous reviendrons sur ce personnage lorsque nous étudierons les sources de la polémique anti-musulmane développée dans le Liber Creaturarum.

Au temps de Ramon Sibiuda, au moment du passage du XIVe au XVe siècle, nous nous apercevons qu'en Aragon la crise intérieure des valeurs chrétiennes est apparue. Les esprits tendent vers le scepticisme167 et l'on se penche avec une attitude nouvelle sur les écrivains anciens, qu'on est en train de redécouvrir partout. La position sceptique, pro-classique et italianisante est représentée

pendant ces années par Bernat Metge (1340? -1413), prince des prosistes catalans du moyen-âge, humaniste élégant qui accumule dans ses écrits les apportations les plus diverses: Cicéron, Ovide, Valère Maxime, Macrobe, Saint Grégoire le Grand, Saint Thomas, Duns Scot, Ramon Llull, Pétrarque, Boccacce168. Au même moment, Francesc Eiximenis O. F. M. (1327-1409) représentera le maintien des idées reçues et l'esprit anti-humaniste'69. Voie moyenne entre Metge et Eiximenis, Antoni Canais (1352-1419), valencien et frère précheur comme saint Vincent Ferrer, mais aux tendances contraires en ce qui concerne l'attitude vers l'époque nouvelle qui s'amorçait, utilisera. les auteurs classiques en vue de livrer bataille contre le scepticisme et le courant paganisant qui commençaient à faire rage parmi les esprits, spécialement entre les gens de cour170. Ainsi, il traduit au catalan le Dictorum factorumque memorabilium de Valère Maxime, le De Providentia de Sénèque, et, sur des textes de Tite Live et du poème Africa de Pétrarque, il rédigera son Scipi6 e Anibal. Mais pour s'opposer aux livres qui exaltaient l'amour profane, il traduit aussi le Soliloquium de arrha animae d'Hugues de Saint-Victorl7l, dont l'influence sera remarquable dans son oeuvre originale Scala de contemplacio172. La position de frère Antoni Canais nous semble assez typique de cette époque, lorsqu'il avoue humblement: "Molles vegades e diverses me abstinch de apparèixer devant persones de gran stament, tementme que no. m entremesclen en alguna difficultat de la quai no. m puscha descabollir" (souvent je m'abstiens d'apparaître devant des gens de premier rang, de peur qu'ils ne m'embarrassent avec quelque difficulté à laquelle je ne sache pas échapper)173. Il entreprend la traduction de Sénèque parce que "lo trobarets tot philosof, qui funda tot son fet en juy e rahb natural" (vous le trouverez pleinement philosophe, fondant tout ce qu'il dit en jugement et raison naturelle)174. Canais, en effet, est conscient des tendances de son temps et il voit qu'elles se répandent surtout "entre homens de paratge, per ço com ligen molt e tots los libres seran adés vulgaritzats, e per ço com conversen ab molt apte hom, e per la rahb natural en què abunden e per la gran speriència de diverses coses en les quais son fets regidors" (parmi la noblesse, parce qu'ils lisent beaucoup et maintenant tous les livres seront rédigés en vulgaire, et parce qu'ils s'entretiennent avec des hommes d'esprit et par le raisonnement naturel dans lequel ils abondent et par la grande expérience de choses diverses qu'ils obtiennent en gouvernant)175. Homme de cour, esprit réaliste, Canais cherche chez les auteurs anciens le remède au scepticisme et à la nouvelle curiosité de son milieu. Nous savons qu'il s'est intéressé aux doctrines lulliennes176, ce qui est très fort pour un dominicain contemporain de Nicolau Eymerich, l'inquisiteur anti-lullien par excellence. Cherchait-il dans les doctrines du majorquin des méthodes spéculatives plus serrées et plus efficaces en vue d'endiguer le courant qui menaçait la foi?

Un autre fait important qui a influencé l'époque de Ramon Sibiuda est la Sentence de Barcelone du 24 mars 1419, par laquelle la bulle contre les oeuvres de Ramon Llull, du pape Grégoire XI, est déclarée nulle, subreptice et sans effet par le légat du pape Martin V, le cardinal Alamanni'77.

Cette considération sommaire de l'époque de Sibiuda manifeste que les causes internes de la longue crise qu'a traversée la chrétienté à la fm du XIVe siècle débouche, d'une part, vers un courant de scepticisme qui se combine avec l'apparition des premiers signes de la Renaissance; à la crise interne s'ajoute la préoccupation face aux apostates de la foi chrétienne qui rejoignent le champ musulman. Un aspect positif de la réponse à la crise interne est donné par le recours aux auteurs payens les plus christianisables, chez lesquels on pense trouver des appuis pour l'orthodoxie et des aliés en vue de combattre les égarements d'une attitude spirituelle nouvelle qui s'amorce et dont on ne sait pas jusqu'où elle peut conduire. Lulle, le champion du dialogue interconfessionel et le grand polémiste des rations necessariae, dont la pensée reste vivante en Aragon, vient d'être rétabli dans l'honneur qui lui revient. C'est, indiscutablement, un contexte de polémique à des niveaux divers que s'ouvre sous nos yeux; nous verrons que l'oeuvre de Sibiuda s'y ajuste d'une façon à la fois précise et originale.

B - L'universite De Toulouse Au Temps De R. Sibiudai78

Fondée en 1229179, l'Université de Toulouse ne comprenait au début que les facultés de droit, médecine et arts, l'enseignement de la théologie étant réservé aux religieux, notamment aux frères mineurs et prêcheurs1S0. En 1360, le chancelier de Toulouse confère pour la première fois la licence en théologie'81, ce qui atteste l'activité de maîtres théologiens en fonctions sur place. La même année, le pape Innocent VI crée la faculté de théologie, dont les premiers statuts seront rédigés en 1366; en 1380 ces premiers statuts seront remplacés et en 1389 des additions viennent compléter les nouveaux statuts, semblables à ceux de la faculté de théologie de Paris1S2. De 1394 à 1425, s'ouvre une période de réformation pontificale de l'ensemble de l'université, dont le résultat immédiat sera l'abaissement du niveau des études et l'avilissement des grades183.

La "collection de collèges" qui était l'Université de Toulouse au temps de Ramon Sibiuda'84 se présente à notre considération comme un corps traversé par toute sorte de tensions. Au niveau académique, l'époque du Schisme d'Occident se solde par "un relâchement de l'organisation du studium, de la discipline et des moeurs, un amoindrissement de conscience pédagogique chez les maîtres, d'émulation chez les écoliers" 185. Pendant de longues années (1398-1409), l'Université de Toulouse s'opposa à l'Université et au Parlement de Paris dans la question de la soustraction d'obéissance à Benoît XIII, que l'Université de Toulouse soutenait1S6. La reprise de la guerre des Cent Ans en 1422 produit à Toulouse un long conflit entre l'Université et le Capitol en raison des activités de certains étudiants anglais "d'origine ou de parti", sur lesquels l'Université entendait faire reconnaître les privilèges universitaires. La lutte dura de 1422 à 1434, entraînant une succession touffue d'événements, avec une grève universitaire de cinq mois, des disputes interminables et des dossiers juridiques imposants187. C'est une époque qui nous apparaît très mouvementée, extérieurement, du moins, peu favorable à l'épanouissement des sciences, et périodiquement agravée par des vagues de peste qui dépeuplaient l'étude188.

La faculté de théologie comprenait au début du XVème s. de sept à huit chaires, dont quelques-unes accessibles aux séculiers189. En fait, il semble bien que la théologie était plutôt l'affaire des religieux; augustins, cordeliers, prêcheurs, mineurs, carmes. Mais dans les documents, à côté des maîtres en théologie religieux, apparaissent des maîtres "in scolis Universitatis", des maîtres "in scolis sancti Augustini Saturnin" (chanoines de Saint Augustin) et des maîtres "scolarum sancti Stephani", la cathédrale'90. Le nombre des maîtres que nous voyons dans les documents jusqu'ici publiés varie d'année en année191, mais la répartition des tâches théologiques universitaires entre les cinq ordres religieux mentionnés, la cathédrale et l'Université même reste constante'92.

Nous ne sommes pas renseignés sur le mode de recrutement des professeurs à Toulouse. Dans le cas des religieux, c'était l'affaire des chapîtres de chaque ordre. Mais, pour les séculiers, nous ne savons pas s'ils étaient nommés par le chancelier, ou s'ils étaient élus par des modes d'élection qui furent plus tard employés, du seizième au dix-huitième siècle, à savoir, la postulatio et la disputatio. D'autre part, il n'est pas exclu que la papauté ne soit intervenue dans cette question. Au quinzième siècle, d'ailleurs, n'était pas très rare l'usage de vendre les chaires vacantes193.

Parmi tous les noms des maîtres en théologie qui ont enseigné à Toulouse au début du XVème siècle, il n'y a que deux auteurs dont les oeuvres aient atteint une certaine notoriété: Jean Capréole, le commentateur thomiste, et Ramon Sibiuda. Nous n'avons pas des renseignements sur l'activité littéraire des autres maîtres ou, en tout cas, leurs oeuvres n'ont pas été conservées. Il est tout de même possible de supposer que chaque couvent se montrait plus ou moins fidèle à la tradition doctrinale de l'ordre respectif.

A Toulouse il était expressément interdit aux séculiers d'enseigner la théologie s'ils n'étaient pas des maîtres-ès-artsi94. Un maître déjà reçu dans une autre université et voulant enseigner à Toulouse devait payer la moitié des droits ordinaires que les nouveaux maîtres payaient au moment d'être incorporés à la corporation magistrale'95.

Quant à la faculté des arts, où, comme nous l'avons vu, Sibiuda a été magister, il semble qu'au début du XVe siècle elle était déjà indépendante de l'enseignement de la médecine196. Dans les documents, nous voyons apparaître pour chaque année un ou deux maîtres artistes "in logica facultate legentes", un ou deux maîtres "in grammatica legentes"197. Tous ces maîtres étaient séculiers.

C - Les Courants Théologiques En Aragon Au Debut Du XVème Siecle

Il n'y a pas eu de faculté de théologie proprement dite à l'Université de Lleida jusqu'en 1430198; toutefois, une activité théologique remarquable a précédé l'établissement de cette faculté. Il n'y a eu de la théologie que dans le couvent des frères mineurs et dans l'école de la cathédrale'99, mais les rotuli de l'Université de la fin du XIVème siècle ne mentionnent que des étudiants en sacre page, aucun magister, aucun licencié200; il faut en conclure qu'on prenait la licence ailleurs, à Paris - c'est surtout le cas des religieux - et à Toulouse principalement.

Dans l'ensemble du royaume aragonnais, la théologie a suivi les grands courants de la pensée classiques au moyen-âge: il y a eu un thomisme, il y a eu des scotistes201, mais le courant lullien, bien enraciné dans le pays, a été suivi et développé. A la fin du XIVème siècle et au début du XVème, le centre le plus important du lullisme catalan se trouvait à Valence202, mais il y avait aussi des lullistes à Lleida, dans les milieux universitaires203. Il ne manquaient pas, en plus, des ermites qui gardaient la tradition lullienne de façon intégrale204; cette tradition était considérée comme la tradition en quelque sorte nationale et les rois aragonnais, d'abord, puis les rois espagnols de la maison d'Autriche l'ont soutenue à fond 205.

Nous verrons dans la deuxième partie de cette étude comment tous ces éléments ont joué un rôle dans la formation et l'organisation de l'oeuvre de Ramon Sibiuda. Avançons ceci: le Liber Creaturarum est une oeuvre de temps de crise. Si, d'un côté, elle semble couper toutes les attaches avec l'époque immédiatement précédente, en fait elle ne cherche des solutions originales qu'en prolongeant la tradition augustinienne du moyen-âge, après avoir tenté de l'adapter aux temps et aux circonstances nouvelles.

Chapitre IV - Description Du "Scientia Libri Creaturarum"

Avant d'entrer dans l'étude des sources de la pensée philosophique du "Scientia libri creaturarum", nous allons jeter un coup d'oeil sur son contenu, sur la méthode de travail sebondienne et sur le caractère général le plus marqué sous lequel cette oeuvre se présente à notre considération. Ceci offrira l'opportunité de traiter quatre questions qui définissent assez vigoureusement le tempérament philosophique de Ramon Sibiuda; ce travail préalable accompli, nous pourrons entreprendre avec plus d'aisance l'étude des sources proprement dite, qui constitue l'objet central de cette recherche.

A - Distribution Delà Matiere 1- Division Generale

L'étude du contenu et de la distribution de la matière du "Scientia libri creaturarum" nous servira d'abord pour exposer les thèmes dont l'oeuvre s'occupe; ensuite, nous signalerons quelles sont les parties philosophiques qui vont retenir principalement notre attention.

Le "Scientia libri creaturarum" est une oeuvre à structure linéaire; les questions s'y enchaînent suivant une logique interne qui se veut rigoureuse; cette rigueur étant portée jusqu'à ses conséquences extrêmes, nous avons affaire à un livre qui ne présente pas les divisions classiques en questions et en articles. Tout ce qu'on a pu faire avec le manuscrit tel qu'il est sorti de la main de son auteur a consisté à ajouter des numéros devant les rubriques que l'auteur lui-même mettait en tête de chaque paragraphe ou chapitre. Mais il ressort des manuscrits les plus anciens que même

cette numération - vulgarisée ensuite par les éditions - n'avait pas été envisagée. Sibiuda a voulu écrire une oeuvre où chaque problème, où chaque thème est lié à celui qui le précède par une relation logique. Pas question de distinguer des parties, des questions, des articles; pas question non plus de développer certains points de doctrine en en faisant l'objet de conclusiones déterminatives ou magistrales. Dans le "Scientia libri creaturarum" les thèmes sont structurés moyennant des liens logiques immédiats et successifs; tour à tour, ils se présentent d'emblée et disparaissent pour laisser la place au suivant.

Par contre, dans ce livre à sens unique, les récapitulations du chemin parcouru ne manquent pas; cela permet de suivre aisément la démarche de l'auteur. C'est pourquoi nous allons prendre ces récapitulations à rebours, car c'est vers la fin de l'oeuvre que nous y trouvons celles qui sont les plus générales; en les suivant de près, nous arriverons à dégager le schéma détaillé de l'ouvrage'

Dans le titre 322, nous avons la récapitulation la plus générale de tout le livre, et nous pensons qu'elle révèle, avec une grande clarté, l'intention dernière, le but profond que poursuivait l'auteur:

Quoniam autem liber iste seu ista scientia est de homine ut in principio dictum est, ideo opportet tractare in ipso libro omnia quae pertinent ad hominem, de principio usque ad fmem, et totum processum hominis sive humanae naturae. Et quoniam data est iam in isto libro cognitio de homine sufficiens et ostensum est

- quod homo factus est a Deo et quod propter ipsum facta sunt omnia, - et qualiter homo obligatur Deo et ad quae obligatur, et quod homo in quantum est talis naturae est praemiabilis et punibilis in suis operibus, et ostensum est totum debitum hominis,

- et ostensum est etiam qualiter homo fuit lapsus a suc primo statu et qualiter facta est operatio, et ostensum est quomodo per Sacramenta surgit de lapsu et sanatur et reducitur ad statum primum, ut possit operari et facere opera quae debet facere, si vult.

Si ergo duo opera quae Deus fecit circa hominem iam praecesserunt, scilicet opus conditionis et opus restaurationis seu reparationis, ideo non restat nisi opus glorificationis et praemiationis seu finalis retributionis, quia tria opera Dei sunt circa hominem, ut dictum est, et etiam includitur in istis opus gubernationis 2.

Une science totale de l'homme, avec toute son histoire: création, chute, rédemption, vie future. Les termes du théologien de métier sont mis à l'oeuvre consciemment: opus conditionis, gubernationis, reparationis, glorifications, voilà ce que, selon l'auteur, contient le "Liber Creaturarum". Ceux qui ont parlé de "somme" à propos de l'oeuvre sebondienne ont raison. Mais ce n'est pas une somme comme les autres; elle a la particularité d'être axée sur l'étude de l'homme. Les titres 1 à 321 contiennent l'étude de la création et de la réparation de l'homme; du titre 322 au 330, Sibiuda étudie les questions relatives à la vie future, à la glorification ou à la condamnation de l'homme.

Remontons maintenant le cours d'une centaine de titres; le titre 223 ouvre la considération de la chute de l'homme; c'est le premier acte ou le prologue, si l'on veut, de l'opus restaurationis. Dans ce titre Sibiuda résume ce qu'il a entendu faire dans les titres antérieurs, lorsqu'il travaillait dans l'opus creationis; il nous apprend un point de vue qui englobe tous les aspects de l'homme en tant que créature:

... omnia quae pertinent ad hominem concluduntur in istis duobus, scilicet in debito et in facto, quia ipsum debitum est ius et ipsa solutio factum: sed ipsum debitum est primum et praecedit, et factum debet sequi post debitum; et ipsum est ultimum et complementum debiti... Et quia ista

scientia est de homine in quantum homo est, et docet cognoscere hominem, et cognitio de homine consistit in duobus, scilicet, in cognitione ipsius debiti et in cognitione ipsius facti seu facere, et cognitio ipsius debiti praecedere debet cognitionem ipsius facti, quod non est nisi tamquam lumen ad cognoscendum ipsum factum... Ideo postquam habemus infallibilem cognitionem de debito hominis in quantum homo est, ad complendam totam cognitionem de homine necesse est nos habere cognitionem de ipso facto ipsius hominis et de suo facere: utrum ius et facere concordant in homine... Usque enim modo non tetigimus hominem nisi superficialiter et in generali, ostendendo suum proprium debitum, nunc autem tangemus ipsum in visceribus et in profundo et in particulari tangendo proprium factum 4.

C'est à dire, du titre 1 à 222 (opus creationis), il s'agissait d'une considération de l'homme a priori, de jure, tel qu'il doit être pour qu'il remplisse toutes les éxigences que son état de créature lui impose; tandis que dans les titres suivants, 223 à 330, Sibiuda introduit une considération historique de l'homme, de facto. Remarquons l'opposition des deux points de vue: superficialiter et in generali se dit du premier mode de considération; par contre, le second atteint l'homme in visceribus et in profundo et in particulari. Remarquons aussi la coloration morale, voire juridique de l'ensemble: cognitio de homme consistit in duobus, scilicet, in cognitione ipsius debiti et in cognitione ipsius facti.

Le "Liber Creaturarum" s'ouvre, donc, par un traité "de opere conditionis", équivalant à une considération théorique et morale de l'homme, tel qu'il doit être - titres 1 à 222 -; il se poursuit par un traité "de opere redemptionis" - titres 223 à 321-, équivalant à une considération historique de l'homme; et il se termine par un traité sur l'eschatologie - titres 323 à 330 -. Des trois grandes divisions, les deux dernières sont strictement théologiques: c'est le thème du salut chrétien, des moyens de se l'approprier dans l'Eglise et de la consomation finale dans l'au-delà. Ces thèmes ne retiendront pas d'une façon particulière notre attention, qui est portée plutôt vers les thèmes de la première partie; ceux-là, d'après la récapitulation qu'en donne Sibiuda dans le titre 222, sont les suivants:

Ecce igitur qualiter per scalam naturae habentem quattuor gradus distinctos invenimus

- primo divinam naturam esse et exsistere ab aeterno sine principio et sine fine,

- deinde invenimus totam scalam et omnes creaturas contentas in Scala a Deo processisse a nihilo per creationem;

- deinde invenimus obligationem hominis ad Deum.

- Ulterius invenimus immortalitatem animae hominis, ita quod invenimus hominem habere animam immortalem, et per consequens quod erat compositus ex duabus naturis, scilicet corporali et spirituali. Et reduximus quattuor gradus scalae ad duas naturas in generali, scilicet, ad naturam corporalem tantum, quae nihil habet immortale, et ad naturam mixtam ex corporali et spirituali, quae habet aliquid immortale;

- et ultimate per istas duas invenimus tertiarn naturam, quae tantum est spiritualis, quae dicitur angelica natura.

Existence de Dieu, création, l'obligation de l'homme en tant que créature à l'égard de Dieu, existence des anges. C'est à partir des titres 1 à 222 où Sibiuda développe les problèmes qui ont un intérêt philosophique plus direct, puisqu'ils sont traités indépendamment d'un cadre théologique précis; tandis que dans les titres où il étudie la condition historique de l'homme "pro statu isto", la pensée de maître Ramon dépend essentiellement de données théologiques, en regard desquelles

une spéculation intellectuelle et humaine ne peut jamais prétendre à des démonstrations purement philosophiques. C'est, donc, à partir de l'étude des titres 1 à 222 que nous pouvons dégager les orientations fondamentales de la pensée sebondienne; en étudiant maintenant les articulations internes de cette partie, nous ne nous bornerons qu'à les esquisser.

2 - Articulations De La Premiere Partie: Titres 1-222

Maintenant nous prenons comme point de départ le titre premier, qui annonce le plan général de la première partie ou opus conditions avec très peu de mots:

Primo opportet videre et considerare ordinem rerum inter se, et diversos gradus rerum ordinatarum in universo et considerare quamlibet rem in se, et quid habet in se ipsa. Secundo, hoc considerato, opportet comparare hominem, qui est supremus inter res mundi, ad omnes alias res. Et ista auteur comparatio fiez duobus modis, scilicet, secundum convenientiam primo, et secundo secundum differentiam, ita quod necesse est considerare quam convenientiam habet homo cum aliis rebus et quam differentiam 5.

Cette comparaison par convenance et par différence aura, respectivement, deux moments: elle sera, d'abord, conduite d'une façon générale, generaliter, ensuite dune façon particulière, specialiter. La comparaison par ressemblance, qui va livrer toute la métaphysique de Sibiuda, comprend les titres 1 à 59; la comparaison par différence, qui donnera son éthique, comprend le reste jusqu'au titre 222, quoique à la rigueur le processus comparatif s'arrête au titre 128, les parties suivantes - un important traité sur l'amour, titres 129-173, et un traité sur les autres devoirs de l'homme, titres 174-222 - se rattachant à ce qui précède comme des développements complémentaires.

A) Comparatio Per Convenientiam Et Primo Generaliter

Une fois établi que l'homme est le degré suprême de l'échelle de nature comprenant quatre degrés: ce qui est, ce qui vit, ce qui sent et ce qui comprend6, Sibiuda déclenche son dispositif comparatif. Il cherche d'abord les ressemblances qui relient l'homme aux degrés inférieurs de la nature. Et il trouve:

... illa ergo quae sunt in aliis rebus trium graduum sunt in homine... Sed tamen debet homo considerare quod illa quae res inferiores habent divisim homo habet omnia illa coniunctim et simul 7.

A partir de cette constatation, la question se pose de savoir d'où vient et comment est maintenu l'ordre universel qui fait que chaque degré de la nature soit et reste stable dans ses structures, sans se mélanger avec les autres, puisque ce n'est pas, évidemment, l'homme celui qui a assigné son lot et son poste à chaque chose. Il va, donc, s'en suivre l'existence d'un ordinateur universel et unique:

Omnia ascendunt ordinate de gradu in gradum, de minore ad majus, semper ad digniora ascendendo. Ergo unitas ordinis demonstrat unum solum ordinatorem, unum gubernatorem, unum artificem, qui tant diversa coniunxit in uno ordine8.

Remarquons que Sibiuda ne fait que prolonger au delà de l'homme la poussée inscrite dans la gradation et l'ordre de l'univers:

Si ergo plures et innumerabiles naturae rerum et diversae quae sunt in mundo tendunt ad unam solam naturam et non ad plures tamquam ad superiorem et digniorem eis, et uni soli serviunt et non pluribus, videlicet, humanae naturae: Ergo multo magis humana natura debet tendere ad unam solam naturam sibi superiorem et non ad plures; et servire uni soli naturae et non pluribus naturis9.

Nous avons ici le genre de raisonnement qui assimile ce qui est premier dans un ordre donné à la cause efficiente de cet ordre de choses. Menant cette dialectique jusqu'au bout, Sibiuda reclamera pour la nature supérieure à l'homme, vers laquelle tend tout l'univers, une unité qualitativement plus grande que celle qui se manifeste dans Monime:

... inferiores naturae quae serviunt humanae sunt plures et diversae in individuis: humana natura est una in natura et in specie, sed pluris et diversa in individuis. Ergo illa natura quae est supra hominem et quae dominatur homini debet esse una in natura et in specie et una in individuisto

Cette nature, comble de l'unité, séparée des autres degrés de l'être, mais les reliant et soutenant tous, c'est Dieu:

Et hoc est divina natura omnia ordinans, omnia regens et etiam omnia conservanstt

De l'unité de Dieu, Sibiuda passe directement à son infinité par ce raisonnement:

Divina natura quae est supra omnes creaturas debet esse maior quam omnes aliae... Sed humana natura est infinita in possibilitate, quia est multiplicabilis, quantum est de se, in infinitum... sequitur quod divina natura sit infinita magis; et hoc non potest esse niai actu, quia inter actum et potentiam nihil est medium. Et quia nullo modo potest multiplicari in individuo, sequitur quod iota infinita actu est in uno individuo, et extra illud individuum non potest esse 12.

La découverte de l'existence de Dieu est le premier fruit du travail consistant à comparer l'homme et les choses qui l'entourent. Maintenant Sibiuda appliquera la même méthode comparative en vue de pousser plus loin la recherche sur Dieu:

Postquam per ipsos gradus comparando unum ad alterum, homo ad tantam notitiam ascendit quod invenit suum factorem quem non videbat esse realiter et existere unum numero et acte infinitum, non debet desistere ab inquisition: immo magis debet laborare si poterit ipsum magis cognoscere in speciali, scilicet, qualis sit, quales conditions habeas. Et hoc comparando istos quattuor gradus ad ipsumt 3_

Si nous avons, d'abord, trouvé les quatre degrés de nature unifiés dans

l'homme, maintenant Sibiuda va les déceler en Dieu, mais d'une façon éminente: l'homme avait l'être, la vie, la sensibilité et l'intelligence comme des choses reçues; Dieu, au contraire, les possède a se et, ne les ayant reçu de personne, il les possède sans aucune limitation, infiniment et de toute éternité. La théologie sebondienne se fondera dans l'étude de la façon d'être en Dieu les quatre degrés de nature, à commencer par la qualité première d'être, sur laquelle il s'étendra longuement, pour étaler les thèses principales de sa métaphysique (titres 9-24).

Selon Sibiuda, de l'analyse de l'être de Dieu, conçu comme une plénitude totale:

... esse fortissimum, potentissimum et virtuosissimum, elongatum in infinitum ab omni fragilitate, debilitate et impotentia...14,

et qui doit entretenir un rapport fondamental avec tout ce qui existe en dehors de lui, l'idée de création se dégage nécessairement:

Postquam ergo sunt duo esse vers et indubitata et unum est primum, non acceptum ab aliquo neque sumptum, per se existens, aeternam et immutabilissimum et sustentatum, necesse est quod aliud esse, quia non est idem quod primum esse, oriatur et veniat a primo esse: alias esset aequali alteri

esse, quia non esset acceptum, et hoc est impossibile, ut sint duo aequalia esse prima. Ergo esse quod sequitur aliud ab esse primo, quod a nullo est acceptum, oritur ab illo. Et quia primum esse non potest dividi, neque diminui, neque mutari: ideo impossibile est quod aliud esse possit recipi de illo esse: ergo necessario opportet quod ortum sit de non esse totaliteris

Les attributs de Dieu sont aussi étudiés en rapport étroit avec les quatre degrés de nature que Dieu, et lui seul, posséde en forme éminente:

Quamvis autem omnia conveniunt Deo per suum esse, tamen magis appropiate aliqua conveniunt ci per vivere, aliqua per intelligere, aliqua per possel6

Ainsi, Sibiuda parvient à parler de Dieu avec un langage et avec des catégories toujours basées sur l'expérience des hommes; même lorsque la portée des raisonnements dépasse ces catégories, on ne cesse pas par là de continuer à s'y référer.

Après avoir étudié la création du monde et les attributs divins, Sibiuda introduit le thème de la Trinité. D'abord, cette affirmation, qui a été dégagée dans des raisonnements antérieurs: Dieu a créé le monde à la façon d'un artisan:

Deus, qui est ipsum esse aeternum, produxit totum esse mundi tamquam artifex, non de proprio esse nec de propria natura, sed de nihilo, quod in infinitum elongatur ab ipso 17.

Or, il y a dans le monde deux sortes de production: la production artificielle et la production naturelle. Celle-ci est plus noble, plus digne, plus radicale et plus convenable à l'homme, en tant que tel. Après qu'on a vu Dieu produisant le monde ad extra, ne devons-nous pas nous demander s'il n'y aura pas dans l'être divin de production intérieure et non plus artificielle, mais naturelle? Comme l'être du monde nous a conduit vers l'Etre suprême, la production du monde renvoie à une autre sorte de production divine, plus noble et sans comparaison avec la production du monde:

Hoc ergo nunc investigandum, an sicut Deus tamquam artifex produxit totum mundum de nihilo, ita in quantum Deus, producat de sua propria natura et de suo proprio esse alterum aliquem, et sic per unam productionem possumus arguere alteram esse de necessitate, sicut per unum esse arguitur aliud esse de necessitatet 8.

Il faut remarquer que, tout comme auparavant Sibiuda a rencontré Dieu en haut de l'échelle de nature qui par les créatures mène à l'homme, maintenant il arrive à la Trinité, en partant de considérations intramondaines. En outre, il parle même de nécessité à l'égard des productions divines:

Quod auteur in Deo est productio de sua natura de necessitate, et non possit aliter esse, ostenditur muftis rationibus 19.

Les arguments qu'il présentera en faveur de cette nécessité reposent sur ce postulat: Dieu, être parfait, ayant produit un monde où des êtres imparfaits se communiquent leur nature, on ne peut pas prendre le risque de supposer qu'à l'intérieur même de Dieu il n'y ait pas de communication de nature. Cette communication de la nature divine ne pouvant pas comporter multiplication de l'essence, Sibiuda avoue qu'il est impossible de savoir comment en Dieu la communication de nature ne nuit pas à son unité, mais il ne renonce pas pour autant à l'affirmer. Au demeurant, pour lui la création resterait une énigme, si l'on ne suppose pas les productions trinitaires:

Sic ergo comparando productionem artificialem et naturalem invenimus quod est impossibile productionem artificialem de nihilo esse primam, immo necesse est productionem naturalem

praecedere productum secundum artem. Et sic per productionem mundi de nihilo factam a Deo, manifestatur nobis alia productio in Deo, quae est de suo esse proprio 20.

La première démarche de la méthode sebondienne nous a mené très loin. En étudiant les quatre degrés de l'échelle de nature et en les mettant en rapport les uns avec les autres, puis avec l'homme en particulier, nous avons été conduits vers l'affirmation qu'il existe une nature suprême et infinie, dans laquelle nous repérons en état éminent les degrés fondamentaux de l'être qui existent séparément dans la nature.

Ensuite, la considération de l'être divin jette un nouveau rayon de lumière sur le monde, qui apparaît désormais comme créé. En partant du monde comme créé, du monde comme quelque chose de produit per artem, Sibiuda nous élève à la considération des productions intérieures dans la divinité. Au delà de la Trinité il n'y a plus rien à chercher; Sibiuda arrête sa démarche et cesse d'appliquer la comparaison par convenance générale. La moisson ayant été superbe, il tentera d'autres exploits dans des directions nouvelles.

b) Comparatio per convenientiam secundo specialitef
La comparaison par convenance in speciali apporte relativement peu. Dans quatre titres - 56 à 59 - Sibiuda rappelle les ressemblances de l'homme avec les degrés inférieurs de la nature. Le ton devient moral et la comparaison tourne vers le genre pondératif et oratoire:

Ex quo tu, homo, potes concludere quod tu es opus magni Dei, qui de isto modico grano (de illo modico semine patris tui) tot diversa et mirabilia membra extraxit, et quod ille idem qui in arboribus ordinavit fieri tot diversitates mirabiles, sicut radices, truncum, frondes: illemet ordinavit quod de ita modico grano patris tui tot mirabilia membra et diversa, sicut in corpore tuo, exirent 2l.

La conclusion qui se dégage de cette comparaison spéciale de l'homme avec les trois degrés inférieurs de la nature c'est une confirmation de ce qui a été précédemment établi: il n'y a qu'un seul et même ordinateur de toutes choses, Tout-puissant et Providentiel. Comme dernière vue métaphysique, un chant à l'unité de la matière et de la vie:

Vide quot species arborum, herbarum, plantarum ac animalium, et tamen omnes de eadem materia... Noli ergo oblivisci quia es de numero creaturarum nec separari potes de consortio earum, quia magnam habes cum eis convenientiam, scilicet, eandem materiam et eumdem artificem 22.

c) Comparatio per differentiam et primo generaliter:
per habere. Dans le titre 62, Sibiuda aborde la comparaison par différence en annonçant que cette partie livrera des connaissances fondamentales:

... nunc videamus quomodo homo differt ab omnibus rebus inferioribus trium graduum, quia haec est clavis et secretum totius cognitions et naturae humanae et totius boni.

D’une façon générale, l'homme se distingue des trois degrés inférieurs par le libre arbitre. Lorsque Sibiuda parle du libre arbitre, il entend parler, en fait, de la totalité de l'esprit humain:

Differt homo ab aliis gradibus per suam dignitatem et nobilitatem, co quod habet nobiliorem et digniorem naturam super alias res, et per istam différentiant dignitatis suae bene consideratam cognoscimus quod habet maximam dignitatem naturalem inter omnes res quas videmus: habet enim liberum arbitrium, ita quod habet rationem per quam iudicat, intelligit et discernit omnia et habet voluntatem liberam et naturalem libertatem, ita quod non potest cogi23.

L'homme, donc, être intelligent et doué de volonté, règne sur toutes choses et a des pouvoirs qui le distinguent de tout ce qui est au dessous de lui. Bien que l'homme soit le "culmen" de l'univers créé, cependant il ne saurait pas s'élever au dessus de Dieu. Son intelligence, les pouvoirs de sa raison ne sont pas adéquats à l'univers divin. Etre qui pense, l'homme ne saurait se situer par sa pensée au delà de ce que Dieu est. Sa condition fondamentale de créature le lui empêche:

Et quia creatura non potest ascendere supra suum creatorem, ideo impossibile est quod homo per suum intelligere et cogitare ascendat supra Deum, qui creavit esse, et etiam qui eum creavit et dedit ci omnia ista... Sequitur ergo quod homo non potest intelligere neque cogitare in corde suo, neque desiderare quod maius est et melius suo conditore. Aliter homo esset maior cogitando quam suus conditor existendo, et esset aliquid maius in creatura quam in creatore; quia quod cogitatur est in corde; et hoc est absurdum valde24.

Les mots quod cogitatur est in corde se retrouvent aussi dans le Proslogion de saint Anselme (chap. IV), où Sibiuda a puisé tout ce qui va suivre. Nous voyons se développer une interprétation de l'argument de saint Anselme tout à fait nouvelle, comme nous aurons l'opportunité de voir plus loin, lorsque nous étudierons l'influence de saint Anselme sur la pensée de Ramon Sibiuda. Pour l'instant, remarquons qu'il transforme le point de départ de l'argument du Proslogion en une de ses regulae:

Regula autem quae radicatur in homine est ista: quod Deus est quo nihil maius âbjiitrti potes[Et ideo sequitur quod Deus est quod quidquid melius cogitari poteit, et quidquid est melius esse quam non esses.

Cette règle a une place précise dans la pensée de Sibiuda:

iste modus cognoscendi est propinquissimus homini, quia ex propria cogitations et ex proprio intelligere potest probare omnia de Deo, nec opportet quod quaerat alia exempla extra se, nec aliquod testimonium quam semetipsum26.

Il va l'appliquer ensuite, dans une sorte de mouvement rétrospectif, à la déduction de toutes les vérités sur Dieu qu'on avait déjà découvertes. Puisque Dieu est id quo maius cogitari non potest, Sibiuda met en oeuvre une dialectique qui permet de réaliser à l'infini des propositions sur Dieu, lesquelles apportent beaucoup de consolation et de joie:

Et per islam regulam potest homo certitudinaliter attribuere Deo sine dubitatione infinitas proprietates et dignitates, per quas habebit magnam consolationem et gaudium, et hoc per istum modum dicendi: Deus est ita bonus quod non potest cogitari melior...27.

Toutefois cette exploitation affective de l'argument du Proslogion

débouchera sur une des pièces maîtresses du système sebondien. La règle que Sibiuda a dégagée de l'argument anselmien se rapporte selon lui à la première fonction qui différencie l'homme de toutes les autres créatures: la faculté de

comprendre. L'homme comprend tout ce qui ne va pas au delà de Dieu, Dieu étant celui au delà duquel on ne peut rien penser. Mais l'homme est aussi un être qui juge, et cette deuxième fonction essentielle le place encore plus au

dessus des autres êtres. C'est pourquoi, déduit Sibiuda, l'homme doit faire garde lorsqu'il émet des jugements intéressant son bonheur ou son malheur in

quantum homo est. Terrain délicat celui de la destinée de l'homme! Sibiuda

s'apprête à donner une règle pour bien diriger le jugement de l'homme dans ce domaine:

Ideo valde utile est et necessarium omni homini habere artem affirmandi vel negandi, ut homo sciat quid debeat affirmare vel negare, seu concedere vel refutare, et sit vertus et non dubius: non quidem ut habeat artem affirmandi et negandi omnia, sed solum quae pertinent ad

hominem in quantum homo est28.

Ce ne sera qu'une règle, une orientation qui laisse intacte la liberté, mais qui n'en engage pas moins l'intelligence, parce que cette règle est fondée dans la nature même de l'homme. Cet engagement de l'intelligence, cependant, ne vise pas tellement le contenu de ce qu'on doit affirmer ou tenir pour faux que l'obligation spécifique de nier ou d'affirmer:

Ideo dabitur haec ars affirmandi et negandi quae magis pertinent homini in quantum homo est... non quidem quod propter hoc homo de facto concedat et affirmet et recipiat et credat, sed quod cognoscat debitum et obligationem affirmandi et credendi: ita quod quilibet homo videbit se esse obligatum de iure naturae ad affirmandum et credendum, quamvis de facto non affirmet nec credat29.

Règle, dont l'énoncé ne paraît pas évident, qui a pour but de montrer obligation de penser telle ou telle chose, abstraction faite du fait de la penser)u de ne pas la penser 1 Sibiuda l'énoncera ainsi:

Homo de iure naturae debet et tenetur affirmare, credere et recipere illam partem tamquam quae magis est ad eius utilitatem, ad eius bonum et meliorationem, perfectionem et dignitatem et exaltationem in quantum homo est, per quam generatur in homine gaudium et laetitia, consolatio, spes, confidentia, securitas, et fugatur tristitia, desperado ab ipso homine, et per consequens sequitur quod debet affirmare illam partem tamquam veram quae magis est amabilis, desiderabilis de se et de sua natura, et quae magis habet de esse et de bono, et aliam partem oppositam tenetur negare tamquam falsam et a se fugare tamquam inimicam Bibi. Si autem homo facit oppositum, tunc utitur intellectu suo contra seipsum et contra hominem et habet intellectum corruptum et deviatum. Et quamvis non intelligat quomodo fieri potest nec quomodo potest esse verum, non est excusatus quin teneatur affirmare vel credere3o

Cette règle de nature n'est que l'envers, appliqué à l'homme, de l'usage que

Sibiuda fait de l'argument ontologique. L'homme pense, et il est tenu de penser sur Dieu ce qu'il y a de plus haut, noble et positif; l'homme juge,

donc il est tenu d'affirmer tout ce qui le promoit, le dignifie et l'exalte. Si, en reprenant l'argument anselmien, Sibiuda partait de la considération de l'homme comme créature, il y revient encore sous un autre aspect à propos de sa règle de nature:

Quaelibet res habet id quod habet ad sui conservationem et utilitatem, et non ad suum malum et damnum: et cuilibet rei data sunt omnia quae habet propter bonum suum, et non propter malum31.

Cette règle de nature une fois établie, on va tout de suite prouver que, la foi chrétienne convenant au plus haut degré au bonheur humain, elle doit être

affirmée et son contraire nié:

Sequitur exinde quod quilibet homo tenetur de iure naturae credere fidem christianam et negare eius oppositum32.

Elle avait été recherchée en vue de cette fin, et Sibiuda lui donnera une souplesse extraordinaire: elle prouve le bien fondé de l'existence de Dieu33, de la Trinité34, des attributs divins35, de la création 16, de l'incarnation 37, de la résurrection des morts38, de l'ascension39, du jugement dernier40, et de l'immortalité de l'âme41. On devine l'usage qu'on pourrait faire de cette règle. Sibiuda se contente d'arriver à la conclusion que, du point de vue naturel, la religion chrétienne n'est nullement un dérèglement de l'esprit, mais au contraire, une donnée tout à fait positive pour l'homme:

... Ulterius sequitur quod fides christiana nullo modo est contra naturam, immo pro natura et pro bono naturae, ad complementum naturae et ad eius perfectionem, quia est ad exaltationem et dignificationem naturae humanae... Ulterius sequitur quod qui credit et affirmat fidem christianam nullo modo est increpabilis, neque a Deo neque ab aliqua creatura, quia credit quod melius est pro humana natura 42

Jusqu'ici maître Ramon a étudié, d'entre tous les éléments qui distinguent l'homme du reste de la création, l'élément différentiel intelligence. Il aborde ensuite la liberté. Constatation préalable:

Homo in quantum homo operatur ex libero arbitrio, sed alise res operantur ex necessitate 43

Conclusion: l'opération de l'homme relève d'une nature autre que celle des animaux. Pour Sibiuda, les animaux poilus aguntur quam agunt44. Mais l'homme agit vraiment et son action est bien à lui, parce que c'est lui-même qui la détermine, et c'est pour cela qu'elle lui est imputable. L'action humaine porte l'homme au delà de lui-même, elle a des conséquences ultérieures:

In homine remanet aliquid quod non est opus, sed sequitur ad opus, et hoc est meritum vel demeritum45.

L'univers moral se déploie: Si l'homme est responsable de son action et de ses oeuvres, si elles lui sont donc imputables parce qu'il en tire du mérite ou du démérite, il faut qu'il y ait une sanction. Mais l'homme en tant que tel ne peut pas s'appliquer la sanction que réclame son agir. Il faut, donc, qu'il existe au delà de l'homme un rémunérateur qui puisse couronner le mérite de l'action humaine ou en réprimer la perversion:

Sic ergo opera hominis in quantum homo est necessario concludunt aliquem esse maiorem supra hominem, qui sit praemiator et punitor, remunerator et retributora6.

Le rémunérateur, bien entendu, doit être en mesure de connaître parfaitement l'homme; ainsi, sa science est immense. Devant assurer l'exécution de la sanction, il faut que son pouvoir y suffise; il doit être, aussi, souverainement juste et, en fin, il ne peut y en avoir qu'un et un seul. La rémunération doit être proportionnée à la qualité de la liberté humaine, qui est spirituelle; c'est pourquoi la sanction relève d'un ordre spirituel, transcendant l'espace et le temps. Par sa nature, la rémunération divise les hommes en deux champs, qui doivent un jour demeurer absolument écartés l'un de l'autre. C'est ce qui donne à penser qu'au delà de la terre il y a deux endroits distingués et séparés où la sanction est administrée.

d) Comparatio per differentiam secundo specialiter: per cognoscere se habere.
On a vu les éléments qui distinguent l'homme des autres créatures, ce que l'homme avait en plus. Maintenant Sibiuda attire notre attention sur la conscience de soi humaine. Non seulement l'homme est placé au plus haut degré de l'échelle de nature, mais lui, et lui seul, il le sait. Et il sait que les

autres choses ne savent pas ce qu'elles ont et ce qu'elles sont. C'est pourquoi seul l'homme jouit de ce qu'il est et de ce qu'il a. Il s'ensuit que toutes les créatures ont été créées pour l'homme, qu'elles n'ont pas leur fin en elles mêmes, mais dans l'homme; et il s'ensuit aussi que, si l'homme est conscient de ce qu'il est et de ce qu'il a reçu, c'est pour qu'il puisse remercier au nom du tout créé celui qui a fait le don. Ainsi l'homme est tenu de satisfaire un dû universel à son créateur:

... quia ex dare et recipere et ex dando et recipiendo oritur obligatio

naturalis ex parte recipientis, et omnis qui dat aliquid bonum sive donum libere, voluntarie et non ex necessitate obligat ilium qui recipit, et hoc maxime si illud qui recipit non potest esse sine illo donc. Quia ergo solus Deus dat et solos homo recipit et omnia suret homini data libere et voluntarie et non ex necessitate naturae, ergo ex omnibus his concluditur infallibiliter naturale debitum ac necessaria et naturalis obligatio hominis ad Deum creatorem omnium; et quod solos homo

tenetur naturaliter et necessario in hoc mundo Deo, et quod aliae creaturae non teneantur Deo de his quae habent, sed solus homo obligatur Deo pro omnibus creaturis insimul, et pro qualibet in particulari. Et sic omnes creaturae clamant et testificantur naturaliter solum hominem in hoc mundo esse obligatum pro ipsis47.

Tout sert à l'homme, dit Sibiuda, tout lui est occasion de joie ou d'enseignement; son obligation vis-à-vis du Créateur n'en est que plus grande. Mais ce n'est seulement pas à cause des créatures qu'il doit remercier Dieu, mais surtout à cause de lui-même, car ce que Dieu a voulu lui communiquer est plus grand que le monde, vu que le monde est destiné à son service. Dans trois beaux titres48, Sibiuda développe un court traité sur la valeur et la dignité de l'homme, où il se montre bien éloigné de la spiritualité du contemptus mundi et prélude clairement les accents de l'humanisme renaissant. Puis il considère l'obligation contractée par l'homme en tenant compte de la qualité du Dieu donateur. Enfin, il se demande comment l'homme rendra à Dieu son dû'et cette question le mène à se demander qu'est-ce que l'homme, en tant que tel, peut donner en échange du bien qu'il a reçu. Ce sera l'amour:

Quia Deus dedit libere, sponte, voluntarie et gratis, sine necessitate, sine coactione et ex sincero aurore et ex tali libertate et spontanea voluntate et tali amore tamquam a radice tota est obligatio: ideo necesse est quod retributio et recompensatio conformis sit et correspondens, scilicet, quod sit libers, spontanea, voluntaria et non coacta... Sola auteur voluntas potest dare et primum quod dare potest est amor. Ergo amor est primum donum voluntatis et maius et preciosius quia est donum liberalissimum, spontaneum et voluntarium et nullo modotest cogi vel aufferri, nec tolli per violentiam ipsi homini invito9.

Amour que Dieu accepte et par lequel l'homme est assimilé à Dieu, et qu'il offre aussi au nom des créatures. Ici Sibiuda voudra que l'homme s'instruise à partir des créatures pour savoir comment doit-il rendre à Dieu son amour:

Est igitur regula et doctrina certa et infallibilis et generalis homini quod ita debet se habere erga Deum ad dandum Bibi servitium, amorem, timorem et honorem et omne quod debet suo modo, sicut creaturae inferiores se habent erga ipsum hominem ad praestandum ei servitium et beneficium suo modo..., ut sicut creaturae serviunt ei, ipse serviat Deo suo modo nec cessare debet donc ita faciat50.

Ainsi l'homme se trouve placé en qualité d'intermédiaire entre Dieu et les créatures, et c'est dans ce rôle qu'il découvre une nouvelle dignité aux créatures, puisqu'il est porté à les aimer in quantum Dei sunt, cet amour s'inscrivant aussi dans l'obligation générale que l'homme a d'aimer son Créateur.

Sibiuda résumera très bien tout le chemin parcouru dans la récapitulation de cette partie qu'il situe au titre 128. Il y a eu un double procès: des créatures à Dieu, de Dieu vers les créatures:

Creaturae nos duxerunt et elevaverunt quasi per quamdam scalam ordinatissimam ad Deum creatorem omnium; ... et iterum ipsae creaturae duxerunt nos profundius et intimius ad ipsum Deum, quia duxerunt nos ad amandum Deum, et in amorem eius, et ostenderunt nos summe obligatos esse ipsi, et ad eum totaliter amandum. Deinde descendimus ab ipso summo creatore ad ipsas creaturas, ita quod per amorem creatoris descendimus ad amorem omnium creaturarum: quia amando Deum creatorem amamus omnes creaturas, et omnia quae sunt sui in quantum sunt sui. Et sic amamus omnes creaturas propter ipsum: et sic fit ascensus et descensus 5l

e) L'amour et les autres devoirs de l'homme

Ensuite Sibiuda développera dans 45 titres un traité sur l'amour, où on ne parlera pas moins de l'amour de Dieu que de l'amour humain. Sibiuda rappelle que l'amour est notre seul bien à nous et qu'il faut savoir en user convenablement:

Nihil habemus in nobis quod vere nostrum sit et quod totaliter in nostra potestate consistat nisi solus amor; et per consequens thesaurus noster, totum bonum nostrum est amor bonus, et totum malum nostrum est amor malus 52.

Cette doctrine de l'amour veut instruire l'homme pour qu'il rende son amour à Dieu, puisqu'il le mérite par sa qualité de donateur, et en même temps pour qu'il soit détourné de l'amour de soi-même. Il n'y a pas de grands desseins métaphysiques dans cette partie, mais elle a un intérêt particulier du point de vue psychologique et mystique, et elle illustre comment un théologien du début du XVe siècle réalise le souhait gersonien d'insister davantage en théologie sur la charité.

Sibiuda compare l'amour de Dieu et l'amour de soi-même - toujours la méthode comparative - et il montre comment notre bien se trouve dans l'amour de Dieu et notre malheur dans l'amour de nous-mêmes. Il analyse les conséquences qui découlent de l'engagement pour l'amour de Dieu: fraternité humaine, joie, épanouissement dans l'éternité du bonheur qu'on goûte en germe dans ce monde; en revanche, s'enfermer dans l'amour propre ne cause que des divisions entre les hommes, tristesse, prolongement dans l'éternité de toutes les frustrations humaines qui accompagnent l'égoisme. Cette étude sur l'amour se rapporte souvent aux résultats des parties précédentes, surtout aux titres où l'on a étudié l'obligation de l'homme vis-à-vis du créateur, et débouche sur les modalités concrètes qu'aura dans l'au-delà la rétribution de la vie morale de l'homme sur terre. C'est un excursus délicieux, dans un style sapientiel et moral, où nous voyons palpiter un esprit à la fois fin et élancé.

Dans les 32 titres qui suivent le traité sur l'amour, premier dû de l'obligation naturelle, Sibiuda étudie les autres devoirs de l'homme à l'égard de son créateur: la crainte, l'honneur, la gloire. Il oppose toujours la crainte, l'honneur et la gloire qui s'originent de l'amour de Dieu et la crainte, l'honneur et la gloire éphémère qui découlent de l'amour de soi-même. On revient toujours au même refrain: comme l'homme est tenu de donner son amour à Dieu par loi de nature, il- doit aussi lui accorder l'honneur, la gloire, la confiance, etc.

Ces deux traités résument la morale qu'on pourrait appeler spéciale de Sibiuda, ils constituent son traité "de virtutibus et vitiis", et ils renferment les aspects mystiques de sa spéculation. Il s'agit toujours d'une morale de la créature. La loi morale fondamentale n'est pas autre que l'obligation naturelle dont on a déjà parlé, la vertu consiste dans l'amour du Dieu créateur sur toutes choses, le vice n'est que l'amour de soi-même; la rétribution du bien agir sera un bonheur éternel, celle du mauvais agir une tristesse également éternelle.

Les titres suivants, 206-216, constituent une transition. On y développe des thèmes tels que la divinité du Christ, le bien fondé de la doctrine chrétienne, on y polémique contre les musulmans et on démontre que la Bible contient la parole de Dieu. De l'éthique on passe à l'apologétique. Le rapport de ces chapitres avec ce qui précède résulte un peu forcé. En effet, Sibiuda introduit le thème de la divinité du Christ par le biais du précédant traité sur l'honneur de Dieu; le lien logique entre les deux parties est si radical que simple: Jésus doit être considéré comme le Fils de Dieu, vu que depuis mille et quatre cents ans on l'adore comme tel et que Dieu, pour préserver son honneur bafoué au cas où Jésus ne serait pas son fils, n'a pas riposté d'une forme manifeste contre cette adoration. Donc, les chrétiens ont raison de maintenir leur foi, qui est bien supérieure à celle des musulmans, puisque les chrétiens croient à Jésus, qui est Dieu, tandis que les musulmans ne croient qu'à un homme purement homme, Mahomet, un simple prophète, tout au plus. Pour déceler dans la Bible la marque authentique de la parole de Dieu, Sibiuda s'en tient au critère suivant: la parole humaine, lorsqu'elle veut enseigner quelque chose, est faite de preuves, de raisonnements, d'efforts de l'intelligence. Dieu. au contraire. ne saurait être cru aue sur parole. nar sa propre autorité. Or, voilà que la Bible ne prouve rien de ce qu'elle affirme, mais assure, impose, commande, menace... On en conclut son origine transcendante.

Sibiuda élargira encore cette transition de son ouvrage avec six titres où il développe le thème de l'immortalité de l'âme, qui a déjà été étudié plus haut, et un court traité d'angélologie. Si l'établissement de l'immortalité de l'âme a un intérêt apologétique certain, et c'est pour ça que Sibiuda y travaille une fois de plus, on n'en peut pas dire autant de l'angélologie, que notre auteur introduit dans son oeuvre de la manière la plus artificieuse:

Postquam est et existit realiter natura corporalis et natura spiritualis simul coniuncta in una persona, ut in homme; et ultra hoc etiam natura corporalis est et existit per se separata: quare etiam non exit et existet natura spiritualis creata per se, sicut natura corporalis? Unde fieret iniuria naturae spirituali seu intellectuali, quia natura corporalis haberet duos modos existendi, scilicet, divisim et coniunctim: quia reperitur coniuncta cum spirituali et reperitur per se existons sine illa; et natura spiritualis non haberet nisi unum modum existendi, scilicet coniunctum. Cum enim nobilior sit natura spiritualis quant corporalis, si corporalis invenitur per se existens sine spirituali, quanto magis debet habere natura spiritualis per se existentiam sine corporali, ut sic habeat duos modos existendi, scilicet, coniunctim et divisim per se? Unde natura corporalis esset totem et pars, et natura spiritualis creata esset tantum pars et non totum: et etiam natura corporalis esset per se existens, et natura spiritualis esset tantum cum alio existens, et etiam natura corporalis faceret per se unum et cum alio unum; et sic duobus modis faceret unum; sed natura spiritualis solum faceret unum cum alio et non faceret unum per se. Sed... hoc esset contra ordinem universi, et contra naturam rerum, et contra nobilitatem et dignitatem et excellentiam naturae spiritualis, et fieret maxima iniuria naturae spirituali, et hoc Deus facere non debet.

La cause de cette introduction un peu subreptice des anges dans le "Liber Creatuarum" est que Sibiuda fera un usage tellement important du "Cur Deus homo" de saint Anselme dans la deuxième partie - opus restaurations - qu'il a besoin de justifier quelque part dans son oeuvre l'existence de ces êtres, cela fût dune manière forcée. Et avec la doctrine angélique - et diabolique - l'auteur termine la première partie, l'étude de l'homme tel qu'il devrait être de jure, sa constitution en tant que créature de Dieu.

Telle nous semble être l'articulation de l'oeuvre de Sibiuda, envisagée du point de vue de l'organisation et de la distribution de la matière.

B - La Methode Sebondienne 1- "Scientia De Homine"

Cette construction ardie est pour son auteur une science. Déjà le titre de l'ouvrage nous en avertit: Scientia libri creaturarum sive libri naturae et scientia de homine54. C'est à cette dénomination

originelle qu'à partir de l'édition de Deventer - circa 1480 - s'est substitué celle de Theologia Naturalis; cependant le projet de Sibiuda n'était pas d'écrire une théologie naturelle au sens qu'aura le mot dans le XVIIe siècle, mais une science toute!.' particulière, dont il dévoile les caractéristiques dans le prologue.

a) Objet
A cette science Sibiuda assigne un seul objet: l'homme. Ista sciencia est de homme in quantum homo est55; hec sciencia est de homine56; quoniam auteur liber seu ista sciencia est de homme ut in principio dictum est...57. L'homme en tant qu'homme: tout ce qui est essentiel pour l'homme, tout ce fi que l'homme est tenu de savoir. La première partie du prologue présente la liste de ces questions: se ipsum, conditorem suum, omne debitum ad quod homo tenetur, corruptio hominis, reparatio hominis58. Tout cela n'est que le contenu de l'Ecriture et de l'enseignement des docteurs saints: si quilibet vult intelligere breviter omnes doctores et totam sacram scripturam habeat istam tcientiamS9. Il s'agit, donc, d'une théologie en raccourci axée sur l'homme.

b) Caractéristiques
Cette science a la vertu de mouvoir la volonté, de la faire adhérer à la doctrine cum laetitia et sponte6°; c'est le fondement de toutes les autres sciences dont l'homme a besoin pour son salut61; c'est une science basée Infailliblement sur des arguments qu'on ne peut pas contredire62; elle tt'allègue pas d'autorités, même pas l'Ecriture, au contraire: elle confirme l'Ecriture et mène l'homme à croire à la révélation63; c'est une science qui r ft'est pas réservée aux seuls clercsM et elle n'est pas difficile:

potest haberi infra mensem et sine labore 65.

En plus, elle facilite l'intelligence des Pères et des théologiens, met en évidence les erreurs des anciens philosophes et des infidèles67, et communique un savoir très noble et très élevé sur Dieu et l'homme.

c) Sources
La source de cette science est ce que Ramon Sibiuda appelle le livre des créatures. Dans le prologue, l'expression liber creaturarum recouvre des significations diverses. D'abord ce livre des créatures est en rapport essentiel avec un autre livre, celui des Ecritures:

Unde duo sunt libri nobis dati a Deo, scilicet, liber universitatis creaturarum sive liber naturae et alius est liber Scripturae sacrae 69.

Il est, d'autre part, la création toute entière:

Quaelibet creatura non est nisi quaedam littera digito Dei scripta, et ex pluribus creaturis sicut ex pluribus litteris est compositus liber unus qui vocatur liber creaturarum. In quo libro etiam continetur ipse homo et est principaliter littera ipsius libri 70.

Par lui, l'homme peut connaître tout ce qu'il lui faut savoir d'une façon nécessaire:

... cum homo sit naturaliter rationalis et susceptibilis disciplinae et doctrinae, et cum naturaliter a sua creatione nullam habeat actu doctrinam nec disciplinam, sit tamen aptus ad suscipiendam illam, et cum doctrina et disciplina sine libro in quo scripta sit non possit haberi, convenientissimum fuit, ne frustra homo esset capax doctrinae et scientiae, quod divina sapientia librum creaverit homini in quo per se sine magistro possit studere doctrinam et disciplinam sibi necessariam. Propter hoc, totum istum mundum visibilem creavit homini et dedit tamquam librum proprium, naturalem, infalsificabilem, Dei digito scriptum 71.

Ce livre des créatures n'admet pas plusieures lectures: c'est un livre à signification unique. Il dit toujours et partout la même chose, on ne peut pas le fausser, à différence des autres livres, y comprise l'Ecriture. L'homme est le lecteur né de ce livre, qui lui est connaturel, mais si l'homme ne peut pas se tromper dans sa lecture, il peut se trouver dans un état bien plus lamentable, qui l'empêche de lire: il peut être aveugle. Et il l'est, dit Sibiuda. C'est pourquoi il a fallu qu'un second livre se substitue au premier:

Secundus auteur liber scripturae datus est homini secundo; et hoc in defectu imi libri, eo quia homo nesciebat legere in primo, eo quia erat caecus 7 .

Ce deuxième livre ne contredit aucunement le premier, d'autant plus que l'auteur des deux livres est le seul et même Dieu. Cependant ce deuxième livre se situe dans un autre niveau:

... uterque liber est ab eodem, quia idem dominus et creaturas condidit et sacram scripturam revelavit. Et ideo conveniunt ad invicem, et unus non contradicit alteri. Sed tamen primus est nobis connaturalis, secundus supernaturalis 73.

Ce n'est pas dans le prologue où Ramon Sibiuda exprime tout ce qu'il pense du rapport entre les deux livres, mais plus loin, dans les titres où il étudie la Parole de Dieu (209-211), et lorsque seront décrits les moyens de s'approprier le salut dans l'Eglise (titres 281 et suivants). D'abord, en étudiant la Parole de Dieu, Sibiuda affirme:

liber creaturarum est porta, ianua, introductorium et lumen quoddam ad librum sacrae Scripturae in quo sunt verba De Preuve:
personne ne peut croire à la Parole de Dieu, s'il n'est pas auparavant établi que Dieu existe et qu'il ne peut pas mentir. Ce point de vue nous place dans un contexte de preambula fidei: le livre des créatures précède le livre des Ecritures du moins en ce sens-là.

Mais, plus loin, lorsqu'il étudie la forme et le mode moyennant lesquels le Christ donne son salut à l'homme déchu, Sibiuda envisage le rapport du naturel au surnaturel d'une autre façon:

Et ideo homo in quantum lapsus est debet primo ascendere per istam scalam nature quia homo lapsus est in profundissimo loco et infimo et distat in infinitum a deo et est inimicus dei // Et ideo primo debet exire de illo loco infimo et ascendere ad gratiam dei et ad donum dei et ad auxilium et ad adiutorium et ad bene esse quia aliter non poterit ascendere per scalam nature // Primo deus ordinauit homini perfecto habenti bene esse scalam nature per quam poterat faciliter ascendere et descendere // Secundo ordinauit homini lapso qui ceciderat de bene esse ad male esse et de gratia ad culpam et de amicicia ad inimiciciam scalam gracie per quam ascenderet ad bene esse et ad gratiam et ad amiciciam suam. Et ideo homo lapsus non potest inuenire deum quem perdidit nisi ascendat per secundam scalam // Et si per primam primo uult ascendere

et ire ad deum tunc frangit collum suum et habet obstaculum et non inuenit deum. sed magis inuenit errorem et diabolum et malum suum75.

Quoique ici il n'est pas question du livre des créatures dans son rapport à l'Ecriture, il est indéniable que ces affirmations ont aussi une valeur lorsqu'il s'agit de déterminer le mode et la forme de la connaissance du salut. En fait, Sibiuda venait de remarquer un peu avant du texte transcrit: scala nature est scala tantum cognoscendi76, la scala gratiae étant la scala recipiendi. Maintenant revenons au prologue.

Sibiuda disait que la science qu'on peut dégager de l'étude des créatures est la scientia homini necessaria77, sapientia et doctrina sibi necessaria ad salutem78 .Or, il ajoute:

Quam quidem sapientiam nulles potest videre nec legere per se in dicto libro semper aperto, nisi sit a Deo illuminatus et a peccato originali mundatus79.

Nous avons mis en relation tous ces textes, parce qu'autrement la pensée de Sibiuda sur ce point fondamental ne serait pas claire. Nous pensons que chez lui la relation du livre des créatures au livre de l'Écriture, du naturel au surnaturel ou, si l'on veut bien, de la raison à la foi, est orthodoxe du point de vue chrétien. Dans l'état de justice originelle l'homme était capable de connaître toutes les vérités nécessaires à son salut avec ses seules facultés rationnelles; cet homme avait la grâce de Dieu (bene esse), son oeil pouvait déceler les vestiges de Dieu dans la création, deviner son plan. Une fois déchu de cet état, l'homme est devenu aveugle et il faut la Parole percutante de Dieu, la révélation et la recréation pour que l'homme redevienne capable de lire dans le grand livre des créatures l'enseignement qu'il en aurait tiré aisément, s'il eût persévéré dans l'état de justice originelle.

Reste à résoudre le problème de savoir pourquoi Sibiuda, le chrétien Sibiuda qui sait que le livre des créatures ne peut être lu qu'à la lumière du baptême et de la grâce divine, se propose comme objet de sa recherche la lecture du grand livre de la création. Ne serait-il pas plus convenant de commencer par la révélation? Ne serait-il pas plus prudent de garder l'ordre des choses, ne fut-ce que par crainte d'échouer - de "frangere collum suum" - dans l'entreprise? La raison du choix sebondien nous la comprendrons mieux lorsque nous étudierons les sources externes et internes du Scientia libri creaturarwn.

Concluons: La science que Ramon Sibiuda entend exposer dans son oeuvre est la science qui se dégage de l'étude du livre des créatures, lu par un chrétien philosophe qui connaît, grâce à la révélation, la signification des créatures. Il ne s'agira, donc, pas d'une science physique au sens d'une philosophie naturelle, mais de la science nécessaire à l'homme pour son salut. Ce n'est pas non plus une théologie naturelle au sens habituel, classique, du mot; la science de maître Ramon présente la sapientia totale, celle que seul un chrétien peut posséder, parce qu'en lui seul se donnent à présent les conditions qui permettent de l'avoir, et que tout homme aurait eu sans le péché et la perte de la grâce originelle:

Ista auteur scientia non est aliud nisi cognoscere et videre sapientiam scriptam in creaturis, et extrahere ipsam ab illis, et ponere in anima et videre significationem creaturarum. Et hoc fit comparando unam creaturam cum altera et coniungendo sicut dictionem diction. Et ex tali coniunctione resultat sentsntia et significatio vers, dum tamen sciat homo intelligere et cognoscere80

2- Certitudo, Experientia

Si le prologue du "Liber Creaturarum" présente surtout l'objet de la recherche sebondienne, la première partie du premier titre pose le problème de la certitude propre à cette science. Remarquons d'abord le terme certitudo: l'on part à la recherche de connaissances qui soient certaines, solides, établies.

Cette exigence de certitude traverse tout le "Liber Creaturarum". Dès le début nous voyons Sibiuda s'enquérir des conditions de la certitude:

Quia homo naturaliter semper quaerit certitudinem et evidentiam claram, nec aliter quiescit nec quiescere potes[, donc pervenit ad ultimum gradum certitudinis. Verum quia certitudo et probatio habet suos gradus, et est maior et minor certitudo et maior et minor probatiogt.

Les degrés de certitude dépendent de la force des témoins:

Virtus tamen probations et causa totius certitudinis oritur ex certitudine et virtute testimoniorum et testium; ex quibus dependet et causatur tota certitudo. Unde quarto magis testes sont certi, manifesta, indubitati et veri, Canto magis est certum illud quod ex eis probatur. Et si testes Sint ita certi et manifesta, et [estimons eorum ita manifesta quod nullo modo posait de eis dubitari, nec nobis possint esse magis manifesta et certiora, tunc illud quod ex eis probatur sine dubio erit nobis manifestissimum, certissimum et evidentissimum82.

Remarquons les couples certitude probatio, certus-manifestus-indubitatusverus, certissimum-evidentissimum-manifestissimum. Le juriste qu'était Sibiuda se montre bien dans cette caractérisation de la certitude par la valeur des témoins et des témoignages. Ce qui est certain est ce qui est vu ou prouvé par un témoin. Plus proche sera le témoin du fait ou de la chose qu'il s'agit de prouver, plus grande sera la foi qu'on lui accordera:

Et quia quanto testes sunt magis extranei, distantes, elongati a re de qua dubitatur, tunc minorera fidem generant et certitudinem. Quanto auteur testes sunt magis vicini, proprii, intimi, intranei, tunc maiorem fidem et credulitatem generant83.

Certitude-foi-crédulité. Nous sommes dans le tribunal de la vérité. S'il y a un tribunal, c'est parce qu'il y a litige. En effet, on dispute sur l'homme. Sibiuda en appelle au meilleur témoin:

Et cura nulla res creata sit propinquior homini quam ipsemet sibi; ideo quidquid probatur de homine per ipsummet hominem et per suam naturam propriam et per illa quae sunt sibi certa de ipso, est maxime certum, manifestum et evidentissimum ipsi homini. Et ista est ultima certitudo et maxima credulitas quae possit causari in homine per aliquam probationem 84.

Et c'est ici que se place l'affirmation la plus radicale du chrétien Sibiuda dans ce titre premier: Si l'homme veut se connaître, il faut qu'il soit lui-même le moyen, l'argument, le témoin de tout ce qu'il y a à prouver sur l'homme, concernant sa destinée:

Et ideo ipsemet homo et sua natura propria debet esse medium, argumentum, testimonium ad probandum omnia de homine, scilicet, quae pertinent ad salutem hominis, vel damnationem vel felicitatem, vel ad bonum vel ad malum eius. Aliter unquam homo erit ultimate certusss.

Après cette chaîne de raisonnements, Sibiuda pose une affirmation de caractère historique. Il dit que l'homme s'ignore, qu'il est assez loin de chez lui, bref, qu'il est aliéné:

Et quia homo est extra seipsum et elongatus et distans a seipso per maximum distantiam, nec umquam habitavit in domo propria, scilicet, in se ipso, immo semper mansit extra domum suam et extra se, ex eo quia ignorat se ipsum, nescit se ipsum. Et de tanto est elongatus et distans a se ipso, et tantum est extra se ipsum, de quanto ignorat se ipsum. Et quia totaliter nescit se ipsum, ideo totaliter est extra se ipsums 6.

Remarquons cette nouvelle association: ignorare se ipsum-esse extra se ipsum. Son contraire, cognoscere se ipsum-redire in se ipsum, ne se fait pas attendre:

Quia ergo homo est totaliter extra se, ideo si debet videre se, necesse est quod intret in se et infra se, et veniat ad se et habitet infra se. Aliter est impossibile quod cognoscat se nec videat se, nec suum valorem, suam naturam et suai pulchritudinem naturalem87.

Pourquoi l'homme s'ignore-t-il, et pourquoi est-il loin de lui même? Parce qu'il est placé dans un haut lieu, et parce que la connaissance -_ du moins la connaissance certaine - commence par les choses inférieures pour se terminer aux supérieures:

Et quia modus cognoscendi hominis est ut per illa quae sunt sibi magis et primo cognita, cognoscat illa quae sunt sibi ignota, et per illa quae scit ascendat ad ea quae nescit, et cum semper res minus nobiles et inferiores sint homini primo oognitae, et res perfectae, digniores, meliores et nobiliores sint ci ultimo cognitae: et ideo quia homo est res dignior, superior et perfectior huius mundi, propter hoc ultimo cognoscit se ipsum, et primo cognoscit alia, quam se ipsum, et de cognition aliorum vent ad cognoscendum se ipsum 88.

Pour monter vers la connaissance de soi-même, l'homme a à sa disposition une échelle immobile et naturelle qui ne peut pas le tromper ni l'égarer, l'échelle de nature:

Quapropter ut homo, qui tantum per cognitionem est elongatus a se, ut totaliter ignoret se et sit extra se, possit reduci, itinerare et ascendere per cognitionem ad se, ideo ordinata est renon et creaturanun universitas tamquam iter, via et scala immobilis et naturalis habens gradus firmos et immobiles, per quam homo veniat et ascendat ad se ipsum. In qua una res est inferior, et alia superior; una perfectior, alia minus perfecta; una nobilior et dignior quam alia ad modum cuiusdam scalae Ascendendo S9.

Nous avons vu que le point de départ de Ramon Sibiuda est l'homme: scientia de homme. Sibiuda veut que cette science soit solide, qu'elle s'appuie sur des arguments certains - et nous verrons plus loin pourquoi Sibiuda cherche cette solidité -. Or, nul témoin peut mieux déposer sur l'homme que l'homme lui-même; il faudra, donc, lui faire tout dire. Mais l'homme étant hors de soi, s'ignorant, vivant dans l'aliénation, il faut que ce soient les choses du monde qui l'amènent jusqu'à lui-même. Sibiuda ne partira pas de l'homme qui se connaît, de l'homme qui a pleine conscience de soi, mais de l'homme, créature parmi les autres créatures, qui s'ignore. A différence de Descartes, qui doute et s'attache à la certitude de cette donnée de sa conscience, Sibiuda s'attache à la solidité du monde extérieur, duquel il ne doute guère (scala immobilis et naturalis, habens gradusfirmos et immobiles), pour en arriver à situer l'homme dans la place qui lui revient. Il n'y a pas la moindre trace de scepticisme ou d'idéalisme dans l'attitude sebondienne, comme certains se sont hasardés de supposer, en voulant faire de notre modeste ouvrier de la pensée une sorte de précédent de Descartes90. Nous aurons l'occasion de voir plus loin que l'attiutde de Ramon Sibiuda n'est que l'aboutissement d'une des directions classiques de la pensée chrétienne au moyen-âge.

C'est, donc, par l'étude et l'analyse de la nature humaine que Sibiuda tentera de dégager toutes les vérités que l'homme doit connaître pour son salut, et la raison en est qu'en employant sa méthode, talis cognicio est nobis ualde propinqua91. En fait, la connaissance qui se fonde sur la nature propre non seulement est plus certaine, mais aussi plus familière et plus plaisante:

cognicio que oritur expropria natura est nobis cercior et magisfamiliaris et placens~.

Au fond, Sibiuda n'invente rien du tout. A travers ces formules peu usuelles, il n'y a que la parole de l'épître aux Romains:

invisibilia Dei per ea quae facta sunt a creatura mundi intellecta conspiciuntur.

C'est la vieille méthode chrétienne d'étudier dans la créature les vestiges du Créateur. L'accent mis par Sibiuda sur la connaissance de l'homme s'inscrit rigoureusement dans cette perspective:

Et quia nullum opus dei est magis propinquum ipsi homini quam ipsemet homo sibi ipsi II Et quia homo est opus dei ideo noticia generata de deo in homine per cognicionem sui ipsius qui est opus dei est maior omnium 93.

Remarquons encore une fois que Sibiuda est hanté par l'éxigence de connaissances certaines, au moins dans ce sens qu'on ne puisse pas douter; il cherche la connaissance qui soit maior omnium, voilà son problème.

Cette connaissance la plus certaine de toutes sera pour maître Ramon l'expérience:

Nulla auteur certior cognitio quam per experientiam et maxime per experientiam cuiuslibet intra se ipsum9ā.

En fait, l'idée que Sibiuda se fait de ce qu'il nomme l'expérience n'a rien à voir avec le sens moderne du même concept. Pour lui, l'expérience représente d'abord le degré suprême de la certitude. L'expérience est définie comme la connaissance personelle d'une chose, et son opposé serait la connaissance par témoins:

Haec scientia... arguit per illa quae sunt certissima cuilibet homini per veram experientiam, scilicet, per omnes creaturas et per naturam ipsius hominis. Et per ipsummet hominem omnia probat, et per illa quae certitudinaliter homo cognoscit de se ipso per experientiam... Et ideo ista scientia non quaerit alios testes quam ipsummet hominem 95.

En quelque sorte l'expérience, telle que Ramon Sibiuda la conçoit, n'est que le témoignage que l'homme apporte sur lui-même, sa conviction intérieure, son aveu:

Et cercius et magis cognoscit homo deum per opera que uidet et percipit per experienciam qu8m per opera que cognoscit per testimonium aliorum. Item quia nichil magis cognoscit homo quam illud quod sentit et uidet per experienciam ideo noticia generata de deo per opera dei que homo uidet per experienciam tenet ultimum gradum cognicionis dei per opera sua 96.

Nous sommes toujours en quête d'une vérité qui est établie par témoignage. Cela est confirmé par les degrés que Sibiuda signale dans la valeur de l'expérience:

Aliquando homo uidet per experienciam opera que deus operatur circa alium hominem vel circa aliam rem extra se // aliquando uidet et sentit per experienciam opera que deus operatur circa se ipsum singulariter. Et iste est ultimus gradus cognicionis per experienciam et iste est certissimus, solidissimus et firmissimus qui semper manet et ibi est complementum cognicionis 91.

Noticia acquisita de deo per experienciam per opera que homo uidet per experienciam habet multos gradus I/ Primus gradus est per opera que homo uidet extra se in aliis. Secundus gradus est per opera que homo uidet et sentit in corpore fieri suo proprio. Tercius adus est per opera que homo sentit et percipit fieri circa suam animams.

La gradation va du plus extérieur au plus intérieur, du plus éloigné au plus intime. Dans son degré suprême, l'expérience est un savoir intime, inébranlable, exclusivement personnel, mais objectif.

La valeur testimoniale plutôt que noétique de la certitude et de l'expérience chez Ramon Sibiuda apparaît en toute clarté lorsqu'il en arrive à opposer expérience et raison:

... multa aliquando homo cognoscit per experienciam que tamen non potest comprehendere per racionem quomodo est... Debet auteur homo hoc concedere licet non possit comprehendere quomodo potest esse, quia non sequitur quod si non possit comprehendere quod ita non sit 99.

Comme exemple de ce que l'homme peut connaître par expérience sans pouvoir le comprendre en raisonnant, Sibiuda donne la trinité de personnes en Dieu, en empruntant un texte du De Trinitate de Richard de Saint-Victor, comme nous aurons l'occasion de voir un peu plus loin, lorsque nous étudierons l'influence des Victorins sur maître Ramon. Comme exemple de ce qu'on peut connaître par raisonnement sans pouvoir l'expliquer par une expérience quelconque, il donne l'unité en Dieu des attributs et de la substance.

Il y a, donc, des vérités qui s'imposent à la conviction humaine par des voies autres que la seule raison, tout comme il y a des vérités rationnelles qui vont à l'encontre de nos schémas cognitifs et de nos expériences habituelles. Pour Sibiuda, il s'agit d'un état de fait. Si ces vérités qui s'imposent à nous par des voies autres que la pure raison sont incompréhensibles, comme c'est le cas de la Trinité, Sibiuda ne les gardera pas moins. Pour lui, l'essentiel n'est pas le contenu de ces vérités, mais la force de conviction par laquelle elles pourraient s'enraciner en nous. Si l'on démontre que nous devons les reconnaître, elles sont vraies, quoiqu'elles, du point de vue de la seule raison, soient incompréhensibles.

Ainsi, l'idée que Sibiuda se fait de l'expérience éclate à nos yeux: elle est une connaissance intime, que nous ne pouvons pas ne pas reconnaître, sur la valeur de laquelle on ne saurait plus douter, même dans le cas où cette connaissance apporterait des données dépassant l'ordre de notre raison. Connaissance sûre, la plus forte du point de vue de son bien fondé, elle peut néanmoins être le véhicule de l'impensable. C'est, donc, par le biais de son concept de certitude et d'expérience que Ramon Sibiuda réussit à faire glisser l'impensable dans le monde des convictions de l'homme. Il n'y aura pas, à proprement parler, une science de l'impensable, mais une certitude qui découle d'une expérience profonde, humaine, enracinée dans l'intimité de chacun. Dissolution de l'ordre rationnel? Les Carreras Artau10° n'ont pas hésité à parler d'une "nouvelle doctrine de la connaissance". Contentons-nous en disant que Sibiuda est dans un univers où, à côté du vrai et du faux, on reconnaît que des impensables démontrables existent, et qu'ils peuvent être rendus même nécessairement croyables. Cette nouveauté apparaît grâce à l'étude et à l'analyse de la nature humaine; et ces impensables démontrables sont d'autant plus croyables et nécessaires, donc vrais, qu'ils sont pleinement d'accord avec l'être et les tendances de la nature humaine; mieux encore, sans certains d'entre eux, la nature humaine ne serait pas adéquatement comprise et expliquée.

Concluons: Comme il y a des vérités appréhendées par la raison, mais que l'expérience humaine habituelle n'arriverait jamais à s'expliquer, il y a aussi des connaissances qui dépassent l'ordre rationnel, mais qui nous sont imposées par une certaine expérience de l'ensemble total du phénomène humain. Pour développer sa science, Ramon Sibiuda se donne un instrument logique particulier, avec lequel on parvient à des vérités d'un ordre autre que l'ordre rationel, mais qu'il faut cependant recevoir, parce que l'expérience nous démontre quelles ont une convenance profonde avec notre nature.

3 - Rationes Probantes

Nous venons de voir que d'après Sibiuda la certitude dépend de l'expérience et que, suivant les degrés de cette expérience, il y a plus ou moins de certitude. Mais son instrument logique ne se limite pas au couple certitude-expérience. Il y a aussi la probatio et les rations probantes. Il faut maintenant en étudier l'articulation.

Selon Sibiuda, la connaissance la plus sûre de l'homme est son expérience. Mais il a aussi affirmé que l'homme revient à lui-même à travers les créatures, parce que le mode de connaissance de

l'homme consiste à monter vers l'inconnu à travers ce qu'il lui est plus connu, et nous avons déjà vu que Sibiuda ne doute guère que l'homme est pour lui-même un inconnu. Donc, à côté du domaine de l'expérience, il y a un espace où les certitudes ne sont pas directement expérimentales, mais relèvent du raisonnement et de la preuve.

Appliquée aux choses, la preuve a deux moments: d'abord, il faut se pencher vers les choses:

Si ergo vis quod fiat in te cognicio tui ipsius et tui conditoris fiat primo in te cognicio creaturarum quia quarto magis appropinquabis te ad creaturas cognoscendum tanin magis appropinquabis ad te ipsum et ad creatorem tuumiot

Ensuite, il faut faire l'analyse de ce que les choses sont par un processus comparatif qui nous signale ce en quoi elles conviennent et ce en quoi elles diffèrent:

Dum enim comparamus unam rem ad aliam duo manifestantur nobis, scilicet, conueniencíam et differenciam unius ad alteram et per islam duplicem comparacionem manifestatur nobis natura cuiuslibet rei naturaliter102.

Il s'agit, comme on voit, d'une connaissance spécifique qui ordonne et classe les choses d'après ses notes essentielles. Est-ce qu'ici ne sommes-nous pas un peu loin du concept d'expérience que proposait Sibiuda? Pas du tout, du moins à en croire les textes. Tout ce qui relève de la connaissance objective des choses par ses notes essentielles n'en vient pas moins s'insérer dans le domaine de l'expérience de l'homme:

... per illa que nota erant per experienciam de homine et de aliis

rebus, ut quia notum erat hominem uiuere sentine et intelligere et alias res uel esse tantum uel uiuere tantum etc. probatum fuit deum esse et qualis debebat esse et quantust03.

On ne peut, donc, pas séparer expérience et preuve. Ceci nous signale encore une fois quelle est la direction qu'a prise notre auteur. Pour lui, il s'agit moins de vouloir tout prouver que de montrer comment tout ce qui est vrai, même ce qui est un vrai impensable, s'articule avec l'homme. Lorsqu'il pourra montrer la vérité d'une chose à travers des preuves rationnelles, il s'en contentera. Lorsque la preuve n'est plus possible, au sens démonstratif du mot, il aura alors recours à la convenance avec la totalité de l'expérience humaine telle qu'il l'entend. Avouons que ce recours n'intervient que très peu et toujours en rapport avec des preuves, des rationes probantes ou necessariae, mais il reste significatif que, pour Sibiuda, compte moins la valeur et le contenu intrinsèque d'une vérité que la possibilité de la mettre en rapport immédiat avec l'homme, soit par la connaissance rationnelle, soit par d'autres voies.

Cela se manifeste aussi par le genre de probations et de rationes probantes que Sibiuda met en mouvement dans son "Liber Creaturarum". Déjà dans le prologue, il avertissait que cette science n'est pas compliquée, quelle ne suppose pas la technicité des arts libéraux, grammaire et logique, pour un usage fécond de la raison:

Ista scientia nulla alia indiget scientia nec aliqua acte. Non enim praesupponit grammaticam nec logicam nec aliquuam de septem liberalibus artibus, nec physicam nec metaphysicaml .

En fait, il y a dans le "Liber Creaturarum" beaucoup d'arguments dune valeur médiocre, et une grande partie de liaisons logiques internes de l'oeuvre donnent à penser que Sibiuda concevait la logique plutôt comme un art de type réthorique. On a l'impression qu'il aurait pu donner plus de caractère et de vigueur à son texte. Parce que, bien qu'il affirme que, pour le comprendre, on n'a

pas besoin de connaître les arts et la philosophie première, cela ne l'empêche pas de reproduire souvent la terminologie de l'artiste et du métaphysicien. S'il s'est contenté d'arguments simples et parfois de transitions et d'enchaînements qui nous semblent aujourd'hui naïfs, c'est qu'il n'accordait pas, nous semble-t-il, une importance décisive au poids des arguments. Pour lui, l'essentiel de l'affaire est que tout soit référé à l'homme. La valeur de ces rationes probantes est à chercher dans cette référence. Il ne faut, cependant, pas inférer de ce que nous venons de dire, que Ramon Sibiuda n'a pas cherché des bonnes raisons et arguments pour appuier ses vues, bien au contraire. Dans le contexte culturel de son temps, et étant donné qu'il vise le public le plus large

possible - ista scientia est communis clericis et laicis et omni conditions ho min umtos -, l'ouvrage de Sibiuda n'est pas dépourvu de valeur

intellectuelle; mais on a le sentiment, en le lisant, que, pour lui, la discussion et l'élucidation strictement rationnelle des problèmes cède la place au désir de donner une dimension humaine directe à toute sorte de vérités métaphysiques, morales et théologiques. Le Liber Creaturarum expose toujours les problèmes en raccourci, il n'est pas l'oeuvre d'un théologien de métier qui étale ses vues particulières, ses sententiae ou ses positiones. L'originalité de Sibiuda consiste en ceci, que toute la théologie est ramené sur l'homme, et qu'il n'y a pas de dogme ou de vérité théologique et morale pour laquelle Sibiuda ne tente de trouver un fondement, une référence ou un

principe de convenance dans la nature humaine. Voici deux textes où cette préoccupation méthodologique apparaît d'une façon assez claire:

Et sic pater quod quilibet in se ipso portat modum et formam et exemplar scriptum et depictum qualiter se debeat habere erga deum // Et hec est sciencia certissima indubitatissima quam nullus negare potest quia in se ipso et per experienciam uidet1O6.

Et ideo quia homo per cognicionem sui ipsius ascendit ad cognicionem dei et tantum quantum cognoscit de se ipso tantum cognoscit de deo, ideo qui ignorat se ipsum in quantum est homo ignorat deum, et qui ignorat se ipsum in quantum est lapsus ignorat deum hominem, scilicet, christum. Et ideo sicut superius quando uolebamus aliquid scire de deo arguebamus per naturam hominis in quantum homo est // ira modo si uolumus aliquid probare et scire de christo deo et homine debemus arguere per naturam hominis lapai et perditi // Nunquam igitur homo debet recedere a se ipso nec a cogitacione sui ipsius, et ira homo potest considerare se ipsum in quantum homo est et in quantum est lapsus et in quantum est reparatus107

4-REGULAE

Ce souci de tout ramener à l'homme apparaît encore avec plus d'éclat dans les regulae. D'abord, qu'est-ce que sont ces regulae? Ce sont des principes qu'on obtient par raisonnement et qui servent à fonder des raisonnements ultérieurs. Nous avons déjà dit que le "Liber Creaturarum" est un ouvrage où l'exposition linéaire de la matière élimine les divisions classiques en questions, articles, conclusions. Les regulae tiennent un rôle semblable aux conclusions classiques des théologiens seulement en tant qu'elles signifient le point de départ ou d'arrivée d'une spéculation; leur importance chez Sibiuda vient du fait que ces regulae, normalement, rendent évident le rapport d'une méthode spéculative ou d'un point concret de doctrine à la nature humaine, en sorte qu'il devient possible de jalonner progressivement le projet de omnia fundare in homine108. Ces règles, Sibiuda les appelle parfois regula et doctrina, parfois regula et modus ad probandum, regula generalis, regula quae est fundamentum firmissimum, regula et ars, etc. L'apparition des regulae au cours du "Liber Creaturarum" signifie qu'on développe des points essentiels, et Sibiuda les sortira chaque fois qu'il voudra attirer l'attention sur quelque point

important.

Les regulae sont, donc, des principes, des axiomes qui ont été découverts par le raisonnement et qu'on applique ensuite à démontrer d'autres vérités:

Ut auteur habeamus regulam et modum ad probandum omnia de ipso esse et ordinato modo procedamus: opportet facere unum fundarnentum et unam radicem in quo omnia fundantur. Primum auteur fundamentum et prima radix est quod ipsum esse dei non est acceptum ab aliquo nec a se ipso. Et exinde sequuntur omnia que dicuntur de ipso. Et ad istud fundamentum sequitur unum aliud, scilicet quod esse dei infinitum elongatur a non esse et ab ipso nichil et fugat totaliter ipsum non esse. per ista duo omnia radicaliter probantur, onde quia ipsum esse dei non est acceptum ab aliquo, sequitur quod est totaliter primum. Et ulterius sequitur quod est simplicissimum et sine partibus. Et exinde sequitur, etc.109

Rursus ponenda est hic quedam generalis regula ad omnia predicta et subsequencia: et est ista. Quia sicut in deo idem est esse quod uiuere et idem est esse quod sentire idem est esse quod intelligere, idem est esse quod bonum esse, idem quod necessarium esse, et sic de omnibus, ita per oppositum in deo idem est non esse quod non uiuere, quod non sentire, quod non s1ig~ere, quod non bonum esse, quod non uerum esse, et sic de omnibus...11

Une des regulae principales qui apparaissent dans le "Liber Creaturarum" est l'argument du Proslogion de saint Anselme, que Sibiuda introduit avec habileté, comme nous avons vu plus haut, en étudiant les articulations des chapitres qui se réfèrent à l'opus conditions, et comme nous verrons encore avec plus de détail dans un prochain chapitre. Sibiuda apprécie cet argument en raison de son immédiateté et de sa clarté, pour lui évidente; il constitue, à ses yeux, le type de raisonnement proche à l'homme, enraciné dans sa nature, que Sibiuda souhaite et cherche en vue d'établir des certitudes indiscutables:

... una regula infallibilis de deo que est fundamentum et radix ad probandum et cognoscendum certissime sine labore omnia de deo. Et iste modus cognoscendi est propinquissimus homini, quia ex propria cogitacione et ex proprio intelligere potest probare omnia de deo // Nec opportet quod querat alfa exempla extra se nec aliud testimonium quam se ipsum. Regula auteur que in homine radicatur est ista: quod deus est quod nichil maius cogitari potest. Et inde sequitur, etc.111

Et quia ista regula se extendit ad omnia que de deo dicuntur et oritur ex nobis et ex natura hominis ideo utile et desiderabile est uidere practicam eiusdem et fundare omnia in 112rn

Si cette interprétation de l'argument de saint Anselme est significative et éclaire le souci fondamental de Sibiuda, qui est tout fonder sur l'homme, il y a dans le "Liber Creaturarum" un moment où ce souci apparaît avec une grande vigueur. Au fond, lorsqu'il emploie l'argument anselmien, Sibiuda se borne à souligner le caractère d'immédiateté à l'homme du discours rationnel de l'argument. Mais dans une autre regula il va plus loin. Il s'agit de la regula et ars affirmandi et negandi, qu'il donne pour le cas où une vérité et son opposée semblent être toutes les deux soutenables du point de vue strictement rationnel. Sibiuda tente de définir, dans cette regula, pour quelle de ces deux vérités l'homme doit se décider:

Omnis res debet et tenetur uti hiis que habet ad suam utilitatem et ad suum bonum ad suum melius et augmentum sui boni et sue melioracionis quantum potest. Et nulla res debet uti hiis que habet contra se ipsam ad destruccionem sui boni et sue utilitatis et dignitatis. quinymo debet suam naturam dignificare exaltare et destruere omnia ista et expellere a se que ipsam minorare et adnichilare (sic)113

De cette règle, il s'en suit fars affirmandi et negandi, un des moments forts du "Liber Creaturarum", que Sibiuda présente ainsi:

Quoniam ergo ad intellectum pertinet affirmare et negare et est actus secundus qui sequitur post cogitare qui eciam est diuisus in dues partes oppositas, quia affirmare et negare sunt opposita et hoc est propter hoc,

qui (sic) omne quod cogitatur et dicitur habet suum oppositum sibi repugnans et contradictorium, que simul non possunt esse. sed necessario illud quod cogitatur et dicitur est uerum uel suum oppositum. Ideo debet unum affirmare homo et aliud negare et unam partem recipere et affirmare tamquam ueram et aliam repellere et negare tamquam falsam // Et concluditur quod homo de ivre nature debet et tenetur et obligatur credere affirmare et recipere istam partem tamquam ueram que erit magis ad utilitatem et hominis perfeccionem et melioracionem et dignitatem et exaltacionem hominis inquantum homo est, et postquam in homine generaliter (sic) gaudium et leticia consolacio spes confidencia securitas / et fugabitur tristicia desperacio ab ipso homine, et per consequens sequitur quod debet affirmare istam partem tamquam ueram que erit magis amabilis et desiderabilis de se et de nature sua, et que magis habet de esse et de bono et aliam partem oppositam tenetur et debet negare tamquam falsam et a se ipso fugace tamquam inimicam sibi. Si auteur homo faciat oppositum tunc utitur intellectu suo contra se ipsum et contra hominem et contra suum bonum ad suum damnum ad suam deprauacionem et tunc facit contra totum ordinem rerum quia quelibet res inferior homine utitur hiis que habet ad suum bonum et homo ad suum malum, et ideo facit contra cursum nature et omnium rerum et contra hominem // Ideo tunc non debet dici homo qui facit contra hominem et habet intellectum deuiatum comiptum et despectum Il Et quamuis non intelligat quomodo fieri potest nec quomodo potest esse uerum, non est excusatus homo quin non teneatur affirmare et credere114.

Les derniers mots donnent bien la mesure du souci de maître Ramon de tout fonder sur l'homme. Il ne s'agit pas seulement de trouver des arguments accessibles à l'expérience humaine; Sibiuda met en place une dialectique qui argumente ad hominem au sens le plus exact du mot. Il oblige l'homme à s'engager, dans tous les cas où un doute pourrait apparaître, pour ce qui lui est plus utile et positif. Choisir entre possibilités distinctes n'est possible que s'il y a un lien originel entre celui qui choisit et la chose qui doit être choisie. Ce qui conditionne le choix est précisément la non-indifférence, c'est-à-dire, l'expérience d'un lien, l'expérience que le choix de l'utile et du positif exalte et dignifie la nature de l'homme. Sibiuda réalise ici le souhait exprimé dans le titre premier:

... ipsemet homo et sua natura propria debet esse medium argumentum testimonium ad probandum omnia de homine115.

L'homme lui-même, sa nature même, devient l'argument décisif. On ne pouvait pas aller plus lois: dans le souci d'insérer l'homme à l'intérieur d'un processus de connaissance. Dans le tribunal de la vérité, l'homme sera, d'après Sibiuda, non seulement le témoin numéro un, mais aussi le code qui fournit les lois.

Chapitre V - Sources Externes Du "Liber Creaturarum"

Nous venons de voir que l'intention de Ramon Sibiuda est de bâtir une science dont l'objet est tout ce qui est essentiel pour le salut de l'homme. Telle qui il la conçoit, cette science doit intéresser tous les hommes, sans discrimination par formation intellectuelle, appartenance à telle classe sociale ou à telle religion concrète. En plus, elle doit être exposée de façon à ne laisser pas de place pour le doute, l'hésitation et l'incroyance: les arguments de cette science doivent être convaincants, infallibilia. Nous étudierons maintenant les causes de cette prise de position, en partant toujours des textes du "Liber Creaturarum".

A - Crise Des Valeurs Chrétiennes
Nous avons fait allusion dans la première partie de ce travail à la crise spirituelle qui travaillait l'époque de Ramon Sibiuda et dont les causes sont très complexes: les vagues de la peste, qui commencèrent à sévir vers la moitié du XIVe s., le grand Schisme d'Occident et le mouvement conciliariste; en philosophie, le nominalisme favorise l'apparition de courants sceptiques au sein même des écoles chrétiennes. Peu à peu s'esquisse partout une attitude intellectuelle nouvelle, qui donne naissance à une curiosité de type nouveau. Les esprits se tournent vers les auteurs anciens, on cherche, on dispute' 16

Le "Liber Creaturarum" confirme cette situation, parce que l'oeuvre réagit contre elle.

Nous avons déjà remarqué plus haut que l'épreuve à laquelle ont été soumises les institutions ecclésiastiques pendant le schisme n'a pas ébranlé en Ramon Sibiuda la conviction que tous les pouvoirs doivent être subordonnés à celui du pape. C'est pourquoi il se soumet aussi lui-même, en tant que docteur ecclésiastique, au jugement supérieur de lEglise:

1436
Raymond de Sebonde
1974 Article by J.M. De Bujanda
L'influence de Sebond en Espagne au XVIe siècle
Renaissance and Reformation Magazine Volume X 1974 Number 2

Nous savons peu de chose du grand philosophe du XVe siècle Raymond Sebond. Les manuscrits et les éditions connus nous offrent, au moins, treize (13) variantes de son nom. Les formes qui ont prévalu sont: Sabundus (latin), Sebond (français) et Sabunde (espagnol). D'après le namuscrit existant dans la Bibliothèque Municipale de Toulouse, qui offre la plus grande garantie d'authenticité, son vrai nom catalan est Sibiuda. D'origine catalane et probablement de Gerona, Raimundo Sibiuda, maître es Arts, en Théologie et en Médecine, enseigne à l'Université de Toulouse où il occupe le poste de Recteur en 1428 et 1435. Entre 1434 et 1436 Sibiuda écrit un traité dont le titre original, d'après le manuscrit de Toulouse est: Scientia libri creaturarum seu naturae et de homine. Cet ouvrage était déjà fini le 11 février 1436, quelques semaines avant la mort de l'auteur qui est survenue le 29 avril de la même année. Nous utilisons dans ce travail l'édition de la Theologia Naturalis publiée par le professeur Stegmûller avec une édition critique du Prologue.

Des dix-sept manuscrits de cette oeuvre signalés par Stegmûller, quinze furent transcrits au XVe siècle. La première édition fut publiée probablement à Lyon en 1484. Dans la deuxième édition celle de Daventer, 1485, qui apparaît avec le titre: Theologia naturalis seu liber creaturarum, l'ouvrage est divisé en sept parties et en trois cent trente-trois chapitres avec ses titres correspondants. Le titre de l'ouvrage et ses divisions, qui ne figurent pas dans les manuscrits primitifs, sont retenus par les éditions postérieures.

Dans le prologue du livre, Sebond présente clairement le but de son oeuvre: "Enseigner la racine, l'origine et le fondement de toutes les sciences et de toute vérité." Cette "science montre à l'homme à se connaître soi-même, la fin pour laquelle il a été fait et qui l'a fait, en quoi consiste son bien et en quoi consiste son mal, ce qu'il doit faire; quelles sont ses obligations et envers qui il est obligé." C'est par cette science que l'homme connaîtra aussi sa situation actuelle de faiblesse et de corruption. On apprendra aussi comment l'homme peut sortir de sa misère et arriver à la perfection. Pour apprendre cette science Sebond propose une méthode fondée sur des arguments infaillibles et irréfutables tirés de l'expérience, des créatures et de la nature de l'homme.

Certaines affirmations du prologue peuvent nous inciter à croire, comme le signale Carreras Artau, que le Liber creaturarum est une oeuvre de rationalisme extrême. Il faut cependant tenir compte, comme le dit Mario Martins, de ce que des affirmations semblables se trouvent chez Raymond Lulle, Raymond Marti, Saint-Anselme, Hugues de Saint-Victor. Certaines expressions du prologue peuvent aussi s'expliquer par des raisons polémiques. A l'intérieur du traité les affirmations sont beaucoup moins catégoriques. L'examen approfondi de l'ouvrage nous montre un écrivain profondément éclectique qui utilise des éléments provenant des différentes écoles médiévales. La conception qui préside à tout l'ouvrage cherche l'accord entre les deux livres de la nature et de la grâce.

Le contenu de la Théologie Naturelle, qui a donné lieu à des interprétations divergentes et parfois contradictoires, a exercé une influence considérable sur les différents courants de pensée.

Au cours des dernières années du XVe siècle et des premières années du XVIe la Théologie Naturelle connaît une diffusion rapide en Europe et principalement en France. Des onze éditions latines réalisées aux XVe et XVIe siècles deux sont publiées à Strasbourg (1496, 1501) une à Paris (1509), cinq à Lyon (1484, 1507, 1526, 1540, 1541), une à Daventer (1485), une à Nùrnberg (1502) et une à Venise (1581).^

L'ouvrage du philosophe catalan est très apprécié par le cercle réformateur de Lefèvre d'Etaples. Nous savons que Beatus Rhenanus en possède un exemplaire et que Charles de Rouelles le considère comme une "oeuvre très savoureuse et très riche". Comme le signale Augustin Renaudet, Lefèvre lui-même ne pouvait que se sentir attiré par la doctrine exposée dans la Théologie Naturelle, qui s'accorde très bien avec les écrits de Nicolas de Cuse et de Raymond Lulle qu'il publia. Les enseignements de Sebond sont aussi à la portée du public français qui dispose d'une traduction française publiée à Lyon en 1519 par Bernard Lecuyer.

Les ressemblances entre la Théologie Naturelle et certains enseignements de St-lgnace dans les Exercices Spirituels peuvent, peut-être, expliquer la faveur dont jouit Sebond parmi les premiers membres de la Compagnie de Jésus. L'inclusion de la Théologie Naturelle dans l'Index de livres interdits publié par Paul IV en 1559, provoque une certaine inquiétude parmi quelques Jésuites influents dans la Curie Romaine. Le P. Lainez, qui collabore à la version moins sévère de l'Index du Concile de Trente, n'est probablement pas étranger au fait que le nouvel Index ne condamne plus l'ouvrage complet mais seulement le Prologue.

Montaigne est celui qui a le plus contribué à la diffusion de l'oeuvre de Sebond. Sa traduction française de la Théologie Naturelle, publiée en 1569 et revisée en 1581, connaîtra cinq rééditions au cours de la première partie du dix-septième siècle. D'autre part, l'Apologie de Raymond Sebond, un des principaux essais du moraliste français, assurera au philosophe catalan une place importante dans l'histoire de la pensée. Les études consacrées à Montaigne sont loin d'être unanimes sur la place occupée par l'oeuvre de Sebond à l'intérieur de sa philosophie morale. Veut-il défendre les thèses de Sebond, comme Montaigne l'affirme expressément, ou bien cherche-t-il un prétexte qui lui permette d'exposer ses idées qui sont en réalité bien différentes de celles de Sebond? Indépendamment de la réponse que l'on donne à cette question on doit reconnaître que la Théologie Naturelle occupe une place centrale dans l'oeuvre de Montaigne. Nous attendons toujours les travaux qui nous diront quelle est l'influence exercée par la Théologie Naturelle sur des écrivains comme St-François de Sales, Pascal et Hugo Grotius.^'*'

En plus de l'influence exercée directement par la Théologie Naturelle, à travers ses nombreuses éditions latines et françaises, les idées de Sebond ont connu une large diffusion grâce à une adaptation qui est publiée sous le titre Viola animae. Dans ce résumé, le chartreux Pierre Dorland condense la matière en quatre-vingt-six chapitres, évite les procédés d'école en supprimant les divisions, distinctions etc. ., améliore considérablement le texte et donne au traité une certaine

saveur de la Renaissance par l'introduction de citations classiques. La Viola animae comprend sept dialogues. Les six prem.iers sont des résumés de chacune des parties de la Théologie Naturelle. Le septième, sur le mystère de la Passion de Jésus-Christ, est un travail original de Pierre Dorland.

Publiée à Cologne en 1499 la Viola animae connaît neuf éditions en latin au cours du XVIe siècle. La traduction française de Jean Martin est publiée en 1551, 1555 et 1556. Si l'influence de Sebond apparaît manifeste en France, elle est loin d'offrir pareille évidence en Espagne. Des historiens de la pensée comme Carreras Artau et M. Batllori croient que la Théologie Naturelle n'a pas apporté une contribution importante à la pensée espagnole. Ce point de vue semble être confirmé par le fait que la seule édition en espagnol de la Theologia Naturalis date de 1854 et qu'elle a été réalisée à partir d'une 18 adaptation italienne.

Dans une brève mais profonde étude publiée en 1953, notre cher maître, le regretté professeur Révah confirmait l'exactitude d'une intuition de Menéndez Pelayo qui considérait la Théologie Naturelle comme ayant un intérêt capital pour l'étude des origines de la mystique espagnole. Nos études actuelles sur la censure inquisitoriale espagnole nous ont apporté, d'une façon fortuite, de nouveaux arguments qui prolongent l'étude du professeur Révah.

La Viola animae publiée à Tolède en 1500 par Petrus de Hagembach est le premier livre de piété, si nous laissons de coté les livres liturgiques, qui est imprimé sous la protection du Cardinal Ximénez de Cisneros, auquel on reconnaît un rôle de premier ordre dans le développement de l'humanisme espagnol. Cette édition décrite par Haebler, et dont on conserve deux exemplaires dans l'Hispanic Society of America de New York, reproduit dans la deuxième feuille l'emblème du siège archiépiscopal de Tolède. Norton croit comme probable que cette marque était réservée aux livres imprimés par ordre de l'Archevêque.

Nous ne connaissons aucun exemplaire qui témoigne de l'existence d'une autre édition latine de la Viola animae en Espagne. L'influence de ce livre s'exerce principalement par l'intermédiaire des traductions et des adaptations qui en vulgarisent le contenu. En 1549, l'imprimeur Francisco Fernandez de Cordoba publia à Tolède une traduction du résumé de Dorland.^^ Nous avons utilisé l'exemplaire existant dans la Bibliothèque Nationale de Lisbonne (Res. 8-19), le seul semble-t-il qui nous soit parvenu de cet écrit qui fut condamné par l'Index de Valdés de 1559.^^^ La Violeta del anima, qui laisse de côté le septième dialogue celui de Dorland, est une traduction fidèle des quatre-vingt-six chapitres de la Viola animae.

Plus encore que par des traductions, la Viola animae exerce son influence en Espagne par l'intermédiaire de deux adaptations. Une heureuse coincidence nous a fait découvrir dans l'Hispanic Society of America de New York une adaptation extrêmement curieuse de la Viola animae. Il s'agit du Despertador del alma, oeuvre anonyme publiée à Seville en 1544 et réimprimée à Saragosse en 1552. De l'édition de Seville on connaît deux exemplaires existant dans la Bibliothèque Nationale de Lisbonne et dans la Bibliothèque Nationale de Madrid. De l'édition de Saragosse de 1552 on connaît seulement un exemplaire existant dans l'Hispanic Society of America.

Le prologue et les trois premiers chapitres,qui introduisent la matière, racontent comment dans l'année 1544, fut trouvé à Rome un tableau dont l'image est reproduite dans l'ouvrage avec une légende en latin. Prié par le chevalier Horosius, Paul.religieux grec de l'ordre de St-Basile, explique les secrets et les trésors contenus dans ce tableau. L'explication comprend quatre colloques. Les chapitres IV à VII expliquent le titre du livre et du tableau, en s'appuyant sur St-Paul qui dans VEpitre au Romains nous montre "comment l'ensemble des créatures forme un livre dont chaque créature est un chapitre." Le chapitre VIII expose l'ordre et le degré existant entre les créatures.

A partir du chapitre VIII le Despertador del alma est une simple adaptation de la Viola animae. L'arrangement offre des formes très variées. Très souvent le texte de la Viola est présenté en résumé et dans une forme beaucoup plus accessible aux lecteurs profanes. Parfois on intercale des explications, des exemples, des témoignages qui explicitent le paragraphe transcrit. Dans la plus grande partie des cas, il s'agit d'une traduction fidèle de chapitres entiers de la Viola. Le Despertador del alma figure parmi les oeuvres interdites par Vlndex de Valdés de 1559.^^

La courroie de transmission la plus importante pour la diffusion des idées de Sebond en Espagne au XVIème siècle est le Libro llamado Lumbre del alma de Fr. Juan de Cazalla dont on fit probablement deux éditions. M. Bataillon affirme qu'en juin 1921 il eut en mains, au Couvent des Dominicains de San Esteban de Salamanque, un exemplaire de la Lumbre del alma, imprimé à Valladolid par Nicolas Tierry le 15 juin 1528. Aujourd'hui cet exemplaire a disparu. Selon Bataillon, le P. Justo Cuervo supposait que le livre de Juan Cazalla était précisément "l'Obra impresa en Valladolid por Maestro Nicolas Tierry, ano de 1528, en romance," interdite par l'Index de Valdés. ^^ Mais selon le P. Cuervo, il semblait difficile d'expliquer l'étrange désignation de l'oeuvre dans l'Index, et de plus la défense même ne se justifie que par une rigueur extrême à cause de la saveur illuministe du titre et d'un appendice sur les douze degrés de la connaissance de Dieu.

La supposition du P. Cuervo, d'après qui la défense de l'Index de Valdés tombe sur le livre de Jean de Cazalla, nous semble une hypothèse très digne d'être retenue. La raison, à notre avis, pour laquelle Vlndex ne cite ni l'auteur ni le titre de l'oeuvre interdite est que la personne chargée de rédiger l'Index ne les connaissait pas. Les livres de cette époque, dont les premières pages étaient supprimées, ne sont pas rares. Il put bien arriver qu'on donna au censeur un exemplaire sans première feuille, et que celui-ci, ignorant par conséquent de quelle oeuvre il s'agissait, se vit obligé de se servir du colophon du livre pour le désigner. La totale coincidence entre le colophon du livre de Cazalla et la désignation du livre défendu par Vlndex, ne permet pas de conclure avec certitude que la Lumbre del alma soit l'oeuvre interdite, étant donné que des presses de Nicolas Tierry purent sortir cette même année de 1528 bien d'autres livres. Mais il existe certains indices qui nous inclinent à penser à une telle identification.

Le franciscain Juan de Cazalla, aumônier majeur et collaborateur du Cardinal Cisneros, fut nommé évêque auxiliaire d'Avila en 1517. Nous savons qu'il sympathisa avec Erasme et qu'il fut en contact avec l'évangélisme français de Lefèvre d'Etaples.^^ Fr. Juan, qui avait eu des rapports avec des cercles d'"illuminés", fut probablement mis en procès par l'Inquisition. Il est probable,par conséquent, que la Lumbre del alma ait continué à exercer une influence parmi ces groupes. Un exemplaire de ce livre, auquel on aurait enlevé la première feuille, pouvait très bien appartenir à l'une des personnes emprisonnées par l'Inquisition. N'oublions pas que parmi les personnes mises en accusation puis exécutées à Valladolid en 1558, se trouvait le docteur Augustin Cazalla, neveu de Fr. Jean.

Nous connaissons aujourd'hui le texte de la Lumbre del alma par un exemplaire imprimé à Seville en 1542, qui est conservé à la Bibliothèque Nationale de Lisbonne. ^^

M. Révah a été le premier à apercevoir que "la presque totalité de la Lumbre del alma est une adaptation fidèle d'une vingtaine de chapitres de la Viola animae". Exception faite de certains paragraphes de l'introduction, du chapitre douze de la première partie et de l'appendice sur "el modo para venir en alguna manera en conoscimiento de dios", toute l'oeuvre est une adaptation, et presque toujours une simple traduction. Cazalla s'est servi du verset 12 du Psaume 136: Quid retribuam Domino proomnibus quae retribuit mihi, pour introduire et placer avec une certaine unité la matière du deuxième et troisième livre de la Viola animae, qu'il propose en forme de dialogue.

La première partie de la Lumbre del alma présente une description des bienfaits et récompenses de Dieu, tout spécialement de l'amour avec lequel Dieu nous a aimés et nous aime. L'homme doit répondre à Dieu avec l'amour, "libre don de la volonté". Tout au long de la deuxième partie, l'auteur présente et développe la thèse concernant la façon dont l'amour de Dieu est notre premier bien et notre propre "luz y lumbre". Par contre, l'amour propre est notre premier mal et notre "ceguedad y tiniebla".

Les idées de Sebond se répandent en Espagne principalement à travers le texte de la Viola Animae qui connaît une édition latine à Tolède en 1500, une traduction castillane en 1549 et deux adaptations: Tesoro de Angeles et Lumbre del alma. Le terrible index de Valdés de 1559 barrait la route à l'influence de Sebond par l'intermédiaire de la traduction castillane et des deux adaptations de la Viola. Cette condamnation veut-elle dire que l'Espagne de la deuxième partie du seizième siècle restera imperméable aux idées de son plus grand philosophe du XVième siècle? Comme dans beaucoup d'autres cas, les condamnations inquisitoriales n'ont pas eu l'effet qu'on aurait pu supposer. Deux auteurs qui connaîtront un grand succès editorial dans toute l'Europe prouvent la persistence de l'influence de Sebond en Espagne.

Le premier est Diego de Estella, dont les oeuvres, principalement la Vanidad del mundo et les Méditaciones del amor de Dios, connaissent de nombreuses éditions dans les principales langues européennes. Les Méditaciones del amor de Dios, tenues en grande estime par St-François de Sales, sont en grande partie une transcription des meilleures pages de la Lumbre del aima. Les emprunts littéraux sont principalement importants dans les méditations 42, 62, 63, 76, 82, 88, 89, 90, 91, 99.^^

Fr. Diego suit généralement avec fidélité le texte de la Lumbre del alma. On peut observer, cependant, le changement de mots et de formes vieillis, et aussi certaines additions, amplifications au omissions. L'adaptation de la forme de dialogue, employée dans la Lumbre del aima, à la forme de monologue des Méditaciones exige certains changements de style. Mais dans l'utilisation de la Lumbre del alma le P. Estella ne se limite pas à copier les textes. Il n'emprunte pas en général des pages entières du livre de Cazalla; d'ordinaire il transcrit quelques lignes, puis développe ces idées, les confirmant par des exemples et des arguments d'autorité de la Sainte Ecriture, ou bien il tire des conclusions. Il utilise également, en d'autres endroits, les idées des textes qu'il a déjà transcrits, leur donnant une expression littéraire un peu différente. Il y a également dans la Lumbre del alma certains passages, que Fr. Diego n'a pas inclus, tout au moins littéralement, et qui offrent une certaine parenté avec \es Méditaciones.

Nous ne nous attarderons pas sur le cas de Fr. Juan de los Angeles, considéré par Menéndez Pelayo comme un des plus agréables prosateurs espagnols. Par les études de Domi'nguez Berrueta et de Fidel de Ros, parmi d'autres, nous savons que Fr. Juan de los Angeles transcrit de longs passages sans signaler qu'ils proviennent de Sebond. Le plagiat du mystique franciscain se trouve dans La Lucha espiritual y amorosa, dans les Diàlogos de la conquista del reino de Dios dans lesquels il utilise plus d'une vingtaine de titres de la Théologie Naturelle. Fr. Juan de los Angeles, qui se limite souvent à traduire, adopte parfois avec liberté les idées du philosophe catalan comme il est habitué de le faire avec beaucoup d'autres auteurs.

Dans l'état actuel des recherches il nous paraît prématuré de vouloir tirer des conclusions définitives concernant le problème de l'influence de Sebond sur l'évolution intellectuelle et mystique de l'Espagne. Mais même si nous sommes persuadés qu'une recherche plus poussée nous apportera de nouvelles données pour mieux éclairer la question, nous pouvons déjà prendre connaissance de l'existence d'une puissante veine sebondienne qui traverse le XVIe siècle espagnol. Ce courant qui apparaît rarement à la lumière du jour, féconde les racines mêmes de la mystique

espagnole. Le cas de Raymond Sebond nous incite à multiplier les enquêtes pour chercher d'autres courants souterrains.

A notre avis, il reste encore d'importants travaux à réaliser sur les différentes courroies de transmission qui ont servi à la diffusion des idées au XVIe siècle. Les abrégés, les adaptations, les recueils, les florilèges ont été souvent des messagers anonymes mais effectifs. Des recherches systématiques sur des ouvrages de ce genre nous apporteront sans doute des données révélatrices.
Université de Sherbrooke

Notes

1 Raimundus Sabundus, Theologia Naturalis seu Liber creaturarum. Faksimile-Neudruck der Ausgabe Sulzbach, 1852. Mit literargeschichlicher Einfùhrung and kritischer Edition des Prologs un des Titulus I von Friedrich Stegmùller (Stuttgart-Bad Cannstatt, 1966). Raymundus Sebeyde, Liber creaturarum sive de homine, [c. 1484, Lyon, Johannes Siber]. Ibid., p. 11*.
2 Ibid., p. 11 • -12*.
3Ibid.. p. 31*: "Quia ista scientia docet hominen cognoscere se ipsum, propter quid factus sit, et a quo factus sit; quid est bonum suum, quid estmalum suum; quid debet facere; ad quid obligatur, et cui obligatur".
4 Ibid., p. 33*.
5 T. et J. Carreras Artau, Historia de la Filosofia Espanola. Filosofia cristiana de las siglos XIII al XK (Madrid, 1943), t. II, pp. 109, 157.
6 Mario Martins, "Sibiuda "a Corte Imperial" e o Rationalismo naturalista," dans Estudos de Literatura Medieval (Braga, 1956), pp. 395-415.
7 Sabundus, Theologia Naturalis, Introduction de F. Stegmùller, pp. 4 •- 11*. Augustin Renaudet, Préréforme et Humanisme à Paris pendant les premières guerres d'Italie (1494-1517) (Paris, 1916), pp. 485, n. 5, 521, n. 1.
8 Joseph Coppin, Montaigne traducteur de Raymond Sebond (Lille, 1925), pp. 57 - 58.
9 M. Batllori, "De Raimundo Sabundo atque Ignatio de Loyola", dans Archivum Historicum Societatis lesu, XXXVIII (1969), pp. 454-463.
10 M. Scaduto, "Lainez e l'Indice del 1559. Lullo, Sabunde, Savonarola, Erasmo", dans Archivum Historicum Societatis lesu XXIV (1955), pp. 3 - 32, p. 27.
11 Lorenzo Riber, "Erasmo en el Indice Paulino con Lulio, Sabunde y Savonarola", dans Boleiin de la Real Academia Espanola, XXXVIII
(1958), pp. 249-263.
12 Voir parmi d'autres: Pierre Villey, Les sources et l'évolution des Essais de Montaigne, (Paris, 1933), t. 2, pp. 171-187. M. Dreano, La Religion de Montaigne (Paris, 1969), pp. 233-273. Hugo Friedrich, Montaigne, Traduit de l'allemand par Robert Rovini, (Paris, 1968), pp. 104-121.
13 Olivier Naudeau, La pensée de Montaigne et la composition des "Essais" (Genève, 1972).
14 Cf. F. Strowski, Pascal et son temps, (Paris, 1909), vol. 3, pp. 236-239.
15 Louis Moereels, "Dorland", dans Dictionnaire de Spiritualité, t. III, cols 1646-1651.
16 J. Coppin, op. cit., pp. 33 - 34.
17 Carreras Artau, op. cit., p. 171; Batllori, loc. cit., p. 454-455.
18 Raimundo Sabunde, Las criaturas. Grandioso tratado del hombre, (Barcelona, 1854).
19 I.S. Révah, Une source de la Spiritualité Péninsulaire au XVIe siècle: La "Théologie Naturelle" de Raymond Sebond. (Adademia das Ciencias de Lisboa), (Lisboa, 1953); Marcelino Menéndez y Pelayo, Historia de las ideas estéticas en Espana, (Consejo Superior de Investigaciones cientificas), (Madrid, 1942), vol. I, p. 428.
20 Viola animae per modum dyalogi, inter Raymundum Sebundium, artium, medicine atque sacre théologie professorem eximium et dominum Dominicum Seminiverbium. De hominis natura {propter quem onmia facta sunt) tractans, ad cognoscendum se, Deum et hominem. Colophon: Finit dyalogus de mysteriis sacre passionis Christi et per consequens totus liber iste (qui Viola animae inscribitur) in septem distinctus dyalogos. In aima Toletana civitate Hispaniarum primate impressus. Anno

natalicii Salvatoris Nostris Millesimo quingentesimo, die ultima mensis Augusti. K. Haebler, Bibliografia Ibérica del siglo XV, (La Haya, 1903-1917), vol. II, no 590. CL. Penney, Printed Books (1468-1 700) in the Hispanic Society of America, (New York, 1965), p. 488.
21 F.J. Norton, Printing in Spain (1501-1520), (Cambridge, 1966), pp. 49-50.
22 Violeta del /anima. Que es summa de la / Tbeologia natural a manera de did/logo. Que tracta del hombre por causa del qual las otras criaturas /son bêchas. Por el conoscimiento de /las quales se alumbra el hombre pa conos/cerse assi y Dios y a las otras cri/aturas. Nuevamente traduzido de la/tin en romance Castellano. Con Privilegio Imperial. Colophon: Fue impresso en la muy noble /villa Valladolid, cerca de las Es/ciielas mayores. Por Francisco /Fernandez de Cordoba impre/ssor. Acabose a xxiiii. dias del / mes de Noviembre, del ano / de nuestra salud de M. D. XLIX.
23 F.H. Reusch, Die Indices librorwn probibitorum des Secbzebnten Jabrhunderts, (Tubingen, 1886, réimp. 1961), p. 240.
24 Despertador / del alma. En el qual se / tracta por via de colloquio / vna doctrina muy util, y / provecbosa para des/pertar el alma q esta / adormida en vi/cios: Y se mue/s'tra como / deve / bivir qualquier christiano. / 1544.
25 Despertador del alma / adormida: dirigido ala muy noble se/nora dona Blanca de Colona Calvillo y de Cardona. Zc. /Impresso en Caragoça a costas de / Miguel de Capilla mercader de libros/Ano de MCLII.
26 Despertador del alma adormida, (Zaragoza, 1552), f. 17v.
27 Comme exemple on peut comparer les passages suivants: "Quarta conditio: quod ista conversio amantis in rem amatam non est violenta, non coacta, non laboriosa, sed spontanea, liberalis, dulcis, delectabilis; et ideo voluntas qui iungit rei amate non potest ab ea separari per aliquam violentiam, sed sponte et mere libère. Quinta conditio: quod amor licet mutet voluntatem in rem amatam, tamem amor semper permanet liberalis amor et suam retinet naturam. Voluntas quoquunque licet permutetur in rem amatam, cuius et naturam induit et formam, tamem semper permanet voluntas, nee ideo destruitur quia mutatur." Viola animae, "Dialogus tertius". Chap. XXII, (Toledo, 1500), f. 3 5v. "La quarta es que la conversion que se haze del que ama en la cosa que ama, no es violenta, ni por fuerza, ni trabajosa, sino muy voluntaria, libre, dulce, y llena de plazer. Y por esto la voluntad, que se ayunta convierte y transforma en la cosa que ama, no se puede apartar délia por ninguna violencia, o fuerza, sino voluntaria y libremente. La quinta es, aunque el amor se convierta y transforme en la cosa que ama, siempre queda en su propia naturaleza, que es siempre ser libre; y la voluntad aunque se mude o convierta en la cosa que ama, y recibe délia naturaleza y forma; pero aunque se mude no se pierde ni destruye porque siempre queda voluntad". Despertador del aima adormida, "Colloquio tercero", Chap. I, (Zaragoza, 1552), f. 80r-v.
28 Reusch, op. cit., p. 233.
29 Ibid., p. 237, Nous utilisons amplement le chapitre IV de notre étude; Diego de Estella (1524-1578). Estudio de sus obras castellanas. (Publicaciones del Instituto Espaiiol de Historia Ecclediàstica, no. 15), (Rome, 1970), pp. 67 - 76.
30 M. Bataillon, dans l'Edition de Juan de Valdés, Dialogo de doctrina cristiana, (Coimbra, 1925), pp. 137-138.
31 M. Bataillon, Erasmo Y Espana, (México-Buenos Aires, 1966), pp. 65-71. Bien que cet ouvrage fut publié premièrement en français en 1937 nous utilisons la deuxième édition espagnole enrichie avec de nombreuses additions. 32 Son procès est mentionné dans celui de Juan de vergara, f. CCCXIX, Cfr. Bataillon, éd. du Dialogo ... de J. de Valdés, p. 141. Angela Selke, El Santo Oficio de la Inquisiciôn. Proceso de Fr. Francisco Ortiz (1529-1532), (Madrid, 1968), pp. 51 -52.
33 LIBRO LLAMADO LUMBRE DEL ALMA / Aqui comienza un /brève tractado que babla de los be/neficios y mercedes que ba el bom/bre rescebido de la muy libe/ral mano de Dios y de la / paga que por ello le es o/bligado a fazer. Co/legido de los doc/tores sanctos /por el muy / reverendo / Padre fray Juan de Caçalla, de la orden /de los Menores, maestro en sancta theo/logia y obispo de Vera. Va a manera de / dialogo, que es mâs aplazible modo de / screvir y al lector de leer. Son dos bermanos, / el uno Antonio y el otro Luis, lla/mados assi por nombres, discipulos del / maestro auctor del présente tractado. Colophon: Esta o bra fue vista y / examinada por mandado de los S.

Inqui/sidores y Ordinario de la villa de Va/lladolid y aprobada. Fue impressa/en la muy noble y muy leal Cib/dad de Sevilla en las casas de /Juan Cromberger que sancta /gloria aya, a ocho- dias / del mes de Abril, / Ano del Senor de / mil y quinien/tos y quaren/ta y dos / anos.
34 Révah, op. cit., p. 22.
35 Lumbre del aima, ff. 31r, 38r, 48r.
36 La dependence de Diego de Estella, à l'égard de la Lujnbre del alma est étudiée dans notre ouvrage déjà cité Diego de Estella, pp. 71 - 76.
37 Juan Domînguez Berrueta, Filosofia mistica espanola, (Madrid, 1947), pp. 57-58, 121-132. P. Fidèle de Ros, "La vie et l'oeuvre de Jean des Anges", âzns Mélanges. . F. Cavallera (Toulouse, 1948), p. 405.

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Prelude
A curiosité naturelle que nous avons de sçavoir une grande diversite de choses, n'est pas satisfaite du rapport que nous sont les sens des objets extérieurs, si la raison n'en conçoit les causes, & ne va reconnoistre les effets jusques dans les intentions de leurs principes. Cette passion de sçavoir la raison de tout, est si forte dans les grands esprits, que l'estude qui la contente leur tient lieu de tous les délices du monde, & au contraire, son ignorance leur est une géhenne insuportable. C'est pourquoy un Philosophe se précipita dans l'Europe, par un desespoir de ne pas entendre la cause de ces tenus si réglez en leurs inconstances. Et l'autre aima mieux mourir en se laissant consommer aux flâmes du mont Ethna, que de vivre & ne pas sçavoir comment cet embrazement se pouvoit entretenir sans consommer sa matière. Mais âpres que nostre esprit a fait ses courses dans l'ordre du monde, qu'il a descouvert les artifices de la Nature, & la dépendance de ses parties, il doit arriver jusques à une première cause, qui serve déportàses pénibles recherches, comme elle est le principe & la fin de tous les Estres. Autrement de s'arrester à une cause finie sans passer plus outre, ce seroit admettre le vuide dans le monde, & dans nostre connoissance, terminer le long chemin des estudes par un précipice, & n'avoir beaucoup appris, que pour moins sçavoir. Car nous avons une inclination de découvrir aussi bien la cause un jusques que celle des effets particuliers: & si ce désir n'est accomply, il se trouve que nostre ignorance est aussi generale que son sujet, & que nous n'aurons connu les parties que pour ignorer le tout. Ce seroit peu s'il ne s'agissoit en cela que de la satisfaction de nostre esprit, & s'il n'y avoie que la curiosité qui souffriss dans l'ignorance du premier Principe. Mais il y va de nostre souverain bien: c'est le fondement de la Religion, & de là dépend le règlement de nos vies, & la conservation des Estats. Croire un Dieu, c'est la seule senté qui arreste le déluge de tous les crimes, qui empesche que l'injustice ne triomphe de la vertu, que les violences, les pillages, les meurtres, ne désertent la Nature. Que les hommes ne s'enoyent dans leur sâng, fit n'esteignént le irrespect pour assouvir la fureur de leurs paillons. C'est pourquoy tous les anciens Legislateurs ont fait de cette créance la première comme la plus necessaire de leurs loix, & ont obligé les peuples de la recevoir avec tant de respect, qu'un Philosophe pour avoir seulement fait dessein de la combattre, fut condamné aux suplices dont on punissoit les plus criminels. La Foy divine nous impose cette mesme nécessité de croire qu'il y a un Dieu, premier principe & cause universelle du monde, & de nier cet article, c'est passer à l'extremité du sacrilège, &arrester la Religion en là source* Mais comme la Foy n'exerce pas le mesme empire sur les sentimens de l'esprit, que la Loy civile sur les actions extérieures, &que l'homme attaché à l'interest de les sêns, obeyt plustost à la crainte des peines présentes, qu'aux espérances des biens qu'il ne connoist pas. Cette Foy se sert sort à propos de la science, pour fonder jusques au plus

profond des coeurs, de poeur y vaincre par la raison les répugnances qu'ils ont a cette importante vérité. Car encore que je me voulusse persuader que la France ne porte point de monstres semblables à Diagoras, & que l'impieté n'est pas assez téméraire pour ses onslever de cœur & de bouche contre Dieu, sous 1e règne de nostre Prince, qui espouse si chèrement les interests de la Foy, & qui n'a des armes que pour en denier les ennemis: Neantmoins il est vray qu'il se trouve des ames rétives qui reculent d'autant plus qu'elles se sentent pressées dans les matières de Religion: elles prennent ombrage d'un consentement public, & se persuadent que 1 obligation qu'on leur impose de croire, est une violence qui se fait aussi bien à la vérité, qu'à leur inclination: De sorte que si le sentiment de Dieu n'est tout à fait esteint dans leurs cœurs, il est si foible, qu'ils ne s'acquittent des devoirs de Religion qu'avec une langueur, qui fait bien paroisse que la puissance en est demy-morte. Que si nous, traitons les matières de théologie en suppoíant un Dieu à ces esprits qui n'en ont pas un vray sentiment, si nous parlons en ces termes racourcis, où les meilleurs yeux y peuvent à peine reconnoistre la vérité, sinons nous servons de ces distinctions, qui laissent autant de dificultez qu'elles ont de paroles: nous ne faisons qu'égarer les ignorans dans en labyrinthe de fausses conclusions, parce qu'ils n'ont pas la veuë du premier Principe. Y procéder de la forte, c'est bastir sàns avoir jetté les fondemens. C’est élever de grands aqueducs sans source, & avancer aussi peu par les austères resolutions de l'Escole aux autres matières de Foy, que celuy qui penseroit achever en cercle sans en avoir rencontré le centre. Cela nous oblige d'étendre cette matière plus au long que ceux qui en ont déja traitté, de promener l'esprit dans les estages du monde, luy ouvrir les secrets de la Nature, & des merveilles que nous y remarquerons, en faire de bons sentiments de Dieu. Ils serviront à deux principales fins: l'une pour combattre l'impieté par ses propres armes, en faisant paroisser que la Nature qu'ils opposent à Dieu, est celle-là mesme qui nous en donne ^instruction; L'autre, pour persuader les vertus en leur donnant la lumière de ce Principe, plus nécessaire a leur entretien, que n'est celle du Soleil aux productions de la terre.

Ainsi un mesme discours formant les esprits au bien, & des fortifiant contre l'erreur, leur fera comme l'un de ces remèdes faciles qui servent tout à la fois de médecine & de nourriture. Si les ames élevées à la pieté se donnent le contentement de cette spéculation naturelle, je croy qu'elles tomberont dans le parjure innocent, de ceux qui aiment, qui protestent tous les jours, que leur amour est en en estât de perfection incapable de recevoir de Accroissement, & neantmoins jamais le Soleil ne se leve, qu'il ne leur découvre dans l'objet qu'ils passionnent, de nouveaux charmes qui leur font accuser leurs premières ardeurs de tepidite. Aussi la devotion n'a point d'entretiens si sublimes, & ne donne point de consolations si ravissantes, qu'elle ne laisse encore dans lés âmes assez déplace, pour y loger, les contentemens qui luy viennent de la considération de la Nature-, nous pouvons dire qu'ils font sàns limites, puis que Dieu mesme, qui est infiny, les ordonne comme en moyen qui nous doit conduire à sa mesme

Chapitre I - L'Homme a un Sentiment Naturel De Dieu

ÎL y a certaines veritez si claires à nos jugement, & fi publiques entre toutes les nations, que nous les pouvons dire inséparables de nostre nature, qu'il suffis d'estre homme pour n'en estre pas ignorant. Cette mesme Providence qui assortit les choses matérielles de qualitez propres aux effets qu'elles prétendent, qui instruit les brutes d'un instinct necessaire à leur conservation,' a gravé ses loix dans nos esprits pour le règlement des discours de nostre raison en la recherche de la vérité, & de nos affections en la poursuite du bien. Mais soit, ou pour les mœurs, ou pour les sciences, elles ont toute cette secrette vertu de répandre dans lésâmes une tranquille lumière, qui gagne le consentement des plus rebelles sans aucun effort, & qui este doucement á la curiosité le droit de douter, & le désir de connoistre davantage.

Comme les puissances naturelles nous estans intimes, nous sont cependant si peu sensibles, que nous n'avons point d'autres asseurances d'en estre assistez, que par le libre exercice de leurs actions, & le repos de la partie où elles résident: Ainsi l'acquiescement de nostre esprit dans ces veritez originaires, & l'éclaircissement qu'il en tire pour d'autres sujets, nous le fait avouer comme

infaillibles, sans que nous en demandions de prévue. Car de chercher la raison de ces principes, c'est demander avec mauvaise foy ce dont nous sommes desja satisfaits, c'est offrir niér la libéralité de la Nature, de nous dire pauvres d'un bien que nous tenons d'elle en propre, & c'est vouloir accroissire la lumière du Soleil d'un nouvel esclat, de confirmer des veritez qui sont au dernier point de la certitude. Qui a jamais demandé preuve de ces maximes, Que le tout est plus grand que la partiel Qu'une chose ne peut en mesme temps estre, & n'estre pas, & d'autres semblables que nous sçavons sans estude, & qui dépendent aussi peu des regles de Dialectique, que la source de ses ruisseaux? En effet les veritez que la Raison nous découvre dans les diverses sciences, découlent de ces premiers principes. Et âpres les longs destours de la ratiocination, elles viennent toutes se rejoindre à ce centre, qui termine leur mouvement & empesche que le progrez n'en soit infiny.

On rapporte sous ces loix de Nature le mariage, l'education des enfans, nombre de contracts, & d'autres veritez & inclinations communes; Mais entre toutes, le culte & la connoissance de Dieu est la plus generale, comme elle est la plus necessaire à la perfection de l'homme. Il s est trouvé des peuples qui n'ont point receu le mariage par en excés de continence, ou de libertées autres farouches en leurs mœuves vivoient égarez dans les solitudes, sans commerce, sans police, sans alliance: cependant il ne s'est point veu de nation si barbare, qui n'ait eu quelque sentiment de Dieu.

Il est vray que l'opinion, qui opère les mesme effets sur les inclinations naturelles, que les arts sur la matière, déguisa de forte les sèntimens de la Religion, selon les divers appétits des peuples, que le monde s'est veu plongé dans 1idolâtrie par l'excez d'une pieté contrefaite, & reduit apres ènterses sacrifices aux ouvrages de ses mains t & aux objets de sa passion, au lieu de les rendre au Dieu dut Ciel & de la Nature. Mais, comme une Mouche & un Eléphant * v Satyre & une Hélène, jettez en fonte, conservent tousjours une mesme matière sous la grande inégalité de leurs figures, & l'hideuse face d'un monstre ne diminue rien du prix de l'or, dont il est moulé, Ainsi quoy que les peuples soient fort criminels des estre emportez à ces sacrilèges adorations, neantmoins il faut avouer qu'ils avorent tous dans leurs cœurs cette égale impression de la Nature, d'adorer un Dieu, & si les moyens en estoient prophanes, le premier motif, & cette première impulsion estoit saincte. Une mesme ame vegetative nourrit la délicate beauté d'un visage & la deformité d'une bosse: Les mesmes influences des Astres concourent à la production du basilic, & de la colombe, & la mesme chaleur naturelle qui soustient la vie, n'ayant de la force que ce qu'il en faut pour corrompre, & non pas pour digérer rhuraidité, engendre des qualitez pestifères qui donnent la mort: Les monstres horribles à la veuë, & pernicieux à nostre santé, ne viennent que d'une matière indisposée, qui abute des influences d'une cause particulière & universelle, & qui ne sçachant pas en débiter les vertus, selòn les proportions d'une espece déterminée, employé de bons principes pour éclorre un mauvais effet. Les plus nobles causes sont deshonorées de ces infâmes productions: c'est la chaleur du Soleil qui animant le sein de la terre en fait naistre la ciguë & la vipère, c'est la vertu generative qui forme ces masses informes dans un sexe qui manque du secours de l'autre, & c'est l'inclination que nous avons d'adorer un Dieu, qui a fait germer l'idolatre entre les hommes, lors que le péché les eut rendus indignes des grâces célestes, qui les devoient secourir pour concevoir un légitime sentiment du premier Principe.

Jamais les peuples n'eussent eslevé des autels, & présenté des sacrifices à des Divinitez imaginaires, s'ils n'eussent tous porté dans l'âme en secret & commun sentiment de Dieu. Car les opérations de l'esprit aussi bien que celles des sens, presupposent toujours une faculté d'où elles procèdent, encore qu'elles soient extravagantes, que l'imperfection des organes, ou du milieu, arreste la chaleur de leur poursuite, & les abuse au discernement de leurs propres fins. Ainsi nos yeux emploient une puissance visive pour voir les objets, lors mesme que l'innocente tromperie de la perspective les racourcit, & que l'artifice des faux miroirs les représente renversez ou multipliez. Mais une pierre ne voit le Soleil ny grand ny petit; & tous les astres qui font ensevelis dans une pure

privation naturelle, n'ont point d'actions, ny généreuses, ny languissantes, pour le sujet avec lequel ils n'ont point de proportion: elles sont hors la puissance d'estre produites, & ce seroit leur donner un titre trop avantageux, de dire qu'elles souffrent une défaillance & une mort, parce qu'elles ne sont pas capables de recevoir l'estre. l'irons donc cette conséquence, que les hommes des siècles idolâtres portoient un vray sentiment de Dieu, encore quel opinion, que la vanité des Princes, & que le dérèglement de leurs passions l'ayent diversite à l'adoration des monstres, des vices, & des pierres. Et par conséquent il y a un Dieu, qui est le propre, & le naturel objet de cette puissance.

La commune inclination de la Nature n'est jamais trompeuse; elle aspire tousjours à une fin légitime;, dont la possession est la félicité du sujet qui est a concev les désirs, & qui s'est eschaussé à sa recherche. Si les brutes sont passionnées pour la génération, c'est qu'elle importe à l'entretien de l'espece: si les oyseaux ont le temps assigné pour leur passage, c'est afin d'éviter l'inclemence d'une saison souz un climat qui doit estre bientost stérile pour leur nourriture, ils se mettent à la suite du Soleil, Se font leur demeure où ses chaleurs ramènent la fertilité avec le Printemps tout de mesme si tous les hommes ressentent une inclination generale d'adorer Dieu, il faut nécessairement qu'il y ait quelque divinité vraye, capable de leur donner ce qu'ils s'en promettent de félicité, & tout autre que les Phantosmes & les Idoles du Paganisme.

C'est âpres cette bonté infinie que souspirent toutes les nations de la terre: C'est pour elle qu'elles ont des vœux & des sacrifices, & qu'elles conservent un désir insatiable de sa connoissance, jusques à ce que la Foy leur en ait apporté quelque lumière. Nostre âge a découvert des peuples barbares, qui estans accostez parles marchands pour le commerce, leur couroient ílis avec une fureur brutale, & voyoient tous les estrangers comme des ennemis qui estoient en butte de leurs armes, & qui leur devoient servir de curée en leurs festins homicides. Que si un Religieux les aborde en leur parlant de Dieu, encores que ce soir avec des paroles imparfaites, & d'une langue grossière, de ce qu'elle est trop délicate pour la rudesse de leur prononciation) neantmoins vous verrez en un instant ces Sauvages apprissez, de l'ygres ils font des agneaux: Cette première instruction de la Foy est un astre de bonne influence qui rend le calme à leurs esprits, & le seul article sur lequel ils signent la paix, ils mettent les armes bas, ils le laissent ravir d'admiration au simple discours qu'on leur fait de Dieu, ils tressaillent d'une allégresse inacoustumée, qui leur apprend la courtoisie pour recevoir ce nouveau Prophète, qu'ils couronneroient comme Roy, si ce n'estoit qu'il leur fist entendre que la grandeur de l'homme ne consiste pas en la domination.

D'où vient cette subite métamorphose de brutes en hommes, contraire à la Magic de Circc, qui transformoit les hommes en brutesse D'où viennent ces extraordinaires satisfactions d'esprit, 8tces complaisances qui font oublier aux Barbares des inhumanitez qui estoient devenues leur naturel par une mauvaise éducation? Nous sçavons que toutes les voluptez qui gagnent les affections, naissent de hi sympathie, & que les plaisirs de l'esprit aussi bien que ceux des sens, procèdent du favorable rencontre des choses semblables. Il faut donc que ces Peuples portent dans leurs ames un secret sentiment de Dieu, puis qu'ils aiment tant ceux qui leur en parlent, qu'ils le ravissent de joye dans cet entretien, & qu'ils en achetent la consolation au prix de leur liberté. Les goûtes d'eau qui se tiennent ramassées en petites boules, se rejoignent avec une extrême avidite, & d'une vitesse qui eschappe à nostre veuë, lors que la pente leur fait le chemin, ou que le mouvement les porte au rencontre: Ainsi cette connoissance naturelle de Dieu, qui à cause de sa foiblesse retenoit retranchée dans des ames qui ne luy permettoient aucun exercice, fait une saillie dans cette occasion, & se plaise à trouver des enseigemens qui la fortifient. Et comme les lumières se portent un si grand amour dans leur ressemblance, qu'i l'instant mesme qu'elles se des couvrent, elles s'embrassent & unissent par un meslange si estroit, qu'il n'y demeure point de distinction sensible: De mesme le rayon de la connoissance de Dieu que chacun possédé, tasche de se rejoindre à celuy d'un autre pour se perfectionner; & par le zele du Prédicateur, & l'attention des auditeurs, il se fait un concours de lumières, d'allégresse, & de volontez.

Que si les Sauvages estoient privez de cette connoissance naturelle de Dieu, le discours qu'on leur seroit, au lieu de gagner leurs affections, irriteroit leurs courages, parce qu'il blesseroit leur liberté: Car on leur presche Dieu tout-puissant qui prend la domination sur les hommes, qui demande leurs adorations & leur servitude, qui découvre ce que la conscience tasche de cacher, qui punit les crimes, qui s'offense de nos plaisirs, qui refuse les voluptez à nos sentimens toutes loix, & toutes considérations ennemies de la liberté naturelle.

Chapitre II - Le Sentiment Que L'homme A De Dieu Vient De Dieu Mesme

Sitost que nostre œil a decouvert la lumière, il se tourne du costé d'où elle luy vient, & envoye ses regards avec une promptitude, qui seroit plus de la moitié du chemin, si n'estoit que cette belle qualité, qui ne veut qu'un instant pour le respandre, devance sa courtoisie; & se laisse aussitost posséder que voir: Neantmoins nostre œil estant prevenu de ce rayon, ne laisse pas de le juire jusques a sa source, & de reconnoistre aussi-tost le lieu & la cause d'où cette faveur luy est envoyée y soit qu'il veuille posséder tout l'espace qui contient ce bel objet, afin que rien n'en eschappe à sa joysance, ou pour sçavoir á qui il est redevable de ce bien fait, & en demander la continue, dans la crainte qu'il a de sa perte. Mais parce que la puissance visive n'est pas capable de tant de discours, je croy que l'œil se laisse transporter de la sorte à sa lumière par une inclination de la Nature, qui en cela fait paroistre dans l'action du sens l'appetit de nostre raison à rechercher l'origine de ses connoissances. Nostre ame ne demeure pas satisfaite du secret sentiment qu'elle a de Dieu; elle pointe bien plus haut, & comme elle est instruite à faire des reconnections sur ses discours, à monter des effets à leur causes des conclusions aux principes; elle fait icy une généreuse faillie jusques au Soleil sur celeste qui l'oblige de cette lumière.

Il est certain qu'elle ne nous vient pas de l'opinion, comme nous allons prouver, a ce qu'elle est generale entre tous les peuples, constante en tous les âges, & que a terre ne porte point d'hommes qui ne portent ce rayon dedans leur cœur: elle ne procède pas aussi de la propre force de nostre ame, comme si elle estoit de la substance, de mesme que cette lueur blasarde attachée à une matière, qui est une partie du corps de certains petits vers qui nous esclairent de nuit. Elle nous vient donc de Dieu mesme, & en cela elle nous donne une double asseurance de son estre, & parce que nous en avons ce vif sentiment, parce qu'il ne nous peut venir que de sa pair.

C'est un présage qui est confirmé de l'experience, un double effet de deux faveurs qui tout à la fois nous rendent certains de la bonté de leur principe. De même que le Soleil qui contribue beaucoup de son influence à nostre génération, a mis dans nostre ciel une certaine qualité lumineuse, par le moyen de laquelle nous le regardons quand il est élevé sur nostre hémisphère l & cette seule action est un effet qui réussit du concours de plusieurs faveurs, en ce que nous sommes si nous le voyons par luy-mesme, il nous donne d'estre, la puissance de voir sa lumière, il nous l'envoye & se rend présent, afin que nous la recevions: Ainsi nostre esprit ne seroit pas capable de la moindre pensée de Dieu, si Dieu mesme ne luy en avoit imprimé l'idée. Le secours particulier de sa grâce n'en renouvelloit le sentiment, de l'infinité de son essence ne le rendoit plus présent aux ames, que le Soleil de l'est aux terres qu'il regarde a plomb quand il est au milieu du Ciel.

Nostre ame a bien d'elle-mesme le pouvoir de se forger des fantosmes, des chumères, des montagnes d'or, & de donner un estre en son imagination à des choies qui ne sçavroient avoir l'existence dans la Nature. Les sens luy ont fourny les images de ces objets, devant qu'elle en peust entretenir ses pensées y elle ne fait qu'une composition intellectuelle des choses qui font séparées, de ramasse sous un concept, les formes que les sens ont veu dans la distinction. Mais s'il n'y avoit point de Dieu, il seroit impossible que nostre esprit en eust la pensée, de que nostre bouche prononçast le terme qui le signifie, parce que nos sens n'ont rien découvert en toute l'estendue de la nature qui rapporte aux éminentes perfections de son essence; de tous nos efforts font trop foibles pour former ce concept incomparable. Le moyen que nostre ame, qui ne le peut pas parfaitement connoistre elle-mesme, ny voir les formes substantielles à travers l'épaisseur de la

matière, puisse avoir d'elle-mesme la pensée de Dieu, qui est un estre intelligible, le plus pur de le plus éloigné du corps? Nous en parlons comme d'une essence infinie en bonté, en grandeur, en pouvoir, en estendue. Couramment nostre esprit qui n'a que des forces limitées, pourroit-il former un concept de l'infiny, s'il n'y avoit un infiny qui luy eust communiqué cette intelligence, de relevé son action jusques à cette portée? Car toutes les opérations se mesurent à J'estre, de comme elles en font des productions, le dernier point de leurs excellences, est de représenter leur principe avec quelque forte d'égalité, mais non pas de le surpasser.

Nostre ame donc qui n'a qu'une puissance finie ne peut d'elle-mesme concevoir une idée de l'infiny, Veu mesme qu'en l'ordinaire de sort procédé, de crises actions familiaires, elle s'en écarte par une certaine crainte d'en venir á une entreprise, où elle ne peust réussir. De fait, quoy que le cours des sciences soit limité, que la Métaphysique leur assigne des objets, de marque leurs bornes & neantmoins nostre esprit ne se donne pas la peine démonter jusques aux premières veritez, mais pour íe reposer, de pour s'écarter tousjours plus de l'infiny, chaque science emprunte d'une autre des principes où elle s'arreste, de tient pour un crime de les revoquer en doute. Si la Dialectique se met en queste de la vérité par la ratiocination, elle se retranche opiniâtrement» entre deux prémices, âpres qu'elle a fait deux pas, elle retourne en arrière par la conclusion, de appréhende si fort le progrès à l'infiny, Qu'elle en fait le dernier de le plus noir de ses péchez.

Enfin nostre esprit souffre plus par la pensée de l'infiny, ou en fait la teste à regarder dans un précipice, qui ne monstre point de fonds, & le ciel à se répandre dans le Vaste des espaces, qui ne le terminer d'aucun òbjet. De sorte que tous les hommes ayants une commune inclination, suivie d'un indicible contentement, â concevoir un estre infini, qui domine au monde; cette idée, qui passe le pouvoir de leurs esprits, leur vient de la libéralité de cette premier Cause, de qu'en cela l'aigreur de l apprehension naturelle de l'infiny & reeëfflgërisée par les délices qui ressentent toutes choses en la possession de leur príncipe. Nostre áhìe est une table d'attente, qui doit recevoir ce crayon & la main de Diète, c'est un miroir qui ne representeroit pas ce Soleil,-s'il ne luy estoit présent, fit si fort rayon n'y figuroit l'image de sa majesté.

Aussi Dieu, qui adonné aux estres in animez un mouvement qui les porte à leurs centres avec vitesse, & une inclination qui le leur fait posséder avec délices, a gratifié l'Homme de cet attrait, qui l'élcue à luy comme à son souverain bien. II est le principe & l'objet de nostre amour, il le produit & le gagne, ce semble picqué d'une espece de jalousie, d'estre le plus avant dans l'estime de la plus noble des créatures. 11 veut que l'homme qui voit toute la Nature au dessous de son excellence, ne ravale pas ses affections à des objets indignes de luy, mais que la pensée d'un Estre éternel & infiny luy inspire de généreuses volontez de le posséder, des désirs qui ne souffrent point de bornes en leur sainte ambition, ny de déchet en leur continue.

Tout ce que l'oeil voit à l'absence mesme du Soleil, c'est tousjours par la vertu de cet Astre, qui a relevé une matière sombre d'une qualité celeste, Et tout ce que nostre esprit conçoit de grand, vient ensuite de l'inclination que Dieu luy a donnée, de connoistre & d'adorer sa toute-puissance. C'est de là que nous formons la pensée d'un instant immuable d'éternité, encore que nous soyons engagez dans la vicissitude du temps, dont les parties périssent plustost qu'elles ne peuvent être apperceuts, C'est delà que nous concevons des Estres dans ^abstraction du sensible, & de la matière, que nostre esprit n'a point de bornes en ses contemplations, ny la volonté en ses appétits, parce que ces deux puissances font emportées par une force supérieure, vers un objet qui est infiny: Enfin c'est de là que nous avons. de l'amour pur une Vertu qui dompte les sens, pour une justice qui blesse nos interests, pour a spéculation de la vérité, qui nous écarte de la conversation commune, & altère nostre bonne disposition dans l'assiduité des estudes; parce que ces exercices nous approchent de l'objet qui possède toutes les veritez, & qui mérite toutes nos affections. L'abus mesme s'y glisse: & les ames médiocres se passionnent pour les grandes richesses, pour les Empires, & pour une réputation qui survit le corps, d'autant qu'elles ont le concept d'une puissance,

d'une domination, & d'une gloire infinie, comme d'un bien qui mérite nostre recherche, & prennent ainsi l'ombre pour le corps à la faveur de la lumière, sans laquelle il n'y auroit point d'ombre.

L'homme estant la plus sublime des créatures mortelles, devoit s'unir au premier Principe, qui seul peut estre son souverain bien, & s'en approcher par une action de l'esprit, qui est la plus noble de toutes ses facilitez, & celle qui les distingue plus des choses inférieures. Autrement, le vuide que la Nature abhorre tant dans le monde, se fût rencontre entre les Estres intelligibles, fi nostre ame n'eust esté rendue capable de l'union avec Dieu, & nous verrions rompre, pour nostre esgard, le cercle que forment toutes choses, par le retour qu'elles font au principe d'où elles sont escoulées. Et parce que la distance est infinie entre le Créateur & la créature. & que nos élans qui partent d'une puissance limitée, nous laissent tousjours dans un éloignement infiny, il falloit que nostre principe secourt est en cela nostre foiblesse, & qu'il nous donnast pour nous approcher de luy, un moyen puissant & libre des sujettions ordinaires à nostre nature.

En tous les autres sujets d'importance, nous cherchons devant que de nous résoudre, la consultation precede l'eclaircissement de l'esprit s l'amour se mesure à la connoissance, le cœur ne se donne que sous la conduite des sens, ou de la raison. Mais pour ce qui est de Dieu, nous ne raisonnons qu'âpres que nous avons connu, & sans faire de longues épreuves de ce sujet qui demande nostre liberté, l'amour nous liure aussi-tost en sa puissance, que son sentiment a esclairé nostre cœur. un instant nous fait voir cette lumière intellectuelle aussi bien que la sensible: nous sommes plustost au Ciel que nous n'avons fait resolution de quitter la terre: ce transport s'acheve en un moment, parce qu'il regarde une éternité, & qu'il se fait par le secours & parles attraits d'une vertu libre des longueurs &de la succession du temps.

Lors que dans le calme d'une belle nuit, l'azur des voûtes du monde se monstre à la terre, &que le silence qu'y gardent les Astres en leurs courses, favorise nostre attention; comme nos yeux de tous les objets ne voyent que le Ciel, nos volontez ne ressentent de toutes les affections que celles qui surpassent la Nature, nos pensées doucement confuses s'emportent au delà du monde dans le neseay quelle este due infinie de lumière, qui tient toutes nos puissances en suspension & qui nous fait admirer plus que nous ne voyons, & jouir d'une félicité que nous ne connoissons pas. Si nous nous enfonçons dans la profonde solitude d'une forest, parmy le silence, & à l'aspect de ces grands arbres, qui portent une certaine majesté dans la hauteur de leurs tiges, & les vastes estendues de leurs branches, aussi-tost nostre esprit de l'omel. De recueille en soy mesme, nostre cœur sent des émotions inaccoustumées, & tout lé corps qui frémit d'une crainte respectueuse, nous advertit de la présence d'une -grandeur infinie., qui par ces devoirs que la Nature luy rend sans contrainte, nous demande les libres hommages de nos volontez. Sans Maistre & sàns autre théologie, l'innocence reclame dans son oppression le secours d'une souveraine bonté, les sermens en attestent la vérité incorruptible, les consciences coupables entendent dans leur intérieur les menaces de sa justice, Scies bonnes sentent la faveur de ses consolations.

Ces libres advens de la Nature devroient suffire á l'homme, pour le porter â l'adoration de Dieu, sans qu'il demandast d'autres démonstrations de son existence & de son pouvoir. Car quelle plus grande folie, que de se servir de la raison, pour se rendre beste, & se vouloir faire ignorant de ce qu'il est impossible de ne pas sçavoir? Nous ne demandons point de preuves, qui nous obligent de confesser qu'il est jour, quand nos yeux voyent la lumière & le globe du Soleil, Nous nous lions au rapport des sens, s'il est question de reconnoistre les premières qualitez, parce qu'on ne les soupçonne pas de faux au jugement qu'ils font de leurs objets. Hé: pourquoy douter des veritez que nostre esprit comprend sans ratiocination, & dont il a une connoissance si familière, qu'elle se peut dire sensible, & comparer à l'attouchement?

Ie ne m'estonne pas que l'homme soit avantagé de ce sentiment de Dieu, sans que, & estude le luy ait acquis, & que sa méditation l'ait recherché: D'autant que comme les choies naturelles qui ont

leurs estres, & leurs actions mesurées du temps, se conçoivent de nos esprits par une suite de ratiocinations qui se fait avec le temps: Aussi Dieu, qui est un estre éternel & nécessaire, est compris de la plus haute partie de nostre ame par une façon d'entendre stable, immobile, qui devance nostre recherche, comme le repos est premier que le mouvement. Puis qu'il n'y a point de proportion du finy avec l'infiny, de nostre ame avec Dieu, il ne falloit pas que cette union se fist avec mesure, & que la délibération precedast nos désirs & nostre amour en mesme bonté universelle, libre de défauts, & dont la possession est nostre félicité. Nos yeux employent d'ordinaire une grande attention, pour juger si la distance ouïes qualitez du milieu ne déguisent point celle des objets: Mais ils ne doutent point de la lumière, ils la reçoivent en un instant, & se repandent avec beaucoup de délices dans les espaces qui font blanchis par cet objet indéterminé: Il importe aussi à nostre bonheur, & à la gloire du premier Principe, que nous le concevions par cette façon de connoistre également libre du temps & de l'erreur, & qui nous mettant tout à la fois dans l'action & dans le repos, est en nous une image de sa perfection, qui nous le fait aimer par sympathie, & un gage de sa faucre qui nous le fait adorer par reconnoissance.

Comme nous ne délibérons jamais de la fin, mais seulement des moyens qui nous y conduisent} cette première appréhension de Dieu, qui est nostre derniere fin, ne devoit pas dépendre du discours de nostre raison, dont les recherches longues & fautives ne pourvoient estre qu'importunes à l'ardeur de nos affections, & périlleuses à nostre félicité. Si ce n'estoit l'obligation qu'ont les corps de traverser les espaces qui font entre eux, & le lieu où ils aspirent, le mesme instant qui détache la pierre d'en haut, la mettroit en son centre. Héi quelle merveille, si l'esprit, qui doit avoir de plus violentes passions de trouver son repos dans son Principe, estant libre de la sujétion des lieux, s'unit sans delay, & devant que la volonté se soit appercu de son désir, à un objet, qui à cause de son infinité n'est jamais dans l'esloignement? Que l'homme seroit heureux, s'il s'abandonnoit tousjours à ces saintes émotions, qui le font doucement concerter avec l'harmonie du monde, qui luy permettent de produire des actions de l'éternité dans le temps; & qui le font docte par une science divine. Ce seroit véritablement faire régner cet âge d'or, dont les Poètes nous parlent, comme d'une fable, puis que nous recevrions la récolte de mille consolations sans aucun travail, & les armes de la dispute estans bas, nous pourrions trafiquer avec le Ciel, de nos vœux, & de ses bénédictions, dans une profonde paix.

Chapitre III - L Homme ne Sçavront Atteindre le Sentiment Naturel qu'il à de Dieu

L'un des plus agréables divertissemens de l'homme, & le sujet d'où il tire ordinairement de la vanités c'est de renverser les Loix de la Nature ces choies matérielles, par les inventions de Part, &: de prendre par ce moyen quelque líberte d'empire dessus le monde, encore qu'il n'en soit qu'une petite partie, on pardonne à ces artifices qui surprennent la Nature en ses desseins, parce qu'ils luy font un continuel hommage, lors mesme qu'ils abusent de ion pouvoir, & qu'arrestant le cours ordinaire de sa vertu ils luy donnent occasion défaire des miracles. Et puis, la violence n'est pas criminelle, qui ne s'exerce que sur des formes insensibles, & qui oblige d'inconstance de la matière, ne luy faisant point souffrir de changemens & d'altérations, qu'elle ne passionne. Mais c'est une espece de parricide, de faire mourir dans nos ames les veritez que le Ciel y a mettre pour nostre conduite, & de renverser ses loix eternelles, pour future celles que l'opinion, que l'ignorance, & que les passions y veulent establir. Cependant il n'y a pas une de ces veritez publiques, que quelque peuple n'ait violées par l'extravagance de ses coustumes, & que quelques scelerats ne prophanent tous les jours par leurs crimes.

Si le mariage est la source des Estres parfaits, & l'entretien des espèces, les Ethiophiens & les Garamantes ne Pont pas receu: & les Poètes couvrent louez le nom d'une Androgine, souz la fable de l'hérésies, & tous les formes prodigieuses des Faunes, des Satyres, & des Minotaures, les effets & l'horrible péché de ceux qui ont abusé de cette necessaire institution. Les siècles passez ont porté des mères qui ont mangé leurs propres enfans: & tous les jours il s'en trouve qui les etouffent dans les dispositions de la vie, qui font un tombeau du lieu que la Nature avoit destiné pour leur

donner l'estre qui l, y es exposent, les exheredent, & violent ainsi la loy naturelle de l'education, par des creautez qui ne se rencontrent pas entre les degres. Toutes les fois que l'homme fuit les mouvemens de passion, & qu'il est idolâtre des objets qu'elle luy présente, il est réfractaire au droit commun, qui luy ayant assigné la raison en propre, veut qu'il employé ses soins à la cuìssuer, & qu'elle soit la règle de ses actions. Enfin les loix de la Nature sont tellement altérées entre les hommes, qu'il nous en faut chercher les vestiges parmy les brutes & la contemplation du monde, qui ne devoit estre qu'un divertissement pour contenter nostre curiosité, nous est maintenant une leçon nécessaire pour former nos mœurs-.

Entre tous ces déreglemens de l'esprit, le plus pernicieux c'est de perdre le certainement naturel qu'on a de Dieu, d'en former un doute, &de ne pas rendre assez de respect à cette première vérité, plus nécessaire à la conduite de nostre vie, que le Pôle à la navigation. Les excez qui font violence aux autres loix naturelles, font des vents impétueux qui escartent l'homme de la route qu'il doit tenir: mais ce dernier est un tourbillon, qui luy ostant tout d'un coup la veuë du Ciel, les moyens & les espérances de toucher le port, luy fait faire naufrage.

Les meschans se sont figuré, que faisant mourir dans leurs Cœurs, & dans l'opinion des hommes, un sentiment qui persuade toutes les vertus, ils donneroient de la réputation à leurs crimes, qu'ils seroient triompher le vice, & qu'ils meriteroient des couronnes par des actions, pour qui les loix n'ont que des supplices. Ils ont crue, que comme des lignes opposées arrivent avec égalité à un mesme centre; que comme la neige est blanche par le froid, & a chaux par la chaleur, ils pouvoient acquérir par un Athéisme bien formé &. Bien résolu, la mesme tranquillité Pame donne une sincère devotion. Ils effacent toutes les loix afin qu'il n'y ait point e crimes, ils taschent de se rendre libres, en persuadant qu'il n'y a point de Dieu: de nier la providence pour ne luy estre point obligez, de ne point reconnoistre la justice, pour ne point craindre la condamnation & mettent le plus* haut point de la sagesse dans l'extremité de l’Athéisme.

Mais, ô pauvres infortunez, vos desseins font aussi trompeurs, qu'ils sont sacrilèges: Noircissez vos ames de tous les crimes; fortifiez-vous dans le niai par la conversation de vos semblables; gaussez-vous des choies saintes, donnez les miracles à la Nature, noyez vostre raison dans les sens5 bouchez luy tant que vous voudrez toutes les avenues, vous verrez tousjours qu'il y a avec Dieu, vous ne sçauriez empescher que cette lumière ne vous esclaire, parce qu'elle vous est intérieure, et qu'elle agit dessus vostre esprit, comme la çháleur naturelle dessus Vostre corps, sens vostre consentement. l'en atteste la conscience de ces esprits forts & déterminez à ne rien croire, si aprés s'estre abandonnez aux desbâuches, apres avoir employé pítíe de discours pour se persuader' qu'il n'y a point dé Dieu, qu'il n'en faut pour résoudre toutes lés questions d'Aristote} aprés s'estre résolus à la liberté, estre Faisant VftPa* radis des plaisirs du corps i aprés avoir accusé la Théologie d'ignorance, l'Eglise de la superstition, les saintes Escritures de faussetés âpres tant dé crimes de sacrilèges, s'il n'est pas Vray, qu'au milieu des plus énormes dissolutions, ils ont esté piques jusque â voie d'un grand sentiment de Dieu.tout d'un coup, l'esprit demeure esblouy de cet éclat, comme l'œil, qui au sortir d'un lieu ténébreux reçoit une grande lumière-, toutes les puissances quittent les charmes des choses sensibles pour lé toucher devers cet objet: le cœur en est tout: la conscience criminelle surprise dedans ses mesfaits, tremble devant son Jugé, elle répand la tristesse dessus le visage, la négligence au maintien, la langueur dans lés actions, de quelque artifice qu'on tasche dé divertir ses pensées. Le libertin porté dans son esprit une point qui le pique continuellement, son cœur entend tousjours une Voix qui l’accule, un advocat importun, dont il ne se sçauroit de scaire, & íl ne peut non plus échappera ce sentiment, qu'à luy-mésme.

Si la naissance, sa fortune, ou son injustice lúy donnent la domination dessus les hommes, il peut la changer en tyrannie, & après les oppressions qui lés réduisent en pauvreté & en servitude, leur ravir les exercices extérieurs de là pieté, ab batte les temples, prophâner les choses sacrées, interdire les cérémonies ô crestaétifices: Mais s'il croit que ces violences soient capables d'arracher

lé sentiment distinct de son cœur, & de celuy de son peuple, ils mesme autant que ces Magiciens qui promettent de tirer là Lune du Ciel en terre, par le murmure des paroles, & par l'espoir en observations de leurs charmes: le veux que, cornu les abçez ont des élans plus vifs, & des battemens plus douloureux, quand le pus s'y forme, que quand la chaleur en a recuit la matier, qu'ainsi l'amé souffre des supplices intérieurs plus cussans, & moins supportables dans les premières résolutions de l'Athéisme, qu'aprés qu'elle s'y est endurcie avec le temps: Neantmoins tout ce que le libertinage donne de repos, n'est qu'un intervalle qui dispose l'ame à de plus violens accez de douleur, si on n'y met la lancette, & qu'on ne la purge de ce sacrilège. Nous contractons de pernicieuses habitudes de tous les vices, nostre cœur se familiarise aux airs corrompus, & la Nature fait passer le poison en son aliment par un long usage: Mais les ames les plus ennemies du bien ne se sçátìroient faire une coustume de l'Athéisme, & se rendre insensibles pour la Majesté de Dieu.

C'est une preuve que ce sentiment nous est naturel, puis qu'il est inseparable de nostre esprit, que nous le conservons malgré toutes les violences, & qu'il renaisse quand nous le croyons tout à fait estoient: tout de mesme que l'eau retient la puissance de sa froideur, lors que le feu l'effluve en bottillons, & elle reprend bientost âpres qu'elle s'est éloignée de son ennemy, & comme les passions qui suivent nos temporisations, lés hontes, les craintes, les colères, reviennent tousjours aptes que là raison les a modérées; elles se cachent, & ne meurent plus, & les coups qui les abbattent, mesçauroient empescher qu*elles ne repoussent, parce qu'elles ont leurs racines dedans la nature.

La mesme Providence, qui a rendu le mouvement du coeur, & dès atterés eotttiHa, & indépendant de nostre choix, parce qu'il est nécessaire à l'entretien de la vie du corps, nous donne le sentiment dé Dieu, avec une espèce de nécessité, Accuse qu'il est la vie de nos ames, & que nous ne devons pas avoir une piece, & profiten d'un bien, dont le défaut ne nous peut estre que fort desadvantageux.

Aussi la Nature, qui se range des contraintes, que nous luy imposons, pat les volettes, qu'elle nous fait souffrit, monstre assez en ces tristesses, & ces géhennes de conscience, que ce sentiment luy appartient, & que c'est la démembrer de l'affoiblir de cette partie qu'elle tient du Ciel, & d'où dépend la perfection, Ie mets icy le sentiment de Dieu entre les mouvemens naturels, comme on compte entre les biens, autant ceux qui viennent de la donation, ou de la libéralité d'un Prince, que ceux qui sont inaliénable de l'âme, elle peut estre prodigue des autres faveurs du Ciel, mais elle tient celle-ci, comme les choses sacrées, qui ne tombent point souz le commerce; ou avec les mesme conditions que les Empereurs Romains imposèrent aux Sénateurs, de ne point disposer de leurs biens, de peur que leur dignité ne fut déshonorée par leur indigence. Voila un effet de la providence de Dieu, qui prévient les chutes de nostre foiblesse, par un secours continuel. Il imprime l'image de sa bonté eternelle dessus une ame inconstante comme le Soleil représente la majesté de sa face, avec un rayon immobile, sur le cours des eaux.

Cette bonté infinie, estant toute libre du péché & de l'ignorance, dans une bienheureuse & continuelle possession d'elle-mesme,a voulu que l'ame de l'homme portast quelque ressemblance de ses perfections, par une lumière qui demeurast ferme entre les déreglemens de l'esprit, & victorieuse des ténèbres & des obscuritez qu'apporte le vice-roy, ce que toutes les Religions ont voulu representer par cette commune cérémonie, de nourrir un feu continuel devant les autels, comme estoit celuy des Vestales, & la lampe qui bruloit au faiste du temple de Diane, sans se consommer, & sans que les injures de l'air la peussent este indre. Il faut bien que ce (bit une vertu souveraine qui gagne l'admiration de ses ennemis, une autorité toute puissante, qui reduit les ames rebelles à la reconnoistre, & qui les tient dans l'adven de ses excellences, encore que les vices y mettent la sédition. O bonté infinie, qui forcez si doucement les mauvaises inclinations, quelles grâces & quelles faveurs ne doivent espérer de vous ceux qui vous adorent, si vous ne permettez pas que les misérables qui vous offensent, soient entièrement pnuez de vos lumière?

Chapitre VI - Outre l’infini Naturel, Nous Pouvons Connoitre Dieu Par La Raison

LE plus haut point de la prudence civile, c'est de conduire les affaires avec une dextérité qui surprenne le dessein des ennemis, qui fasse tourner les machines de leurs conseils, & la violence de leurs entreprises à leur propre désavantage: en sorte que leurs attaques avancent leurs pertes, & les forcent de venir à composition. Cette sagesse n'est qu'une image de celle que Dieu pratique ordinairement pour obliger les hommes à son service, & se rendre le Monarque souverain des cœurs. Il leur donne une inclination naturelle pour reconnoistre, aussi puissante que celle qui conduit les Estres privez de raison á leurs fins: Que s'ils se seulement contre cet instinct, & qu'ils fassent difficulté de suivre en mouvement estranger de leur nature: Il arrive que cette mesme résistance combat leurs desseins, qu'elle est tout ensemble une peine de leur rébellion, & un advertissement de leur devoir,

Elle punit l’homme par les remords de conscience qui l'accompagnent, & elle l'instruit en ce qu'il doit nécessairement qu'il y a un Principe superieur qui luy donne cette impression, qu'il combat, & qu’il ne peut vaincre. Car de deux contraires mouvemens qui emportent tout à la fois une mesme chose, l’u n luy est propre, l'autre estranger & quelque inconstante que íbit sa nature, elle ne monstre en mesme temps qu'une prétention, & ne se met qu'à la poursuit d'un terme. Ainsi la Philosophie s'est appercu qu'il n'y avoit qu'un premier Mobile, de ce que les Sphères inférieures roulent d'Orient en Occident, & d'Occident en Orient: Et que le mouvement de violence qui fait tous les jours achever le tour du monde aux Planètes, est plus puissant que le naturel, avec lequel elles n'avancent qu'un degré, ou quelques minutes. jugeons de mesme qu'il y a un Dieu qui donne à l'esprit de l'homme cette impression de sa Majesté si puissante, qu'elle force les résistances de la raison, & luy laisse aussi peu de liberté de ne la pas accepter, qu'il en reste aux Cieux de ne point recevoir l'impression du premier Mobile quelque diligence qu'ils employent, ils font tousjours emportez, & quelque discours que fasse l'esprit, il est surmonté par le sentiment de Dieu. Il se voit réduit à l'adorer, autant par la première opération de cette lumière naturelle, que parce qu'elle surmonte son aveuglement, & se trouve doublement obligé de cette faveur a la bonté de Dieu qui la luy présenté, & à l’injustice qui la luy impose,d'autant qu'une mesme grâce sert de remède à son ignorance, & de très créatif contre ses leeretez.

Mais d'où vient que l'homme ferme les yeux a une si belle lumière, qu'il renonce aux droits du Ciel, aux prérogatives de la nature, & qu'il pèche contre le sentiment commun de toutes choses, qui monstrent de la passion pour ce dont elles recevoient de l'avantage le croy que comme nous avons dit, il esleve des nuages pour obscurcir un Soleil, qui découvrir ses deforrnitez, il impose le silence à une voix qui l'accuse, & tasche de dépossséder un juge qui luy prononce sa condamnation. Peut-estre aussi que la mesme ambition qui luy fait attaquer ce qui est de plus éminent, Je fait soulever contre un Principe le plus certain de touces les ventez, ou que son inconstance veut la nouveauté, que son opinion n'estime que le difficile; que la vanité n'est pas satisfaite d'une connoissance communes qu'elle veut tout tenir de son industrie, & quitter cette vérité qui luy est acquise par Nature, pour la prouver puis après avec la raison., comme on lâche le gibier pour avoir le contentement de la chasse, & comme on s'écarte d'un but, pour se donner l'honneur de l'avoir touché de loin.

Si la vérité de cette derniere considération, possède l'esprit des Libertins, ie les tiens moins criminels, puisque leurs propositions sont plustost des essais de leur raison, que des impostures de l'Athéisme, leur jugement a plus de témérité que de sacrilège. Ils se gouvernent en cela comme ceux, qui dans les premiers bouillons de la jeunesse sont prodigues de leurs propres forces, parce que la vigueur de leurs courages qui se promet tout, ne leur permet pas d'en appréhender la perte, ny d'en estimer aílèz l'acquisition. Mais soit que les Libertins se plongent dans la méconnaissance decret instinct, par malice, par foiblesse, ou par vanité, Dieu supplée à leurs manquemens: sa bonté les ayme jusques à contenter leurs appétits, & s'ils onc abusé d'une première faveur, il la fait

suivre d'une autre. Il est certain que cette vérité, qu'il y a un Dieu se peut moins changer par les extravagances de l'espoir, que les Loix publiques par les conventions particulières, & que l'ame la conclue incorruptible parmy la diversité des opinions, comme les Cieux sont tousjours demeurez les mesmes, encores que les Poètes les ayent remplis de fables. Neantmoins si l'homme détourne ses yeux de cette lumière, s'il se divertit d'une pensée dont il ne se peut défaire, & qu'il refuse opiniastrement de vivre sous cette conduite, Dieu luy substitue la raison, tout-de-mesme que le Magistrat ordonne aux mineurs un tuteur, quand la mort ou civile ou naturelle, leur ravit celuy que le père leur avoit nommé.

Un bon soldat seroit offensé, s'il estoit cru aller au péril par la seule nécessité que luy impose le commandement de son Capitaine, & l'impitoyable rigueur des Sergens de bande. Un homme de bien se veut conserver la réputation de pratiquer la vertu, encore qu'il n'y eust point de Loix; Neantmoins il eu certain que les commandemens sont nécessaires pour époinçonner les meilleurs courages, & que les Philosophes pratiquent plus parfaitement la vertu sous l'obeissance des Loix. Mais ce n'est pas une petite industrie à celuy qui tient le gouvernement, de se laisser prevenir par la bonne volonté de ses sujets, & de recevoir comme de leur liberté, des devoirs qu'autrement il eust exigé par force. Peut-estre que Dieu se plais dans cette pratique, & qu'il permet à l'homme de se flatter d'une apparence de liberté, quand il se persuade de ne le connoistre que par les discours de la raison; encores que la Loy divine gravée dans son cœur, luy rende ce sentiment comme nécessaire

Si la Nature a si bien pourveu a la seurete des sens, qu'elle a doublé les organes le ceux dont elle se peut le moins passer, comme de la veuë & de l'ouye, afin qu'un seul accident ne nous peut priver tout à fait de leurs exercices, &c des fonctions sans lesquelles la vie nous seroit ou impossible ou langoureuse: II estoit plus á propos que nous fussions assortis de deux puissances, de l'instinct, & de la raison, qui se secondassent, afin d'empescher que riens ne manquassions jamais d'avoir un vray sentiment du premier Principe, & de luy rendre nos adorations, qui importent à sa gloire, à la fin generale du monde, & un estre derniere félicité. Par ce moyen nostre liberté ne sera que l'ornement de nostre nature, sans estre l'occasion de la perte, & nous en l’environs, comme des villes d'importance, qui sont conservées au dedans par des Citadelles, & défendues au dehors par les fortifications, & par les armées. Car si nous voulons combattre cette vérité qui commande dans nos esprits, nous trouvons que toute la Nature se ligue pour son parti; qu'il n'y a pas une seule petite créature, qui par la conformation de ses organes, par les merveilles de ses qualitez & de ses vertus, ne contraigne la raison de confesser qu'il y a un Dieu, & ne fasse régner ce sentiment dans nos cœurs, aussi bien par l'avantage des armes, que par un droict de Nature.

Ces deux manières de connoissance sont fort couvrailles aux deux parties desquelles l'homme est composé. Cari instinct universel en son estendue, libre du lieu, du temps de la corruption, a de grands rapports avec les éminente á qualitez de l'ame immortelle; & la raison lente en son procédé, fautive & sujette au* altérations, nous est, à l'esgard de Dieu, ce que les sens nous sont pour les objets máteriels: Et parce que vivants entre les choies sensibles, nous avons beaucoup d'inclination pour les sens, nous n'agréons pas tant t'instinct qui nous donne une pensée de Dieu prompte, qui nous surprend, &qui est sans suite, que la raison qui puísse en instruit avec un progrès de certitude tempéré à nostre foiblesse.

Cette lumière changeante satisfait agréablement nostre nature mesme, comme le diamant a plus d'éclat dans le mouvement, la vérité nous parois plus belle, quand nous la voyons par les reprises, &avec les divers brillans que luy donnent les discours de nostre raison.

Ce n'est tousjours qu'un mesme objet, dont nous voyons plus distinctement l'estendue avec deux yeux: d’autant que, comme deux lumières semellent avec une union, où il ne se peut remarquer de diversité, Ainsi de l'instinct naturel que nous avons de Dieu, & de la raison qui nous le persuade,

s'en fait un parfait éclaircissement dans Famé, qui chasse toutes les difficultez, & contente toutes nos inclinations. Cet instinct est nostre Soleil, sinons sçavons tirer advantage de ses influences, & de ses rayons. Mais, parce que, selon la vicissitude des choses humaines, il passe quelquefois à son occident, & se dérobe à nos yeux; nous découvrons à Ion absence toutes les beautez du Ciel $ nous avons dix mille lumières pour une, autant d'astres qu'il y a au monde, ce sont autant d'astres qui nous éclairent, & qui-nous donnent la veuë des grandeurs de Dieu.

En effets toutes les choses naturelles ne prennent de si agréables postures, ne se parent de tant de couleurs, de tant de figures inutiles à leur action, & ne nous découvrent leurs beautez, que pour attirer nos yeux, & nous faire admirer dans leurs livrées, & dans la magnificence de leur équipage, la toute puissance de leur seigneur.

Si nous contemplons un objet si ravissant, nostre courtoisie, & notre curiosité contentera les désirs de la Nature, nous releverons l'Estre matériel à la fin la plus éminente qu'il puisse avoir de servir à la connoissance de son Créateur, & son sentiment se gravera dedans nos esprits par une diversité de concepts infinis en nombre, pour comprendre avec plus de facilité un Estre infiny en perfections. Puisque le monde n'est fait, & n'est embelly, que pour estre veu, & que nous en sommes les habitans pour en estre les admirateurs: la relation qui est entre nous & luy, ne permet point de repos à nostre contemplation, parce qu'il nous monstre tousjours autant de merveilles que s'il nous estoit nouveau. Et comme les yeux ne travaillent que pour le cœur, l'esprit ne doit considérer toutes ses beautez, que pour enflammer la volonté à l'adoration de leur Principe: ses ardeurs doivent croistre à l'infiny parmy tant d'attraits; ses flammes allumées par tant de motifs, doivent épurer nos cœurs, & n'en faire qu'une région de feu d'amour. Allons donc nous ravir dans le tableau de la Nature, tirons le rideau,qui nous cache sa beauté, & âpres en avoir admiré le dessein en gros, & la delicace des traits qui achevent chacune de ses parties, donnons mille applaudissemens, & rendons nos vœux avec mille profondes adorations à la bonté & a la sagesse de son Créateur.

Chapitre XII - De L’ordre & Du Mouvement Des Cieux

LE Ciel est le corps Ie plus grand du monde, le plus accomply en sa forme & en sa matière, le plus puissant en ses qualitez, le moins sujet aux altérations, qui foussient tous les Estres par ces influences; & qui anime toutes les beautez par sa lumière. Nostre esprit se trouve remply d'un extraordinaire contentement, lorsche nos yeux se répandent un peu à loisir fut l’or & d'azur de ce beau lambris: & comme il n'a tant de raretez, que pour estre le sujet de nostre admiration, il semble aussi que la Nature nous aye donné tout exprès une taille droite pour nous en faciliter la veuë,& nous apprendre par la disposition mesme de nostre corps que la contemplation du plus bel objet du monde, nous appartient, comme aux plus nobles & aux plus connoissans des Estres animez.

Un grand Philosophe disoit, qu'il n'estoit nay que pour voir le Ciel, &c faisoit son estude principale de ce grand sujet, où du concert de plusieurs mouvemens réguliers & dissemblables, il tiroit les instructions de nostre vie, qui se conduit par une constance modérée, selon la diversité des evenamens. jamais, dit Sénèque, l'homme ne concevra cette grandeur de courage, qui l'élève au dessus des choies corruptibles; jamais il ne méprisera mieux les thresors de l'avarice, l’éclat de l'or & des pierreries, l,orgueil des grands édifices, & la pompe des vétemens, que quand la contemplation le portera au dessus des Cieux, pour voir rouler fous ses pieds ces vastes estendues de lumière; pour y admirer les proportions de leurs grandeurs, de leurs vertus, de leurs mouvemens, de leurs rencontres. De là comme la terre n'est qu’un petit point ténébreux, il se mocque asseurement de l'ambition des hommes, qui se contente départager ce dont la petitesse semble indivisible: a peine remarque-t-il, l’estendue des Empires comme des atomes; & ces formidables armées, qui épuisent un Royaume pour renverser l'autre, font moindres a ses yeux qu'un amas confus & frétillant de fourmis, qui sont un grand païs de nos pas, & dont les plus longues courses s'achevent dedans une espace que nous tiendrions pour une prison. On a quelquefois trouvé

Socrate & Platon cous, droits ayans les bras croisez, & A les yeux elevez fixement en haut, ravis en extase en la consideration du Ciel. Ce n’est pas que les spéculations universelles, libres du temps, du lieu, de la matière, ne fus sent des objets plus dignes de la contemplation de ces Philosophes, comme plus rapportans à la dignité de l'ame: Neantmoins la veut du Ciel encore qu'il ne soit qu'un corps, leur a donné des sentimens tjuipat foient l'humain.tous les jours nous y enlevons les mains dans les disgrâces, & jeux dans l'étonnement, par un instinct qui nous fait, conjecturer, qu'il y a là haut quelle Puissance infini & qui préside au monde, donc la bonté est le support de nos misères, & là Majesté est le premier sujet de toutes nos admirations. Comme nous n'avons point d'inclination, naturelle que pour ce dont nous pouvons avoir la jouissance y se çroye jusque nous, ne ressentirions pas cette complaisance intérieure à la Yeuc du Ciel, que nous ne pouvons approcher qu'avec les yeux, ny ces mouvemens, pour un sujet qui ne promet rien au corps, s'il n'estoit le throne d'un Dieu, qui peut estre possedé de nos 3itt.es comme leur souverain bien. Et de mesme que le frontispice du Palais porte les Armes & les Escussons du Prince qui les abastis: les Cieux nous demonstreroient continuel, demonstre les marques de la grandeur de Dieu, nous estions allez curieux pour en faire les observations, & allez bons pour ne les pas tourner en mauvais age.

Leur circonférence qui enclost le monde, représente l’immensité de son Principe: leurs influences, la bonté, leurs mouvemens, sans repos, qu'il est tout acte; leurs revolutions, & là durée de leurs substances est une parfaite image de l Eternité. Je en ne nous figure mieux l'estre intelligible, que leurs lumières, & comme la connoissance de Dieu vides le futur & le passé au présent, les Astres nous donnent quelque présage de l'advenir, & une partie des Arrests de la Providence, devant qu'ils s'exécutent sur les choies matérielles, nous paroissent affichez sur ces superbes portiques. C'est pourquoy les Anciens soisoient une espece de Théologie de la considération des Cieux, & la sainteté estoit tenue ignorante ou imparfaite, si elle n'estoit conduite ou échauffée par cette contemplation. L'Astrologie fut la première entre les sciences, lors que les premiers d'entre les hommes l'a plant en estime que les Roys de Perse, un Atlas, un Ptolémée, & d'autres Princes, le faissient leur estude principale, & que les sphères estoient maniées des mesmes mains qui portoient les sceptres.

Il est vray que, comme il se fait une plus insupportable corruption des viandes les plus délicates, l'on aveu connoistre les plus dangereuses impietez de l'Astrologie, qui est la première d'entre les sciences naturelles. Car les Cieux rendent de si vivans témoignages qu'il y a un Dieu, que les peuples prenans les figures pour les realitez, & les ombres pour les corps, adorèrent les Cieux comme les Divinitez. Les Perses n'avoient des voeux & des sacrifices que pour le Soleils & toutes les nations ont donné le nom des Planectes à leurs Idoles., de Jupiter, de Mars, d'Apollon, de Venus, de Mercure, de Diane. Les Egyptiens & veut des sacrifices au l’agneau Apis, & disoient plus, qui leur avoit enseigné l'agriculture, preooitlaÇ forme de cet animal, parce que le l’agneau est une constellation composée d'estoiles humides, fort heureuses pour le labourage Les Israélites aáorertfpr le Veau au désert, soit par la coustume qu'ils en aevient veu pratiquer en Egypte, Que comme quelques-uns disent parce que le Soleil estoit en cette partie du Zodiaque, quand ils sortirent de cap traité.

Ostez mesme les interests de Religion, les abus de cette science se sont trouvez si préjudiciables à l'Estat, lors que les professeurs ont fait des prédictions d'une Tyrannie prochaine, de la mort des Grands, des pertes d'armées, & i'aur/es semblables evenamens qui mettoient les esprits en émotion, que les. ikúx se sont armées contre ces mauvais Prophètes, les rendant doublement menteurs,& par la conversation de ce dont ils avoient prédit la ruine, a part les supplices avec lesquels elles chastierent leur témérité, au lieu des récompenses qu'ils s'estoient promises de leur industrie, Les constitutions Ecclésiastiques condamnent la superstition des Horoscopes, qui ostent à l'homme les droits de la liberté, qui luy font perdre les affections de la vertu, qui donnent l'excuse au vice, qui est purrissent les servantez, enflamment les concupiscences i, fomentent les haines sauvages & mélancoliques, & font de plus violentes impressions furies esprits foibles parleurs

svu^ríHaeuiès. Obscjr avons, a que n'en sont les Planètes dessus les corps avec toutes leurs influences.

Ces considérations m'empeschent de remarquer dans les Cieux quantité d'effets dignes de merveille, de peur qu'en voulant donner quelque sentiment de Dieu, je n'engage les esprits dans la superstition, & que je n'augmente le mal par la médecine. C'est pourquoy je ne m'arreste qu'aux choses les plus générales, comme à leur ordre, à leurs mouvemens, à leurs rencontres, qui dépendent de la connoissance commune des Philosophes, qui se peuvent voir sans péril, Scaver de grandes instructions du Créateur. Premièrement les Cieux des Planètes ont un département avec un ordre, sans lequel la terre ne seroit pas habitée. Saturne qui est le plus froid en ses qualitez, & le plus lent en son mouvement, est au quartier le plus éloigné de nous, de peur que ses malignes influences n'esteignent la chaleur d'où dépend la vie, & n'arrestent les actions qui entretiennent le monde. Jupiter tient sa séance entre les glaçons de cette Planette infortunée & les feux de Mars, afin d'adoucir leurs mauvaises impressions par le favorable tempérament des siennes. Le Soleil marche entre les six Planètes comme un Roy entre six Princes, auxquels il donne beaucoup de sa lumière Se de sa vertu pour pension, tant qu'ils demeurent dans le respect d'une médiocre distance: Mais sitost qu'ils s'approchent trop prés de sa grandeur, sa justice punit leur témérité d'une entière suspension de puissance. Il est aussi au milieu des autres Planètes pour recueillir toutes leurs influences dans son globe, & les digérer par l'éminence de sa chaleur, afin qu'elles soient dans une modération plus accordante à l'entretien de nos vies. Venus, Mercure, & la Lune, sont les plus proches de nous, à cause qu'ils nous défendent de la violence des autres Planètes, par leurs qualitez médiocrement chaudes & humides, propres aux générations; celles qui forment les meilleurs temperamens, & qui remédient aux imperfections de la terre sèche & froide.

Si l'ordre qui se remarque aux moindres petites choses, suppose la conduite de la raison; que doit-on dire de la disposition de ces grands corps de lumière, dont les plus petits égalent l'estendue de toute la terre, les autres la passent avec des excés qui ne font pas crus, que quand l'esprit s'y trouve forcé par les démonstrations de Mathématiques? Certes, il faut que ce soit une main toute-puissante qui aye eslevé ces grandes machines; une Sagesse infinie qui aye disposé ces globes avec une système, un ordre & une proportion qui nous marque régulièrement les temps & les saisons. C'est une bonté que nous ne scavrions reconnoistre avec d'assez grands hommages, qui a prescrit a ces corps célestes des grandeurs, des mouvemens & des influences si précisément nécessaires à la conservation de nos vies, que le moindre de leurs défauts priveroit le monde de sa beauté, & peut estre de ion existence.

Les Planètes supérieures ont leurs qualitez plus fortes s d'où vient que les Estres qui dépendent de l'influence particulière de Mars, font les tyrans Scies bourreaux e des inférieurs, comme nous le voyons aux tigres, aux loups, aux oyseaux de proye, en toutes les bestes carnassières, & selon les Astrologues, en ces humeurs téméraires qui se font une justice de la violence, & un passe-temps de la cruauté. Le fxx mesme dominé par cette furieuse Planète, répand le sang, terrasse les arbres, coupe & altère les autres métaux: Saturne envoya de si profondes impressions, que les maladies font incurables aux remèdes: comme nous le voyons en la lèpre, aux fièvres quartes, aux phtisies, aux chancres, aux imaginations mélancoliques, & en ces histoires amours, qui estans gravées sur des cœurs de bronze, se conferment parmy les orages, se repaissent de leurs disgrâces, & ne finissent qu'avec la vie. La Providence d'une a disposé ces Planètes, pour inspirer la constance St la vigueur aux choses inférieures, qui, selon l'inclination de leur matière, sont lasches à l'action, & trop promptes à l'inconstance, mais de peur qu'ils n'víùrpent la domination du monde, ou qu'ils ne changent leurs secours en une espece de tyrannie, la mesme Sagesse a tempéré l'excés de leurs forces par la modération de Jupiter, de Venus, de la Lune, & d'une infinité de favorables Constellations: de sorte que nous en recevrions toujours de grandes commoditez, si l'indisposition des corps n'y apportoit de l'empeschement.

Il paroist bien que ces Planètes & le Soleil mesme, relèvent d'une Puissance supérieure, en ce qu'ils font obligez d'achever tous les jours le tour du monde, sans repos, de prendre leurs logemens, quoy qu'incommodes, dans chacun des Signes du Zodiaque, de souffrir les exils, les déchets, les eloignemens, les rétrogradations a de perdre leurs forces par la rencontre de leurs ennemis. Cependant afin qu'il ne survienne point de dommage à la parme du monde, de laquelle ils font a biens, & où ils ne peuvent envover leurs rayons, il reste toujours sur l'horison un nombre d'estoiles fixes d'une mesme vertu, qui leur servent delicatenans. Et la Lune comme voisine de la terre, son alliée, fit qui s'accommode à les altérations par les changemens de la lumière, halle tout aprés son mouvement, pour dans un mois, joindre les autres Planètes par toutes les sortes d'aspects, & afin que tempérant par son ' humidité naturelle, les vertus qu'elle recueille de leur contribution s elle nous les rende plus favorables.

Et d'amant que le monde inférieur a besoin de la diversité des saisons pour entretenir ses vicissitudes & ses naissances s que la terre ne peut produire ses fruicts qu'estant tantost esmerveillée par la chaleur, resserrée par le froid, nourrie & l'humidité, les Planètes nous apportent ces changemens, quand ìl suivent leur route dans le Zodiaque: Car ce cercle qui environne le Ciel, comme une cícharpe, en biaisant du Septentrion au Midy fait que le cours qui est régulier pour eux, est inégal pour nous qui ne tenons pas son centre. De sorte que les approches & l'elloignenient que le Soleil fait de nous tenant ce chemin, nous cause l'adversité des saisons de l'année, & ceux des Planètes nous donnent à propos les pluyes, les vents, les jours d'Este au cœur de l'Hyver, fit nous font respirer lès fraise heurs du Printemps en Esté, de peur que nos forces ne s'exhalent dans la continue d'une trop grande fi chaleur.

Ie ne fais point icy de remarque de ce qui se dit des exils, des exaltations ', des cheutes, des tripliçitez, des termes, & des aspects des Planètes, d'où naissent les diverses impressions de l'air: le me contente de tirer cette conclusion de ce que nous avons dit, qu'un ordre si admirable, & si necessaire à la conservation du monde, est l'effet d'une souveraine sagesse. Car si les choses naturelles ne se portent par inclination qu'à ce qui leur est plus avantageux; si la pierre ne cherche le centre da monde, que parce qu'il donne repos à sa pesanteur: II faut que ce soit une authorité toute-puissante, qui contraigne le Soleil d'abandonner le Lyon, où il a une augmentation de forces, pour aller esteindre sa chaleur, &: faire mourir se vertu dans l'Aquanus, qui force la Planète Jupiter de perdre sa pureté dans la Vierge de le Gemini} Enfin qui bannisse les autres de leurs maisons, qui les faste descendre de leur apogée, reculer dans leurs épicycles, de endurer ses incommoditez particulières pour le bien gênerai du monde.

C'est encore sacrifier à la fortune, & prendre l'ordre pour le propre effet de l'inconstance, de dire que les Planètes font ces rencontres 'heureuses ou infortunées par la nécessité de leur mouvement circulaire qui les y emporte: Car ce mouvement mesme, d'où l'on fait dépendre tout l'ordre du monde y reçut d'une cause supérieure plus puissante que ne sont les corps: d'autant que le corps de soy ne peut luire & continuer ce mouvement, que par la force de ces qualitez. Or la qualité qui C; est limitée, obligée au lieu, attachée à certaines parties de la matière ne produit aussi qu'un effet tousjours limité, qui est semblable de non pas contraire à les propres conditions, comme la chaleur cause la chaleur & la dilatation; le froid les glaces & le retentissement du sujet qu'il engourdy. Mais nous voyons des effets dissemblables à leur principe dans la continue du mouvement circulaire, en ce que la course est infinie, n'ayant point d'arrest, ny ses prétentions d'objet qui soit arresté, il cherche de fuit tout ensemble son terme} il ne s'en veut approcher que pour le perdre, & on ne sçavroit dire s'il y tend ou s'il s'en escarte, parce que son éloignement est la fin delà poursuites que sa suite ie rapproche du mesme point qu'il veut esquiver. Par exemple, Mars qui est maintenant proche de l'apogée de son excentrique, n'y sera pas plustost arrivé qu'il en partira, semblable a ces esprits qui souffrent un reflues continuel d'affections, dont la rigueur n'est modérée que par l'inconstance. Tous les mouvemens de la Nature ont leurs termes, les corps ont leurs centres, de des lieux sortables à leurs qualitez, où ils cessent leurs agitations: mais les Cieux emportez d'un

mouvement circulaire, n'ont ny terme, ny commencement, ny fin, ny repps, que par nostre imagination: ils montent se descendent, & son ccúns cette continuelle contrainte, pour monstrer qu'ils ne suivent pas un mouvement propre aux corps, mais celuy qui leur est imprime par une vif vu estrangere Il est vray que pour trouver le principe de ce mouvement, quelques-uns ont dit que le Ciel estoit animé d'une forme intelligente, afin que le plus beau des corps cuit une forme la plus parfaite, & plus excellente, que celle des Estres inférieurs dont il a le gouvernement, Ie laisserois l'esclairci l'élément de cette vérité aux Philosophes, si elle n'importoit beaucoup à la Religion Chrestienne: En ce que si les Cieux font animez, c'est d'une ame bien heureuse, qui en cette considération, & par reconnoissance des faveurs que nous en recevons meriteroit de nous un culte qui seroit renaìstre l'idolatri, se qui fortifieroit l'opinion de ceux qui croyent que les Astres font des impressions sur les volontez par la vertu de leurs formes comme il s'enfonce dessus la matière par les qualitez de leurs corps, le dis donc qu'il n'est pas à croire que les Cieux soient animez, parce qu'ils n'ont pas les organes nécessaires aux fonctions de l'ame végétante, sentative ou raisonnable: ils n'ont pas les sens, sans lesquels l'ame vue au corps n'a point d'action, & s'ils en avoient, ils leurs seroient inutiles, parce qu'ils ne rencontreroient point hors d'eux mesmes d'objets capables de les terminer. Ils seroient continuellement offensez par la violence du premier Mobile, par leurs déchets, leurs rétrogradations, & par ces aspects infortunez qui les affligent d une suspension de forces» Enfin tous les Estres qui ont l ame, quand ce ne seroit que la sensitive, se portent vers les objets qu'ils passionnent, aussi des mouvemens indeterminez, & ne sont point réduits à cette nécessité, d'aller continuellement un mesme train: de forte que leur action ne soit qu'un retour sur leurs pas, comme nous le voyons aux Cieux.

Ils ne font donc pas animez: & comme il n'est pas nécessaire qu'ils le soient pour avoir un mouvement circulaire, qui leur peust estre imprimé par une force de dehors, afin de ne pas admettre en la Nature le superflu, & ne leur pas donner une forme qui seroit répugnante à la nécessité de leurs fonctions, & inutile à l'influence de leurs vertus: la commune opinion des Philosophes est, qu'ils font meus par une Intelligence. Car, comme il n'y a que l'esprit capable défaire une reflexion dessus soy-mesme, aussi est-il seul qui puisse donner le mouvement circulaire au corps: & leurs périodes ne nous rameneroient pas les saisons avec un règlement qui n'eschape jamais de sa justice, si elles n'estoient entreprises avec dessein, & conduites avec science, Par ce moyen il se fait une liaison de la Nature intelligible avec la corporelle: de forte que, comme les estres corruptibles reçoivent leurs impressions & leurs mouvemens des Cieux: ainsi les Cieux empruntent le leur des intelligences, afin que l'estre spirituel, qui est le plus éminent, soit le principe de toutes les actions matérielles.

Ces formes mouvantes ne force pas encore le premier Principe, & le Dieu de la Nature que nous cherchons: d'autant qu'elles sont dans le nombre, dedans la multiplicité, leurs vertus sont limitées à certains emplois, & chacune est attache à un globe, où elle fait les fonctions d'une forme particulière, Or nous devons trouver un Principe, & une Essence infinie, qui soit la source de tous les estres, une unité & un repos qui appuyé tous les mouvemens, un Acte tres-pur, qui répande universellement ses influences sur toutes choses, & aussi bien sur l'estre intelligible, que sur le matériel.

Ses grâces nous pressent de faire un cercle de nos connoissances, en les conduisant des créatures à nous, & de nous à luy, pour admirer sa bonté répandue sur les choses inférieures, la reconnoistre avec toutes fortes d'hommages dans les prérogatives de nostre Nature, d'adorer dans le throne de sa Majesté avec le silence & ì'extasie.

C'est peu de chose, de voir continuellement la vicissitude du jour & de la nuíct, du mouvement & du repos, du plaisir & de la douleur: Que la mémoire nous représente le cours des années de nostre vie, la suite des siècles, le retour alternant des laissons, de la paix, des guerres, des fertilisez, des sécher elles, des déluges: Que les Histoires nous fassent voir les changemens des Empires, les

transmigrations de* Peuples, & le retour que toutes choses font à leurs principes. Il faut que nostre esprit salle une découverte plus estendue pour contenter pleinement ses affections. U faut voir au delà du temps, anticiper tous les âges, monter au dessus des Cieux, du monde, de la Nature, porter jusques dans l'Eternité, & dorer le cercle de nos connoissances dans le repos qui est le principe & la fin de ces altérations.

Nostre ame porte en les actions l'exemplaire de tous les mouvemens corporels. Sa régénération lésait lorsqu'elle est un jeux choies divines la corruption, quand elle chssoud les forces parmy les matérielles: elle seroist par le souvenir, elle diminue par l'oubliances les altérations sont les divers mouvemens de la volonté: elle donne l'estendue de ses pensées sur divers sujets: elle les ramasse en elle-mesme: elle monte en haut par la connoissance des choies universelles: elle descend dans les singulières, elle se porte à droit & à gauche par la considération des différences opposées qui font les especes par la division des genres: Enfin elle va devant & derrière, quand elle contemple les causes avec leurs effets. Mais comme de tous les mouvemens, le circulaire est le principal, en ce qu'il a plus de continue> plus d'égalité, moins d'extravagances, &c qu'il ramène les parties au point d'où elles font écoulées: ainsi de tous les mouvemens de nostre âme, le plus noble c'est celuy qui par les créatures l'élevé à Dieu, comme à son principe; & l'en fait descendre toute pleine de sainctes instructions pour y monter avec plus de courage. C'est la où la raison & la volonté seront entièrement satisfaites en leurs connoissances, & en leurs amours, mais avec une jouissance qui leur faire a la liberté de la recherche, & un repos qui n'empeschera pas la continue de l’action, semblable à celuy des Cieux, qui i ou lent autour de leur centre sans s'en éloigne, ny changer d'espace. Car cette bonté' souveraine retient nos ames attachées à elle par les délices dont elle remplit toutes ces puissances: Et comme l’amour & la connoissance le donnent réciproquement leurs chaleurs & leurs lumières, il le fait un mouvement perpetuel d'extases & d'affections vers un objet, dont on ne sçavroit jamais égaler l'immensité.

Chapitre XIII – De La lumière & des influences du Soleil

Nous avons veu que le mouvement des Cieux nous porte à la cognoissance du premier Principe, & que leurs revolutions nous font des advertissemens publics, de rapporter les efforts de nos esprits & de nos volontez à cette bonté originelle. Mais nostre contemplation auroit beaucoup de défauts} & nous laisserions ce qui nous peut donner un plus exprès sentiment de Dieu, si nous ne faisions Une considération particulière des influences & de la lumière du Soleil. Nos yeux ne voyent rien de si accomply; nos vies n'ont rien de si nécessaire que cet Astre, qui est l'âme des beautez, le cœur du monde, la source de nos plaisirs, la joye & la vigueur de la Nature. A son lever l'Océan appaise la mutinerie de ses ondes, les maladies alentissent leurs violences, les oyseaux le saluent avec leurs concerts; les fleurs taschent deluy agréer, en luy découvrant ce qu'elles ont de rare, enfin tout reprend le mouvement, la liberté, l'action, la couleur par sa lumière; comme à son absence, & dans l'horreur des ténèbres, le monde n'estoit qu'un grand sepulchre, où les Estres estoient ensevelis tous vivans.

Si les choses mesmes insensibles se monstrent recònnoissantes des faneurs de sa lumière par les tressaillemens de leur joye, l'homme qui est le juge des perfections de la Nature, & qui les tire toutes à son avantage, se doit ravir d'admiration à la veuë de cette beauté: Et je croy que l'aurore ne donne une nouvelle vivacité à nos esprits, qu'afin que nous employons les premières, &les plus pures de nos pensées, pour concevoir quelque chose du premier Principe du monde par l'aspect du Soleil naissant.

II donne sa lumière & ses influences à tous les Cieux: il assiste á toutes les générations, il préside à la force de nos cœurs, à la subtilité de nos esprits 5 il forme les métaux au centre du monde, il fait éclorre les poissons dans les abysmes, & cache une chaleur vitale dans la vipère &dans la ciguës que les glaces de leurs poisons né sçavroient esteindre. Comme ses approches font l'or & les parfums aux Indes, donne à nostre climat la fertilité de ce qu'il a d'agréable aux yeux, & de nécessaire à la

vie: Aussi son esloignement rend nos terres mortes, & leur fait éprouver dans une saison quelque chose, & la misere de ces plages unfortunées, qui sous les Pôles languissent entre les glaces eternelles.

Il faut advoiler qu'une vertu si admirable, & si nécessaire, & la conservation du monde, ne peut provenir que d'un Principe, dont la puissance n'a point de bornes, & que les qualitez corporelles sçavroient produire de si grands effets. Car il ne faut pas alléguer icy avec le commun des Philosophes, que le Soleil est une cause universelle qui concourt avec tous les agens particuliers, & qui peut imprimer dessus la matiere autant de formes, qu'il-y trouve de differentes dispositions. Cette maxime laisse encore l'esprit dans la mesme difficulté de sçavoir si cette cause, qu'on appelle universelle, a cette vertu d'elle-mesme, & de son propre, ou si elle remprunte d'un autre principe. Or je dis, que le Soleil estant un estre singulier, un corps qui a sa quantité mesurée, ses qualitez jusques à une certaine estendue, ne peut de luy-mesme fournir á une multiplicité infinie de productions, & y combattre & surmonter les propres vertus par ces effets il este chaud, & nous voyons qu'il preste son influence aussi bien à la production de son influence aussi bien a la production de la Mandregore et du Pavot, que de la Rue, & de la Canelle, & du Laurier, dont les Poètes le disent amoureux. II agit également en la génération des Hiboux, qui fuyent sa lumière, & des Aigles qui supportent ses rayons avec délices, qui en imitent la vigueur par leur courage. Il n'est pas animé, comme nous en avons fait la preuve, & neantmoins il donne la vie, & d'une corruptible il en fait éclorre les animaux que nous appelions imparfaits.

La portée des actions se mesure à l'estre: & comme l'essence du Soleil n'est semblable à celle des choses qui peuplent le monde comme sa substance est éloignée de la leur, aussi ne les peut-il pas produire par vue vertu qu'il possède en propre. Il n'appartient qu'à un estre infiny, à un pouvoir qui n'ait point de bornes, à un pur acte, estoigné de l'imperfection se de l'indigence & la matière, sans corps, & libre des limites de la quantité, de fournir cette vertu formatrice à une infinité de naissances qui se font au monde, ou bien de commettre quelque estre particulier qui en fasse la distribution. Quant au Soleil qui n a que des forces limitées, il les épulseroit en ces largesses continuelles, si une bonté infinie ne prévenoit cette défaillance, & ne ver soit dans son globe les favorables qualitez qu'il nous communique. Aussi n'est-il pas à présumer, qu'une si petite partie de Cieux, qui n'y est remarquable que par sa lumière, peust avoir l'empire de la Nature, & que le tout fust dépendant de cette patchouli, si un premier Principe luy avoit donné cette commission, & n'avoit recueilly tant de vertus dans un petit espace, pour nous faire entendre la souverainement parfaite unité de son Essence.

La lumière est la plus ravissante de ses qualitez. & selon l'opinion de quelques uns, c'est elle qui les contient toutes comme s'ils vouloient dire par ce rapport, que les choses ont autant de perfection qu'elles ont d'éclat, & que la beauté doit tenir le gouvernement du monde. Il est vray que les inclinations de plusieurs choses qui font particulières pour d'autres objets, font communes, ^concourantes pour celuy-cy. Toutes les Planètes le courbent, s'élevent, & font violence à leur propre disposition, pour mettre leur teste au jour: Et on peut dire, que quand Diogene ne vouait rien d'Alexandre, sinon qu'il ne luy ostast point son Soleil, que ce Philosophe eut en cela des affections conformes à celles de la Nature, qui fait son thresor & son souverain bien de la lumière.

Elle est la seule chose du monde qui se fait connoistre par elle*mesme, & qui nous découvre toutes les autres: Aussi nous la devons regarder comme un Principe naturel, & comme l'une de ces veritez originels qui est devenue' sensible, afin de plus donner un plus vif, ficplus aisé sentiment de Dieu. Ie croy que si un homme nourry dans les ténèbres depuis sa naissance, & qui n'auroit jamais connu d'autre lumière que celle de la ratiocination, estoit tout d'un coup tiré du cachot, de mis en présence du Soleil, la clarté de cét Astre efblouiroir moins ses yeux, que son esprit -y & que set objet d'une beauté, dont jamais il n'auroit veu l'idée, le metrroic dans l'extase. Mais, après que ses yeux je seroient petit à petit défilez pour le contempler, & que sa raison le seroigneúse en estât

d'en faire le jugement, il sèroit & craindre, qu'âpres les complaisances d'amour, que Ion cœur concevroit pour tant de beauté, Un'en vingt aux adorations, & ne persuadait que cét Astre fust le Dieu, donc il avoit eu plusieurs, fois, des pensées, cojûhtses. Et à la vérité, là créance sembleroit estre appuyée de la raison: parce que la lumière a trop de beauté pour n'estre pas quelque choie de surnaturel, ses qualitez font trop éminentes, son pouvoir trop A absolu, ses effets trop miraculeux, pour naistre du corps & de la matière.

Toutes les qualitez corporelles ont certaines proprietez qu'elles ne peuvent excéder Scieur pouvoir est; borné à certains effets. La lumière n'a point* ce semble; délimites en son être, en son estendue en son action. Elle contient éminemment toutes les autres qualitez, je dis mesme la vertu de toutes les autres choies, puy; qu'elle concourt universellement à leur naissance. Elle n'est combattue' par aucun contraire, elle se répand en en moment, se reserve, à l'estroit sans s'incommoder; le dilate sans se rompre-, s'écoule sans s'amoindrir > s'a ceroist, & remplit tous les es faces, où les autres agens exhalent leurs forces. Nous la voyons aussi pure parmy es cloaques, qu'entre les parfums, aussi belle sur le fumier, que dessus les roses, & jamais elle ne ravalle sa condition céleste, jusques à se mester avec les choies inférieures, & à s'altérer de leurs qualitez.

On pourroit juger qu'elle est d'une nature autre que celle des corps, puis qu'elle les pénètre sans violence: qu'elle trouve place dans la solidité du cristal & du diamant; & si elle s'arreste à la surface du bois, du drap, de la terre, ce n'est -pas par impuissance, mais par un dédain de se joindre plus estroittement à des matières de si peu de prix. Nos yeux mesme ne la scavroient voir avec sa pureté dans le Soleil, comme lien l'excellence de sa nature, elle n'avoit point de proportion avec les organes corporels, & quand elle est mollement répandue dans i'air, ce n'est pas tant elle que nous voyons, que les objets qu'elle a éclairez. Elle passe aussi bien la portée de nos esprits que de nos íêns, en ce que nous n'en pouvons proprement parler que par négations, en rapportant ce qui ne luy convient pas, afin de faire concevoir quelque chose de ce qu'elle est. Car de dire qu'elle soit l'acte & la perfection des choses visibles, qui fait voir ce qui peut estre veu, c'est seulement toucher un de ses effets, & non pas expliquer Ion essence & sa nature.

De ces considérations, l'Empereur Julien l'Apostat prend sujet de défendre, le culte qu'il rendoit aux Astres, qu'il appelle des Dieux visibles, & les images des invisibles qui leur presidoient. C'estoit une idolâtrie,démettre plusieurs Principes du monde, & de penser qu'un corps eust les perfections de Dieu. Mais il ne le fust fias trompé, & la créance n*eust pas esté sacrilège, s'il n'eust fait que reconnoistre a lumiere pour une qualité qui passe le pouvoir des corps, & qui ne leur est donnée que par une faveur particulière de Dieu. Les Platoniciens disent qu'elle est le ris des Cieux, que les intelligences donnent cet éclat aux Astres, par un certain rejaillissement de leur gloire: comme quand l'ame est touchée d'une vive joye, elle dilate le cœur, met la sérénité sur le front, le ris sur les lèvres, & fait etinceler les yeux par une grande quantité d'esprits. La lumière est, disent-ils, dans les ames, un triomphe de la vérité: & dessus les corps, elle est la fleur de la bonté, le plaisir, des sens, l'ame de la beautés & l'interprete des perfections de toutes choses. Il paroist bien qu'elle prend son origine d un Principe heureux, puis qu'elle porte le bon-heur atout ce qui la reçoit, & qu'elle est recherchée avec les mesmes ardeurs, & les mesmes passions, que le bien. Si elle diminue quelque chose de son éclat, à mesure qu'elle s'abaisse aux degrez inférieurs de la Nature: si elle est moindre dans les diamans que dans les Astres, plus obscure sur la terre que dans le Soleil, c'est, comme le ris qui n'est qu'une foible expression de la joye du cœur, & des plaisirs intérieurs de l'ame. Et que c'est de là que nous avons de si puissantes inclinations pour la volupté, parce que la lumière qui est un effet de la joye, concourt à nostre génération: & comme principe, elle nous donne des mouvemens conformes à la nature. Aussi les anciens Romains eurent cette superstition de croire les choses infortunées, si elles n'estoient faites en un beau jour, & où le Ciel ne fust point couvert de nuages.

Quoy qu'il en soit, il me suffit de conclure que la lumiere n'est pas une qualité comme sont les autres, purement corporelle, & qu'elle a un principe plus relevé, que ce qui tombe dessous nos sens. Elle doit venir d'une cause immatérielle, parce qu'elle le rencontre dans tous les Estres avec une différente proportion. Elle est éclatante dans le feu, qui approche de la condition des Cieux -y plus sombre, mais plus douce & plus agréable clans les diamans, elle n'a que de la blancheur dessus les perles! & toutes les couleurs qui distinguent les objets, ne font autre chose que des rayons de lumière obscurcis par la matière. Cela me fait dire aussi qu'elle n'est pas purement incorporelle, parce qu'elle se rencontre attachée aux corps, & qu'elle en releve par une dépendance commune aux autres accidens. Ses forces font limitées; d'où vient qu'elle est plus puissante, recueillie dans la concavité des miroirs, que répandue en sa liberté dans les espaces de l'air, le mouvement échappe à la force, &c elle n'agit puissamment, que sur ce qui atten, en repos son impression.

L’erreur des Perles, qui ravis de la lumière, adorèrent le Soleil pour Dieu, est donc fort grossière, si nous cherchons la vérité, autrement que par les sens, & si nous en croyons plustost le discours de nostre raison, que le rapport de nos yeux. Il est vray que le monde ne monstre rien de si beau & de si éclattant que cet Astre. Mais il faut considérer que c'est un corps, & par conséquent imparfait, à cause qu'il est limité qu'il subsiste par une composition de parties dépendantes l'une de l'autre. Il n'est qu'un point en la quantité, lion en fait la comparaison avec les autres sphères: il est dans le mouvement Perpétuel, qui est un estât de pauvreté, & qui est au repos, ce que la recherche est a la jouissance. Encore souffre-t-il des contraintes continuelles, quand il est emporté du premier Mobile contre son inclination, quand la Lune le met en interdit, & l'empesche de répandre sa lumière, quand il endure une suspension de forces dans des maisons desavantageuses, ou par la rencontre des Planètes infortunées.

Estant mesme dans la pleine liberté de ses influences &dé sa lumière, il a, selon le jugement des Astrologues, de beaucoup moins favorables que Jupiter. Il ne domine que de flus les planètes jaunes, qui ne font pas les plus exquises en vertu, & que les curieux trouvent les moins remarquables en beauté s ses parfums ne font que des fa* perfectez en la Nature, pour la satisfaction du moindre des sens: son or cède en prix aux diamans de Jupiter, aux topases, aux émeraudes de Venus i & un sage Législateur bannit ce métal funeste de lés Estats, comme la matière du plus lasche de tous les vices, & la source des plus grands malheurs qui démembrent une République. Enfin si le Soleil inspire quelque générosité de courage aux bilieux, ce n'est que pour leur faire perdre la paix dans l’ambition, & les précipiter dans les entreprises, aussi malheureuses qu'elles font inconsidérée.

Ou si le tempérament du sang dépend de son influence, il ne fait en cela que fortifier la moindre partie de l'homme, & la rendre plus insolente contre l'esprit fou courage n'est que pour des conquestes dont la continence fait les vertus, & cette humeur languissante dans les délices, n'a' rien de comparable à la vivacité, & aux inventions de Mercure, non plus qu'aux profondes spéculations d'un Saturne bien disposé.

De la nous pouvons connoistre, qu'une puissance supérieure assujettit le Soleil d'emprunter l'influence des autres Planètes, pour nous estre bien favorable, comme le Législateur de Lacédémone obligea le Roy de n'agir dans les affaires publiques, que par l'aduis de quarante Conseillers d'Estat, appeliez Ephores. Le Soleil' pratique au monde la Loy que Platon prescrit à un Gouverneur de ville avec tant de sévérité, que personne ne s'y est voulu soumettre: C'est à sçavoir que ce Prince se dépouillast tout à fait de ses interests particuliers, pour rechercher ceux de fort Estat, que ses revenus ne fussent qu'une pension qu'il trouvaille les plaisirs dans les affaires, son repos dans la vigilance, & que toutes les heures du jour hi y estrans comptées & destinées aux diverses occupations de sa charge, il ne fust qu’un serviteur public. Quel avantage reçoit le Soleil des deux mouvemens qui le tiraillent? Que luy revient-il de ses influences, & de sa lumiere? Le profit est nostre, & la reflation d’y satisfaire luy est imposée par une puissance supérieure. Son

trouvement régulier nous fait tous les ans la suite si nécessaire des quatre faisons: Lé violent qui tous les jours le fait lever & coucher, nous marque le temps de l'action & du repos, & la plus parte de ses devoirs estans ou forcez, ou empruntez, on périt dire que son gouttier hemént n'est qu'une éclatante servitude. Les autres Planètes se contrôle sans cesse par leurs aspects: Saturne arreste son activité avec sa froideur: Mars l'arrhe de tempes, tes & de foudres: Jupiter l'adoucit aux occasions: Venus le rend tiàM: Mercure inconstant, & toutes ses impressions le mettent en tutelle, & portent sés marquises de son impuissance, soit qu'il en profite quand elles sont bornes, ou qu'il né s'en puisse défendre, quand elles luy font désavantageuses.

C'est une Sagesse infinie qui a dispense de force le gouvernement du monde, qu'encore que le Soleil y fust le premier en lumière & en chaleur, il ne fuit pas le plus puissant en vertu, & n'en eust pas la parfaire Monarchie.

Comme il ne le peut palier de l'alliance des autres Planètes, je croy qu'il est fort périlleux au Prince de luire les mouvemens & les ouvertures de son esprit sans le modérer par le conseil. Quand l'Histoire de tous les âges luy tourneroit les plus véritables maximes du gouvernement, il s'agit toujours beaucoup moins du droit, que d'un fait, dont il ne pourroit avoir une allègre connoissance, que par l'entremise de quantité d'yeux & de bouches. Ce qui arrive de bien sans conseil, est au jugement du peuple, un coup de fortune & les succez désavantageux sont les peines, que mérite la témérité. Ceux mesmes, qui eussent conclure à l'entreprise, sont les premiers qui la blasement, pour se venger du mépris qu'ils ont souffert, n'y ayans pas esté appeliez: & les reproches celons si publics, que la plus éclatante vertu est obscurcie. Mais c'est une grande consolation à celuy qui tient le gouvernement, des pouvoirs décharger du malheur de ses affaires furie nombre de ses Conseillers: son honneur n'est point blesse par la déroute de ses desseins, on estime son courage, & on ne peut dresser des triomphes à là victoire, & tant de personnes ont lors un resta à sa justification, que tout le crime est de la fortune.

Voila comment le Soleil emprunte la vertu des autres Planètes pour nostre instruction, & afin que l'experience de ces médiocres qualitez, nous delivrant de l'erreur de ceux qui l'ont adoré pour Dieu.

Neantmoins parmy ces défauts, il conserve encore assez de perfections, pour estre au monde un image du premier Principe, & pour nous en donner un vif sentiment. Car quand nous le voyons dans un beau jour le maistre du Ciel, qui éclaire, qui nourrit, & qui anime la terre, il faut que nostre esprit s'élcue à une souveraine Unité, qui préside au monde, qui le conserve, qui:le peuple des substances dont ce -bel Astre nous découvre les qualitez. Ses rayons se répandent jusques sur la terre, sans quitter son corps: ils conservent leur pureté parmy les ordures, & ne souffrent point de mellange avec les choses inférieures. Ainsi Dieu est présent par tout, a cause de l'immensìté de son essence, & neantmoins tellement recueilly dans, son Unité tres-simple, qu'il demeure souverainement parfait entre les défauts du monde, un Acte qui vivifie, une Bonté qui perfectionne, une Unité qui assemble, une Puissance qui supporte, & qui affermit toutes choses. C'est luy qui a compassé les parties du monde, qui en a fait la disposition, & dispense les actions & les mouvemens, comme le Soleil nous distribué les jours, les mois, les faisons, nous règle le temps, & nous donne l'invention des nombres, par qui routes choses font mesurées;

Si la lumière sensible répand dans les corps une chaleur virale, qui est le principe de leur action i sans doute il y a une lumière originelle, qui éclaire tous les hommes qui viennent au monde, & qui causeroit un embrazement d'amour dans nos esprits, nos passions terrestres ne luy faisoient point de résistance. Mais quoy que les impies s'opiniastrent, que les Athées détournent tant qu'ils voudront leurs pensées du Ciel, dans l'horreur mesmes de leurs sacrilèges & de leurs blasphèmes, cette lumière divine sollicite leurs yeux de la recevoir s & la pointe de son rayon pénètre leurs consciences, pour leur faire avoir de cœur ce qu'ils nient de bouche.

Chapitre XIV - De la Disposition des Estoiles fixes

IL semble que la Nature veuille recompenser la perte des commoditez du jour par les beautez de la nuict,|& satisfaire à l'absence d'un Astre, dont nous ne pouvons supporter l'éclat, par la montre d'une infinité d'autres, qui ont assez de lumière pour gagner nostre admiration, sans offenser nostre veuë. Le Ciel ne nous donne ors que ce qu'il faut de clarté pour le regarder, afin d'avoir nostre attention toute entière: Et le monde appaise ses bruits, & garde un profond silence, de peur de nous interrompre en ce temps destiné à la contemplation; Ainsi toutes choses prestent du secours, & rendent beaucoup de respect à l'action que nostre esprit entreprend, parce qu'elle ne se termine pas seulement à juger du cours & de la vertu des Astres, niais á s'élcuer par leur aspect, à la connoissance d'un Estre infiny.

Apres que mes yeux se sont restez sur un nombre d'Estoiles fixes, étincelantes plus ou moins, selon leur grandeur qu'ils ont pris plaisir à voir Jupiter éclatant d'une lumière nette & tranquille, Venus dans une beauté qui ravit d'admiration, & la Lune pleine déplus de lumière dans un plus grand corps, mon esprit s'accoustume à trouver toujours déplus en plus déplus beaux objets, & porte ses espérances & ses idées au delà de ion ordinaire. Las s d'épeler toujours ces caractères lumineux comme d'une langue qui ne luy soit pas connue, St de n'avancer en ses connoissances qu'avec un progrez tout plein de langueur, il fait enfin paroistre sa capacité, il franchit les choies matérielles, & s'élève jusques à la source de la lumière intelligible! Il conçoit une splendeur détachée de tout sujet, libre du lieu, du temps, des dimensions, du déchet, de l'accroissemen, toujours égale, & toujours parfaite; qui se répand par tout, qui pénètre tout, qui donne la vie & la force à toutes choies 5 qui est le vray Soleil sur celeste, de qui les Astres ne font que des rayons obscurcis. Sa bonté les a enrichis de lumière $ sa sagesse les a mis en cette déposition telle, que, comme ils n'ont rien que de bon en leurs qualitez, il ne se rencontre rien d'inutile en leurs figures.

On ne sçavroit assigner d'autre cause*de ce que cette voûte est marquetée d'estoiles, avec une telle suite ou de tels intervalles que parce qu'une Intelligence supérieure les a voulu disposer avec cet ordre. Car les Cieux ayans une forme & une matière commune, toutes leurs parties devroient estre dans un mesme éclats Scia justice de leur tempérament* qui leur donne une forme ronde, la plus égale d'entre les figures, leur devroit rendre la face d'un mesme teint, Sinon pas élever dessus leur front des rougeurs si fort apparentes. Si les Cieux ont une matière liquide, pourquoy la lumière ne se répand-elle pas dans chacune de ses parties, comme la transparence dans celles de l'air? Et qui empesche, que comme des goûtes de Mercure, se rejoignent quand elles s'approchent, de mesme les Estoiles ne rayent leurs corps, aussi bien que leurs lumières & leurs influences, au point de leurs conjonctions? Ou si les Cieux font solides, d'où vient que leur estendue n'est pas également éclatante comme le diamant Scie cristal$ qu'en ces pierreries une petite paille soit tenue pour un grand defaut, & qu'en ce corps supérieur, qui doit estre le plus parfait, il y ait plus de ténèbres que de lumières?

Si les choies se consentent une plus entière beauté, quand elles font moins alterées par leurs contraires, ceux qui n'admettent point de contrariété dans les Cieux, ne scavroient rendre raison de ce qu'une partie a plus de lumière que l'autre, puis e qu'elle a une mesme pureté & un mesme tempérament. Si on dit que les Estoiles font les plus solides parties des Cieux & je m'estonne de ce que cette matière se trouve épaisse en quelques endroits, & plus relaschée aux autres, que la lumière, qui est diffusive de sa nature, se voit enfermée dans de si petites espaces, veu que le retroussement est l'effet naturel du froid, & cependant hies Cieux ont quelqu’une de toutes les qualitez, c'est la chaleur. La lumière qui nous l'apporte icy-bas, monstre que le thresor en est là haut: & si nous disons que Saturne est froid, ce n'est que comme l'air à proportion de nostre corps, à qui une moindre chaleur que la sienne, passe pour froid à son sentiment.

Enfin si les Cieux sont transparens, d'où vient qu'ils ne nous représentent pas une infinité de Soleils par une multiplication d'especes & de reflections? D’où vient que sa face ne se représente pas sur le

poly des Sphères, comme elle fait icy bas dans les fontaines, & sur les miroirs? Et d'où vient que sa lumière ne se redouble pas en chaque partie des Cieux aussi bien que sur le corps de la Lune? Ces raisons nous obligent de reconnoistre, que puisque les Cieux n ont pas d'eux-mesmes ces distinctions départies & de lumières, ils l'ont receu d'un premier Principe, & d'une Puissance telle qu'on se la doit figurer pour manier ces vastes machines, où les Estoiles, qui ne nous paroissent que de petits points, font plusieurs fois plus grandes que toute la terre.

Ce seroit peu, si les Cieux n'avoient point un plus grand sujet de merveille, que la différence de leurs parties obscures ou lumineuses, & n'y eust rien à y considérer A âpres la diversité. Mais ce qui nous doit ravir dans de profondes adorations de la Sagesse divine, c'est que toutes ces pieces soit placées avec tant de rapport entr'elles, avec un ordre si nécessaire a la conservation du mondé, que nous verrions là ruine par le défauts ou par la transposition de k moindre Estoile, Cela se peut juger de ce que toutes les altérations de l'air & de la nature, le font par l'acheminement des Planètes aux divers Signes da Zodiaque, ou les faisons semblent à cette heure anticiper l'une sur l'autre, à cause que l'A ries de la huitième Sphere astainvicé fut le Taureau du premier Mobile. Que ferois-ce donc y si les Signes mânquoient, ou s'ils estorent hors de leur places y puisque la seule destruíssité de jetter regards cause de si notables altérations?

L'avotie que nos yeux ne nous obligent pas à faire le jugement, parte que la disposition des estoiles nous semblé faite par haïiirii qué le&n^OTôSaVleuts constellations ne nous paroissent que dessus les globes artificiels, & qu'il faut auèitéíhh. áié pour les reconnoistre» Mais en cét a nous tléaoiiS fctìi&Èeter qu'il ne s'agit pas iey d'une disposition matérielle, d'une industrie ui échWqné qui aye enrichy le Ciel de broderie, & qui de la diversité des Estoiles aye formé tes compartiments & des fleurons: II s'agit du concertée du rapport de leurs vertus, <faï ne peut être ent<*rt<tó de nos oreilles, ny veu de nos yeux, mais seulement compris de nostre raifort par de longues expériences.

Quand on voit aux fontaines artificielles des fotìds entaillées avec etáflt d'irtegf- B lité, que les touches représente en certains endroits, Sclaiííerit avec autres de fort grands espaces vuides > un ignorant ne se seroit pas que cette machine, qui l'oeil par La disproportion de ses parties, fuit capable de charmer l'oreille par un jeu d'orgues, par l'harmonie des neuf Muses, & de donner la toifciVrt Rossignol dé p4Érrc. Qui n'auroit jamais entendu parler âù la Musique, prendroit les Jiures de tablatures marquez de notes inégales, blanches, noires, droites, crochue?* hadtéV basses, liées, ic disjointes, pour des barbouilleries de petit enfant. Sine le ftgureroic jamais que cette confusion de caractères signifiant une concert de vo&, & vte1 règlement de tons. Ie dy la mesme chose de la déposition des Estoiles, qu'elle est d'autant plus utile pour conclure l'harmonie du monde, qu'elle nous paroisse plus confuse, & que nostre oeil y rencontre moins de proportion.

Encore ijadmire comment elles font rangées si heureusement, que lés Constellations portent les propriétés des animaux, qui peut représenter les figures. Comme le Bélier qui est en terre le capitaine de fort troupeau, Si si courageux au combat, est dans le Ciel un amas d'Estoiles chaudes qui dominent destìts la teste le premier des membres, sur le Printemps le premier entre les saisons, & dé la complexion du planète Mars, qui présidant à la bile k à la cólere, esté cteu lé Dieu des batailles. Le Bœuf, animal propre au labourage, estant Ciel formé d'Estoiles humides, comme font les Hyades & Pleyades & d'autres chaudes, comme est l'œit oualdebaran-. parce que la terre reçoit la fertilité, & la vie, du concours décès C deux favorables quartiez. Ainsi les ancrés Constellations ont des forées rapportantes à leurs figures, & la terre n'est renouvellée par les sortent, que pateé que le Soleil faisant sa demeure en ces divers Signes, se transforme en du aflkez: jamais- il n'est si chaud & si violent que dans le Lion, si amoureux qu'avec la Vierge, si juste, & si modéré que dans les Balancés: il nous itìoflde de pluyes dairis le Verse eau, & nous traitee comme des poissons, quand il a son logement dans leur Signe. Comme l'esprit se fait d'une connoissance d'un degré à l'autre, on a passé de ces innocentes remarques à la superstition des images & des anneaux constellez, auxquels Albert lé Grand attribue de trop grandes forces pour en rapporter si peu de

raison. Céla neantmoins nous fait connoistre que ladilposicion des Estoiles feves ttefk fàs bazar, deufe, sans vertu, et sans une particulière providence.

Je ne m'arreste pas davantage à ces curiositez, St n'ay pas destoirí étíreprésentés icy tout l'ordre des Cieux: Cela appartient à Une science fépài^é, étent léfufetéffc sì vaste, qu'âpres toutes les observations, toutes les éstudès», 8Ue^áuaìldfcplutteut9 siécles l' il faut encore que nous mourions ignorans dé cés principales parties. Je m'arreste à ce qui est de plus familier, & à ce qûi ïïaiSs donne vné éonnomsincepîtts-' aisée, que leur ^ff ófòoa eiW&effoé & k Sagesse dw&é. Gúf ft k-ratfotì néusÉut avoiier que l'ordre des Elemens dans le monde inférieur dépend de la puissance & de la sagesse du premier Principe. Nous devons dire le mesme des parties des Cieux, particulièrement des Signes du Zodiaque, qui ne l'ont autre choie que les Elemens repetez trois fois, pour signifier par leur nombre, le mystère de la Trinité divine. Le Bélier, le l'agneau, le Gemini, l'Eícreuisle, font le feu, la terre, l'air, l'eau: Puis le Lion recommence le règne du feu, ainsi de suite avec cette différence, qu'il se fait icy en passage de l'extremité à l'autre > de l'eau au feu, afin de causer les altérations qui entretiennent le monde, & resveiller la Nature par cette contrariété.

Ce n'est pas que les conjonctions des Planètes supérieures qui se font en ces Signes, particulièrement au Bélier, tous le 794 ans, soient capables d'apporter des changemens de Royaumes, moins encore de Religion, comme nous le prouverons plus bas; parce qu'en un mot ces grands effets dépendent de la liberté de l'homme qui domine aux Astres, & d'un ressort particulier de la Providence divine qui se reserve ces dispositions. Neantmoins ìl faut avouer, que la rencontre de ces Planètes attache de puissantes qualitez à la matiere, & que comme les aspects ordinaires font des changemens d'un jour & aussi ces grandes conjonctions impriment de profondes influences, qui répondent à l'estendue des siècles, & ne laissent guerres autre chose que la volonté des hommes libre de leur violence. Dans le Zodiaque, les Signes de mesme nature font disposez en triangle, & rendent favorable l'aspect des Planètes qui se trouvent en cette constitution. Les contraires, comme le Bélier, le Cancer, le Capricorne, forment le quarré du cercle, & font cause que • les Planètes qui en prennent les qualitez, s'offensent d'un regard injurieux, et font sur lés corps des altérations semblables à celles que nous voyons au rencontre du feu & de Peau. De là procèdent les crises aux jours septénaires, parce que la Lune entrant lors dans un Signe d'une qualité opposée à celuy où elle estoit an temps du premier accez, elle irrite la Nature, & luy fait faire un effort pour preparer l'humeur qui est la source du mal. Ne faut-il pas que ce soit une Bonté souveraine qui aye placé ces vertus au Ciel, &í donne la vitesse du mouvement à la Lune, afin qu'elle nous delivrast plus promptement de la maladie par cette influence, que la Médecine par tous ses remèdes?

Ce qui me semble plus digne de considération, c'est que les Estoiles fixes ayans des qualitez différentes, donnent aux terres, ausquelles elles font verticales, £c qu'elles regardent à plomb, la force de produire une grande diversité de choses. Et comme nous avons plus de passion pour ce qui est Je moins en nostre puissance, comme l'opinion estime les choses par la nouveauté, l'avarice a faut ses thresors, & le luxe ses voluptez, de ce que les terres estrangeres avoient de commun. L'or dont autrefois les Indiens ont enchaisné leurs esclaves &c leurs criminels, est aujourd'huy entre nous le principal ornement de la Noblesse, &. une récompensé de la vertu. Le trafic e de ce .qui manque à un pais, l'entretient dans l'intelligence d'une nation estrangere, & toutes le? antipathies naturelles cèdent aux charmes de la volupté & du profit. Admirable Providence de Dieu, qui entretient la société des hommes par cela mesme, qui de foy la devroit rompre, puis qu'il employé leur cupidité pour nourrir la paix, qu'il nous l'a rendue nécessaire en ce que l'aversion des estrangers tournerait à nostre desavantage, de que c'est nous haï de ne nous pas mettre en leur amitié.

Quelques uns se font servis de cette industrie pour concilier des esprits contraires, dont le choq pourroit esbranler l'Estat, de les mettre en des charges également dépendantes les unes des autres, afin que la nécessité de leur secours, amolist leurs cœurs, & que les devoirs au commencement forcez ou contrefaits, le changeassent par la continue en de légitimes affections. L'economie de nos corps se maintient avec cette ordonnance, que toutes ses parties trafiquent de leurs vertus, qu'elles soient tout ensemble libérales de leurs puissances, & accommodées de celles des autres. Les mesmes veines meseraïques qui déchargent le chile dedans le foye, reportent le sang dans les intestins. Si le cerveau reçoit le sang par les jugulaires intérieures, & il se nourrit des artères qui luy sont envoyez du cœur, il répand surtout le corps la lumière de ses esprits, &. l'imperceptible tisseure des nerfs qui portent le sens. La paix de nos ames seroit eternelle, si nous pouvions y establir ce commerce, que l'imaginative donnast la matière au jugement, et en recevoir la direction que l'intellect empruntast la chaleur de la volontés & qu'en eschange il là conduìsistance, ses lumières, que les passions irascibles combatiffent fous la raison, & que les concupiscibles ne trafiquassent en désirs que par ses conseils. Nous serions par ce moyen riches en contentemens: nous ne connoistrions le trouble que par le récit des ancres, & nostre raison imiteroit la Providence due au gouvernement des Cieux & du monde.

Chapitre XV - De L'ordre Général Du Monde

L'Ordre qui est une belle disposition départies dans les sujets sensibles, aie né sçay quoy de ravissant, & jette au dehors des rayons de grâce qui gagnent nostre estime sans consultation, & qui nous obligent de l'agréer, si-tost que nous le regardons. Nos yeux se répandent avec délices dans ces longues allées -y où l'art contraint la Nature de marcher droit, où, les arbres tiennent bien leur rang, & avancent à la file jusques à leur terme. Il n'y a que l'ordre qui met de la différence entre un compartiment bien entretenu, &une terre laissée en friche. La beauté qui satisfait la raison dans un discours, qui charme l'oreille par la Musique, qui ravit les yeux dans les tableaux, dans les peintures, dans les édifices, consiste en l'ordre & en la disposition de leurs parties.

Il ne faudroit point demander la raison de ce que l'ordre revient à nos sens, & à nos esprits: parce que nous tenons cette humeur de la Nature i qui estant le principe du repos & du mouvement, arreste nostre curiosité, & veut que nous rendions le mesme respect à cet instinct, qu'aux autres loix qu'elle nous inspire avec la naissance.

Neantmóins on peut dire que nous aymons l'ordre par interest, parce qu'il nous ayde à la connoissance des choies, dont il oste la confusion, que nostre Nature estant composée, nous concevons avec moins de difficulté & plus de plaisir l'estre composé par l'ordre i que le simple, qui ne se laisse voir que par artifice, & avec ces abstractions qui cachent la moitié d'un sujet, pour découvrir l'autre. Nous l'aimons encore par sympathie; d'autant qu'en cette distribution qui assigne le premier rang aux plus nobles & aux plus grandes de ses parties, nous voyons une image de nostre raison, qui procède ordinairement des choses universelles aux particulières, &qui rire ses consequences des veritez les plus générales. Le corps n'a de la .vigueur & de la beauté que par cette agréable disposition départies ajustées aux lieux qui leur font propres, avec une proportion dont le dérèglement fait les Monstres. Nos desseins ne sont jamais couronnez d'une heureuse issue, que par l'ordre que nous apportons à leur conduite. Quelle merveille donc si nous avons l'ordre, où consiste nostre perfection, qui est l'appuy de nostre puissance, qui nous est & si naturel & si nécessaire? Enfin l'ordre est la production légitime de la raison, comme nous en ferons la preuve: de forte qu'il est veu d'elle avec la complaisance que reçoit le Peintre de son ouvrage, & que ressent une mere affectionnée à la rencontre de son enfant. Et bien que l'ordre qui se présente à nos yeux, ne soit pas nay de nostre propre industrie: Neantmóins nous l'adoptons comme un effet de cette raison qui est commune à toute l'espece, & sommes bien aises de voir nostre dessein achevé, encore que ce soit par les mains d'un autre.

Mais je croy, que s'il se peut rendre quelque raison plausible de ce que nous aymons l'ordre, C'est parce qu'il est un puissant moyen qui nous ayde à la connoissance de Dieu: Et comme nous avons une grande inclination naturelle pour ce Soleil, nous cherissons le rayon qui nous le découvre:

Car jamais personne n'a pris le loisir de contempler la disposition du monde, l'alliance de ses parties, les revolutions des Cieux, la suite Continuelle des corruptions & des naissances, qu'il n'en aye tiré cette conclusion, qu'un ordre si accomply estoit l'œuvre d'une souveraine Sagesse. Elle n'est pas moins admirable eh la formation d'une mouche que d'un aigle, Sedans l'economie des fourmis, que dans la police l'ome de tout le monde, puis que nous tenons l'artifice plus excellent, qui se déployé tout entier dans un sujet racourcy. Neantmoins comme i'industrie a bien plus d'éclat sur des colosses, que dans ces petites figures où elle semble enfermée, & où elle eschape à nostre veuë par la délicatesse des traits: Aussi la Providence divine paroist plus dans l'ordre gênerai du monde, & dans ses parties, & nous concevons un plus exprez sentiment de la grandeur par la contemplation de ce vaste sujet, pour l'accomplissement & pour la conduite duquel il saut que la toute-puissance se rencontre avec une souveraine íàgeíle.

L'impieté ne s'est jamais monstrée si déraisonnable, denier l'ordre au monde: Son nom, qui est pris de la beauté & de l'ornement, en est un tesmoignage public. S'il n'y avoit point d'ordre, nous ne ferions pas, & comme la connoissance se fait par la distinction des objets, nous ne pourrions rien connoistre, parce que le monde sèroit un chaos, & toutes choses seroient perdues dans la confusion. Aussi je n'entreprens pas de prouver cette vérité comme une proposition qui soit débattue, mais i'ay dessein de contempler l'admirable disposition de la Nature, pour en tirer des sentimens du premier principe.

D'abord je voy dans le monde, que tous les Estres y tiennent leur rang, félonie degré de leur perfection) comme dans une Republique où la Loy commande, & où la corruption ne s'est point encore glissée, les charges se donnent au mérite, & on peut juger de la vertu par la pourpre. Ainsi les Cieux les plus accomplis de tous les Estres en la forme, & en la matière, les moins sujets à l'alteration, enrichis des plus nobles qualitez, ont l'empire dessus les corps élémentaires à qui leurs influences donnent toute forte d'impressions.

Les Elemens gardent le mesme ordre, Le feu, le plus pur & le plus actif, est voisin des Cieux; l'air le fuit, & puis l'eau $ Scia terre qui n'a en partage qu'une disposition à recevoir les liberalitez des autres, est à leurs pieds, & Fait le centre du monde, tous les estres composez de ces corps simples; font divisez en quatre bandes, & le rapportent à quatre Genres généraux 5 à sçavoir à l'inanimé, au végétant, au sensitif, & au raisonnable: de forte que le degré inférieur sert au supérieur, sans s'échaper jamais de la sujétion qui suit la bassesse de sa naissance, Le simple composté des 3uatre Elemens, n'a qu'un estre mort, sans action, sans vigueur, exposé aux priíès e tous les autres, & qui tient beaucoup des affections pâlîmes de la matière où là forme est ensevelie. La plante succe sa nourriture de la terre; les brutes la prennent des plantes, & l'homme qui est le plus noble, tient les degrez inférieurs à son estre, esclaves de ses commoditez & de ses plaisirs. Et parce que la raison a plus de vigueur qu'il ne luy en faut pour s'élever par dessus l'estre sensitif, elle réfléchit sa lumière dessus le dernier des degrez de l'estre; elle y met l'ordre, & luy semant parce moyen ç de principe, elle ferme le cercle de la Nature. Cela se fait lors qu elle embellit les choses matérielles par les inventions de l'art, quand elle s'assujétit la terre de faire des productions selon son dessein, lors qu'un Dédale cachoit dedans les ouvrages un secret principe de mouvement, qui les faisoit, dit Platon, eschapper des mains de leurs maistres, comme des esclaves fugitifs, lors qu'un Architas nt voler un pieon de bois, qu'Albert le Grand donna la parole à une teste de bronze, lors que Alchimie ouvre les métaux, & met en liberté la puissance generative enfermée dans l'épaisseur de leur matière: Enfin cela se fait ordinairement, lors que le Peintre anime une toile par la mesme application de ses coloris; ou que le Sculpteur tire une excellente figure d'une masse de boìs ou de pierre.

Ces effets de l'esprit de l'homme donnèrent tant d'admiration aux premiers siècles, qu'ils mirent les Autheurs des arts au nombre des Dieux, comme s'il n'appartenoie qu'à Dieu d'establir l'ordre entre des choses qui d'elles-mesmes ne font pas capables de s'y reduire. Il ne faut pas douter que si Vulcan mérita des honneurs divins, pour avoir trouvé l'invention de nourrir le feu $ & l'aères, parce qu'elle donna l'industrie de l'agriculture, que les hommes de ce premier âge, considerans les feconditez de la Nature, & la continue de ses générations, ne jugeassent qu'une Intelligence supérieure, luy avoit donné cet ordre & cette conduite; puis qu'ils reconnoissent quelque divinité en ceux qui n'en avoient que l'imkarion. C'est pourquoy ils seignoient que Pallas Maistresse des arts, estoit née du cerveau de Jupiter; que Mercure, qui préside aux inventions, estoit le truchement & le Heraut des Dicuxj ique cec de l'homme avoit d'industrie, luy venoit du feu, que Prométhée déroba, au Ciel, pour luy attacher à Panìe. Toutes ces fables signifient une mesme vérité, que Dieu est l'Autheur de l'ordre du monde 5 que si l'art farde la matière, & luy donne quelque agréable disposition, c'est par le secours, & à l'exemple du premier Principe.

Il ne faut pas moins qu'une Puissance & une Sagesse infinie, pour avoir enrichy la Nature d'une diversité d'estres sans nombre, les avoir rangez avec vrfordrefahs confusion, qui ne salle de tant de contraires, qu'une beauté, & qui rapporte des intentions si diverses à une fin si generale. Cet ordre est pareil à celuy d'une Republique bien policée, ou de plusieurs offices qui font subalternes, on monte jusques aux plus éminentes charges, & jusques à la Puissance souveraine qui en est la source. Toutes choses font réglées au monde. Les espèces & les Estres particuliers ont leurs grandeurs limitées, leurs activités ont leurs ressorts; leurs résistances ont leurs barrières: & c'est pourquoy nous appelions les choses parfaites, quand elles font arrivées au dernier point de la grandeur & de l'excellence qui leur est permise. C'est par l'obligation de cette Loy, que la terre se précipite, que le feu s'envole pour joindre leurs centres: Et comme ces mouvemens les ont portez aux lieux que la Nature leur a fait propres, ils monstrent par un grand repos, qu'ils y ont l'accomplissement de leurs appétits. De là viennent les serrettes iympathies des choses, qui concourantes à une mesme fin, assemblent leurs forces, & s'entrepressent leurs assistances B par une inclination bien esloignée de celle des hommes, entre qui une mesme prétention d'amour ou d'honneur, allume des passions qui des'esteignent que par le làng d'un rival.

Cet ordre du monde est le fondement de nos consultations; quand nous faisons choix des moyens propres pour l'accomplissement de nos entreprises: parce qu'il y a certaines choses nées pour les autres, ausquelles comme elles coulent par instinct, elles nous y conduisent sans travail, si nous suivons doucement leurs cours. Autre les Stoïciens ont mis le Destin en cette entrefaite de causes, & ont dit que c'est la bonne fortune, qui n'est aveugle que pour les esprits qui n'ont pas le veuf; de la dépendance & de l'ordre des choses, où elle consiste. En effet, qui sçavroit bien prendre les avantages de la Nature, & s'embarquer avec ses inclinations; il ne manqueroit jamais de toucher le port qu'il s'est proposé: Il égaleroit les prodiges des Démons, l'art acheveroit dessus la matière ce que l'esprit peut concevoir de plus grand & de plus miraculeux Scrieh ne seroit difficile en la conduite des hommes, à celuy qui connoistroit le ressort de leurs passions.

C'est pourquoy on peut dire que la Loy de la Nature est une Vérité universelle, qui doit servir de premier Principe aux sciences: celle qui donne l'invention aux arts, & d'où la Prudence doit emprunter les règles de la conduite, dans la vie civile ou particulière. Cependant que les diverses sciences s'entretiennent de leurs objets, Q elles ne font que comme des flambeaux qui esclairent une salle, & laissent les ténèbres au reste du monde/Car toutes ensemble elles ne nous donnent, comme les Estoiles qu'une lumière sombre, trompeuse, & qui nous permet à peine de discerner le chemin du précipice. Mais la connoissance des veritez naturelles répand dedans les esprits une lumière aussi universelle, que l'est celle du Soleil au monde; & le faneur toutes choses nous paroissent avec leurs propres couleurs: Nous en remarquons les distances, les grandeurs, les figures, & les proportions; & s'il faut agir, l'homme n'a point dérègle plus propre & plus infaillible,

puis qu'il est l'abrégé du monde, & qu'il doit vivre sous les mesmes Loix, comme il est composé des mesmes parties. Aussi les Stoïciens, les plus austères des Philosophes; mettoient la derniere perfection de l'homme à vivre selon la Nature, non pas comme on l'a fort mal inter Íireté, qu'ils fissent estât de future l'appétit des sens; mais de former leur raison bus la conduite du monde, & se faire quittes de l'inconstance qui seroit de nos résolutions, se preferons une Loy, comme celle de la Nature, immobile dans les changemens, & dont l'ordre toujours égal nous est une image de l'Eternité.

Certes comme Rome quittòit la palme de la sagesse Politique à la Grèce quand elle envoya recueillir lès Loix pour s'en servir. Comme la Lune a moins de lumière que le Soleil, de qui elle la tient par emprunt: Il faut conclure, que, puis que tous les arts, toutes les sciences, & la plus fine sagesse des hommes se règlent dessus la Nature, il y a une souveraine Intelligence, une Vérité originelle qui a estably cet ordre, & l'entretient avec des Loix si justes, qu'elles disposent de toutes les altérations sans en estre atteintes. Voyons-en les preuves.

Chapitre XVL - l’ordre Est Un Effet De La Raison: Et L’ordre Du Monde Suppose Une Raison Universelle

Les remarques particulières que nous avons faites de l’ordre des Elemens dans les mixtes, du mouvement régulier des Cieux, des vertus si bien proportion* nées des Planètes, de la disposition des Estoiles fixes, des sympathies, des dépendances des causes, & mille autres considérations, forcent les esprits rebelles de confesser, que le monde est fous la conduite d'une souveraine Intelligence. Encore ce que nous en avons veu est bien peu de chose: Car s'il nous estoit permis de passer B pour un peu dans l'Eternité, que relevez au dessus des choses mortelles, en ce point heureux qui égale tous les temps, il nous est permis de voir l’ordre de la Nature* la liaison de ses parties, la suite des causes, les longues revolutions des Cieux, enfin ce que tous les siècles ont porté de diffèrent, tous les evenamens qui font limitez à certains âges que toutes choses, le passé &l'avenir, souvent recueillis au présent, & nous souvent monstrez comme un seul objet, qui se peust contempler d'une veuë: Nous advoisserions qu'il n'y a pas un seul petit animal, la moindre petite plante, qui n'aye d'admirables sympathies, non feulement avec les autres Espèces, mais encore avec les qualitez des Elemens, avec les pierres, les minéraux, & les Planètes: il n'y surprit éclipse qui ne nous est une lumière pour contempler Dieu, Disgrâce particulière qui ne est remarquée tres-importante au bien général du mondé 5 & ce qui paroist à nos interests & à nos passions un coup de fortune* seroit reconnu pour l’errée d'une souveraine Providence.

Or je demande, qui a disposé ces choses de la forte $ supposé mesme que les Elemens s'entretinssent dans le monde par l’ordre de leurs propres lieux, & par une égale résistance qu'ils font à leurs admirez? D'où vient la disposition des \ Cieux? Qui a marqué les logemens des Planètes dans le Zodiaque? Qui a compassé leurs grandeurs, leurs mouvemens, leurs influences? De répondre que toutes choses onc toujours esté en Ce mesme estât, l'aymerois autant dire envoyant un lut parfaitement bien monté, que le bois se seroit luy-mésme séparé du tronc, se seroit rendu poly & souple, pour se joindre avec matière, & se courber en la voûte qui forme le corps de cet instrument. On oseroit dire, que les cordes seroient jaillies dessus d'elles-mesmes, qu'elles auroient choisi leurs places, estans immobiles, qu'estans privées de l’oíiye & de la raison, elles se fussent emparées des cheuilles, selon la partie qu'elles doivent tenir en cette harmonie? Si nous voyons une armée sur pied avec le grand attirail des armes, qui tiennent les peuples suspendus en l'attente de leurs foudres, contemplans ces bataillons bien formez, cette fourmilière d'hommes marcher d'un pas, & tourner comme si ce n'estoit qu'un corps, nous disons, sans autre consultation, que cet équipage est l'entreprise d'un Prince y que cette conduite, & cette discipline militaire, dépend de la prudence d'un Generali. Si nous répandons nos yeux dessus un parterre, envoyant la liaison des carreaux entrecoupez d'une si agréable & si proportionnée diversité, prenans plaisir à future les tours d'un Dédale, les fleurons & les traits hardis de la broderie, nous jugeons qu'un maistre fort entendu a fait ce compartiment, & a reduit la Nature à ne produire que sur les lignes du dessein

qu'il luy a tracé. Enfin quand nous lisons les histoires dans l'estendue des tapisseries $ quand nous voyons les peintures, & ce qui consiste en ordre & en proportion $ nous en tirons cette consequence, que ces choses ne sont pas faites d'elles-mesmes, ny par hazard, mais qu'elles font disposées par artifice, & qu'elles font un oeuvre de l'eprit de l'homme. L'ordre qui consiste en une certaine disposition de parties dépendantes-les unes des autres, est le propre effet de la raison: C'est le premier d'entre les objets sensibles, que nostre esprit ayme par sympathie, & qu'il recherche par nécessité. Si les Sciences dressent leurs démonstrations, si l'Art acheve son œuvre, si la Mémoire retient les espèces; si la Logique raisonne-, si la Police commande, si la Médecine guérit 3 ce n'est que par le moyen de l'ordre: parce qu'il est un effet gênerai de la raison, plus necessaire à l'accomplissement de toutes ses entreprises, que la lumière pour nous donner la veuë des couleurs. Nostre ame, qui est purement spirituelle, libre de la contrariété, & qui comprend les degrez inférieurs de la Nature en son essence, à ce privilege de faire l'assemblage de diverses choses parles opérations.

Comme elle peut considérer la chaleur du feu sans la sécheresse, la dignité hors dé la personne, & voir dans l'abstraction, les choses qui font inséparablement alliées, elle peut de mesme joindre les choies différentes & contraires, par l'entremise de ce qu'elles ont de semblable, & en faire un compose dans son concept. Et mesme elle a formé l'idée de cette union, elle commande aux mains de l'exécuter dessus la matière, & les conduit pour disposer les parties avec une dépendance, & une suite si bien proportionnée, qu'elle en cache aucunement la diversité, &les met en cet estât, que nous appelions l'ordre.

Pour cela il faut premièrement former un dessein, délibérer des moyens qui en peuvent donner l'accomplissement, connoistre chacune des parties estant séparées, & le changement que leur donnera la composition, &puis les approprier avec une correspondance, qui faste un tout de plusieurs, & quelque choie déplus accomply g que ne font les pieces, estans disjointes. Or toutes ces actions, la prétention de la lin; le choix des moyens, le jugement de la qualités & de ce qui doit réussir de l'assemblage, ce sont autant d'effets qui dépendent de la raison, & qui ne sçavroient partir des Estres qui en sont privez.

Cela mesme passe les termes de la Nature, en ce que les choses corporelles reçoivent un estre meilleur que celuy qui leur estoit propre avec une plus grande estendue, & ce que la naissance & le lieu avoient sépare d'inclination, entre dans une société de biens. Encore qu'il soit impossible d'affranchir plusieurs parties de la multiplicité qui naisse de leur existence singulière, telle, qu'elles ne sçavroient estre une choses qu'elles ne cessent aussi-tost a' estre l'autre: Neantmoins la raison les joint si dextrement quand elle les met en ordre, qu'elle fait de leur diversité, comme un corps de Republique, où les droits de chaque particulier s'estendent dans ceux des autres & clés interests privez s'accroissent par la, puissance commune. • Quand le hazard porte des choses différentes à la rencontre, elles s'amassent comme un tas de pierres sans distinction de la petitesse ou de la grandeur, avec une inégalité qui laisse du vide mal à propos, qui s'eslev où il faudroit s'applanir & toute sa déposition est celle que l'œil condamne, & que l'art évite. Où si le meslange se fait de choses liquides, elles se pénètrent, le confondent, de sorte que chacune noye la vertu dans celle de l'autre, & de beaucoup de bonnes qualitez simples qui n'ont point de sympathie, il s'en fait souvent une mauvaise composition; C La seule raison est capable de joindre plusieurs choies, de sorte qu'elles ne perdent rien de leur beauté & de leur vertu, mais qu'elles reçoivent un nouveau lustre de leur assemblage; Elle ale droit défaire les unions, puisqu'elle est une unité exempté des divisions de la matière: de traiter les societez, elle qui tient icy-bas une qualité moyenne entre le monde intelligible & le corporel, qui commande au corps selon son idée, &qui a l'industrie de retrancher ce qui résiste à leur assemblage.

Aussi les choses ne s'y portent pas d'elles-mesmes. Une pierre ne se taillera pas pour faire la clef d'une voûte: un diamant ne fer polit pas, & ne prend pas de luy-mésme dans une rose la place où il

doit avoir un plus grand éclat. L'industrie des ouvriers fait ces agréables assortimens: Elle bastit un Palais d'une carrière; elle acheve des pieces plus belles & plus délicates que la Nature, d'une masse qui n'avoit qu'une dureté rebelle à toutes les formes. Enfin l'ordre s'establit d'autant plus parfait, que la raison qui le conduit est plus excellente, & nous tenons les loix des Estats, & l'economie des sciences de ces forts Esprits, que nous reverrons encore dans l'Antiquité. Ce qui nous contraint de reconnoistre, que l'ordre & la disposition des parties du monde dépendent d'une raison supérieure.

On dit à cela, que quelquefois le hazard aissable l'ordre & que i'Agathe de Pyrrhus representóit naturellement les neuf Muses, & Apollon, tenans leurs instrumens de Musique, qu'il s'est veu des pieces de marbre qui portoient la figure d* un Satyre, d'une Salemandre, d'un serpent, d'oiseaux, & d'autres formes & la Nature imiter l'Art par une rencontre hazardeuse, comme l'Art imite tous les jours la Nature avec dessein» Pour respondre à semblables objections $ il n'est pas necessaire de recourir aux resveries des Platoniciens, & dire que l'ame du monde estant pleine de toutes les formes, s'est débauchée, en imprimant celle d'un animal sur la matière d'une pierre encore molle, & qui n'avoit pas là consistance: Ou que les Démons qui habitent les Elemens, se sont jouez en ces productions extravagantes, & ne pouvans faire des corps véritables, se sont contentez d'en tirer les représentations sur des -matières inaccoustumées, afin que ce miracle fist un tesmoignage de leur puissance. Dire cela, c'est toujours reconnoistre l'industrie d'un Agent qui a conduit ces ouvrages selon son idée. Mais je ne veux pas combattre cette fiction par une autre. Ilmesurnt de dire, auquel on se figuroit faussement ces représentations dans les veines du Porphire, comme il le fait tous les jours dans le feu, & dans les nues, ou que P Art a voulu tromper plustost l'esprit que les yeux, fassent croire que ces portraits estoient achevez par les mains de la Nature, encore que le pinceau ou le urin les eust gravez sur le marbre, &eust seulement fait servir quelques veines & quelques taches pour mieux déguiser cet artifice; B Si les corps célestes dominent sur les inférieurs, je ne trouve point estrange, que la matière estant sur le point de prendre sa consistance, &c de le déterminer à estre du marbre, ne reçoive quelquefois l'impression du Signe qui tient d'ascendant du Ciel, & qui en a la domination: Que l'Hydre & le Serpentaire ne fasse un serpent: le Lion, la Vierge, le Scorpion, le Gemini, ainsi des autres, ne peignent leurs représentations sur un mixte, qui en sa naissance est susceptible de toutes sortes de traits & de qualitez. En cela il n'y a point de hazard, puis que la cause en est déterminée: que le Ciel fait ces graveures fous la conduite d'une Intelligence, & que l'on voie toujours de-mesmes effets i quand ille rencontre de mesmes dispositions. Outre ce que Dieu, qui est présent à toutes les parties du monde, qui le soustient, &qui le gouverne, en exclus le hazard, & rapporte ces naissances prodigieuses à des fins tres-importante, encores qu'elles ne foient pas connues. Quand ce ne seroit que pour satisfaire la curiosité de l'homme, par un spectacle extraordinaire, ou pour monstrer par ces miracles t qu*il est le souverain Monarque du monde, qui a prescrit des formes particulières aux espèces, comme le Prince se fait connoistre l'autheur de la Loy par les privileges & les dispenses qu'il en accorde. Ie croy que ces pierres emi sont naturellement imprimées défigures humaines, font des reproches publics a ceux qui fous* un visage d'homme portent une coeur de marbre, insensible aux devoirs de Religion & de charité. Enfin il faut tirer cette consequence generale, O que toutes les parties qui font en ordre, y sont réduites par la raison, & que si|la fortune porte quelquefois la flèche d'un mauvais Archer au blanc elle ne peut faire une belle disposition de plusieurs pieces, qui dépend d'un dessein i à cause que le bonheur d'une feule rencontre ne sçavroit suffire à la multiplicité de tant de rapports.

Si le flus & reflus de l'Ocean se font à des heures déterminées: si les accez des fièvres, si les crises, si les maladies chroniques ont leur temps prefix sans autre assignation, que de la Nature; cela dépend, comme nous avons dit, de la disposition du Ciel, &des influences de la Lune, dont le mouvement est conduit d'une Intelligence. Si l'Echo rend une voix qui signifie nos pensées, elle est premièrement concevez d'un esprit, & prononcée d'une bouche raisonnable, qui se fait à elle-mesme la responsif par l'artifice de la demande, & qui emplit le creux des rochers des mesmes accens, qui viennent refrapper l'oreille. Nous pouvons dire la mesme choie de la Nature, qu'elle est

de foy insensible, incapable de la connoissance & de la rechercha de la fin: que si elle monstre une conduite raisonnable, pour la conservation, elle luy est inspirée par une Intelligence supérieure.

Tout l'ordre qui se rencontre dans les choses artificielles ou morales, estant un effet de nostre raison, il faut conclure,- que celuy que nous avons remarqué entre les parties du monde dépend d'une Raison universelle. Deux cordes de luth qui font d'une mesme-nature, ne sçavroient rencontrer d'accord, si la main de celuy qui touche cet instrument ne les bande & ne les relasche, jusques á les réduire au, ton, dont ion esprit a concévridée. Hé; le moyen que les vastes corps des Cieux &des Elemens,&: tous les Estres qui partagent leurs qualitez ennemies, fussent d'une Intelligence, si un Raison supérieure ne relevoit les forces des natures par trop hautaines, & ne relevoit les baises, pour faire réussir cette harmonie, où consiste l'estre & la perfection du monde?

Une fortune privee se doit manier avec beaucoup d'industrie: mais il en faut bien plus pour le maniement d'une grande charge, & plus encore pour le gouvernement d'un Royaume & d'un Empire, où la prudence je doit toujours mesurer à l'importance de son sujet. Quelle sera donc la sagesse du Principe qui commande au monde, qui conserve l'ordre de ses parties, & qui donne loy atout ce qui a l'estre? Elle doit estre d'autant plus relevée par dessus celle des Princes & de leurs Ministres:, que le Monde, les Cieux, les Èlemens, les composez ont plus d'esteridue' que les Royaumes & que ces choses privées de raison, sont bien plus rebelles au commandement que les Peuples, qui se laissent au moins conduire par leurs interests ou forcer par l'appréhension des supplices.

II faut avouer que la prudence est moins nécessaire en la conservation, qu'en l'établissement d'un Estat qui subsiste le plus souvent par la seule contrariété de ceux qui ne se sçavroient accorder á sa ruine, et il s'entrenent sans beaucoup de difficulté, lors que la coustume a fait passer la domination endroit de naturel, & que les peuples perdent leur liberté sans ressentiment, fous le pouvoir de celuy que la naissance & la succession ont rendu leur Prince. Mais quand il est question d'estever nouvellement une Monarchie, de donner le premier ply aux esprits d'une extravagant populace avec des Loix, dont la rigueur soit adoucie par l'utilité, qui désarment les ennemis, qui coupent chemin aux désordres, & qui contiennent au présent la félicité future d'une Republique, c'est le chef-d'œuvre de ces grands esprits que l'Antiquité adoroit pour des demy-Dieux. Encore quelque prevayance que l'on apporte à l'establissement des Loix, quelque veuë que l'on aye de i'avenir, & de quelques modérations qu'on les assaisonne, elles ne sont pas eternelles, & les plus l'ages qui reverent l'Antiquité, sont contraints de les changer avec les âges: Parce que les nouvelles maladies qui les accueillent, veulent estre guéries par une diversité de remèdes, & que nostre nature, qui devient facilement insensible pour ce, dont elle a l'usage continuels doit estre refueillée par la nouveauté.

De là nous pouvons connoistre, que la Raison qui préside au gouvernement du monde, qui eu infiniment plus excellente que celle de tous les Législateurs: D'autant qu'elle a estably des Loix avec tant de justice, & d'une utilité si universelle; qu'elles sont toujours demeurées les mesmes,sans que la longue révolution des siecles y fait naistre quelque apparente utilité, qui ait donne sujet de les changer. Le premier Mobile n'a rien perdu de la régularité de son mouvement, qui luy fait faire le tour du monde en 14 heures. Le Soleil employé toujours un an pour retour Q ner au point du Zodiaque, d'où il est party.

Saturne acheve son cours en 30; ans, Jupiter en onze, & toutes les autres Planètes n'ont rien achever diminué du terme de leurs Periodes. Le jour & la nuit partagent toujours le temps: les saisons servirent avec un uniforme ordre: les chaleurs; les froidures, les pluyes, & les serenitez tempèrent la terre & si la huitième Sphère a iunce de flus le premier Mobile, ce n'est pas un changement, mais la continue d'un chemin qu'elle doit reprendre, âpres l'avoir acheve.

Ce ne sont pas là de ces artifices qui ne sont connus que de peu de gens, de ces Loix, dont les utilitez font couvertes, & les rigueurs apparentes:tout le monde voit le bel ordre de la Nature, il conserve tous ces estres & il anime toutes les vies, & si nous ne luy rendons pas ce qui luy est deu d'admiration, c'est que ce bien nous est ordinaire, & que cette bonté souveraine est si libérale des ces faveurs, qu'elle previent nos désirs & ces grâces sont si continuelles, qu'elles nous tiennent tousjours empeschez à les recevoir, sans estre attentifs à les reconnoistre.

Chapitre XVII - Des Moyens des Lesquels Se Fait L'alliance Des Parties Du Monde

L'Esprit de í'homme n*est pas satisfait de connoistre simplement que le monde s'entretient par l'ordre de ses parties t mais comme il est capable de conseil, & qu'il peut tirer des instructions de cette conduite, il veut avoir l'intelligence de ces ressorts, & sçavoir quels font les moyens propres pour faire l'alliance d'une si grande diversité. C'est neantmoins une entreprise qui paroist n'avoir point de proportion avec nos forces: Parce que si nous ne pouvons concevoir l'admirable composition des quatre Elemens dans le corps d'un petit animaux, & comment le feu se tient couvert avec une quantité si bien mesurée, si justement détrempé d'humeur, arresté de seicheresse, a l'enty de froid, qu'il le met précisément dans le degré d'une espece, & luy donne assez de vigueur pour les actions nécessaires à son entretien. Quelle apparence que nous peussions découvrir toutes les merveilles du grand corps de la Nature, voir les sympathies des essences, les degrez de perfection & de déchet, necessaires pour ne faire de tant de contraires qu'un monde, de tant d'altérations, qu'une durée; un estre constant d'une vicissitude continuelle? Il semble que nostre foiblesse se doit icy contenter d'une connoissance confuse, & que le jugement que nous en pouvons porter, est pareil à celuy que seroit d'un luth, un homme, qui ne l'ayant jamais touché, se laisseroit insensiblement transporter à sa douceur. Il se plonge dans de profondes pensées, à mesure que les basses s'enfoncent dans le creux des notes, il accompagne de ses soupirs les tons à demy-mourans, dans la mignardise de leurs langueurs, il est attentif aux feintes alarmé des passades, calme en la gravité des accords, a la igre aux reprises, courageux dans les batteries: enfin revenant à soy de ces transports, sans examiner davantage cette musique complète en un seul instrument, il en juge l'excellence par le contentement de son oreille, & la suspension de son esprit. Ainsi lors que nous voyons l'agréable diversité des parties du monde, le grand nombre des espèces, l'ordre & les revolutions des temps mesurez des Cieux, l'accord de tant de contraires, les délices, & les utilitez qu'ils nous apportent, tout cela nous doit suffire, sans chercher d'autres démonstrations, pour conclure que le monde est l'oeuvre d'une souveraine Intelligence. Mais parce que la veuë generale d'un objet, n'en donne qu'une connoissance fort confuse, & que ce seroit mal juger de la beauté d'un parterre, de se contenter de ce premier agréement que nos yeux reçoivent de sa bigarrure, sans se donner le plaisir de voir en chaque fleur les artificieux caprices de la Nature: taschons pour mieux juger de la perfection du monde, de remarquer la liaison particulière de ses parties, & puis que a Sagesse divine y déployé ouvertement ses artifices, nous ne devons pas négliger d'en faire le sujet de nostre contemplation.

Pour cela il faut remarquer, que Dieu voulan a faire de toutes les parties du monde comme un cœur & un concert de diverses voix, il affoiblit les extremitez des corps, il raale quelques individus de chacune espece, & releve les autres de qûalitez avantageuses, afin de les joindre proprement aux degrez de la Nature qui les juivens & qui les devancent. Par ce moyen il se fait une tissure de toutes les parties, si délicate, que le progrez de la perfection surprend nostre veuë, & n'est pas plus sensible au monde y qu'en la croissance & en l'augmentation des corps. C'est ainsi que l'eau épaissit son fonds pour s'allier à la terre, & subtilise sa surface de vapeurs, afin de donner le commencement à l'air, dont la plus haute partie prend les qualitez de feu. Et cet Elément, le plus pur, le plus leger, qui tient moins de l'impuissance de la matière, comme s'il estoit atranchy de corruption par l'estoignement de ses contraires, imite les perfections, & fuit le mouvement du Ciel, afin d'en faire la liaison avec le monde inférieur. La Lune qui luy est voisine, semble tenir quelque peu des altérations élémentaires; si ce n'est par le déchet de sa substance, au moins en l'extravagance de son cours, aux changemens de la lumière empruntée, en la fréquence de ses

éclypses, & par les taches qui gâtent son teint, lors mesme qu'elle paroit au plus grand éclat de sa beauté. Les autres Planètes se rapportent aux quatre Elemens, ils gardent un mesme ordre, & font une semblable alliance de leurs qualitez. Les plus eíloignez du monde inférieur sujet aux altérations, font les plus lents en leurs courses, & les moins susceptibles de changemens-, jusques à ce qu'on vienne au premier Mobile, qui n'a qu'un seul mouvement régulier & uniforme, mais qui emporte les autres, pour nous représenter la puissance d'une Souveraine Unité.

Toutes les espèces du monde s'entretiennent avec un ordre pareil, & toujours par l'entremise d'une qui partage les qualitez de celles qui l'environnent. Les Météores ne sont qu'un mélange imparfait des Elemens, & font le milieu entre eux & les autres mixtes, que nous appelions parfaits. Les Métaux recevans leur augmentation par une vertu qui usurpe le voisinage, qui retient les matières qui les touchent, & qui s'approprie la vapeur qui ne pensoit qu'effleurer leurs corps, s'eslevent déja du simple composé élémentaire, & donnent commencement au vegetable, qui est équipé d'organes nécessaires pour succer sa nourriture dedans soy, & en faire la digestion: & le vegetable monte au sensitif par le moyen de quelques plantes parfaites, comme sont les palmes, les mercuriales, & d'autres qui ont une distinction de sexe, qui demonstrent piquées d'amour & de complaissance leurs approches, qui languissent si leurs branches ne se baisent, & que leurs racines né s'embrassent.

On rapporte plusieurs autres choses qui font le nœud du vegetable avec le sensitif, comme les sponges, qui par une crainte de perdre la vie, frissonnent d'horreur quand la main les arrache de leurs rochers. Les huîtres n'ont de tous les sens que l'attouchement, qui leur sert pour emprisonner leur proye, & se retrancher dans leurs forteresses, aux approches de leurs ennemis. Enfin les animaux capables de instruction des hommes, & qui monstrent les effets d'une puissance de plus grande estendue, que l’instinct particulier de leur nature, approchent aucunement de la nostre, dans laquelle la différence des esprits est si remarquable; que le plus bas estage de ceux du vulgaire, guidé seulement des sens, & gourmandé par les passions, est aussi rapportant à l'instinct des brutes, que les autres sublimes destinez au gouvernement, & aux sciences, approchent de Dieu, & ne sont perfectionnez que par l'union dont ses grâces les favorisen, le passe infinies remarques qui se pourroient faire sur ce suject, pour conclure que cette aimable disposition; cette suite si accordante, & si bien proportione, dépend d'une raison supérieure qui préside au monde. Car comme l’artifice d'un excellent Peintre se fait reconnoistre en se cachant, lors qu'il trompe nostre veuò par le meslange des couleurs bien adoucies, qui se reçoivent d'une complaisance, & si erdent amoureusement l'une dans l'autre, avec une insensible confusion, sans que 'oeil s'apperçoive de leur deffaillance: Ainsi la sagesse du premier Principe ne se monstre pas si admirable, en ce qu'elle amis des bornes á l'Océan, qu'elle â marqué G le ressort des Elemens, distingue les Cieux & les Planètes t qu'en ce qu'elle a joint, toutes ces parties avec une douceur qui en couvre les différences, & qui de tontes n'en fait qu’un corps parfaitement bien proportionne.

II estoit nécessaire qu'il y eust une grande diversité d'estres; pour mieux représenter l'infinité du premier Principe, comme nous en serons la preuve. Aussi de voient ils s'entretenir de sorte que chacun des Elemens, par exemple, possedast ses forces toutes entières dans son milieu, & les affoiblist en ses extremitez pour s'allier avec ses voisins, afin de porter un double portrait de l'unité divine se conservant la sienne particulière, & en formant une generale. Par ce moyen les ànimositez cessent aussi bien dans le monde que dans les Estats, par la considération d'un bien gênerai qui dépend de la prétention, & de la conduite d'une cause universelle. Car il se fait une égalité dans la Nature qui en bannit la division, & par conséquent le vuide, pair l'entremise d'un Estre moyen, qui concilie dans foy les différences des deux parties, & figure ainsi, encore que ce soit avec beaucoup d'inégalité, le Verbe divin, qui est un moyen souverainement égal, & de mesme essence que ses extrêmes, et la l’unité, dont nous ne pouvons encore toucher les mystères!

On voit en cet assemblage un amour égal Pour l'union, dans une grande inégalité de forces & de vertus. Car files estres inférieurs se relèvent de leur bassesse, les nobles leur viennent à la

rencontre, & semble qu'ils contestent à qui avancera le l’omel; a plus à cette alliance, par humidité, ou par ambition. L'áir se revest de qualitez avantageuses pour joindre le feu, & le feu rabat beaucoup de sa violence pour le recevoir, & ainsi la recherche réciproque de choses différentes en perfection, accomplit fort heureusement le mariage de la Nature. Platon le décrit entre la pauvreté & Purus le Dieu des richesses, à la façon que les Loix Romaines le permettoient entre les personnes d'inégale condition, afin que la misère d'une famille fuste soulagée par abondance de l'autre, que le bienfait estant au lieu du mérite, entretinst les alliances; & que la fortune, qui favoriser innocence de l'amour parmy les disgrâces de la Nature, donnast le contentement aux particuliers, & le repos à la Republique par un commerce de cœurs & de biens. Ainsi l'union qui se fait au monde entre les choses basses & supérieures, empesche que le bien ne s'estouffe de son abondance, cependant que la foiblesse languiroit en l'attente de son secours: Le vuide est remply, la playe de la diversité est refermée, la vertu des Cieux descend jusques au centre de la terre, & le monde recueilly par ce moyen en son unité, a plus de rapport à celle de son Principe.

C'est une Amour éternel qui inspire ces affections d'alliance aux choses insensibles, c'est un pouvoir absolu qui affoiblit l'extremité des estres supérieurs, afin qu'estans moins puissans, ils se rendent plus accostables: Enfin c'est une Sagesse infinie qui conserven la paix du monde, ne permettant pas qu'en la suite de les parties, il se fasse en passage d'une extrémité à l'autre. La sagesse humaine n'a point de plus heureuse méthode au gouvernement que d'y éviter les extremitez comme un écueil, de déguiser les nouveautez par les couleurs de l'antiquité, d'accomplir les grands desseins avec de petits progrez: de forte que le peuple se trouve surpris par les Ministres d'Estat, comme les malades par les Médecins, qui font palier les remèdes en forme de nourriture, & qui en donnent plustost l'effet, que l'apprehension.

Celuy qui commande doit passer d'une clémence ordinaire a une severité qui semble contrainte & se destacher des mauvais partis, âpres de longues froideurs; & faire rechercher pour les alliances qui luy font utile, ménager les autres avec une continuité modérée qui lésasse aimer par habitude, éceíleuer la puissance, comme ces terres qui s'amassent insensiblement de ce que les fleuves y portent d'arène. Le Prince est, selon Platon, dans un estât moyen entre Dieu & les autres hommes. C'est pourquoy il doit souvent monter au Ciel, pour prendre dans les thresors de la Sagesse divine, l'idée du vray bien; &puis descendre à son peuple, pour la luy communiquer par un bon gouvernement, qui se règle sur celuy du monde, qui modère l'éclat de la grandeur, qui mesure sa puissance au devoir de la justice, qui tienne les peuples en sujétion, plus par l'amour, que par la contrainte. Ainsi l'homme qui est un petit monde en la disposition de son corps, qui manie les renés d'un Empire, quand il commande à ses passions, est doublement tenu de garder ces loix, pour acquérir la médiocrité, de laquelle se forment toutes les vertus. Cette obligation luy vient de ce que nostre ame, quoy qu'immortelle, a deux portions, dont l'une prompte, agile, pénétrante, ne met ses délices, qu'aux opérations qui font propres aux intelligences; l'autre pelant & grossière, n'a de l'affection que pour le corps, ny du commerce qu'avec les sens. C'est pourquoy il est nécessaire que la vertu morale modère ces deux puissances, déserte que la plus & ne vive pas tellement le party du corps, qu'elle rompe tout á fait avec la raison, & que la supérieure ne s'exhale pas de forte dans ses contemplations, qu'elle abandonne toute la conduite de la vie.

Puisque nous devons estre liez avec tous les hommes, autant par affection, que par la Nature, il faut, selon la loy de la société, épouser les humeurs de tous, voir asaye a trecf de iieompkiíànce les douleurs avec de la compassion, nous abaíllèr à la foiblesse pour la relouer, Ô£ t representer tous les visages pour conquérir tous les cceursv Mais cependant que nous sommes aux autres sans paroles, en apparence,cri cérémonies 4 en dktûkimes, en charité, l’interieur dort demeurer nostre, eûaÏQpá deceJ5aherationsy&daifis la vérité des essentimens, comme le feu conserve sapureté au milieu de là région. Cette conduite, morale n'est propre qu'aux grands Esprits, qui onr un bqn iugeroèruj pome a discèrner le bien, & assez de générosité pour en vaincre les difficultez, cár elle

dépend de la raison & de la force, puis que la' Verni ' ne & exelRce que sur des objets periiLdèi (Stril nous remarquons rentre les par ries, du monde cette mesme médiocrité, que là prudence establit dans la police, de dans la mo-, ralej ne devons-nous pas conclure deux choses, la première, que cette condescendance de la Nature est l'œuvre d'une Sagesse supérieure: la seconde, qu'une main toute-puissante affoiblit ainsi les extremitez, de fait violence aux inclinations particulières, pour entretenir une paix universelle?

Si les Elemans ont l'inclination commune de se conserver; ils devroient rallier leurs forces, le recueillir en eux mesmes, de en cette figure ronde que la Nature leur donne, comme un Fort régulier où ils sont moins en prise. Cependant le feu diminue beaucoup de sa chaleur, l'air de ion humidité pour se joindre ensemble; la terre est moite, l'eau grossière: ainsi ils se relaschent pour s'écouler les uns dans les autres: & encore qu'ils soient ennemis, leurs sorties ne se font que pour quitter leurs avantages, de pour traitter de leurs alliances. Ce procédé ne suit pas le dessein ordinaire de la Nature, qui échauffe tous les estres au combat à la veue de leurs ennemis, de qui arme leurs extremitez de tout ce qu'elle a de force Se de violence. La tige des arbres est couverte d'une rude efforce, les fruits se défendent par la cureté, par des espines, ou par l'amertume: tous les animaux ont leurs armes aux pieds, ou à la teste, les scorpions de les mouches portent leur venin à laquelle, de mesme que nous plaçons les forts d'importance sur les frontières pour bouderies courses des ennemis. De là vient que les nations marquées de quelque imperfection naturelle, ne font jamais tant persécutées que de leurs voisins, qui s'arment d'in- B jures & de violence pour se défendre d'un vice, qui leur pourroit estre ou imprimé par le commerce, ou reproche par soupçon. C'est donc une puissance superiure qui donne cette loy aux Elemens, qui modère leurs extremitez, qui les arreste sur le point, de dans l'occasion, où selon le cours ordinaire de la Nature, ils devroient rendre de plus grands combats.

Nous voyons souvent le passage d'une extrémité à l'autre, sans aucune modération. Entre les Signes du Zodiaque, ceux qu'une éminente vertu fait appeller mastes, & diurnes, l'ont suivis immédiatement des foibles nocturnes, Se efféminez. Le triangle de la qualité du feu est joint à celuy de l'eau $ ce qui cause, disent quelques- uns, les amitiez des mélancoliques avec les extrêmement joyeux, des vieillards & des enfans, le précipice des hautes fortunes} de que les plus dangereuses maladies surprennent ses plus allègres fantez. Pourquoy donc les Elemens ne vivent-ils pas l'ordre & la proportion des Cieux, qui font les plus accomplis entre les corps, de qui leur tiennent lieu de Principes? D'où vient que le monde inférieur n'a pas une quantité sans liaison semblable à celle des nombres, où l'unité est suivie de deux, le pair de l'impair, le divisible de l'indivisible, puis mesme que la forme ronde, qui se termine par tout avec un points monstre que chacune de les parties doit estre recueillie en elle-mesme, sans s'estendre dessus les autres? D'où vient que le feu se joint à l'air, l'air à l'eau, de l'eau à la terre par leurs qualitez sympathiques, linon C d'une Sagesse supérieure, qui a donné cette aymable disposition aux choses contraires, afin de former un tour de une continuité de leurs différences?

Toutes choses demandent d'avoir plus d'estendue, plus de durée, plus de forces: Cependant le feu prend l'humidité, l'air se refroidit, la terre denient mobile de coulante estant détrempée y de au lieu que ces Elemens devroient augmenter leurs forces, ils se mettent en prise de leurs ennemis. Rien n'empeícherent qu'ils n'en fussent entièrement consommez, que le feu ne prist une entière possession de juir, & ainsi des autres, si une Souveraine Puissance ne les retenoit en bride, de ne les obligeoit à ces accommodements. Car si l'air trouve les qualitez du feu avantageuses, il ne dervoit pas s'abaisser à celles de l'eau, qui l'obscurcit de vapeurs, fie qui luy este sa pureté. Il ne sçavroit naturellement avoir de l'inclination pour deux choses qui font contraires, de se conserver l'alliance avec deux ennemis: Ce font deux mouvemens opposez, dont un corps simple n'est pas capable, de où il ne íe porte que par l'impulsion d'une vertu estrangere.

Quand le voy des poissons qui volent, des oiseaux qui nagent, des Crocodiles & des Veaux marins qui broutent en terre, des Loutres qui vont picorer dans l'eau, de semblables animaux qui font des actions propres à deux espèces, afin d'estre faire le noeud, le prends cela selon la nature des choies pour un aussi grand prodige, que si il voyois le feu nager, l'eau voler la terre courir: parce que le feu domine aux oiseaux, l'eau aux poissons, la terre aux animaux qu'elle porte, & que leurs actions se doivent rapporter aux qualitez de leurs Elemens. C'est donc une force supérieure qui affoiblit les extremitez des estres, contre leurs inclinations, ou qui les este le plus que leur portée, qui les assortit de plusieurs facilitez, pour faire une estroite liaison de la Nature, & que le monde ne soit qu'un corps continu, qui représente l'unité du premier Principe. Et parce que les contraintes <me souffrent les estres particuliers pour un interest public, font des preuves extrêmement fortes pour monstrer qu'ils font commandez d'une Puissance supérieure, nous en serons le discours fumant.

1675
Yves de Paris
Theologie Naturelle
1991
The Natural Theology Of Yves De Paris
Robert L. Fastiggi
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Chapter Two - The Philosophical and Theological Context of Seventeenth Century France

Before investigating the actual texts of Le Discours apologétique and La théologie naturelle, an appreciation of the historical context of Yves' writings is essential. One of the best sources of information on the historical mileu of Yves' writings is the two volume, Le Père Yves de Paris et son temps (15901678), written by Julien-Eymard under his family name of Charles Chesneau. Since the publication of this work in 1946, there have appeared a number of other important historical studies which also deal with intellectual history of the sixteenth and seventeenth centuries.1 The aim of this present chapter is to provide a survey of the various historical and intellectual currents of seventeenth century France which help in understanding the motivations and concerns of La théologie naturelle. As we will see, Yves writes during an age marked by both religious revival and philosophical scepticism.

The Catholic Revival
Yves de Paris lives during an extremely turbulent but creative period of French history. The seventeenth century is often referred to as le grand siècle or "the great century" by many historians. The greatness of this age is manifest in the enormous strength of the French monarchy as well as the impressive artistic, literary, scientific and philosophical personalities of the day. This is the century of Louis XIV as well as the era of Molière, Racine, Boileau, Pascal and Descartes. It is a sad truth, however, that this period of philosophical and religious creativity is also an age of political turmoil and violence.

For the first ten years of Yves life, France is in civil war. In 1589, Henry III, the French monarch, is assassinated. His successor, Henry of Navarre, is strongly resisted by the Catholic majority because of his Protestant faith. In 1593, Henry finally abjures his Protestantism. In 1595, he is absolved of heresy by Pope Clement VIII and peace is restored to France in 1598 by the Treaty of Vervins and the Edict of Nantes.

Yves de Paris' adult years are also lived during a time of political and religious struggle. The years 1618-1648 see Europe embroiled in the Thirty Years' War. Although Germany suffers the most violence, the entire continent is affected. As one account relates:

Not until the twentieth century would the Western world again know the wanton pillaging, raping and killing of a semi-guerrilla force which no government could control.2

The Thirty Years War reflects the darker side of an age of tremendous religious devotion and renewal. The political turmoil between Catholic and Protestant rulers coexists with a tremendous surge of interest in spirituality and theology. From the time of Luther's excommunication in 1521, Europe is immersed in a great upsurge of intellectual and religious fervor as well as the unhappy and violent consequences of religious intolerance and hatred.

The Catholic reaction to the Protestant Reformation brings with it a renewal of spirituality and theology. A recent study of the Counter-Reformation by the French historian, Jean Delumeau, demonstrates how profound and widespread is the Catholic revival during the sixteenth and seventeenth centuries. Some of the statistics on the new religious orders speak for themselves. The Jesuits are founded in 1540. Before the death of their founder, Ignatius Loyola, the Jesuits already total 1,000 members and a hundred foundations.3 By 1640, the Jesuits have over 15,000 members and 550 foundations. During this first century of their existence, they also send missionaries to North and South America, India, China and Japan.

The Capuchins are founded in 1528 as a reform of the Franciscan Order. By 1643, they total 21,000 members with 1379 houses. By the time a young lawyer named Charles de la Rue takes the Capuchin habit in 1619 to become Yves de Paris, the Capuchin order is flourishing. We need only mention names like Benoit de Canfield (1662-1610), Lawrence of Brindisi (15591619) and Joseph du Tremblay (1577- 1638) to realize that the Capuchins of seventeenth century are a vital force in the religious life of France. Not only in France but all throughout Europe, Capuchin friars become renown for their fervor and example. As Delumeau writes:

Dressed in coarse frieze, bare-footed whatever the time of the year, accustomed to frequent and rigorous fasts, sleeping on boards, preaching in season and out of season, the Capuchins made a vivid impression on the men of the sixteenth and seventeenth centuries. They cared for the plague-ridden and the incurably sick and buried the dead. Their sermons were enormously popular. During some missions in the Low Countires, Capuchins were seen in the churches with an inscription on their backs enumerating their sins.4

The Capuchins are only part of a great revival of interest in spirituality which takes place in Europe during the sixteenth and seventeenth centuries. The spirit of reform and renewal is also manifested in a number of extraordinary religious personalities who emerge in the Catholic Church at this time. In Spain, St. Teresa of Avila (1515-1582) and St.John of the Cross (15411591) are the inspiration behind a reform of the Carmelite Order which leads to the creation of one hundred convents of strict observance by the year 1648.5 The Carmelite reform also spreads to Italy and France. The convent of the discalced Carmelites on Rue St. Jacques in Paris is established in 1604 through the combined efforts of Cardinal Bérulle and Mme Acarie who later becomes Marie de l'incarnation.6 This convent becomes a center for devotional and spiritual life in the city of Paris. It is at this convent that Bossuet delivers his famous sermon in 1675 on the occasion of the religious profession of the Duchess of Vaujour.7 The ref rom of the Carmelite Order takes place with a simultaneous growth of some new religious orders begun in the sixteenth and seventeenth centuries. The Ursulines are founded by St. Angela Merici in Italy in the year 1537. In 1610, they are introduced into Paris by Mme de Sainte-Beauve, and their apostolate in the education of young French women

becomes an integral part of French Catholic culture. By 1715, the Ursulines have over 300 houses in France.8

Another new impressive order for women is begun in 1610 by St. Francis de Sales and St. Jane Frances de Chantal.9 Called the Order of the Visitation, this new order also plays an important role in the education of young French girls along with the Ursulines. From its initial convent at Annecy, the order spreads rapidly. At the time of St. Jane Frances's death in 1641, there are 86 convents.10 Probably the most renowned member of the Order of the Vistitation is the seventeenth century visionary, St. Margaret Mary Alacoque (1647-1690). Her four visions of Jesus during the years 1673-1675 do much to promote devotion to The Sacred Heart of Jesus.11

Along with the Ursulines and the Nuns of the Visitation, another important new religious order for women is founded in 1633 by St. Vincent de Paul and St.Louise de Marilac. Calling themselves the Daughters of Charity, these sisters dedicate themselves to the service of the poor, the sick and the abandoned children. By 1660, their total number of houses is over one hundred.12 Not wishing these Daughters of Charity to be like traditional nuns in a cloister, St. Vincent urges them to be among the people, wearing no veil and having only a dull, grey habit as their attire.

The introduction of the reformed Carmelites in France, as well as the founding of the Order of the Visitation and the Daughters of Charity are all linked to three of the most outstanding religious personalities of seventeenth century France: Cardinal Pierre de Bérulle (1575-1629), St. Francis de Sales (1567-1622) and St. Vincent de Paul (1581-1660). That three spiritual figures of their magnitude exist simultaneously certainly qualifies seventeenth century France as one of the great renaissances of Catholic spirituality.

Cardinal Bérulle is usually understood as the founder of the French School of Spirituality or L'École Francaise.13 His influence on the religious life of France is nothing short of enormous. He is respected and admired by all who know him.

St. Vincent de Paul calls Bérulle "one of the holiest men I have known."14 St. Francis de Sales says that Bérulle is "all that would desire myself to be."15 The theocentrism and incarnationalism of Bérulle's spirituality have a profound impact on the spirituality of Jean-Jacques Olier (1608-1657), the founder of the Sulpicians.16 The French Oratory, founded by Bérulle in 1611, becomes a pivotal force in French theology and devotion. By 1631, the Oratory has seventy-one houses, including twenty-one colleges and six seminaries.17 The list of those directly influenced by Bérulle's Oratory includes some of the most significant spiritual and philosophical figures of the seventeenth century: St. John Eudes (1601-1680), Louis Thomassin (1619-1695), Charles de Condren (1588-1641), Nicholas Malebranche (1638-1715), Francois Bourgoing (15851662) and the great preacher, Jean-Baptiste Massillon (1663-1742).

Along with Cardinal Bérulle, St. Francis de Sales and St. Vincent de Paul are the two other most influential spiritual figures of the French Catholic revival of the seventeenth century. All three of these men know each other, and they all work in their own special ways to renew the spiritual life of France. St. Francis de Sales labors for years in eastern France to help restore

Catholicism to areas converted to Calvinism.18 According to one account, his efforts are nothing short of heroic:

He set out on foot with a Bible, a breviary and one companion, his cousin, Louis of Sales. Every door and every heart was closed against him. He was insulted and threatened with death. However, after four years of strenuous labor and prayers, hardly a hundred heretics remained. It is claimed

that he converted 72,000 Calvinists. All the glory of this result must be attributed under God to the virtues, wisdom, preaching, sufferings and perseverence of "the Apostle of the Chablais.19

St. Francis is the author of two notable spiritual classics, L'introduction à la vie dévote (1609) and Traité de l'amour de Dieu (1616). The subsequent popularity and dissemination of these two works have led to the rightfully deserved title of "Doctor of the Church" granted to St. Francis de Sales by Pope Pius IX in 1877. The spiritual influence of the gentle bishop of Geneva is remarkable. Among those influenced by his works are the fideist, Jean-Pierre Camus (1584-1654), who serves as St. Francis' secretary. Mention could also be made of Francois Fénelon (1651-1715) and Jacques Bénigne Bossuet (16271704), both of whom claim inspiration from the example and writings of St. Francis de Sales. Bossuet credits Francis for bringing devotion out of the cloisters and into the middle of the world.20 Yves de Paris is also influenced by St. Francis de Sales. Even though Yves engages in a quarrel with J.P. Camus, the former secretary of Francis, there can be little doubt that the writings of Yves owe much inspiration to the devout humanism of the bishop of Geneva.

If Cardinal Bérulle and St. Francis de Sales reflect a theoretical approach to devotion and contemplation, St. Vincent de Paul reflects a spirituality not so much in theory as in practice.21 This is not to suggest that Bérulle and St. Francis de Sales are not active in the corporal works of mercy because they certainly are. But it is to suggest that the greatest influence of St. Vincent de Paul is not so much in spiritual writing as in spiritual living. Through his dedication to the needs of the poor, St. Vincent inspires many others to follow his example. In addition to helping to start the Daughters of Charity in 1610, he also establishes an order of priests dedicated to doing missionary work, especially in the countryside.22 Formally known as The Congregation of the Mission, members of this order are more commonly known as Vincentians or Lazarists (after St. Lazare in Paris). Begun in 1625, the Lazarists already establish thirty-three houses by the time of St. Vincent's death in 1660. By the year 1700, the Congregation adds fifty more foundations, including some in Poland and Italy.23

St. Vincent sees in the poor the reflection of God. He reaches out to all he meets with both charity and humility. In an age of religious warfare, St. Vincent reminds Catholics to treat Protestants as their brothers and sisters. His care reaches out to the sick, the dying and those who have been abandoned, especially children. He works out new ways of organizing relief efforts for victims of war and disease, as well as for the hungry and the homeless. Even the cynical Voltaire is impressed with St. Vincent and refers to him as "my saint."24 Vincent de Paul's whole spirituality is reflected in one statement he makes to some members of the Daughters of Charity:" In serving the poor we are serving Jesus Christ...A Sister may go to the sick ten times a day, and ten times a day she will find God there."25

This brief sketch of the religious revival of seventeenth century France gives us an appreciation for the times in which Yves de Paris lives. It is indeed an age of great religious devotion and renewal. We now need to consider some of the philosophical and theological currents which also exist during this epoch.

Scholasticism

Although Yves de Paris is usually thought of as a humanist and an apologist, there is, nevertheless, a strong influence of scholastic theology and philosophy evident in his thought. If the essence of scholasticism is, as Gordon Leff maintains, "the application of reason to revelation,"26 then certainly Yves is, at least generically, a scholastic. However, the specific method of scholasticism which gives rise to the systematic organization of theological topics is reflected more clearly in Yves Digestum sapientiae (1648-1672) than in his other writings which are mostly apologetic in nature. Nevertheless, even in Yves' apologetic writings, though written in a rhetorical style, there is still the influence of scholastic thinkers like Aquinas and Lull.

Yves lives in a period of tremendous variety and creativity. The currents of many different intellectual movements are circulating at the same time in the waters of French culture. The influence of both Neoplatonism and scepticism are spreading to France through the writings of Ficino and Pompanazzi. There is a revival of Greek scepticism beginning in the sixteenth century which leads to the nouveaux pyrrhoniens and the libertins érudits, who are both targets of Yves' apologetics. There is also the impact of humanism, both in scholarship and attitude, with its subsequent influences in both education and philosophy. To all these movements, there is also added a strong Augustinian spirit which manifests itself in the profound theocentrism of thinkers like Bérulle and Olier and in the somber religiosity of the Jansenists.

Where does scholasticism fit into this panorama of ideas? One might intitially be tempted to think that scholasticism is on the decline in seventeenth century France. This, however, is not the case. Scholasticism continues to flourish in the various religious orders which still make use of a basically scholastic approach to theology. What is occurring, though, is that growing as much ease as if he had achieved the habit after continual exercises. His ideas had found their unity.30

We should not conclude form this that Yves is a total disciple of Lull and Aquinas, but this passage does illustrate a passion for unity which becomes a constant idea for him. As mentioned earlier, the primary influence on Yves is Marsilio Ficino.31 It is from the Neoplatonism of Ficino that Yves derives his initial desire for unity, harmony and synthesis. As Eymard observes:

The Platonist of Florence, like the Capuchin of Paris, professes that the world represents divine unity and that it represents it by the grace of three laws: symbolism, continuity and affinity."32

In his writings, Yves cites Ficino on numerous occasions.33 He also frequently cites Augustine and Aquinas. In the Jus naturale, Yves cites Aquinas 111 times.34 In his citations of Aquinas, though, Yves often platonizes the meaning. He uses the authority of Aquinas to serve his own ideas.35

One anomaly in the writings of Yves de Paris is the absence of references to Bonaventure. This is particularly strange since his ideas often show greater affinity to those of Bonaventure than Aquinas.36 In 1550, the Capuchins had departed from their fellow Franciscans (who generally followed Scotus) and decided to return to Bonaventure as their chief theologian.37 However, the Capuchins would often try to reconcile Bonaventure and Aquinas in a type of scholastic harmony. Perhaps Yves de Paris absorbed the ideas of Bonaventure in his theological training but remained more focused on the texts of Aquinas.

In his Digestum sapientiae, Yves lists a variety of thinkers who helped inspire his thought. He fails to include Bonaventure in this list, but he does mention Plato, Seneca, Plotinus, lamblichus and Philo as the principal non-Christian sources. Tertullian, Augustine and Bernard are listed among the Fathers of the Church and Aquinas and Ficino among the theologians.38 Along with this group, we can also add Nicholas of Cusa whom Yves mentions at another point.39 Except for Seneca, Tertullian and Aquinas, all of these thinkers are in the Platonic thinker. It is not surprising to find that Yves often "platonizes" Aquinas and often quotes him in defense of ideas that are not traditionally understood as Thomist.40

Although Yves is a unique and original thinker within the Capuchin tradition, his desire to show the harmony between various philosophical and theological movements is in keeping with the conciliatory spirit of the Capuchins of his time. For example, Jean-Marie Zamorra d'Udine (d. 1649) attempts a reconcilation between Scotism and Thomism.41 Bonaventure de Langres is another Capuchin who works at this same theological synthesis in his book entitled Bonaventura et Thoma 1655). Two other Capuchins, Marc de Baudren and Gian Francesco Leoni de Carpi, attempt a

complete synthesis of Thomism, Scotism and Bonaventurianism in their respective works, the Paradisus (1661) and the Enucleatio (1685).42 This spirit of conciliation is so strong among the Capuchins of Yves time that one Capuchin named Juan de Rada declares that Aquinas and Duns Scotus differ more in name than reality 43

The spirit of theological harmony prevalent among the Capuchins of the seventeenth century helps to explain Yves' tendency to use the writings of Aquinas to support Neoplatonic ideas. Moreover, members of other religious orders also interpret Aquinas in a Platonic manner in the seventeenth century. Most notable among these is Cardinal Bérulle who believes that Aquinas is primarily a disciple of Augustine and always strives to demonstrate the harmony of Thomism and Augustinianism.44

It should be clear by now that Yves de Paris cannot be placed exclusively in any of the schools of theology of the seventeenth century.45 An attempt could be made to include Yves within the Augustinian school since the influence of Augustine is certainly present in his work. However, Augustinianism is probably best understood more as an underlying current in seventeenth century thought rather than as a theological school in the strict sense. As one Church historian notes: "All the world is Augustinian in some manner."46 Moreover, there seems to be an "inevitable confusion" over how to interpret the writings of Augustine.47 Thinkers as diverse as Luther, Jansen and Bérulle all claim Augustinianism to be at the heart of their theologies.

In a very broad sense, we can place Yves in the school of Augustine since he does adopt the Augustinian doctrine of illumination. However, the question as to how Yves adopted this doctrine has never been perfectly resolved. Eymard suggests that perhaps Yves absorbed his idea of divine illumination from his Bonaventurian professors, or perhaps he was influenced by some of the Oratorian thinkers like Condren or Bourdoise, whom he certainly knew 48

The existence of the various schools of theology in the seventeenth century attest to the fact that scholasticism is still quite strong at this time. Yves de Paris, with his deep faith in the ultimate unity of all knowledge shows a definite scholastic influence in attitude if not so much in style. In this respect, Yves shows an awareness of the scholastic schools of his time. The Digestum sapientiao, although inspired by the ars combinatorial of Ramon Lull, shows a thematic affinity with the Summa theologi ca of Aquinas and the De reductione artium ad theolgiam of Bonaventure in the sense that he believes in the possibility of a unified structure to all knowledge and all reality. This belief that reality can be reduced to various principia absoluta and principia relativa is definitely scholastic in inspiration. As C. Vasoli observes: "The faith of Yves in this method is such that he does not doubt his ability to supply the essential key for a total study of the created world and a means which permits a restructuring of the encyclopedic system of wisdom (sapientia)."49

The Digestum sapientiae reveals an underlying metaphysical spirit in Yves' thought. Although Yves states in his preface to La théologie naturelle his desire to avoid "the inexorable rigor of the School,"50 his familiarity with the metaphysical underpinnings of scholastic theology is evident throughout. In a certain sense, Yves can be understood as a literary metaphysician. By this is meant a thinker who elaborates on themes and ideas which are essentially metaphysical but in a style which is more in the mode of oratio than ratio.

A brief survey of the various schools of theology present in the seventeenth century should help us better situate Yves within the theological context in which he lives. As we will see Yves lives in age in which theological activity is diverse as it is rich. However, it is difficult to place the author of La théologie naturelle into one exclusive "school" of theology.

Schools of Theology in Seventeenth Century France

One of the amazing truths about France during the seventeenth century is that scholasticism flourishes in the midst of growing anti-scholastic movements like fidesim and scepticism. The various religious orders continue to produce theological minds of remarkable depth and insight. Usually, these various schools of theology center around the different religious orders. Thus, the Dominicans make up a significant Thomist school, the Franciscans form schools of Bonaventurianism and Scotism and so forth. An investigation of these various schools of theology manifests an extremely rich and vibrant scholastic movement.

Among the great Thomists of this time, mention should be made of Jean-Baptiste Gonet O.P. (1616-1681), Noel Alexandre O.P. (1639-1724), Guillame de Contenson O.P. (1639-1724) and Charles René Billuart O.P. (1685-1757).51 Gonet teaches at the University of Bordeaux and is one of the most vocal defenders of the Thomist school. He is an ardent anti-Jansenist, but he is also a Gallican. Noel Alexandre is an esteemed theologian who is much admired by many bishops and cardinals, including Cardinal Orsini, the future Pope Benedict XIII. Alexandre teaches at the Sorbonne and is probably the leading theologian in Paris during the last quarter of the seventeenth century. As a great scholar of ecclesiastical history, Alexandre writes a ten volume work on dogmatic theology entitled Theologia dogmatisa et moralis secundum ordinem concilii Tridentini. (1694).

The Dominicans of this time are also active in the debates with the Jesuits over the question of efficacious grace. In this matter, they are decidedly anti-Molinist. Francois Jacques-Hyacinthe Serry O.P. (1659-1738) is a student of Alexandre at the Sorbonne. Later, he becomes a consulting theologian of the Holy Office in Rome before returing to the Sorbonne to teach. Serry writes a history of the controversies on grace as well as a history of the Dominican Order. In his treatise on grace, Serry tries to show how the position of Molina and the Jesuits undercuts God's sovereign Providence over salvation.

Joining Serry in these anti-Molinist polemics is Charles René Billuart O.P. (1685-1757), professor of philosophy at Douai and Revin. Wanting to show how the theology of Aquinas can be applied to the theological needs of his day, Billuart writes a number of systematic texts including the Cursus theolgiae universalis and the Institutiones theolgicae.

Probably the most unique Dominican theologian of seventeenth century France is Guillaume de Contenson (16411674), professor at Albi and later Toulouse. Having an interest in mysticism, Contenson tries to show how there are realms of the heart as well as the mind in his Theologia mentis et cordis (1669). His affinity for some of the ideas of Pascal might help to explain why he sought to save Jansenism from the accusation of heresy. His ecclesiology is very interesting. He maintains that the decisions of the Church are not infallible, but Catholics should obey them out of respect for the unity and authority of the Church.

The Thomistic school is one of the most influential of the time in which Yves de Paris lives. However, there are also some other theological schools of great importance. The Jesuits use the Summa theologica of Aquinas as one of their official texts for seminary formation. Many early Jesuit theologians like Bellarmine and Suarez show their admiration for the texts of Aquinas. It would be wrong, though, to think that the Jesuits join forces with the Dominicans to form a monolith of Thomism in the seventeenth century. As Willaert points out, the Thomism of the Jesuits must be understood in the context of their humanistic formation.52 Although their theological formation is Thomistic, the Jesuits of the seventeenth century are steeped in an humanistic optimism engendered, to a large extent, by their missionary activities and encounters with non-Christians. They are essentially humanistic eclectics who adapt their theological foundations to the the polemical and missionary needs of their work.

Francois Noel S.J. (1651-1729) is a perfect example of this humanistic optimism prevalent among the Jesuits of his day. A man of many interests, Noel writes books on mathematics, physics, astronomy, as well as a summary of the theology of Suarez. From 1684-1708, Noel serves as a missionary in China. He spends the last years of his life in a monastery in Prague writing on a number of subjects, including the fundamental harmony between Chinese and Christian philosophy.

Not all the French Jesuits of this age are as optimistic as Francois Noel. There is the notable example of Francois Garasse S.J. (1585-1631) who reacts to what he understands as a crisis of scepticism and atheism in France with a book entitled, La doctrine curieuse des beaux esprits de ce temps, ou pretendus tels. In this book, Father Garasse rails against the scepticism, atheism and libertinism brought about by the philosophy of Pierre Charron and others. Garasse follows this work with another another entitled, La somme theologique des veritez capitales de la religion Chréstienne (1625). This book continues the attack against scepticism, equating pyrrhonism with atheism. The circulation of this text leads to many complaints against Garasse. Saint-Cyran presses the Sorbonne for a condemnation. After several months of investigation, the Faculty of Theology at the Sorbonne does condemn the book as containing "many heretical, erroneous, scandalous, rash propositions...and innumerable buffooneries which are unworthy to be written or read by Christians and by theologians."53 Needless to say, this incident is certainly not the highlight of the seventeenth century for the French Jesuits.

A more talented and appreciated member of the Society of Jesus emerges in France towards the end of the seventeenth century. Paul-Gabriel Antoine S.J. (1678-1743) is the author of numerous books including Theologia dogmatisa and Theologia moralis. These books come to be used as standard textbooks throughout Europe. In fact, Antoine's Theologia moralis competes with the writings of Alphonsus Liguori (1696-1787) in the field of moral theology' during the eighteenth century.

The Carmelites are another order of this era who, like the Jesuits, use Aquinas as a theological foundation but move beyond a strict Thomism. Philippe de la Trinité (1603-1671) is a missionary to Goa, India where he teaches theology from 16291641. A Thomist and a mystic, Philippe attempts to give a systematic study of the mystical ascent in his Summa theologiae mysticae (1659). Named as a general of his order in 1665, he dies in the odor of sanctity in 1671.

Another outstanding Carmelite of this period is Honoré de Sainte-Marie (1651-1729). A theologian and an historian, Honoré tries to reconcile Thomism with the philosophies of Descartes and Gassendi. He also undertakes an historical investigation of the identity of the Pseudo-Dionysius in which he weighs the evidence for and against the alleged authorship of these mystical writings by Dionysius mentioned in the Acts of the Apostles. Honoré also gets involved in the polemics against the Jansenists. In this regard, he argues that Jesus desires the salvation of all in opposition to the Jansenist view of a limited salvific will.

As previously mentioned, the Augustinian current during the seventeenth century is extremely great. The Catholic universities of Salamanca, Paris and Louvain all hold Augustine in the highest esteem.54 The University of Louvain declares Augustine to be "the incontestable master of all the theologians of Louvain."55 Starting in 1493, a serious "Augustinian School" develops for the purpose of editing the works of the Doctor of Grace. By the time of the Council of Trent, one could speak of an Augustinian school led by Cardinal Seripando.56 This school is officially contained within the Augustinian Order, however, its influence extends throughout Catholic Europe. At the Council of Trent, great pains are taken to try to present the orthodox and truly Augustinian theory of grace in the "Decree on Justification (1547)." The result is a position which seeks to avoid the two extrmes of Pelagianism and Protestant predestinationism.

Although the Augustinian Order does not exert the influence in France of either the Jesuits or the Franciscans, there is one outstanding French Augustinian who deserves mention. Henri Noris O.S.A.(1631-1672) is one of the most indefatigable theologians of this era. Obsessed with the threat of Pelagianism, he undertakes a massive history of the heresy in his Historia pelegiana (1670-1672). It is said that from the ages of 22 to 44 Noris would spend 14 hours each day studying, enjoying only 3-5 hours sleep every night. Although some of his works are examined on suspicion of heresy, nothing is ever discovered that can be considered unorthodox. Eventually, Noris is honored by becoming a consulting theologian for the Holy Office.

Among some of the other religious orders, various schools of theology are active in seventeenth century France. A Bonaventurian school emerges within the Franciscan Order during the sixteenth century. However, in the seventeenth century the Franciscans tend to be more Scotist than Bonaventurian.57 As we have seen, the Capuchins declare Bonaventure their official theologian in 1550. However, in reality they tend to be irenic in their theological approach. The Capuchins of this time usually try to show the basic harmony of the systems of Aquinas, Bonaventure and Scotus.

The French School of Spirituality is not generally thought of as a school of theology but more as a movement of interiority and devotion. Nevertheless, the brilliance of Cardinal Bérulle leads to the formation of the French Oratorians who greatly influence the theological scene. For the most part, Bérulle is a follower of Augustine.58 However, he also tries to show the essential harmony between Thomism and Augustinianism.59 Bérulle is also influenced by Bonaventure and Benedict of Canfield.60 Bérulle's theology is a blending of Neoplatonic exemplarism with an overwhelming sense of the grandeur of God. As Paul Cochois observes in reference to Bérulle:

To honor God is to recognize with reverence that one participates in his being and in his perfections, and that this participation or dependence that we all have received from him makes us also surge back towards him, proclaiming the power and goodness of his infinite majestey.61

This same type of Neoplatonic exemplarism is also found in the most brilliant theologian of the French Oratorians, Louis Thomassin (1619-1685). From his early studies, Thomassin is rooted in the philosophy of Plato.62 He adds to this Platonic framework a deep affection for Augustine and the Church Fathers in general. Thomassin seeks to harmonize the roles of faith and reason, but for him, faith must always come first. Nevertheless, Thomassin comes extremely close to Yves de Paris' idea of "a natural awareness of God." Molien observes that Thomassin

thinks, with Augustine, that between our spirit through which we understand the Father and the Truth, that is to say the interior light by which we comprehend, no creature is interposed... The knowledge of God is in the mind before any experience of the corporeal senses.63

Thomassin emerges as the most profound theological mind of the Oratory after the death of Bérulle. His thought reflects a confidence in the harmony between philosophy and reason. Though he sounds closer to fideism than Yves, in actuality, the two theologians reflect a very similar Neoplatonic spirit.

From this brief review of some of the theological schools of seveteenth century France, we have an idea of the richness, depth and variety of theological thought during the time of Yves de Paris. From what has been observed, we can formulate a theological portrait of Yves as a thinker who blends various elements of Augustinianism, Neoplatonism and scholasticism of his day. Though Yves does not always write with "the inexorable rigor' of scholastic terminolgy, his desire to find a comprehensive wisdom of faith, philosophy and theology is at least scholastic in spirit. It is safe to say that Yves' theological approach is both humanistic and scholastic in a way quite expressive of Renaissance and Post-Renaissance Catholicism.

Humanism, Natural Philosophy and Neoplatonism

Humanism can be defined in a number of ways. Fundamentally, it can be referred to as a literary movement characteristic of the Renaissance that emphasized a curriculum of studies related to human values. This type of humanism can be called literary humanism.64 A typical definition of literary humanism is given by Peter Herde.65

Humanism is best defined as the rise of classical scholarship, of the studia humanitatis (a term used in the general sense of literary education by ancient Roman authors like Cicero and taken up by Italian scholars of the late fourteenth century), during the Renaissance.

The influence of literary humanism on Renaissance Europe is enormous. Beginning in Italy in the late fourteenth century and blossoming in Northern Europe during the fifteenth and sixteenth centuries, literary humanism provides an alternative method and attitude of education to the scholastic one that is employed during most of the Middle Ages.

Besides humanism of the literary type, humanism can also be understood as a basic appreciation of the human in both its aesthetic and spiritual domains. This is what Glendon calls "attitudnal humanism," defined as "the tendency.. .to perceive and organize all reality from the perspective of man: in other words, an anthropological focus."ss Even though many of the humanists maintain a strong religious sense in their writings, the appreciation of the human generates a renewed interest in moral philosophy and an understanding of humanity as the microcosm of the spiritual universe.

The humanism of the Renaissance is not only rich and varied; it is also complex. Both the literary and attitudnal currents of humanism lead to an explosion of ideas and creativity in Renaissance Europe. There is a tremendous revival of interest in classical literature. This interest leads to a revival of Platonism in Marsilio Ficino (1433-1499) and a revival of Aristoteliansim in Pietro Pompanazzi (1462-1525). Stoicism is revived by Juste Lipsius (1547-1606) and Pyrrhonism by Michel de Montaigne (1533-1592), Pierre Charron (1541-1603) and Francisco Sanchez (1552-1632). In addition, there is also a revival in the study of the Greek and Latin Fathers of the Church as well as an attempt to study the Scriptures in their original Hebrew and Greek forms.

Renaissance humanism also takes a turn from the world of the human to the world of the cosmos. The desire to understand humanity within the context of creation leads to the philosophy of nature for its own sake. In many ways, the origin of this philosophy of nature can be traced to the brilliant work of Nicholas of Cusa (1401-1464). In the writings of Nicholas, two important ideas emerge: first the idea of the universe as an harmonious whole in which each individual thing mirrors the entire universe; and secondly, the idea of the human person as the microcosm of the universe. For Nicholas, the universe is a theophany or manifestation of God. Thus, everything in the cosmos mirrors the divine to some extent. However, it is in the human mind that the reality of God is most clearly reflected. Thus, Cusa states: "Just as God is the absolute being who enfolds all beings, so our mind is the image of that infinite being who enfolds all beings."67 Or, as Karl Jaspers observes in reference to Cusa's thought:

When man as image of God's infinity discovers the creative bent of his mind, he embraces the whole universe. Just as he is second God, so he is a second world, the microcosm.68

The theocentric universe of Cusa is altered by some later Renaissance philosophers of nature into a vision of organic, self-sufficient unity with strong suggestions of pantheism or monism. Out of this movement, there emerge various natural philosophers like Girolamo Fracastoro (1483-1553), Girolamo Cardano (1501-1576), Bernadino Telesio (1509-1588), Francesco Patrizzi (1568-1639) and Giordano Bruno (15481600).

From these philosophers, a number of important ideas emerge. One is the notion of sympathies and antipathies in the universe which serves as an explanation for various celestial attractions and repulsions. Another idea is the image of the material universe as a manifestation of divine immanence. The tendency in both Campanella and Bruno is to experience the entire cosmos as an organic whole with each part manifesting and participating in the divine essence. Although their intentions were probably quite Christian and orthodox, some of their writings suggest an intellectual bridge to the monistic philosophy of Spinoza.

The movement of natural philosophy also had its mystical and esoteric counterparts, especially in Northern Europe. In the thought of Agrippa von Nettesheim (1486-1533), there is a continuation of the themes of microcosm and macrocosm as well as the idea of sympathies and antipathies. As Copleston observes regarding the thought of Agrippa:

Man unites in himself the three worlds, namely the terrestial world of the elements, the world of the heavenly bodies and the spiritual world... Further, the harmonious unity of the three worlds in man, the microcosm, reflects the harmonious unity which exists between them in the macrocosm.69

Agrippa also combines his interests in speculative philosophy with various writings on alchemy and the occult sciences.

The mixture of naturalism and alchemy is also found in other figures of the same period: most notably Theophrastus Bombast von Hohenheim known as Paracelsus (1493-1541) and John Baptist van Helmot (1577-1644). In these two physicians, we see a combination of empirical medicine, alchemy and astrology. The underlying idea is the same one operating in Agrippa: the human person as the microcosm participates in the three realms of the terrestrial, the elemental and the spiritual. Paracelsus posits some other interesting ideas, including the existence of an astral body and an immanent vital principle called the archeus which animates both the universe as a whole and individual humans.

These ideas of the philosophers of nature as well as those of Nicholas of Cusa influence members of the German mystical movement like Sebastian Frank (1499-1542), Valentine Weigel (1533-1588) and Jacob Boehme (1575-1624). By far the most interesting of these Protestant mystics is Boehme who develops a scheme for the Trinity with the Father as "original will," the Son as "the heart of the will" and the Spirit as "the moving life" emanating from both the Father and the Son. Boehme also tries to explain the problem of evil in terms of the unfolding dualities which emerge from God, the mysterium magnum beyond all loving and good. Some scholars have found a link between Boehme's triadic schemes and German Idealists like Hegel and Schelling.70

The movement known as natural philosophy or the philosophy of nature can be seen as a bridge between Neoplatonism and modern science. It is unfortunate that the development of the modern scientific method by men like Leonardo da Vinci (1452-1519), Galileo Galilei (1564-1642) and Sir Isaac Newton (1642-1727) often took place without the same sensitivity to the harmony and unity of the universe that the natural philosophers possess. Although all of these thinkers are sincerely religious, they tend to see the universe more from the model of mechanics than from the image of spirit and organism. The application of mathematical principles to the world of scientific observation further contributes to this mechanistic view of nature. Although neither the mechanistic model nor the Copernican theory contain within them anything irreligious, their impact on culture may have planted some of the seeds that blossom into scepticism and deism within a century. Nevertheless, this newly developed scientific method helps to expand the horizons of humanity and usher in the age of modernity.

In Yves de Paris, we can find the influences of both Humanism and the philosophy of nature. The image of the human person as the microcosm of the universe is a theme found within Yves' writings. We also find the idea of cosmic sympathies and antipathies. However, if there is one Renaissance thinker that has a special influence on Yves, it is, as we have said, Marsilio Ficino.

In the person of Ficino, we find a synthesis of humanistic optimism with Neoplatonic metaphysics. Ficino is also an important figure in the history of literary humanism. As a young man, he is commissioned by Cosimo de' Medici to translate the major works of Plato into Latin. Not only does Ficino apply himself to this task, but he also does translations of the Hermetic Poimandres, the Orphic Hymns and the Chaldaic Oracles.71

Ficino is convinced that there is a basic harmony between Christianity and Platonism. His thought, though, is not purely Platonic but rather Neoplatonic and eclectic with many ideas of Augustine and Dionysius guiding his Theologia platonica. In Ficino, there is a belief in a tradition of a primordial philosophy or wisdom that goes back to many pre-Christian sources. As Copleston observes:

It is not only Plato, Plotinus, lamblichus and Proclus whose thought is synthesized with that of St. John, St. Paul and St. Augustine, but also Hermes Trismegistus and other pagan figures make their appearance as bearers of the spiritual movement which springs from an original primitive revelation of the beauty and harmoniously ordered and graded system of reality.72

The main spiritual vision of Ficino is that of a beautiful and harmonious universe emanating from the unity and light of God. Humanity is the bond or link between the spiritual and material aspects of the universe. Since the human person is the image of God, all humans possess a natural desire for immortality and deification. The desire of every human soul is to become like God, and for Ficino "such striving is no less natural to men than the effort to flight is to birds."73

Ficino develops a very rich theological anthropology in which the human soul's natural desire for God is the main theme. Although he does not argue in the systematic manner of the scholastics, his line of reasoning is, nonetheless, persuasive. In his Epistolae, Book Il, No. 1, he writes:

A very famous member of the Platonic Academy is Count Giovanni Pico Della Mirandola (1463-1494) whose Oration: On the Dignity of Man (1486) is considered by many to be the most moving statement of Renaissance optimism. Ficino's great openness to Non-Christian sources, including thinkers like Hermes and Zoroaster, leads to the idea of a primordial or perennial philosophy that runs as a parallel course through ancient, Hebrew and Christian sources. In many ways, it is the thought of Ficino that inspires Augustinus Steuchus to publish his De philosophia perenni in 1542.78 On the other hand, some scholars find in Ficino a syncretism and universalism that serves as a link to the natural religion of Deists like Herbert of Cherbury and others. Be that as it may, Ficino considers himself to be an orthodox Catholic, and he sees in his Non-Christian sources evidence of a primordial divine wisdom rather than an undercutting of the Christian faith.

The texts of Yves de Paris reveal the influence of Renaissance humanism, natural philosophy and Neoplatonism. Yves lives in an age of competing philosophical and spiritual currents, and he can correctly be understood as riding the tide of Renaissance humanism in a France that is being buffeted by the waves of scepticism, fideism and spiritual austerity (i.e. Jansenism). In La théologie naturelle, the familiar themes of Augustine, Nicholas of Cusa and Ficino are evident in ideas like divine illumination, the human person as the microcosm of the universe and the harmony and unity of the cosmos. The difference, though, is not one of ideas but of setting. Yves senses in the sceptics, the fideists and the Jansenists a threat to his grandiose and splendid Neoplatonic world. He senses a challenge to the unity of consciousness that finds an harmony between the

realms of the natural and the divine and the particular and the universal. In Yves' mind, much more is at stake than a shift in spiritual focus. He senses a threat to the very core of the Catholic spirit which has maintained the harmony between reason and revelation and philosophy and faith. In order to better understand this polemical milieu, we must take a look at the growth of scepticism, fideism and Jansensim in seventeenth century France.

Scepticism and Fidéisme

Scepticism as a philosophical attitude in the West has its origins in ancient Greece. The original meaning of the Greek term skeptikos means "inquirers."79 However, before long the term sceptic comes to refer to someone who doubts whether knowledge is possible or doubts the reliability of evidence for real knowledge. Richard Popkin in his study, The History of Scepticism from Erasmus to Spinoza (1979), identifies two original forms of of ancient Greek scepticism. The first is called Academic scepticism and maintains that no knowledge is possible. This form of scepticism can be traced back to Arcesilas (c.315-241 B.C.) and Carneades (c. 213-129 B.C.)80

The second form of scepticism is called Pyrrhonian scepticism after Pyrrho of Ellis (c. 360-270 B.C.). The Pyrrhonians feel that the Academic sceptics assert too much in saying that nothing can be known. They prefer, instead, to suspend judgments on all questions for which the evidence is not certain. For the Pyrrhonians or Pyrrhonists, scepticism is more of a mental attitude than a philosophy in the strict sense. Richard Popkin offers this explanation.

The Pyrrhonian sceptics tried to avoid commiting themselves on any and all questions, even as whether their arguments were sound. Scepticism for them was an ability, or mental attitude, for opposing evidence both pro and con on any question that was not self-evident, so that one would suspend judgment on the question. This state of mind then led to a state of ataraxia, quietude, or unperturbedness, in which the sceptic was no longer concerned or worried about matters beyond appearances. Scepticism was a cure for the disease called Dogmatism or rashness.81

The Pyrrhonian movement continues in ancient Hellenic culture until about 200 A.D.. It especially thrives in a community of physicians in the city of Alexandria. Sextus Empiricus (c. 150225 A.D.) is considered to be the greatest theoretician of this Alexandrian community. In all probability, it is the two extant works of Sextus, Outlines of Pyrrhonism (Hypotyposes) and Against the Dogmatists (Adversus mathematicos), that lead to the revival of scepticism in France in the sixteenth and seventeenth centuries. The works of Sextus are hidden in obscurity for many years until a Latin translation of the Hypotyposes is published by Henri Estienne. In 1569, a Latin translation of Adversus mathematicos follows. The stage is set for the revival of classical scepticism.

Popkin argues that the introduction of the writings of Sextus Empricus come at a time when Europe is undergoing its own form of a crise pyrrhonienne due to the challenge of the "rule of faith" brought about by the Protestant Reformation.82 Martin Luther (1483-1546) shocks the theological world by denying the authority of the papacy and the councils on matters of faith. He makes Scripture and individual conscience the norms of truth instead of ecclesiastical approval.

The problems implicit in Luther's position are quickly recognized by many people in Europe. If Scripture is the guide to truth, how do we know for sure what Scripture is saying? Erasmus of Rotterdam (1466-1536) is one Christian humanist who challenges Luther. In Erasmus' opinion, Scripture "contains numerous passages which have puzzled many, without ever anyone succeeding in completely clarifying them."83 Luther, however, insists that the Holy Spirit is guiding him to the correct understanding of Scripture. He replies to Erasmus that "the Holy Spirit is no sceptic, and what He has written into our hearts are no doubts or opinions, but assertions, more certain and more firm than all human experience and life itself."84

The debate between Erasmus and Luther illustrates one of the major intellectual questions of the sixteenth and seventeenth centuries, namely, the question of a reliable criterion of truth. The revival of Greek scepticism only compounds a crisis that the Protestant Reformation helps to create. Pyrrhonism, though, is not always seen as an enemy or threat to the Christian faith. In fact, there develops a school of Catholic Pyrrhonists who feel that the arguments of the sceptics can be used to confound the Protestants. The leader of this movement is the French Jesuit, Francois Veron (1575-1644).85 In his book, La victorieuse méthode pour combattre tous les ministres: par la seule bible (1621) makes use of sceptical arguments in an effort to reduce the Protestant view of Scripture as "the rule of truth" to absurdity. Veron's method is to raise sceptical questions about the reliability of "inner persuasion by the Holy Spirit" when interpreting Scripture. Since the appeal to this "inner persuasion" is, at best, ambiguous, Veron concludes, along with Erasmus, that it is wiser and safer to remain within the ancient and venerable Catholic Church.

This alliance between the Counter-Reformation and Pyrrhonism results from a number of factors. Since the time of Michel de Montaigne (1533-1592), there is a growing acceptance of sceptical arguments against the reliability of reason to gain certain knowledge in the areas of religion and science. Montaigne, however, does not believe that this scepticism threatens the Catholic faith. As Popkin explains:

First Montaigne dwells on the theological crisis, pressing the problem of the role of faith. Because of our rational inability to discover, or justify, a criterion of religious knowledge, he offers total scepticism as a 'defense' of the Catholic rule of faith. Since we cannot tell by rational means which standard is the true one, we therefore remain in complete doubt and accept tradition; that is, we accept the Catholic rule of faith.86

There is considerable discussion on the sincerity of Montaigne's position. On the one hand, his scepticism regarding the ability of reason to prove the truths of the Christian faith is perfectly in harmony with classical Christian fideism. On the other hand, Montaigne seems to lack the passionate religious zeal of people like Francis de Sales, Pascal and Bérulle. Moreover, his fondness for quoting ancient pagan philosophers like Seneca, Horace, Juvenal and Cicero does not seem to be balanced by the equal inspiration of either Scripture or Christian writers.87

In all probability, Montaigne is best seen as one having a cautious and tolerant view of religion. His own ancestry is mixed: his mother being a Spanish Jewess who converts to Protestantism while his father, siblings and himself are Catholic. His essays are begun in 1572, the year of the St. Bartholomew's Day Massacre of several thousand Protestants in France.88 Sensing that a passionate religious conviction might result in turmoil and bloodshed, Montaigne maintains a type of aloof fideism, saying that religious beliefs cannot be proven but only held as a matter of faith.

Montaigne's influence, though, extends to ecclesiastical circles. Among his friends and disciples are Pierre Charron (1541-1603) and Jean-Pierre Camus (1584-1652), secretary to Francis de Sales and later the Bishop of Bellay. Charron's fideist treatise, De la sagesse (1601), enjoys an enormous popularity in France. Likewise, Camus' Essay sceptique contributes to the formation of a significant fideist school in early seventeenth century France.

It is important to realize that both Charron and Camus are men of deep spirituality. They find in scepticism a deep affinity with the negative theology of many Christian mystics. Writing before the time of Descartes, they employ a type of systematic doubt about the reliability of both sense experience and human reason in the quest for certain knowledge. However, for these spiritual fideists, it is the influence of divine grace and not the cogito which provides the way out of the circle of doubt.89 Grace produces faith, and faith is the only sure basis of truth, wisdom and

knowledge. For Charron and Camus, scepticism paves the way for the spiritual humility which relies upon faith alone.

Although this fideistic position seems to resemble the theology of Luther and other Protestant reformers, both Charron and Camus feel that Pyrrhonism provides a support for Catholicism. In his Trois veritez (1595), Charron argues that outside of the Catholic Church "no religious truth can be found, no reading of Scripture validated, and that only in accepting the Church's authority can any unique rule of faith be found."90 Charron also accuses the Calvinists of "insupportable pride" in the belief that their judgments should replace a religious tradition centuries old. He sees the Calvinist reliance on subjective assurance as dangerous and unreliable. In this regard, Charron argrees with Francois Veron that the only secure source of truth is the authority of the Catholic Church.

The spiritual sincerity of fideists like Charron, Camus and Veron is impressive. However, their use of sceptical arguments to support the Catholic faith indirectly helps to pave the way for the second wave scepticism in France: namely, the libertins érudits. These "learned libertines" represent a movement away from the religious dimensions of fideistic scepticism to a more detached, secular and cynical version of Pyrrhonism which culminates in the critical, anti-ecclesial spirit of Voltaire (16941778) .

How does this secular style of Pyrrhonism develop? Certainly, scepticism and doubt are part of the intellectual milieu of the early part of the seventeenth century in France.91 The use of sceptical arguments in religious discussions is often found in people like Charron and Camus who are profoundly Christian in their spirituality and character. However, when the sceptical arguments are filtered down, on a popular level, to people of less intense spirituality, the result can be Pyrrhonism for the sake of Pyrrhonism rather than Pyrrhonism at the service of the faith.

This phenomenon of the de-sacralization of scepticism gives birth to the famous libertins of the mid-century like La Mothe le Vayer (1588-1672), Guy Patin (1601-1672) and Gabriel Naudé (1600-1653).92 In some respects, the roots of this libertinism is found in Montaigne. However, it can also be linked to the Italian Neo-Averroist, Pietro Pompanazzi (1462-1525) whose ideas are circulating in France at this time. Pompanazzi's De immortalitate animae (1516) argues that the Christian belief in the immortality of the soul cannot be supported by human reason. In a type of revival of the "double truth" theory, Pompanazzi claims that although the immortality of the soul and many other Christian beliefs can be disproves by reason, they can still be accepted on the basis of faith alone. This bifurcation of the realms of faith and reason becomes one of the major themes of the libertins érudits.

The influence of libertinism is felt even within the inner-circles of the French monarchy. Gabriel Naudé is the librarian to both Richelieu and Mazarin and also secretary to Cardinal Bagni. Guy Patin is a learned medical doctor who becomes rector of the medical school at the Sorbonne. Francois de Mothe Le Vayer is the teacher of the king's brother. Also influential at this time is the priest, scientist and philosopher, Pierre Gassendi (15921655), who employs many sceptical arguments in philosophy. Samuel Sorbière (1615-1653), the editor of Gassendi's works, as well as the writer, Cyrano de Bergerac (1619-1655) can also be included in the growing elite of sceptics and freethinkers in the Parisian intellectual milieu.

Although the libertins erudits often give the impression of being cynical and irreligious, their actual stance towards matters of faith is difficult to assess. As Popkin observes:

Men like La Mothe Is Vayer, Naudé, Patin, all extremely learned, and wise in the ways of the politics of ecclesiastical organizations, might well have had a contempt for the credulity of simple

men, and for the working of the religious organization to which they belonged, without condemning what they may have regarded as the core of Christianity.93

Popkin's moderate assessment of the religious sincerity of the libertines must be balanced, though, by the evidence of an increasing concern on the part of many people in France over the growth of impiety. Marin Mersenne (1588-1648), a priest and theologian, asserts in his Quaestiones in genesim (1623) that there are 50,000 atheists in Paris alone.94 Fr. Beurrier, the curé of St. Etienne-du-Mont in Paris from 1653-1675, reports that a sceptical lawyer told him that not only he (the lawyer) did not believe in the Mass and the sacraments but that 20,000 other inhabitants of Paris are also atheists.95 To these observations, we should also add the vehement voice of the Jesuit, Francois Garasse, who writes his book La doctrine curieuse des beaux esprits de ce temps (1623) against the "atheists and libertines of our century."96

Even if some of these reports of widespread atheism are exaggerated 97, it seems plausible that there is some truth to the growth of impiety. Although the libertines of the court might still maintain a type of "mild fideism," the strong reactions of Mersenne, Garasse and Yves de Paris indicate that the skeptical and latitudarian attitudes of the libertins are perceived as genuine threats to orthodox faith. We must keep in mind that in a country with Catholicism as the state religion, freedom of written expression is not the norm. Perhaps writers like Yves de Paris and Francois Garasse are reacting to an oral tradtion of scepticism and libertinism whose extent is hard to estimate by written sources alone.

Jansenism

In the Jansenist movement, we find an example of sincere fideism motivated by profound theological convictions. Questions of orthodoxy aside, Jansenism represents a deep spiritual awareness of God's omnipotence and the utter dependence of human beings on supernatural grace. This recognition of the absolute need for divine grace combines with a pessimsitic view of human nature's spiritual potential to create a theological vision which is suspicious of the Renaisasance humanism of the Jesuits and the neo-pagan trends of the libertins. It is no surprise that Jean-Ambroise Duvergier, the famous l'abbé de Saint-Cyran (1581-1643), reacts so strongly against La Mothe le Vayer's work, On the Virtue of the Pagans, published in 1641.98 Likewise, the Jansenist author, Antoine Arnauld (1612-1694), writes a tract entitled On the Necessity of Faith in Jesus Christ (1642), attacking the paganism of La Mothe le Vayer. The Jansenists, therefore, are at the center of the theological debates of the seventeenth century.

The Jansenists take their name from the Dutch theologian, Cornelius Jansen (1585-1638), who is professor of Holy Scripture at Louvain University. Jansen works for a number of years on a summa of the thought of St. Augustine. Upon being named bishop of Ypres in 1636, Jansen is almost finished with his project. However, he dies of the plague in 1638 before ever publishing his work. After his death, his disciples see to the publication of his book which is called the Augustinus. The work is published in 1640 inspite of some efforts of the Jesuits at Louvain to prevent them.99 Jansen's book serves as the inspiration of a movement which eventually bears his name.

Delumeau points out that the Jansenist movement begins as a theological debate.100 One of the key issues raised by the Protestants and the Council of Trent is the question of the relationship of free will to divine grace. The Council affirms the reality of both free will and the need for grace without explaining how actually the two can be harmonized. The issue which the Council raises touches off some of the most important theological debates of the sixteenth and seventeenth centuries. The debate is especially intense at Louvain University where Baius (1513-1589) defends a predestinarian view and the Jesuit Lessuis (1554-1623) tries to uphold the harmony of human freedom with divine grace. The same debate also takes place between the Dominican Banez (d. 1604) and Molina (d. 1600).

In his theological treatise, De concordia liberi arbitri cum divinae gratiae dons (1588), Molina argues that original sin has taken away certain supernatural gifts, but it has not totally destroyed human freedom. God's sufficient grace restores the supernatual gifts to the individual, and God's foreknowledge of the good works of the person is what determines the predestination to salvation. Bandez argues that Molina's position makes human salvation dependent on human actions and, therefore, is a form of Semi-Pelagianism. While Banez admits that human beings can act freely, it is only because of God's predestined grace that people can 'freely" choose to follow God.

This theological debate over grace, predestination and free will is extremely complex. A papal commission is appointed to study the problem in 1597, and it sits for nine years without coming to a definite solution. Pope Paul V finally decides to let the matter stay as it is, but he forbids anything to published on the topic of grace without the consent of the Holy Office.101 The followers of Jansen, however, break this code by their publication of the Augustinus in 1640.

Although Jansenism begins as a theological debate, it soon becomes a spiritual movement. In some respects, it reflects one side of the pervasive Augustinian current moving through France at this time. As we have seen, the rich and diverse thoughts of Augustine are open to numerous interpretations. The Jansenists reflect the anti-Jansenist side of Augustine with a strong emphasis on the impotence of the human will without grace. This same sense of spiritual poverty is also found in the French School of Bérulle, Condren and Bourgoing. It should come as no surprise that the spiritual formation of Saint-Cyran is closely connected to the religious thought of Cardinal Bérulle.1 02 Jansenism also has a definite affinity with the fideism of Charron and Camus.103 Even the austerity of Jansenism is part of the spiritual milieu of the times. As Daniel-Rops observes:

The people of Port-Royal were inclined towards austerity; they entertained a gloomy and tragic outlook on Christian life. But the austerity of Port-Royal was not unique; quite the contrary. The writings of many prominent Catholics of the day, including among others St. Vincent de Paul, Berulle, Olier and even the gentle St. Francis de Sales, contained statements that the solitaries of Port-Royal would gladly have claimed as their own.' 04

Jansenism is as complex as it is rich and diverse. On the one hand, it appears to be a Catholic version of the Protestant sense of the depravity of the human soul apart from grace. This certainly is the theological anthropology that Jansen and Saint-Cyran find in Augustine. On the other hand, in Saint-Cyran at least, one can find strong currents of Christian Neoplatonism in his understanding of the indwelling of the Incarnate Word and the Trinity in the human soul.105 Moreover, to call Jansenism a form of Catholic Protestantism is a total distortion in consideration of its supremely Catholic sacramentalism.

In the final analysis, Jansenism can best be described as an exaggerated sense of human spiritual impotence not properly balanced with a sense of God's universal salvific will and the innate dignity of the human person. Another problem with the community of Port-Royal and the entire Jansenist movement is its tendency to become a self-styled "true Christianity" within the larger Church. Jean-Jacques Olier (1608-1657), the founder of the Society of Saint-Sulpice, refers to the "haughty and insolent zeal" and "undeniable pride" present in the Jansenist conviction that they are the representatives of "true Christianity" within the Catholic Church.106 It is perhaps unfortunate that spiritual pride and certain political entanglements help to disfigure some of the deep and sensitive spiritual insights of the Jansenist movement.

In consideration of Yves de Paris' relation to the Jansenists, we should remember that his first volume of La théologie naturelle comes out in 1633, some seven years before the publication of Augustinus. However, when the controversy emerges, Yves senses in Jansenism a movement which

is antithetical to his humanistic optimism and intrinsic confidence in the natural spiritual potential of human beings. Therefore, Yves follows his polemics against the sceptics and the libertines with an equally forceful polemic against Jansenists.

All together, Yves writes three anti-Jansenist works during the years 1644-1645. His first, entitled La remonstrance à la reine (1644), is a self-conscious attack on De la fréquente communion (1643) of Antoine Arnauld. Yves argues that although an attitude of total contrition and detachment from one's sins is to be preferred, God is willing to accept any sign of humility and faith as an indication of one's worthiness of the sacrament. Yves also stresses the benefits of frequent communion in drawing people closer to the Lord Jesus who wishes to unite more intimately with them.107 Therefore, Yves disagrees with the severe restrictions placed on the reception of communion by Arnauld.

In le souverain pontife (1645), Yves counters the argument of Barcos, the nephew of Saint-Cyran, which maintains that Peter and Paul are equal heads of the early Church. Barcos' position, expressed in his preface to Arnauld's De la fréquente communion, is.indicative of the generally Gallican spirit of the Jansenist movement. Yves argues that it is Christ's expressed will that Peter and his successors be the sovereign authorities of the universal Church. Moreover, the Pope is needed to preserve the unity of the faith and prevent disorder. Furthermore, Yves argues that the sovereign pontiff is infallible because of the promise made to Peter by Christ himself.108

Yves' third anti-Jansenist polemic is entitled, Les misericordes de Dieu dans la conduite de l'homme (1645). In this work, Yves focuses his critique directly against the ideas of Jansen himself. In opposition to the position of the Augustinus, Yves endeavors to show the truth of a merciful God who offers numerous ways to win sinners over to salvation. As Eymard observes, Les misericordes is not so much a book of polemical attack as "a treatise on spirituality, designed to give courage to weak humans in general and to poor sinners in particular; the tone is peaceful."109

Les Misericordes also reveals the strong Molinist tendencies of Yves. Like Molina, Yves affirms the absolute necessity of grace for salvation. However, Yves also insists that if we do all we can to follow God and love our neighbor, God is bound to take notice and bless us. This is Yves' version of the praedestinatio post merita praevisa (predestination after foreseen merits) which is at the heart of Molina's position. Yves tries to place the doctrine of divine mercy within the cosmic order of beauty and magnificence He develops a vision of the universe in which the very structure of nature is enveloped in God's mercy and grace.

At the core of Yves' resistance to the Jansenists is a fundamental difference in spiritual orientation. Yves recognizes the wounds of original sin, but he places greater emphasis on the grandeur of God's compassion and the innate dignity of the human person. The Jansenist woridview is more pessimistic and sober. True, they do recognize the power of divine grace, but they seem to emphasize grace at the expense of the natural gifts of goodness and freedom which Yves maintains are completed or perfected by grace. The Jansenists dwell upon the tragedy and misery of the human condition while Yves dwells more upon the natural powers inherent in all humans as a result of the divine authorship of human nature. The Jansenists stress the need for God to take the initiative in rescuing the elect souls from the mass of corrupt humanity. Yves stresses the human soul reaching out for the source of the goodness, truth and beauty towards which it has an innate attraction. Finally, Yves argues that his vision is more in harmony with the revelation of a loving God who creates the universe out of love and draws all things back to Himself.

In spite of Yves' aversion to Jansenism, it is interesting to note some similarities between his language and that of the Jansenist sympathizer, Pascal (1623-1662). Whereas Yves talks of a "natural inclination towards God," Pascal will talk of the "reasons of the heart" which compel one to

seek the presence and the love of God. Even though Pascal is strongly influenced by the Jansenist community of Port-Royal, his Pensées are, nonetheless, a reasoned attempt to offer an apologia for the Christian faith. Thus, he talks of how "it is natural for the heart to love the universal being or itself, and it hardens itself against either as it chooses."l 10 Such a statement seems to stress both the need for a human choice and a natural inclination to love either God or the self. (We are reminded of the two loves described by St. Augustine and the Fundamental Option described by Karl Rahner and others). There are numerous other passages in Pascal in which the attempt is made to shake people out of indifference and recognize their need to either choose God or remain in misery. Although he is influenced by Jansenism, there is no doubt that Pascal still upholds the importance of human initiative.

In spite of these similarities between Yves and Pascal, there are still some profound differences in orientation and attitude. As Eymard points out: "Père Yves is more humanist and Pascal more Augustinian... the one has a tendency to consider human nature as good, the other to see it weakened throughout by sin."111 In the final analysis, Yves remains the Neoplatonist with a strong confidence in the innate dignity of human nature. Pascal, on the other hand, represents the mid-seventeenth century sense of human weakness and limitation in which God's grace is the only path out of tragedy, misery and sin.

The Place of Yves de Paris In the Intellectual Milieu of Seventeenth Century France

We see that the intellectual milieu of seventeenth cenury France is one of revival, vitality, controversy and ferment. The place of Yves de Paris in this age can best be understood in terms of what he supports and what he attacks. Yves clearly supports the sense of cosmic order, unity and harmony which he absorbs from Neoplatonism and natural philosophy. He also supports the innnate dignity of the human person as made in the image of God: an idea characteristic of Renaissance humanism. We also find in Yves the theological belief in the presence of the divine within the very structure of the human soul. This idea shows the influence of both Augustinain illuminationism and Neoplatonic light metaphysics . In the final anaylis, Yves sees the human person as part of a beautiful and harmonious universe emanating from a loving God. The individual has a natural awareness of God because human nature is molded in the image of its creator and exists as the microcosm of the universe.

This spiritual vision of Yves is threatened by the currents of scepticism, fideism and Jansenism. Scepticism suggests that true knowledge of God is impossible. This threatens Yves' sense of the human mind having an innate understanding of the divine. Fideism implies a separation of the realms of faith and reason and of nature and revelation. Yves' universe is one of unity and harmony, not one of separation and discord. He seens Christian Pyrrhonism as a step towards libertinism and unbelief. For Yves, it is only when grace builds on nature that a true foundation of faith is built. Scepticism is a failure to understand and appreciate the presence of the divine both within the human soul and within the cosmos. Ultimately, Yves understands scepticism to be a failure to appreciate the majestic art of divine creation.

In a similar fashion, Yves' optimistic and humanistic soul reacts with an allergic withdrawal from the somber worid of the Jansenists. In Yves' opinion, the Jansenists fail to appreciate the reality of divine mercy which pulstates throughout the created order. Yves observes the presence of divine grace within the natural powers of the intellect and the soul. Human freedom has not been totally destroyed by the Fall. Instead, all human beings freely search for the source of goodness, truth and beauty which they sense within their souls. Grace completes the natural, God-given powers which all people possess. For Yves, Jansenist spirituality is too dark and pessimistic. He prefers the more optimistic light which emanates from a Neoplatonic universe.

Chapter Three - Le Discours Apologetique of Yves do Paris

Our primary purpose in this chapter and the one that follows is to illuminate the fundamental texts of Yves' argument for the natural awareness of God. Thus, our concern will be with the elucidation of the writings themselves rather than with a critical evaluation. The important task of evaluating and critically examining Yves principal arguments is saved for the final chapter. However, in the course of our textual study, some possible interpretive frameworks will inevitably emerge.

An examination of the table of contents of La theologie naturelle reveals the wide range of its concerns:

A) Dedication to Lord Colbert, Minister of State
B) Prologue (Avertissement)
C) Apologetic Discourse (Discours aplogetique)
D) The Natural Theology (La théologie naturelle)
Book I
Part 1: Of the Existence of God
Part 2: The World is not Eternal but is Created by God
Book II
Part 1: God is the Creator of Things Visible and Invisible; On the Immortality of the Soul
Part 2: On the Nature and Existence of Angels
Book III
Part 1: On the Perfections of God Part 2: On the Providence of God Part 3: On the Justice of God
Book IV
Part t: On Religion
Part 2: The Christian Religion is the True Religion
Part 3: On the Mysteries and Practices of the Christian Religion

As can be seen from this outline, La théologie naturelle takes on the characteristics of a summa of theology. The four volumes take up 720 pages in the 1675 edition of Les oeuvres francoises de Ives de Paris, Capucin (Alphonse de Chartres O.F.M. Cap., editor). The original editions of La théologie naturelle are published as four separate books from 1633-1637. These original editions are longer in page number because the dimensions of the books are smaller and the print is larger. Although all the topics of La théologie naturelle are worth examining, this present study concentrates on Yves' notion of /e sentiment natural de Dieu. In many respects, the notion of the natural awareness of God is at the very heart of what is called natural theology.

All four volumes of Yves' work fall under the We of "the Natural Theology; However, it is clear that many of the topics that Yves treats are more traditionally placed under the title of dogmatic theology. This is so especially in Volume:V, part 3 where topics like the sacraments, the passion, death and resurrection of Jesus, holy images, the truth of the Sacred Scriptures, grace, original sin and the virgin birth are treated. Yves might justify the inclusion of these sacred mysteries as the final completion of natural religion by the truths of the Catholic faith. In any case, this question of Yves understanding of natural religion and its relationship to the Catholic faith must be treated

in our final chapter.

It is noteworthy that Yves begins La théologie naturelle with a dedication to Monseigneur Colbert, Ministre d'Estat (Minister of State). This dedication reflects Yves' loyalty to the monarchy. He writes in a most obliging way to M. Colbert and points out that he wrote La théologie naturelle to create ',the essential integrity in hearts and to hold the mind in one continual recognition of the obligations it has before God."1 Yves' concern here is not only to receive the approval of M. Colbert but also to show that his theology is respectful of the established order of God reflected in the

French monarchy. This type of homage to the crown is typical of the age in which Yves lives. To teach people their obligations before God indirectly teaches them to respect and obey a Catholic monarch.

The dedication to M. Colbert is followed by a three page Prologue (Avertissement) and by the twelve page Discours Aplogetique. Both of these statements reveal some significant points of Yves' basic theological orientation. The Avertissement can be understood as an explanation of why Yves calls his work "the Natural Theology." As Yves writes:

I name this theology natural because leaving aside the authorities of the Church, I make an attempt to clarify the first truths by reasons taken solely from nature of which the senses give us experience and which can be understood by minds not crippled by passion.2

Yves' desire is to show that the human mind is capable of understanding and knowing certain truths from arguments taken solely from nature (des raisons seulement prises do la nature). Yves is obviously reacting against the sceptical argument that the truths of religion cannot be proven from natural reason but can only be accepted on faith or on the authority of the Church. It is soon evident that his opponents are the libertine erudits. According to Yves, one could make use of the authority of Scripture, the Fathers and Tradition to support the truths of the faith. However, he does not believe that the libertines respect these authorities. As he observes:

I have seen how the libertines who doubt the one God make fun of the authorities whom we regard as oracles: denying the Principle, they stop all our truths at their source...This is why I did not want in any way for my discourse to expose the Temple to sacrilege. prefer for it to have less brilliance but more respect: and it I only expose natural reason in this melee, once victory is gained over these first rebellions of the mind, the truth of the Gospel which reigns above them will enter in triumph.3

This passage reveals a number of important issues. For one thing, it shows that Yves regards the libertines to be more than fideists. He does not believe that they respect the traditional arguments taken from elther scripture or tradition. This passage also shows that Yves recognizes that the truths known by natural reason are not the highest truths. The truth of the Gospel is said "to regin above" the truths obtained by natural reason alone.

What then is the point of Yves' work? The answer is found in his title for the introduction: "the Apologetic Discourse." The idea of an apology for the Christian faith goes back to the early Church. Primarily, this type of writing is a rhetorical defense of Christianity which seeks to persuade the reader of the reasonableness of the faith by the use of whatever reasons, arguments and examples that might be effective. As Eymard explains:

The apologist, in the strict sense of the word, is not one who seeks to convert sinners, heretics or infidels, nor one who is content to refute the theses of his adversaries: he is one who wishes to prove for human intelligence, in as much as possible, the credibility and palitability of the Christian religion.4

Yves' work, therefore, can be understood within the the genre of a Christian apology. While he wants to employ reasons taken solely from nature, his aim is not merely to set up propositional proofs for the existence of God. Instead, Yves sees his effort as one which makes use of persuasive arguments taken from many angles. As he explains:

My propositions are not laws that carry necessity but rather thoughts which persuade one to take notice: and I would be pleased to conquer like Philip of Macedon with words which make clear to

the rebels that their happiness consists in their submission. This is why I avoid the inexorable rigor of the School.5

Yves' self-conscious decision to follow a methodology different from that of traditional scholasticism shows that he is a man of his times. As a Christian humanist, he is writing for the educated layperson or priest rather than for the theological specialist. However, this apologetic approach does not mean that his arguments are devoid of philosophical persuasion. As Yves himself explains:

The reasons of philosophy retain all their force under these ornaments just as soldiers conserve their prowess under a retinue of peace: and in this manner, I will call upon all the sciences to come to my aid; would like to give them their proper homage to piety. As the heavens shine with stars of differing grandeur and luminosity, I will have no difficulty in employing a multitude of reasons of various forcefuless; the little ones being collectively powerful, they will make their impressions on certain minds with which they are suited.6

Yves is convinced that his method will ultimately prove to be an effective vehicle for reaching out to people of various backgrounds. Yves believes that his arguments can be understood as aids to the mind in the movement towards a comprehenisve vision of the faith. As such, his reasonings should be judged by the force they will have to persuade"? Yves states that he hopes to avoid insulting the intelligences of those who might see some of his arguments as self-evident. Such people are encouraged to regard these reasonings as "ornaments" which help to embellish thebeauty of the whole design.

This Avertissement, then, is a type of cautionary foreword to the reader. He wishes to make both his intentions and his approach clear. He humbly asks his readers to judge for themselves the force of the persuasions he will offer. Finally, he concludes his Avertissement with a statement of his submission and loyalty to the Catholic Church:

Before commencing, I proclaim publicly that I submit all my words and all my thoughts to the Catholic Church, Apostolic and Roman. I disavow at this hour all that could be interpreted to the disadvantage of the Faith and am most ready to correct the mistakes of which the sages will give me charitible notice.8

Following this foreword is the twelve page introductory essay. Discours apologetique. While this essay is intended as an introduction to the four volumes which follow, in some ways it could stand on its own as a separate work. The subtitle of the Discours is: "That it is permitted to clarity the truths of religion by natural reasons." (Qu'il est permis d'eclaircir!es veritez de la

religion par les raisons naturelles). This "Apologetic Discourse" gives us a very clear picture of Yves understanding of the relationship of faith and reason. In the opening passage, he acknowledges the difficulties inherent in the human mind's search for Truth. He states that human beings must accept the disgrace of being only able to see Truth "in a shadow" and only being able to conserve it with "continual struggle."9

This sober description of the human condition, though is counter-balanced by Yves' conviction that there is engraved in the human soul a definite idea of truth. Thus, humans are placed in the paradoxical situation of searching after that truth which they already possess. The reason for this situation is the extent to which human reason is hindered by the world of the senses and the passions. As Yves explains:

But what conceals this celestial treasure the most from us is that the will, overtaken by the passions, suspends reason, forcing judgment to pursue their concerns, and from the struggle it remains opposed to itself, even to the point of making an idol out of an object of sense just as the pagans fashioned dvinities from their vices.10

According to Yves, the only way out of this struggle is for human reason to discover its essential link to the light of God which enables it to transcend the limitations of corporeal existence. For this reason, "the Christian religion declares an open war against the pleasures of the body."11

Human reason is not independent of heaven, and our true felicity is rooted in a spiritual end that goes beyond the mere satisfaction of our bodily appetities. Moreover, Yves maintains that the errors and doubts of the libertines originate from their loss of the connection between human reason and God. Thus, he writes:

Here is the first proposition of the libertines and the source of all the impieties that lose souls: to make human reason independent of Heaven and religion and to make it [human reason] the judge of [religion's] mysteries.12

Yves' point is that reason can only be properly understood in light of its divine origin. Moreover, the proper use of reason can only be made when the human mind is purified of its attachments to bodily desires. Yves, therefore, believes in the harmony between faith and reason. However, reason must be properly illumined by the divine light in order to be in harmony with faith.

Another area that Yves explores is the rapport between nature and religion. Since God is the source of both nature and religion, the harmony between the two is apparent. As Yves explains:

Nature and religion are two portraits of the same face and have a necessary rapport between them because of the one they have as their prototype... and the eye must struggle through the somber colors of nature to support that of faith in which God is more pristinely represented.13

While recognizing the essential harmony between nature and religion, Yves also sees the need for the elucidation of nature by faith. Without faith, the human mind is often blind to the truths reflected in nature. In this regard. Yves makes use of the analogy of a portrait:

But as a painting could not reveal to the eyes the beauty of the body without saying something of the qualities of the spirit, which are, nevertheless, the most powerful allurements of a legitimate attraction: just so the world deploys the virtues of sensible things in which we recognize several traits of God's perfections; but we cannot know that which precisely explains his essence except by the support of faith.14

Just as physical beauty can add to the attraction of virtuous soul so also can natural reason enhance the truths known by faith. Nature reflects the beauty of God that is known most perfectly by faith. Although the material world reveals the power, beauty and immensity of God, the divine essence is spiritual and, therefore, cannot be fully contained in the world of nature. The world of sense gives us a taste of the divine, but our souls are not satisfied by sensible things themselves but only by the divine nature which they reflect. For Yves, this explains why the Catholic Church gives such importance to liturgy and outward ceremony:

This is why the Church gives credence to the most elevated of her mysteries and renders them more adorable by the majesty of ceremonies. If she imprints this lustre on actions and material forms in order to oblige our respect; how much more will it be permitted to employ human reason, which is a more expressive portrait of the divine, in order to entice the mind to submission to the falth.15

This last passage reflects the confidence Yves has in the unity and harmony of the created order. He is convinced that human reason reflects the same divine order as the material universe. Reason can serve as a means of elucidating the truths of religion because the power of reason flows from the same divine source as the truths of faith. Although faith is needed to elucidate the presence of God in nature, human reason (when properly employed) can also serve as a vehicle for the defense of faith.

We may wonder whether Yves' presentation involves a type of circular reasoning. On the one hand, he insists that natural reason needs the help of faith in order to be used correctly. On the other hand, reason can also be used to help elucidate the truths of faith. The explanation for this apparent circular logic is that Yves' spiritual vision includes faith and reason as two aspects of one and the same divine mystery. Yves' basic point is that the libertines have separated the intrinsic unity of faith and reason and have put reason as the judge of faith. In Yves mind, such a separation is disastrous. It can only lead to impiety and the ultimate undermining of the Christian religion.

Yves' purpose is to restore human reason to its sacral dimension. He makes it clear that he could prove the truth of the Catholic Church to the libertines "by her long possession, by miracles, by common belief, by agreement and by the extent of her doctrine."16 However, these arguments, convincing though they may be, do not directly confront the claim of the sceptics and libertines that reason provides no support for the faith. Yves' task is to demonstrate how a proper use of reason will elucidate the same truths that are known by faith, tradition and authority. Thus, he looks towards nature as the defense of the faith. Yves sees the universe as a revelation of God, a theophany, in which "its beauty, Its grandeur, the intelligence of its parts" all lead to She awareness we must have of a first principle'17

Since the libertines and sceptics have lost their sense of faith, it must be shown that the truths of faith are supported by natural reason. In this regard, Yves has an enormous respect for the power of human reason. As he writes:

In effect, reason is the principle power of man: it could not be useless in the achievement of his end; and if we don't give it [reason] its fair share of glory, it would be to accuse nature of having badly ordered her forces, of having led our hopes by a useless aid...For never is humanity elevated to a sublime state in this life in which reason does not play some role.18

However, Yves recognizes reason's limitations as well as its powers. He points out that it often requires "great effort to discern the truth" and "that compared to the swiftness of the angels, it is severely lacking."19

Nevertheless, in spite of its limitations, natural reason is one of our greatest gifts. While it may be true that natural reasons do not have the force or certitude of the decrees of the Church, they can still serve the Church very well. Human reason can give order to the human spirit and render it properly disposed to the divine. Faith, therefore, should gain the allegiance of reason. Just as a prince best gains the support of his people by courtesy and gentleness rather than by tyranny, so also should faith win reason to its cause by gentle persuasion. With reason as its friend, faith can stand up to its opponents with confidence and ease.

Yves explains the role of reason as " the medium between the first divine truth and the Ignorance of the material world. (la raison esf moyenne entre la premiere verite divine & 1'ignorance du monde materielj"20 He goes onto show that that it is through the intervention of reason that creatures reunite with their origin and humanity with God. The theological and metaphysical explanation for this mystery is the emanating influence of the logos, the eternal word of God. As Yves explains:

The Eternal Word, that inexhaustible source of lights, communicates itself first to the blessed spirits and gives them a tranquil understanding of all the knowledge that serves their happiness; then, it expands its ray and imprints its portrait on material bodies; it bursts out in the stars; it shines in the fire; it sparkles in the rocks; it becomes adorable in the beauties of nature; it commands in the instincts of animals and plants; and finally it terminates its humble descent into the order of the world which is the image of reason... From that, this divine ray wishes to return again to its source, winning over our senses by the delights of all these objects, yielding love to reason and obliging research into that true beauty of which this world is only the portrait. And as the will yearns for its sovereign good, as the understanding searches for its rest in the first truth, the soul, already elevated above mortal things, needs only a little ray of divine faith which unites it to God and gives it the means of completing this beautiful circle of light by its return into the Word.21

This passage reflects the heart of Yves de Paris' spiritual vision. The entire universe is filled with the light of the divine logos. Since God's emanating light is diffused throughout the universe, human reason, properly disposed, should be able to discover both within itself and the material universe evidence of God's existence. Only a "little ray of divine faith" Is needed to awaken the soul to its awareness of its highest good.

Yves goes on to elucidate the essential harmony that exists between faith and reason. He compares faith to the light of the sun which shines on a mirror to produce a more perfect image. In the same way faith combines with natural reason to perfect the image of God which is already in the soul. Since "all things are one in the idea of God; the soul is clarified by "the double light" of faith and reason and discovers the same divine logos operating "in the mysteries of faith as in the governance of the world."22 Ultimately, religion and philosophy are two reflections of the one divine light.

For Yves, the harmony between faith and reason has some very important implications for Christian apologetics. As he writes:

If we can reach this point, of showing that faith has nothing directly contrary to reason, that it is one and the same intelligence that leads us to the adoration of God; we will attract all of the world to the Church, because natural reason is the same in all, and in making this marriage with the faith, we place all people who hold to these two parties into one same alliance.23

Yves is convinced that this alliance between faith and reason is far better than the position of the radical fideists. If faith "declares an open war against reason," then the Church could only hope to gain assent to her teachings by either blind faith or coercion.
Yves much prefers the path of gentle, intelligent persuasion. Yves has no illusions of being able to prove the truths of the faith by natural reason alone. In fact, he says that such an enterprise "would give offense to the grandeur of the Christian religion which receives its understandings directly from the first truth."24 However, a proper use of natural reason could be used to direct the soul towards its ultimate fulfillment in God. As Yves writes:

The natural light is never strong enough to satisfy our desires and put us in possession of our end; when we have seen that the most solid reasons of philosophy still leave an emptiness in our souls, we will sigh after that which can replenish it, and by a secret and powerful inclination, we will direct ourselves in search of the infinite 25

Yves believes that the human mind, in its deepest quest for truth, will only be statisfied by the infinite God. In the final analysis, this natural desire for God (le desir nature! de Dieu) is the result of the natural awareness of God.

Yves continues his Discours apologetique with additional arguments for the use of reason in the clarification of the faith. He points out how dangerous it is to follow the external practices of the Catholic faith without any interior conviction . Without an inner commitment to the faith, many people come to receive religion "as one of the customs under the sole authority of usage, without examining what it proposes." They are engaged in their religion "more by birth than by choice" and "believe it is enough to satisfy obligations by giving them appearances at the reservation of the interior."26 Yves believes that the remedy to this type of nominal, conventional religion is to "employ reason in the service of the faith." When people see the inner logic of their faith, they no longer will follow it only for the sake of social respect or appearance. Religion must appeal to the whole person: intellect as well as will. The separation of faith and reason by the sceptics, the fideists and libertines can lead to various forms of superficial religiosity devoid of an inner conviction.

Yves next responds to the accusation that the use of reason in defense of the faith lowers the dignity of the faith. As he explains:

If several theologians find it strange that faith should lower itself to the point of receiving its clarifaction from reason, I can only point them to the Eternal Word who Himself was made man and who dwells in our nature in order to make us capable of such truths.27

Once again, Yves invokes "the admirable mystery" of the Incarnation as the support for his theological enterprise. Just as the Eternal Word dwells in the human soul without any change on the part of its divine nature, so also will the faith not be subject to any alteration if it expresses itself in the terms of natural reason. As Yves puts it:

Moreover, the faith, covering its divinity under human appearances will neither be altered or devalued but only better understood. Jesus Christ treats the most sublime instructions of our salvation under a veil and with the familiarity of parables. The angels take on bodies if it is a question of appearing before humans, and putting aside their own language which has its use in heaven, they speak in our language because we are not capable of theirs 28

The point is that the mysterious truths of revelation must be communicated in ways that can be understood. Of course, these mysteries are not fully understood in this life, but they can at least by clarified sufficiently so that even simplest of souls can grasp them. As Yves explains:

Never does the High Priest sanctify the people without stripping himself of the mysterious pomp of the vestments of the High Priesthood: He appears in ordinary garments in order to teach us to treat religion with words and reasons appropriate to the littleness of our minds.29

Yves elaborates on this theme with other examples drawn from scripture and tradition. Isaiah receives a book from God and is told to write it down in human style. St. Paul says that we should temper our religious instructions according to capacities of our listeners. Thus, mik is suitable for infants, more solid food for those who are stronger and the sacred banquets for those who have reached maturity. Moreover, St. Paul also teaches that "visible things must some us by degrees to lead to invisible things."30 Ina similar way, Yves notes that the "great St. Denis" only explains divine perfections by comparisons taken from material things."31 Yves then lists all the authorities from tradition who lend support to his position:

Origin, St. Basil and St. Ambrose find in the history of the world's creation the laws of faith and morality; if he needs to combat impiety, St. Cyril uses natural reasons as weapons against Julian the Apostate; St. Augustine uses them against the idolators...as does Justin Martyr, Lactantius and

others.., and then, the Catholic Church while in the brilliance of her power and grandeur, the Angelic Doctor, St. Thomas believed it necessary to compose the book which we have of his against the Gentiles, where the truths of the faith are clarified by natural demonstrations32

Yves sees himself in line with this impressive theological tradition even though he humbly admits that he does not belong in the company of these "great doctors" of the Church. He goes on to explain that his apologetic style tries to avoid a direct confrontation with the ideas of atheism because that would give their ideas too much exposure and make them seem more logical than thery really are. Yves prefers to follow the advice of St. Denis (Pseudo-Dionysius) to:

never combat evil except by establishing the truth with such powerful reasons that like a great light, it will cause the false light of deceit to die and will win over minds by the sheer brilliance and allure of its beauty.33

Yves' desire is to defend the truth by showing its attraction rather than by striving for a systematic refutation of false ideas. He hopes that by clarifying the truths of the faith he will confound "the pernicious maxims of the atheists (les pernicieuses maximes des athees)"34 Yves hopes to construct a natural theology which will overwhelm the reader with evidences for the presence of God both within nature and in the inner depths of the human soul. Through this approach, the sensitive mind will be led to an understanding of divine things by an intellectual and spiritual ascent. As he writes:

The knowledge of divine things drawn from a consideration of creatures must be complete and very exact; inasmuch as the world is a portrait of the unity and perfection of the divine, the sage must contemplate it with all its traits, colors, shadows. proportions and all its vastness before he can sense its rapport with the beauty of Its prototype 35

Yves is stressing a crucial point. There is a need for a total vision of the harmony and beauty of the cosmos in order to gain a sense of the unity and perfection of the divine. As Yves observes:

If [the sage] does not have this universal view his remarks will be surprises and the partiality of his thoughts will be in opposition to the nature of God which has no disunity. And as charity joins together all that it wishes to encounter into one subject; as music charms the ear by a softness which springs from the harmony of all the voices; just so the soul will never know how to judge divine perfections by natural contemplation if it does not make itself attentive to the harmony which forms all the parts of the world.36

For Yves, it is this cosmic unity of creation that reflects the nature of the divine logos. Human reason, therefore, must be attentive to the truths that nature sets before our eyes. There are, however, people who are "carried to an extreme presumption of their powers... by placing themselves against the truths that nature makes evident and all the nations revere."37 These people are the sceptics and the libertines. According to Yves, their arguments are not those of true philosophy because they are too tied down to the world of sense, and their insights are swayed by the "violence of their passions."38 Yves offers this explanation for the increasing number of libertines:

Perhaps because these minds, not being able to carry out the necessary work for the discovery of truth, give credence to such opinions in order to flatter themselves in their impotence; or in the Interest of the body, so as to indulge themselves in all the affairs of the world, they take so much time that they do not leave enough time for study39

Apparently, there are enough people who belong to these "pernicious sects"40 of scepticism that Yves feels it necessary to write his apologetic. He seems to sense the same threat to the faith as

Mersenne and Garasse. No doubt, the popularization of scepticism and radical fideism is giving birth to a growing number of libertines and agnostics at this time in France.

Yves' use of the word "atheists" might be an exaggeration used for polemical purposes.41 In any case, the threat to the integrity of the Christian faith by the libertines is perceived by Yves to be serious. He explains his purpose in writing La théologie nature lie as a cure to the abuses of his age:

This is why, in order to provide a remedy for these great abuses. I have designed to counter these spirits by a detailed consideration of the marvels of nature, to enter into its counsels, to examine its paths and to omit no part of the world where we have not yet discovered the qualities and the sympathies. This contemplation will enable us to see sensible things through another eye in a way not perceived by the common among people. By all this, we will admire a secret power that sustains their lives, that perfects their being, that animates their actions: we will find ourselves surrounded by an infinite light and in the midst of such raptures of our spirit, our hearts could not refuse to give profound adoration to the divine majesty.42

Here we see the apologetic thrust of Yves' natural theology. He wishes to stop theabuses of human reason by expanding its horizons. He is utterly convinced that a sensitive examination of the world of nature will lead the human soul to the contemplation of "the infinite light" that surrounds creation. Yves believes that by opening up the "spiritual eye" of the human mind, the "secret power" which animates and sustains creation will be perceived.

It is apparent that Yves' method is to use words to persuade, stir emotions and lead the mind to the contemplation of the inner logic of nature and the universe. His desire to avoid a totally systematic, scholastic approach is self-conscious. Yves desires to reach a wider audience. He refers to scholastic treatises as "huge, brute diamonds" whose beauty is only appreciated by "the masters of science" while "the common minds remained confused in the generality of their propositions."43 Here we see the influence of Renaissance Humanism on Yves. Following the example of Erasmus, who believes that every Christian should, in some sense, be a theologian, and Thomas More, who communicates a type of natural theology in his book, Utopia, Yves desires to appeal to the theological and spiritual instincts of the general populus. However, Yves is not anti-scholastic (like Erasmus and More) since he clearly recognizes the importance and value of the systematic approach.

In the final analysis, Yves' natural theology is an attempt to present the basic harmony between nature and faith and reason and revelation. His apologetic makes use of the basic lines of logic found in the scholastic approach, but his mode of expression is more literary. Yves is convinced that such an approach will be more effective in dealing with the challenge of the libertins. Thus, he writes.

This is why we disguise philosophy in rough apparel in order to win over rebel spirits as much by condescension as by the necessity of reasoning, and to complete the stuggle with a victory, which would be less glorious for us if it were less acceptable to our enemies.

This passage concludes the Discours apologetique of Yves de Paris. It sets the stage for the La théologie naturelle which follows. We now have a sense of what Yves hopes to accomplish. He hopes to show that all humans have a natural awareness of God. His approach will include a consideration of the interior presence of the idea of God in the human mind as well as the outward contemplation of the evidence for God in the cosmos. It remains to be seen if his natural theology succeeds in its effort to lead us to that point 'Where our hearts could not refuse to give profound adorations to the divine majesty.'"

Chapter Four - The Arguments for the Natural Awareness of God According to La Théologie Naturelle

We now come to the arguments of Yves de Paris for the natural awareness of God contained in La théologie naturelle. If there is a single section of this text which deserves special attention, it is the first seven chapters of the first volume. These chapters contain a self-conscious effort on the part of Yves to show that all humans possess un sentiment nature! de Dieu. The listing of the chapter headings gives us a preview of his undertaking:

Chapter I: Humanity has a natural awareness of God. Chapter II: The awareness of God comes from God Himself.

Chapter III: Humanity cannot extinguish the natural awareness that it has of God.

Chapter IV: The awareness of God does not come from the opinion of people.

Chapter V: The awareness of God does not come the invention of princes.

Chapter VI: Besides natural instinct, we can know God by reason.

Chapter VII: The origin of idolatry. How the philosophers liberated themselves by reason, and how they have ascribed false divinities to nature and nature to God.

These seven chapters are followed by twenty more in Book One, part one. These remaining chapters tend to focus more on the evidence for the existence of God found in the order, unity and intelligence of the universe. For example, Chapter VIIII is entitled: 'The assemblage of contrary things in the world and their conservation suppose a God" Other chapters deal with similar themes like "The harmony of elements in the world (Chapter IX), 'The order and movement of the heavens (Chapter XII), and "Order is an effect of reason and the order of the world presupposes a universal reason" (Chapter XVI)." Our primary focus is on the first seven chapters which present Yves' arguments for the innate consciousness of God. However, it will also be important to summarize some of the other sections of La theologie naturelle which shed light on Yves' overall apologetic.

The Prelude

Yves begins Book One of La théologie naturelle with a two page prelude. He points out in this prelude that our natural curiosity about the universe as well as our natural desire to know indicates a movement towards God as the first principle:

The natural curiosity we have to know a great diversify of things is not satisfied with the account our senses give us regarding external objects if reason does not conceive the causes ...This passion to know the reason for everything is so strong in great minds that the study which pleases them finds its home in all the wonders of the worlds, while on the contrary, its ignorance (i.e. of the reason) is for them an insupportable hell.1

The presence of the "natural curiosity" to know the reasons behind all things is, for Yves, a strong suggestion of a natural awareness of God. Since external objects do not satisfy the profound desire to know the underlying causes behind appearances, there is a a natural movement of the mind towards an ultimate source. According to Yves, if this natural movement of the human mind is not directed towards a real end, there would be a logical hole in the order of nature. As he observes:

But after our mind has made its way through the order of the world, where it has discovered the edifices of nature and the dependence of its parts, it must finally arrive at a resting place for its

painful researches since it is the source and end of all beings. Otherwise, to stop itself at a finite cause without passing beyond it would be to admit a void in the world and in our knowledge, to terminate a long path of studies with a precipice._2

Yves sets the tone for his entire discussion with this observation of the natural desire of the human mind to know the first cause of the universe. Knowledge of this first principle is important not only for human happiness but also for the structure and well-being of society. For Yves, the first principle is:

the foundation of religion, and on it depends the regulation of our lives and the conservation of the state. To believe in God: this is the only truth that can stop the flood of every crime...so that acts of violence, pillages and murders don't break the foundations of nature; so that human beings will not drown in their blood and extinguish their species in order to satisfy the fury of their passions. This is why all the ancient legislators made this belief the first and most necessary of all their laws and obliged the people to receive it with so much respect.3

Yves sees a moral and political imperative in his mission to combat the tide of impiety and scepticism in his beloved France. He senses a threat to the social order it faith is made into a matter of conventional observance without any sincere convictions. His apologetic, therefore, is intended to awaken the hearts and minds of those who have lost their sense of the presence of God. Yves acknowledges that impiety has not reached the point of total destruction "under the reign of our dear prince who so dearly espouses the interests of the faith."4 However, the dangers of lukewarm faith are too real to ignore. Without a dynamic awareness of the presence of God, people might end up performing the obligations of religion with a languor which gives the impression of a force which is half-dead."5

The mere legislation of religion is not enough. There must be a return to the foundations of faith grounded in the first principle of all unity, goodness and truth. Until there is the reawakening of this sense of the first principle, all attempts to persuade the ignorant of the truths of the faith are doomed to failure. As Yves observes, it is like "building without having laid the foundations; it is like erecting grand aqueducts devoid of a source... like those who think they can construct a circle without having recognized the center."6

Yves realizes that since so many people have such a dim awareness of God he must slowly open up their hearts and minds to the presence of the divine around them. His purpose is to lead the mind through the stages of the world, opening it to the secrets of nature and the marvels we discover there, creating in it the proper sensitivities of God (des bons sentiments de Dieu).?

By this method, Yves hopes to achieve two final goals: first, 'to combat impiety by its own weapons, showing that the same nature which they [the libertines] oppose to God is the same one which gives us instruction of Him."8 Secondly, Yves wishes to "persuade the faculties by giving them the light of this principle which is as necessary to their support as the the sun is to the productions of the earth."9

The Universality of the Idea of God

With these goals in mind. Yves begins the first chapter of La théologie nature tie. The title of this chapter reveals a theme which is quite important for his entire apologetic: "Humanity has a natural awareness of God (L'homme a tan sentiment natural do God can result in idolatry and false devotions, especially in consideration of human sinfulness.17 Yves' point, though, is that even pagan practices reflect an inner consciousness of God. As he writes:

Never would these people have elevated altars and presented sacrifices to imaginary divinities it they had not carried within the soul a secret and common awareness of God. For the operations of the mind as well as those of the senses always presuppose a faculty out of which they proceed.18

Pagan religions demonstrate a general inclination to adore the divine. This inclination suggests a natural (albeit dim) awareness of the one God. According to Yves' logic, every natural inclination must have a true and existing reality which can satisfy or fulfill ft. Thus, Yves states: "The common inclination of nature is never mistaken, it always aspires after a legitimate end whose possession is the fulfillment of the subject which has sensed the desire within it."19 Following this line of reasoning Yves concludes:

Likewise if all humans deeply sense a general inclination to adore God, there must necessarily be some true divinity capable of giving them that which will lead to their happiness more than the phantoms and the idols of paganism.20

Yves is absolutely convinced that the natural awareness of God is what is behind every single religious act. He points out that all the religious actions of every nation on earth are signs of an inner yearning for the infinite God:

It is after this infinite goodness that all the nations of the earth yearn; it is for it that they have their vows and sacrifices, and [they] nourish an insatiable desire for its knowledge inasmuch as they carry in their faith a certain degree of light.21

We might wonder what is the extent of Yves' knowledge of non-Christian and pagan religions. Certainly, he is aware of the religions of antiquity, at least in a general way. However, his descriptions of the newly discovered peoples of the "Age of Exploration," seem to be influenced by a certain degree of Romanticism. Thus, Yves observes:

Our age has discovered some barbarian peoples._who carry themselves with a brutal fury and view all strangers as enemies to be wiped out by their weapons and to some as the spoils of their murderous designs. But if a religious priest or brother should approach them, talking to them about God, even though with imperfect words and in a rough language,... you will see these savages tamed in an instant, from tigers they become lambs: this initial instruction of the faith is an omen of good Influence which makes their spirits calm,... they put down their weapons; and they fall into rapt admiration over his simple discourse to them about God; they tremble with an unaccustomed excitement.22

This description of an instanameous calming of the savage soul might not be typical of all missionary encounters.

However, for Yves, such transformations have occurred often enough to ask:

From whence comes this sudden metamorphosis of brutes into human beings?... From whence come these extraordinary satisfactions of the spirits and these compliances which make the barbarians forget those inhumane ways which had become natural to them because of a bad education?23

For Yves, the answer is clear: these people "carry within their souls a secret awareness of God"24 Just as a small light is perfected by a greater light, so the dim, natural awareness of God possessed by these savage people is brightened and perfected by the preaching of the missionaries.

Yves does mention that there are times when the barbarians become irritated instead of attracted to the preaching of the one true God. This he explains as a reaction to what the barbarians sense is

a limitation on their freedom. Thus, some people react with anger at God "because He demands their adoration and their servitude," and also because God "uncovers that which the conscience would try to conceal."25 Yves, therefore, is not entirely seduced by the romantic image of "the noble savage." However, his fundamental orientation is optimistic. He does not believe that these occasional examples of resistance to the Word of God disprove his central thesis of the natural awareness of God .

It is probably safe to conclude that Yves is aware of the successful as well unsuccessful missionary campaigns of the Church in the Americas as well as Asia. He tends to deal with the barbarian peoples in general terms rather than specific examples. Yves certainly does not adopt the methodology of a twentieth century anthropologist. His style is literary and speculative, not empirical and scientific. As far as Yves is concerned, the very fact that these newly discovered people have any religion at all is support for his thesis. His general argument in this first chapter is that the universality of religion reflects a natural awareness and natural desire for God.

The Divine Source of the Human Awareness of God

In chapter II, Yves continues his apologetic with a demonstration that "the awareness which humanity has of God comes from God Himself."26 Here Yves sets forth a more philosophical argument flowing from the origin of the human consciousness of the divine. He begins with analogy of the human eye which instinctively turns towards light whenever it dwells within darkness. Yves points out that the reaction of the eye is immediate. Moreover, it does not have to know the source of the light in order to experience it. In the same way, the human mind experiences the light of the divine even though it does not always recognize the source. However, there is a difference. While the human eye is not capable of intellectual, discursive research into the origin of the light, the human mind is. Thus, Yves argues that:

Our soul does not remain satisfied by the secret awareness which it has of God; it points to something much higher, and since it is instructed to make reflections on its discourses, to rise from effects to their causes, from conclusions to principles, it makes here a bountiful leap (une genereuse saille) up to the celestial sun which has bestowed this light upon it.27

The human mind, therefore, needs to reflect upon the origin of its inner awareness of the divine. Where does this sense of God come from? Yves points out that this sense of the divine could not come from opinion because it is "general among all people, constant in all ages" and there are no people on earth who "do not carry this force inside their hearts."28 Yves dismisses the suggestion that the idea of God is simply a human invention. For him, the universality of the concept of the divine is sufficient evidence that the notion of God cannot be reduced to the opinion of some people.

Yves also argues that the idea of God could not be the product of the human soul itself. As he states, the awareness of the divine could not proceed from the same force as our soul, since if it is from the same substance, It would be like having the night illuminated for us by that dull glimmer which forms part of the bodies of certain little moths.29

Vves, therefore, is convinced that true explanation for our inner sense of the divine must be found in God Himself. To say that the human soul could be the source of this notion of God is as absurd as trying to find our way through the dark with the light generated by certain little glowing insects (les petits vers). Yves attempts to illustrate his basic point in numerous ways. For now, though, he feels confident enough to assert that the awareness of God comes to us, therefore, from God Himself, and in this, He gives us a double assurance of his being, since we have in us this keen awareness (ca vif sentiment and since it could only come to us from his part 30

Yves returns at this point to the comparison with the sun. Since the eye can only respond to the sun because its contains a certain "luminous quality" which is capable of sensing the light of the sun, in a similar way, the human mind is only capable of thinking about God because God has already placed within it a certain awareness or sensitivity to His presence. Yves words on this point are very clear:

Our mind would not be capable of even thinking about God if God Himself had not imprinted the idea in us, or if a particular help of his grace had not awakened this awareness in us, and if the infinity of his essence had not made itself present to souls.31

Yves' next concern is with the uniqueness of the idea of God. While our mind has the ability to "forge phantoms, chimeras, mountains of gold and to give existence in its imaginations to things which have no existence in nature," these fictions can be explained by "an intellectual composition" created from the data supplied by the senses. However, the idea of God is unique because there are no such sense experiences of God:

Our senses have not discovered anything in the entire expanse of nature which resembles the eminent perfection of [God's] essence, and all our efforts are too weak to form this incomparable concept.

According to Yves, the very fact that we have an idea of God is sufficient proof that God exists. Since the human mind is not an adequate source for the eminent perfection of the divine essence, the explanation of the idea of God must transcend the limits of the finite, human intellect. Yves continues to impress this reasoning:

How could the medium of our soul, which cannot even perfectly know itself, nor even see the substantial forms beneath the density of matter, have by itself the idea of a God who is an intellectual being, perfectly pure and completely devoid of corporeality? We are speaking of an essence infinite in goodness, in grandeur, in power and in extension; How could our mind, which has only limited powers, form by itself a concept of infinity if there isn't an infinite being which has communicated this understanding to it...?33

The major thrust of this argument is the recognition that the idea we have of an infinite and perfect being can only be due to divine causality. Once we understand that the idea of God is not explicable by the unaided powers of the human mind, we can appreciate the divine as the source of our concept of the infinite God. Yves points out that the very concept of the infinite is something truly extraordinary:

After all, our mind embraces more by the idea of the infinite than that of a head gazing down over a precipice with no sign of a bottom and the eye expanding itself out into the vastness of those spaces which do not terminate on any object. Moreover, since all people...find an unspeakable contentment in conceiving of an infinite being who rules over the world, it must be concluded that this idea, which surpasses the power of their minds, comes to them from the munificence of this first cause34

Yves' argumentation involves a twofold movement. First, there is the movement of the mind in search of the source of its idea of the infinite. Secondly, there is the movement of God towards the human soul which helps to explain and clarify the initial experience of the divine presence. In the order of creation, the movement of the divine is primary. However, in the order of human experience, the movement of the mind towards its infinite source is encountered first. Yves joins these two movements together in his understanding of the human soul as the image of God. Thus, he explains:

Our soul is a blank sheet of expectation (tine table d'attente) which must have its portrait drawn by the hand of God: it is a minor which would not represent the sun if [the sun] were not already present within k, and if its ray had not fashioned the image of its majesty.35

According to Yves, the soul can only reflect the image of God because the divine is already present within it. However, the soul, as the image of God, reflects the divine majesty and not its own. Thus, what Yves means by le sentiment natural de Dieu is not something separated from divine (or supernatural) causality. God is the source of the human mind's awareness of God. This awareness, though, is natural in the sense that it is part of the very nature of what it means to be human. Vves argument is that the human mind is fashioned in such a way by God that it is naturally open to the infinite.

Yves' natural theology is an attempt to bring to light the overwhelming effects of the divine upon the order of creation and the operations of the human mind. As he points out: "Everything that our mind conceives of as greatness comes, in turn, from the inclination that God has given us to know and adore his omnipotence "36 Yves entire anthropology is based on an understanding of the human person as a creature whose ultimate good is found in union with God. As he writes:

Man, being the most sublime of mortal creatures, must unite himself to the first principle who alone could be his sovereign good, and this is done by an action of the mind, which is the most noble of his faculties.37

So strong is this desire humans have to unite with God that Yves believes it must be grounded in reality. Otherwise, there would be "the void which nature most abhors... if our soul had not been made capable of union with God."38

Yves' spiritual vision is one of emanation and return. God pours out his divine essence in the act of creation. Nature, therefore, reflects the power, beauty and wisdom of God. However, it is in human beings more than any of type of creature on earth that this desire to unite with the source is most keenly felt. The movement of the human mind, therefore, is essentially one of returning to its first principle. Yves recognizes that this process of return, though natural to the human spirit, must be aided by divine grace. As he writes:

Because the distance is infinite between the creator and the creature... we are always left in an infinite estrangement (tin elaignement inlinl it is necessary that our source assist our weakness and supply us with a means of approaching Him which is powerful and free of the usual limitations of our nature.39

Yves goes on to explain that there are certain moments of grace in which the power of Gods presence can overwhelm us. This knowledge of God differs from other types of knowing because ordinarily we must search out the answer before we understand it. However, in regard to the knowledge of God, "we reason only after we have known."40 According to Yves, since God is already present within the human mind, certain grace-filled moments can move the mind to an immediate apprehension of the divine. As he explains:

This movement is achieved in one moment because it contemplates an eternity, and because it is achieved by the assistance and the attraction of a force free from the durations and successions of time.41

Yves goes on to explain that there are certain contemplative moments which elevate the human mind to an overwhelming sense of the power and depth of God. In these spiritual experiences,

there is a suspension of the usual boundaries of mundane knowledge. He proceeds to provide some examples:

When in the calm of a beautiful night, the falling color of the sky arches over the earth and the silence which watches over the stars absorbs our attention; when our eyes out of all these objects see only heaven, our wills experience only those affections which transcend nature; our thoughts softly confess that they are transported into I know not what infinite expanse of light which holds all our powers in suspension, which makes us admire more than we can see and revel in a happiness which we know not 42

A similar rapture can take place "in the profound solitude of a forest, amid the silence and the countenance of those huge trees which carry a certain majesty in the helght of their trunks and the vast expanse of their branches." In such a forest, our heart "senses unaccustomed emotions" and our body "trembles with a respectful awe." Here we are awakened to "the presence of an infinite grandeur which demands homage.43

Yves believes that experiences like these carry more weight than even the most rational proofs for the existence of God. As he points out: "we do not demand proofs if we have forgotten to reflect on whether or not it is daytime when our eyes see the light and the sphere of the sun "44 In other words, we seem to trust our most basic sense experiences without suspecting that they might be deceiving us. Such instinctual trust leads Yves to ask:

Alas! Why doubt those truths which our mind comprehends without rational reflection and of which it has a knowledge so familiar that it can be spoken of as sensible and compared to that of touching?45

Yves is not at all surprised by the fact that many people have a deep awareness of God without any formal study or research. Since God is the first principle which makes any human thought possible, It is no wonder that many comprehend the qualities of the divine without any philosophical training. Yves maintains that

God, who is an eternal and necessary being, is understood by the highest part of our soul in a firm, unshakeable mode of knowledge which is prior to our research like repose is to motion.

Yves believes in the possibility of knowing God in an instantaneous intuition. Since God Is a spiritual reality, his spiritual essence is not limited by the boundaries of space and time As Yves explains:

This primary apprehension of God, who is our final end, need not depend on the discourse of reason...Since this does not have the same obligation of bodies to travel across the spaces that lie between themselves and the desired end, the same instant that the rock above is removed, it is placed in the center. Ohl What a marvelous thing, if the mind... could be free from the limitations of space and unite itself immediately to a reality which, because of its infinity, is never in separation. Man would be so happy if he always abandoned himself to these holy emotions which are tenderly designed with the harmony of the universe, which allow him to bring forth the actions of eternity into a moment._47

Yves goes on to say that if all humans followed these 'holy emotions, there would emerge that "golden age of which the poets speak."46 If we all recognized the divine presence within our souls, wars would end, and we would find ourselves surrounded by a profound peace. Yves presents contemplation as the solution to the problems that plague humankind. Like Augustine, Yves believes that God is more intimate to us than we are to ourselves. He believes that the divine is

present to the soul without the need for mediation through the senses. Therefore, the human mind is capable of knowing God in an immediate, contemplative intuition.

The Awareness of God cannot be Extinguished
Yves' third chapter is entitled: °Man cannot extinguish the natural awareness that he has of God." 49 In this chapter, Yves tries to show how even in the most depraved humans, there still remains the natural awareness of God. Even the atheists cannot extinguish within themselves this innate sense of the divine.

Yves begins this chapter with some reflections on why various distortions of natural law have emerged in the course of human history. He points out that among the Ethiopians the natural law of marriage has yet to be received. Likewise, some pagan poets have distorted natural law with their fables about fauns, satyrs and androgynous beings.'50 Yves mentions that in antiquity there are even cases of mothers who eat their children. His explanation for most of these abuses is that people can follow the distortions of their passions instead of the laws of nature which they know through a proper use of reason.

As terrible as some of these distortions of natural law are, Yves believes that the most dangerous is the loss of the natural awareness of God. As he writes:

Among all these disorders of the spirit, the most pernicious is to lose the natural awareness which one has of God...The excesses which do violence to the laws of nature are like impetuous winds which sidetrack man from the route he ought to take; but this latter is a whirlwind which in one blow deprives him of his view of the sky, the means and hopes of touching port, leaving him totally shipwrecked.51

Yves goes on to describe the dangers of atheism. He states that atheists operate under the delusion that their denial of God will give them tranquility of soul. Actually, the inner desire they nurture is to be free from all moral restraints. As Yves observes:

They try to make themselves free in persuading themselves that there is no God: to deny his providence in order not to be obligated to Him, to not recognize his justice in order to have no fear of condemnation and to place the highest point of wisdom in the extremity of atheism.52

Yves is absolutely convinced that these atheists are fooling themselves. He, therefore, gives them this stern warning:

But, oh poor wretches, your designs are as mistaken as they are sacrilegious: darken your souls with every sort of crime, fortify yourselves in conversations with your cronies, laugh at holy things, attribute miracles to nature, drown your reason in the senses, try to confound Him as you travel down every path, you will yet see that there is a God; you do not know how to stop this light which you try to dim because it is inside of you, and it operates over your mind like natural heat over your body, without your consent.53

Yves accuses the atheists (called les libertins in the same paragraph) of trying to evade the undeniable presence of God. He relates how he has witnessed

The conscience of these powerful minds.... after they have employed so much discourse to convince themselves that there is no God. after having accused theology of ignorance, the Church of superstition and the Holy Scriptures of corruption, be yet prodded (pique) to the quick by a natural awareness of God.

Yves is utterly convinced that not even the libertins can escape the influence of the divine upon their consciences. The divine light can break into the intellect at any moment in an overwhelming way:

All at once, the mind dwells in the amazement of this light, just as the eye upon leaving a darkened place receives a great brightness; all the faculties let go of the charms of sensible things in order to focus on this object; the heart is totally moved by it; the criminal conscience caught in the midst of its wicked deeds, trembles before its judge.. 55

For Vves, such epiphanies of the divine light occur frequently enough to convince him that even the unbelievers carry within their minds a hidden sensitivity to God's presence. The disturbances felt by a guilty conscience can only be explained by the inner presence of a divine judge. As Yves observes:

The libertine... still understands a voice which accuses him, an obtrusive lawyer that he knows not how to dispossess, and he cannot escape this awareness which dwells inside of him.56

Yves admits that circumstances of birth or fortune may hinder people from a true appreciation of the sacred. However, if we believe that injustices like poverty and oppression remove the awareness of God from the heart, Yves tells us that we deceive ourselves:

As much as those magicians who convince themselves that they can bring the moon and sky down to earth by the murmur of words or by the dark observances of their charms.57

Yves underlying premise is that the awareness of God is part of the necessary order of creation. Since divine providence is needed to govern the celestial bodies and maintain our own bodies in existence, it follows that God has implanted his image upon the human mind since it is also part of the order of creation. As Yves explains:

The same providence, which has established the movement of the heart and the adjacent arteries independently of our choice, because it is necessary for the maintenance of the body's life, gives us an awareness of God with an element of necessity, since He is the life of our souls, and otherwise, we would not have such a plain disposition towards a good whose loss would be so disastrous for us.58

For Yves de Paris, the awareness of God is as natural as the flow of blood through our veins and the beating of our hearts.

Just as these natural bodily processes occur without our consent for the maintenance of bodily life, so also the does natural awareness of God instinctively guide our soul towards the divine life for which it has been created. Yves has a strong sense of natural final causality. Everything in nature is directed towards its proper end. The human soul is no exception. The unbelievers can try to extinguish this innate consciousness of God, but they can never succeed because their nature is designed by the very God whom they deny. Hence, Yves declares:

This light [of God] is the dowry and inalienable estate of the soul; it [the soul] can be wasteful of other heavenly favors, but it holds on to this one like those sacred things which never decline by usage... Here is one effect of God's providence which, knowing beforehand the defects of our weakness, supplies us with continual help. He imprints the image of his eternal goodness on an inconstant soul, just as the sun represents the majesty of its face with a constant ray of light on all things.59

Yves is firmly convinced that this divine light cannot be removed by even the disorders of immorality and ignorance. Therefore, he points out that this "infinite goodness" is present even in the midst of "the disorders of the spirit," and it remains victorious "even in the clouds and obscurities which accompany vice."60 Yves believes that it is the innate consciousness of the divine light which explains why so many religions employ the ceremony of lighting a fire before an attar. As he observes:

This, I believe, is what all the religions have desired to communicate by this common ceremony of maintaining a continual fire in front of the altars, like that of the Vestals and the lamp which burned before the Temple of Diana.61

Yves finds a deep symbolism in this archetypal use of fire before an attar. The fire represents the light of the divine which continually guides the hearts and minds of humans in the course of this life. If he were aware of them, Yves, no doubt, would make mention of the tire sacrifice in Hinduism and the sacred fire of Zoroastrianism. Yves seems to attach the same importance to these burning flames placed before non-Christian altars that Paul discovers in the attar to the unknown God in Athens (Acts 17:2324). Like Paul, Yves believes that these pagan altars correspond to an inner sense of the divine that all humans have by nature.

For Yves de Paris, the evidence for the natural awareness of God is manifest in the design of human nature. He is overwhelmed with awe at the presence of the divine in even the most disordered human souls. Thus, he ends chapter III with this meditation:

0 infinite goodness which so softly moves even the most wretched inclinations, what favors could those who worship you not hope for? 62

The Awareness of God does not Come from Opinion

In chapter IV, Yves attempts to show the error of the sceptics who maintain that the awareness of God is simply a matter of opinion. The title of this chapter is: "The awareness of God does not come from the opinion of people." 63 Yves senses a real danger from the Pyrrhonians (les pyrrhoniens) 'who make a science of doubt and who maintain that in all things the affirmation is just as true as the negation "64 Following this logic, these sceptics make the awareness of God simply a matter of convention for which "the times and numbers lend authority."65 Yves makes up his mind to combat this "pernicious proposition" by the use of several key propositions.

Yves first points out that the mere fact that the awareness of God is universal among all nations is sufficient to demonstrate that it could not come from opinion. He explains that opinion lacks this type of universality since it "is never in vogue, except in one city or one kingdom." Furthermore, opinion has definite limits since "one people prides itself in being separate from one mode and one belief while another merits a distinction of honor from it." 67 Yves notes that "styles of dress, festivals, honors, laws are all the effects of opinion" and that they are "more different among foreign nations than their climates and attitudes."68 However, if the awareness of God were simply a matter of opinion or convention, then it would be impossible to recognize any point of resemblance with foreign peoples on this matter. Belief in God would not be any more enduring in the world than 'fashions, twists of fate and the imaginings of folly."69

At this point, Yves challenges his opponents to provide evidence of any newly discovered people who are without any awareness of God. He also cautions that one should not mistake a lack of outward religious expression for a lack of an awareness of the divine:

If the primitives (sauvages) have no ceremonies, temples or sacrifices, that does not mean that they do not carry the awareness of God inside the soul in such a way that it could fail to be discovered by those lacking a great familiarity with them.70

Yves argues that devotion to God can be very difficult to detect in a people one only superficially encounters. In some cases, he points out, the awareness of God is honored by an interior devotion which goes beyond the need to offer sacrifices:

Since the devotion believed to be the most sublime reaches a point in which there is no need to offer any sacrifices except those of the heart, natural piety rests on this principle: to worship God with the mind alone and to recognize Him only by means of an instinct which is prior to the discourse of reason.71

Here Yves reestablishes his argument from common consent on the principle that the deepest awareness of God cannot be detected on an external basis. His point is that those who claim that there might be some people without any religious convictions fail to understand the nature of the consciousness of God. These people are also guilty of faulty logic since they try to argue from an exception (which is undemonstrated) to a rule. Yves offers the comparison of concluding that all creatures are birds of prey by a sole encounter with a vulture. Such logic would place swans and quail and other birds in the same category as the vultures. As Yves writes:

Nature has its monsters and its prodigies which do not follow the customary productions, and laws which are universally accepted have their rebels. Likewise, we can recognize a man who denies God either by folly, ambition or the influence of self-delusion in order to give license to all of his crimes; but never would we find an entire people living Inside this blindness.72

From this, Yves concludes that the awareness of God is "natural to the human mind even if there are a few who are ignorant of it."73 Yves believes that the more we consider the matter the more we recognize that the inclination to worship God is "universal among all humans and that it is a property inseparable from our species."74 Yves also indicates that thoughtful and wise people usually are the most devout:

The sages who carry souls free from the errors of people have been the greatest worshippers of God, since they follow the light of instinct and of judgment whereas opinion can only be lost in darkness.75

Yves believes that the truly wise always recognize the importance of devotion to God. Moreover, he suggests that even a child raised without proper religious training would still carry an innate consciousness of God. Such a child would "conceive of some infinite being above the world and he would humble himself under its power and give recognition to it by acts of interior adoration without calling it by the name of God"76 Yves also maintains that such a child, upon reaching the age of reason, will be naturally moved towards piety if given any type of exposure to it in adolescence. This is why "people ordinarily consecrate themselves to God at this first age."77

Yves is supremely confident of the strength of this natural awareness of God as well as its universality. Just as nature has arranged all the elements to serve certain functions, so also has God arranged the human mind in such a way that it cannot help but experience the influence of the divine. Therefore, Yves observes:

Having placed an awareness of the divine in the human heart as an inviolate law, it [nature] will give so much resolution for maintaining it so that all public or private interests yield to this single enterprise.78

Yves goes on to point out that there is no power stronger in society than religious devotion. Religion is "capable of arming fathers against their children, of destroying alliances and making people profligate with their blood and their possessions."79 Yves observes that even the pretext of religion is "a powerful machine which can undermine the foundations of a monarchy."80 Thus, an oracle can stop a battle because people have fear of disobeying a divine command. Moreover, the religious instinct is so strong that many horrible things can be explained as the religious impulse gone astray. As Yves relates how

One has seen in the heat of paganism mothers who have have taken the children they are nursing and have made them sacrificial victims on the agar, and with a forceful piety listen with pleasure at the cries of these poor little innocents who burn between the hands of idols.81

Rather than seeing such horrors as a reason for discrediting religion altogether, Yves interprets such acts as an indication of the power of the religious instinct. As Yves explains: Just as fever and frenzy come from an excess of natural heat which at the correct temperature is the first cause of health so also come these enraged adorations, born of the corruption of morals and the intemperance of humanity, from the sense of religion. 82

Yves' ultimate point is that the power of the religious instinct is not something that can be explained away as opinion or convention. Rather, it is a natural impulse which can express itself even in those distorted ways which are forged by human weakness. If it were only a matter of custom, one would not find such passionate devotions and ascetical practices. Thus, Yves feels that he has sufficiently established his thesis that the awareness of God is not something explicable as either a social invention or an opinion. Yves acknowledges that the religious impulse is sometimes carried to intemperate extremes, but as he explains:

There is intemperance in these sacrifices, but it is founded on this celestial awareness that there is a God to whom we are obliged for all that we are and for whom we do not know how adequately to recognize his majesty by all the oblations of our fortunes and our persons.8

According to Yves, the power of the religious impulse is so strong that the only adequate explanation that can be given for it is the impression of the divine upon human nature. As he points out: "Without this impression [of the divine], man would not carry himself with so much ardor into actions that carry away his satisfactions and place the body and the mind in servitude, without any hope of deriving human advantages."84 It is only because human nature has such a deep and firm impression of the divine that people are willing to give up their very lives for a religious conviction. Moreover, Yves contends that the religious instinct is not something forced upon humans from without but rather something that emerges from within the deepest recesses of human nature. For Yves, there is nothing in nature which is not ordered towards some real purpose. As he explains, nature "does not impose either torments or slaveries: but on the contrary, it employs all its efforts and all its industries for the conservation of liberty."85 In the final analysis, the religious impulse, manifested even in its distorted forms, clearly shows that the Instinct to worship a higher belng Is not a matter of opinion but of the very nature of what it means to be human.

The Awareness of God does not Come from Human Authorities

Chapter V is concerned with refuting another explanation for the origin of the awareness of God. Yves tries to expose the error of those who claim that the awareness of God is an invention of princes, kings or other rulers. Yves does not hesitate to tell us how he feels about this line of reasoning:

But I find the extravagance also criminal and not very reasonable of those who explain this consciousness of the divine as the invention of princes who, as they say, thrust the fear of a powerful divinity unto the populace in order to make them pliable to the observances of laws, conserve public homage, avoid the menace of vengence...and acquire profits without being subject to the scorn that follows great severity.86

Yves finds such an explanation to be part of "the clouds with which the libertines conceal the truth from our age."B? He feels that this argument is "a demonstration for weak minds," and that a correct exercise of reason cannot help but conquer "this conjecture."88 Yves points out that the desire of princes to dominate and exercise power over the minds of their people is so strong that it would seem strange for them to invent a being more powerful than themselves for the people to serve:

What would be the advantage for them to dissemble a God whose majesty would some as a reproach of their impotence, obscure the brilliance of the scepters and for whom they could only serve as little companions? What would be the advantage of making subjugation insupportable by a plurality of masters? Of killing the courageous by a redoubling of fear? To extinguish the forces and lessen allegiances at the expense of religion?89

In Yves' estimation, the princes would only stand to lose power by the invention of a supreme being. Why would they want to create a being recognized by the people as more powerful than they are? In so doing, the princes would only create "a diversion of respects." They would give the people a sense of "protection from this sovereign being who, being good, will not allow oppressions and tyrannies." Thus, the princes would place their own power in jeopardy if they created the notion of God. This is why "they have deployed all the efforts imaginable to suppress it and....have regarded God as a rival to whom is attached the darkening of their glory and the usurping of power."90

Yves, therefore, thinks that it is absurd to argue that monarchs would create the idea of God as a means of securing the respect and obedience of their people. The course of history actually shows monarchs either directly attacking God or making themselves equal to God. Moreover, the poets, wishing to show the boldness of such designs, "give us a description of the armed giants who packed the mountains together in order to ascend to heaven and expel Jupiter from his emprie."91 Yves also points to several examples from ancient times which demonstrate the same ambition of princes to appropriate to themselves honors which belong only to God:

Several princes of antiquity, seeing themselves as the masters of benefits, life and fortune, changed their palaces into temples and demanded sacrificial homages from people. Ninus sat up altars to his father Bellus and had him called god; Alexander had himself called the son of Jupiter, and the emperors, after having embraced Christianity. still retained a little of this vanity connected with rulers, when among the titles of their grandeur, they attributed to themselves that of divinity.92

Yves provides other examples of how princes and monarchs have tried to give themselves divine qualities. He mentions how such rulers "knowing that it is almost impossible to remove the awareness of God from the minds of the people," have tried to give to the gods the same qualities as themselves so that people would conceive "the gods like the monarchs and the monarchs with the dignity of gods "93 Yves points out that these arrogant rulers have had attars erected to themselves and also had the statues of the gods dressed up like kings so that people would see little difference between them and the gods. Yves also mentions how some of these rulers might actually have deluded themselves into believing that they possessed such divine qualities. Thus, he mentions one emperor who challenged Jupiter to combat in front of his people because of bad

weather. Yves relates how another "threw nets to the bottom of the sea in order to capture Neptune and punish him for having battered some ships with a storm."94

In Yves' opinion, such arrogance on the part of monarchs inevitably leads to tragedy. As he writes:

The insolent ambition of these princes was always ill-fated when taken to such an extreme...the smashing of thunderbolts by giants, the placing of the Prometheans and others into the torments of the lower worlds because of their attacks against the gods: all signify the public hatred and the inevitable misfortunes which overwhelm sacrileges. 95

Having argued his point that ambitious and arrogant rulers can hardly be thought of as the creators of the idea of God, Yves next points out that the wisest rulers have always recognized the power of the divine and have cooperated with it:

The wisest legislators have done like the navigators who take advantage of a a wind they know they cannot overcome and like the doctors who make use of the inclinations of nature In order to facilitate the effects of remedies; seeing that the first and most pure affection of the people is towards God, they win them over by sympathy and have exhibited great zeal for religion by the establishment of the magnificence of ceremonies and the means of sacrifices; thus, they please people by this correspondence of temperament and render them more obedient to laws.96

Yves believes that it is perfectly appropriate for the government to join itself to the purposes of religion provided it does so with proper reverence. In fact, he seems to suggest that such a cooperation between the state and the Church helps to produce the harmony proper to human nature. Instead of seeing the awareness of God as an artifice of rulers, it is necessary to grasp that this awareness is actually the foundation for all true government. Just as the arts build upon nature, so also must the art of government build upon the awareness of God which is natural to humanity. For Yves, this natural awareness of God must be firm because "it is the foundation for all laws: since without it, all forces are weak, counsels are without substance and enterprises are doomed."97

For Yves, the lawyer, human law is based on divine law. The inner consciousness of justice and goodness which exists deep within the human spirit is the result of the natural awareness of God which is present there. The same Is true of all the arts. As Yves explains:

Architecture has not made the earth upon which it lays the foundations of its buildings; agriculture has not fashioned the heavens it makes use of and without whose lights and influences she could not produce any fruits."8

Yves believes that anything of lasting value is only possible because of the natural order created by God. Thus, the best government is one which pays attention to the divine source of all goodness, justice and truth. The truly wise ruler is the one who recognizes that religion reflects what is deepest and most natural to humanity. Thus, the cultivation of religious piety is the surest source of order, harmony and peace within any regime. As Yves writes:

Religion is a general favor from heaven upon which human happiness depends: it renders our spirits calm; it is the common mother of all virtues...it is the bond of civil society and the most effective means princes could employ for the preservation of the power... it is necessary to proclaim that civil administration (police) is reducable to a superior cause, this awareness of God which is its foundation, rule and defense.99

In these lines, Yves reveals to us his political philosophy. The most secure foundation for any regime is the awareness of God. The best rulers are pious and humble. They understand their authority in terms of service to the people, and they also know that they receive all their power from God. Yves explains it this way:

When the lawmakers bring themselves to the awareness that in this common enterprise they receive their laws from the mouth and revelation of God, they suppose as a premise that the people have an innate consciousness of some divinity; and this belief, whose wisdom is infallible, is generously inclined to give laws power and necessity. 100

Yves goes on to point out that while human laws are subject to change, "the laws of nature have so much justice because they are exempt from change."101 According to Yves, the natural awareness of God maintains the same kind of constancy as other laws of nature. Just as -fire rises, the earth rotates from its center, the heavens continue their circular movements and nourish the earth by their intluences,"102 so also is the innate consciousness of God something universal and unchanging. From this Yves infers "that the awareness of God is engraved into the hearts of human beings by the hand of nature, since it is, as we have said, constant throughout all ages and universally received by all peoples."103

By these arguments in Chapter V, Yves believes that he has effectively refuted the claim that the awareness of God is creation of human rulers. His basic point Is that rulers would not invent the idea of a supreme being since that being would be recognized by the people as a higher source of authority than the rulers themselves. Yves also observes that many monarchs, emperors and princes have tried to elevate themselves to the status of the divine, but they have always met with tragedy. Yves' conviction is that the best way for a ruler to win the affections of the people is to cultivate genuine piety for the divine. Since he is confident that all people share an innate consciousness of the divine, Yves feels that only a regime which respects God as the true foundation of justice, peace and goodness can succeed in maintaining harmony and happiness.

The Knowledge of God by Instinct and Reason

In Chapter VI, Yves endeavors to show that "besides natural instinct, we can know God by reason." 104 In this very important section, Yves wishes to show that the human mind can recognize the existence of God through a proper exercise of its rational faculties. His first point is that philosophy must come to the conclusion that God has given the human mind a natural impression of Himself. Yves argues that just as philosophy has recognized that 'there could only be one prime mover.. .we must also judge that there is a God who gives to the human mind this impression of his majesty which is so powerful that it overwhelms the resistances of reason "105 Yves also believes that this "natural light"106 of the divine is operative in the human mind in the very first movements of rational discourse.

Yves, though, is aware that some people seem to be blind to this innate presence of the divine. Therefore, he raises this question:

But how does it come about that man doses his eyes to a light so beautiful that he would deny the rights to heaven to the prerogatives of his nature and that he would sin against the awareness common to all things to show a longing for that which will benefit them? 107

Yves answers this question by observing the way a person can blind himself or herself to the reality of God for the sake of moral convenience. Such a person • raises up clouds to obscure a sun that would expose his deformities; he imposes silence on a voice which accuses him; and he tries to remove himself from a judge who pronounces his condemnation." 108

Yves also suggests that some people may entertain the possibility of God's non-existence as a mental exercise to see if they can arrive at the knowledge of the God's existence by the use of reason alone. These people "let go of a truth which they have acquired by nature in order to discover it afterwards by the use of reason, just as one would release the game for the convenience of the hunt.-'09 Yves admits that if this is the tact that the libertines follow, he does not look down upon them. As he says: "I hold them to be less criminal since their propositions are more the exercises of reason than the delusions of atheism; their judgment has more boldness than sacrilege.'11 However, Yves is convinced that if the libertines make proper use of the gift of reason, all their doubts about the existence of God should vanish. As he writes:

Whether the libertines plunge themselves into the ignorance of this instinct by malice, by weakness or by vanity, God supplies them with what they are lacking: his goodness is directed just to the point of satisfying their appetittes, and if they abuse this first favor. He will follow it with another. It is certain that this truth, that there is a God, changes less by the extravagances of the mind than public laws by particular conventions... Nevertheless, X man turns his eyes away from this light, if he diverts himself from the idea of which he can hardly foresake, and if he obstinately refuses to live under its guidance, God appoints him with reason just as a magistrate will supply minors with a tutor when death, whether civil or natural, has deprived them of the one which their fathers had appointed.111

At this point, Yves begins his examination of how God, in his divine wisdom, has provided two complementary means for humans to be aware of his existence: instinct and reason. If the libertines fail to apprehend God by the instinctual knowledge of the divine, they most certainly should be persuaded by a proper use of reason. God, though, does not wish to force humans to believe in Him. Thus, God "permits man to flatter himself by an appearance of liberty when he [man] convinces himself to only know God by a discourse of reason, even though the divine law is engraved in his heart in such a way as to make this awareness necessary."112

Yves compares the double means of knowing God (by instinct and by reason) to the functioning of the two eyes. Just as God increases our capacity for vision by supplying us with two eyes instead of one, so also does he give us the double vision of instinct and reason in order to increase our apprehension of his reality. Thus, Yves points out that "if is quite appropriate that we combine these two powers of Instinct and reason which work together to insure that we will never be lacking in having a true awareness of the first principle."113

Since these two powers are meant to work together our liberty should serve as "the ornament of our nature without being the occasion of its loss."114 Our freedom should press itself into the defense of the natural awareness of God "just as important cities are conserved by outside citadels and defended by fortifications and by armies'115 However, if we use our freedom to deny the innate consciousness of the divine, disaster is certain to follow. As Yves describes:

For if we want to combat this truth which rules inside our minds, we will find that all of nature will align itself with its cause; since there isn't one little creature which by the formation of its organs, by the marvels of its qualities and powers, does not compel reason to concede that there is a God.116

Yves seems to be articulating here the basic argument from design. However, in a certain sense, he is linking the powers of instinct and reason into an integrated view of the human person. If the human mind should stray from that which it knows by instinct. it will place itself outside the entire course of nature. Nevertheless, even it human reason should disengage itself from the thrust of instinct, the way instinct is operative throughout the whole natural order should convince reason to

concede the truth which it should know by instinct: namely, that there is a God. Yves continues by explaining how these two ways of knowing correspond to two aspects of human nature:

These two manners of knowledge are quite suitable to the two parts from which humanity is composed. For instinct, universal in its outreach, free from place, from time, from corruption, has great ingredients with the eminent qualities of the immortal soul; and reason. slow in its procedure, fallible and subject to alterations, is for us, in regard to God, that which our senses are to material objects. And because living among sensible things, we are greatly inclined to the senses, we can only agree that inasmuch as instinct gives a sudden thought of God which startles us and is instantaneous, reason gives us a progression of certitude tempered by our weakness.117

Yves sees instinct and reason as two complementary modes of knowledge which correspond to our nature as spiritual and sensible creatures. Even though Yves suggests that the knowledge given by instinct is more firm and constant, he still maintains that the knowledge of God by reason has its own special quality and importance. As Yves explains:

This changing light proves quite agreeable to our composite nature; and as the diamond has more brilliance when in motion, truth seems even more beautiful when we recapture its diverse sparklings manifested by the discourse of our reason. 118

According to Yves, instinct and reason mutually enrich and clarify each other. Our instinctual awareness of God gives us an intuitive and emotional grasp of the divine which reason alone could not supply. Reason, in turn, demonstrates to the intellect the beauty, order and depth of the divine presence which is grasped by natural instinct. Yves returns again to the analogy of the two eyes:

It is always two that we will see the same object more distinctly with two eyes than with one: Inasmuch as two eyes joined together can observe more than if they were separate. Just so, the natural instinct which we have of God and reason which persuades us of Him form a perfect clarification in the soul which removes all difficulties and pleases all our inclinations. This instinct is our sun if we know how to take advantage of its influences and its rays. But, due to the vicissitudes of human things, it sometimes passes into its sunset, and removed from our eyes, we discover in its absence all the beauties of heaven; we're given tan thousand lights instead of one; as numerous as there are creatures in the world, so many are the stars which shine upon us and give us the vision of the grandeurs of God. 119

Yves is certain that, even apart from our instinctual awareness of God, reason can discover countless evidences for the existence of God spread throughout the book of nature. Our reason is able to discover in diversity what natural instinct grasps in unity. Yves states that all the colors, beauties and attractions of nature all manifest "the omnipotence of their Lord in the magnificence of their attire."120 Yves also explains that it is only fitting for human reason to search out the source of whatever beauty it encounters in nature:

If we contemplate an object so ravishing, our courtesy and curiosity will only please the desires of nature if we raise up the material reality to the most eminent end it could have in serving the recognition of its creator; and its awareness will impress itself in our minds by a diversity of concepts, infinite in number, in order to apprehend with greater facility, a being infinite in pedections.121

Yves believes that everything in nature, in some way, reflects the beauty, wisdom and power of its creator. God can be discovered even in the smallest creature since it manifests his divine authorship. The human mind should be able to discover the reflection of God in the intricate

designs of nature. Such arrangements of natural beauty can only be explained by a supreme principle of beauty and intelligence. Hence, Yves observes:

Since the world is only created and only adorned in order to be seen; and since we are the inhabitants intended to be its admirers: the rapport between ourselves and [the world] does not allow our contemplation any repose since it will always elevate us to over new wonders. And as the eyes work only for the heart, the mind cannot consider all of [nature's] beauties without the will also being inflamed to the adoration of their source.122

According to Yves, the beautiful things of nature should always lead the mind to ascend to the source of such beauty: namely, God. Although we might wish to call such an ascent spiritual, Yves seems to place such contemplation of nature in the realm of the rational. However, since Yves sees instinct and reason working in intimate harmony, the ability to distinguish the spiritual from the rational is difficult and perhaps unnecessary.

What is clear is that Yves believes instinct and reason form complementary trades of knowing God. His ultimate desire is to lead the the heart and the mind on a mutual journey into the realm of the divine. Thus, Yves concludes Chapter VI with this appeal:

Let us go then into the wonderment of natures tableau; let us remove the curtain which hides its beauty from us; and after admiring the design as a whole and the delicacy of the traits which complete each of its parts, let us give a thousand praises and lift our voices with a thousand profound adoration of the goodness and the wisdom of its creator. 123

Yves returns to the contemplation of God in the beauties of nature many times in La theologie naturelle. Indeed, it is clear that Yves finds the classical argument for the exitence of God taken from the order of the world as most persuasive.1 24 However, it is interesting that Yves links the argument from the order of the world to the idea of the natural awareness of God. For example, in Book 3, Chapter III of La théologie naturelle. Yves argues that we can only appreciate the beauties of nature because God has engraved his image into our minds. As he explains:

But in order to follow the ordinary course of nature and to avoid making her forces useless, it is necessary to employ reason for researching the knowledge of God; otherwise, it would be necessary to reverse the order which has been placed in the world: For since He [God] is an intellectual substance. He has engraved his image on all things according to the capacity of their nature; and since He has created that which represents Him; there must be someone who can know Him.125

In other words, if God had not already placed his image within our minds, we would not be capable of discovering his

presence within the order of nature. However, it is likewise true that God would not have created the world with so much order and beauty unless there were rational creatures capable of appreciating such order and beauty. As Yves writes:

There must be an observer of this eloquence which by the sequence of time, by the forms, actions and movements of bodies pronounces a continual panegyric to its creator; otherwise, these beauties, these spectacles, these magnificent events would be, in a certain sense, useless; creatures would not return to their source, and the world would be fashioned in a type of Ingratitude if humanity is devoid of reason as a means of taking hold of these considerations which unite it [the world] to God. 126

Yves is convinced that God has given humanity the power of reason in order to discover the traces of the divine in the material universe. Yves is also convinced that the ability to recognize the presence of God in the world presupposes the divine image within the human soul. Moreover, this image of God within the soul is so deep that all human beings can be said to possess a natural instinct for the presence of God. Thus, in the final analysis, Yves presents a theological anthropology which relates the deepest aspirations of the human heart as well as the natural inclinations of the human intellect to God as the ultimate source and final goal.

The Origins of Idolatry

If the image of God is present in all humans, why are there so many examples of idolatries and false impressions of God? This is the question Yves tries to resolve in Chapter VII which is entitled: "The origins of idolatries. How the philosophers liberated themselves by reason and how they ascribed false divinities to nature and nature to God"127 Yves begins this chapter with another analogy taken from nature. He points out that just as the clouds sometimes obscure the sunlight so also:

The passions have sometimes produced the same effect in the mind of human beings; when not being able to extinguish the natural light which they have of God, they have produced reflections of his image, and instead of one divinity, they have gone over to the worship of several.128

This is Yves' explanation for the existence of polytheism and idolatry. The natural light of God is distorted but not entirety eliminated. In a similar way. Yves believes that people have also projected the inner sense of God unto material things. Since human nature is attached to material things, it is easy for an individual to squander "the interior awareness which he has of infinite perfection and apply it to mortal things."129

The passions also plays a role in the distortion of the natural awareness of God. Yves goes on to explain how people can give the title of God to whomever or whatever seems more powerful than themselves. This is why so many monarchs have been hailed as gods since these rulers are able to bestow various benefits upon their subjects. Likewise, some people have honored gods who give vent to their distorted passions. As Yves points out, such "depraved people who have made bodily pleasures their sovereign good have built temples to Bacchus, to Venus...and other infamous deities."13g According to Yves, so many pagan deities actually can be understood by the passions they serve. As we are told:

The Egyptians, being fearful by nature, adored venomous and ravenous beasts in order to escape their vengeful actions by the merit of supplication. The Gauls turned to the god More and made sacrifices to him by the effusion of human blood in order to satisfy their warlike temperament. 131

Yves also observes that the deities of various cultures correspond to the character and ambition of their people. As he points out:

The Athenians, who are inclined towards the sciences, present their most solemn oblation to Pallas who they say was born out of the brain of Jupiter and is the god who expresses wisdom. 132

In a similar manner, the religion of the Romans corresponds to their desire to win over the hearts of all the people they conquer. This is why they "dress up altars to gods of all the nations and forge so many We of gods they fear or from whom they hope to be rewarded'133

Yves, though, is convinced that the truly wise ones of every age will recognize the abuses of these religions. Moreover, the enlightened will also attempt to express, in some manner, the truth that there is but one God. For Yves, the impetus to move from polytheism to monotheism is comparable

to the move from the disorder of a popular state to the security and order of a strong monarchy. Thus, he believes that:

These ridiculous and sacrilegious extravagances of religion form a powerful reason for sages to take notice of the abuse and depart from the superstition of these fanciful divinities.134

Yves points out that the true philosophers transcend the religious abuses of their age and recognize the truth of the one God. This Is usually done by including all the gods within the realm of nature and then recognizing nature's dependence on one divine principle. As Yves explains:

This is why the true sages, after having reduced all these fanciful divinities to nature, will finally refer (rapponerent) nature to God. They will say that this great number of gods signifies the diverse effects of one infinite power and of one sovereign principle who includes within the unity of its being all the perfections shared among all inferior things.135

Yves notes this movement in all true philosophy towards a transcendent unity behind the multiplicity of phenomenal reality. He refers to Augustine in support of this idea as well as the Roman philosopher, Seneca. As Yves points out, Seneca:

Makes long Invectives against those who reduce those qualities which fill life with happiness to nature and not to God. Nature, says this philosopher, is the order in which all things act, and it is maintained in this world according to the law it has received from the first principle.t96

Besides Seneca, Yves makes mention of other great philosophers like Plato and lamblichus who understand the many pagan gods as symbols or representations of the one divine power. Such sages recognize Neptune as the name for the divine force governing the sea. Mercury is understood as "the sovereign reason which speeds through the guidance of the world."137 As Yves observes:

Finally, you can give as many names as there are diverse subjects upon which [God) deploys his power and honor Him by as many titles as his munificent hand gives us favors. But it is only the same giver under the different qualities, and these particular acknowledgements are the articles of the general obligation we all have towards Him for our lives and our desitinies.138

Yves finds a similar recognition of the divine unity hidden behind the multiple deities in the ceremonies of the ancient priests of Egypt towards the god, Pan, 'who signified all things in his name just as they represented them in his figure"139 Likewise, in ancient Judaism the high priest wears a mysterious cloak with various colors and symbols representing diverse stars, rocks and signs of the Zodiac. Yves mentions that the Jewish philosopher, Philo, interprets this tradition as the high priest carrying all of nature with him and returning all of nature back to God. Moreover, the high priest would inscribe the name of God on his countenance (front) in order to show "that the world depends more on God than the life and guidance of the body on the head."14o

Yves concurs with Philo that the entire world of nature must be referred back to the single power which created and sustains it: namely, God. As far as Yves is concerned, no other explanation is possible:

It belongs only to a sovereign unity to maintain the differing beings in their composition; to an infinite goodness to animate the imperfect material of this inexplicable diversify of forms; to an eternity to give constantly to the mortal being the vigor to conserve its species by the succession of generations. All things move and continue in their duties in obedience to [God's] decrees; the massive celestial bodies and elements become small and docile to the strict observance of the law He has established for them when He endowed them with existence.141

Yves believes that all human beings should be able to recognize the power of God behind the complexity, order and beauty of the universe. For Yves, it is comparable to a stranger who enters into a new city in which everything operates smoothly. After such a stranger observes 'the goodness of its appearance... the beauty of its places, the grandeur of its buildings... the good faith of its commerce, the modesty of its arms, the equity of its justice," he will ask "what is the cause of such a great intelligence that even contrary dispositions and possessions all work towards the public good.'142 If this stranger is told that such peacefulness Is due to the law, he will not be satisfied. He would still want to know who is the prince "who rules this state and whose wisdom is the principle of its laws and under whose authority emerges the spirit with the power of subjecting minds to obedience."143 In a similar way, when we observe the harmony which exists within the complexity of nature, we are ultimately led to a recognition of God. As Yves writes:

But as the law of the state comes from the prince on whose authority it depends: so also the law of nature must also be referred back to the sovereign wisdom of a God who has established It and whose infinite power maintains the order in spite of the rebellion of contrary parts...Just as the effect cannot be without the influence of a cause...one cannot admire nature and not adore God.144

This passage brings Chapter VII of La théologie naturelle to a close. These first seven chapters provide Yves' fundamental arguments for the innate consciousness of God. In Chapter VIII and following, he moves to the consideration of the order, beauty and harmony of creation as an argument for the existence of God. Although interesting and expansive, these sections do not add to the basic argument from the order of the world which Yves expresses in chapters VI and VII. Since our focus is on Yves' understanding of the inward natural awareness of God, we need not give a detailed exposure of all four volumes of La théologie naturelle. However, since the notion of an innate consciousness of the divine is central to Yves' overall apologetic, it should be helpful to summarize the entire scope of the four volumes.

The Scope of La theologle naturelle
Each of the four books or volumes of La théologie naturelle is divided into either two or three parts. The division of these books into the various parts helps give us an idea of the massive scope of the entire work. The divisions are as follows:

Book One
Part 1: On the Existence of God Part 2: The World is not Eternal but was Created by God.

Book Two
Part 1: God is the Creator of Things Visible and Invisible; On the Immortality of the Soul
Part 2: On the Nature and Existence of Angels

Book Three
Part 1: On the Perfections of God Part 2: On the Providence of God Part 3: On the Justice of God

Book Four
Part 1: On Religion
Pan 2: The Christian Religion is the True Religion
Part 3: On the Mysteries and Practices of the Christian Religion.

The breadth and scope of this outline helps us see La théologie naturelle as a type of summa of the major themes of Christian philosophy and theology. Yves' desire is to use reason to clarify the truths of the faith and provide an overall apologetic for the Catholic religion. The second part of Book

One, for example, tries to show that it is unreasonable to think of the world as eternal. Because the world is contingent (since it is not necessary for it to exist) and because neither its composite nature nor its changeability are signs of eternality, the only reasonable conclusion is that God created the world from nothing. Yves then goes on to explain that God created the world freely and without any offense to his immutable nature. Yves also points out that the world is an image of God, and that the imperfections that we perceive in no way detract from the divine perfection. It is only due to our ignorance and blindness that we fail to appreciate how all the contrary aspects of the universe fit into the overall plan of divine Providence.145

For Yves, creation is a theophany, a manifestation of God's own nature. Thus, we read: "Since God has his own perfections as the principle object of his love, He diffuses Himself into the world which is his image "146 Yves goes on to describe how in the cosmos God's "unity is represented by the harmony of the elements and the species; by the sympathies and by that intimate union which out of an innumerable diversity of parts forms but one world."1 47

Yves' argument for the immortality of the soul in Book Two parallels his argument for the natural awareness of God. He proceeds by showing the human person to be the highest of the animals and the summit of the material world. Yves then develops the evidence of a common consent for the immortality of the soul from various philosophers and cultures. He next raises the question of the origin of such a feeling and desire for immortality. Yves points out that the human will is not satisfied by any finite good. Yves then concludes that since human belngs have a natural desire for immortality and since nothing finite and material can satisfy the will, then reality must provide in some way for the ultimate fulfillment of this innate desire and sense of immortality. Therefore, the immortality of the soul is real and not imaginary.

The second part of Book Two deals with the existence and nature of angels. This section is interesting because it reveals the sense of order, harmony and hierarchy that is found in Yves' cosmology. Yves understands angels to be spiritual intelligences who have no bodily or material composition at all.148 The glory of the angels consists in their being spiritual images of the immensity, power and wisdom of God, their creator.

The angels exist in a series of three hierarchies which are each composed of three orders. According to Yves, the three hierarchies correspond to three modes of contemplating God.149 In the first hierarchy composed of Seraphims, Cherubims and Thrones, God is contemplated, worshipped and served in his essence as divine love, wisdom, eternity and immutability. In the second hierarchy composed of Dominions, Virtues and Principalities, God is contemplated, worshipped and served as creator and sustainer of the universe. In the third hierarchy composed of Powers, Archangels and Angels, God is contemplated, worshipped and served as the creator and sustainer of particular choices.

Yves' angelology reveals a cosmic view of order and harmony which follows a Trinitarian pattern. As he explains:

Now we see three levels of elements: fire, air and water and earth (which combine together to form but one globe); solid bodies have three dimensions: height, width and depth. There are three orders in the heavens: the planets, fixed stars and the other spheres (which without light can only be known by movement). God can likewise be considered in three manners: first, as the goodness which He is by essence; secondly, as creator and sustainer of the universe and finally according to the providence and graces by which He assists particular persons. By this, the sages have been able to clarity the truth which they have taken from revelation: that there are three hierarchies of angels which correspond to the three levels of the material world and the three considerations of the archetype.150

What this trinitarian pattern reveals is an essential harmony and correspondence between the macrocosm of God and the angels and the microcosm of the material universe.

Yves also believes in the existence of guardian angels, and he states that it is the understanding of "all the ancient philosophers, of Trismegistus, Plato, lamblichus, Porphry, that God has supplied each person with an intelligence which inspires good counsels, which leads him to the good and diverts him from evil "151 Yves also finds support for belief in prophetic spirits among "the Pythagorians, the Brahmins and the other philosophers of India "152 These examples lend support to Yves thesis that all human beings carry within themselves a sense of the spiritual.

Book Three is interesting because Yves discusses the question of the knowability of God before discussing God's perfections. He points out that God desires to be known by humanity, and therefore, God designs human beings in such a way that makes possible the knowledge of the divine. Yves speaks again of instinct and reason as the two modes of knowing God, and he also mentions ecstasy and revelation as two other ways people can come to know God.

Yves points out that our knowledge of God is confused" because He [God] is incomprehensible and ineffable and because we must adore Him with silence."t53 However, Yves also states "even though God is ineffable humanity can and must search out what are his perfections."154 Yves indicates that there are two principal ways of discerning divine perfections: that of affirmation and that of negation. As he observes:

From this we sensibly discern that there are two ways to know God: in the one we attribute several perfections, like colors, which represent Him; in the other, we simply negate from his essence everything which reason judges not to be harmonious with it.155

This dual method of affirmation and negation is consistent with the scholastic method derived from Pseudo-Dionysius and Aquinas. Like his predecessors, Yves also uses this method to remind us how humble and cautious we must be in our attempt to clarity all of the divine perfections:

All that theology can say by these two methods is less in regard to his infinite perfections than the effects of art compare to those of nature; this is why our mind is never totally satisfied, and if I had all the sublime thoughts that were ever in the minds of the world's greatest people, I would still discover infinite spaces into which I could never arrive; all that conceive of Him, all that I say of Him, is always less than what He is...Finally, we must avow that this sovereign cause is understood better by negations than by affirmations, by silence than by discourse; and it is true to say that if this mysterious silence which instructs the upright minds could be as easily communicated to the rest of our thoughts, our reasonings would be less necessary; but we must at least use words to describe this silence.156

It is with this caution and humility that Yves de Paris proceeds in the rest of Book Three to establish the fundamental perfections of God like unity, Immensity, eternity, immutability, beauty, wisdom and goodness. In his investigations, Yves continually returns to the basic theme of the human mind's ability to discover the reflection of God in the material universe. He also consistenly points out that our awareness of God in nature is only possible because God has impressed his own image upon human nature and because He guides our minds through the influence of the divine light.

Yves constructs his whole theology around the fundamental spiritual vision of the human mind seeking its infinite source. He calls Plato 'that holy philosopher who stated so well the truth that since our hearts "incline towards infinity," they must be elevated "as far as God"157 Yves expresses

the basic Platonic conviction that we are always seeking that supreme goodness which is somehow already present within our souls.

Yves views life as a continual movement towards that object which is "the source, the medium and the end of our happiness "158 This dynamic movement of the mind towards its supreme good is also sensitive to the presence of God in creation since God is "the source, the medium and the end of all things."159

In Book Four, Yves return to some of the themes of Book One. He discusses the nature of religion in all its complexity and diversity. Yves stresses the idea that religion is something natural to human beings since all people possess a natural awareness of God. He returns to the theme of the universality of the belief in a sovereign power. In an effort to support his claim, Yves relates this story:

In writing these things, I wanted to avail myself of one of the fathers of our order, back three months from Canada...I asked him if the people of that country believe in a God and how they adore Him. He told me he had the same curiosity years ago, so that when he arrived in the new surroundings among these barbarian peoples, through the mediation of an interpreter, he interrogated an old chieftan, who was considered to be the wisest, if he believed in a sovereign master who had made the heavens and the earth and who governs the world... These people, although primitive, are naturally moved to discover and choose as their leader the one who can give the best speeches. That is why this primitive man was at ease on this occasion, since he seemed prepared with a long discourse with which he carried on with for a long time, making use of gestures and words which fell into a cadence of well-measured intervals. He said, in summary, that seeing the sky, the earth, the sea, the animals, he judged that all these things must have been produced and sustained by a sovereign power, and he also said that he had received this truth from the tradition of their ancestors.160

The missionary goes on to describe to Yves that these people have various rituals by which they render honor to God and that they petition God in times of need. For Yves, the missionary's report is only one more indication of the universal nature of Is sentiment natural de Dieu.

Christianity Is the True Religion

In Book Four, Yves also tries to demonstrate that the Christian religion is the true one. His basic argument centers around the idea that the true religion could not be of a human origin but must be given by God. Since God is one, he would only establish one religion as the true one. Yves then goes on to provide an apologetic for the Christian faith. Since the times of idolatry were tilled with so many calamities, it is fitting for God to give Himself as the remedy for the troubles of the world. Yves continues with an exposé of the miracles of Jesus, the witnesses of the apostles and martyrs, the miracles of the saints and the progress of the Christian faith during the times of persecution.

Yves' apology for the Christian religion tries to persuade by emphasizing the positive attributes of the Christian faith. He points out the unity and spread of the faith throughout the world.

Yves speaks of the triumphs of the Church and of the sanctity of the Christian religion. He also compares the greatness of Christianity with some other religious traditions. In this regard, Yves reveals a certain degree of ignorance and prejudice typical of his day. For example, Yves mentions that Judaism was established by God, but at this time it is 'most infirm" since it is "without altars, without priests and without sacrifices."161 Yves also points out that the demise of Judaism is evidence of God's abandonment of this religion after the time of Christ. He refers to the Jewish religion as "the ruins of a great edifice which no longer serves the knowledge of what it once was."l62 Moreover, Yves states that all the great prophets had predicted this "general ruin."1 63

Yves' estimation of Islam is no less severe. Influenced by the prejudices of his age, he writes that the religion of Mohammad:

Appropriated unto itself several stories taken from the Bible but only to create a monster comparable to the Egyptian god, Anubis, who had the head of a dog on the body of a man. For this unfortunate sect supposes a God, angels and the immortality of the soul; it speaks of Abraham, Isaac and the other patriarchs but only to serve as a foundation for its abominations which blaspheme against God, which ruin the society of human beings and which makes their condition resemble that of beasts.164

Yves sets up a standard for judging the truth of a religion according to its ability to lead its members to the true awareness of God and to proper morality. As can be expected, he finds the Christian religion to be without equal according to these standards:

In so far as the religions of the Jews and the Turks are not to be followed, it is more urgent for us to return to Christianity which has the most holy and sublime feelings of God that can be imagined...it prescribes the best laws for the regulation of morals that man can live with in the world, since he is a citizen of heaven. If the weaknesses of nature cause him to tall into some sin, it has the sacraments to assist him and to give him grace. Moreover, it is established by the most extraordinary ways that surpass more human prudence: it is confirmed by so many miracles, by the witness of the saints, by the blood of the martyrs: one can see with such clarity the accomplishment of all the prophecies; its [Christianity's] extent, its constancy, its triumphs give us such manifest proofs of a divine power, that one must be devoid of reason to lack the faith after so many powerful persuasions.165

Does this mean that only Christians can be saved? Yves answers this question with the answer-- no. As he explains:

God does not hold so much rigor against the infidel peoples; his goodness exceeds their demerits; and all the doctors remain in agreement that if the barbarians observe well the natural law, it they cooperate with the graces which the divine mercy offers them, then they will receive the particular instructions of the faith necessary to their salvation.166

Here we see the compassionate side of Yves. Even though he remains supremely confident of the truth and superiority of the Christian faith, he cannot accept the thought of God depriving the unbaptized of the beatific vision. As Yves writes:

To plead that these barbarians cannot be elevated to the beatific vision is to accuse God of doing violence to their freedom and of not distributing his graces equally; our own love would fail in this: it would make our sovereign Lord appear cruel when he is just. 167

Yves makes sure to point out that Gods compassion towards Non-Christians does not mean that Christians can leave the true faith without offense. He writes that "we should leave the salvation of other people to the judgment and mercy of God and give our whole effort to the good maintenance of our own."168 The thought of Christians abandoning their faith is offensive to Yves because he knows that they have been blessed with a perfectly holy religion,.. which helps them see the way they should take to go to heaven, which gives them the helps needed for all the necessities of this great voyage and which gives life to the hopes of beatitude by the sublimity of its mysteries.169

The Mysteries of the Christian Faith

The third and final section of the fourth book deals with an examination of the principal mysteries of the Christian faith. In this final part of La théologie naturelle, Yves attempts to show the harmony between the mysteries of the faith and human reason. He understands that these mysteries surpass the ability of the human mind to fully comprehend them. In fact, Yves mentions that he was so held in awe by the prospect of writing about the mysteries of the faith that he was not even certain he should undertake such an enterprise:

This name mystery signifies, it seems, that which ought to be revered with such religious silence that reason would detract from it and that it demands more humility than the exercise of our judgments. This consideration held me a long time in irresolution as to whether I should some day give attention to these matters with natural reason. Fear hold my pen with this thought: that I was attempting the impossible, like touching heaven with the hand, to believe that one could know by reason those things which transcend h. Nevertheless, when I saw all those authors who have treated natural theology also expanding on particular mysteries of the faith as does St. Thomas in a large part of his work against the Gentiles; persuaded myself that I could follow his method...170

Thus, Yves believes that it is permitted to clarify the mysteries of faith by the use of natural reason. Besides the support of theologians like Aquinas, Yves invokes a theological foundation in the Incarnation. As he writes: Since the Divine Word, who is the eternal truth, united Himself to a human nature, He showed us that one can form a marriage of divine faith and natural reason " 000

Yves believes that true theology manifests a fundamental harmony between the natural and the supernatural knowledge of God. As he explains: "Natural reason can be brought into harmony with the divine faith, and that, following St. Thomas, these two lights, which have the eternal truth as their common source, are united and strengthened rather than weakened by their encounter."172 Reason, therefore, can be "a faithful guardian of the fafth."173

Yves proceeds in this section to expound on the various mysteries of the faith like the Trinity, original sin, the birth, death and resurrection of Jesus, grace, the sacraments, the resurrection of the body and the final judgment. Although Yves states that "it is necessary to believe before knowing divine things,"174 his consistent position throughout is one of the ultimate harmony between faith and reason. For example, Yves acknowledges that the Trinity is a mystery given to us by supernatural revelation. However, he also uses natural reason to show how appropriate it is for the Father to pour out his being in the perfect image of the Son. As Yves writes:

God is a perfectly simple essence, but since this is so, and since He has no faults, He must possess all the perfections possible without limit ...Now fecundity is a very great perfection because it supposes a nature so abundant that it can make the greatest donations without becoming impoverished.175

From this insight Vves proceeds to show that Gods perfection of fecundity must involve a production of an essence equal to his infinite nature. Therefore, the production of God "in order to be infinitely perfect, must be infinitely similar to his infinite nature, by an identity that exceeds all resemblances."176

Yves' conclusion is that God must generate a perfect image of himself in order to be supremely perfect in his fecundity. This generation, though, must take place within Himself "because He is perfectly gathered together (recuellly) in the unity of his essence."177 Yves further explains how the Trinity in no involves a threat to the divine unity:

This Trinity of persons is not repugnant to either the unity or the simplicity of God because we only adore but one essence and because the persons hold firmly to his infinite perfection, proceeding

from his infinite fecundity which is expressed within Himself without flowing away to the outside (sans secouler au dehors). When the Eternal Father engenders the Word, there is a unity which is repeated; and the Holy Spirit, proceeding from the two, is the bond of their marriage and the expression (terms) of their fecundity.178

This exposition of the Trinity is a good example of how Yves believes reason can be used to show the "inner logic" of the truths given to us in revelation. Since the human mind is illuminated by the same Divine Logos who reveals the mind of God, a proper use of the rational faculties can result in a deeper appreciation and penetration into the mysteries of the faith.

In this final section of Book Four, Yves also tries to show the value and importance of the main teachings and devotions of the Catholic Church. It is clear that he is providing an apology for the richness and depth of the Catholic faith. Yves chooses not to get entangled in a polemical attack against Protestant ideas. Instead, he emphasizes the theological and moral foundations of Catholic traditions like the sacraments, the papacy, devotion to Mary, the communion of saints, the veneration of holy images and the commandments of the Church. It is apparent that Yves' approach is one of irenic persuasion. He wishes to attract not only those who have attacked Catholic devotions and practices but also those Catholics in France who have grown lax in their practice of the faith. For example, in reference to the Church requirement of attendance at Mass on Sundays and holy days. Yves writes:

This sovereign Lord is always imparting Himself and can be found in the host as soon as the priest has made his consecration; heaven becomes promptly present on earth in order to bestow favors upon us incomparably more precious than those given by the Old Law; Alas! The Christian will find it difficult to leave the affairs of the world several half-hours of the week in order to lift up his prayers to this sublime mystery and receive its blessings? 179

Yves desire throughout this section and throughout the entire work is to awaken the hearts and minds of people to the power and glory of God and to show how the Catholic faith supports and nourishes the human desire for God. Towards the conclusion of this book, he explains his intentions:

My reader, this matter of religion is so vast: theology, controversy, contemplation impress me with so much beauty that it was hard for me to make the choice of confining this great subject to one volume; also, have not attempted here to convince all the heretics nor to satisfy all the curious with demonstrations which move right up to the ultimate point of certitude; but I have advanced probabilities which oblige one to make a good judgment of the Christian faith and which dispose minds to receive its oracles with more respect.180

Yves here expresses his humble spirit. His decision to clarify the truths of religion by the use of human reason rests upon the premise that the human mind is illuminated by the light of the Divine Word. Thus, humanity is ultimately dependent upon divine assistance to understand the truths of the faith. However, there should never be any conflict between the truths of reason and the truths of revelation. Yves always speaks from the perspective of unity and harmony. The arguments of the sceptics and the libertines appear to him as not only dangerous but also foolish.

For Yves, the human mind is so innately disposed to the light of God that to claim (like the sceptics) that reason cannot discover or support divine truth is a contradiction of the very nature of humanity.

The major ideas of La théologie naturelle should now be clear. Yves believes that all human beings possess a natural awareness of God, and this Innate consciousness of the divine helps guide the

human mind to the truths of revelation Moreover, human reason, properly disposed, can help in the elucidations of the mysteries and practices of the Catholic faith. There are certainly many critical issues that can and should be raised regarding the natural theology of Yves de Paris. The purpose of the final chapter is to explore these critical questions more deeply.

1688
Robert Boyle, Scientist and Theologian
An Inquiry Into The Final Causes Of Natural Things
Book

Link at Google Book

Chapter I

Section I
Here I propose to deliver my thoughts upon these four questions.
1. Whether, indefinitely speaking, there be any final causes of things corporeal, knowable to men?
2. Whether, if that question be believ'd in the affirmative, we may consider final causes in all sorts of bodies, or only in such as are peculiarly qualified?
3. Whether, or in what sense, the acting for ends may be ascribed to an unintelligent and inanimate body?
4. And lastly, how far, and with what cautions, arguments may be framed upon the supposition of final causes?

To begin with the first question. Those who would exclude final causes from the consideration of the naturalist, seem to do it, either because, with Epicurus, they think the world was produced by atoms and chance, without the intervention of a Deity; and, consequently, that 'tis in vain to seek for such causes: or because, with Des Cartes, they imagine, that God being omniscient, 'tis rash and presumptuous for men to think they know, or can discover what ends he propos'd to himself, in his creatures. The supposition on which the Epicureans have rejected final causes, has been disallow'd by the philosophers of almost all other sects; and some have written sufficient confutations of it: I shall, however, in the progress of our work, make such occasional observations, as may serve to discredit sound reasonable an opinion. But the Cartesian argument having been so prevalent among learned and ingenious, men, I shall bestow the more pains in the consideration of that.

One thing, perhaps, that kept so great a philosopher as Des Cartes, from allowing the consideration of final causes in physics, was, that the school philosophers, and others, are apt to propose it too unwarily; as if there were no creature in the world, that was not solely, or chiefly design'd for the service of man. And, indeed, I have seen a body of divinity, publish'd by a famous author, wherein he urges this argument for the annihilation of the world,- " That since the world was made for the sake of " man, in his travelling capacity; when once man is possess'd of his everlasting state of happiness, or misery, there will be no further use of the " world. " The opinion that gives rise to such presumptuous and unwarrantable expressions, was, as I conjecture from his objection, very shocking to Des Cartes; but the indiscretion of men ought not to prejudice truth, which is not to be thrown away with the groundless conceits that some people have pinn'd upon it.

Since then, I cannot close in either with the doctrine of the Epicureans, or Cartesians, I shall leave each party to maintain its respective opinion, and proceed to declare my own: but, to clear the way, 'tis necessary to premise a distinction.

In speaking of the ends which the author of nature is said to have things corporeal, any of these four particulars may be signified.

First, Some grand and general ends of the universe; such as exercising and displaying the creator's wisdom; the communication of his goodness, and the admiration and thanks due to him from his intelligent creatures, &c. And these ends, because they regard the whole creation, I call the universal ends of God, or nature.

Secondly, In a more restrain'd sense, the ends design'd in the number, fabric, situation, and motion of great masses of matter, that make large parts of the world; since 'tis very probable, that these bodies, such as the fun, moon, fix'd stars, and the terraqueous globe, were so framed, and placed, as not only to persevere in their own present state, but also to conduce to the universal ends of the creation, and the good of the whole, whereof they arc considerable parts. Upon which accounts, these ends may be call'd cosmical, or systematical; as they regard the symmetry of the great system of the world.

Thirdly, ends that more peculiarly concern the parts of animals, and, perhaps, plants too; or those to which the particular parts of animals are destined for the welfare of the whole creature, consider'd as an entire and distinct system of organiz'd parts, design'd to preserve himself, and propagate his species, upon that stage to which his structure, and circumstances determine him to act his part. And these ends, to distinguish them from others, may be call'd animal ends.

Lastly, The same expression, may signify another sort of ends, which relate particularly to man, may be called human ends and are those aimed at by nature, where she is said to frame animals, vegetables, &c. for the use of man. And these ends may farther be distinguish'd into mental and corporeal, not only as man is an animal framed, like others, for his own preservation, and the propagation of his species; but also, as he is made to have dominion over other animals, and works of nature, and fitted to make them subservient to his purposes. This distinction being thus settled, as well from the vulgar notion of final causes, which, allows of none but those we have call'd human ones; as from theirs who wholly reject them all.

'Tis an acknowledg'd principle of the Cartesian philosophy, that there is always the same quantity of motion in the world; because, say they, there is no reason why God, who is immutable, should, at the beginning of things, have given such a quantity of motion to matter, as should need to be afterwards augmented, or lessen'd. But do not those who employ this negative argument, take upon them to judge of the ends that God may have proposed to himself in natural things? For, without supposing - that they know what God design'd in setting matter in motion, 'tis hard for them to shew, that his design could not be best accomplished by sometimes adding to, and sometimes taking from the quantity of motion, he originally communicated to matter. And, I think, it may be worth considering, whether by this doctrine of theirs, the Cartesians do not more take upon them, than other philosophers, to judge of God's designs. For, is a man be known for very wise, and to have various ways of compassing his several ends; he who, seeing some of those ways have a direct tendency, to a rational end, shall conclude that end to be one of the number intended, expresses more respect to that man, than he who should conclude, his end cannot be such; and that he has no other design knowable, except the general one. And, indeed, it seems more easy to know, that a particular end, for which an engine is proper, may, among others, if it ended by the artifices, that never so skilful; than to know negatively, that he can have no other than such a certain end.

How will a Cartesian be sure, that among the many ends he grants God may have proposed to himself, in the production of his mundane creatures; none; j& not, that we, whom he has made intelligent Beings, and capable of admiring and praising him, should find just cause to do so, for the wisdom and goodness" he has display'd in the world? Which attributes we could not well discern,

and celebrate, unless we knew that the creatures were made for such uses, and that they are exceedingly well fitted to them. God's immutability is, indeed, alledg'd to prove, that the quantity of motion never varies; but to me 'tis not evident why God's having particular ends, tho' some of them seem to require a change in. his way of acting in natural things, must be more inconsistent with his immutability, than his causing many things, decreed from eternity, to be brought to pass in process of time. And, particularly, it seems not clear, why God may not as well be immutable, tho' he should sometimes vary the quantity of motion in the world; as he is, tho', according to the opinion of most Cartesians, he daily creates multitudes of actuating rational fouls, to unite them to lifeless human bodies. I say not this, as if I absolutely rejected the Cartesian doctrine about the continuance of the same quantity of motion in the whole mass of matter. For whether that be true or not, 'tis no un-useful, or improbable hypothesis; and I have not so much argued against that, as, upon the same grounds they argue for it.

To come then to the thing itself; M. Des Cartes objects, that 'tis a resumption in man to pretend he is able to discover the ends that the omniscient proposed to himself in the making of his creatures. Now I consider, by way of answer, that there are two very different ways, wherein a man may pretend to know the ends of God in his visible works;. for he may either pretend to know only some of God's ends in some of his works, or he may pretend to know all his ends. He who presumes to discover God's ends, in this latter sense, will scarce be excused from a high presumption, and no less a degree of folly. But to pretend to know God's ends, in the former sense, is no presumption; and, to take notice of them, rather a duty. For there are some things in nature, so curiously contrived, and so exquisitely fitted for certain operations and uses, that it seems little less than blindness in him who acknowledges a most wife author of things, not to conclude, that, tho' they may, perhaps, have been design'd for other uses, yet they were also design'd for these. Thus he who considers the admirable fabric of the coats, humours, and muscles of the eye, and how excellently all the parts are adapted to compose an organ of vision, can scarce help confessing, that the author of nature intended it should serve the animal, to which it belongs, to fee with. The Epicureans, indeed, who believe the world to have been produced merely by a casual concourse of atoms, may have a kind of excuse, which other philosophers, who acknowledge a deity, want. Thus, the very supposition, for instance, that a man's eyes were made by chance, argues, that they need have no relation to a designing agent; and the use that a man makes of them, may be either casual too, or at least an effect of his knowledge, not of natures. But when, upon the anatomical dissection, -and the optical consideration of this part, we find it to be as exquisitely fitted for an organ of sight, as the best artificer could have framed a little engine, purposely design'd for the use of seeing; it sounds very harsh to say, that an artificer, who is too intelligent to do things by chance, or to make a curious piece of work, without knowing to what purpose, should not design it for an .use to which 'tis wholly adapted.

"Tis possible, indeed, he may have design'd more uses of it than one, and, perhaps, such as we cannot find out: however, among its several uses, this, ^/W to which we fee it so admirably adapted, should be thought one. And I see not how it magnifies God's wisdom, or expresses our veneration of it, to exclude from the number of his ends, in framing human eyes, that most obvious and ready use, which, we are sure, is made of them; and which they could not be better fitted for. Thus, suppose a countryman, brought into the garden of a mathematician, should there see one of those curious gnomonic instruments, that shew, at once, the place of the fun in the zodiac, his declination from the equator, the day of the month, the length of the day, &c it would, indeed, be presumption in him, whilst unacquainted both with mathematics, and the several intentions of the artist, to pretend himself able to discover all the ends for which so curious and elaborate a piece was framed: but, when he fees it furnish'd with a stile, with horary lines, with numbers, and, in short, with all the requisites of a sun-dial; and manifestly perceives the shadow to mark, from time to time, the hour of the day; 'twould be no presumption in him to conclude, it a sun-dial; whatever other uses it was design'd for.

And I demand of those, who will not allow that any natural things are directed to ends knowable by men, whether, if the divine author of them had really design'd them for such ends, the things themselves are not so framed and directed, as in that cafe they ought to be? And whether the fabric and management of natural things do really countenance, or contradict our supposition?

For my part, I confess, I think it no disparagement to the wisdom of any agent whatsoever, to suppose his productions design'd for such ends, among others, as they are excellently fitted for; unless it appear'd that such ends were unworthy the wife agent. But that cannot be justly said in our case; since 'tis not injurious to the divine author of things, to believe that some of the ends, to which he destined several of his corporeal works, were to exert and communicate his goodness; and to receive from his intelligent creatures an ardent love, a high admiration, and an obsequious gratitude for having display'd so much wisdom and beneficence in them.

And, indeed, I can by no means assent to the assertion of Des Cartes, that none of God's ends in his corporeal works are more manifest than others, but that all of them lie equally hid in the abyss of the divine wisdom; for there are many of his creatures, some of whose uses are so manifest and obvious, that the generality of mankind have in all ages, and almost in all countries, acknowledg'd them. And as to what he adds, that, in physics, all things ought to be made out by certain and solid reasons!; I answer, first, that I see not how God's designing some of his works for particular uses, amongst others, is inconsistent with the physical accounts of their creation. Thus, a man may give a mechanical reason of the structure of every wheel, and other part of a watch, and of their way of acting upon one another, when rightly set together; and, in short, of the contrivance and phenomena of the little machine; tho' he supposes •\^>T\J that the artificer designed it to shew the hours of the day, and tho' he has that use in view, whilst he explains the fabric and operations of the watch. Secondly, I readily admit, that, in physics, we should ground all we deliver upon as solid reasons as possible; but there is no necessity that those reasons should be always precisely physical, especially when we are treating not of any particular phenomenon, produced according to the course of nature established in our system; but of the first and general causes of the world itself: from which causes, I see not why the final uses that appear manifestly to have been design'd, should be excluded. And to me 'tis not very material, whether in physics, or any other science, a thing be prov'd by the peculiar principles of that science; provided it be firmly prov'd by the common grounds of reason. And here let me observe, that the fundamental tenets of Des Cartes's own philosophy, are not prov'd by arguments strictly physical; but either by metaphysical ones, the more general dictates of reason, or the particular testimonies of experience. Thus, when, for instance, he truly ascribes to God all the motion that is found in matter, and consequently all the phenomena that occur in the world; he proves it not by a precise physical argument, that God, who is an immaterial a<rent, is the efficient cause of motion in matter; but only hence, that since motion does not belong to. the essence and nature of matter* matter must owe its motion to some other Being: and then 'tis most agreeable to common reason to infer, that since matter cannot move itself^ but must be mov'd by some other Being, that Being is immaterial; since, otherwise, some matter must, contrary to the hypothesis, be able to move itself. And when Des Cartes attempts to demonstrate, that there is always the same quantity of motion in the universe; and, consequently, that as much motion as one body communicates to another, it loses itself; he proves it by the immutability of God, which is not a strict physical argument, but rather a metaphysical one; as he had before prov'd, that God was the cause of all motion in matter, not by principles peculiar to physics, but by the common grounds of reason.

But tho' Des Cartes speaks very dogmatically and universally against men’s pretending to know any final cause in natural things j yet shave met with a passage in his writings, where he seems to speak more cautiously, and opposes their opinion, who teach, that God had no other end in making the world, than that of being praised by men. His words are these. " "Tis self-evident, that we cannot

know the ends of God, unless " he reveals them to us; and supposing it morally true, that all things " were made to the end that we should praise God for them; in which sense ** it may be said, that the sun was made to give us light; yet it would be " very childish and absurd to say, metaphysically, that God, like a proud " man, had no other end in making the world, but to be prais'd by men " for it; and that the fun, which is vastly larger than the earth, was *' wholly design'd to give us light, who inhabit but a very small part of the V surface of the terraqueous globe." But he, at the same time, delivers two or three other things, wherein I cannot acquiesce. As, first, that 'tis self-evident, we cannot know the ends of God, unless he himself reveals them V-Z'W^ to us. For what he here says to be self-evident, is not so to the generality of mankind, or even of philosophers; and, therefore, I think it ought not to be barely asserted, but prov'd. In the next place, he does not shew how we are obliged to praise God for his works, if God had no intentions that we should do so, or that we should discover none of the ends for which he design'd them. Isa judicious man should see a book written in some language which he is an utter stranger to, and should know nothing farther of it than that 'twas composed by a very intelligent physician; he might, indeed, conclude, that it was not written by chance; but could not, by inspecting the book itself, be convinced, that it was form'd with great skill and kindness, and deserv'd his praise and thanks; since he was unable to know any of the particular ends to which the several chapters of it were design'd; and, consequently, could not see how well they were fitted to answer such ends. What Des Cartes says, that it is childish and absurd to think God had created the sun, which is vastly bigger than the earth, only to afford light to a small number of men, is somewhat invidiously propos'd; for there are few eminent writers who confine the utility of the fun directly to its affording light to man: and the small bulk of mankind ought not to make it seem absurd, that God may have had an especial eye to their welfare in framing that bright globe; since that most excellent machine, the human body, appears to be a more admirable thing than the sun: besides, the rational and immortal foul that resides in it, is incomparably more noble than a thousand masses of brute unorganized matter can be justly reputed. And since, in this very discourse, our author confesses that we may know the ends of God's corporeal works, if he reveal them to us; a Christian philosopher may be allow'd to think the sun was made, among other purposes, to enlighten the earth, and for the use of man: since the scripture teaches, that not only the fun and moon, but the stars of the firmament, which Des Cartes, not improbably, thinks to be so many suns, were made to give light to the earth, and were divided to all the nations that inhabit it. Perhaps it were not rash to add, that we may know some of God's ends in things corporeal, without lessening our veneration of his wisdom; as we know some of them in other matters, of which the scripture furnishes us with a multitude of instances; as, particularly, 'Job's sacrificing for his friends, and the declared uses of the Urim and Thummim: since God may, if he pleases, declare truths to men, and instruct them by his creatures and actions, as well as by his word. And thus he taught Noah by a rain-bow, and' yonah by a gourd and a worm; and regulated the encampments of the Israelites by the guidance of a cloud, and a fiery pillar. ^Lastly, Des Cartes objects, that those he dissents from, talk as if they look'd upon God as a proud man, who design'd his works only to be praised for them; but I know not whether he herein speaks so cautiously and reverently of God, as he ought, and elsewhere uses to do. For as humility, tho' a virtue in men, is extremely remote from being any of God's perfections; so that may be pride in a man, who is but a creature imperfect, dependant, and having nothing of his own, which wou'd be none at all in the creator, who is incapable of vice, and who may, if he pleases, justly propose to himself his own glory for one of his ends, and both require and delight to be prais'd by men for his works; since he is most worthy of all praise, which it is their duty and reasonable service to pay him.

'Tis not without concern, that I find myself obliged thus to oppose some sentiments of M. Des Cartes, for whom I have, otherwise, a great esteem; for I am not at all of their mind, who think that author a favourer of atheism, which, to my apprehension, would subvert the very foundation of his own philosophy. But, judging that his doctrine, as generally understood, as to the rejection of final causes from the consideration of philosophers, tends to weaken one of the best, and most

successful arguments for the being of a God, whom they ought to admire, praise, and reverence; I think it my duty to prefer an important truth before my respect to any man, how eminent soever, who opposes it; and to consider more the glory of the great author of nature, than the reputation of any of her interpreters.

And to confirm what I have hitherto deliver'd, 'tis remarkable that the excellent contrivance of the great system of the world; and especially the curious fabric of animal bodies, with the uses of their several senses and parts, have been the great motives, which in all ages and nations induced philosophers to acknowledge a Deity; and that the noblest and most intellectual praises have been paid him by the priests of nature; as proceeding from the transcendent admiration rais'd in them by the attentive contemplation of the fabric of the universe, and of the curious structures of living creatures. And, therefore, it seems injurious to God, as well as unwarrantable in itself, to banish from natural philosophy the consideration of final causes; from which, chiefly, I cannot but suppose that God must reap the honour due to those glorious attributes, his wisdom and his goodness. And, I confess, I somewhat wonder, that the Cartesians, who have generally, and some of them with skill, maintained the existence of a Deity, should endeavor to make men throw away an argument, which the experience of all ages shews to have been the most successful, and in some cafes the only prevalent one, to establish, among philosophers, the belief and veneration of God. I know the Cartesians say, that their master has demonstrated the existence of a God, by the innate idea men have of a Being infinitely perfect, who left it upon the human mind, as the mark of an artist impressed upon his work; and that they also ascribe to God the creation of matter out of nothing, and its motion; which sufficiently argue the immensity of his power. But tho' I would by no means weaken the argument drawn from the innate notion of God, since many learned men have acquiesced in it; yet why may we not reasonably think, that God, who has taken care men should acknowledge him, may have also provided for the securing a truth of so great consequence, by stamping characters, or

leaving impressions of his wisdom and goodness, as well externally upon the world, as internally upon the mind? The bare contemplation of the V»/^VN^ fabric of the world, without considering any part of it as destined to certain uses, may still leave men unconvinced that there is any intelligent, wife, and provident author and disposer of things; since we fee, the Aristotelians, notwithstanding the extent, symmetry, and beauty of the world, generally believed it to have been eternal. And tho' they did not allow it . to have been created by God, yet because they asserted that animals, plants, &c. act for ends; they were obliged to acknowledge a provident and powerful Being, that maintain'd and govern'd the universe, which they call'd Nature; tho' they often dangerously mistook, by confounding this Being with God himself; and at other times speaking of it as coordinate with him; as in that famous axiom of Aristotle," God and nature " do nothing in vain." I acknowledge, therefore, that as I set a just value upon the Cartesian proof of God's existence; so I see no reason why we should give up any other strong argument, that proves so noble and important a truth j especially since the Cartesian way of considering the world, tho* very proper, indeed, to shew the greatness of God's power, does not, like the way I plead for, manifest that of his wisdom and beneficence. For while a Cartesian only shews, that God is admirably wise, upon the supposition of his existence; the same thing is manifested in our method, by the effect of a wisdom as well as power, that cannot reasonably be ascribed to any other than a most intelligent and potent Being: so that by this means men may, at once, be brought to acknowledge God, to admire him, and to praise him.

Section II

BEFORE I proceed to the second question; Whether we may consider final causes in all sorts of bodies, or only in such as are peculiarly qualified? I must divide natural bodies into animate and inanimate. The former term I here take in the larger sense, to comprehend not only animals, but

vegetables, tho' I shall not reject the opinion of those, who are unwilling to allow plants such a soul or life, as is confessedly granted to animals.

Of the inanimate bodies of the universe, the noblest, and those which chiefly deserve to be consider'd on this occasion, are the fun, planets, &c For when men saw those vast luminous globes, and especially the sun, to move so constantly and regularly about the earth j diffusing thereon both light and heat, and by their various revolutions to produce day and night, summer and winter, and the vicissitudes of seasons; they concluded, that these motions were guided by some divine Being, and design'd for the benefit of man. Whether this be a demonstrative proof, I shall not now debate; but surely it may carry thus much of probability with it, that in case a man shall think the fabric of the celestial bodies was the production of an intelligent and divine agents the irregular phenomena will not contradict him, since there is nothing in that fabric unworthy a divine author: and the motions V/V^O and effects of the fun and stars may well allow us to think, that, among other purposes, they were made to illuminate the terrestrial globe, and brine heat and other benefits to the inhabitants of it. So that the contemplation of the heavens, which so manifestly declare the glory of God, may justly excite men both to admire his power and wisdom in them; and to return him thanks and praises for the great advantages we thence receive. On the other hand, it may be said, that in bodies inanimate, whether the portions of matter they consist of, be greater or less; the contrivance is very rarely so exquisite, but that the various motions and occursions of their parts may, without much improbability, be suspected capable, after many essays, to cast one another into several of those circumvolutions call'd by Epicurus, and by Des Cartes, Vortices; which being once made, may continue a long time, after the manner explain'd by the latter. But allowing this hypothesis to be possible; when I consider that we are not yet sufficiently acquainted with the true system of the world, nor usually sensible how small a part the terrestrial globe makes of the universe; I am apt to suspect, that men often assign the systematical ends and uses Of the celestial bodies upon slender evidence; concluding them made and moved only for the service of the earth, and its inhabitants. And tho' I will not deny, that as we actually receive benefits by the established order and motion of the heavenly bodies, so one of the several uses intended by the author of nature, may particularly regard our species; yet perhaps 'twill not be easy to prove, that some of whole bodies and motions are not rather intended for other purposes, than to cast their beams, or shed their influences upon the earth: at least, it seems probable to me, that the situations of the celestial bodies do not afford, by far, so clear and cogent arguments of the wisdom and design of the author of the world *, as do the bodies of animals and plants. And for my part, I think I fee more of admirable contrivance in the muscles of a human body, than in what we yet 'know of the astronomical world: and the eye of a fly, &s far as appears to us, seems to be a more curious piece of workmanship, than the body of the fun itself.

As a noble instance of wisdom and design in the situation of the planets, take an observation of the great Sir Is. Newton. hose planets, says he, have the greater density, which are placed nearest the sun. Thus Jupiter is more dense than Saturn, and the earth more dense than Jupiter. For it was necessary to place the planets at different distances from the fun, that each "might receive a greater or a less degree of his heat, according to its density. If our earth were placed in the orbit of Saturn, the water of it would be frozen up; and if in the orbit of Mercury, 'twould presently exhale in vapour. For the sun's light, to which his heat is proportionable, is seven times more dense in the orbit of Mercury, than with us; and I have found, by the thermometer, that water will boil with a heat seven times as great as that of the summer’s sun. But the matter of Mercury is, doubtless, fitted for heat; and therefore must be denser than that of our earth: since all dense matter requires a greater degree of heat, to perform the operations of nature.

As for other inanimate bodies, the matter whereof seems unorganiz'd, tho' there be no absurdity in supposing that these were also made for distinct and particular purposes, if not also for human uses; yet most of them are of such easy and unelaborate textures, as to make it seem possible, that

various occursions and jostlings of the parts of the universal matter might, at one time or other, have produced them: since we see, that in some chymical sublimations and crystallizations of mineral and metalline solutions, and other phenomena, where the motions appear not to be particularly guided and directed by an intelligent cause, bodies of as various textures as those are producible.

If it be said, that supposing chance, or any thing else, without the particular guidance of a wise and all-disposing cause, can make a finely-shaped stone, or a metalline substance, growing, as silver sometimes does, in the form of a plant; ought we not to allow, that chance may also make vegetables and animals? I can by no means grant the consequence. For there are some effects so easy, and readily to be produced, that they do not infer any knowledge or intention in their causes; whilst there are others that require such a number and conjunction of conspiring causes, and such a continued series of motions or operations, that 'tis utterly improbable they mould be produced without the superintendency of a rational agent, wise and powerful enough to range and dispose the several intervening materials and instruments, in a manner necessary to produce such a remote effect: it will not therefore follow, that, if chance could produce a flight contexture in a sew parts of matter, we may safely conclude it able to produce so exquisite and admirable a contrivance, as that of the body of an animal. What does it argue then, if sometimes, in sawing pieces of variegated marble, we happen to meet with the delineations or pictures of towns, woods, and men? For, besides that the delightfulness and rarity of such spectacles inclines the imagination to favour them, and to supply their defects; would any wise man conclude from hence, that a real town or wood, much less numbers of men, mould be made by such a fortuitous concourse of matter? What comparison is there betwixt the workmanship that seems to be express'd in a few irregular lines, drawn upon a plane, with perhaps two or three colours luckily placed, and the great multitude of nerves, veins, arteries, ligaments, tendons, membranes, ones, glands, &c. required to compose a human body; every one of the numerous parts whereof, must have its determinate size, figure, consistence, situation, connexion, &c. and many, or all of them together, conspire to exercise and perform determinate functions and uses? And, indeed, I never saw any inanimate production of nature, or,' as they speak, of chance, whose contrivance was comparable to that of the meanest limb of the most despicable animal; nay, there is infinitely more art express'd in the structure of a dog's foot, than in that of the famous clock at Strasburg.

And tho' the paw of a dog be far inferior in its structure to the hand of a man, yet even this is inconsiderable, if compared to the eye; the several eyes, and other parts whereof, how numerous soever, could none of them be spared or alter'd, unless for the worse; as may appear from those many diseases observ'd in that small admirable organ: for each of those diseases consists m this, that the humours, or other parts of the eye, are brought to a state different from that whereto nature had design'd it. *T would be tedious to enumerate the several distempers of the eye; wherefore I shall only mention two or three particulars, wherein one would scarce imagine that a small recess from the natural state could bring any considerable or sensible inconvenience. That which we call the pupil, is not a substantial part of the eye, but only an aperture of the eyes; almost perpetually changing its bigness, according to the different degrees of light the eye chances to be exposed to. And therefore, it should seem, that whilst this hole remains open, it performs its office, by giving entrance to the incident rays of light. And yet I lately saw a woman, who, after a sever, was not able to dilate the Papillae of her eyes, as before, and tho' they were but very little narrower than ordinary, yet she complain'd she had thereby almost lost her sight. The preternatural constriction of the pupil is indeed no frequent distemper; yet physicians have given it a place among the stated diseases of the eye. And, on the other side, tho' a competent wideness of the pupil be requisite to a clear and distinct' vision; yet if its dilatation exceeds the due limits, there is thereby produced a distemper worse than the former; because it often almost totally deprives the patient of sight. It may seem also but a flight circumstance, that the transparent coats of the eye should be devoid of colour, and of as little moment, that the cornea should be very smooth,

provided it remain transparent: yet when either of these circumstances is wanting, the sight may be greatly vitiated. Thus we see, that in the yellow jaundice, the adventitious colour wherewith the eye is ting'd, makes the patient think he sees many objects yellow, which are of a contrary colour. And I know a gentleman, who having had a small pustule excited and broken upon the cornea, tho' the eye has long been cicatriz'd, yet a very little inequality or depression, that still remains upon the surface of that transparent coat, so affects him, that when he comes into the open fields, or the streets, he for a pretty while thinks he sees objects very glaring, and as many others as men usually do stones at the bottom of clear water: which I impute to the want of uniformity in the refraction of those reflected rays of light, that fall upon the unequal surface of the cornea. To give a further proof, that the eye was made with design, I shall here take notice of an observation or two, that do not occur in the dissection of that part, and are therefore often unobserv'd by anatomists.

I have found in frogs, that, besides those parts of the eye which they have in common with men, dogs, cats, and most other animals, there is a peculiar membrane or cartilage, which is not commonly perceiv'd; wherewith they can at pleasure cover the eye, without too much hindering the sight, because the membrane is both transparent and strong; so that it may pass for a kind of moveable cornea, or occasional safe-guard to the eye. In furnishing frogs with this strong membrane, the providence of nature seems very conspicuous; for, they being amphibious creatures, design'd to pass their lives in watery places, which, for the most part] abound in plants, endow'd with sharp edges, or points; and the progressive motion of this animal, being not by walking, but by leaping, if his eyes were not provided with such a case, he must either shut them, and so leap blind-fold; or, by leaving them open, must run the risk of having the cornea cut, prick'd, or otherwise offended; whilst this membrane, as was said, is like a kind of spectacle, that covers the eye, without taking away the sight: and as soon as the occasion for it is over, the animal withdraws it into a little cell, where it rests till its use be again required. This membrane becomes visible, by applying the point of a pin, or any such sharp thing, to the eye of a frog, whilst his head is held steady; for to screen his eye, he will presently cover it therewith, and afterwards withdraw it, upon a removal of the suspected danger. And because many birds are destin'd to fly among the branches of trees, and bushes; lest, by this means, the prickles, twigs, leaves, &c. should wound or offend their eyes, nature hath also given them such another kind of horny membrane, as we find in frogs.

'Tis known that men, and most four-footed beasts, and birds, have several muscles belonging to their eyes, by the help of which, they can turn them any way; and so obvert the organ offense to the object. But nature, not having given that mobility to the eyes of flies, she, in recompense, furnishes them with a multitude of little protuberant parts, finely rang'd upon the convex of their large bulging eyes: so that by means of these numerous little studs, numberless rays of light are reflected from objects placed on either hand, above, or beneath the level of the eye, and conveniently fall upon that organ, to render the objects they come from, visible to the animal; and by the help of a good microscope, and a clear light, some hundreds of these little round protuberances may be discover'd, curiously rang'd, on the convexity of a single eye of an ordinary flesh-fly.

But some may here pretend, that all organs of sight ought to be conform'd to those of men; these being the best, and most perfect. And, indeed, man being justly reputed the most perfect of animals, it is not strange he should presume, that his eyes, and other parts of his body, are the best contriv'd of any to be found in nature; yet we cannot, from hence, safely conclude, that all eyes, which, in other animals, are of different structures from those of man, should, for that reason, be defective. For, first, the admirable wisdom display'd by the author of nature, in fitting the eyes, and other organical parts of animals, to their several uses, and the respective functions we fee them exercise, may justly persuade us, that the things whose reasons and uses we do not alike

discern, are, nevertheless, most wisely constituted: God having too much knowledge to do any thing unskilfully; and we having to much presumption, if we suppose he had no ends in framing his creatures beyond the reach of our discovery. And, secondly, the eye is not to be consider'd abstractedly, as an instrument of vision; but as an instrument belonging to an animal, that is to make use of it in particular circumstances. And, therefore, it ought highly to recommend the wisdom and providence of the great author of things, that he has furnish'd various species of animals, with organs of sight, very differently framed and placed; since this diversity nobly manifests his great providence and knowledge, in having so admirably suited the eyes of all animals, both to the rest of their bodies, and to those parts of the great theatre of the world, on which he design'd they shall live and act. Thus, tho' several beasts, as horses, oxen, &c. have their eyes furnished with a seventh muscle, besides the six they share in common with men; we must not conclude, that either the organs of vision are imperfect in men, or that those of these beasts have something superfluous: for they being to feed, for the most part, on the grass of the field; and that they may the better chuse their food, being obliged to turn their eyes, for a long time together, downwards j the seventh muscle excellently serves them for that purpose, by enabling them to continue unwearied by such a posture; whilst man, who has no such necessity of looking assiduously downwards, would be only incumber'd by a seventh muscle.

On the other hand, the deficiency observable in the eyes of some animals, compared to those of man, may be ascribed to the just contrivance of nature, that, on most occasions, declines doing what is unnecessary to the particular ends she aims at in the fabric of a part. Thus moles, being destined to live, for the most part, under ground, have their eyes so little, in proportion to their bodies, that 'tis commonly believe they have none at all; but, tho' I have found the contrary, yet their eyes are very different from those of other four-footed beasts; which need not be wonder'd at, considering that nature design'd these creatures to live under ground, where sight is of no use; and where large eyes would be more expos'd to danger: besides, their sight, as dim as it is, serves them to perceive when they are no longer underground; which seems to be the most necessary intelligence they want from their eyes.

Tis observed, that the organs of vision in a camelion, are of a very uncommon structure; since, to omit other considerable peculiarities, his eyes often move independently on each other; so that, for instance, he can look directly forward with the right eye, and, at the same time, directly backward, towards his tail, with the left; or may turn the pupil of the former strait upwards, whilst the other is turn'd directly downwards. This peculiar power seems to have been granted him by providence, that as he is a very low animal, and destin'd to live, for the most part, in trees and bushes, and there to feed chiefly on flies; he may perceive them, which way soever they chance to come, within the reach of his tongue, which, being of a great length, he suddenly darts out, and therewith catches his prey.

Many fish have the crystalline humour of their eyes almost spherical; and, consequently, much rounder than it is found in man, and other terrestrial animals. And this difference of figure, tho* it would be inconvenient for us, is very well accommodated to them; since they, living in the water which, as a thicker medium, much more refracts the rays of light than the air, thro' which they pass to our eyes; 'twas fit their crystalline humour should be of that figure, to refract the rays already refracted by the water, and thereby make them converge, so as to paint the images of objects at the bottom of the eye.

Should a person of curiosity survey and consider the various structures' of the organs of vision, in different animals, and compare them with the other parts of the respective animal; the scene he is designed to act on, and the uses each of them is to make of his eyes, in the most ordinary circumstances; he might, doubtless, offer a probable reason of the differences in those organs, which, to a common observer, would seem to be errors, or defects in nature. Thus, tho' the pupil of

the eye be oblong in horses, oxen, and some other quadrupeds, as well as in cats; yet, in the former kinds of animals, it lies transversely from the right side of the eye to the left, whilst, in cats, its situation is perpendicular: for horses and oxen, being usually obliged to find their food on the ground, they the more conveniently receive the images of the grass, &c. in a horizontal view,, by having their Pupil/a transversely placed; whilst cats, being to live chiefly, on rats and mice, which are animals that usually climb, and run upon steep places; the most commodious situation of their pupil, for discovering and pursuing these objects, is the perpendicular. But, to proceed: the different structures, and situations of the eye, in different animals, wonderfully shew a great variety in the skill of the divine author. And, indeed, if I might presume to guess at any of God's ends, that are not manifest; I, should think that the delightful variety, we may. observe, not only in animals themselves, consider'd as entire systems; but in those parts of them which, appear destin'd for the same function.; as particularly, that the organ of vision was design'd, at least, among other ends, to display the great creator's, manifold wisdom; and to shew, that his skill is not confined either to one fort of living engines, or in their parts of the same kind, to the same contrivance; but is able to make a multitude of surprizing organs, all of them curious, and exquisite in their kind, with regard to their different, uses.

To be able to frame clocks and watches, ships, mills, &c. manifests a far. greater skill in an artificer, than the power of making but one of those engines, how perfectly soever he contrived it. And the same superiority of Knowledge would be display'd, by contriving engines of the same kind, or for the same purposes, after very different manners.

Thus weights are of great use and necessity in the famous clock of Strasburg; and therefore it recommends the contrivers of watches, that they give them a very little and portable bulk, which is wanting in the Strasburg machine; and still more, that, they can make a clock without weights, and substitute a spring to perform their office.

And thus tho' it seems absolutely necessary that an animal should be furnish'd. with feathers, in order to fly; yet the wife creator hath shewn, that he is not confined to apply them for that purpose; since a flying-fish is able to move a great way in the air. And the India have lately afforded a sort of flying squirrels, one whereof I saw, alive, at Whitehall. And tho' the flight of these is small, yet there is another kind of animal, without feathers, that long continues upon the wing, and that is the bat; some whereof I have seen but little less than hens: and was assur'd, by a credible eyewitness, that, in the kingdom of Gokonda, he had seen much bigger.

This consideration is alone sufficient to justify the wisdom of the creator, who, being a most free, as well as a most wife agent, men ought not to find fault, if he think fit to recommend his wisdom, by displaying it in very different manners: tho' there are many cafes wherein the less perfect fabric, or situation, of an eye, or other organical part, may be more convenient than the correspondent organ of man, to obtain the ends for which it was given to an animal design'd to act upon its respective stage, and live by its peculiar provision. Besides, an organical part may, in some animals, be intended for more uses than in others; and, therefore, require a different structure: as, in moles, the feet are differently framed, or situated, from those of other quadrupeds; because the chief use they are to make of them, is not to walk upon the ground, but to dig themselves ways under it; provident nature wisely suiting the fabric of the parts to the uses wherein they were to be employ'd: as, a mechanic employs one contrivance of his wheels, pinions, &c. when he makes a mill to be driven by water; and another, when it is to be mov'd by the wind. The camelion has a tongue, both peculiarly shaped, and of a length disproportionate to that of his body, because, as we before observed, he is to take his prey, which are flies, by shooting out that instrument; and could not often, otherwise, approach very near them, without frighting them away. And, in many cases, where this reflection does not so properly take place, we may observe, there is a wonderful compensation made for that which seems a defect in the parts of an animal, of a particular species,

compar'd with the correspondent ones of an animal of some other species. Thus birds, which want teeth to chew their food, are not only furnish'd with hard bills to break it; and, birds of prey, with crooked ones to tear it; but, which is more considerable, have crops to prepare and soften it, and very strong muscular stomachs, to digest and grind it: in which work, they are usually assisted by gravel, and little stones, that they are led, by instinct, to swallow j great quantities whereof are often found in their stomachs. And let it be here observ'd, that chance is really no natural cause, or agent, but a creature of man's own making. For the things that are done in the corporeal world, are really done by the parts of the universal matter, acting and suffering according to the laws of motion, established by the author of nature. But we men, looking upon some of these parts as directed in their motions by God, or nature, and as disposed to the attainment of certain ends; if, by the intervention of other causes, that we arc not aware of, an effect be produced, very different from that which we supposed was intended,- we say that effect was produced by chance: so that chance is indeed but a notion of ours, and signifies no more than K*/^T\J that in our apprehensions the physical causes of an effect did not tend to the production of what they have, nevertheless, produced. And therefore I wonder, that the philosophers who preceded Aristotle, never treated of chance among natural causes.

And as some stones, of the most curious shapes, have embolden'd many favourers of Epicurus to set them in competition with those animals, or parts of animals, from their likeness whereto they have receiv'd their names; we ought to consider, that several learned men have, of late, made it very probable, that these stones were once really the animals, or those parts of them which they resemble, and were afterwards turn'd into stones by the supervention of some putrescent matter, or petrifying cause. And, allowing some of these sorts of stones to be the production of the mineral kingdom; yet it would not clearly follow, that they owe their shapes to chance, since 'tis no absurdity to admit seminal principles in the more elaborate forts of fossils. However, I think it very injurious to make these productions rival the animals to which they are compared. For the shape, in which alone they and the animals agree, being an external thing, is not worthy to be mentioned, in comparison of that wherein they differ; the rude and flight texture of the best shaped stone being immensely inferior to the internal contrivance of an animal; which must consist of a multitude of parts of a determin'd figure, bulk,, situation, &c. as is obvious to those who have seen dissections skilfully made. And 'tis not only in the firm and quiescent parts that this great internal difference between stones, and the animals they resemble, is to be found: there appears a far greater difference between a living animal, and a stone, than any the anatomical knife can shew us betwixt a dead one, and a stone, tho' ever so curiously figured. For there are numberless liquors, spirits, digestions, secretions, coagulations, motions of the whole body, of the limbs and other parts, which are lodg'd and performed in a living body, and are, perhaps, more admirable than the structure of the solid and quiescent parts themselves: so that, tho' a stone, in external appearance very like a shell-fish, were made by chance; yet from thence to conclude, that chance may make a living shell-fish, would be to argue worse than he who should pretend, that because an unskilful smith may make a hollow piece of metal like a watch-case, and fill it with some rude stuff, he must, therefore, be able to make a watch; for there is less difference betwixt the skill expressed in making the cafe of a watch and the movement, than in* making a body like a shell, and the internal parts of a real fish: or, that because putrefaction and winds have sometimes made trees hollow, and blown them into the water, where they swim like boats j therefore the like causes may make a regular galley, according to the laws of travel architecture, man it, steer it, excite and guide all its motions to the best advantage, for the preservation, and various uses of the vessel. In short, if chance sometimes does strange things, 'tis in regard to what she herself, not to what nature uses to perform.

And now, to give my thoughts upon the second question, i. I think l/YV^ he naturalist may draw arguments from the ends and uses of the parts of living bodies, provided he proceeds herein with due caution. 2. 'tis my opinion, that the inanimate bodies here below, proceeding not from seminal

principles, have but a more slight texture; such as earths, liquors, flints, pebbles; and will not sufficiently warrant reasonings drawn from their supposed ends. 3. it seems to me, that the celestial bodies abundantly declare God's power and greatness, by the immensity of their bulk, and, if the earth stand still, the celerity of their motions; and also argue his wisdom, and general providence, with regard to them: because he has, for so many ages, kept such a variety of vast vortices, or other masses of matter in motions immensely rapid, without permitting them to destroy one another, or lose their regularity. And I lee no absurdity in supposing that, among other uses of the fun, and of the stars, the service •of man might be intended; tho' I doubt whether, from the bare contemplation of the heavens, and their motions, it can be cogently inferr'd, -that the chief end of them all, is to enlighten the earth, and bring benefits to the creatures that live upon it.

Revelation

Hitherto I suppose the naturalist to discourse merely upon physical grounds; but if revelation be admitted, we may rationally believe more, and speak less doubtfully of the ends of God, than bare philosophy will warrant us to do. For if God is pleas'd to declare any thing to us concerning his intentions in the making of his creatures, we ought to believe it, tho' the consideration of the things themselves did not give us the least suspicion of it; which yet, in our case, they do. The scriptures expresly teach us, that " God made the two great luminaries, the greater to rule " the day, and the lesser to rule the night;" that " he made the stars al" so, and set them in the firmament, or expansum of heaven, to give light upon the earth. And these are reckon'd among the uses of these luminaries: to divide the day from the night; and to be for signs, and for seasons, and for days and years. And Moses, dissuading the Israelites from worshipping the sun, the moon, and the stars, says, that the Lord had imparted them unto all nations under the heaven. And therefore those Cartesians, who admit the authority of holy scripture, should not reject the consideration of such final causes as revelation discovers to us; since 'tis certainly no presumption to think we know God's ends, when he himself acquaints us with them: nor to believe that the fun, tho', generally, esteem'd a nobler body than the terrestrial globe, was made, among other purposes, to enlighten it. 'sis recorded, in the book of Genesis, that God s design in making man, was, that he should " sub" due the earth, and have dominion over the fish of the sea, and over the " fowl of the air, and over the cattle, and over all the earth, and over every living thing that moveth upon the earth. And the same book informs us, that, after the deluge, God deliver'd all terrestrial beasts, and fowl, and fish, and every moving thing that lives, into the hands of men, and intended that they should eat animals; as, before the stood, he had appointed them all the sorts of wholesom vegetables for their food. And, since God was pleased to appoint, that men should live on these creatures; it cannot be absurd to say, that, among other purposes to which he destin'd the fun, his shining upon the earth was one; since, without his light and heat, men could not provide for themselves; and neither those plants, that men and cattle must feed upon, could grow and ripen; nor, consequently, those animals that were to be their principal food, and serve them for other uses, could be sustain'd, and provided for. Many other texts might be here alledged to the same purpose; but I shall content myself to mention that of the royal prophet, when, speaking of man to his maker, he says, " Thou hast made him a little lower than the " angels, and hast crown'd him with glory and honour. Thou madest him to have dominion over the works of thine hands, and hast put all things under his feet.

Indeed, if we consider only that visible part in man, his body; the smallness thereof may make it seem improbable, that portions of the universe, incomparably greater than he, should be intended for his service. But Christians will not think this incredible, if they consider man, as he chiefly consists of a rational mind, which proceeds immediately from Cod, and is capable of knowing him, loving him, and being eternally happy with him. They who despise man, consider'd in this capacity, very little know the worth of a rational foul. But God, who is the best judge in this case, was pleas'd to consider men so much, that it gave David cause to admire, as we just now saw; and not only to form them in his image, at their first creation; but, when they had wilfully lost, and forfeited it, he vouchsafed to redeem them by the sufferings and death of his own son, who is

incomparably more excellent than the whole world. And 'tis not incredible, that God should have intended many of his other works to be serviceable to man; since, by miraculous operations, he hath, sometimes, suspended the laws of nature; and, sometimes, over-ruled them for his fake: as appears by the flood, by the passage of the Israelites thro' the red-sea, and the river of Jordan; by the standing-still of the sun and moon, at Joshua's command; by the inefficacy of the burning fiery-furnace on Daniel's three companions, and, in short, by the stupendous eclipse of the sun, at the crucifixion of the Messias.

And we shall the less scruple to admit, that such vast bodies, as the sun and moon may tend to serve mankind, if we consider, 'tis far from being a constant rule, that a thing more excellent cannot be employ'd for the good of a less excellent. Thus an angel was sent to relieve Hagar in the wilderness; another had regard to the life of a prophet's ass; and many more were employed on earth, in doing good offices to particular persons: and, of all the angels in general, the epistle to the Hebrews informs us, that they are ministring spirits, sent forth to minister unto them who shall be heirs of salvation.

Section III

Preparatory to the discussion of the third question, " Whether, and in what sense, the acting for ends may be ascribed to an unintelligent, with they are an inanimate body? it will be necessary to clear the grand difficulty before, and ever since the time of Aristotle, perplexed those who allow the consideration of final causes in natural philosophy. This difficulty is obvious enough; for much the greater part of bodies being senseless, and, most of them, lifeless too; it seems inconceivable how they should constantly act for ends they are not capable of pre-designing, and, appositely employ means they have no knowledge to make choice of.

Aristotle, who expresly teaches, that nature does nothing in vain; and, rightly judg'd, that the actions of natural agents had a tendency to certain ends; takes no notice of this difficulty, but seems rather to shift it off than resolve it.

But, to consider the difficulty itself, there are two accounts on which the actions of natural agents may be said to tend to a certain end; as, either when the agent has a knowledge of that end, and acts with an intention to obtain it; or, when the action of the proximate agent is directed as it ought, to obtain an end, which, yet, is neither known, nor intended, by that proximate agent; but by a remoter, that is intelligent. In the former of these senses, I cannot admit, that any inanimate body acts for ends; since that pre-supposes the agent both to know the end he is to obtain, and to purpose to obtain it: things whereof inanimate bodies are incapable. And, to fancy with some, that they may have a knowledge, sui generis, as they speak; which, tho' confined to the actions proper to a particular kind of body, shall yet suffice to determine them to those actions, is, to offend against that rational, and receiv'd rule in philosophy, that Beings are not to be multiply'd, without there appears a necessity for them; and to introduce a fort of knowledge that seems unintelligible.

It remains, then, that I embrace the second sense, in which 'twas formerly said, natural things may work for an end; tho', in this cafe too, we must speak somewhat improperly: for the action may more justly be attributed to the remote intelligent, than to the immediate agent, which is but, as it were, the instrument of the other. Now, it appears tome, that the most wife, and powerful author of nature, whose piercing sight is able to penetrate the whole universe, and survey all the parts of it at once; did, originally, frame material things into such a system, and settle among them such laws of motion, as he judged suitable to the ends he proposed to himself in making the world. And as, by virtue of his vast and boundless intellect that he, at first, employ'd; he was able, not only to fee the present state of things he had made, but to foreknow all the effects that particular bodies, peculiarly qualify'd, and acting according to the laws of motion, by him established, would, in particular circumstances, have on one another; so, by the same omniscient power, he was able

to contrive the whole fabric, and all its parts, in such a manner, that, whilst his general concourse maintain'd the order established, each part of this great engine should, without either intention, or knowledge, as regularly and constantly act towards the attainment of the respective ends he design'd them for, as if themselves really understood, and industriously prosecuted those ends. Thus, in a well-made clock, the spring, the wheels, the balance, &c. tho' each of them act according to the impulse it receives, and the determination that is given it by the other parts of the engine, without knowing what the neighbouring parts, or what themselves perform; yet their tendencies are so determined, and over-ruled, and their motions so regulated, by the structure of the machine, that the whole could not proceed more conveniently, nor better perform the office of a clock, if they knew they ought all to conspire, and were design'd to make the index truly mark the hours. 'Tis not easy, indeed, to conceive, how one agent should, by so simple an instrument as local motion, direct such a multitude of others, as make up a world, to act with the same regularity, as if each of them went upon its own particular design, and yet all conspire to obey the laws of nature. But if we consider, that this great work is ascribed to an omniscient, and almighty agent, it will not appear incredible; especially since ‘tis manifest, that a multitude of bodies act as we have supposed: and that, if we will not ascribe to God the direction, and superintendency of the motions that are manifestly fitted for the attainment of ends, we must ascribe them to nature; which will not lessen, but increase the difficulty. And, upon viewing a great engine, wherein the works of many trades, and a great variety of other motions were perform'd by little puppets, that managed the tools of the several artificers; whilst all of them were set on work by a single spring, which communicated motions, regulated and determined by the particular structure of the little statues, &c. I could not think it impossible, that the great creator should be able, by the motions and structures of matter, to set very many partial, and subordinate, engines a-going. For 'twill not, I hope, be laid, that the multitude of these, any thing near surpasses that of those which I saw in the hand of an illiterate tradesman, so far as the narrow knowledge of that artificer is surpassed by the boundless understanding of an omniscient artist. And God's wisdom and skill is more display'd in making so many various bodies act according to their particular designations, while they all conspire to the general ends of the universe; than barely in causing bodies to act, appositely, for ends to themselves unknown. For, if moving bodies be duly disposed, and have a sufficient connection, 'tis not difficult to direct a few or them to the attainment of an end proposed by tin understanding agent, tho' unknown to the immediate agents: as, anciently, among the Jewish husbandmen, and, at this day, in some parts of the east, the ox, by treading the corn, separates the grain from the straw, as well as the labourer who thrashes it, en purpose to make that separation; and a horse or an ass," by going round in a mill, may grind the corn as well as the miller himself.

This doctrine, however, is not inconsistent with the belief of any true miracle; for it supposes the ordinary and settled course of nature to be maintained; without at all denying, that the most free and powerful author of nature is able, whenever he thinks fit, to suspend, alter, or contradict, those laws of motion, which he, alone, at first established, and which requires his perpetual concourse to uphold.

Section IV

We come to our last question, With what cautions, final causes are to be considers by the naturalist? I must observe, that the cases, whereto it may relate, are so many and various, that I can only touch upon some few of them.

And to make way for what I am to offer, by a distinction; there are two ways of reasoning from the final causes of natural things, that ought not to be confounded. For sometimes men draw arguments from the use of bodies, that relate to the author, of nature, and the general ends he is. supposed to have intended in things corporeal: as when from the manifest usefulness of the eye, and all its parts, for vision, 'tis inferr'd that the eye was originally framed by a very intelligent

Being, with a particular, care that animals should be furnish'd with the fittest organ of so necessary a sense. And sometimes, also, men ground arguments- upon the supposed, ends of things, as to the peculiar, nature of the things themselves; and conclude, that this affection of a natural body or part ought to be granted, or that deny'd; because by this, and not by that, or by this more than by. that, the end design'd by nature may be best and most conveniently obtain'd. The latter fort of arguments I usually call purely physical; and those of the former may be stiled physico-theological, or, by a shorter name, meta-physical ones.

But in order to be the more clear upon this subject, I shall refer my, thoughts of it to the five following propositions.

Proposition I
As to the generality of the. celestial bodies, it seems unsafe to draw arguments of their nature, on a supposition of particular ends, at least of the human ones design'd by God in their formation.

I am by all means for encouraging the contemplation of the celestial part of the world, and the shining globes that adorn it, and especially the sun and moon, in order to raise our admiration of the stupendous power and wisdom of him, who was able to frame such immense bodies; and, notwithstanding their vast bulk, and scarce conceivable rapidity, keep them for so many ages constant both to the lines and degrees of their motion, without interfering with one another.

And, doubtless, we ought to return thanks and praises to the divine goodness, for having so placed the sun and moon, and determin'd the former, or else the earth, to move in particular lines, for the good of men, and other animals. And how disadvantageous would it have been to the inhabitants of the earth, if the luminaries had moved after a different manner? I dare not, however, affirm, that the sun, moon, and other celestial bodies, were made, solely, for the use of man; much less presume to prove one system of the world to be true, and another false; because the former is better fitted to the conveniency of mankind, or the other less suited, or perhaps altogether useless to that end. Thus men sometimes alledge, that the sun ought to be in perpetual motion, to shine upon the earth; because, as they fancy, 'tis more convenient for man, that those distant bodies, than that the earth, which is his habitation, should be kept in motion. But considering things as mere naturalists, it seems not very likely, that a most wise agent should have made such vast bodies as the sun and the fix'd stars, (especially, if we suppose them to move with such a prodigious rapidity, as vulgar astronomers assign them) chiefly to illuminate a little globe, that, without an hyperbole, is but a physical point in comparison of the immense celestial space; while those lights might as well illuminate the earth, if they were a thousand times less than they are; provided they were placed at a proportionable distance from it. And twill be very hard to say, what considerable use the terrestrial globe, or its inhabitants, derive from that multitude of celestial spheres which compose the milky way; since each of those stars is so far from being singly, able to enlighten the earth, that Aristotle, and the generality of philosophers, for many ages, took the whole number of them for a meteor. And what light, or other known advantage, can the earth, or its inhabitants, receive from those many fix'd stars, that the telescope, only, can discover, among the six or seven conspicuous ones of the Pleiades; or among those which the naked eye discovers in the belt or girdle of Orion?

I foresee, it may be said,, that these and the like celestial bodies are, at least, thus far useful to man, as to discover to him the power and greatness of the divine maker. And, indeed, tho' perhaps his wisdom appears as great to us men in the structure of a glow-worm, as in the disposition of the small stars, that make up the galaxy; yet the immensity of his power could.

It seems difficult to say, what advantages the earth can receive from the comets; yet late discoveries have led us to conjecture at their use: and that most sagacious philosopher, Sir If.

Newton, supposes that one final cause of comets, is, to recruit the seas, and the moisture in the planets, by a condensation of their vapours, and exhalations thereon. For as seas are absolutely necessary to the constitution of our earth, to the end that the heat of the sun may thence raise vapours in great plenty, which gathering into clouds, fall down in rain, and thereby water the earth, and fit it for vegetation; or else being condensed by the cold tops of the mountains, distil down in springs and rivers; so- comets seem necessary to preserve the waters in the planets, by " continually repairing, and supplying with their exhalations and condensed vapours, all that liquor, which being wasted in. vegetation and putrefaction, could not possibly be so well declared by less productions. These arguments, nevertheless, are not purely physical, but of that sort which I call physico-theological, whose inferences relate to the general designs of God in the universe, which I therefore stile cosmical ends; but do not reach to prove any thing about the determinate nature of particular bodies. And since the utmost that philosophy teaches, is, that in general, the good of man was one of the ends design'd by God in framing the world as we see it,; there may, by the same omniscient author of nature, be other ends designs of those telescopical, and other small or remote stars, whose uses to us are doubtful or inconsiderable; to attain which ends, those celestial bodies and motions may be admirably contrived and directed. And we being unable by mere reason to discover what those ends are, we have nothing near so great cause to think there may not be such ends, as the infinite wisdom of God gives us to think there may,- 'tis presumptuous to judge of the system of the world, and of the design of vastly remote fix'd stars, by its being greater or less advantageous to us: especially since tho' it were certain, that, among other uses, God intended they mould in some sort be serviceable to us; yet he has no way declared in what capacity, or to what degree, they shall be so. And therefore, if they prove serviceable in any measure; that is, so far as we know, all he design'd they should be: and that itself, being an unmerited favour, deserves our humble thanks. And it seems very likely, that God did not design equal advantages to all the parts of the earth, from the present system of the universe; since the countries inhabited by the Samoids and Nova-Zemblans, and other nations that lie very near the arctic pole, want many conveniences and advantages enjoy'd by the inhabitants of the temperate zones.

But tho bare philosophy does not favour this bold opinion, yet I know 'twill be pretended that revelation does. And I readily confess, that the terraqueous globe and its productions, especially the plants and animals 'tis furnish'd with, appear, from the scripture, to have been design'd for the use and benefit of man; who has, therefore, a right to employ any of them he is able to subdue; and that the sun and moon were appointed by God to give light upon the earth, and be useful to all the nations that inhabit it: and that therefore the royal prophet had reason to exclaim, is turn'd into dry earth upon them. For all vegetables wholly grow from liquids, and afterwards, in great measure, change into dry earth by putrefaction; and a terrestrial part perpetually falls from putrefied fluids. Hence the bulk of dry earth is constantly upon the increase, and the fluids, unless by some means supplied, must continually decrease, and at length be exhausted. But the vapours of comets being continually rarified in the empty celestial space, are diffused every way therein, and spread thro' the whole heavens; afterwards they are gradually attracted by the planets, from their principle of gravity, and probably intermix'd with their atmospheres. " I farther suspect," says this great philosopher, that the spirit, which is the least, the most subtile, and the best part of our air, and which is necessary to the life of all things, comes principally from the comets. (Newton. Princip. p. 471, 473.)

How manifold are .thy works, O Lord! how wisely hast thou made them all! For he applies these expressions to the terraqueous globe and its inhabitants; as he elsewhere justly says, that " the heavens declare the glory of God, and the firmament sheweth his handiwork." But these general declarations, tho' they properly excite our wonder and thankfulness, yet I fear, are not good topics, from whence to draw such physical conclusions in particular cases, as some learned men venture upon. For I do not remember 'tis any where declared in scripture, that the service of man was the only, or principal use, of all the celestial bodies. And this single consideration should make us very

cautious, how we estimate the great system of the world by our conveniences. And if it be said, that man alone has a rational faculty, whereby to refer the great works of God to the glory of their maker; I answer, that tho' this has been affirm'd by many, yet I have never found it prov'd. And I somewhat wonder, that divines should, on this occasion, overlook that passage in Job, which they generally interpret of the angels. For the question which God there puts to Job, may be justly applied to Adam himself; " Where wast thou, when " I laid the foundations of the earth? declare, if thou hast understanding. " When the morning-stars fang together, and all the sons of God shouted " for joy?" And, indeed, if we may presume to conjecture at such things, it seems reasonable to me, that God created the angels before the material world, that he might have intelligent Beings to pay him the just tribute of praises for so admirable a spectacle, as that of the rising world, or the beginning and progress of the creation. However, it appears from these words in Job, that before man was made, God wanted not intelligent spectators and applauders of his corporeal works. And since the angels are a nobler order of intellectual creatures than men, and no unconcern'd spectators at the works of God; how do we know, that in the system of that part of the heavens which is invisible to us without the help of telescopes, and in the plants, animals, or other furniture, whatever it be, of those particular stars that serve us men, barely for declarations of their maker's power; such intelligent spirits as angels may not discern as wise designs, and as admirable contrivances, as those manifested in forming and furnishing the earth? And in this case, God will lose none of the glory due to the divine attributes display'd in the fabric of the celestial part of the world,' tho* the fix'd stars should not be principally design'd for the service of man.

But, secondly, 'tis yet more unsafe to form arguments upon the nature of particular inanimate bodies in the sublunary world, from the uses we think them design'd for.

This will be made evident, by considering how little we know of the A«i those that particular purposes of nature, in those terrestrial bodies, which being inorganical, cannot, by their curious structure, disclose to us the particular ends to which they were ordain'd. And their motions wanting that constancy and regularity of the celestial bodies, the caution given about drawing arguments from the astronomical system, will not, sure, be thought unfit to take place in clays, chalks, stones, &c. whose textures, compared with those of living creatures, are very simple, slight, and seldom more V/YV curious than may be made artificially, by dissolving stones and metals in chymical menstrua, and afterwards crystallizing the solutions. 'Tis true, revelation speaks rather of God's having destin'd animals and vegetables, than other inanimate bodies, to the service of men; yet there is no absurdity, to conceive, in the general, the same to be one of the ends design'd by the author of nature, in making metals, stones, and those other inanimate parts of the terrestrial globe, that man is able to master and make use of it is very unlikely, that the internal part of the earth, which may, for ought we know,-contain great varieties of fossils, and other creatures, should be made chiefly for the service of men, from whose sight they lie hid j and who will, in all probability, never descend to a thousandth part of the depth requisite to discover them, and do not so much as know what kind of bodies they are. And tho' it will not hence follow, that the terraqueous globe was made by chance, any more than that the other plants were so; because the admirable structure of plants and animals proves the existence and providence of a most wife and powerful author of things, who may justly be supposed to have made nothing in vain, even among the inanimate portions of our globe; yet that those inanimate portions were made for determinate ends, is more easily deduced from the knowledge we have, by other means, of their being produced by a wife author, than from the contemplation of those bodies themselves. And, perhaps, it is worth inquiry, whether some things may not be made, even by a wise agent, not out of a primary intention, but as productions that will naturally follow, upon the establishment and preservation of those grand laws and rules of motion, that were most fit to be settled among things corporeal. And 'tis very possible, that, according to such a general establishment, many parts of the terrestrial globe are so disposed of, as not to be serviceable to men; because the whole mass could not otherwise be so well suited to the general ends of the universe. Thus, tho' the eclipses of the fun

and moon be usually unwelcome, and, if astrologers may be credited, often prejudicial to men; yet " the great former of all things" did not think fit to alter the tracts or lines of motion that he assign'd the luminaries, to avoid the eclipses that must yearly ensue upon their moving in such lines. Whence we also learn, that some phenomena may not belong to the primary intention of nature; but are only the necessary consequences and effects of the primitive constitution of the world, and the universal laws of motion.

But if it be here demanded, to what «end the deep and hidden parts of the terraqueous globe, and the telescopic stars of the firmament, were made, if not for the use-of man? I freely acknowledge, that I cannot tell: and perhaps such an answer may be more expressive of the profound reverence we owe the great author of nature, than their opinion, who •would have all these made for the sole use of man.

Proposition II

'Tis often allowable for a naturalist, from the manifest and apposite uses of the parts of animal bodies, to settle some of the particular ends for which the creator design'd them: and in some cafes we may, from the known nature and structure of the parts, draw probable conjectures about the particular offices of them.

To obviate mistakes, it must be here observ'd, that I speak only of those ends and uses of the parts of an animal, that relate to the welfare and propagation of the animal itself, and which, therefore, I call animal ends; tho I do not thereby deny any declaration made in the holy scriptures, that God design'd the entire animals, as well as their parts, to be serviceable many ways to man. This premised, I come to consider distinctly the two parts of the proposition.

And, first, there is no work of nature known to us, wherein the consideration of final causes may so justly take place, as in the structure of animal bodies. For my own part, I confess, that when I assist at a skilful dissection, I cannot but wonder there should be philosophers, who ascribe the admirable contrivance of a human body to blind chance. The Stoic, who in Cicero, ask'd an Epicurean why chance did not make palaces, and erect other buildings, seems to have proposed a pertinent question. But the most commodious houses are far less curious structures than the human machine: for the materials of a palace are few, in comparison to the parts of an animal body; and their disposition exceeding flight, compared to the curious and elaborate contrivance of the numerous solids and fluids of the human structure: the former whereof, alone, are above some hundreds; yet in every one of these parts, the bulk, figure, consistence, texture, situation, connexion, and aptness for motion, are the most commodious that can possibly be devised; whilst all of them are wonderfully symmetrical, both to one another, and the whole body. And this number of parts is so artificially contrived and set together, that tho' no room be lost, many of them, at the same time, exercise very different motions, while each moves freely, and rather promotes than hinders the motion of others.

Hurts or diseases may (hew how excellently all the parts of our bodies are contrived, in order to our welfare. For if even a finger be swell'd, displaced, kept in a wrong posture by contractions, have its continuity violated, its tone chang'd by strains or contusions, its sense or motion taken away, its membranes fretted by (harp humours, or its motions disorders by convulsions; we quickly find, how commodiously the parts affected were framed or disposed; their natural figure, connexion, tone, &c. being now alter'd.

The eye, to single out again that part for an instance, is so exquisitely adapted for seeing, and so little fitted for almost any other office in the body; and that use is so necessary for the welfare of the animal, that it may well be doubted, whether any considering man can really think it not

designed for that use. The six or seven muscles, which move the whole ball of the eye upwards, downwards, to the right-hand, to the left, and to various oblique positions; and the several coats and humours that make up the organ, have not only their magnitude, figure, consistence, situation, and connexion, admirably adapted to that end; but the transparency of the cornea, and the three humours, the opacity of the uvea, the semi-opacity of the retina, and the several motions of the parts of the eye, which are requisite to receive, transmit, refract, and dispose the visual rays, that come from the object, after the manner necessary to make the liveliest picture of it in the bottom of the eye; wonderfully conspire to complete this matchless instrument of vision: whence we may as properly conclude, that an eye, as that a telescope, is made to view objects with. But, in that admirable perforation of the uvea, which we call the pupil, nature has greatly exceeded art. For tho' we are obliged to employ opaque bodies, with several circular apertures, to the object-glasses of telescopes, that some may let in less light, and others more, according as the objects require to be illumin'd; that part of the uvea, which is suspended in the aqueous humora, is an aperture that widens and contracts it self, in an instant, according to the exigency of the object.

But for the uses of the several parts of the eye, I refer my reader to Scheiner's Oculus, and Des Cartes's D’optrics; whence it will appear, that, in forming this part, nature not only acted with design, but with so great skill in optics, that a more than ordinary acquaintance with that science is necessary to understand the wisdom or the several contrivances; which, perhaps, no degree of skill whatever in it, would enable a man to alter for the better.

'Twere tedious to mention other parts of the body, that manifestly appear to have been ordain'd to certain uses. The books of anatomists are full of passages to this purpose: of which I shall only say in general, that tho* what they deliver is sufficient to shew all the part s of the body to be the effects of an intelligent cause; yet, unless their descriptions, and reflections, be improved by mathematics, mechanics, and chymistry, we shall have but an imperfect notion how intelligent that cause is; or how much wisdom is display'd in the structure of a human body, and its several parts.

I know ‘tis objected, by the Epicureans, that the parts of animals were first made, and their uses afterwards discover'd, by the sagacity of men. But this is a sophistical objection. For, first, many of the internal parts perform their functions, without our having any knowledge of their structure, or situation; so far are they from being applied to such uses by our sagacity. And as for the limbs, and other parts, which we move at pleasure, ‘tis true, they cannot be employ'd to their respective uses, till actually form'd; nevertheless, they might be originally so form'd, as, in due time, to be fit for such uses. And, in effect, we fee that a chick is furnish'd with compleat eyes and wings, before it be hatch'd; tho* whilst inclosed in the egg, it can make no use of them, either to see, or fly. And why was it, do the Epicureans think, that nature provided a whole set of temporary parts for pregnant females, and animals in the womb; which, when they are come into a freer state, partly shrink away of themselves, and partly turn to a ligament, fitted no longer for the former, but for a more seasonable use? And 'tis to be noted, that these umbilical vessels, and the placenta to which they are fasten'd, is of no necessity or use to the female before conception; and therefore, those temporary parts, appear to have been design'd by nature for the propagation of the species.

And tho' the sagacity of men, may have sound out some uses of the particular parts of their bodies, which seem not to have been primarily intended by the author of nature; yet this does not prove, that those uses were undesign'd: for the prescience, and goodness of God, are sufficient to render it probable, that he who gave man both the limbs of his body, and the endowments of his mind, did both foresee what uses men might, according to their sagacities, and emergencies, make of these parts; and so contrive the parts, that they should be applicable to such uses.

And, we may now proceed to the latter part of our proposition; which asserts, that, in some cases, from the known ends of nature, as well as from the structure of the parts, probable conjectures may be form'd about the particular offices of them.

This could not have been seasonably spoken to before; because the arguments that were founded on the uses of the parts of animals, suppose those parts to have been destin'd to particular uses, knowable by us; and that the several parts of the body were contrived as wisely, and commodiously as men are able to devise, in order to the ends of nature: which must always be understood to have united in her designs, the uses of the parts, and the welfare of the whole.

And, indeed, if we consider how admirable a fitness there is in the parts of a human body, to those particular ends we can discover them to have been design'd for; it seems allowable to conjecture, that such a part was not primarily design'd to such an use, if it is, on the account of its structure, or otherwise, less fitted for it than the constant wisdom of nature, seems to require; especially if there be any other parts, by which the office may be more commodiously performed. And, on the other side, it seems probable, that such a part was destin'd to such an use, if the use itself appear to be necessary, and the part better fitted for it than any other.

Thus, tho' anatomical and optical writers, for many ages, unanimously concluded, the crystalline humour to be the principal seat of vision; yet the industrious Scheiner justly rejects that receiv'd opinion, upon shewing, that it suits not with the skill and providence of nature, that it should be so, since it wants many requisite qualifications for that purpose; and especially since most of these are to be found in the retina. And, I remember, upon asking our famous Harvey, what induced him to think of a circulation of the blood j he said, that observing the valves in the veins of many parts of the body, so placed, as to give free passage to the blood towards the heart; but to oppose the passage of the venal blood, the contrary way; he imagin'd that so provident a cause, as nature, had not thus placed so many valves without design: and as no design seem'd more probable than that, since the blood could not well, because of the interposing valves, be sent by the veins, to the limbs, it should be sent thro' the arteries, and return thro' the veins, whose valves did not oppose its course that way.

Thus, tho' the ancient anatomists, and physicians, believ'd the parts were nourished by the venal blood; the modern writers teach them to be nourished by the blood, in its passage thro' the arteries. Not that they think the blood, which runs thro' the veins, altogether unfit to supply the parts with that vital liquor; but because they judge the veins to be less fit for this purpose, than the arteries; into the latter whereof the blood comes immediately from the left ventricle of the heart, agitated, and spirituous, and, by a brisk impulse, better suited to answer this end. But the writings of physicians, and anatomists, being filled with instances of this kind, I forbear to mention any more.

Proposition III
It is rational, from the manifest fitness of some things, to cosmical, or animal ends, to infer, that they were thereto ordained by an intelligent agent.

Care seems to have been taken, that the body of an animal should be ' provided not only with all things that are ordinarily necessary, and convenient; but with some super-abundant provision against accidents. Thus, tho' a man may live, and propagate his species, after the loss of an eye; yet nature furnishes us with two, that, in cafe one be destroy'd, the other may suffice for vision. And the like may be said of the ears. In short, nature has furnish'd men with double parts of the same kind, where it is highly useful, and may be permitted, without prejudice, to the rest of the body. And this is the more considerable, because, in other parts, nature appears to husband things so, as to avoid doing what is superfluous. Thus, within the skull, some vessels, that would, in other

parts of the body, have double coats, are very thin; the skull being ordinarily sufficient to defend them from external injuries.

Another argument, that nature acts with design, about animals, may be drawn from what anatomists observe of those parts of the womb, or the foetus, that are to be found but at certain times, when there is need of them j and not at others, when they would be useless. Thus, when a woman is with child, the vasa umbilicalia are produced to be canals, either for the blood, or alimental juice, and spirits, that then ought to pass between the womb and the fœtus, by means of the placenta. And tho', as long as the child continues in the womb, these temporary parts continue with him; yet, as soon as he comes into the world, the umbilical vessels, particularly the two arteries, and the vein, together with the membranes they are wrapp'd up in, with the chorion, and the amnios, that involve the fœtus, are thrown off, as unnecessary, and expell'd in the after-birth j there remaining only that part of the umbilical vessels that lies within the child's abdomen, between the navel and the liver; where its use is considerable, tho' new; for it serves now no longer to convey blood, or an alimental liquor, to and fro, but degenerates into a ligament.

Thus, also, the Foramen ovale, gives passage to the blood from the right ventricle of the heart to the left, that the circulation of it may be maintain'd; for it cannot in the embryo, as in a born child, pass thro' the vessels of the lungs, from one of the ventricles to the other: whence this contrivance seems to be an expedient that nature employs, till the foetus is excluded; when that temporary conformation is obliterated. For the child, now breathing the free air, is in a condition to make the blood circulate thro' the pulmonic vessels, according to the primary intention of nature. From which, and the like instances, we may infer, that these temporary parts were framed by a fore-knowing, as well as a designing agent; who intended they should serve for such a purpose, and then be laid aside: for 'tis utterly improbable, that an undesigning agent should so appositely, and exquisitely, frame scaffolds for a future building, if he did not, before-hand, destine both the one and the other, to concur to the same ultimate effect.

Another argument, for our present purpose, may be drawn from the consideration of what, in animals, is commonly call'd instinct: which, in some cases, more directly regards the welfare of the creature j in others, the propagation of the species; and, sometimes again, respects both. The writers of voyages, and natural history, recount strange instances of the instinct observable in certain animals. But we need not lay the stress of our argument upon dubious, or suspected relations; since what I have met with, in authors of good authority, or receiv'd from the mouths of credible travellers, may serve my present turn; especially, if we may take the word instinct in a latitude, so as to comprize those untaught methods, and expedients, that are made use of by some animals, to avoid dangers, provide for their future necessities, or to catch their prey.

Surprizing things are related, not only by poets, but by more credible writers, about the sagacity and government of bees; in point, both of œconomy, and politics. But tho* I shall not build any thing upon suspected authorities, yet, having long kept a transparent hive, and thereby gained the opportunity to make frequent observations of the actions of these little animals; 1 confess, I discover'd some things that I did not believe before: which induced me to look upon them, as very fit instances of creatures endow'd with natural instinct and providence. For, 'twere hard for a mathematician, in contriving so many cells as bees make in the area of one of their combs, to husband so little space more skilfully than these animals. And they not only carefully, and seasonably, lay up their honey, to serve them all the winter; but, curiously, close the particular cells with covers of wax, that keep the included liquor from spilling, and from external injuries. I do not here mention the prognostication of weather that may be made in the morning, by their keeping within their hives, or flying early abroad, to furnish themselves with wax, or honey; V/VN»^ or, by their unexpected return before a storm: because, I suspect, that these things are not so much the effects of instinct, as of a tenderness, and quickness of sense; something analogous

whereto, may be seen in a good weather-glass; and is, also, to be found in many wounded, and valetudinary persons, who are affected with such beginning alterations in the air, as other men perceive not. But, among the peculiarities to be observ'd in the conduct of bees; 'tis very remarkable, that, after a fight, they take up the dead which lay on the ground, and, as I have observ'd, fly away with them far from their hive.

Another obvious instance of the instinct that nature has given to some despicable insects, may be taken from ants. For, 'tis known, that these little creatures do, in the summer, hoard up grains of corn against the winter. And their sagacity is the more considerable, if it be true, what many learned men affirm, that they eat off the germen of the grains they lay up, lest the moisture of the earth, exposed to the rains, should make them sprout. But, whatever become of this tradition, these insects perform some other actions, greatly resembling those proceeding from sagacity and industry.

The natural skill of spiders, in weaving their webs, that are so fitly contrived, both to catch their prey, and give them immediate notice of its being caught, is a thing which, if it were not familiar, would be look'd upon as admirable. And this skill is not, as some imagine, an effect of imitating their parents; for if the eggs be taken away, and enclosed in a glassy when they come to be hatch d by the heat of the fun, the little creatures will, immediately, fall to spinning in the glass itself; as was related to me by an eminent mathematician, who made the experiment. And I saw the less reason to distrust it, because having, by an external heat, hatch'd many eggs of silk-worms, in a place where there had not been any of a long time before, nor, probably, ever, till then; yet the worms, produced by these eggs, did, in autumn, of their own accord, climb up to such convenient places as I had prepared for them, and there weave those curious oval prisons, wherein they enclose themselves, and which are unravel'd into extremely fine silk.

But this provident industry is not confined to insects, for 'tis to be found in many of the greater animals; particularly in the beaver; a creature whereof, indeed, many fabulous stories are related: yet sober, and judicious persons, who were either born, or lived in New-England, where these animals abound, have assured me, that the beavers, with their sharp teeth, cut pieces of wood, and fit them to their purpose; that, by joining their labours, they lay these together, so as to build themselves strong winter-houses; in which there is, sometimes, a kind of second story for the inhabitants to retire to, when the water chances to overflow; that, for these houses, they chuse a very convenient situation, just by some river, or other water, that can furnish them with fish; and that the hole belonging to each house, is placed just by the water, that

they may, immediately, flounce into it, and so save themselves, when their houses are attack'd. And, to facilitate their swimming, and the catching of their prey in the water; nature has given them two feet, not made like those of dogs, or cats, or in the manner of their other two; but furnish'd with broad membranes betwixt their toes, like the feet of geese, ducks, and other aquatic animals, that are to use them as oars, to thrust away the water, and facilitate their motions.

The various arts employ'd by animals of different kinds, about the materials, the construction, and the situation of their nests, is usually remarkable, and, sometimes, wonderful. Of this skill, we have many eminent instances; but 'tis particularly remarkable, that, in countries abounding with apes and monkeys, creatures very greedy of birds eggs, there is a fort of bird, whose eggs they, peculiarly, affect, that hang their nests near the end of some long flexible branches, which reach over the water; and, by that means, avoid their enemies, who cannot swim.

In the nests of wasps, which they often, for greater security, make under ground j I have observ'd a very curious, and artificial structure, to conceal, and shelter their young ones, till they are ready to fly.

But the instinct that nature has planted in animals, for their own preservation, is much inferior to that providence she has furnished them with, for the propagation of their species.

There are-many remarkable things to be met with in the nests of several birds, both as to the materials, the structure, and the situation of the places wherein they are built. I have seen nests, and, particularly, some made in the Indies, which would raise a man's wonder how the birds should find such odd, but commodious materials to build with. There are birds in the east, which make their nests of a white substance, that looks almost like ising-glass, dissoluble in liquors, and so very well tasted, that it makes the chief sauce used in the southern parts of India. The structure, also, of the nests of several birds, both as to their figure, magnitude, and accommodations, wherewith they are furnish'd, for warmth and softness, may deserve the applause of mathematicians; especially if it be consider'd, that these little untaught architects had no tools to make their curious buildings with, except their bills and feet. Much more foresight, however, appears in the situation of the place, that some birds make choice of, to build their nests in; as may be observ'd, not only in the pendulous nests of swallows, and the secret ones of some European birds; but very conspicuously in the hanging nests that we lately mention'd, to be so oddly placed by some birds, to secure their eggs from apes and, monkeys; and by the situation of the nests used for sauce as we just now related, to be found only upon high and steep rocks: which are so fasten'd to the concave parts of them, that look downwards, and, commonly, hang directly over the sea; that there is no getting them, without much trouble, and danger: upon which account, as well as that of their delicacy, they are very dear, even in the East-Indies, where they are found.

The like care to contrive their nests advantageously, and make them in secure places, is visible in insects; as may be observ d in the subterraneal nests of the wasps, formerly mention'd, and in the eggs of snails, which I have sometimes found hid under-ground; and have hatch'd in glasses furnished with the same earth wherein they were found.

If I should here set to view the several effects and arguments of the wonderful providence, that the most wife author of nature exercises about the propagation of animals, by distinguishing them into male and female; by furnishing both sexes with mutual appetites and organs exquisitely adapted to the increase of their kind; by the admirable formation of the fœtus in the womb, without the female's knowing how it is perform'd; by the strange subtilties and courage, that several creatures, either oviparous or viviparous, have, to hide and defend their young; by the full provision that is made for the nourishment of the foetus, and the welfare of the female after she has brought forth; and the like: I might much enrich and adorn my argument. But instead of pursuing a speculation, that would lead me too far, I shall look back upon the intimation I lately gave, that even those meaner parts of animals, which seem to have been framed with the least care and contrivance, are yet worthy of their author. For tho' the teeth be some of the least elaborate parts of the human body, yet even these afford numerous phenomena applicable to our present purpose: but I shall only transiently consider a sew of them.

And first, 'tis remarkable, that tho' when a man comes to his full stature, all the other bones of the body cease to grow, the teeth continue to increase, in length, during his whole life. This growth of the teeth appears not only by their continuing for many years of the same length, but by the unsightly shooting of one tooth, when that which was opposite to it in the other jaw is wanting; whence it has liberty to sprout without opposition. of this difference in point of growth betwixt the teeth and other bones of the body, what reason can be so properly assign'd, as its being intended to repair the daily waste of substance, proceeding from the frequent attritions of the upper and lower jaw in mastication?

2. Tho* the bones of the body are generally invested with a very thin sensible membrane call'd Periosteum; that part of each tooth, which is not cover'd by the gums, wants if; which would be subject to very frequent and painful compressions and lacerations.

3. To enable the teeth to break and make comminutions of the more solid kind of aliment, nature has providently framed them of a closer and harder substance than almost any other bones in the body; tho' these are so numerous, that anatomists reckon above three hundred of them. And I have met with it in authors of good credit, that some men's teeth have been so hard, as, when struck against another fit body, to produce sparks of fire.

4. That these bones, whose use is so great, may themselves be continually nourish'd and supplied; tho' they are set in bone, the wise author of filings has admirably contriv'd a cavity on each side of the jaw-bone, wherein wherein are lodg'd an artery, a vein, and a nerve; which, thro' lesser cavities, fend their twigs to each particular tooth.

5. As infants are designed, by nature, to feed, for a considerable time, on milk, they remain long without teeth; whilst several animals, which are often early reduced to seek aliment, that is neither fluid nor soft, come into the world with teeth already form'd in their jaws.

6. The bony substance appointed for the comminution of the aliment, ought not, for several reasons, to be in either jaw entire, or all of one piece j and therefore nature has providently made, for that use, a competent number of distinct bones in either jaw. And because men may have occasion to feed often upon very different sorts of aliment; and because usually the same aliment may require different preparations in the mouth, to facilitate the digestion of it in the stomach j nature has provided men with two rows of teeth, for the most part equal in number, and corresponding to each other, yet of different shapes, for different uses; the fore-teeth are broader, and have a kind of edge, to cut the more yielding fort of aliment, whence they are call'd Incisores; others being stronger, and more fitly shaped to tear the tougher food, arc term'd Count. There is also a third sort, whose principal office it is to grind the aliment cut or torn by the others: and, for this purpose, they are made much broader, and somewhat flattish, with their upper surfaces uneven and rugged; that by their knobs and little cavities, they may the better retain, grind, comminute, and mix the aliment; and for this reason they are call'd Molares.

7. And because the operations to be perform'd by the teeth, often require a considerable firmness and strength, partly in the teeth themselves, and partly in the instruments that move the jaw, wherein the lower sett of them is fix'd; nature has provided the lower, or moveable jaw, with strong muscles, that it may bear forcibly against the upper; and has not only placed each tooth in a distinct cavity of the jaw-bone, as it were in a close, strong, and deep socket; but furnish'd the several sorts of teeth with hold-fasts, suitable to the stress, that, by reason of their different offices, is to be laid on them. And therefore the Incisores and Canini have usually but one root; whilst the Molares, that on many occasions are employ'd to break hard bodies before they can be ground, are furnished with three roots, and often with four, in the upper jaw, whose substance is somewhat softer, and whose grinders serve as so many little anvils for those of the lower to strike or press against.

If it shall be said, that allowing, tho' man is indeed advantageously furnish'd with teeth, yet there are many other animals, some whereof have not near so many teeth, nor so commodiously shaped and placed as his; others, that are not furnish'd with any teeth at all; and that several animals have some of their other parts less convenient in their kind, or are not otherwise near so well provided for as they would be, if they were not rather the productions of chance, than of an intelligent and designing agent: I must declare, that many particulars might be farther alledg'd, to shew the final causes of things corporeal, as the consideration of them leads to a high veneration of their divine

author; and to manifest, that when his providence is deny'd or condemn'd, 'tis for want of due consideration.

But I have already, in great measure, prevented myself in the answering this objection, by obviating some exceptions relating to the eyes of man and other animals. For the considerations that have been alledg'd to that purpose, may, mutatis mutandis, be applied to the varieties to be found in the teeth, and other parts, of different kinds of creatures.

'Tis known, that oxen, sheep, &c. are not furnish'd with near so many teeth as men, horses, dogs, &c. But this defect, if it be any, is supplied partly by the power and instinct they have to chew the cud, and thereby make a second attrition of the aliment, that is already greatly soften'd; and partly by the successive cavities, or stomachs, thro which that aliment is transmitted, and by that means elaborated and fitted for further uses. The beaver, the tortoise, the bee, and the humming-bird, which sucks the exudations of flowers with his little long bill, like the bee, and many other animals, have their mouths, and their ways of preparing their aliment for the stomach, very different from what is observ'd in men; and yet each respectively very convenient; all circumstances consider'd.

These, and the like expedients, are in many animals such as afford no cause of taxing the author of nature, for not having given some of them all the same parts wherewith others are furnish'd; but rather, the providence and wisdom of God, in the contrivance of his visible works, may be as well discover'd by the seeming omission of this or that part, useful to other animals, but unnecessary to those wherein it is not found; as by granting those parts to such animals, whose compleatness or welfare they are necessary or highly conducive to: and therefore 'tis not strange, that he has not given to men, and many forts of birds, such tough, transparent, and moveable membranes, as frogs are provided with, to defend their eyes from such accidents as the others are not usually exposed to.

Bats are esteem'd a contemptible fort of creature, yet they may afford us a considerable argument to our present purpose. For we have here an animal that flies like a bird, tho' it wants feathers, and has a fabric quite different from that of birds. And here too, we may observe the compensation that is made for parts that seem either deficient, or less advantageous, than those of the same denomination in other birds; as also the regard which the divine artist appears to have to the symmetry of parts in his animated works, and to their fitness to the places they are to frequent. For the bat being to act sometimes like a bird, and on some occasions like a terrestrial animal, or mouse, he ought to be furnish'd with parts' suitable to such different designs: and, therefore, the want of feathers in his wings is supplied with a broad membranous expansion, and a kind of toes furnish'd with articulations. And because this animal was to forbear settling on the ground, otherwise than his occasions required, each of his wings is furnish'd with a strong crook, like the claw of a bird's foot; by the help of which, he can fasten to trees, walls, &c. and there keep himself at what distance he pleases from the ground. And as he is furnish'd with teeth, which other birds want, to chew his food, and thereby prepare it for digestion; he needs no crop, or such a strong muscular stomach, as is usually found in birds.

In short, to omit the peculiar structure of other internal parts, wherein the bat differs from other birds; since the female was not, like them, to be oviparous; but, like mice, and other quadrupeds, to bring forth her young ones alive; she is not only furnished with an uterus, fitted for that purpose; but, in regard she does not exclude, together with the fœtus, a competent stock of aliment, to nourish it, till it can shift for it self; the bat is furnished with teats to give fuck: and 'tis observ'd, that as she has but two of these, so she brings forth but two young ones at a time; while mice are much more prolific.

The writers of natural history, and travellers, afford numerous instances of the various, and excellent contrivances, that are to be found in animals differing from man, in the fabric of the mouth, and other parts, subservient to the preparation and digestion of their aliment.

But, to be silent, as to the mouths of tortoises, camelions, &c. the hardness of whose gums, with regard to their aliment, supplies the want of teeth, there is an American beast, which serves as a notable instance, to manifest how the wife architect can compensate the want of teeth, by the rare structure of the mouth and tongue; and their fitness to seize, and make use of that aliment, which, tho* uncommon for a beast of his bulk, he seems to have been destined to live upon. The animals of this kind are, by Hernandus, call'd, Achoas, and Tamendom and, of these, he says, " they are quadrupeds, about the size of lambs, whose bellies almost " touch the ground; that they have no teeth at all, but live upon ants; " whose hillocks they turn up with the two large claws they have fixed <c to their fore-feet, and then thrusting out their long rough, cylindrical " tongue, they roll it upon as many as they can, and so draw them into " their mouth, which is exceeding narrow." Pifo adds, that " their tongue, which is sometimes two feet in length, lies doubled up in a " cavity, between the sides of the lower jaws; which, in order to catch " their prey, they thrust into the trunks of trees, and there suffer it to " continue, with a moisture upon it, till cover'd with ants j and then suddenly draw them with it into their mouths. "

Tis also to be consider'd, that many things may be useful, in an organical part, besides those whereby its office is primarily and chiefly perform'd. Thus, tho' the eye-lids, and their motions, together with the little glands that belong to them, are not at all necessary to the act of vision; yet they are to the compleatness, and welfare of the eye: as is manifest by the pain and prejudice that organ receives, if the eve-lids be considerably disorder’d.

But, besides those uses of the pans of a human body, which I call anatomical, because they are such as anatomists have discover'd, by mere dissection; there may be several others, which I term chymical, because these parts prepare spirits of several sorts, and, perhaps, perform operations, very important, if not necessary, to the welfare of a living man.

And there may still be other uses, very proper to be consider'd, in some parts of a human body $ as the mechanical advantages, for which the various shapes, and structures of different muscles, the seeming irregular fabric of the bones, and, especially, of the processes, and protuberances, are admirably fitted. And, in some parts, too, there are peculiar ones; as for instance, optical ones in the eyes; which must be consider'd, before the design of nature therein, can, without rashness, be censured.

Thus, tho' the figure of the crystalline humour, be much more spherical in most fish, than in men, and other terrestrial animals; yet he who understands the doctrine of refractions, and considers, that fish under water, are to fee thro' a far thicker medium than air, will readily acknowledge, that this difference between their eyes, and those of men, is not an imperfection in the former; but, whilst those creatures are in their own element, a great advantage.

And, to be short, I think there are so many sciences, and other parts of knowledge, some of them, perhaps, scarce yet discovered, that may be requisite to warrant a man in censuring the ends of God, in the bodies of animals; that very few men are qualified to condemn them justly; and those who have knowledge enough to judge right, will not be forward to condemn, but admire them. Thus men may easily be too rash, in thinking a part inartificially framed, upon supposition, that by the anatomical dissection of it, they know all the uses whereto the skill of the divine artist could design it.

And, it will not necessarily follow, that because in some particular bird, or beast, or fish, we are unable to say why this, or that part is not to be found; or why it is otherwise framed, or situated, than that which is analogous thereto in man; it must, therefore, be casually, or undesignedly framed, or placed: since we cannot expect from brute animals, answers to those proper questions about their own bodies, which we can receive from men about theirs. Nay, notwithstanding the great diligence, with which the more curious physicians are obliged to cultivate anatomy, and the frequent opportunities they have to do it, and to inquire of living men about what they observe, and see, when the natural use of their parts is hinder'd, or perverted; yet we are, to this day, at a loss, as to the true uses of the visible parts of the body; to say nothing of the invisible ones. So that ‘tis no wonder, if, in animals, whose fabric we have much less concern to inquire into, and much less opportunity to examine, we, sometimes, find parts, of whose uses and fitness, men are, hitherto, unable to give a satisfactory account. For even in man, himself, tho' there be numerous valves found in his veins, yet, for those many ages, that the true uses of them were unknown, an Epicurean physician might have thought he had reason to look upon them as superfluous parts; which, since the circulation of the blood is discover'd, are acknowledg'd of the greatest utility.

And, since God is both a most free, and a most wife agent, it need not seem strange, that he should adorn some animals with parts, or qualities, that are not necessary to their welfare, but that seem design'd for their beauty; such as the disposition of the camelion to change his colour; and the lovely green, blue, yellow, and other vivid colours, that adorn some sorts of pigeons, parrots, and the smaller birds; and especially, that admirable little creature, the humming-bird.

On the other side, God's wisdom sometimes seems to be provident, and sollicitous, not to bestow on an animal, or a part of it, more than is necessary for the use whereto either is designed. Thus the veins are, by anatomists, observ'd to have but one coat, and usually to lie more exposed than the arteries that accompany them, which have stronger, and double coats, because they are to convey a more important liquor; which liquor, besides that 'tis more agitated, and spirituous, is forcibly impell’d into them, by the strong muscular contraction of the heart. And, 'tis observable, that tho' the nerves usually lie deep, to be kept both safe and warm; being very liable to be offended both by cold, and the contact of external bodies; yet, as 'tis necessary that the optic nerve should expand itself into the eye, the membranes which invest that nerve, and other coats of the eye, except the retina, are made vastly more firm than the Dura, and the Pi mater, whence they proceed; and tho' exposed to the free air, are less sensible of the cold, than most parts of the body; and will bear, without danger, several liquors, and other offensive things, whose pungency would put other nerves of the body into convulsive motions-.

This conduct makes it seem, as if God, like an excellent writing-master, did, in the great volume of his creatures, intend to bestow on some of them, things rather ornamental, than necessary, as flourishes on the capital letters of nature; and sometimes to employ characters of different shapes, to stand for the same letters; and sometimes, also, to employ abbreviations, to express, in short, that which might be very justifiable, had it been more sully delineated.

And, if we allow, as 'tis very probable, that God design'd, by the great variety of his works, to display to his intelligent creatures, the great abundance of his wisdom; 'tis obvious, that much of the variety, observable in the analogous parts of animals, may be very conducive to so comprehensive a view; whereto the beauty of some creatures, and parts, as well as their more necessary, or convenient structure, may be subservient: especially if the innocent delight of man be also intended; as it seems to be, in the curious colours, and shapes of several flowers; in the melodious music of birds; and, in the vivid, and curiously variegated colours of the feathers of several winged animals; particularly those that make up the peacock's train.

"sis worth our observing, that we are not near such competent judges of wisdom, as of justice and veracity: which are estimated by eternal and fixed bounds, or rules, very intelligible to a moderate understanding. But, as for wisdom, the more profound it is, the less we are able to look thro'it, penetrate to the bottom of it, and judge knowingly of its actions. And therefore, tho' we may safely conclude, that God acts wisely, when he does any thing that has an admirable tendency to those ends, we justly suppose him to have design'd; yet we cannot lastly conclude in the negative, that this, or that, is unwise, because we do not discern a wise tendency therein. For so wise an agent may have other designs than we know of, and further aims than we can discern, or suspect; and may have at hand, or furnish himself with such means to compass his • ends, and that even by the co-operation of what we think useless, or improper, as are far above the reach of our conjectures; and without the knowledge of which, we rashly censure the wisdom of his proceed, In the double horizontal dial, formerly mention'd, it would be rash of any to condemn, or despise, the various lines they find traced upon that useful instrument, because they see they are not necessary to shew the hour of the day; since the mathematician, who drew those lines, may be well supposed to have more ends than one, or two, in making the instrument; and not to have drawn them by chance, or unskilfully, tho' the inconsiderate censurers do not know for what other, or farther purposes, the artist may have design'd them.

Suppose some Indian fisher-man, unacquainted with European arts and affairs, should come on board a man of war, under sail; he would quickly perceive, by the use made of the tackling, that this floating building was very artificially contrived; yet, if he should fix his eyes upon one -or the guns, or the anchors, and perceive that no use was made, or likely to be made of them, in sailing, he would be strongly tempted to think, that those heavy masses were useless clogs, and burdens to the vessel. But if he were told the necessity, and usefulness of the guns, for defence; and of the anchors, to stay the ship in storms; he would presently alter his mind, and confess, that he had blamed the contrivers for that, which nothing but his ignorance kept him from commending.

I have dwelt the longer on this third proposition, because I think it a duty, that our reason owes to its author, to endeavour to vindicate his manifold wisdom, in this libertine age; wherein too many, who have more wit than philosophy, labour upon Epicurean, and some even upon Cartesian principles, to depreciate the wisdom of God; whilst others presume to censure his contrivances, in the bodies of animals.

I had also a desire, that the reader should not barely observe the wisdom of God, but actually be convinc'd of it. To which purpose, in my opinion, 'tis very conducive, if not necessary, besides general notions, to observe, with attention, some particular instances of the divine skill, wherein it is conspicuously display'd. 'Tis true, that in the idea of a Being infinitely perfect, boundless wisdom is one of the attributes included: but, for my part, I am of opinion, that this general and indefinite idea of the divine wisdom, will not give us so great a veneration for it, as may be produced in our minds, by knowing, and considering the admirable contrivances of the particular productions thereof; and their exquisite fitness for those ends and uses, to which they appear to have been design'd.

Proposition IV
We ought not to be hasty in concluding upon the particular use of a thing, or the motive which induced the author of nature to frame it in a peculiar manner.

It has been already shewn, that some parts are so excellent^ and manifestly fitted for a certain use, and so much better adapted to that, than to any other; as to make it seem perverse, to doubt of its being design'd thereto. But the like cannot be laid, in general, of all the parts 01 the body; especially of the internal. There are many uses, either necessary, or highly conducive to the welfare of the animal, that have no part so much more conspicuously fitted for them than another,

as to leave it easy to determine the true, and primary offices thereof; especially, with so much certainty, as thereon to ground philosophical inferences. And, of this difficulty, I conceive, there may be four reasons; tho' they do not all occur in each particular cafe.

And, first, the whole animal itself, that we consider, is a part of the universe; and, therefore, cannot well he supposed to have been framed, and furnish'd with the parts it consists of, merely for its own fake. An^»' when we say, that all its parts are contriv'd to the best advantage to. the animal; I conceive, this is to be so understood, in a limited sense j that the parts are excellently framed for the welfare of the animal, as far as that welfare is consistent with the general ends of the author of nature, in the constitution, and government of the universe; Which ends, because they relate to the whole world, I call cosmical. It has not, indeed, been prov'd, that none of these cosmical ends are discoverable by us: however, to discover them all, is no easy task. Yet, it seems presumptuous to suppose, that the welfare of particular animals is any farther design'd, and provided for, than will consist with the cosmical ends of the universe, and the course of God's general providence; to which his particular providence ought, in reason, to be subordinate. And, tho' it seems great rashness in men, to determine positively, and exclusively of others, what ends the omniscient creator proposed to himself, in giving to the world its present frame; yet, as far as I can hitherto discern, I see nothing more likely to have been one grand motive of so great a variety, as. we observe in his corporeal works, especially in animals, than that he might, by so many very different contrivances as are to be met with in the structure of men, quadrupeds, birds, fish, reptiles, &c exercise and display his manifold wisdom. As man, even upon account of his body, is acknowledg'd the most perfect of animals; if God had barely design'd to give every creature the most advantageous structure, it seems, that he should have made no other animals than men.- But, then, there could not have been that diversity of contrivance among living automata, which so greatly recommends the wisdom of him, who could frame so many, and so differing animals; tho' not all equally perfect, yet all admirably furnish'd for those purposes to which he design a them. It does not, therefore, argue any want of providence, that he has not furnish'd man with wings, fish with feet, and birds with fins and scales-; because these parts would have been either superfluous, or burdensome, or unsuitable to his design of fitting some animals to live on the earth, and others in water: and if he design'd any to inhabit both, he furnishes them with pares of a peculiar structure; as was formerly noted of the beaver. Were it not for this consideration, it would be hard to assign the reason why vegetables are not the food of all animals; but that some should be carnivorous, and furnish'd with appetites, and organs, to devour others, and live, as birds and beasts of prey, upon the weaker. And 'twill be hard to shew, why, even in animals of the same kind, the safety of some should be so much better provided for than that of others; as we see some ants, and glow-worms, furnish'd with wings, and others not. And, even in our own species, those of the female sex are not so happily framed, 'in order to their own welfare, as males; since the uterus, &c which are not necessary to the good of individuals, but to the propagation of the species, subject that tender sex to a sett of diseases peculiar to them. So that men may, sometimes, mistake, when they peremptorily conclude, that this, or that part of an animal, must, or cannot have been framed for such a particular use; -without considering the cosmical, primary, and over-ruling ends, that may have been design'd by nature, in the construction of the whole animal.

Men sometimes, erroneously, conclude, that such an office cannot belong to such a part, because they think it is not so commodiously framed for it, as might be wish'd; without considering, whether the structure they propose, would not, in some other as considerable respect, oppose the welfare of the animal; or, whether it would be consistent with the other uses, design'd by nature, in that fort of creature. For, in the living works of so excellent an architect as nature; it must not be expected, that any particular end should be prosecuted, to the prejudice of the whole: but it must rather be suppos'd, that the aims, not only at particular expedients, but universal symmetry; while she excellently fits the several parts for their respective offices; tho' only so far as a due regard to the design, and welfare of the whole, will permit. Thus, as we before observ'd, tho' man be allow'd

the most perfectly framed of any animal in the world; yet his body is not made the model for nature to form the correspondent parts of other animals by. The lungs of a dog, a bird, a frog, a viper, &c. are of a structure very different from those of man. He is not furnish'd with so many stomachs as an ox, or a sheep; because nature intended not that he should ruminate like them. And tho' his gall be lodg'd in a peculiar bag, within the liver; yet Were rash to say, that the secretion of the bile is none of the uses of those livers, wherein such a cystis is not to be met with: since, in some animals, as

in horses and pigeons, that bitter humour is not usually, as in man, collected into one bag: and tho' it be so in vipers $ yet, as far as I have \^Y\J observ'd, the containing cystis does not at all touch the liver.

'Tis difficult to determine the true and primary use of apart; because nature often sits one part for several uses.

And, 4thly, it sometimes increases the difficulty, that nature may compass the same ends by several means j each of them sufficiently commodious. I join these two observations together, because, in effect, they often concur to render it hard to determine the true use of a part. Neither does nature constantly employ only one part to perform a particular office; but the design'd effect is, sometimes, produced by a series of successive operations, to which several parts may differently contribute.

Neither the mechanism of a human body, nor of very considerable parts thereof, is to be assign'd from the bare structure of the visible matter, whether solid, or fluid, to be found in the vessels, and cavities of a dead body, skilfully dissected. For the body of a living man is a very compounded engine, many of whose functions are perform'd, not by the blood, and other visible fluids, barely as they are liquors; but, partly, by their circulation, and other motions; and, partly, by a very agile, and invisible, sort of fluids, call'd spirits animal and vital; partly, perhaps, by little springy particles; by somewhat that may be call'd the vital portion of the air; and, by things analogous to local ferments: the important operations of all which, cease with life; and the agents themselves are not to be discern'd in a dead carcass. So that, besides those manifest uses, which the visible fabric of the engine may suggest to an anatomist; there may be chymical uses of some parts, that serve for the elaboration of spirits, and other fluids: which uses, as we formerly observ'd, are not suggested to the anatomist, by the inspection of the structure of the parts; but, to discern them, may require no ordinary skill in chymical principles, and operations.

Such considerations as these, lead me to think it exceeding difficult to determine, with any certainty, the principal use of many particular parts; especially, if other uses be excluded. It is not enough to secure us, that we understand the chief function, and end, of a part, to know, that it is contrived for such a purpose; since this fitness hinders not, but that the primary use of the part may be another more conducive to the general welfare of the animal, or the cosmical ends of nature. And it ought not to seem strange, that some pieces of workmanship, consisting of many parts, all of them curiously contrived, should, by one learned man, be guess'd to be design'd for this use; and, by others, for that; while both of them may be worthy of the artificer.

When some very politic prince does a great thing, without declaring why; the guesses of the statesmen are often very different; tho' none of them ascribe to him a design unbecoming a wise man. So, when a learned author expresses himself ambiguously; one reader interprets his words to this sense, and another, to that: yet both of the senses pitch'd on, may fairly agree with the context, and the main scope of the writer. This I say, because I would, by no means, disparage the wisdom of nature, by proposing the difficulties I have hitherto mentioned; tho', I confess, that, upon the account of them, and some others; I look upon many of the arguments that several

authors draw from final causes, but as conjectures. And, in many cases, I allow what is suggested to me, upon the supposition of the intended uses- of particular parts, rather as proper hints to excite, and direct, a more thorough inquiry, than as safe grounds to build physical conclusions on.

Proposition V
The naturalist should not suffer the search, or discovery, of final causes, to make him undervalue, or neglect, the inquiry after their efficients.

Tis true, to inquire for what purpose nature would have particular effects produced> is a curiosity worthy of a rational creature. But this is not the proper task of a naturalist j whose work is not so much to discover the manner wherein, as for what reason particular effects are produced. Thus, an ignorant rustic, in England, knows something of a watch, if he is able to tell you, that 'tis an instrument made to measure time v which is more than every American savage would be able to say; and more than those civiliz'd Chinese knew, who took the first watch they saw for a living creature: yet the English rustic, who knows no more of a watch, than that 'twas made to shew the hour of the day, understands but very little of the nature of that machine. And, as the two things men aim at in physics, are to understand after what manner nature produces the phenomenon we contemplate \ and, in cafe it be imitable by us, how. we may, if occasion requires, produce the like effect, or come near it; these ends cannot be attain'd by the bare knowledge of the final causes of things, nor of the general efficient. But, to answer those intentions, we must know the particular efficients, with the manner, and progress, of their operating; and what dispositions they either find, or produce in the matter they work on. Thus, he who would thoroughly understand the nature of a watch, must not rest satisfy'd with knowing, in general, that a man made it for such uses \ but he must, particularly, know of what materials the spring, the wheels, the chain, and the balance are made; he must know the number of the wheels, their magnitude, shape, situation, and connexion, in the engine 5 and after what manner one part moves another, in the whole series of motions; from the expansive endeavour of the spring, to the revolutions of the- index that points the hours. And much more must a mechanic know all this, if he means to make a watch himself, or to give sufficient instructions for it to be made. In short, the neglect of efficient causes, would render philosophy useless \ but the. studious search after them, will not prejudice the contemplation of final causes. For the wife author of nature has so excellently contriv'd the universe, that the more clearly, and particularly, we discern how suitable the means are to the ends to be obtained by them; the more plainly we discern the admirable wisdom of the author of things $ who is " wonderful in counsel, and excellent in working." Nor will the sufficiency of the intermediate causes make it needless to admit a first, and supreme cause; since that order of things, by virtue whereof these means become sufficient to such ends, must have been, at first, instituted by an intelligent cause. And if it be irrational to ascribe the excellent fabric of the universe, and the actions that have manifest tendencies to determinate useful ends, to so blind a cause as chance; it will be rather more irrational to ascribe to chance, the first formation of the universe, of which the present state of things is but the natural consequence, or effect. For it may, indeed, be plausibly slid, that, in the present state of things, the several parts of the universe are, by the contrivance of the whole, determin'd, and thereby qualify'd to obtain their ends; but it cannot be, rationally, pretended, that, at the first formation of the world, there was a sufficiency in the senseless materials of it, without any particular guidance of a wife superintendent, to frame bodies which are so excellently contriv'd, and fitted to their respective ends.

Upon the whole, it appears, that all consideration of final causes, is not to be banish'd from natural philosophy; but that 'tis rather allowable*, and, in some cases, commendable, to argue, from the manifest uses of things, that the author of nature pre-ordain'd them; that the fun, and moon, with the other celestial bodies, excellently declare the power, wisdom, and glory of God; and were, some of them, among other purposes, made to be serviceable to man; that, from the suppos'd ends of inanimate bodies, whether celestial, or sublunary, ‘tis very unsafe to draw arguments, to prove

the particular nature of those bodies, or the true system of the universe; that, as to animals, and the more perfect sort of vegetables, 'tis warrantable to say, particular parts were preordained to particular uses, relating to the welfare of the animal, or plant itself, or to its species; but that such arguments may easily deceive, if those who form them are not very cautious to avoid mistaking, among the various ends that nature may have in the contrivance of an animal body, and the various ways which she may successfully take to compass the same ends; and lastly, it appears that a philosopher, never-the-less, must not let the search, or knowledge of final causes, make him neglect a careful inquiry after efficients.

1691
John Ray
The Wisdom of God Manifested in the Works of the Creation
Book

Psalm. CIV. 24.
How manifold are thy works, O Lord! In Wisdom hast thou made them all.

In these Words are two Clauses, in the first whereof the Psalmist admires the Multitude of God's Works, How manifold are thy Works, O Lord! In the second he celebrates his Wisdom in the Creation of them; In Wisdom hast thou made them all.

Of the first of these I shall say little, only briefly run over the Works of this visible World, and give some guess at the Number of them; whence it will appear, that upon this account they will deserve Admiration, the Number of them being uninvestigable by us, and; so affording us a demonstrative Proof of the unlimited Extent of the Creator's Skill, and the Foecundity of his Wisdom and Power. That the number of corporeal Creatures is unmeasurably great, and known only to the Creator himself; may thus probably be collected: First of all, the Numbers of fix'd Stars is on all hands acknowledg'd to be next to infinite: Secondly, Every fix'd Star, in the now-receiv'd Hypothesis, is a Sun or Sun-like Body, and in like manner incircled with a Chorus of Planets moving about it; for the fix'd Stars are not all placed in one and the same concave Spherical Superficies, and equidistant from us, as they seem to be, but are variously and disorderly situate, some nearer, some further off, just like Trees in a Wood or Forest; as Gassendus exemplifies them. And as in a Wood, tho' the Trees grow never so irregularly, yet the Eye of the Spectator, wherever plac'd, or whithersoever remov'd, describes still a circle of Trees: So would it in like manner wherever it were in the Forest of Stars, describe a Spherical Superficies about it. Thirdly, each of these Planets is in all likelihood furnished with as great Variety of corporeal Creatures, animate and inanimate, as the earth is, and all as different in Nature as they are in Place from the Terrestrial, and from each other. Whence it will follow, that these must be much more infinite than the Stars: I do not mean absolutely according to Philosophick Exactness infinite, but only infinite or innumerable as to us, or their Number prodigiously great.

That the fix'd Stars are innumerable, may thus be made out: Those visible to the naked Eye are by the least Account acknowledg'd to be above a Thousand, excluding those towards the south Pole, which are not visible in our Horizon: Besides these, there have been incomparably more detected and brought to light by the Telescope; the Milky-way being found out to be; (as was formerly conjectr'd) nothing but great Companies or Swarms of Minute Stars singly invisible, but by reason of their Proximity mingling and confounding their Lights, and appearing like lucid Clouds. And it's likely that, had we more perfect Telescopes many Thousands more might be discovered; and yet after all, an incredible Multitude remain, by reason of their immense Distance beyond all Ken by the best Telescopes that could possibly be invented or polish'd by the Wit and Hand of an Angel:

For if the World be (as Des Cartes would have it) indefinitely extended; that is, so far as no human Intellect can fansie any Bounds of it; then what we see, or can come to see, must be the least Part of what is undicoverable by us, the whole Universe extending a thousand times further beyond the utmost Stars we can possibly descry, than those be distant from the Earth we live upon. This Hypothesis of the fix'd stars being so many Suns, etc. seems more agreeable to the Divine Greatness and Magnificence. But that which induces me much to doubt of the Magnitude of the Universe, and immense Distance of the fix'd Stars, is the stupendous Phoenomena of Comets, their sudden Accension or Appearance in full Magnitude, the Length of their Tails and Swiftness of their Motion, and gradual Diminution of Bulk and Motion, 'till at last they disappear. That the Universe is indefinitely extended, Des Cartes, upon a false ground, [that the formal Ratio of a Body was nothing but Extension into Length, Breadth and Proximity, or having partes extra partes, and that Body and Space were synonymous Terms] asserted; it may as well be limited this Way, as in the old Hypothesis, which places the fix'd Stars in the same spherical Superficies; according to which (old Hypothesis) they may also be demonstrated by the same Mediums to be innumerable, only instead of their Distance substituting their Smallness for the Reason of their Invisilbility.

But leaving the Celestial Bodies, I come now to the Terrestrial; which are either inanimate or animate. The inanimate are the Elements, Meteors and Fossils, of all Sorts, at the Number of which last I cannot give any probable Guess: But if the Rule which some considerate Philosophers deliver, holds good, viz. how much more imperfect any Genus or Order of Beings is, so much more numerous are the Species contain'd under it: As for Example Birds being a more perfect Kind of Animal than Fishes, there are more of these than of those; and for the like Reason more Birds than Quadrupeds, and more Insects than of any of the rest, and So more Plants than Animals, Nature being more sparing in her more excellent Productions. If this Rule, I say, hold good, then should there be more Species of Fossils, or generally of inanimate Bodies, than of Vegetables, of which there is some Reason to doubt, unless we will admit all Sorts of formed Stones to be distinct Species.

Animate Bodies are divided into four great Genera or Orders, Beasts, Birds, Fishes and Insects.

The Species of Beasts, including also Serpents, are not very numerous: Of such as are certainly known and describ'd, I dare say not above 150; and yet I believe not many, that are of any considerable Bigness, in the known Regions of the World, have escap'd the Cognizance of the Curious. [I reckon all dogs to be of one Species, they mingling together in Generation, and the Breed of such Mixtures being prolifick.

The Number of Birds known and describ'd may be near 500; and the Number of Fishes, secluding Shell-Fish, as many: But if the Shell-Fish be taken in, more than six times the Number. How many of each Genus remain yet undiscover'd, one cannot certainly nor very nearly conjecture; but we may suppose the whole Sum of Beasts and Birds to exceed by a third part, and Fishes by one Half; those known.

The Insects, if we take in the Exanguious both Terrestrial and Aquatick, may, in Derogation to the precedent Rule, for Number, vie even with Plants themselves: For the Exanguious alone, by what that Learned and Critical Naturalist, my honour'd Friend, Dr. Martin Lister, hath already observ'd and delineated, I conjecture, cannot be fewer than 3000 Species, perhaps many more.

The Butterflies and Beetles are such numerous Tribes, that I believe in our own native Country alone the Species of each Kind may amount to 150 or more. And if we should make the Catterpillers and Hexapods, from whence these come, to be distinct Species, as most Naturalists have done, the Number will be doubled, and these two Genera will afford us 600 Species: But if those be admitted for distinct Species, I see no Reason but their Aureliae also may pretend to a specifick Difference from the Caterpillers and Butterflies, and so we shall have 300 Species more; therefore we exclude

both these from the Degree of Species, making them to be the same Insect under a different Larva or Habit.

The Fly-kind, if under that Name we comprehend all other flying Insects, as well such as have four, as such as have but two Wings, of both which Kinds there are many subordinate Genera, will be found in Multitude of Species, to equal, if not exceed, both the forementionʼd Kinds.

The creeping Insects that never come to be wingʼd, thoʼ for Number they may fall Short of the flying or winged, yet are they also very numerous; as by running over the several Kinds I could easily demonstrate. Supposing then there be a Thousand several Sorts of Insects in this Island and the Sea near it, if the same Proportion holds between the Insects native of England, and those of the rest of the World, as doth between Plants domestick and exotick, (that is, as I guess, near a Decuple) the Species of Insects in the whole Earth (Land and Water) - will amount to 10000, and I do believe they rather exceed than fall short of that Sum.

Since the Writing hereof, having this summer, Ann. I691. with some diligence prosecuted the History of our English Insects, and making Collections of the Several Species of each Tribe, but particularly and especially of the Butterflies, both nocturnal and diurnal, I find the Number of such of these alone as breed in our Neighbourhood [about Braintree and Notably in Essex] to exceed the Sum I last Year assignʼd to all England, having myself observʼd and describʼd about 200 Kinds great and small, many yet remaining, as I have good Reason to believe, by me undiscoverʼd. This I have, since the writing hereof found true in Experience, having every Year observʼd not a few new Kinds: Nor do I think that, if I should live 20 Years longer, I should by my utmost Diligence and Industry in searching them out, come to an End of them. If then within the small Compass of a Mile or two there are so many Species to be found, surely the most modest Conjecture cannot estimate the Number of all the Kinds of Papillionʼs native of this Island to fall short of 300, which is twice so many as I last Summer guessʼd them to be; wherefore, using the same Argumentations, the Number of all the British Insects will amount to 2000 and the total Sum of those of the whole Earth will be 20000.

The Number of Plants containʼd in C. Bauhinʼs Penax is about 6000, which are all that had been describʼd by the Authors that wrote before him, or observʼd by himself; in which Work, besides Mistakes and Repetitions incident to the most wary and knowing Men in such a Work as that, there are a great many, I might say some Hundreds, put down for different Species, the which in my Opinion are but accidental Varieties: Which I do not say to detract from the excellent Pains and Performance of that Learned, Judicious and Laborious Herbarist, or to defraud him of his deservʼd Honour, but only to shew that he was too much swayʼd by the Opinions then generally current among Herbarists, that different Colour or multiplicity of leaves in the flower and the like Accidents, were sufficient to constitute a specifick difference. But supposing there had been 6000 then known and describʼd, I cannot think but that there are in the World more than triple that Number; there being in the vast Continent of America as great a Variety of Species as with us, and yet but few common to Europe, or perhaps Africk and Asia. And if on the other Side the Equator, there be much Land still remaining undiscoverʼd, as probably there may, we must suppose the Number of plants to be far greater.

What can we infer from all this? If the Number of Creatures be so exceeding great, how great nay, immense must needs be the Power and Wisdom of him who formʼd them all! For (that I may borrow the Words of a noble and excellent Author) as it argues and manifests more Skill by far in an Artificer, to be able to frame both Clocks and Watches, and Pumps, and Mills and Granadoes, and Rockets, than he could display in making but one of those sorts of Engines; so the Almighty discovers more of his Wisdom in forming such a vast Multitude of different Sorts of Creatures, and all with admirable and irreprovable Art, than if he had created but a few; for this declares the

Greatness and unbounded Capacity of his Understanding. Again, the same Superiority of Knowledge would be display'd, by contriving Engines of the same Kind, or for the same Purposes, after different Fashions, as the moving of Clocks or other Engines by Springs instead of Weights: So the infinitely Wise Creator hath shewn many Instances, that he is not confin'd to one only instrument for the working one Effect, but can perform the same thing by divers means. So, though feathers seem necessary for flying, yet hath he enabled several creatures to fly without them, as two Sorts of Fishes, one Sort of Lizard, and the Bat, not to mention the numerous Tribes of flying Insects. In like manner, though the Air bladder in Fishes seems necessary for swimming, yet some are so form'd as to swim without it; viz. First, the Cartilagineous Kind, which by what Artifice they poise themselves, ascend and descend at pleasure, and continue in what Depth of Water they list, is as yet unknown to us. Secondly, the Cetaceous Kind, or Sea-Beasts, differing in nothing almost from Quadrupeds but the want of Feet. The Air which in Respiration these receive into their Lungs, may Serve to render their Bodies equiponderant to the Water; and the Constriction or Dilatation of it, by the help of the Diaphragm and Muscles of Respiration, may probably assist them to ascend or descend in the Water, by a light Impulse thereof with their Fins.

Again, though the Water being a cold Element, the most Wise God hath so attemper'd the blood and Bodies of Fishes in general, that a small degree of heat is sufficient to preserve their due Consistency and Motion, and to maintain Life; yet to shew that he can preserve a Creature in the Sea, and in the coldest Part of the Sea too, that may have as great a degree of heat as Quadrupeds themselves, he hath Created great variety of these Cetaceous fishes, which converse chiefly in the Northern Seas, whose whole Body being encompassed round with a copious Fat or Blubber (which by reflecting and redoubling the internal heat, and keeping off the external Cold, doth the same Thing to them that Clothes do to us) is enabled to abide the greatest Cold of the Sea-Water. The reason why these fishes delight to frequent chiefly the Northern Seas, is, I conceive, not only for the Quiet which they enjoy there, but because the Northern Air which they breathe being more fully charg'd with those particles suppos'd nitrous, which are the Aliment of Fire, is fittest to maintain the vital Heat in that Activity which is sufficient to move such an unwieldy bulk, as their bodies are, with due Celerity, and to bear up against and repel the ambient Cold; and may likewise enable them to continue longer under Water than a warmer and thinner Air could.

Another instance to prove that God can, and doth by different Means produce the same Effect, is the various Ways of extracting the nutritious Juice out of the Aliment, in several Kinds of Creatures.

I. In Man and viviparous quadrupeds the Food moisten'd with the Spittle [saliva] is first chew'd and prepar'd in the Mouth, then swallow'd into the Stomach, where being mingled with some dissolvent Juices, it is by the Heat hereof concocted, macerated, and reduc'd into a Chyle or Cremor, and so evacuated into the Intestines, where being mix'd with the Choler and Pancreatick Juice, it is further subtiliz'd and render'd so fluid and penetrant, that the thinner and finer Part of it easily finds its Way in at the straight Orifices of the lacteous Veins. 1. In Birds there is no Mastication or Comminution of the Meat in the Mouth; but in such as are not Carnivorous, it is immediately swallow'd into the Crop or Craw, or at least into a Kind of Antestomach (which I have observ'd in many, especially Piscivorous Birds) where it is moisten'd and mollified by some proper Juice from the Glandules distilling in there, and thence transferr'd into the Gizzard or Musculous Stomach, where by the working of the Muscles compounding the Sides of that Ventricle, and by the Assistance of small Pebbles (which the Creature swallows for that Purpose) it is, as it were, by Mill-stones ground small, and so transmitted to the Guts, to be further attenuated and subtiliz'd by the forementionʼd Choler and Pancreatick Juice.

3. In oviparous Quadrupeds, as Chamaelions, Lizards, Frogs, as also in all Sorts of Serpents, there is no Mastication or Comminution of the Meat, either in Mouth or Stomachs; but as they swallow Insects or other animals whole, so they avoid their Skins unbroken, having a Heat, or Spirits,

powerful enough to extract the Juice they have Need of, without breaking that which contains it; as the Parisian Academist tells us. I myself cannot warrant the Truth of the Observation in all. Here, by the by, we take Notice of the wonderful Dilatability or extendableness of the Throats and Gullets of Serpents: I myself have taken two entire adult Mice out of' the Stomach of an Adder, whose Neck was not bigger than my little Finger. These Creatures, I say, draw out the juice of what they swallow without any comminution, or so much as breaking the Skin; even as it is seen that the juice of grapes is drawn as well from the Rape (Whole grapes pluck'd from the Cluster, and Wine poured upon them in a Vessel), where they remain whole, as from a Vat, where they are bruis'd; to borrow the Parisian Philosophers Similitude.

4. Fishes, which neither chew their Meat their Mouths nor grind it in their Stomachs, do by the Help of a dissolvent Liquor, therey Nature provided, corrode and reduce it, Skin, Bones and all, into a Chylus or Cremor; and yet (which may seem wonderful) this Liquor manifests nothing of Acidity to the Tast: But not withstanding, how mild and gentle soever it seems to be, it corrodes Flesh very strrangely and gradually, as Aqua fortis or the like corrosive Waters do Metals, as appears to the Eye; for I have observ'd Fish in the Stomachs of others thus partially corroded, first the superficial Part of the Flesh, and then deeper and deeper by degrees to the Bones.

I come now to the second part of the words; In Wisdom hast thou made them all. In discoursing whereof I shall endeavour to make out in particulars what the Psalmist here asserts in general concerning the Works of God, that they are all very wisely contriv'd and adapted to Ends both particular and general.

But before I enter upon this Task, I shall, by way of Preface or Introduction, say something concerning those Systems which undertake to give an Account of the Formation of the Universe by Mechanical Hypotheses of Matter, mov'd either uncertainly, or, according to some Catholick Laws, without the intervention and assistance of any superior immaterial Agent.

There is no greater; at least no more palpable and convincing Argument of the Existence of a Deity, than the admirable Art and Wisdom that discovers itself in the Make and Constitution, the Order and Disposition, the Ends and Uses of all the Parts and Members of this stately Fabrick of Heaven and Earth: For if in the Works of Art, as for Example, a curious Edifice or Machine, Counsel, Design, and Direction to an End appearing in the whole Frame, and in all the several pieces of it, do necessarily infer the Being and Operation of some intelligent Architect or Engineer, why shall not also in the Works of Nature, that (grandeur and Magnificence, that excellent Contrivance for Beauty, Order, Use, &c. which is observable in them, wherein they do as much transcend the Effects of humane Art as infinite Power and Wiidom exceeds finite, infer the Existence and Efficiency of an Omnipotent and All-Wise Creator?

To evade the force of this Argument, and to give some Account of the Original of the World, Atheistical Persons have set up two Hypotheses.

The first is that of Aristotle, that the World was from Eternity in the same Condition that now it is, having run through the Successions of infinite Generations; to which they add, Self-existent and unproduced: For Aristotle doth not deny God to be the efficient Cause of the World; but only asserts, that he created it from Eternity, making him a necessary Cause thereof; it proceeding from him by way of Emanation, as Light from the Sun.

Doctrine they ought to do, being (as we said) all perfectly solid and imporous, and the vacuum not resisting their Motion, they would never the one overtake the other, but like the Drops of a Shower would always keep the same Distances, and so there could be no Concourse or Cohaesion of them, and consequently nothing created; partly to avoid this destructive Consequence, and partly to give

some Account of the Freedom of Will (which they did assert contrary to the Democratick Fate) they did absurdly feign a Declination of some of these principles, without any shadow or pretence of Reason. The former of these motives you have set down by Lucretius, de Nat. rerum, 1. 2. in these Words: <> Corpora cum deorsum rectum per inane feruntur Ponderibus propriis, incerto tempore fortè, Incertiq; locis, Spatio discedere paulùm; Tantum quod momen mutatum dicere possis.

And again; <> Quod nisi declinare solerent, omnia deorsum Imbris uti guttae caderent per inane profundum, Nec foret offensus natus, nec plaga creata Principiis, ita nil umquam natura creâsset. Now Seeds in downward Motion must decline, Tho' vary little from the exactest Line; For did they still move strait, they needs must fall Like Drops of Rain, dissolv'd and scatter'd all, For ever tumbling thro' the mighty Space, And never join to make one single Mass.

The Second Motive they had to introduce this gratuitous Declination of Atoms, the same Poet gives us in these Verses, Lib. 2.

Si semper motus connectitur omnis, Et vetere exoritur semper novus ordine certo, Nec declinando faciunt primordia motûs Principium quoddam quod fati foedera rumpat, Ex iinito ne caufazn caufa fequatur; Libera per terras unde haec animantibus extat, Unde haec est, inquam, fatis avolsa voluntas?

Besides, did all things move in direct Line, And still one Motion to another join In certain Order, and no Seeds decline, And make a Motion fit to dissipate The well-wrought Chain of Causes and strong Fate; Whence comes that Freedom living Creatures find? Whence comes the Will so free, so unconfin'd, Above the Power of the Fate?

The Folly and Unreasonableness of this ridiculous and ungrounded Figment, I cannot better display and reprove than in the Words of Cicero, in the Beginning of his first Book de finibus Bonorum et Malorum. This Declination (saith he) is altogether childishly feign'd, and yet neither doth it at all solve the Difficulty, or effect what they desire: For First they say the Atoms decline, and yet assign no Reason why. Now nothing is more shameful and unworthy a Natural Philosopher (turpis Physico) than to assert any thing to be done without a Cause, or to give no Reason of it. Besides, this is contradictory to their own Hypothesis taken from sense, that all Weights do naturally move perpendicularly downward.

Secondly, again supposing this were true, and that there were such a Declination of Atoms, yet will it not effect what they intend. For either they do all decline, and so there will be no more Concourse than if they did perpendicularly descend; or some decline, and some fall plum down, which is ridiculously to assign distinct Offices and Tasks to the Atoms which are all of the same Nature and Solidity. Again, in his book de Fato he smartly derides this fond Conceit thus; What Cause is there in nature which turns the Atoms aside? Or do they cast Lots among themselves which shall decline, which not? Or why do they decline the least Interval that may be, and not a greater? Why not two or three minima as well as one; Optare hoc quidem est non disputare, For neither is the Atom by any extrinsical Impulse diverted from its natural Course; neither can there be any Cause imagin'd in the Vacuity through which it is carried, why it should not move directly; neither is there any Change made in the Atom itself, that it should not retain the Motion natural to it, by Force of its Weight or Gravity.

As for the whole Atomical Hypothesis, either Epicurean or Democritick, I shall not, nor need I, spend time to confute it; this having been already solidly and sufficiently done by many learned Men, but especially Dr. Cudworth, in his Intellectual System of the Universe, and the late Bishop of Worcester, Dr. Stillingfleet, in his Origines Sacrae. Only I cannot omit the Ciceronian confutation

thereof, which I find in the place first quoted, and in his first and second Books de Natura Deorum, because it may serve as a general Introduction to the following Particulars.

Such a turbulent Concourse of Atom could never, (saith he) hunc mundi ornatum efficere, compose so well-order'd and beautiful a Structure as the World is; which therefore both in Greek and Latin hath from thence [ab ornatu et munditie] obtain'd its Name. And again most fully and appositely in his second De Nat Deorum: If the works of Nature are better, more exact and perfect than the Works of Art, and Art effects nothing without Reason, neither can the Works of Nature be thought to be effected without Reason. For is it not absurd and incongruous that when thou beholdest a Statue or curious Picture, thou shouldest acknowledge that Art was usd to the making of it; or when thou seest the course of a Ship upon the Waters, thou shouldst not doubt but the Motion of it is regulated and directed by Reason and Art; or when thou considerest a Sun-Dial or Clock, thou shouldst understand presently, that the Hours are shewn by Art, and not by Chance; and yet imagine or believe, that the World, which comprehends all these Arts and Artificers, was made without Counsel or Reason. If one should carry into Scythia or Britain such a Sphere as our Friend Posidonius lately made, each of whose Conversions did the same Thing in the Sun and Moon and other five Planets, which we see affected every Night and Day in the Heavens, who among those Barbarians would doubt that that Sphere was compos'd by Reason and Art? A Wonder then it must needs be, that there should be any Man found so stupid and forsaken of Reason, as to persuade himself; that this most beautiful and adorn'd World was or could be produc'd by the fortuitous concourse of Atoms. He that can prevail with himself to believe this, I do not see why he may not as well admit, that if there were made innumerable Figures of the one and twenty Letters, in Gold, suppose, or any other Metal, and there well shaken and mixt together, and thrown down from some high Place to the Ground, they when they lightted upon the Earth would be so dispos'd and yank'd that a Man might see and read in them Ennius's Annals; whereas it were a great Chance if he should find one Verse thereof among them all. For if this concourse of Atoms could make a whole World, why may it not sometimes make, and why hath it not somewhere or other in the Earth made, a Temple, or a Gallery, or a Portico, or a House, or a City? Which yet is so far from doing, and every Man so far from believing, that should anyone of us be cast, suppose, upon a desolate island, and find there a magnificent Palace, artificially contriv'd according to the exact Rules of Architecture, and curiously adorn'd and furnish'd, it would never once enter into his Head, that this was done by an Earthquake, or the fortuitous Shuffling together of its component Materials; or that it had stood there ever since the Construction of the World, or first Cohaesion of Atoms; but would presently conclude that there had been some intelligent Architect there, the Effect of whose Art and Skill it was. Or should he find there but upon one single Sheet of Parchment or Paper, an Epistle or Ora tion written, full of profound Sense, expressed in proper and significant Words, illusrated and adorn'd with elegant Phrase; it were beyond the Possibility of the Wit of Man to persuade him that this was done by the temerarious Dashes of an unguided Pen, or by the rude Scattering of Ink upon the Paper, or by the lucky Projection of so many Letters at all Adventures; but he would be convinc'd by the Evidence of the Thing at first Sight, that there had been not only some Man, but some Scholar there.

The Cartesian hypothesis consider'd and censur'd

Having rejected this Atheistick Hypothesis of Epicurus and Democritus, I should now proceed to give particular Instances of the Art and Wisdom clearly appearing in the several Parts and Members of the Universe; from which we may justly infer this general Conclusion of the Psalmist, In Wisdom hast thou made them all: But that there is a Sort of professed Theists, I mean, Mons. Des Cartes and his Followers, who endeavour to disarm us of this decretory Weapon, to evacuate and exterminate this Argument, which hath been so successful in all Ages to demonstrate the Existence, and enforce the Belief of a Deity, and to convince and silence all Atheistick Gainsayers. And this they do,

First, By excluding and banishing all Consideration of final Causes from Natural Philosophy, upon Pretence, that they are all and every one in particular undiscoverable by us; and that it is Rashness and Arrogance in us to think we can find out God's Ends, and be Partakers of his Counsels.

Atque ob hanc unicam rationem totum illud causarum genus quod àe fine peti folet, in rebus Physicis nullum usum habere existimo; non enim absq; temeritate me puto investigare posse fines Dei. Meditat. Metaph.

And for this only Reason, I think, all that Kind of Causes which is wont to be taken from the End, to have no use in Physicks or natural Matters; for I cannot without rashness think myself able to find out the Ends of God.

And again in his Principles of Philosophy; Nullas unquam rationes circa res Naturales à fine quem Deus aut Natura in iis faciendis fibi proposuit admittiimus, quia non tantum nobis debemus arrogare ut ejus Conciliorum participes esse possimus.

We can by no Means admit any Reasons about natural Things, taken from the End which God or Nature propos'd to themselves in making of them; because we ought not to arrogate so much to ourselves, as to think we may be Partakers of his Counsels.

And more expressly in his fourth Answer, viz. to Gassendus's Objections;

Nec fingi potest, aliquos Dei fines magis quàm alios in propatulo esse: omnes enim in imperscrutabili ejus Sapientiae abysse sunt eodem modo reconditi:

That is, Neither can nor ought we to feign or imagine that some of God's Ends are more manifest than others; for all lie in like Manner or equally hidden in the unsearchable abyss of his Wisdom.

This confident Assertion of Des Cartes is fully examined and reprov'd by that honourable and excellent Person, Mr. Boyl, in his Disiquisition about the final Causes of Natural Things, Sect. 1 from Page 10 to the end; and therefore I shall not need say much to it, only in brief this, that it seems to me false and of evil Consequence, as being derogatory from the Glory of God, and destructive of the Acknowledgment and Belief of a Deity:

For first, Seeing (for Instance) that the Eye is employ'd by Man and all Animals for the Use of Vision, which, as they are fram'd, is necessary for them, that they could not live without it; and God Almighty knew that would be so; and seeing it is so admirably fitted and adapted to this Use, that all the Wit and Art of Men and Angels could not have contriv'd it better, if so well, it must needs be highly absurd and unreasonable to affirm, either that it was not Design'd at all for this Use, or that it is imposible for Man to know whether it was or not.

Secondly, How can Man give Thanks and Praise to God for the Use of his Limbs and Senses, and those his good Creatures which serve for his Sustenance, when he cannot be sure they were made in any respect for him; nay, when 'tis as likely they were not, and that he doth but abuse them to serve Ends for which they were never intended.

Thirdly, This Opinion, as I hinted before, supercedes and cassates the best Medium we have to demonstrate the Being of a Deity, leaving us no other demonstrative Proof but that taken from the innate Idea; which, if it be a Demonstration, is but an obscure one, not satisfying many of the Learned themselves, and being too subtle and metaphysical to be apprehended by vulgar Capacities, and consequently of no Force to persuade and convince them.

Secondly, They endeavour to evacuate and disannul our great Argument, by pretending to solve all the Phenomena of Nature, and to give an Account of the Production and Efformation of the Universe, and all the corporeal Beings therein, both celestial and terrestrial, as well animate as inanimate, not excluding Animals themselves, by a slight Hypothesis of Matter so and so divided and mov'd. The Hypothesis you have in Des Cartes's Principles of Philosophy, Part 2.

All the Matter of this visible World is by him suppos'd to have been at first divided by God into Parts nearly equal to each other, of a mean Size viz. about the Bigness of those whereof the Heavenly Bodies are now compounded; all together having as much Motion as is now found in the World and these to have been equally mov'd sevrally every one by itself about its own Centre, and among one another, so as to compose a fluid Body and also many of them jointly, or in Company about several other Points so far distant from one another, and in the same Manner dispos'd as the Centres of the fix'd Stars now are.

So that God has no more to do than to create the Matter, divide it into Parts, and put it into Motion, according to some few Laws, and that would of itself produce the World and all Creatures therein.

For a Confutation of this Hypothesis, I might refer the Reader to Dr. Cudworth's System p.603, 604. but for his ease I will transcribe the words:

"God in the mean Time standing by as an idle Spectator of this Lusus Atomorum, this sportfull Dance of Atoms, and of the various Results thereof. Nay, these mechanick Theists have here quite outstripp'd and outdone the Atomick Atheists themselves, they being much more extravagant than ever those were; for the professed Atheists durst never venture to affirm, that this regular system of Things resulted from the fortuitous Motions of Atoms at the very First, before they had for a long Time together produced many other inept Combinations, or aggregate Forms of particular Things and nonsensical Systems of the whole; and they suppos'd also, that the Regularity of Things here in this World would not always continue such neither, but that some time or other, Confusion and Disorder will break in again. Moreover, that besides this World of ours, there are at this very instant innumerable other Worlds irregular, and that there is but one of a thousand or ten thousand among the infinite Worlds that have such Regularity in them, the Reason of all which is, Because it was generally taken for granted, and look'd upon as a common Notion, that twn apo tuKEs kai tou automatou ouden aei houtw ginetai, as Aristotle expresseth it; none of those Things which are from Fortune or Chance come to pass always alike. But our mechanick Theists will have their Atoms never so much as once to have fumbled in these their Motions, nor to have produc'd any inept System, or incongruous forms at all, but from the very first all along to have taken up their Places, and ranged themselves so orderly, methodically and directly; as that they could not possibly have done it better had they been directed by the most perfect Wisdom. Wherefore these Atomick Theists utterly evacuate that grand Argument for a God taken from the Phaenomenon of the Artificial frame of things, which hath been so much insisted upon in all Ages, and which commonly makes the strongest impression of any other upon the minds of Men &c the Atheists in the mean Time laughing in their sleeves, and not a little triumphing to see the cause of Theism thus betray'd by its profess'd Friends and Assertors, and the grand Argument for the same totally slurred by them, and so their work done, as it were, to their Hands.

Now as this argues the greatest Insensibility of Mind, or Sottishness and Stupidity in pretended Theists, not to take the least notice of the regular and artificial Frame of things, or of the Signature of the Divine Art and Wisdom in them, nor to look upon the Wcrlds and Things of Nature with any other Eyes than Oxen and Horses do; So there are there many Phaenomena in Nature, which being partly above the force of these mechanick powers, and partly contrary to the same, can therefore never be salv'd by them, nor without final Causes and some vital Principle: As for

Example, that of Gravity or the Tendency of Bodie downward, the Motion of the Diaphragm in Respiration, the Systole and Diastole of the Heart, which is nothing but a Muscular Constriction and Relaxation, and therefore not mechanical but vital. We might also add, among many others, the Intersection of the Plains of Equator and Ecliptick, or the Earth's diurnal Motion upon an Axis not parallel to that of the Ecliptick, nor perpendicular to the Plain thereof. For tho' Des Cartes would needs imagine this Earth of ours once to have been a Sun, and so itself the Centre of a lesser Vortex, whose Axis was then directed after this Manner, and which therefore still kept the same Site or Posture, by Reason of the striate Particles finding no fit Pores or Traces for their Passages through it, but only in this Direcrtion; yet does he himself confess, that because these two Motions of the Earth, the Annual and Diurnal, would be much more conveniently made upon parallel Axes, therefore, according to the Laws of Mechanism, they should be perpetually brought nearer and nearer together, till at length the Equator and Ecliptick come to have their axes parallel, which, as it hath not yet come to pass, so neither hath there been for these last Two Thousand Years (according to the best Observations and Judgments of Astronomers) any nearer approach made of them one to another. Wherefore the continuation of these two motions of the Earth, the Annual and Diurnal, upon Axes not parallel is resolvable into nothing but a final and mental Cause, or the <> to Beltizon, because it was best it should be so, the Variety of the Seasons of the Year depending thereupon. But the greatest of all the particular Phaenomena is the Formation and Organization of the Bodies of Animals, consisting of such Variety and Curioisity; that these mechanick Philosophers being no Way able to give an Account thereof from the necessarv motion of Matter, unguided by Mind for Ends, prudently therefore break off their System there when they should come to Animals, and so leave it altogether untouch'd. We acknowledg indeed there is a Posthumous piece extant, imputed to Cartes, and entitled, De la formation du Foetus, wherein there is some pretence made to salve all this fortuitous Mechanism. But as the Theory thereof is built wholly upon a false supposition, sufficiently confuted by our Harvey his Book of Generation, that the Seed doth materially enter into the composition of the Egg: So is it all along precarious and exceptionable; nor doth it extend at all to the diffierences that are in several Animals, nor offer the least Reason why an Animal of one Species might not be formed out of the Seed of another. Thus far the Doctor, with whom for the main I do consent.

I shall only add, that Natural Philosophers, when they endeavour to give an Account of any the Works of Nature by preconceiv'd Principles of their own, are for the most Part grossly mistaken and confuted by Experience; as [example of such error in simple matter of anatomy] obvious to Sense, and infinitely more easie to find out the Cause of, than to give an Account of the Formation of the World; that is, the Pulle the Heart, which he attributes to an Ebullition and sudden Expansion of the Blood in the Ventricles, after the Manner of Milk, which being heated to such a Degree, doth suddenly and as it were all at once, flush up and run over the Vessel. Whether this Ebullition be caus'd by a Nitro-Sulphureous ferment lodged especially in the left Ventricle of the Heart, which mingling with the Blood excites such an Ebullition, as we see made by the Mixture of some Chymical Liquors, viz . Oil of Vitriol, and deliquated Salt of Tartar; or by vital flame warming and boiling the Blood.

But this Conceit of his is contrary both to Reason and Experience: For, first, it is altogether unreasonable to imagine and affirm that the cool venal Blood should be heated to so high a Degree in so short a Time as the Interval of two Pulses which is less than the sixth part of a Minute. Secondly, in cold Animals, as for Example, Eels, the Heart will beat for many Hours after it is taken out of the Body, yea tho' the Ventricle be opened and all the Blood squeez'd out. Thirdly, the process of the Fibres which compound the Sides of the Ventricles running in Spiral Lines from the Tip to the Base of the Heart, some one Way, and some the contrary, do clearly shew that the Systole of the Heart is nothing but a Muscular constriction, as a Purse is shut by drawing the Strings contrary ways: Which is also confirm'd by Experience; for if the Vertex of the Heart be cut off, and a Finger thrust up into one of the Ventricles, in every Systole the Finger will be sensibly and

manifestly pinch'd by the Sides of the Ventricle. But for a full Confutation of this Fancy, I refer the Reader to Dr. Lower's Treatise de Corde Chap. 2 and Des Cartes's rules concerning the transferring of Motion from one Body in Motion to another in Motion or in Rest, are the most of them by Experience found to be false; as they affirm who have made Trial of them.

This Pulse of the Heart Dr. Cudworth would have to be no Mechanical but a Vital Motion, which to me seems probable, because it is not under the Command of the Will; nor are we conscious of any Power to cause or to restrain it, but it is carried on and continued without our knowledge or notice; neither can it be caused by the Impulse of any external Movent, unless it be Heat. But how can the Spirits agitated by Heat, unguided by a vital Principle, produce such a regular reciprocal motion? If that Site which the heart and its Fibres have in the Diastole be most na tural to them, (as it seems to be) why doth it again contract itself, and not rest in that posture? If it be once contracted in a Systole by the Influx of the Spirits, why, the Spirits continually flowing in without let, doth it not always remain so? [for the Systole seems to resemble the forcible Bending of a Spring, and the Diastole its flying out again to its natural Site.] What is the Spring and principal Efficient of this Reciprocation? What directs and moderates the Motions of the Spirits? They being but stupid and senseless Matter, cannot of themselves continue any regular and constant Motion, without the Guidance and Regulation of some intelligen Being. You will say, what Agent is it which you would have to effect this? The Sensitive Soul it cannot be, because, that is indivisible, but the Heart, when separated wholly from the Body in some Animals, continues still to pulse for a considerable Time; nay, when it hath quite ceased, it may be brought to beat anew by the Application of warm Spittle, or by pricking it gently with a Pin or Needle. I answer, it may be in these Instances, the scattering Spirits remaining in the Heart, may for a Time, being agitated by Heat, cause these faint Pulsations though I should rather attribute them to a plastic Nature Nature or vital Principle, as the Vegetation of Plants must also be.

But, to proceed, neither can I wholly acquiesce in the Hypothesis of that Honourable and deservedly famous Author I formerly had occasion to mention; which I find in his Free Enquiry into the Vulgar Notion cf Nature, p. 77, 78. delivered in these Words.

"I think it probable that the great and Wise Author of Things did, when he first formed the Universal and Undistinguished Matter into the World, put its parts into various Motions, whereby they were neccesarily divided into numberless Portions of differing Bulks, Figures and Situations in respect of each other: And that by his infinite Wisdom and Power he did so guide and over-rule the Motions of these Parts, at the beginning of things, as that (whether in a shorter or a longer time Reason cannot determine) they were finally disposed into that beautiful and orderly Frame that we call the World; among whose Parts some were so curiously contriv'd, as to be fit to become the Seeds or seminal Principles of Plants and Animals. And I further conceive, that he settled such Laws or Rules of local Motion among the Parts of the universal matter, that by his ordinary and preserving Concourse, the several Parts of the Universe thus once completed should be able to maintain the great Construction or System and Oeconomy of the mundane Bodies, and propagate the Species of living creatures. The same Hypothesis he repeats again page 124, 125 of the same Treatise.

This Hypothesis, I say, I cannot fully acquiesce in, because an intelligent Being seems me requisite to execute the Laws of Motion. For first, Motion being a fluent Thing, and one part of its Duration being absolutely independent upon another, it doth not follow that because any thing moves this Moment, it must necessarily continue to do so the next; unless it were actually possesse'd of its future Motion, which is a Contradiction; but it stands in as much Need of an Efficient to preserve and continue its Motion as it did at first to produce it. Secondly, Let Matter be divided into the subtilest Parts imaginable, and these be mov'd as swiftly as you will, it is but a senseless and stupid Being still, and makes no nearer Approac to Sense, Perception or vital Energy, than it had before;

and do but only stop the internal Motion of its Parts, and reduce them to Rest, the finest and most subtile Body that is, may become as gross, and heavy, and stiff as Steel or Stone.

And as for any external Laws or established Rules of Motion, the stupid Matter is not capable of observing or taking any Notice of them, but would be as sullen as the Mountain was that Mahomet commanded to come down to him; neither can those Laws execute themselves. Therefore there must, besides Matter and Law, be some Efficient, and that either a Quality or Power inherent in the Matter itself, which is hard to conceive, or some external intelligent Agent, either God himself immediately, or some Plastick Nature.

Happening lately to read The Christian Virtuoso, written by the same Author of the Enquiry into the vulgar notions of Nature, (the illustrious Mr. Boyle) I find therein these Words: "Nor will the Force of all that has been said for God's special Providence be eluded, by saying with some Deists, That afiter the first Formation of the Universe all Things were brought to pass by the settled Laws of Nature. For though this be confidently, and not without Colour, pretended, yet I confess it doth not satisfie me: For I look upon a Law as a Moral, not Physical Cause, as being indeed but a notional Thing, according to which an intelligent and free Agent is bound to regulate its Actions. But inanimate Bodies are utterly uncapable of Understanding; what it is, or what it enjoins, or when they act conformably or unconformably to it: therefore the Actions of inanimate Bodies, which cannot incite or moderate their own Actions, are produced by real Power, not by Law."

All this being consonant to wat I have here written, against what I took to be this Honourable Person's Hypothesis, I must needs, to do him Right, acknowledge myself mistaken; perceiving, now, that his Opinion was, that God Almiglaty did not only establish Laws and Rules of local motion among the Parts of the Universal Matter, but did, and does also himself, execute them, or move the Parts of Matter, according to them: So that we are in the main agreed, differing chiefly about the Agent that executes those Laws, which he holds to be God himself immediately, we a Plastick Nature; for the Reasons alledg'd by Dr. Cudworth, in his System, pag. 149. which are,;

First, Because the former, according to vulgar apprehension, would render the Divine Providence operose, solicitous and distractious; and thereby make the Belief of it entertain'd with greater Difficulty, and give Advantage to Atheists.

Secondly, it is not so decorous in Respect of God, that he should <>autourgein hapanta, set his own Hand as it were to every work, and immediately do all the meanest and triflingst things himself drudgingly, without making use of any inferiour or subordinate Ministers. These two Reasons are plausible, but not cogent; the two following are of greater Force.

Thirdly, the slow and gradual Process that is in the Generation of Things, which would seem to be a vain and idle Pomp or trifling formality, if the Agent were omnipotent.

Fourthly, those <>hamartEmata, as Aristotle calls them, those Errors and Bungles which are committed when the Matter is inept or contumacious, as in Monsters, &c. which argue the Agent not to be irresistible; and that Nature is such a Thing as is not altogether uncapable, as well as human Art, of being sometimes frustrated and disappointed by the Indisposition of the Matter; Whereas an omnipotent agent would always do its Work infallibly and irresistibly, no Ineptitude or Stubbornness of the Matter being ever able to hinder such an one, or make him bungle or fumble in any thing. So far the Doctor.

For my Part, I should make no Scruple to attribute the Formation of Plants, their Growth and Nutrition, to the vegetative Soul in them; and likewise the Formation of Animals to the vegetative Power of their Souls; but that the Segments and Cuttings of some Plants, nay, the very Chips and

smallest Fragments of their Body, Branches or Roots, will grow and become perfect plants themselves, and so the vegetative Soul, if that were the Architect, would be divisible and consequently no spiritual or intelligent Being; which the plastick Principle must be, as we have shewn: For that must preside over the whole Oeconomy of the Plant, and be one single agent, which takes Care of the Bulk and Figure of the whole, and the Situation, Figure, Texture of all the Parts, Root, Stalk, Branches, Leaves, Flowers, Fruit, and all their Vessels and juices. I therefore incline to Dr. Cudworth's Opinion, that God uses for these Effects the subordinate Ministry of some inferiour Plastick Nature; as in his Works of Providence he doth of Angels. For the Description whereof I refer the Reader to his System.

Secondly, in particular I am difficult to believe, that the bodies of Animala can be form'd by matter divided and mov'd by what Laws you will or can imagine, without the immediate Presidency, Direction and Regulation of some intelligent Being. In the Generation or first Formation of, suppose, the Human Body out of (though not an Homogeneous Liquor, yet) a fluid Substance, the only material Agent or Mover is a moderate Heat. Now, how this, by producing an intestine Motion in the Particles of the Matter, which can be conceiv'd to differ in nothing else but Figure, Magnitude and Gravity, should by Vertue thereof, not only separate the Heterogeneous Parts, but assemble the Homogeneous into Masses or Systems, and that not each Kind into one Mass, but into many and disjoin'd ones, as it were so many Troops; and that in each Troop the particular Particles should take their Places, and cast themselves into such a Figure; as for Example, the Bones being about 300, are form'd of various sizes and shapes, so situate and connected, as to be subservient to many hundred Intentions and Uses, and many of them conspire to one and the same Action, and all this contrarily to the Laws of Specifick Gravity, in whatever Posture the body be formed; for the Bones, whose component Parts are the heavier, will be above some parts of the Flesh which are the lighter; how much more then, seeing it is form'd with the Head, (which for its Bigness is the heaviest of all the Parts) uppermost. This, I say, I cannot by any Means conceive. I might instance in all the Homogenous Parts of the Body, either Sites and Figures, and ask by what imaginable Laws of Motion their Bulk, Figure, Situation and Connection can be made out? What account can be given of the Valves, of the Veins and Arteries of the Heart, and of the Veins elsewhere, and of their Situation; of the Figure and Consistency of all the Humours and Membranes of the Eye, all conspiring and exactly fitted to the use of Seeing; but I have touched upon that already, and shall discourse on it largely afterward. You will ask me, who or what is the Operator in the Formation of the Bodies of Man and other Animals? I answer, The sensitive Soul itself, if it be a spiritual and immaterial Substance, as I am inclinable to believe: But if it be material, and consequently the whole Animal but a mere Machine or Automaton, as I can hardly admit, then must we have Recourse to a Plastick Nature.

That the Soul of Brutes is material, and the whole Animal, Soul and Body, but a mere Machine, is the Opinion, publickly own'd and declar'd, of DeS Cartes, Gassendus, Dr. Willis, and others. The same is also necessarily consequent upon the Doctrine of the Peripateticks, viz. that the sensitive soul is educed out of the power of the Matter, for nothing can be educed out of the Matter, but what was there before, which must be either Matter or some Modification of it. And therefore they cannot grant it to be a spiritual Substance, unless they will assert it to be educed out of nothing. This Opinion, I say, I can hardly digest. I should rather think Animals to be endued with a lower Degree of Reason, than that they are mere Machines. I could instance in many Actions of Brutes that are hardly to be accounted for without Reason and Argumentation; as that commonly noted of Dogs, that running before their Masters, they will stop at a Divarication of the way, till they see which Hand their Masters will take; and that when they have gotten a Prey, which they fear their Masters will take from them, they will run away and hide it, and afterwards turn to it. What account can be given why a Dog, being to leap upon a Table which he sees to be too high for him to reach at once, if a Stool Chair happens to stand near it, doth first mount up that, and from thence the Table? If he were a Machine or Piece of Clockwork, and this Motion caused by the striking of a

Spring, there is no Reason imaginable why the Spring being set on Work, should not carry the machine in a right Line toward the Object that put it in Motion, as well when the Table is high as when it is low: Whereas I have often observ'd the first Leap the Creature hath taken up the Stool, not to be directly toward the Table, but in a Line oblique and much declining from the Object that mov'd it, or that part of the Table on which it Stood.

Many the like Actions there are, which I shall not spend Time to relate. Should this true, that Beasts were Automata or Machines, they could have no Sense or Perception of Pleasure or Pain, and consequently no Cruelty could be exercis'd towards them; which is contrary to the doleful Significations they make when beaten or tormented, and contrary to the common Sense of Mankind, all Men naturally pitying them, as apprehending them to have such Sense and Feeling of Pain and Misery as themselves have; whereas no Man is troubled to see a Plant torn, or cut, or stampt, or mangled how you please; and at last seemingly contrary to the Scripture too: For it is said, Proverbs 12 10 A righteous Man regardeth the life of his Beast; but the tender Mercies of the Wicked are cruel. The former Clause is usually English'd, A good Man is merciful to his Beast; which is the true Exposition of it; as appears by the opposite Clause, that the Wicked are cruel, What less then can be inferr'd from this Place, than that Cruelty may be exercis'd towards Beasts, which, were they meer Machines, it could not be? To which I do not see what can be answer'd, but that the Scripture accommodates itself to the common, tho' false, Opinion of Mankind, who take these Animals to be endued with Sense of Pain, and think that Cruelty may be exercis'd towards them; tho' in Reality there is no such thing. Besides, having the same members and Organs of Sense as we have, it is very probable they have the same Sensations and Perceptions with us.

To this Des Cartes answers, or indeed saith, he hath nothing to Answer; but that if they think as well as we, they have an immortal Soul as well as we: Which is not at all likely, because there is no Reason to believe it of some Animals without believing it of all, whereas there are many too imperfect to belleve it of them, such as are Oysters and Sponges, and the like. To which I answer, That there is no Necessity that they should be immortal, because it is possible they may be destroyed or annihilated. But I shall not wade further into this Controversie, because it is beside my Scope, and there hath been as much written of it already as I have to say, by Dr. Moore, Dr. Cudworth, Des Cartes, Dr. Willis and others Pro and Con.

Of the visible works of God, and their Division.

I come now to take a View of the Works of the Creation, and to observe something of the Wisdom of Ciocl discernible in the Formation of them, in their Order and Harmony, and in their Ends and Uses: And first I shall run them over slightly, remarking chiefly what is obvious and expos'd to the Eyes and Notice of the more careless and incurious Observer. Secondly, I shall select one or two particular Pieces, and take a more exact Survey of them; though even in these, more will escape our Notice that can be discover'd by the most diligent Scrutiny: for our Eyes and Senses, however armed or assisted, are too grosss to discern the curiosity of the workmanship of Nature, or those minute Parts by which it acts, and of which Bodies are compos'd; and our Understanding too dark and infirm to discover and comprehend all the Ends and Uses to which the infinitely wise Creator did design them.

But before I proceed, being put in Mind thereof by the Mention of the Assistance of our Eyes, I cannot omit one general Observation concerning the Curiosity of the Works of Nature in Comparison of the Works of Art which I shall propose in the late Bishop of Chester's Words, (Treatise of Natural Religion, Lib. I. C. 6.) "The Observations which have been made in these latter Times by the Help of the Microscope, since we had the Use and Improvement of it, discover a vast difference between Natural and Artificial Things. Whatever is natural, beheld thro' that, appears exquisitely form'd, and adorn'd with all imaginable Elegancy and Beauty. There are such inimitable Glidings in the smallest Seeds of Plants, but especially in the Parts of Animals in the Head or Eye of a small Fly;

such Accuracy, Order and Symmetry in the Frame of the most minute Creatures, a Louse, for example, or a Mite, as no Man were able to conceive without seeing of them.

Whereas the most curious Works of Art, the sharpest and finest Needle, doth appear as a blunt rough Bar of Iron, coming from the Furnace or the Forge: The most accurate Engravings or Embellishments seem such rude, bungling and deform'd Work, as if they had been done with a Mattock or Trowel; so vast a Difference is there betwixt the Skill of Nature, and the Rudeness and Imperfection of Art. I might add, that the Works of Nature, the better Lights and Glasses you use, the more clearer and exactly form'd they appear; whereas the Effects of Human Art, the more curiously they are view'd and examin'd, the more of Deformity they discover. This being premised, for our more clear and distinct Proceeding in our cursory View of the Creation, I shall rank the Parts of this material and visible World under several Heads. Bodies are either inanimate or animate. Inanimate Bodies are either celestial or terrestrial. Celestial as the Sun, Moon and Stars: Terrestrial are either simple, as the four Elements, Fire, Water, Earth and Air; or mixt, either imperfectly, as the Meteors, or more perfectly, as Stones, Metals, Minerals, and the like. Animate Bodies are either such as are endued with a Vegetable Soul as Plants; or a Sensitive Soul, as the Bodies of Animals, Birds, Beasts, Fishes, and Insects; or a Rational Soul, as the Body of Man and the Vehicles of Angels, if any such there be.

I make use of this division to comply with the common and receiv'd Opinion, and for easier Comprehension and Memory; tho' I do not think it agreeable to Philosophick Verity and Accuracy, but do rather incline to the Atomick Hypothesis. For these Bodies we call elements are not only the only Ingredients of mix'd Bodies; neither are they absolutely simple themselves, as they do exist in the World, the Sea-water containing a copious Salt manifest to Sense; and both Sea and Fresh-water sufficing to nourish many Species of Fish, and consequently containing the various Parts of which their Bodies are compounded. And I believe there are many Species of Bodies which the Peripateticks call mix'd, which are as simple as the Elements themselves, as Metals, Salts and some sorts of stones. I should therefore, with Dr. Grew and others, rather attribute the various Species of inanimate Bodies to the divers Figures of the minute Particles of which they are made up: And the Reason why there is a set and constant Number of them in the World, none destroy'd nor any new ones produc'd, I take to be, Because the Sum of the Figures of those minute Bodies into which Matter was at first divided, is determinate and fix'd.

2. Because those minute Parts are indivisible, not absolutely, but by any natural Force; so that there neither is nor can be more or fewer of them: For were they divisible into small and diversly figur'd parts by Fire or any other natural Agent, the Species of Nature must be confounded, some might be lost and destroyed, but new ones would certainly be produc'd; unless we could suppose these new diminutive Particles should again assemble and marshal themselves into Corpuscles of such Figures as they compounded before; which I see no Possibility for them to do, without some theos apo mEKanEs to direct them: Not that I think these inanimate Bodies to consist wholly of one Sort of Atoms, but that their Bulk consists mainly or chiefly of one Sort. But whereas it may be objected that Metals (which of all others seem to be most simple) may be transmitted one into another, and so the Species doth not depend upon the being compounded of Atoms of one Figure; I Answer, I am not fully satisfied of the Matter of Fact: But if any such Transmutation be, possibly all Metals may be of one Species, and the Diversity may proceed from the Admixture of different Bodies with the Principle of the Metal. If it be ask'd, why may not atoms of different Species concur to the Composition of Bodies? and so, tho' there be but a few Sorts of original Principles, may there not be produced infinite Species of compound Bodies, as by the various Dispositions and Combinations of Twenty-four Letters innumerabl Words may be made up? I answer, because the Heterogeneous Atoms or Principles are not naturally apt to cohere and stick together when they are mingled in the same Liquor, as the Homooeneous readily do.

I do not believe that the Species of Principles or indivisible Particles are exceeding numerous but possibly the immediate component Particles of the Bodies of Plants and Animals may be themselves compounded.

Of the Heavenly Bodies.

Before I come to treat of the Heavenly Bodies in particular, I shall premise in general, that the whole Universe is divided into two Sorts of Bodies, the one very thin and fluid, the other more dense, solid and consistent. The thin and fluid is the Ether, comprehending the Air or Atmosphere encompassing the particular Stars and Planets. Now, for the Stability and Perpetuity of the whole Universe, Divine Wisdom and Providence hath given the solid and stable Parts a two-fold Power, one of Gravity, and the other of Circular Motion. By the first they are preserv'd from Dissolution and Dissipation, which the Second would otherwise infer: For it being by the Consent of Philosophers, an innate Property of every Body moved circularly about any Centre to recede or endeavour to recede from that Centre of its Motion, and the more strongly the swifter it is mov'd, the Stars and Planets being whirled about with great Velocity, wouid suddenly, did nothing inhibit it, at least in a short Time be shatter'd in Pieces, and Scatter'd every Way through the Ether. But now their Gravity unites and binds them up fast, hindring the Dispersion of their Parts, I will not dispute what Gravity is; only I will add, that, for ought I have heard or read, the Mechanical Philosophers have not as yet given a clear and satisfactory Account of it.

The Second Thing is a Circular Motion upon their own Axes, and in some of them also, it's probable, about other Points, if we admit the Hypothesis of every fix'd Star's being a Sun or Sun-like Body, and having a Choire of Planets, in like manner moving about him. These Revolutions, we have Reason to believe, are as exactly equal and uniform as the Earth's are; which could not be, were there any Place for chance, and did not a Providence continually over-see and secure them from all Alteration or Immunition, which either internal Changes in their own Parts, or external Accidents and Occurrences, would at one time or other necessarily induce. Without this circular motion of the Earth, here could be no living: One Hemisphere would be condemn'd to perpetual Cold and Darkness, the other continually roasted and parch'd by the Sun-beams. And it is reasonable to think, that this circular Motion is as necessary to most other Planetary Bodies, as it is to the Earth. As for the fix'd Stars, if they be Sun-like Bodies, it is is probable also each of them moves circularly upon its own Axis as the Sun doth: But what Necessity there is of such a Motion, for Want of understanding the Nature of those Bodies, I must confess myself not yet to comprehend; tho' that it is very great I doubt not, both for themselves, and for Bodies about them.

First, for the Celestial or Heavenly Bodies, the Equability and Constancy of their Motions, the Certainty of their Periods and Revolutions, the Conveniency of their Order and Situations, argue then to be ordain'd and govern'd by Wisdom and Understanding; yea, so much Wisdom as Man cannot easily fathom or comprehend: For we see, by how much the hypotheses of Astronomers are more simple and conformable to reason, by so much do they give a better Account of the Heavenly Motions. It is reported of Alphonsus King of Aragon, (I know not whether truly) that when he saw and consider'd the many Eccentricks, Epicycles, Epicycles upon Epicycles, Librations, and Contrariety of Motions, which were requisite in th old Hypothesis to give an Account of the Celestial Phaenomena, he should prefume blasphemously to say, that the Universe was a bungling Piece; and that if he had been of God's Counsel, he could have directed him to have made it better. A Speech as rash and ignorant, as daring and prophane.

For it was nothing but Ignorance of the true Process of Nature that induced the Contrivers of that Hypothesis to invent such absurd Suppositions, and him to accept them for true, and attribute them to the great Author of the Heavenly Motions: For in the New Hypothesis of the modern Astronomers, we see most of those Absurdities and Irregularities rectified and remov'd, and I doubt not but they would all vanish, could we certainly discover the true Method and Process of Nature in those

Revolutions: for Seeing in those Works of Nature which we converse with, we constantly find those Axioms true, <>Natura non facit circuitus, Nature doth not fetch a Compass when it may proceed in a streight Line; and <>Natura nec abundat in superfluis, nec deficit in necessariis, Nature abounds not in what is superfluous, neither is deficient in what is necessary. We may also rationally conclude concerning the Heavenly Bodies, seeing there is so much Exactness observ'd in the Time of their Motions, that they punctually come about in the same Periods to the Hundredth Part of a Minute, as may beyond Exception be demonstrated by comparing their Revolutions, surely there is also used the most simple, facile, and convenient Way for the Performance of them.

Among these Heavenly Bodies;

First, the Sun, a vast Globe of Fire, esteeemed by the ancienter and most modest Computation above 160 times bigger than the Earth, the very Life of this inferiour World, without whose salutary and vivifick Beams all Motion both Animal, Vital and Natural would speedily cease, and nothing be left here below but Darkness and Death. All Plants and Animals must needs in a very short Time be not only mortified, but, together with the Surface of Land and Water, frozen as hard as a Flint or Adamant: So that of all the Creatures of the World the ancient Heathen had most Reason to worship him as a God, tho' no true Reason; because he was but a Creature, and not God: And we Christians do think that the Service of the Animals that live upon the Earth, and principally Man, was one End of his Creation; seeing without him there could no such Things have been. This Sun, I say, according to the old Hypothesis, whirl'd round about the Earth daily with incredible Celerity, making Night and Day by his rising and setting; Winter and Summer by his Access to the Several Tropicks, creating such a grateful variety of Seasons, enlightning all Parts of the Earth by his Beams, and cherishing them by his Heat, situate and mov'd so in Respect of this sublunary World (and it's likely also in Respect of all the Planets about him) that Art and Counsel could not have Design'd either to have placed him better, or mov'd him more conveniently for the Service thereof, as I could easily make appear by the Inconveniences that would follow upon the Supposition of any other Situation and Motion, shews forth the great Wisdom of him who so dispos'd and mov'd him.

Secondly, The Moon, a Body in all Probability somewhat like the Earth we live upon, by its constant and regular Motion, helps us to divide our Time, reflects the Sun-beams to us, and so by illuminating the Air, takes away in some Measure the disconsolate darkness of our winter Nights; procures or at least regulates the Fluxes and Refluxes of the Sea, whereby the Water is kept in constant Motion, and preserv'd from Putrefaction, and so render'd more salutary for the Maintenance of its Breed, and useful and serviceable for Man's Convenience of Fishing and Navigation; not to mention the great Influence it is suppos'd to have upon all moist Bodies, and the Growth and Increase of Vegetables and Animals: Men generally observing the Age of the Moon in the planting of all Kinds of Trees, sowing of Grain, grafting and inoculating, and pruning of Fruit-Trees, gathering of Fruit, bcutting of Corn or Grass; and thence also making Prognosticks of Weather, Because such Observations seems to me uncertain. Did this Luminary serve to no other Ends and Uses, as I am Persuaded it doth many, especially to maintain the Creatures which in all likelyhood breed and inhabit there, for which I refer you to the ingenious Treatises written by Bishop Wilkins and Monsieur Fontenelle on that Subject, yet these were enough to evince it to be the Effect and Product of Divine Wisdom and Power.

Thirdly, As for the rest of the Planets besides their particular Uses, which are to Us unknown, or meerly conjectural, their Courses and Revolutions, their Stations and Retrogradations, observ'd constantly so many Ages together in most certain and determinate Periods of Time, do sufficiently demonstrate that their Motions are instituted and govern'd by Counsel, Wisdom and Understanding.

Fourthly, The like may be said of the fix'd Stars, whose Motions are regular, equal and constant: So that we see nothing in the Heavens which argues Chance, Vanity of Error; but, on the contrary,

Rule, Order, and Constancy; the Effects and Arguments of Wisdom: Wherefore, as Cicero excellently concludes, <>Coelestem ergo admirabilem ordinem incredibilemque constantium, ex qua conservatio et salus omnium omnis oritur, qui vacare mente putat, noe ipse mentis expers habendus est.: Wherfore whoever thinketh that the admirable Order and incredible Constancy of the Heavenly Bodies and their Motions, whereupon the Preservation and Welfare of all Things doth depend, is not governed by Mind and Understanding, he himself is to be accounted void thereof.

And again, "shall we (saith he) when we see an Artificial Engine, as a Sphere or Dyal, or the like, at first Sight acknowledge, that it is a Work of Reason and Art? <>Cum autem impetum coeli, admirabili cum celeritate moveri vertique videamus, constantissime conscientem vicissitudines anniversarias, cum summa Salute et conservatione rerum omnium, dubitare quin ea non solum ratione fiant, sed excellenti quadam Divinaque ratione: " And can we, when we see the Force of the Heavens mov'd and whirl'd about with admirable Celerity, most constantly finishing its anniversary Vicissitudes, to the eminent Welfare and Preser vation of all Things, doubt at all that these Things are perform'd not only by Reason, but by a certain excellent and divine Reason?

To these Things I shall add an Observation which I must confess myself to have borrowed of the honourable Person more than once mention'd already, that even the Eclipses of the Sun and Moon, though they be frightful Things to the superstitious Vulgar, and of ill Influence on Mankind, if we may believe the no less superstitious astrologers, yet to knowing Men, that can skilfully apply them, they are of great Use, and such as common Heads could never have imagin'd: Since not only they may on divers Occasions help to settle Chronology, and rectifie the Mistakes of Historians that writ many Ages ago; but which is, though a less Wonder, yet of greater Utility, they are (as Things yet Stand) necessary to define with competent certainty, the Longitude of Places or Points on the Terraqueous Globe, which is a Thing of very great Moment not only to Geography, but to the most useful and important Art of Navigation. To which may be added, which I shall hereafter mention, that they serve to demonstrate the spherical Roundness of the Earth: So that I may well conclude with the Psalmist, Psalm 19.1. The Heavens declare the Glory of God, and the Firmament sheweth his handy Work.

Of Terrestrial and Inanimate Simple Bodies

I come now to consider the Terrestrial Bodies; I shall say nothing of the whole Body of the Earth in general, Because I reserve that as one of the Particulars I shall more carefully and curiously examine.

Terrestrial Bodies, according to our Method before propounded, are either inanimate or animate, and the inanimate either simple or mixt. Simple, as the four Elements, leire, Waters Earth and Air: I call these Elements in Compliance (as I said before) with the vulgarly-receiv'd Opinion; not that I think them to be: the Principles or component Ingredients of all other sublunary Bodies: I might call them the four great Aggregates of Bodies of the same Species, or four Sorts of Bodies, of which there are great Aggregates. These, notwithstanding that they are endued with contrary Qualities, and are continually encroaching one upon another, yet they are so balanc'd, and kept in such an Equilibrium, that neither prevaileth over other, but what one gets in one Place it loseth in another.

First, Fire cherisheth and reviveth by its Heat, without which all Things would be torpid and without Motion, nay, without Fire no Life, it being the vital Flame residing in the Blood that keeps the bodily Machine in Motion, and renders it a fit Organ for the Soul to work by. The Uses of Fire (I do not here speak of the Peripateticks' Elementary Fire in the Concave of the Moon, which is but a meer figment, but our ordinary Culinary) are in a manner infinite for dressing and preparing of Victuals, bak'd, boil'd and rost; for melting and refining of Metals and Minerals; for the fusion of Glass, [a Material whose Uses are so many, that it is not easie to enumerate them, it serving us to make Windows for our Houses, Drinking-Vessels, Vessels to contain and preserve all Sorts of

fermented Liquors, distill'd Waters, Spirits, Oils, Extracts, and other Chymical Preparations, as also Vessels to distil and prepare them in; for Looking-Glasses, Spectacles, Microscopes and Telescopes, whereby our Sight is not only reliev'd, but wonderfully assisted to make rare Discoveries] for making all Sorts of Instruments for Husbandry, mechanick Arts and Trade, all Sorts of Arms or Weapons of War defensive and offensive; for fulminating Engines; for burning of Lime, baking of Bricks, Tiles, and all Sorts of Potters Vessels or Earthen Ware, for casting and forging Metaline Vessels and Utensils; for Distillations, and all Chymical Operations hinted before in the Use of Glass; for affording us Lights for any Work or Exercise in Winter Nights; for digging in Mines and dark Caverns; and, finally, by its comfortable Warmth

*7l securing us from the Injuries of Cold, or relieving us when we have been bitten and benum'd with it. A Subject or Utensil of so various and inexplicable Use, who could have invented and formed, but an infinitely wise and powerful Efficient?

Secondly, The Air serves us and all Animals to breath in, containing the Fewel of tha vital Flame we speak of, without which it would speedily languish and go out; so necessary it is for us and other Land-Animals that without the Use of it we could live but very few Minutes: Nay, Fishes and other Water-Animals cannot abide without the Use of it; for if you put Fish into a Vessel of a narrow Mouth full of Water, they will live and swim there, not only Days and Months, but even Years; but if with your Hand or any other Cover you stop the Vessel so as wholly to exclude the Air, or interrupt its Communication with the Water, they will suddenly be suffocated; as Rondeletius affirms he often experimented.

If you fill not the Vessel up to the Top, but leave some Space empty for the Air to take up, and then clap your Hand upon the Mouth of the Vessel, the Fishes will presently contend which shall get uppermost in the Water, that so they may enjoy the open Air; which I have also observ'd them to do in a Pool of Water that hath been almost dry in the Summer-Time, because the Air that insinuated itself into the Water did not suffice them for Respiration. Neither is it less necessary for Insects than it is for other Animals, but rather more, these having more Air-Vessels for their Bulk by far than they, there being many Orifices on each Side their Bodies for the Admission of Air, which if you stop with Oil or Honey, the Insect presently dies, and revives no more. This was an Observation of the Ancients, though the Reason of it they did not understand; (<>Oleo illito Insecta omnia ex animantur.<> Pliny.) which was nothing but the intercluding of the Air; for tho' you put Oil upon them, if you put it not upon or obstruct those Orifices therewith, whereby they draw the Air, they suffer nothing: If you obstruct only some, and not others, the Parts which are near and supplied with Air, from thence are by and by convulsed and shortly relaxed and deprived of Motion, the rest that were untouched still retaining it. Nay, more than all this, Plants themselves have a Kind of Respiration, being furnish'd with plenty of Vessels for the Derivation of Air to all their Parts; as hath been observ'd, nay, first discover'd, by that great and curious Naturalist <>Malpighius<>.

Another Use of the Air is to sustain the Flight of Birds and Insects. Moreover, by its gravity it raises the Water in Pumps, Siphons and other Engines, and performs all those Feats which former Philosophers through Ignorance of the Efficient Cause attributed to a Final, namely, Nature's abhorrence of a Vacuity or empty space. The elastic or expansive Faculty of the Air, whereby it dilates itself, when compressed, (indeed this lower Region of it, by Reason of the Weight of the Superincumbent, is always in a compressed State) hath been made Use in the common Weather-glasses, in Wind-guns, and in several ingenious Water-Works, and doubtless hath a great Interest in many natural Effects and Operations.

Against what we have said of the Necesssity of the Air for the Maintenance of the Vital Flame it may be objected, That the Foetus in the Womb lives, its Heart pulses, and its Blood circulates; and yet it draws in no Air, neither hath the Air any Access to it. To which I answer; That it doth receive

Air, so much as sufficient for it in its present State, from the maternal Blood by the <>Placenta uterina<> or the Cotyledons. This Opinion generally propounded, viz. That the Respiration of the Dam dl serve the Foetus also, or supply sufficient Air to it, I have met with in Books; but the explicit Notion of it I owe to my Learned and Worthy Friend Dr. Edward Hulse<>, which, comparing with mine own Anatomical Observations, I found so consonant to Reason, and highly probable, that I could not but yield a firm Assent to it. I say then, That the chief Use of the Circulation of the Blood through the Cotyledons of a Calf in the Womb (which I have often dissected) and by Analogy thro' the Placenta uterina in an Humane Foetus, seems to be the Impregnation of the Blood with Air, for the feeding of the vital Flame: For if it were only for Nutrition, what Need of two such great Arteries to convey the Blood thither? It would (one might rationally think) be more likely, that as in the Abdomen of every Animal, so here, there should have been some lacteal Veins form'd, beginning from the Placenta or Cotyledons, which concurring in one common Ductus, should at last empty themselves into the <>Vena cava.

Secondly, I have observed in a Calf, the Umbilical Vessels to terminate in certain Bodies divided into a Multitude of carneous Papillae, (as I may so call them) which are receiv'd into so many Sockets of the Cotyledons growing on the Womb; which carneous Papillae may without Force or Laceration be drawn out of those Sockets. Now these Papillae do well resemble the Aristoe or Radii of a Fish's Gills, and very probably have the same Use to take in the Air; so that the maternal Blood which flows to the Cotyledons, and encircles these Papillae, communicates by them to the Blood of the Foetus, the Air wherewith itself is impregnate; as the Water flowing about the carneous Radii of the Fish's Gills doth the Air that is lodg'd therein to them.

Thirdly, That the maternal Blood flows most copiously to the Placenta uterina in Women, is manifest from the great Hemorrhagy that succeeds the Separation thereof at the Birth.

Fourthly, After the Stomach and Intestines are form'd, the Foetus seems to take in its whole Nourishment by the Mouth; there being always found in the Stomach of a Calf plenty of the Liquor contain'd in the Amnios wherein he swims, and Faeces in his Intestines) and Abundance of Urine in the <>Allantoides; so that the Foetus in the Womb doth live as it were the Life of a Fish.

Lastly, Why else should there be such an instant Necesity of Respiration so soon as ever the Foetus is fallen off from the Womb.

I know that if the Foetus be taken out of the Womb inclos'd in the Secundines, it will continue to live, and the Blood to circulate for a considerable Time, as Dr. Harvey observes. The reason whereof I conceive to be, because the Blood still circulates through the Cotyledons or Placenta, which are now expos'd to the open Air, and so from thence receives sufficient Supplies thereof, to continue its gentle Motion and feed the vital Flame. But when, upon exclusion of the Young, the Umbilical Vessels are broken, and no more Air is receiv'd that Way, the Plastick Nature, to preserve the Life of the Animal, speedily raises the Lungs, and draws into them Air in great Abundance, which causes a sudden and mighty Accension in the Blood; to the Maintenance whereof a far greater Quantity of Air is requisite, than would serve to feed the mild and languid Flame before.

This Way we may give a facile and very probable Account of it, to wit, because receiving no more Communications of Air from its Dam or Mother, it must needs have a speedy Supply from without, or else extinguish and die for Want of it; being not able to live longer without Air at its first Birth, than it can do afterward.

Upon this Occasion, give me leave to discourse a little concerning the Air's insinuating itself into the Water. I say therefore, That the Air, at least that Part of it which is the Aliment of Fire, and Fewel of the vital Flame in Animals, easily penetrates the Body of Water expos'd to it, and

diffuseth itself through every Part of it. Hence it is that we' find Fish in subterraneous Rivers, and some Fish in the Earth itself; which can no more live without Air there than in the open Waters: Hence the Miners, when they come once at water, are out of all Danger of Damps. You'll say, How gets the Air into the Water in Subterraneous Rivers, and into the Earth to the fossil Fishes; I Answer, The same Way that the Water doth: Which I suppose to be by its upper Superficies; the Water descending by Pores and Passages that there it finds into Chinks and Veins, and by Confluence of many of them by Degrees swelling into a Stream, the Air accompanies and follows it by a conltant Succession.

As for fossil Fishes, some make their Way into the Earth up the Veins of Water opening into the Banks of Rivers, where they lie till they grow so great that they cannot return: In which Veins they find Air enough to serve their Turn, needing not much by Reason that they lie still, and move but little. Others in Times of Floods are left in the Meadows and with the Water sink into the Earth at some Holes and Pores that the Water finds or makes, by which also they are supplied with Air. The Reason why the Miners are out of Danger of Damps when they come to Water, I conceive is, becausc then presently the Air that stagnated in the Shaft sinks into the Water, and fresh Air descends and succeeds, and so there is a Circulation; in the same Manner as by the sinking of an Air-Shaft the Air hath Liberty tc circulate, and carry out the Steams both of the Miners Breath and the Damps, which would otherwise stagnate there. Indeed, though there were no Damps, yet the nitrous Part of the Air being spent and consum'd by the breathing of the Miners, the remaining Part would be render'd altogether unfit for Respiration, unless new and fresh Air could succeed.

And here methinks appears a Necessity of bringing in the Agency of some Super-intendent intelligent Being, be it a Plastick Nature, or what you will: For what else should put the Diaphragm, and all the Muscles Serving to Respiration, in Motion all of a sudden so soon as ever the Foetus is brought forth? Why could they not have rested as well as they did in the Womb? What aileth them that they must needs bestir themselves to get in Air to maintain the Creature's Life? Why could they not patiently suffer it to die? That the Air of itself could not rush in, is clear; for that, on the contrary there is requir'd some Force to remove the incumbent Air, and make Room for the External to enter. You will say, the Spirits do at this Time flow to the Organs of Respiration, the Diaphragm and other Muscles which concur to that Action, and move them. But what rouses the Spirits, which were quiescent during the Continuance of the Foetus in the Womb? Here is no appearing Impellent but the external Air, the Body suffering no Change but of Place, out of its close and warm Prison into the open and cool Air: But how or why that Should have such an Influence upon the Spirits, as to drive them into those Muscles electively, I am not subtil enough to discern. As for the Respiration of the Chick in the Egg, I suppose the Air not only to be included in the White, but also to be supply'd through the Shell and Membranes.

Thirdly, Water is one Part, and that not the least of our Sustenance, and that affords the greatest Share of Matter in all Productions, being not (as it exists in the World) a simple and unmix'd Body, but containing in it the Principles or minute component Particles of all Bodies: To speak nothing of those inferiour Uses of Washing and Bathing, dressing and preparing victuals. But if we shall consider the great Concepticula and Congregations of Water, and the Distribution of it all over the dry Land in Springs and Rivers, there will occur abundant Arguments of Wisdom and Understanding. The Sea, what infinite Variety of Fishes doth it nourish! Psalm 104. 25. In the Verse next to my Text; The Earth is full of thy Riches: So is this great and wide Sea, wherein are Things creeping innumerable, both small and great Beasts, &c. How doth it exactly compose itself to Level or equal Superficies, and with the Earth make up one Spherical Roundness? How doth it constantly observe its Ebbs and Flows, its Spring and Nepe-tides, and still retain its Saltness, so convenient for the Maintenance of its Inhabitants, serving also the Uses of Man for Navigation, and the Convenience of Carriage? That it should be defined by Shores and Strands and Limits, I mean at first, when it was natural to it to overflow and stand above the Earth. All these Particulars declare Abundance of

Wisdom in their primitive Constitution. This last the Psalmist takes Notice of in the 6th, 7th, 8th, and 9th Verses of this Psalm: Speaking of the Earth at the first Creation, he saith, Thou coveredst it with the Deep as with a Garment, the waters stood above the Mountains: At thy rebuke they fled, at the Voice of thy Thunder they hasted away (the Mountains ascend, the Valleys descend) unto the Place thou hast prepared for them. Thou hast set a Bound that they may not pass over: That they turn not again to cover the Earth. But what Need was there (may some say) that the Sea should be made so large, the its Superficies should equal if not exceed that of the dry Land? Where is the Wisdom of the Creator in making so much useless Sea, and so little dry Land, which would have been far more beneficial and serviceable to Mankind? Might not at least half the Sea have been spar'd and added to the Land, for the Entertainment and Maintenance of Men, who by their continual Striving and Fighting to enlarge their Bounds, and encroaching upon one another, seems to be straitened for Want of Room.

To this Objection against the Wisdom of God in thus dividing Sea and Land, Mr. Keil, in his Examination of Dr. Burnet's Theory of the Earth, p.92, 93. thus answers: This, as most other of the Atheists' Arguments, proceeds froon a deep ignorance of Natural Philosophy; for if there were but half the Sea that now is, there would be also but half the Quantity of Vapours, and consequently we could have but half so many Rivers as now there are to supply all the dry Land we have at present, and half as much more; for the Quantity of Vapours which are rais'd, bears a Proportion to the Surface whence they are rais'd, as well as to the Heat which rais'd them. The wise Creator therefore did so prudently order it that the Sea should be large enough to supply Vapours sufficient for all the Land, which it would not do if it were less than now it is.

But against this it may be objected, Why should not all the Vapours which are rais'd out of the Sea fall down again into it by Rain? Is there not as much Reason that the Vapours which are exhaled out of the Earth should be carried down to the Sea, as that those raised out of the Sea be brought up upon the dry Land? If some by Winds be driven from the Sea up Land, others by the same Cause will be blown down from Land to Sea, and so balancing one another, they will in Sum fall equally upon Sea and Land; and consequently the Sea contribute nothing to the Watering the Earth, or the Maintenance of Rivers.

To which I answer, That as to the Watering of the Earth these needs no Supply from the Sea, there being suffiicient Water exhaled out of itself to do that; there is no more return'd upon it by Rain so as to Rest upon it, than an equivalent quantity to what was rais'd of of it.

But the Rivers must be supplied otherways. Our Opinion is, That they have their Supply from Rain and Vapours. The Queftion is, Whence these Vapours are brought? We answer, From the Sea. But what brings them up from the Sea? I answer, The Winds: And so I am arriv'd at the main Difficulty. Why should not the Winds carry them that are exhaled out of the Eartb down to the Sea, as well as bring them up upon the Earth, which are rais'd from the Sea. Or which is all one, why should not the Winds blow indifferently from Sea and Land? To which I answer, That I must needs acknowledge myself not to comprehend the Reason hereof. God is truly said, Psalm 135.7. To bring the Wind out of his Treapures. But the Matter of Fact is most certain, viz. That the Winds do bring abundantly more Vapour up from the Sea than they carry down thither.

First, because otherwise there can no Account be given of Floods. It is clear, That Floods with us proceed from Rain; and it is often a vast Quantity of Water they carry down to the Sea. Whence come those Vapours which supply all this Water? I hope those who bring up Springs and Rivers from the great Abyss, will not bring those Vapours, which unite into Drops, and descend in Rain from thence too. Should they rise from the dry Land only, they would soon render it dry indeed; more parch'd than the Desarts of Libya. We should quickly come to an End of Floods, and of Rain too, if

nothing were return'd from the Sea again, not to mention, that the Sea must needs in such a Case overflow its Shores, and enlarge its bounds.

But this Way there is an easy Account to be given. It is clear, that the Sun doth exhale Vapours both from Sea and Land; and that the Superficies of Sea and Land is sufficient to yield Vapours for Rain, Rivers and Floods, when heated to such a Degree as the Sun heats it: So that there wants only Wind to bring up so great a Proportion of Vapours from the Sea as may afford Water for the Floods; that is, so much as is return'd back again to the Sea.

Some may perchance demand, To what Purpose serve the Floods? What use is there of them? I answer, To return back tothe Sea the Surplusage of Water after the Earth is sated with Rain. It may be further ask'd, What need more Rain be poured upon the Earth than is sufficient to water it? I reply, That the Rain brings down from the Mountains and higher grounds a great Quantity of Earth, and in Times of Floods spreads it upon the Meadows and Levels, rendering them thereby so fruitful as to stand in Need of no Culture or Manuring. So we see the Land of Egypt owes its great Fertility to the Annual Overflowing of the River Nilus: And it's likely the Countries bordering upon the River of Ganges may receive the like benefit by the Overflowing thereof. Moreover, all Rain-water contains in it a copious Sediment of Terrestrial Matter, which by standing it precipitates, and is not a simple Elementary Water. This Terrestrial Matter serves for the Nourishment of Plants, and not the Water itself, which is but a Vehicle to derive this Nutriment to all the Parts of the Plants: And therefore the more Rain, the more of this Nutricious Matter may be precipitated upon the Earth, and so the Earth render'd more fruitful. Besides all this, it's not unlikely, that the Rain-water may be endu'd with some vegetating or prolifick Virtue, deriv'd from some Saline or Oleose Particles it contains: For we see, that Aquatick Plants, which grow in the very Water, do not thrive and flourish in dry Summers, when they are not also water'd with the Dew of Heaven.

Secondly, Another Argument to prove, That the Winds bring up more Vapours from the Sea than they carry down thither, is, Because the Winds do more frequently blow from the Sea than to the Sea. This appears from the Trees which grow on and near the Sea-shores all along the Western Coast of England, whose Heads and Boughs I have observ'd to run out far to Landward, but toward the Sea to be so snub'd by the Winds, as if their Boughs and Leaves had been par'd or shaven off on that Side.

It is also observ'd, that the Western Wind, which is the most violent and boisterous of all with us in England, which comes from off the great Atlantick Ocean, is of longest Continuance. Julius Caesar, in his 5th Book of Commentaries de Bello Gallico, saith of it, Magnam partem omnis temporis in his locis fluere consuevit; it is wont to blow in these Quarters a great Part of the whole Year: Which Observation holds true at this Day, the Wind lying in that Corner at least three Quarters of the Year.

Since this Motion of the Winds is constant, there is doubtless a constant and settled Cause of it, which deserves to be enquir'd into, and search'd out by the Study and Endeavours of the most sagacious Naturalists. But however the Wind be rais'd, it may more easily blow from Sea to Land, than from Land to Sea, because the Superficies of the Sea being even or level, there is nothing to stop its Course; but on the Land there are not only Woods, but Mountains to hinder and divert it.

Having myself seen so much of the Bottom of the Sea round about the Coasts of England and a great Part of the Low Countries, of Italy and Sicily, I must needs adhere to what I deliver'd, That where the Bottom of the Sea is not Rocky, but Earth, Owze or Sand, and that is incomparably the greatest Part of it, it is by the Motion of the Waters, so far as the Reciprocation of the Sea extends to the Bottom, brought to a Level; and if it should be now unequal, would in Time be level'd again. By Level I do not mean so as to have no Declivity (for the Reciprocation preserves that, the Flood

hindering the constant carrying down of the Bottom) but only to have an equal and uniform Descent from the Shores to the Deeps. Now all those Relations of Urinators belong only to those Places where they have dived, which are always Rocky for there is no Reason why they should dive wbere the Bottom is level and sandy. That the Motion of the Water deccends to a good Depth, I prove from those Plants that grow deepest in the Sea, because they all generally grow flat, in Manner of a Fan, and not with Branches on all Sides like Trees; which is so contriv'd by the Providence of Nature, for that the Edges of them do in that Posture with most ease cut the Water flowing to and fro; and should the flat Side be objeeted to the Stream, it would soon be turn'd Edge-Wise by the Force of it, because in that Site it doth least resist the Motion of the Water: Whereas did the Branches of these Plants grow round, they would be thrown backward and forward every Tide. Nay, not only the Herbaceous and Woody Submarine Plants, but also the Lithophyta Stone-Plants themselves affect this Manner of growing, as I have observ'd in various Kinds of Corals and Pori. Hence I suepect all those Relations concerning Trees growing at the Bottom of the Sea and bringing forth Fruit there: And as for the Maldiva Nut, till better Information, I adhere to Garcia's Opinion, which may be seen in Clusius. Further I do believe, that in the great Depths of the Sea there grow no Plants at all, the bottom being too remote from the external Air, which though it may pierce the Water so low, yet I doubt whether in quantity sufficient for the Vegetation of Plants: Nay, we are told, That in those deep and bottomless Seas there are no Fish at all; yet not Because there are no Plants or Insects to feed them, for that they can live upon Water alone, Rondeletius's Experiment about keeping them in a Glass doth undeniably prove, but because their Spawn would be lost in those Seas, the Bottom being too cold for it to quicken there; or rather because being lighter than the Water there, it would not sink to the Bottom, but be buoy'd up by it, and carried away to the Shallows.

Again, The great Use and Convenience, the Beauty and Variety of so many Springs and Fountains, so many Brooks and Rivers, so many Lakes and Standing Pools of Water, and these so scatter'd and diepers'd all the Earth over; that no great Part of it is destitute of them, without which it must, without a Supply otherways, be desolate and void of Inhabitants; afford abundant Arguments of Wisdom and Counsel: That Springs should break forth on the sides of Mountains most remote from the Sea: That there should Way be made for Rivers thro' Straits and Rocks, and subterraneous Vaults, so that one would think that Nature had cut a Way on Purpose to derive the Water, which else would overflow and drown whole Countries: That the Water passing thro' the Veins of Earth, should be rendred fresh and potable, which it cannot be by any Percolations we can make, but the saline Particles will pass throug a tenfold Filtre: That in some Places there should spring forth Metallick and Mineral Waters, and hot Baths, and these so constant and permanent for many Ages; so convenient for divers Medicinal Intentions and Uses, the Causes of which Things, or the Means and Methods which they are perform'd, have not been as certainly discover'd; only in general, Pliny's Remark may be true, Tales sunt aquae, qulais terra per quam fluunt. Hence they are Cold, Hot, Sweet, Stinking, Purgative, Diuretick or Ferrugineous, Saline, Petrefying, Bituminose, Venenose, and of other Qualities.

Lastly, The Earth, which is the Basis and Support of all Animals and Plants, and affords them the hard and solid Part of their Bodies, yielding us Food and Sustenance, and partly also Cloathing; for I do not think that Water supplies Man and other Animals, or even Plants themselves, with their Nourishment, but serves chiefly for a Vehicle to the alimentary Particles, to convey and distribute them to the severl Parts of the Body. Water, as it exists in the World, is not a simple unmix'd Body, but contains the Terrestrial component Parts of the Bodies of Animals and Plants: Simple Elementary Water nourishes not at all. How variously is the Surface of this Earth distinguish'd into Hills, and Valleys, and Plains, and high Mountains, affording pleasant Prospects? How Curiously cloath'd and adorn'd with the grateful verdure of Herbs and stately Trees, either dispers'd and scatter'd singly, or as it were assembled in Woods and Groves, and all these beautified and illustrated with Elegant Flowers and Fruits, quorum omnium incredibilis multitudo, insatiabili

varietate distinguitur, as Tully saith. This also shews forth to them that consider it, both the Power and Wisdom of God: So that we may conclude with Solomon, Prov. 3. 19. The Lord by Wisdom hath founded the Earth, by Understanding hath he establish'd the Heavens.

But now, if we pass from Simple to Mix'd Bodies, we shall still find more Matter of Admiration, and argument of Wisdom. Of these we shall first consider those they call imperfectly Mix'd, or Meteors.

Of Meteors.

As first of all, Rain, which is nothing else but Water, by the Heat of the Sun divided into very small invisible Parts, ascending in the Air, till encountring the Cold, it be by Degrees condens'd into Clouds, and descends in Drops; this, though it be exhaled from the Salt Sea, yet by this Natural Distillation is render'd fresh and potable, which our Artificial Distillations have hitherto been hardly able to effiect; notwithstanding the Erninent Use it would be of to Navigators, and the Rewards promis'd to those that should resolve that Problem of distilling fresh Water out of Salt. That the Clouds should be so carried about by the Winds, as to be almost equally diepers'd and distributed, no Part of the Earth wanting convenient Showers, unless when it Pleaseth God, for the Punishment of a Nation, to with-hold Rain by a special Interposition of his Providence, or, if any Land wants Rain, they have a Supply some other Way; as the Land of Egypt, though there seldom falls any Rain there, yet hath abundant recompence made it by the annual Overflowing of the River. This Distribution of the Clouds and Rain is to me (I say) a great Argument of Providence and Divine Disposition; for else I do not see but why there might be in some Lands continual successive Droughts for many Years, till they were quite depopulated; in others as lasting Rains till they were overflown and drown'd; and these, if the Clouds mov'd casually, often happening; whereas since the ancientest Records of History we do not read or hear of any such Droughts or Inundations, unless perhaps that of Cyprus, wherein there fell no Rain there for Thirty six Years, till the Island was almost quite deserted, in the Reign of Constantine; which doubtless fell not out without the Wise Disposition of Providence, for great and weighty Reasons.

Again, If we consider the Manner of the Rain's Descent, distilling down gradually, and by Drops, which is most convenient for the watering of the Earth; whereas, if it should fall down in a continual Stream like a River, it would gall the Ground, wash away Plants by the Roots, overthrow Houses, and greatly incommode, if not suffocate Animals: If, I say, we consider these Things, and many more that might be added, we might in this respecrt also cry out with the Apostle, O the Depth of the Riches both of the Wisdom and Knowledge of God!

Secondly, Another Meteor is the Wind; Which how many Uses it doth serve to, is not easie to enumerate, but many it doth, qviz. to ventilate and break the Air, and dissipate noisom and contagious Vapours, which otherwise stagnating, might occasion many Diseases in Animals; and therefore it is an Observation concerning our Native Country, Anglia ventosa, si non ventosa, venenosa: To transfer the Clouds from Place to Place, for the more commodious watering of the Earth: To temper the Excesses of the Heat, as they find, who in Brazil, New Spain, the Neighbouring Islands, and other the like Countries near the Equator, reap the Benefit of the Breezes: To fill the Sails of Ships, and carry them on their Voyages to remote Countries, which, of what eminent Advantage it is to Mankind, for the procuring and continuing of Trade and mutual Commerce betsvcen the most distant Nations, the illustrating every Corner of the Earth, and the perfecting Geography and Natural History, is apparent to every Man. That the Monsoons and Trade-winds should be so constant and periodical even to the 30th Degree of Latitude all round the Globe, and that they should so seldom transgress or fall short of those Bounds, is a Subject worthy of the Thoughts of the greatest Philosophers. To this may be added the driving about of Windmills for grinding of Corn, making of Oil, draining of Pools, raising of Water, sawing of Wood, fulling of Cloth, &c. That it should seldom or never be so violent and boisterous, as to overturn Houses; yea,

whole Cities; to tear up Trees by the Roots, and prostrate Woods; to drive the Sea over the lower Countries; as were it the Effeet of Chance, or mere natural Causes not moderated by a superiour Power, it would in all likelihood often do. Hurricanes, Spouts, and Inundations would be more frequent than they are. All these Things declare the wisdom and Goodness of Him who bringeth the Wind out of his Treasures.

Of Inanimate Mix'd Bodies.

I proceed now to such inanimate Bodies are called Perfecte Mixta, perfectly mixt, improperly enough, they being many of them (for ought I know) as simple as those they call Elements. These are Stones, Metals, Minerals and Salts.

In Stones, which one would think were a neglected Genus, what Variety? What Beauty and Elegancy? What Constancy in their Temper and Consistency in their Figures and Colours? I shall speak of first some notable Qualities wherewith some of them are endued. Secondly, the remarkable Uses they are of to us. The Qualities I shall instance in are, First, Colour, which in some of them is most lively, sparkling, and beautiful; the Carbuncle or Rubine shining with red, the Sapphire with blue, the Emerald with green, the Topaz, or Chrysolyte of the Ancients, with a yellow or Gold-colour, the Amethyst as it were tinctured with Wine, the Opal varying its Colours like changeable Taffata, as it is diverisy expos'd to the Light. Secondly, Hardness, wherein some Stones exceed all other Bodies, and among them the Adamant all other Stones, being exalted to that Degree thereof, that Art in vain endeavours to counterfeit it, the factitious Stones of Chymists in Imitation being easily detected by an ordinary Lapidist. Thirdly, Figure, Many of them shoot into regular Figures, as Crystal and bastard Diamonds into hexagonal; others into those that are more elegant and compounded, as those form'd in Imitation of the Shells of Testaceous Fishes of all Sorts, Sharks Teeth and Vertebres, &c. If these be originally Stones, or primary Productions of Nature in Imitation of Shells and Fishes Bones, and not the Shells and Bones themselves petrified, as we have sometimes thought. Some have a Kind of Vegetation and Resemblance of Plants, as Corals, Pori, and Fungites, which grow upon the Rocks like Shrubs: To which I might add our ordinary Star-stones and Trochites, which I look upon as a Sort of Rock-Plants. Secondly, For the Uses; some serve for Building and many sorts of Vessels and Utensils; for Pillars and Statues and other carved works in relieve, for the Temples, Ornaments of Palaces, Portico's, Piazza's, Conduits, &c. as Freestone and Marble; some to burn into Lime, as Chalk and Limestone; some, with the Mixture of Beriglia or Kelp, to make Glass, as that the Venetians call Cuogolo, and common Flints, which serve also to strike Fire; some to cover Houses, as Slates, some for marking, as Morochthus, and the fore-mentioned Chalk, which is a poluKrEson, serving moreover for manuring Land, and some Medicinal Uses; some to make Vessels of which will endure the Fire, as that found in the Country of Chiavenna near Plurs. To these useful Stones I might add the Warming-Stone, digg'd in Cornwall, which being once well heated at the Fire, retains its Warmth a great while, and hath been found to give Ease and Relief in several Pains and Diseases, particularly in that of the internal Haemorrhoids. I might also take Notice, that some Stones are endued with an Electrical or attractical Virtue.

My honoured friend Dr Tancred Robinson in his Manuscript Itinerary of Italy, relates the many various Figures he observ'd naturally delineated and drawn on several Sorts of Stones digged up in the Quarries, Caves and Rocks, about Florence, and other parts of Italy, not only representing Cities, Mountains, Ruins, Clouds, Oriental Characters, Rivers, Woods, Animals, but also some Plants (as Ivy, Mosses, Maiden-hair, Ferns, and such Vegetables as grow in those Places) so exactly design'd and impress'd upen several Kinds of Stones, as though some skilful Painters or Sculpters had been working upon them. The Doctor observes also the wonderful Diversity of Shapes and Colours that Oars and other fossils shoot into, resembling almost every Thing in Nature, for which it seems very difficult to him to assign any Cause or Principle. In the Pyrites alone he believes he

himself may have seen at home and abroad above a hundred Vareties, and yet he confesses he has been but a rude Observer of them.

In the Diaphanous Fossils (as Ambers, Crystals, Agates, &c.) preserv'd in the Cabinets of the great Duke of Tuscany, Cardinal Chigi, Settali, Moscardi, and other Repositories or Musaeums of that Curious Country, he takes Notice of the admiral Diversity of Bodies included, and naturally imprifon'd within them, as Flies, Spiders, Frogs, Locusts, Bees, Pismires, Gnats, Grashoppers, Drops of Liquor, Hair, Leaves, Rushes, Moss, Seeds, and other Herbage; which seem to prove them to have been once in a State of Fluidity. The Bononia Stone digg'd up in the Appenines is remarkable for its shlning Quality. The Amianthus for its Incombustibility. The Oculus Mundi for its Motion and Change of Colour. The Lapis Nephriticus, Calaminaris, Ostiocolla, Aetites, &c. for their Medicinal Uses." I might spend much Time in the discoursing of the most strange and unaccountable Nature and Powers of the Loadstone, a Subject which hath exercis'd the Wits and Pens of the most acute and ingenious Philosophers; and yet the Hypotheses which they have invented to give an Account of its admirable phaenomena seems tc me lame and unsatisfactory. What can we say of the subtlety, activity, and penetrancy of its Effluvia, which no Obstacle can stop or repel, but they will make their Way through all sorts of Bodies, firm and fluid, dense and rare, heavy and light, pellucid and opake? Nay, they will pass through a Vacuity or empty Space, at least devoid of Air and any other sensible Body. Its attractive Power of Iron was known to the Ancients: its Verticity and Direction to the Poles of the Earth is of later Invention; which, of how infinite Advantage it hath been to these two or three last Ages, the great Improvement of Navigation, and Advancement of Trade and Commerce, by rendring the remotest Countries easily accessible; the noble Discovery of a vast Continent or new World, besides a Multitude of unknown Kingdoms and Islands; the Resolving experimentally those ancient Problems of the Spherical Roundness of the Earth; of the Being of Antipodes, or the Habitableness of the Torrid Zone, and the Rendring the whole Terraqueous Globe circumnavigable; do abundantly demonstrate: whereas formerly they were wont to coast it, and creep along the Shores, scarce daring to venture out of the Ken of Land, when they did, having no other Guide but the Cynosura or Pole-Star, and those near it, and in cloudy Weather none at all.

As for Metals, they are so many ways useful to Mankind, and those Uses so well known to all, that it would be lost Labour to say any Thing of them: Without the Use of these we could have nothing of Culture or Civility; no Tillage or Agriculture; no Reaping or Mowing; no Plowing or Digging, no Pruning or Lopping, Grafting or Incision; no mechanical Arts or Trades; no Vessels or Utensils of Household-stuff; no convenient Houses or Edifices, no Shipping or Navigation. What a Kind of barbarous and sordid life we must necessarily have lived, the Indians in the Northern Part of America are a clear Demonstration. Only it is remarkable, that those which are of most frequent and necessary Use, as Iron, Brass and Lead, are the most common and plentiful: Others that are more rare, may better be spar'd, yet are they thereby qualifiied to be made the common Measure and Standard of the Value of all other Commodities, and so serve for Coin or Money, to which Use they have been employ'd by all civil Nations in all Ages.

Now, of what mighty Importance the use of Money is to Mankind, the Learned and Ingenious Dr. Cockburn shews us, in the Second Part of his Essays concerning the Nature of Christian Faith, p. 88.

Whenever; saith he, the Use of Money began, it was an admirable Contrivance br rewarding and encouraging Industry, for carrying on Trade and Commerce certainly, easily, and speedily, for obliging all to imploy their various Parts and several Capacities for the common Good, and engaging every one to communicate the Benefit of his particular Labour without any Prejudice to himself. Covetousness indeed, or an inordinate Love of Money, is vicious, and the Root of much Evil, and ought to be remedied; but the Use of Money is necessary, and attended with manifold Advantages. Where Money has not yet taken Place, where the Use of it hath not yet been introduc'd, Arts and Sciences are not cultivated, nor any of those Exercises ply'd, which polite Mens Spirits, and which

abate the Uneasinss of Life. Men there are brutish and savage, none mind any thing but Eating and Drinking, and the other Acts of brutal Nature; their Thoughts aspire no higher than merely to maintain their Life and Breath: Like the Beasts they walk abroad all the Day long, and range about from Place to Place, only to seek their Food. Whatever may be suppos'd to follow if all were acted with great Generosity and true Charity, yet according to the present Temper of Mankind it is absolutely necesary that there be some Method and Means of Commutation, as that of Money, for rendring all and every one mutually useful and serviceable.

Now Gold and Silver by their Rarity at wonderfully fitted and accommodated for this Use of Permutation for all Sorts of Commodities or making Money of: Whereas were they as common and easie to come by as Straw or Stubble, Sand or Stones, they would be of no more Use for Bartering and Commerce than these.

And here he goes on to shew the Wonderful Providence of God, in keeping up the Value of Gold and Silver, notwithstanding the vast Quantities which have been digg'd out of the Earth in all Ages, and so continuing them a fit Material to make Money of. For which I refer to the Book.

Of these, Gold is remarkable for its admirable Ductility and Ponderosity, wherein it excels all other Bodies hitherto known. I shall only add concerning Metals, that they do pertinaciously resist all Transmutation; and tho' one would sometimes think they were turn'd into a different Substance, yet do they but as it were lurk under a Larva or Vizzard, and may be reduc'd again into their natural Form and Complexions, in Dispite of all the Tortures of Vulcan or corrosive Waters. Note, That this was written above Thirty Years since, when I thought I had Reason to distrust whatever had then been reported or written to affirm the Transmutation of Metals one into another.

I shall omit the Consideration of other Minerals, and of Salts and Earths, because I have nothing to say of their Uses, but only such as refer to Man, which I cannot affirm to have been the sole or primary End of the Formation of them. Indeed, to speak in general of these Terrestrial Inanimate Bodies, they having no such Organization of Parts as the Bodies of Animals, nor any so intricate variety of Texture, but that their production may plausibly be accounted for by an Hypothesis of Matter divided in minute Particles or Atoms naturally indivisible, of various but a determinate number of Figures, and perhaps also differing in Magnitude and these mov'd, and continually kept in Motion according to certain establish'd Laws or Rules; we cannot so clearly discover the Uses for which they were created, but may probably conclude, that among other Ends they were made for those for which they serve us and other Animals; as I shall more fully make out hereafter. It is here to be noted, That, according to our Hypothesis, the Number of the Atoms of each several Kind that is of the same Figure and Magnitude is not nearly equal, but there be infinitely more of some Species than of others, as of those that compound those vast Aggregates of Air, Water, and Earth, more abundantly than of such as make up Metals and Minerals: The Reason whereof may probably be, because those are necessary to the Life and Being of Man and all other Animals, and therefore must be always at Hand; these only useful to Man, and serving rather his Convenience than Necessities. The Reason why I affirm the minute component Particles of Bodies to be naturally indivisible by any Agent we can imploy (even Fire itself) which is the only Catholick Dissolvent, other Menstruums being rather Instrumcnts than Efficients in all Solutions, apt by Reason of the Figure and Smalness of their Parts to cut and divide other Bodies (as Wedges cleave Wood) when actuated by Fire or its Heat, which else would have no Efficacy at all (as wedges have not, unless driven by a Beetle:) the reason, I say, I have already given; I shall now instance in a Body whose minute Parts appear to be indissoluble by the Force of Fire and that is common Water, which distil, boil, circulate, work upon how you will by Fire, you can only dissolve it into Vapour, which when the Motion ceases, easily returns into Water again; Vapour being nothing else but the minute Parts thereof, by Heat agitated and separated one from another. For another Instance, some of the most learn'd and experienc'd Chymists do affirm Quicksilver to be intransmutable, and therefore call it

Liquoor aeternus. And I am of Opinion, that the same holds of all simple Bodies, that their component Particles are indissoluble, by any natural Agent.

We may here note the Order and Method that Metals and Mincrals observe in their Growth, how regularly they shoot, ferment, and as it were vegetate and regenerate; Salts in their proper and constant Figures; as our ingenious Countryman Dr. Jordan observes at large in his Discourse of Barhs and Mineral Waters.

Of Vegetables or Plants.

I have now done with inanimate bodies both simple and mix'd. The Animate are,

First, Such as are endued only with a Vegetative Soul, and therefore commonly called Vegetables or Plants; of which if we consider either their Stature and Shape, or their Age and Duration, we shall find it wonderful; for why should some Plants rise up to a great Height, others creep upon the Ground, which perhaps may have equal seeds, nay the lesser P1ant many Times the greater Seed. Why should each Particular so observe its Kind, as constantly to produce the same Leaf for Consistency, Figure, Division, and Edging, and bring forth the same Kind of Flower, and Fruit, and Seed? and that tho' you translate it into a Soil which naturally puts forth no such Kind of Plant, so that it is some logos spermatikos Seminal form or vertue which doth effect this or rather some intelligent plastick Nature; as we have before intimated: For what Account can be given of the Determination of the Growth and Magnitude of Plants from Mechanical Principles, of Matter mov'd without the Presidency and Guidance of some superiour Agent? Why may not Trees grow up as high as the Clouds or Vapours ascend; or if you say the Cold of the superiour Air checks them, Why may they not spread and extend their lateral Branches so far till their Distance from the Centre of Gravity depress them to the Earth, be the Tree never so high? How comes it to pass that tho' by Culture and Manure they may be highly improv'd, augmented to a double, treble, nay, some a much greater Proportion in magnitude of all their Parts; yet is this Advance restrain'd within certain Limits? There is a maximum quod sic which they cannot exceed. You can by no Culture or Art extend a Fennel Stalk to the Stature and Bigness of an Oak: Then why Should some be very long-livd, others only Annual or Biennial? How can we imagine that any Laws of Motion can determine the Situation of the Leaves, to come forth by Pairs, or alternately, or circling the Stalk; the Flowers to grow singly, or in company and tufts, to come forth the Bosoms of the Leaves and Branches, or on the Tops of Branches and Stalks? the Figure of the Leaves, that they should be divided into so many Jags or Escallops, and curiously indented round the Edges; as also of the Flower-leaves, their Number and Site, the Figure and Number of the Stamina and their Apices, the Figure of the Stilc and Seed-Vessel, and the number of Cells into which it is divided. That all this be done, and all these Parts duly proportion'd one to another there seems to be necessary some intelligent plastick Nature, which may understand and regulate the whole Oeconomy of the Plant: For this cannot be the Vegetative Soul, because that is material and divisible together with the Body; which appears, in that a Branch cut off of a Plant will take Root, and grow, and become a perfect Plant itself; as we have already observ'd. I had almost forgotten the Complication of the Seed-leaves of some Plants in the Seed, which is so strange, that one cannot believe it to be done by Matter, however mov'd by any Laws or Rules imaginable. Some of them being so close-plaited, and straitly folded up and thrust together within the Membranes of the Seed that it would puzzle a Man to imitate it, and yet none of the Folds sticking or growing together; so that they may easily be taken out of their Cafes, and spread and extended even with one's Fingers.

Secondly, if we consider each particular Part of a Plant, we shall find it not without its End or Use; the Roots, for its stability and drawing Nourishment from the Earth, the Fibre to contain and convey the Sap; besides which there is a large Sort of Vessels to contain the proper and specifick Juice of the Plant, and others to carry Air for such a Kind of Repiration as it needeth; of which we have

already spoken. The outer and inner Bark in Trees serve to defend the Trunk and Boughs from the Excesses of Heat and Cold and Drought and to convey the Sap for the annual Augmentation of the Tree; for, in Truth, every Tree may in some Sense be said to be an annual Plant, both Leaf, Flower and Fruit, proceeding from the Coat that was superinduced over the Wood the last Year, which Coat also never beareth any more, but together with the old Wood serves as a Form or Block to sustain the succeeding annual Coat.

The Leaves before the Gemma or Bud be explicated to embrace, and defend the Flower and Fruit, which is even then perfectly form'd; afterwards to preserve the Branches, Flowers and Fruit from the Injuries of the Summer Sun, which would too much parch and dry them, if they lay open and expos'd to its Beams without any Shelter: The Leaves, I say, qualifie and contemper the Heat, and serve also to hinder the too hasty Evaporation of the Moisture about the Root: <1717> But the principal Use of the Leaves (as we learn of Seignior Malphigii, Monsieur Perault, and Monsieur Mariotte) is to concoct and prepare the Sap for the Nourishment of the Fruit, and the whole Plant, not only that which ascends from the Root, but what they take in from without, from the Dew, moist Air and Rain. This they prove because many Trees, if despoil'd of their Leaves, will die; as it happens sometimes on Mulberry-Trees, when they are pluck'd off to feed Silk-Worms. And because if in Summer-Time you denude a Vine-Branch of its Leaves the Grapes will never come to maturity: But tho' you expose the Grapes to the Sun-Beams, if you pluck not off the Leaves, they will ripen notwithstanding. That there is a Regress of the Sap in Plants from above downwards, and that this descendent Juice is that which principally nourisheth both Fruit and Plant, is clearly proved by the Experiments of Seignior Malphigii, and those rare ones of an ingenious Country Man or our own Philosoph. Transact. Num. 187 Thomas Brotherton Esquire, of which I Shall Num- 187- mention only one, that is, If you cut off a Ring of Bark from the Trunk of any Tree that Part of the Tree above the Barked Ring shall grow and increase in Bigness, but not that beneath. But whether there be such a constant Circulation of the Sap in Plants as there is of the Blood in Animals, as they would from hence infer, there is some Reason to doubt.

I might add hereto the pleasant and delectable cooling and refreshing Shade they afford in the Summer-Time; which was very much esteem'd by the Inhabitants of hot Countries, who always took great Delight and Pleasure to sit in the open Air, under shady Trees; Hence that Expression so often repeated in Scripture, of every Man's sitting under his own vine, and under his own Fig-Tree, where also they us'd to eat as appears by Abraham's entertaining the Angel under a Tree, and standing by them when they did eat, Gen. xviii. 8. Moreover, the Leaves of Planes are very beautiful and ornamental. That there is great Pulchritude and Comeliness of Proportion in the Leaves, Flowers and Fruits of Piants, is attested by the general Verdict of Mankind, as Dr. More and others well observe. The adorning and beautifying the Temples and Buildings in all Ages, is an evident and undeniable Testimony of this; for what is more ordinary with Architects than the takingin Leaves and Flowers and Fruitage for the garnishing of their Work; as the Roman the Leaves of Acanthus Sat. and the Jewish of Palm-Trees and Pomegranates: And these more frequently than any of the five regular Solids as being more comely and pleasant to behold. If any Man shall object, that Comeliness of Proportion and Beauty is but a mere Conceit, and that all things are alike handsome to some Men who have as good Eyes as others; and that this appears by the Variation of Fashions, which doth so alter Mens Fancies, that what e'er-while seem'd very handsome and comely, when it is once worn out of Fashion appears very absurd, uncouth and ridiculous. To this I Answer, That Custom and Use doth much in those Things where little of Proportion and Symmetry shew themselves, or which are alike comely and beautitul, to disparage the one, and commend the other: But there are Degrees of Things; for (that I may use Dr. More's words) Antidote against Atheism 1.2.c.5. I dare appeal to any Man that is not sunk into so forlorn a Pitch of Degeneracy that he is as stupid to these Things as the basest Beasts, whether, for Example, a lightly-cut Tetraedrum, Cube or Icosaedrum have no more Pulchritude in them than any rude broken Stone lying in the Field or High-ways or, to name other solid Figures, which tho' they be not regular,

properly so call'd, yet have a Settled Idea and Nature, as a Cone, Sphere or Cylender, whether the Sight of those do not more gratify the Minds of Men, and pretend to more Elegancy of Shape than those rude Cuttings or Chippings of Free-stone that fall from the Mason's Hands, and Serve for nothing, but to fill up the Middle of the Wall, as fit to be hid from the Eyes of Men for their Ugliness. And therefore it is observable, that if Nature shape any thing but near to this Geometrical Accuracy, that we take Notice of it with much Content and Pleasure, and greedily gather and treasure it up. As if it be but exactly round, as those spherical Stones found in Cuba, and some also in our own Land, or have but its Sides parallel, as those rhomboideal Selenites found near St. Ives in Huntingtonshire, and many other Places in England. Whereas ordinary Stones of rude and uncertain Figures we pass by and take no Notice of at all. But tho' the Figure of these Bodies be Pleasing and agreeable to our Minds, yet (as we have already observ'd) those of the Leaves, Flowers and Fruits of Trees, more. And it is remarkable, that in the Circumscription and Complication of many Leaves, Flowers, Fruits, and Seeds, Nature affects a regular Figure. Of a Pentagonal or Quincuncial Disposition, Thomas Brown of Norwich produces several Examples in his Discourse about the Quincunx. And doubtless Instances might be given in other regular Figures, were Men but observant.

The Flowers serve to cherish and defend the first and tender Rudiments of the Fruit: I might also add the masculine or prolifick Seed contained in the Chives or Apices of the Stamina. These beside the Elegancy of their Figures, are many of them endued with splendid and lovely Colours, and likewise most grateful and fragrant Odours. Indeed such is the Beauty and Lustre of some Flowers, that our Saviour saith of the Lilies of the Field (which some, not without Reason, suppose to have been Tulips) that Solomon in all his Glory was not arrayed like one of these. And it is observ'd by Spigelius Isag. ad rem Herbariam, That the Art of the most skilful Painter cannot so mingle and temper his Colours, as exactly to imitate or counterfeit the native ones of the Flowers of Vegetables.

As for the Seeds of Plants, Dr. More Antidote against Atheism 1.2.c.6. esteems it an evident Sign of Divine Providence, that every Kind hath its Seed: For it being no neceifary Result of the Motion of the Matter, (as the whole Contrivance of the Plant indeed is not) and it being of so great Consequence, that they have Seed for the Continuance and Propagation of their own Species, and also for the gratifying Man's Art, Industry and Necessities, (for much of Husbandry and Gardening lies in this) it cannot but be an Act of Counsel to furnish the several Kinds of Plants with their Seeds.

Now the Seed being so necessary for the Maintenance and Increase of the Several Species, it is worthy the Observation, what Care is taken to secure and preserve it, being in some doubly and trebly defended. As for Instance, in the Walnut, Almond, and Plumbs of all Sorts, we have first a thick pulpy Covering, then a hard Shell, within which is the Seed enclos'd in a double Membrane. In the Nutmeg another Tegument is added besides all these, viz. the Mace <1717>between the green Pericarpium and the hard Shell, immediately enclosing the Kernel. Neither yet doth the exteriour Pulp of the Fruit or Pericarpium serve only for the Defence and Security Security of the Seed, whilst it hangs upon the Plant; but after it is mature and fallen upon the Earth, for the Stercoration of the Soil, and Promotion of the Growth, though not the first Germination of the Seminal Plant. Agric.l.2.c.6 Hence (as Petrus de Crescentiis tells us) Husbandmen, to make their vines bear, manure them with Vine-leaves, or the Husks of exprest Grapes; and they observe those to be most fruitful, which are so manured with their own: Which Observation holds true also in all other Trees and Herbs. But Besides this Use of the Pulp or Pericarpium, for the Guard and Benefit of the Seed, it serves also by a secondary Intention of Nature in many Fruits for the Food and Sustenance of Man and other Animals.

Another Thing worthy the noting in Seeds, and argumentative of Providence and Design) is that pappose Plumage growing upon the Tops of some of them, whereby they are capable of being wafted with the Wind, and by that Means scatter'd and disseminated far and wide.

Furthermore, most Seeds having in them a Seminal Plant perfectly form'd, as the Young is in the Womb of Animals, the elegant Complication thereof in some Species is a very pleasant and admirable Spectacle; so that no Man that hath a Soul in him can imagine or believe it was so form'd and folded up without Wisdom and Providence. But of this I have spoken already. Lastly, The immense Smalness of some Seeds, not to be seen by the naked Eye, so that the number of Seeds produced at once in some one Plant; as for Example, Reedmace [Tipha Palustris Harts-Tongue, and many Sorts of Ferns may amount to a Million, is a convincing Argument of the infinite Understanding and Art of the Former of them.

And it is remarkable that such Mosses as grow upon Walls, the Roofs of Houses and other high Places, have Seeds so excessively small, that when shaken out of their Vessels they appear like Vapour or Smoke, so that they may either ascend of themselves, or by an easie impulse of the Wind be rais'd Up to the Tops of Houses, Walls or Rocks: And we need not wonder how the Mosses got thither, or imagine they sprung up spontaneously there.

I might also take Notice of many other Particulars concerning Vegetables, as First, That Because they are design'd for the Food of Animals, therefore Nature hath taken more extraordinaly Care, and made more abundant Provision for their Propagation and Encrease, so that they are multiplied and propagated not only by the Seed, but rnany also by the Root, producing Off-sets or creeping under Ground, many by Strings or Wires running above Ground as Strawberry, and the like, some by Slips of Cuttings, and some by several of these Ways. <1717>And for the Security of such Species as are producd only by Seed, it hath endued all Seed with a lasting Vitality, that if by Reason of excessive Cold, or Drought, or any other Accident, it happen not to Germinate the First Year it will continue its Foecundity, I do not say two or three, nor six or seven, but even twenty or thirty Years; and when the Impediment is remov'd, the Earth in fit Case and the Season proper, spring up, bear Fruit, and contlnue its Species. Hence it is that Plants are sometimes lost for a while in Places where they formerly abounded; and again, after some Years, appear new: Lost either because the Springs were not proper for their Germination, or because the Land was fallow'd, or because Plenty of Weeds or other Herbs prevented their coming up, and the like, and appearing again when these Impediments are remov'd.

Secondly, That some Sorts of Plants, as Vines, all sorts of Pulse, Hops, Briony, all Pomiferous Herbs, Pumpions, Melons, Gourds, Cucumbers, and divers other Species, that are weak and unable to raise or support themselves, are either endued with a faculty of twining about others that are near, or else fuirnish'd with Claspers and Tendrils, whereby, as it were with Hands, they catch Hold of them, and so ramping upon Trees, Shrubs, Hedges or Poles, they mount up to a great Height, and secure themselves and their fruit.

Thirdly, That others are armed with Prickles and Thorns, to secure them from the Browsing of Beasts, as also to shelter others that grow under them. Moreover they are hereby render'd very useful to Man, as if design'd by Nature to make both Quick and Dead Hedges *112 and Fences. The great Naturalist Pliny hath given an ingenious Account of the Providence and design of Nature in thus arming and fencing them in these Words Inde (speaking of Nature) excogitavit aliquas aspectu hispidas, tactu truces, ut tantum non vocem ipsius Naturae fingentis illas, rationemque reddentis exaudire videamur, ne se depascat avida quadrupes, ne procaces manus rapiant, ne neglecta vestigia obterant, ne infidens ales infringat; his muniendo aculeis telisque armando, remediis ut salva ac tuta sint. Ita hoc quoque quod in iis odimus hominum causa excogitatum est.

<1717>It is worthy the noting, That Wheat, which is the best Sort of Grain, of which the purest, most savory and wholesome Bread is made, is patient of both Extreams, Heat and Cold, growing and bringing its Seed to Maturity, not only in temperate Countries, but also on one Hand in the Cold and Northern, viz. Scotland, Denmark &c. on the other, in the hottest and most Southerly, as Egypt, Barbary, Mauritania, the East lndics, Guinea, Madagascar, &c. scarce refusing any Climate.

Nor is it less observable, and not to be commemorated without Acknowledgement of the Divine Benignity to us, that (as Pliny rightly notes) nothing is more fruitful than Wheat, Quod ei natura (saith he) [rectius naturae Parens] tribuit, quod co maxime hominem alit, utpote cum e modio, si et aptum solum, quale in Byzacio Africae campo centeni quinquaginta modii reddentur. Misit ex eo loco Divo Augusto procurator eius ex uno grano (vix credibile dictu) 400 paucis minus germina: Misit et Neroni similiter 360 stipulas ex uno grano.

"Which Fertility Nature (he should have said, the Author of Nature) hath confer'd upon it, because it feeds Man chiefly with it. One Bushel, if sown in a fit and proper Soil, such as is Byzacium, a Field of Africa, yielding 150 of annual Encrease; Augustus's Procurator sent him from that Place 400 within a few Blades springing from the same Grain: And to Nero were sent thence 360."

If Pliny a Heathen could make this Fertility of Wheat argumentative of the Bounty of God to Man, making such plentiful Provision for him of that which is of most pleasant Taste and wholesome Nourishment, surely it ought not to be passed over by us Christians without Notice taking and Thanksgiving .

Dr. More Antid. l.2.c.6. As for the Signatures of Plants, or the Notes impressed upon them, as Indices of their Virtues, tho' * some lay great Stress upon them, accounting them strong Arguments to prove that some understanding Principle is the highest Original of the Works of Nature; as indeed they were, could it certainly be made appear, that there were such Marks designedly set upon them; because all that I find mention'd and collected by Authors, seem to me to be rather fancied by Men, than design'd by Nature to signifie or point any such Virtues or Qualities as they would make us believe. I have elsewhere, I think upon good Grounds, rejected them; and finding no Reason, as yet, to alter my Opinion, I shall not further insist on them:

<1717>Howbeit, I will not deny, but that the noxious and malignant Plants do many of them discover something of their Nature by the sad and melancholick Visage of their Leaves, Flowers and Fruit. And that I may not leave that Head wholly untouch'd, one Observation I shall add relating to the Virtues of Plants, in which I think there is something of Truth, that is, that there are, by the wise Disposition of Providence, such Species of Plants produc'd in every Country as are most proper and convenient for the Meat and Medicine of the Men and Animals that are bred and inhabit there: Insomuch that Solemander writes, that from the Frequency of the Plants that sprung up naturally in any Region, he could easily gather what Endemial Diseases the Inhabitants thereof were subject to: So in Denmark, Friesland, and Holland, where the Scurvy usually reigns, the proper remedv thereof, Scurvy-grass, doth plentitifully grow.

Of Bodies endued with a sensitive Soul, or Animals.

I proceed now to the Consideration of Animate Bodies endu'd with a Sensitive Soul, call'd Animals. Of these I shall only make some general Observations, not curiously consider the Parts of each particular species, save only as they serve for Instances or Examples.

First of all, because it is the great Design of Providence to maintain and continue every Species, I shall take Notice of the great Care at abundant Provision that is made for the securing this End. Quanta ad eam rem vis, ut in suo quaeque genere permaneat? Cicero. Why can we imagine all

Creatures should be made Male and Female but to this Purpose? Why should there be implanted in each Sex such a vehement an inexpugnable Appetite of Copulation? Why in viviparous Animals, in the Time of Gestation should the Nourishment be carried to the Embryon in the Womb, which at other Times goeth not that Way? When the Young is brought forth, how comes all the Nourishment then to be transfer'd from the Womb to the Breasts or Paps, leaving its former Channel, the Dam at such Time being, for the most Part lean and ill favour'd?

<1717>To all this I might add, as a great Proof and Instance of the Care that is taken, and Provision made for the preservation and Continuance of the Species, the lasting Foecundity of the Animal Seed or Egg in the Females of Man, Beasts and Birds. I say, the Animal Seed because it is to me highly probable, that the Females, as well of Beasts as Birds, have in them from their first Formation the Seeds of all the Young they will afterwards bring forth, which when they are all spent. and exhausted by what Means soever, the Animal becomes barren and effete. These Seeds in some Species of Animals continue fruitful, and apt to take Life by the Admixture of the Male-Seed fifty Years or more, and in some Birds fourscore or an hundred. Here I cannot omit one very remarkable Observation I find in Cicero: Atque ut intelligamus (saith he) nihil horum esse fortutitum, sed haec omnia providae solertisque naturae, quae miltiplices foetus procreant, ut Sues, ut Canes, his mammarum data est multitudo, quas easdem paucas habent eae bestiae quae pauca gignunt. "That we may undertsand that none of these Things (he had been speaking of) is fortuitous, but that all are the Effects of provident and sagacious Nature; multiparous Quadrupeds, as Dogs, as Swine, are furnished with a Multitude of Paps: Whereas those Beasts which bring forth few, have but a few."

That flying Creatures of the greater Sort, that is Birds, should all lay Eggs, and none bring forth live Young, is a manifest Argument of Divine Providence, designing thereby their Preservation and Security, that there might be the more Plenty of them; and that neither the Birds of Prey, the Serpent, nor the Fowler, should straiten their Generations too much. For if they had been viviparous, the Burden of their Womb, if they had brought forth any competent Number at a Time, had been so great and heavy, that their Wings would have fill'd them, and they become an easie Prey to their Enemies: Or, if they had brought but one or two at a Time, they would have been troubled all the Year long with feeding their Young, or bearing them in their Womb. Dr. More Antid. Atheism, l.2. c.9.

This Mention of feeding their Young puts me in mind of two or three considerable Observations referring thereto.

First, Seeing it would be for many reasons inconvenient for Birds to give Suck, and yet no less inconvenient, if not destructive, to the Chicken upon exclusion, all of a sudden to make so great a change in its Diet, as to pass from liquid to hard Food, before the Stomach be gradually consolidated, and by use strengthen'd and habituated to grind and concoct it, and its tender and pappy Flesh fitted to be nourish'd by such strong and solid Diet; and before the bird be by little and little accustom'd to use its Bill and gather it up, which at first it doth but very slowly and imperfectly; therefore Nature hath provided a large Yolk in every Egg, a great part whereof remaineth after the Chicken is hatch'd, and is taken up and enclos'd in its Belly, and by a Channel made on purpose receiv'd by degrees into the Guts, and serves instead of Milk to nourish the Chick for a considerable time; which nevertheless mean while feeds it self by the Mouth a little at a time and gradually more and more, as it gets a perfecter Ability and Habit of gathering up its Meat, and its Stomach is strengthened to macerate and concoct it, and its Flesh hardned and fitted to be nourish'd by it.

Secondly, That Birds which feed their Young in the Nest, tho' in all likelihood they have no ability of counting the number of them should yet (tho' they bring but one morsel of Meat at a time, and

have not fewer (it may be) then seven or eight Young in the Nest together, which at the return of their Dams, do all at once with equal Greediness, hold up their Heads and gape) not omit or forget one of them, but feed them all; which, unless they did carefully observe and retain in Memory which they had fed, which not, were impossible to be done: this, I say, seems to me most strange and admirable, and beyond the Possibility of mere Machine to perform.

<1717>Another Experiment I shall add, to prove, that tho' Birds have not an exact Power of numbring, yet have they of distinguishing many from few, and knowing when they come near to a certain Number: And that is, that when they have laid such a Number of Eggs, as they can conveniently cover and hatch, they give over and begin to sit; not because they are necessarily determin'd to such a Number; for that they are not, as is clear, because they are an Ability to go on and lay more at their Pleasure. Hens, for example, if you let their Eggs alone, when they have laid fourteen or fifteen, will give over and begin to sit, whereas, if you daily withdraw their Eggs, they will go on to lay five times that Number: [Yet some of them are so cunning, that if you leave them but one Egg, they will not lay to it, but forsake their Nest.] This holds not only in domestick and mansuete Birds, for then it rnight be thought the Effect of Cicuration or Institution, but also in the wild; for my honour'd friend Dr. Martin Lister inform'd me, that of his own Knowledge one and the same Swallow, by the subtracting daily of her Eggs, proceeded to lay nineteen successively, and then gave over; as I have elsewhere noted. Preface to Mr. Willughby's Ornithol.

Now that I am upon this Subject of the Number of Eggs, give me Leave to add a remarkable Observation referring thereto, viz. That Birds, and such oviparous Creatures, as are long-liv'd, have Eggs enough at first conceiv'd in them to serve them for naany Years laying, probably for as many as they are to live, allowing such a Proportion for every Year, as will serve for one or two Incubations; whereas Insects, which are to breed but once, lay all their Eggs at once, have they never so many. Now, had these Things been govern'd by Chance, I see no Reason why it should constantly fall out so.

Thirdly, The marvellous speedy Growth of Birds that are hatch'd in Nests, and fed by the Old ones there, 'till they be fledg'd, and come almost to their full Bigness, at which Perfection they arrive within the short Term of about one Fortnight, seems to me an Argument of Providence, designing thereby their Preservation, that they might not lie long in a Condition expos'd to the Ravine of any Vermine that may find them, being utterly unable to escape or shift for themselves.

Another and no less effectual Argument may be taken from the Care and Providence us'd for the Hatching and Rearing their Young: And first, they search out a secret and quiet Place where they may be secure and undisturb'd in their incubation; then they make themselves Nests every one after his kind, that so their Eggs and Young may lie soft and warm, and their exclusion and growth be promoted. These Nests some of them so elegant and artificial, that it is hard for Man to imitate them and make the like. I have seen Nests of an Indian Bird so artificially compos'd of the Fibres, I think, of some Roots, so curiously interwoven and platted together, as is admirable to behold: Which Nests they hang on the end of the Twigs of Trees over the Water, to secure their Eggs and Young from the ravage of Apes and Monkeys, and other Beasts that might else prey upon them. After they have laid their Eggs, how silently and patiently do they fit upon them 'till they be hatch'd, scarce affording themselves time to go off to get them Meat? Nay, with such an ardent and impetuous desire of sitting are they inspir'd, that if you take away all their eggs, they will sit upon an empty Nest: And yet one would think that sitting were none of the most pleasant Works.

After their Young are hatch'd, for sometimes they do almost constantly brood them under their Wings, lest the Cold and sometimes perhaps the Heat should harm them. All this while also they labour hard to get them Food, sparing it out of their own Bellies, and pining themselves almost to death rather than they should want. Moreover it is admirable to observe, with what courage they

are at that time inspir'd, that they will even venture their own Lives in defence of them. The most timorious, as Hens and Geese become then so couragious, as to dare to fly in the Face of a Man that shall molest or disquiet their Yotmg, which would never do so much in their own defence. These things being contrary to any motions of Sense, or instinct of self-preservation, and so eminent pieces of self-denial, must needs be the Works of Providence, for the continuation of the Species and upholding of the World:

Especially if we consider that all these pains is bestow'd upon a thing which takes no notice of it, will render them no thanks for it, nor make them any requital or amends; and also, that after the Young is come to some growth, and able to shift for it self, the old one retains no such zorgE to it, takes no further care of it, but will fall upon it, and beat it indifferently with others.

To these I shall add three Observations more relating to this Head.

The first borrow'd of Dr. Cudworth, System, pag. 69. One thing necessary to the Conservation of the Species of Animals; that is, the keeping up constantly in the World a due numerical Proportion between the Sexes of Male and Female, doth necessarily infer a superintending Providence. For did this depend only upon Mechanism, it cannot well be conceived, but that in some Ages or other there should happen to be all Males or all Females, and so the Species fail. Nay, it cannot well be thought otherwise, but that there is in this a Providence, superior to that of the Plastick or Spermatick Nature, which hath not so much of Knowledge and Discretion allow'd to it, as whereby to be able <1691 text="alone"> to govern this Affair.

<1717>The Second of Mr. Boyle, in his Treatise of the high Veneration Man's Intellect owes to God, p. 32. that is, the Conveniency of the Season (or Time of Year) of the Production of Animals, when there is proper Food and Entertainment ready for them. So we see, that, according to the usual Course of Nature, Lambs, Kids, and many other living Creatures, are brought into the World at the Spring of the Year; when tender Grass and other Nutritive Plants, are provided for their Food. And the like may be observ'd in the Production of Silk-worms, (yea, all other Eruca's, and many Insects more) whose Eggs, according to Nature's Institution, are hatch'd when Mulberry-Trees begin to bud, and put forth those Leaves, whereon those precious Insects are to feed: The Aliments being tender, whilst the Worms themselves are so, and growing more strong and substantial, as the Insects encrease in Vigour and Bulk.

To these I shall add another Instance, that is of the Wasp, whose Breeding is deterr'd 'till after the Summer-Solstice, few of them appearing before July: Whereas one would be apt to think the Vigorous and quickning Heat of the Sun in the Youth of the Year would provoke them to generate much sooner: [Provoke them, I say, because every Wasps-Nest is begun by one great Mother-Wasp which over-lives the Winter, lying hid in some hollow Tree or other Latibulum;] because then, and not till then, Pears, Plumbs and other Fruit, design'd principally for their Food, begin to ripen.

The Third is mine own, That all Infects which do not themselves feed their Young nor treasure up Provision in Store for their Sustenance, lay their Eggs in such Places as are most convenient for their Exclusion, and where when hatch'd, their proper Food is ready for them: So, for example, we see two sorts of white Butterflies fastening their Eggs to.Cabbage Leaves, because they are a fit Aliment for the Catterpillers that come of them; where should they affix them to the Leaves of a Plant improper for their Food, such Caterpillers must needs be lost, they chusing rather to die that to taste of such Plants: For that Kind of Insect (I mean Catterpillers) hath a nice and delicate Palate, some of them feeding only upon one particular Species of Plant, others on divers indeed, but those of the same Nature and Quality; utterly refusing them of a contrary.

Like Instances might be produced in the other Tribes of Insects; it being perpetual in all, if not hinder'd or imprifon'd, electively to lay their Eggs in Places where they are seldom lost or miscarry, and where they have a Supply of Nourishment for their Young so soon as they are hatch'd, and need it. Whereas should they scatter them carelesly and indifferently in any Place, the greatest Part of the Young would all in Likelihood perish soon after their Exclusion for want of Food, and so their Numbers continually decreasing, the whole Species in a few Years in danger to be lost: Whereas no such thing, I dare say, hath happened since the first Creation.

It is here very remarkable, that those Insects, for whose Young Nature hath not made provision of sufficient Sustenance, do themselves gather and lay up in store for them. So for example: The Bee, the proper Food of whose Eulae Bee-maggot is Honey, or perchance Erithace, (which we english Bee-Bread) neither of which Viands is any where to be found amass'd by Nature in quantities sufficient for their maintenance, doth her self with unwearied diligence and industry, flying from Flower to Flower, collect and treasure them up.

To these I shall now add an Observation of Mr. Lewenhoeck's, concerning the sudden growth of some sorts of Insects, and the Reason of it.

It is (saith he) a wonderful thing, and worthy the Observation in Flesh-Flies, that a Fly-Maggot, in five days space after it is hatch'd arrives at its full growth and perfect magnitude. For if to the perfeccting of it there were requir'd, suppose a Months time or more, (as in some other Maggots is needful) it is impossible that about the Summer-Solstice any such Flies should be produc'd; because the Fly-Maggots have no ability to search out any other Food than that wherein they are placed by their Dams. Now this Food, suppose it be Flesh, Fish, or the Entrails of Beasts lying in the fields, expos'd to the hot Sun-beams, can last but a tew Days in case and condition to be a fit Aliment for these Creatures, but will soon be quite parch'd and dry'd up. And therefore the most Wise Creator hath given such a Nature and Temperament to them, that within a very few days they attain to their full growth and magnitude. Whereas on the contrary, other Maggots, who are in no such danger of being straitned sor Food, continue a whole Month or more before they give over to eat, and cease to grow. He proceeds further to tell us, that some of these Fly-Maggots which he fed daily with fresh Meat, he brought to perfection in four days time; so that he conceives that in the heat of Summer the Eggs of a Fly, or the Maggots contain'd in them, may in less than a Month's space run thro' all their changes, and come to perfect Flies, which may themselves lay Eggs again.

Secondly, I shall take notice of the various strange Instincts of Animals; which will necessarily demonstrate, that they are directed to Ends unknown to them, by a wise Superintendant.

As, 1. That all Creatures shoul know how to defend themselves, and offend their Enemies; where their natural Weapons are situate, and how to make use of them. A Calf will so manage his Head as tho' he would push with his Horns even before they shoot. A Boar knows the use of his Tushes; a Dog his Teeth; a Horse of his Hoofs; a Cock of his Spurs; a Bce of her Sting; a Ram will butt with his Head, yea tho' he be brought up tame, and never saw that manner of Fighting. Now, why another Animal which hath no Homs should not make a Shew of pushing, or no Spurs, of striking with his Legs, and the like, I know not, but that every Kind is providentially directed to the Use of its proper and natural Weapons.

2. That those Anitnals that are weak, and have neither Weapons nor Courage to fight, are for the most Part created swift of Foot or Wing, and so being naturally timorous, are both willing and able to save themselves by Flight.

3. That Poultry, Partridge, and other Birds, should at the first Sight know Birds of Prey, and make Sign of it by a peculiar Note of their Voice to their Young, who presently thereupon hide

themselves: That the Lamb should acknowledge the Wolf its Enemy, tho' it had never seen one before, as is taken for granted by most Naturalists, and may, for ought I know, be true, argues the Providence of Nature, or more truly the God of Nature, who, for their Preservation hath put such an Instinct into them.

4. That young Animals, so soon as they are brought forth, should know their Food: As for Example; such as are nourish'd with Milk presently find their Way to the Paps, and suck at them, whereas none of those that are not destin'd for that Nourishment ever offer to suck or seek out any such Food.

Again, 5. That such Creatures as are whole-footed, or Fin-toed viz. some Birds, and Quadrupeds, are naturally directed to go into the Water, and swim there, as we see Ducklings, tho' hatch'd and led by a Hen, if she brings them to the Brink of a River or Pond of Water, they presently leave her, and in they go, tho' they never saw any such Thing done before; and tho' the Hen clucks and calls, and doth what she can to keep them out: <1717>This Pliny talues Notice of, Hist. Nat. lib. 10. cap. 55. in these Words, speaking of Hens: Super omnia est Anatum Ovis subditis atq; exclusis admiratio, primo non plane agnosctentis foetum: mox incerftos incubitas sollicite convocantis: Postremo lamenta circa piscinae stagna, mergentibus se pullis natufa duce.

So that we see every Part in Animals is fitted to its Use, and the Knowledge of this Use put into them: For neither do any Sort of web-footed Fowls live constantly upon the Land, or fear to enter the Water, nor any Land-Fowl so much as attempt to swim there.

6. Birds of the same Kind make their Nests of the same Materials, laid in the same Order, and exactly of the same Figure; so that by the Sight of the Nest one may certainly know what Bird it belongs to. And this they do, tho' living in distant Countries, and tho' they never saw, nor could see any Nest made, that is, tho' taken out of the Nest and brought up by Hand; neither were any of the same Kind ever observ'd to make a different Nest. either for Matter or Fashion. This, together with the curious and artificial Contexture of such Nests, and their Fitness and Convenience for the Reception, Hatching, and Cherishing the Eggs and Young of their respecrive Builders, (which we have before taken notice of) is a great Argument of a Superior Author of their and other Natures, who hath endu'd 'em with these Instincts, whereby they are as it were acted and driven to bring about Ends which themselves aim not at, (so far as we can discern) but are directed to; for (as Aristotle observes oute teknE oute zEtEsanta oute boulousamena poiei They act not by any Art, neither do they enquire, neither do they dclibcrate about what they do. And therefore, as Dr. Cudworth saith well, they are not Masters of that Wisdom according to which they act, but only passive to the Instincts and Impresses thereof upon them. And indeed to affirm that brute Animals do all these things by a Knowledge of their own and which themselves are Masters of, and that without Deliberation and Consultation) were to make them to be endu'd with a most perfect Intellct far transcending that of Human Reason: Whereas it is plain enough, that Brutes are not above Consultation, but below it; and that these Instincts of Nature in them are nothing but a kind of Fate upon them.

<1717>The migration of Birds from an hotter to a colder Country, or a colder to an hotter, according to the Seasons of the Year, as their Nature is, I know not how to give an account of, it is so strange and admirable. What moves them to shift their Quarters? You will say, the disagreeableness of the temper of the Air to the connstitution of their Bodies, or want of Food. But how come they to be directed to the same Place yearly, though sometimes but a little Island, as the Soland Goose to the Basse of Edinburgh Frith, which they could not possibly see, and so it could have no Influence upon them that way? The Cold or the Heat might possibly drive them in a right Line from either, but that they should impel Land-Birds to venture over a wide Ocean, of which they can see no End, is strange and unaccountable: One would think that the sight of so much

Water and present fear of drowning should overcome the Sense of Hunger, or disagreebleness of the Temper of the Air. Besides, how come they to steer their Course aright to their several Quarters, which before the Compass was invented was hard for a Man himself to do, they being not able, as I noted before, to see them at that Distance? Think we that the Quails for Instance, could see quite cross the Mediterrownean Sea? And yet, it's clear, they fly out of Italy into Africk, lighting many times on Ships in the Midst of the Sea, to rest themselves when tir'd and spent with flying. That they should thus shift Places, is very convenient for them, and accordingly we see they do it; which seems to be impossible they should, unless themselves were endu'd with Reason, or directed and acted by a superior intelligent Cause.

The like may be said of the migration of divers Sorts of Fishes. As for Example; The Salmon, which from the Sea yearly ascends up a River sometimes 400 or 500 Miles, only to cast their Spawn, and Secure it in Banks of Sand, for the preservation of it 'till the Young be hatch'd or excluded, and then return to Sea again. How these Creatures when they have been wandring a long time in the wide Ocean, should again find out and repair to the Mouths of the same Rivers, seems to me very strange, and hardly accountable, without recourse to Instinct, and the Direction of a Superior Cause.

That Birds, seeing they have no Teeth for the Mastication and preparation of their Food, should for the more convenient comminution of it in their Stomachs or Gizzards, swallow down little Pebble-stones, or other hard Bodies, and because all are not fit or proper for that use, should first try them in their Bills, to feel whether they be rough or angular, for their turns; which if they find them not to be, they reject them. When these by the working of the Stomach are worn smooth, or too small for their use, they avoid them by siege, and pick up others. That these are of great use to them for the grinding of their Meat, there is no doubt. And I have observ'd in Birds, that have been kept up in Houses, where they could get no Pebbles, the very Yolks of their Eggs have changed colour, and become a great deal paler, than theirs who have had their liberty to go abroad.

Besides, I have observed in many Birds, the Gullet, before its entrance into the Gizzard, to be much dilated, and thick set, or as it were granulated, with a Multitude of Glandules each whereof was provided with its excretory Vessel, out of which, by an easie pressure, you might squeeze a Juice or Pap, which serve, for the same Use which the Saliva doth in Quadrupeds; that is, for the macerating and dissolution of the Meat into a Chyle. For that the Saliva, notwithstanding its insipidness, has a notable Virtue of macerating and dissolving Bodies, appears by the effects it hath in killing of Quicksilver, fermenting of Dough like Leaven or Yeast, taking away Warts, and curing other cutaneous Distempers; sometime exulcerating the Jaws, and rotting the Teeth.

Give me leave to add one particular more concerning Birds, which some may perchance think too homely and indecent to be mentioned in such a Discourse as this; yet because it is not below the Providence of Nature, and designed for Cleanliness, and some great Men have thought it worth the observing, I need not be asham'd to take notice of it; that is, that in young Birds that are fed in the Nest, the Excrement that is avoided at one time is so viscid, that it hangs together in a great lump as if it were inclosed in a Film, so that it may easily be taken up, and carried away by the old Bird in her Bill. Besides, by a strange instinct, the young Bird elevates her hinder parts so high, for the most part, that she seldom fails to cast what comes from her clear over the side of the Nest. So we see here is a double provision made to keep the Nest clean, which, if it were defiled with Ordure, the Young Ones must necessarily be utterly marred and ruined.

7. The Bee, a Creature of the lowest forms of Animals, so that no Man can suspect it to have any considerable Measure of Understanding, or to have Knowledge of, much less to aim at any End, yet makes her Combs and Cells with that Geometrical Accuracy, that she must needs be Acted by an Instinct implanted in her by the wise Author of Nature. For First, she plants them in a perpendicular

Posture, and so close together as with conveniency they may, beginning at the Top, and working downwards, that so no room may be lost in the Hive, and that she may have easie Access to all the Combs and Cells. Besides, the Combs being wrought Double, that is, with Cells on each Side, a common Bottom or Partition-wall, could not in any other Site have so conveniently, if at all, received or contained the Honey. Then she makes the particular Cells most Geometrically and Artificially, as the famous Mathematician Pappus demonstrates in the Preface to his third Book of Mathematical Collections. First of all, (saith he, speaking of the Cells,) it is convenient that they be of such Figures as may cohere one to another, and have common sides, else there would be empty spaces left between them to no Use, but to the weakening and spoiling of the work, if any Thing should get in there. And therefore, tho' a round Figure be most capacious for the Honey and most convenient for the Bee to creep into, yet did he not make choice of that, because then there must have been triangular Spaces left void. Now there are only three rectilineous and ordinate Figures which can serve to this Purpose; and inordinate, or unlike ones, must have been not only less elegant and beau tiful, but unequal. [Ordinate Figures are such as have all their Sides, and all their Angles equal.] The three ordinate Figures are, Triangles, Squares and Hexagons. For the space about any Point may be filled up either by six equilateral Triangles or four Squares, or three Hexagons; whereas three Pentagons are too little, and three Heptagons too much. Of these three the Bee makes use of the Hexagon, both because it is more capacious than either of the other, provides they be of equal compass, and so equal matter spent in the Consruction of each: And Secondly, because it is most commodious for the Bee to creep into: And Lastly, because in the other Figures, more Angles and Sides must have met together at the same point, and so the Work could not have been so firm and strong. Moreover, the Combs being double, the Cells on each Side the Partition are so order'd, that the Angles on one Side, insist upon the Centers of the bottoms of the Cells on the other Side, aml not Angle upon, or against Angle; which also must needs contribute to the Strength and Firmness of the Work.

<1717>These Cells she fills with Honey for her Winter Provision and curiously closes them up with Covers of Wax, that keep the included Liquor from spilling, and from external Injuries, as Mr. Boyle truly observes, Treatise of Final Causes, p.169

Another sort of Bee, I have observed, may be called the Tree-Bee, whose Industry is admirable in making provition for her young. First, she digs round Vaults or Burrows [Cuniculosl in a rotten or decayed Tree, of a great length, in them she builds or forms her cylindrical Nest or Cases resembling Cartrages, or a very narrow Thimble, only in proportion longer, of pieces of Rose or other Leaves, which she shares off with her Mouth, and plats and joins close together by some glutinous Substance. These Cases she fills with a red Pap, of a thinner consistence than an Electuary, of no pleasant taste, which where she gathers, I know not:

<1717>And which is most remarkable, she forms these Cases, and stores them with this Provision, before she hath any young one hatch'd, or so much as an Egg laid.

For on the top of the Pap she lays one Egg, and then closes up the Vessel with a cover of Leaves. The enclos'd Egg soon becomes an Eula, or Maggot, which feeding upon the Pap till it comes to its full growth, changes to a Nympha, and after comes out a Bee.

Another Insect noted for her seeming Prudence, in making provision for the Winter, proposed by Solomon to the Sluggard for his imitation, is the Ant, which (as all Naturalists agree) hoards up Grains of Corn against the Winter for her Sustenance: And is reported by some Pliny l.11.c.30. to bite off the germen of them, lest they should sprout by the Moisture of the Earth, which I look upon as a mere fiction; neither should I be forward to credit the former Relation, were it not for the Authority of the Scripture, because I could never observe any such storing up of Grain by our Country-Ants.

Yet there is a Quadruped taken notice of even by the Vulgar for laying up in Store Provision for the Winter, that is, the squirrel, whose Hoards of Nuts are frequently found, and pillaged by them.

The Beaver is by credible Persons, Eye-witnesses, affirm'd to build him Houses for shelter, and security in Winter-time: See Mr Boyle of Final Causes, p. 173.

Besides these I have mention'd, an hundred others may be found in Books relating especially to Physick, as, that Dogs when they are sick, should vomit themselves by eating Grass: That Swine should refuse Meat so soon as they feel themselves ill, and so recover by Abstinence: That the Bird Ibis should teach Men the Way of administering Clysters, Pliny lib. 8. cap. 27. The wild Goats of Dictamnus for drawing out of Darts, and healing Wounds: The Swallow the use of Celandine for repairing the Sight, &c. ibid. Of the Truth of which because I am not fully satisfied, I shall make no Inference from them.

Thirdly, I shall remark the Care that is taken for the Preservation of the Weak and such as are exposed to injuries, and preventing the encrease of such as are noisome and hurtful: for as it is a Demonstration of the Divine Power and Magnificence to create such Variety of Animals, not only great but small, not only strong and couragious, but also weak and timorous; so is it no less Argument of his Wisdom to give to these Means, and the Power and Skill of using them, to preserve themselves from the Violence and Injuries of those. That of the weak some should dig Vaults and Holes in the Earth, as Rabbets, to secure themselves and their young; others should be arm'd with hard Shells; others with Prickles, the rest that have no such Armature, should be endued with great Swiftness or Pernicity: And not only so, but some also have their Eyes stand so prominent, as the Hare, that they can see as well behind as before them, that so they may have their Enemy always in their Eye; and long, hollow, moveable ears, to receive and convey the least Sound, or that which comes from far, that they be not suddenly surprised or taken (as they say) Napping.

<1717>Moreover, it is remarkable, that in this Animal, and in the Rabbet, the Muscles of the Loyns and Hind-legs are extraordinarily large in Proportion to the rest of the Body, or those of other Animals, as if made on Purpose for swiftness, that they may be ablc to escape the Teeth of so many Enemies as continually pursue and chase them. Add hereto the Length of their Hind-legs, which is no small Advantage to them, as is noted by Dame Julan Barns, in an ancient Dialogue in Verse between the Huntsman and his Man; the Man there asks his Master, What is the Reason, why the Hare when she is near spent makes up a Hill; The Master Answers, That Nature hath made the Hinder-legs of the Hare longer than the Fore-legs; by which Means she climbs the Hill with much more ease than the Dogs, whose Legs are of equal length, and so leaves the Dogs behind her, and many Times escapes away clear, and saves her Life. This last Observation, I must confess my self to have borrowed out of the Papers of my honoured friend Mr. John Aubrey, which he was Pleased to give me a Sight of.

I might here add much concerning the Wiles and Ruses, which these timid creatures make use of to save themselves, and escape their Persecutors but that I am somewhat diffident of the Truth of those Stories and Relations, I shall only aver what myself have sometimes observ'd of a Duck, when closely pursued by a Water-dog; she not only dives to save herself (which yet she never does but when driven to an exigent, and just ready to be caught because it is Painful and Difficult to her) bu when she comes up again, brings not her whole Body above Water but only her Bill, and Part of her Head, holding the Rest underneath, that so the Dog, who the mean Time turns round and looks about him, may not espy her, 'till she have recover'd Breath. As for Sheep, which have no natural Weapons or Means to defend or secure themselves, neither Heels to run, nor Claws to dig; they are deliver'd into the Hand, and committed to the Care and Tuition of Man, and Serving him for divers Uses, are nourished and protected by him; and so enjoying their Beings for a Time, by this Means

propagate and continue their Species: So that there are none destitute of some Means to preserve themselves, and their Kind; and these Means so effectual that notwithstanding all the Endeavours and Contrivances of Man and Beast to destroy them, there is not to this Day one Species lost of such as are mention'd in Histories, and consequently and undoubtedly neither of such as were at first created.

Then for Birds of Prey, and rapacious Animals, it is remarkable what Aristotle observes, That they are all solitary, and go not in Flocks, GampsOnuchOn uden agelaion. No Birds of Prey are gregarious. Again, That such Creatures do not greatly multiply, tOn gampsOnuchOn . They for the most Part breeding, and bringing forth but one or two, or at least a few Young Ones at once: Whereas they that are feeble and timorous are generally Multiparous; or, if they bring forth but few at once, as Pigeons, they compensate that by their often breeding, viz. every Month but two throughout the Year; by this Means providing for the Continuation of their Kind.

<1717>But for the Security of these rapacious Birds, it is worthy the noting that because a Prey is not always ready, but perhaps they may fail of one some Days; Nature hath made them patient of a long inedia, and besides, when they light upon one, they gorge themselves so therewith, as to suffice for their Nourishment for a considerable Time.

Fourthly, I shall note the exact fitness of the Parts of the Bodies of Animals to every one's Nature and Manner of Living. A notable Instance of which we have in the Swine, a Creature well known, and therefore what I shall observe of it is obvious to every Man. His proper and natural Food being chiefly the Roots of Plants, he is provided with a long and strong Snout; long, that he might thrust it to a sufficient Depth into the Ground, without offence to his Eyes; strong and conveniently formed for the rooting and turning up the Ground. And besides, he is endued with a notable Sagacity of Scent, for the finding out such Roots as are fit for his Food. Hence in Italy, the usual Method for finding and gathering of Trufles, or subterraneous Mushromes (called by the Italians Tartusali, and in Latin Tubera terrae) is by tying a Cord to the Hind-leg of Pig, and driving him before them into such Pastures as usually produce that Kind of Mushrome, and observing where he stops and begins to root, and there digging, they are sure to find a Trufle; which when they have taken up, the drive away the Pig to search for more. So I have myself observed, that in Pastures where there are Earth-nuts to be found up and down in several Patches, tho' the Roots lie deep in the Ground, and the stalks be dead long before and quite gone, the Swine will by their Scent easily find them out, and root only in those Places where they grow.

This rooting of the Hog in the Earth, calls to mind another Instance of like Nature, that is the Porpesse, which as his English Name Porpesse, i.e. Porc pesce, Swine-fish imports, resembles the Hog, both in the Strength of his Snout, and also in the Manner of getting his Food by rooting. For we found the Stomach of one we disected, full of Sand-Eels or Launces, which for the most Part lie deep in the Sand, and cannot be gotten but by rooting or digging there. We have seen the Country People in Cornwall, when the Tide was out, to fetch them out of the Sand with Iron-hooks thrust down under them, made for that Purpose.

Furthermore, That very Action for which the Swine is abominated, and looked upon as an unclean and impure Creature, namely wallowing in the Mire, is Design'd by Nature for a very good End and Use, viz. not only to cool his Body, for the fair Water would have done that as well, nay, better, for commonly the Mud and Mire in Summer-time is warm; but also to suffocate and destroy Lice, Fleas, and other noisom and importunate Insects, that are troublesome and noxious to him. For the same Reason do all the Poultry-kind, and divers other Birds bask themselves in the Dust in Summer time and hot Weather, as is obvious to every one to observe.

2. A Second and no less remarkable Instance, I shall produce, out of Dr. More's Antidote against Atheism, lib. 2. cap. 10. in a poor and contemptible quadruped, the Mole.

First of all (saith he) her Dwelling being under Ground, where nothing is to be seen, Nature hath so obscurely fitted her with Eyes that Naturalists can scarcely agree, whether she hath any Sight at all or no. [In our Observation, Moles have perfect Eyes, and Holes for them through the Skin, so that they are outwardly to be seen by any that shall diligently search for them; tho' indeed they are exceeding small, not much bigger than a great Pins-head. But for amends, what she is capable of for her Defence and warning of Danger, she has very eminently conferr'd upon her; for she is very quick of hearing [doubtless her subterraneous Vaults are like Trunks to convey any Sound a great Way.] And then her short Tail and short Legs, but broad Fore-feet armed with sharp Claws, we see by the Event to what purpose they are, she so swiftly working herself under Ground, and making her Way so fast in the Earth, as they that behold it cannot but admire it. Her Legs therefore are short, that she need dig no more than will serve the meer thickness of her Body: And her Fore-feet are broad, that she may scoup away much Earth at a Time: And she has little or no Tail, because she courses it not on the Ground like a Rat or Mouse, but lives under the Earth, and is fain to dig herself a Dwelling there; and she making her way through so thick an Element; which will not easily yield as the Water and Air do; it had been dangerous to draw so long a Train behind her; for her Enemy might fall upon her Rear, and fetch her out before she had perfected and got full Possession of her Works: Which being so, what more palpable Argument of Providence than she?

Another Instance in Quadrupeds might be the Tamandua, or Ant-Bear, described by Marcgrave and Piso, who saith of them, that they are Night-walkers, and seek their Food by Night. Being kept tame, they are fed with Flesh, but it must be minced small, because they have not only a slender and sharp Head and Snout, but also a narrow and toothless Mouth; their Tongue is like a great Lute-string (as big as a Goose-quill) round, and in the greater Kind (for there are two Species) more than two Foot long, and therefore lies doubled in a Channel between the lower Parts of the Cheeks. This when hungry they thrust forth, being well moistened, and lay upon the Trunks of Trees and when it is covered with Ants, suddenly draw it back into their Mouths; if the Ants lie so deep that they cannot come at them, they dig up the Earth with their long and strong Claws, wherewith for that Purpose their Fore-feet are armed. So we see how their Parts are fitted for this Kind of Diet, and no other; for the catching of it, and for the eating of it, it requiring no Comminution by the Teeth, as appears also in the Chamaeleon, which is another Quadruped that imitates the Tamandua in this Property of darting out the Tongue to a great Length, with wonderful Celerity; and for the same Purpose too of catching of Insects.

Besides these Quadrupeds, there are a whole Genus of Birds, called Pici Martii, or Woodpeckers, that in like Manner have a Tongue which they can shoot forth to a very great Length, ending in a sharp stiff bony Rib, dented on each Side; and at Pleaeure thrust it into the Holes, Clefts, and Crannies of Trees to stab and draw out Cossi, or any other Insects lurking there, as also into Ant-hills, to strike and fetch out the ants and their Eggs. More over, they have short, but very strong Legs and their Toes stand two forwards, two backwards, which Disposition (as Aldrovandus well notes) Nature, or rather the Wisdom of the Creator, hath granted to Woodpeckers because it is very convenient for the climbing of Trees, to which also conduces the stiffness of the Feathers of their Tails, and their bending downward, whereby they are fitted to serve as a Prop for them to lean upon, and bear up the Bodies.

As for the Chamaelion, he imitates the Woodspite, not only in the Make, Motion, and Use of his Tongue for striking Ants, Flies, and other Insects; but also in the Site of his Toes, whereby he is wonderfully qualified to run upon Trees, which he doth with that swiftness, that one would think he flew, whereas upon the Ground he walks very clumsily and ridiculously. A full Description of the outward and inward Parts of this Animal, may be seen at the End of Panarolus's Observat. It is to be

noted, that the Chamelion, tho' he hath Teeth, uses them not for chewing his Prey, but swallows it immediately.

<1717>I shall add two Instances more in Birds, and those are,

1. The Swallow; whose proper Food is small Beetles, and other Insects flying about in the Air; as we have found by dissecting the Stomachs both of Old Ones and Nestlings: Which is wonderfully fitted for the catching of these Animalcules; for she hath long Wings, and a forked Tail, and small Feet, whereby she is as it were made for swift Flight, and enabled to continue long upon the Wing, and to turn nimbly in the Air. And she hath also an extraordinary wide Mouth, so that it is very hard for any Insect that comes in her Way to escape her. It is thought to be a Sign of Rain, when this Bird flies low near to the Ground; in which there may be some Truth; because the Insects which she hunts may at such Times, when the superior Air is charged with Vapours, have a Sense of it, and descend near the Earth. Hence, when there are no more Insects in the Air; as in Winter-time, those Birds do either abscond, or betake themselves into hot Countries. 2. The Colymbi, or Douchers, or Loons, whose bodies are admirably fitted and conformed for diving tnder Water: Being covered with a very thick Plumage; and the Superficies of their Feathers lo smooth and slippery, that the Water cannot penetrate or moisten them: Whereby their Bodies are defended from the Cold, the Water being kept at a distance; and so poised that by a light Impulse they may easily ascend in it. Then their Feet are situate in the hindmost part of their Body, whereby they are enabled, shooting their Feet backwards, and striking the Water upwards, to plunge themselves down into it with great Facility, and likewise to move forwards therein. Then their Legs are made flat and broad, and their Feet cloven into Toes with appendant Membranes on each side; by which Configuration they easily cut the Water, and are drawn forward, and so take their Stroke backwards; and besides, I conceive, that by means of this Figure, their Feet being mov'd to the Right and Left-hand, serve them as a Rudder to enable them to turn under Water: For some conceive, that they swim easier under Water than they do above it. How they raise themselves up again, whether their Bodies emerge of themselves by their Lightness, or whether by Striking against the Bottom, in manner of a leap, or by some peculiar motion of their Legs, I cannot determine: That they dive to the Bottom is clear, for that in the Stomachs both of the greater and lesser Kinds we found Grass and other Weeds; and in the lesser kind nothing else; though both prey upon Fish. Their Bills also are made streight and Sharp for the easier cutting of the Water, and Striking their Prey. Could we see the Motions of their Legs and Feet in the Water, then we should better comprehend how they accend, descend, and move to and fro; and discern, how wisely and artificially their Members are formed and adapted to those Uses.

II. In Birds, all the Members are most exactly fitted for the use of flying. First, The Muscles which serve to move the Wings are the greatest and strongest, because much Force is required to the Agitation of them; the underside of them is also made Concave, and the upper Convex, that they may be easily lifeed up, and more strongly beat the Air, which by this means doth more resist the descent of their Body downward. Then the Trunk of their Body doth somewhat resemble the Hull of a Ship; the Head, the Prow, which is for the most part small, that it may the more easily cut the Air, and make way for their Bodies; the Train serves to steer, govern, and direct their Flight; and however it may be held erect in their standing or walking, yet is directed to lie almost in the same plain with their Backs, or rather a little inclining, when they fly. That the Train serves to steer and direct their Flight; and turn their Bodies like the Rudder of a Ship is evident in the Kite, who by a light running of his Train moves his Body which way he Pleases. Iidem videntur artem gubernandi docuisse caudae flexibus,in Coelo monstrante natura quod opus esset in profundo, Pliny. lib. 10. cap. 10. They seem to have taught Men the Art of steering a Ship by the Flexures of their Tails; Nature shewing in the Air what was needful be done in tte Deep.

And it's notable that as Aristotle truly observes, that whole-footed Birds, and those that have long Legs, have for the most part Short Tails; and therefore whilest they fly, do not, as others, draw them up to their Bellies, but stretch them at length backwards, that they may serve to steer and guide them instead of Tails. Neither doth the Tail serve only to direct and govern the flight but also partly to support the Body, and keep it even; wherefore, when spread, it lies parallel to the Horizon, and stands not perpendicular to it, as Fishes do. Hence Birds that have no Tails, as some sorts of Colymbi or Duckers fly very inconveniently with their Bodies almost erect.

<1717>To this I shall add further, That the Bodies of Birds are small in comparison of Quadrupeds, that they may more easily be supported in the Air during their Flight; which is a great Argument of Wisdom and Design: Else why should not we see Species of Pegasi, or Flying Horses, of Griffins, of Harpies, and an hundred more, which might make a shift to live well enough, notwithstanding they could make no use of their Wings. Besides, their Bodies are not only small, but of a broad Figure, that the Air may more resist their Descents, they are also hollow and light; nay, their very Bones are light: For though those of the Legs and Wings are solid and firm, yet have they ample Cavities, by which means they become more rigid and stiff; it being demonstrable that a hollow Body is more stiff and inflexible than a solid one of equal Substance and Matter. Then the Feathers also are very light, yet their Shafts hard and stiff, as being either empty or filled with a light and spungy Substance; and their Webs are not made of continued Membranes, for then had a Rupture by any Accident been made in them, it could not have heen consolidated, but of two Series of numerous Plumulae, or contiguous Filaments, furnished all along with Hooks on each side, whereby catching hold on one another, they stick fast together; So that when they are ruffled or discomposed, the Bird with her Bill can easily preen them, and reduce them to their due Position again. And for their firmer Cohaesion, the wise and bountiful Author of Nature hath provided and placed on the Rump two Glandules, having their excretory Vessels, round wich. grow Feathers in form of a Pencil, to which the Bird turning her Head, catches hold upon them with her Bill, and a little compressing the Glandules, squeezes out and brings away therewith an oily Pap or Liniment, most fit and proper for the Inunction of the Feathers, and causing their little Filaments more strongly to cohere. And is not this strange and admirable, and argumentative of Providence, that there should be such an Unguent or Pap prepared, such an open Vessel to excern it into, to receive and retain it; that the Bird should know where it is situate, and how, and to what Purposes to use it? And because the Bird is to live many Years and the Feathers in time would, and must necessarily be worn and shattered, Nature hath made Provision for the casting and renewing them Yearly.

Moreover, those large Bladders or Membranes, extending to the Bottoms of the bellies of Birds, into which the Breath is received, conduce much to the alleviating of the Body, and facilitating the Flight. For the Air received into these Bladders, is by the Heat of the Body extended into twice or thrice the Dimensions of the external, and so must needs add a Lightness to the Body. And the Bird when she would descend, may either compress this Air by the Muscles of the Abdomen, or expire as much of it as may enable her to descend swifter, or slower, as she pleases. I might add the Use of the Feathers in cherishing are keeping of the Body warm; which, the Creature being of small bulk, must needs stand in great stead against the Rigor of the Cold.

And for this Reason we see, that Water-Fowls, which were to swim, and sit long upon the cold Water, have their Feathers very thick set upon their Breast and Bellies, and besides a plentiful Down there growing, to fence against the Cold of the Water, and to keep off its immediate Contact. That the Tails of all Birds in general do not conduce to their turning to the Right and Left, according to the common Opinion, but rather for their Ascent and Descent, some modern Philosophers have observed and proved by Experiment for that it you pluck off, for instance, a Pigeon's tail, she will nevertheless with equal facility turn to and fro: Which upon second Thoughts, and further Consideration, I grant to be true, in Birds whose Tails are pointed, and end in a right Line: But in those that have forked Tails, Autopsy convinceth us, that it hath this use; and therefore

they pronounce too boldly of all in general. For it is manifest to sight, that the fork'd-tail'd Kite, by turning her Train sideways, elevating one Horn, and depressing the other, turns her whole Body. And doubtless the Tail hath the same use in Swallows, who make the most sudden Turns in the Air of any Birds, and have all of them forked Tails.

III. As for Fishes, their Bodies are long and slender, or else thin for the most part, for their more easie swimming and dividing the Water. The Wind-bladder, wherewith most of them are furnished, serves to poise their Bodies, and keep them equiponderant to the Water, which else would sink to the bottom, and lie groveling there, as hath by breaking the Bladder been experimentally found. By the Contraction and Dilatation of this Bladder, they are able to raise or sink themselves at pleasure, and continue in what depth of Water they will. The Fins made of gristly Spokes or Rays connected by Membranes, so that they may be contracted or extended like Womens Fans, and furnished xwith Muscles for Motion, serve partly for Progression, but chiefly to hold the Body upright; which appears in that when they are cut off, it wavers to and fro, and so soon as the Fish dies, the belly turns upwards.

The great strength by which Fishes dart themselves forward with incredible Celerity, like an Arrow out of a Bow, lies in their Tails, their Fins mean time, least they should retard their motion, being held close to their Bodies. And therefore almost the whole Musculous Flesh of the Body is bestow'd upon the Tail and Back, and serves for the Vibration of the Tail, the Heaviness and Corpulency of the Water, requiring a great Force to divide It.

<1717>In Cetaceous Fishes; or as the Latins call them, Sea-Beasts, Belluae Marinae the Tail hath a different Position from what it hath in all other Fishes; for whereas in these it is erected perpendicular to the Horizon, in them it lies parallel thereto, partly to supply the use of the hinder Pair of Fins which these Creatures lack, and partly to raise and depress the Body at pleasure. For it being necessary that these Fishes should frequently ascend to the top of the Water to breath, or take in and let the Air, it was fitting and convenient that they should be provided with an Organ to facilitate their Ascent and Descent as they had occasion. And as for their turning of their Bodies in the Water, they must perform that as Birds do, by the Motion of one of their Fins, while the other is quiescent. It is no less remarkable in them, that their whole Body is incompassed round with a copious Fat, which our Fishermen call the Blubber, of a great Thickness; which serves partly to poize their Bodies, and render them equiponderant to the Water; partly to keep off the Water at some Distance from the Blood, the immediate Contact whereof would be apt to chill it, and partly also for the same Use that Cloaths serve us, to keep the Fish warm, by reflecting the hot Steams of the Body, and so redoubling the Heat, as we have before noted. For we see, by Experience, that fat Bodies are nothing near so sensible of the Impretsions of Cold as lean. And I have observed fat Hogs to have lain abroad in the open Air, upon the cold Ground in Winter Nights, whereas the lean ones have been glad to creep into their Cotes, and lie upon Heaps to keep themselves warm.

I might here take Notice of those Amphibious Creatures, which we may call Aquatic Quadrupeds (though one of them there is that hath but two Feet, viz. the Manati, or Sea-Cow) the Beaver, the Otter, the Phoca or Sea-Calf, the Water-Rat, and the Frog, the toes of whose Feet are joined by Membranees, as in Water-fowls for swimming; and who have very small Ears, and Ear-holes, as the Cetaceous Fishes have for hearing in the Water.

To this head belongs the adapting of the Parts that minister to Generation in the Sexes one to another; and in Creatures that nourish their Young with Milk, the Nipples of the Breast to the Mouth and Organs of Suction; which he must needs be wilfully blind and void of Sense, that either discerns not, or denies to be intended and made one for the other. That the Nipples should be made spungy, and with such Perforations, as to admit passage to the Milk when drawn, otherwise to retain it; and

the Teeth of the Young either not sprung, or so soft and tender, as not to hurt the Nipples of the Dam, are Effects and Arguments of Providence and Design.

<1717>A more full Description of the Breasts and Nipples I meet with, in a Book of that ingenious Anatomist and Physician, Antonius Nuck, entitled, Adenographia Curiosa, Cap. 2. He makes the Breasts to be nothing but Glandules of that Sort they call Conglomeratae, made up of an infinite Number of little Knots or Kernels, each whereof hath its excretory Vessel, or lactiferous Duct; three or four, or five of these presently meet, and join into one small Trunk; in like manner do the adjacent Glandules meet and unite; several of these lesser Trunks or Branches concurring, make up an Excretory Vessel of a notable Bigness, like to that of the Pancreas, but not so long, yet sufficiently large to receive and retain a good Quantity of Milk; which before it enters the Nipples is again contracted, and straitned to that Degree, that it will scarce admit a small Bristle. Who now can be so impudent as to deny, that all this was contrived and designed purposely to retain the Milk, that it should not flow out of its self, but easily be drawn out by pressure and function; or to affirm that this fell out accidentally than which there could not have been a more ingenious Contrivance for the Use to which it is imploy'd, invented by the Wit of Man?

To this Head of the Fitness of the Parts of the Body to the Creatures nature and manner of living, belongs that Observation of Aristotle, tOn ornithOn hosa men champsOnocha sarkophaga panta. Such Birds as have crooked Beaks and Talons, are all carnivorous; and so of quadrupeds; karcharodonta carnivora omnia. All that have serrate Teeth, are carnivorous. This Observation holds true concerning all European Birds, but I know not but that Parrots may be an Exception to it. Yet it is remarkable, that such Birds as are carnivorous have no Gizzard, or musculous, but a Membranous Stomach, that kind of Food needing no such grinding or comminution as Seeds do, but being torn into strings or small Flakes by the Beak, may be easily concoeted by a Membranous Stomach.

To the fitness of all the Parts and Members of Animals to their respective Uses, may also be referred another Observation of the same Aristotle, Panta ta zOa artiQs echei podas. All Animals have even Feet, not more on one side than another; which if they had, would either hinder their walking, or hang by not only useless, but also burthensome. For though a Creature might make a limping shift to hop, suppose with three Feet, yet nothing so conveniently or steddily to walk, or run, or indeed to stand. So that we see, Nature hath made choice of what is most fit, proper, and useful. They have also not only an even number of Feet, answering by Pairs one to another, which is as well decent as convenient; but those too of an equal length, I mean the several Pairs; whereas were those on one side longer than they on the other, it would have caused an inconvenient halting or limping in their going.

I shall mention but one more Observation of Aristotle, that is, PtEnon monon oQden, there is no Creature only volatile, or no flying Animal but hath Feet as well as Wings, a power of walking or creeping upon the Earth; because there is no Food, or at least not sufficient Food for them to be had always in the Air; or if in hot Countries we may suppose there is, the Air being never without store of Insects flying about in it, yet could such Birds take no rest, so having no Feet, they could not perch upon Trees; and if they should alight upon the Ground, they could by no means raise themselves any more, as we see those Birds which have but short Feet, as the Swift and Martinet, with difficulty do. Besides, they would want means of Breeding, having no where to lay their Eggs, to sit, hatch, or brood their Young. As for the Story of the Manucodiata, or Bird of Paradise, which in the former Ages was generally received and accepted for true, even by the Learned, it is now discover'd to be a Fable and rejected and exploded by all Men: those Birds being well known to have Legs and Feet as well as others, and those not short, small, nor feeble ones, but sufficiently great and strong, and arm'd with crooked Talons, as being the Members of Birds of Prey.

<1717>It is also very remarkable, That all flying Insects should be covered with shelly Scales, lile Armour, partly to secure them from external Violence, from Injuries by Blows and Pressures: partly to defend their tender Muscles from the Heat of the Sun-beams, which would be apt to parch and dry them up, being of small Bulk; partly also to restrain the Spirits, and to prevent their Evaporation.

I shall now add another Instance of the Wisdom of Nature, or rather the God of Nature, in adapting the Parts of the same Animal one to another, and that is the proportioning the length of the Neck to that of the I.egs. For, seeing Terrestrial Animals, as well Birds as Quadrupeds, are endued with Legs, upon which they Stand, and wherewith they transfer them selves from Place to Place, to gather their Food and for other conveniences of Life, and so the Trunk of their Body must needs be elevated above the Superficies of the Earth, so that they could not conveniently either gather their Food or Drink, if they wanted a Neck, therefore Nature hath not only furnished them therewith, but with such an one as is commensurable to their Legs, except here the Elephant, which hath indeed a short Neck; for the excessive weight of his Head and Teeth, which to a long Neck would have been unsupportable, but is provided with a Trunk, wherewith, as with a Hand, he takes up his Food and Drink, and brings it to his Mouth.

I say, the Necks of Birds and Quadrupeds are commensurate to their Legs, so that they which have long Legs have long Necks, and they that have short Legs, short ones, as is seen in the Crocodile, and all Lizards; and those that have no Legs, as they do not want Necks, so neither have they any, as Fishes. This equality between the Length of the Legs and Neck, is especially seen in Beasts that feed constantly upon Grass, whose Necks and Legs are always very near equal; very near, I say, because the Neck must necessarily have some Advantage, in that it cannot hang perpendicularly down, but must incline a little: Moreover, because this Sort of Creatures must needs hold their Heads down in an inclining Posture, for a considerable time together, which would be very laborious and painful for the Muscles; therefore on each side the Ridge of the Vertebres of the Neck, Nature hath placed an aponeurOsis, or nervous Ligament of a great Thickness and Strength, apt to stretch and shrink again as Need requires, and void of Sence, extending from the Head (to which, and the next Vertebres of the Neck, it is fastened at that end) to the middle Vertebres of the Back (to which it knit at the other) to assist them to support the Head in that Posture, which aponeurOsis is taken notice of by the Vulgar by the Name of Fixfax, or Or Pack-wax, or Whit-leather. It is also very observable in Fowls that wade in the Water, which having long Legs, have also Necks answerably long: Only in these too there is an Exception, exceeding worthy to be noted; for some Water Fowl, which are Pamipeds, or whole-footed, have very long Necks, and yet but short Legs, as Swans and Geese, and some Indian Birds; wherein we may observe the admirable Providence of Nature. For such Birds as were to search and gather their Food, whether Herbs or Insects, in the bottom of Pools and deep Waters, have long Necks for that purpose, though their Legs, as is most convenient for Swimming, be but short.

Whereas there are no Land-Fowl to be seen with short Legs and long Necks, but all have their Necks in Length commensurate to their Legs. This instance is the more considerable, because the Atheists usual Flam will not here help them out. For (say they) there were many Animals of disproportionate Parts, and of absur'd and uncouth Shapes produced at first in the Infancy of the World; but because they could not gather their Food, or perform other Functions necessary to maintain Life, they soon perished, and were lost again. For these Birds, we see, can gather their Food upon Land conveniently enough, notwithstanding the length of their Necks. For example, Geese graze upon Commons, and can feed themselves fat upon Land: Yet is there not one Land Bird, which hath its neck thus disproportionate to its Legs; nor one Water one neither, but such as are destined by Nature in such manner as we have mentioned to search and gather their Food. For Nature makes not a long Neck to no purpose.

Lastly, Another Argument of Providence and Counsel relating to Animals, is the various kinds of Voices the same Animal uses on divers occasions, and to different Purposes. Hen-Birds, for Example, have a peculiar sort of Voice when they would call the Male; which is so eminent in Quails, that it is taken Notice of by Men, who by counterfeiting this Voice with a Quailpipe, easily drew the Cocks into their Snares. The common Hen, all the while she is broody, sits, and leads her Chickens, uses a Voice which we call Clocking. Another she employs when she calls her Chickens to partake of any Food she hath found for then; upon hearing whereof they speedily run to her. Another when upon sight of a Bird of Prey, or apprehension of any danger, she would scare them, bidding them, as it were, to shift for themselves whereupon they speedily run away, and seek Shelter among Bushes, or in the thick Grass, or elsewhere dispersing them selves far and wide. These Actions do indeed necessarily infer Knowledge and Intention of, and Direction to the Ends and Uses to which they serve, not in the Birds themselves, but in a superiour Agent, who hath put an Instinct in them of using such a Voice upon such an occasion; and in the Young of doing that upon hearing of it, which by Providence was intencled. Other Voices she hath when angry, when she hath laid an Egg, when in Pain, or great Fear, all significant, which may more easily be accounted for, as being Effects of the several Passions of Anger, Grief, Fear, Joy: Which yet are all argumentative of Providence, intending their several Significations and Uses.

I might also Instance in Quadrupeds; some of which have as great a Diversity of Voices as Hens themselves: And all of them significant, for Example, That common domestick Animal the Cat, as is obvious to every one to observe and therefore I shall not spend Time to mention Particulars.

Object[ion?].

But against the Uses of several Bodies I have Instanced in, that refer to Man, it may be objected, That these Uses were not designed by Nature in the Formation of the Things; but that the Things were by the Wit of Man accommodated to those Uses.

To which I answer, with Dr.More, in the Appendix to his Antidote against Atheism, That the Several useful Dependencies of this Kind (viz of Stones, Timber, and Metals, for building of Houses or Ships, the Magnet, for Navigation, &c. Fire for melting of Metals, and forging of Instruments for the Purposes mentioned) we only find, not make them. For •whether we think of it or no, it is, for Example, manifest, that Fuel is good to continue Fire, and Fire to melt Metals, and Metals to make Instruments to build Ships and Houses, and so on. wherefore it being true, that there is such a subordinate usefulness in the Things themselves that are made to our hand, it is but Reason in us to impute it to such a Cause, as was aware of the usefullness and serviceableness of its own Works. To which I shall add, that since we find Materials so fit to serve all the Necessities and Conveniencies, and to exercise and employ the Wit and Industry of an intelligent and active Being, and since there is such an one created that is endued with Skill and Ability to use them, and which by their help is enabled to rule over and subdue all inferior Creatures, but without them had been left necessitous, helpless, and obnoxious to Injuries above any other; and since the Omniscient Creator could not but know all the Uses, to which they might and would be employed by Man, to them that acknowledge the Being of a Deity, it is little less than a Demonstration, that they were created intentionally I do not say only, for those Uses.

Methinks, by all this Provision for the Use and Service of Man, the Almighty interpretatively speaks to him in this manner: I have now placed thee in a spacious and well-furnished World, I have endued thee with an ability of Understanding what is beautiful and proportionable, and have made that which is so, agreeable and delightful to thee; I have provided thee with Materials whereon to exercise and employ thy Art and Strength: I have given thee an excellent Instrument, the Hand, accomodated to make use of them all; I have distinguished the Earth into Hills and Valleys and Plains, and Meadows, and Woods; all these Parts capable of Culture and Improvement by thy

Industry; I have committed to thee for thy assistance in thy Labours of Ploughing, and Carrying, and Drawing, and Travel, the laborious Ox, the patient Ass, and the strong and serviceable Horse:

I have created a Multitude of Seeds for thee to make choice out of them, of what is most pleasant to thy Taste, and of most wholsome and plentiful Nourishment; I have also made great Variety of Trees, bearing Fruit both for Food and Physick, those too capable of being meliorated and improved by Transplantation, Stercoration, Insition, Pruning, Watering and other Arts and Devices. Till and Manure thy Fields, sow them with thy Seeds, extirpate noxious and unprofstable Herbs, guard them from the invasions and spoil of Beasts, clear and fence in thy Meadows and Pastures; dress and prune thy Vines, and so rank and dispose them as is most suitable to the Climate; Plant thee Orchards, with all Sorts of Fruit-Trees, in such order as may be most beautiful to the Eye, and most comprehensive of Plants; Gardens for culinary Herbs, and all Kinds of Salletting; for delectable Flowers, to gratifie the Eye with their agreeable Colours and Figures, and thy Scent with their fragrant Odors; for Odoriferous and Ever-green Shrubs and Suffrutices; for Exotick and Medicinal Plants of all sorts and dispose of them in that comely Order, as may be both pleasant to behold, and commodious for access. I have furnished thee with all Materials for Building, as Stone, and Timber, and Slate, and Lime, and Clay, and Earth, whereof to make Bricks and Tiles, deck and bespangle the Country with Houses and Villages convenient for thy Habitation, provided with Out-houses and Stables for the harbouring and Shelter of thy Cattle with Barns and Granaries for the reception, and custody, and storing up thy Corn and Fruits. I have made thee a sociable Creature, ZOon politikon, for the improvement of thy Understanding by Conference, and Communication of Observations and Experiments; for mutual help, and assistance, and defence; build thee large Towns and Cities with streight and well-paved Streets, and elegant Rows of Houses, adorned with magnificent Temples for my Honour and Worship, with beautiful Palaces for thy Princes and Grandees, with stately Halls for publick Meetings of the Citizens and their several Companies, and the Sessions of the Courts of Judicature, besides Publick Portico's and Aqueducts.

I have implanted in thy Nature a desire of seeing strange and foreign, and finding out unknown Countries, for the improvement and advance of thy Knowledge in Geography, by observing the Bays, and Creeks, and Havens, and Promontories, the Outlets of Rivers, the Situation of the Maritime Towns and Cities, the Longitude and Latitude, &c of those Places: In Politicks, by noting their Government, their Manners, Laws, and Customs, their Diet and Medicine, their Trades

*l64 and Manufactures, their Houses and Buildings, their Exercises and Sports, &c. In Physiologv, or Natural History, by searching out their Natural Rarities, the Productions both of Land and Water, what Species of Animals, Plants, and Minerals, of Fruits and Drugs are to be found there, what Commodities for Bartering and Permutation, whereby thou may'st be enabled to make large Additions to Natural History, to advance those other Sciences, and to benefit and enrich thy Country by increase of its Trade and Merchandize: I have given thee Timber and Iron to build the Hulls of Ships, tall Trees for Masts, Flax and Hemp for Sails, Cables and Cordage for Rigging. I have armed thee with Courage and Hardness to attempt the Seas, and traverse the spacious Plains of that liquid Element; I have assisted thee with a Compass, to direct thy Course when thou shalt be out of all Ken of Land, and have nothing in view but Sky and Water. Go thither for the Purposes before-mentioned, and bring home what may be useful and beneficial to thy Country in general, or thy self in particular.

I perswade my self, that the bountiful and gracious Author of Man's Being and Faculties, and all things else, delights in the Beauty of his Creation, and is well Pleased with the Industry of Man, in adorning the Earth with beautiful Cities and Castles, with pleasant villages and Country-Houses, with regular Gardens and Orchards, and Plantations of all sorts of Shrubs, and Herbs, and Fruits, for Meat, Medicine, or moderate Delight, with shady Woods and Groves, and Walks set with Rows of elegant Trees; with Pastures cloathed with Flocks, and Valleys covered over with Corn, and

meadows burthened with Grass, and whatever else differenceth a civil and well cultivated Region, from a barren and desolate Wilderness.

If a Country thus planted and adorn'd, thus polished and civilized, thus improved to the height by all manner of Culture for the Support and Sustenance, and convenient Entertainment of innumerable multitudes of People, be not to be preferred before a barbarous and inhospstable Scythia, without Houses, without Plantations, without Corn-fields or Vineyards, where the roving Hords of the savage and truculent Inhabitants, transfer themselves from place to place in Waggons, as they can find Pasture and Forrage for their Cattle, and live upon Milk, and Flesh roasted in the Sun, at the Pomels of their Saddles; or a rude and unpolished America, peopled with slothful and naked Indians, instead of well-built Houses, living in pitifu1 Huts and Cabbins, made of Poles set end-ways; then surely the brute Beasts Condition, and manner of Living, to which, what we have mention'd doth nearly approach, is to be esteem'd better than Man's, and Wit and Reason was in vain bestowed on him. Larly, I might draw an Argument of the admirable Art and Skill of the Creator and Composer of them, from the incredible Smalness of some of those natural and enlevined Machines, the Body of Animals.

Any Work of Art of extraordinary Fineness and Subtlety, be it but a small Engine or Movement, or a Curious carved or turned Work of Ivory or Metals, such as those Cups turned of Ivory by Oswaldus Nerlinger of Suevia, mention'd by Joannes Faber in his Expositions of Recchus his Mexican Animals, which all had the perfect form of Cups, and were gilt with a Golden Border about the Brim, of that wonderful smalness, that Faber himself put a thousand of them into an excavated Pepper corn; and when he was weary of the Work, and yet had not filled the Vessel, his Friend, John Carlus Schad, that shewed them him, put in four hundred more. Any such Work, I say, is beheld with admiration, and purchased at a great Rate, and treasured up as a singular Rarity in the Musaeums and Cabinets of the Curious, and as such is one of the first things shew'd to Travellers and Strangers. But what are these for their fineness and parvity (for which alone, and their Figure, they are considerable) to those Minute Machines endued with life and motion, I mean, the Bodies of those Animalcula, not long since discovered in Pepper-water, by Mr Leuenhoek of Delft in Holland, (whose Observations were confirmed and improved by our learned and Worthy Country-man Dr Robert Hook) who tells us, That some of his Friends (whose Testimonials he desired) did affirm, That they had seen l0000, others 30000, others 45000 little living Creatures, in a Quantity of Water no bigger than a Grain of Millet; and yet he made it his Request to them, that they would only justify (that they might be within compass) half the number that they believed each of them saw in the Water. From the greatest of these Numbers he infers, that there will be 8280000 of these living Creatures seen in one drop of Water; which number (saith he) I can with Truth affirm, I have discerned. This (proceeds he) doth exceed belief: But I do affirm, if a larger Grain of Sand were broken into 8000000, of equal Parts, one of these would not exceed the bigness of one of those Creatures.

Dr. Hook tells us, That after he had discovered vast multitudes of those exceeding small Creatures which Mr. Leuenhoek had described, upon making use of other Lights and Glasses, he not only magnified those he had discovered to a very great bigness, but discovered many other sorts very much smaller than them he first saw, and some of them so exceeding small, that Millions of Millions might be contain'd in one drop of Water. If Pliny, considering such Insects as were known to him, and those were none but what were visible to the naked Eye, was moved to cry out, That the Artifice of Nature was no where more conspicuous than in these. And again, In his tam parvis atque tam nullis quae ratio, quanta vis, quam inextricabilis perfectio? And again, Rerum natura nusquam magis quam in minimis tota est, Hist. Nat. l. 111. c. I. What would he have said if he had seen Animals of so stupendous smallness, as I have mention'd? How would he have been rapt into an Extasie of Astonishment and Admiration?

Again, if considering the Body of a Gnat, (which by his own Confession is none of the least of Insects) he could make so many admiring Queries, Where hath Nature disposed so many Senses in a Gnat? Ubi visum praetendit? ubi gustatum applicavit? ubi odoratum inseruit? Ubi vero truculentam illam et portione maximam vocem ingeneravit? Qua subtilitate pennas adnexuit? Praelongavit pedum crura? Disposuit jejunam caveam uti alvum? Avidam sanguinis et potissimum humani sitim accendit? Telum vero perfodiendo tergori quo spiculavit ingenio? Atque ut in capaci, cum cerni non possit exilitas, ita reciproca geminavit arte, ut fodiendo acuminatum pariter sorbendoque fistulosum esset. <**122> Which Words should I translate, would lose of their Emphasis and Elegancy; If, I say, he could make such Queries about the Members of a Gnat, what may we make? And what would he in all likelihood have made had he seen these incredibly small living Creatures? How would he have admired the immense Subtilty (as he phrases it) of their Parts? For to use Mr. Hook's words in his Microscopium p. 103. If these Creatures be so exceeding small, what must we think of their Muscles and other Parts? Certain it is, that the Mechanism by which Nature performs the Muscular Motion, is exceeding small and curious, and to the performance of every Muscular Motion, in greater Animals at least, there are not fewer distinct parts concerned than many Millions of Millions, and these visible through a Microscope.

Use. Let us then consider the Works of God, and observe the Operations of his Hands: Let us take notice of, and admire his infinite Wisdom and Goodness in the Formation of them: No Creature in this sublunary World is capable of so doing, beside Man, and yet we are deficient herein: We content ourselves with the Knowledge of the Tongues, on a little Skill in Philology, or History perhaps, and Antiquity, <**123> and neglect that which to me seems more material, I mean, Natural History, and the Works of the Creation: I do not discommend, or derogate from those other Studies: I should betray mine own Ignorance and Weakness should I do so; I only wish they might not altogether jostle out, and exclude this. I wish that this might be brought in fashion among us; I wish Men would be equal and civil, as not to disparage, deride, and vilifie those Studies which themselves skill not of, or are not conversant in; no Knowledge can be more pleasant than this, none that doth so satisfie and feed the Soul; in comparison whereto that of Words and Phrases seems to me insipid and jejeune That Learning (saith a wise and observant Prelate) which consists only in the Form and Pedagogy of Arts or the critical Notions upon Words and Phrases, hath in it this intrinsical imperfection that it is only so far to be esteemed, as it conduceth to the Knowledge of Things, being in itelf but a kind of Pedantry, apt to insect a Man with such odd Humours of Pride and Affectation, and Curiosity, as will render him unfit for any great Employment. Words being but the Images of Matter, to be wholly given up to the study of these, what is it but Pygmalion's Frenzy, to fall in Love with a Picture or Image? As for Oratory, which is the best skill about Words, that hath by some wise Men been esteem'd, but a voluntary Art like to Cookery, which spoils wholesome Meats, and helps unwholesome, by the variety of Sauces, serving more to the Pleasure of Taste, than the Health of the Body.

It may be (for ought I know, and as some Divines have thought) part of our Business and Employment in Eternity, to contemplate the Works of God, and give him the Glory of his Wisdom Power, and Goodness, manifested in the Creation of them. I am sure it is part of the Business of a Sabbath-day, and the Sabbath is a Type of that Eternal Rest; for the Sabbath seems to have been first instituted for a Commemoration of the Works of the Creation, from which God is said to have rested upon the Seventh-Day.

<1717>It is not likely that Eternal Life shall be a torpid and unactive state, or that it shall consist only in an uninterrupted and endless Act of Love; the other Faculties shall employed as well as the Will, in Actions suitable to, and perfective of their Natures; especially the Understanding, the Supreme Faculty of the Soul, which chiefly differenceth us from brute Beasts, and makes us capable of Virtue and Vice, of Rewards and Punishments, shall be busied and employed in contemplating the Works of God, and observing the Divine Art and Wisdom manifested in the Structure and

Composition of them; and reflecting upon their Great Architect the Praise and Glory due to him. Then shall we clearly see to our great satisfaction and admiration, the Ends and Uses of these Things which here were either too subtle for us penetrate and discover, or too remote and unaccessible for us to come to any distinct view of, viz the Planets, and fix'd Stars; those illustrious Bodies, whose Contents and Inhabitants, whose Stores and Furniture we have here so longing a desire to know, as also their mutual subserviency to each other. Now the Mind of Man being not capable at once to advert to more than one thing, a particular View and Examination of such an innumerable number Qf vast Bodies, and the great multitude of Species, both of animate and inanimate Beings, which each of them contains, will afford Matter enough to exercise and employ our Minds, I do not say, to all eternity, but to many Ages, should we do nothing else.

Let it not suffice us to be Book-learned, to read what others have written, and to take upon Trust more Falsehood than Truth: But let us ourselves examine things as we have opportunity, and converse with Nature as well as Books. Let us endeavour to promote and encrease this Knowledge, and make new Discoveries, not so much distrusting our own Parts, or despairing of our own Abilities, as to think that our Industry can add no thing to the Invention of our Ancestors, or correct any of their Mistakes. Let us not think that the bounds of Science are fixed like Hercules's Pillars, and inscribed with a Ne plus ultra. Let us not think we have done, when we have learnt what they have delivered to us.

The Treasurers of Nature are inexhaustible. Here Is Employment enough, for the vastest Parts, the most indefatigable Industries, the happiest Opportunities, the most prolix and undisturb'd Vacancies.

<1717>Multa venientis aevi populus ignota nobis sciet: Multa seculis tunc futuris, cum memoria nostri exoleverit reservantur. Pusilla res mundus est, nisi in eo quod quaerat omnis mundus habeat, Seneca Nat. Quaest. lib. 7. cap. 31. The People of the next Age shall know many Things unknown to us: Many are reserved for Ages then to come, when we shall be quite forgotten, no Memory of us remaining. The World would be a pitiful samll Thing, indeed, if it did not contain enough for the Erlquiries of the whole World. Yet, and again, Epistle 64. Multum adhuc restat Operis, multumque restabit, nec ulli nato post mille saecula praecludetur occasio aliquid adhuc adjiciendi. Much Work still remains, and much will remain, neither to him that shall be born after a thousand Ages, will matter be wanting for new additions to what hath already been invented.

Much might be done, would we but endeavour, and nothing is insuperable to Pains and Patience. I know that a new Study at first seems very vast, intricate, and difficult; but after a little resolution and progress, after a Man becomes a little acquainted, as I may so say, with it, his Understanding is wonderfully cleared up and enlarged, the Difficulties vanish and the thing grows easie and familiar. And for our encouragement in this Study, observe what the Psalmist saith, Psalm 111:2 "The works of the Lord are great, sought out of all them that have pleasure therein." Which though it be principally spoken of the Works of Providence, yet may as well be verified of the Works of Creation. I am sorry to see so little count made of real Experimental Philosophy in this University; and that those ingenious Sciences of the Mathematicks are so much neglected by us: And therefore do earnestly exhort those that are young, especially Gentlemen, to set upon these Studies, and take some pains in them. They may possibly invent something of eminent Use and Advantage to the World; and one such Discovery would abundantly compensate the Expence and Travel of one Man's whole Life. However, it is enough to maintain and continue what is already invented: Neither do I see what more ingenious and manly Employment they can pursue, tending more to the Satisfaction of their own Minds, and the Illustration of the Glory of God. For he is wonderful in all his Works.

But I would not have any Man cross his natural Genius or Inclinations, or undertake such Methods of Study, as his Parts are not fitted to, or not serve those Ends to which his Friends upon mature

Deliberation have designed him; but those who do abound with Leisure, or who have a natural Propension and Genius inclining them thereto, or those who by Reason of the Strength and Greatness of their Parts, are able to compass and comprehend the whole Latitude of Learning.

Neither yet need those who .are designed to Divinity itself, fear to look into these Studies, or think they will engross their whole Time, and that no considerable Progress can be made therein, unless Men lay aside and neglect their ordinary Callings, and necessary Employments. No such matter. Our Life is long enough, and we might find Time enough, did we husband it well: Vitam non accepimus brevem sed fecimus, nec inopes eius, sed prodigi sumus, as Seneca saith, <1717>"We have not received a short Life, but have made it so; neither do we want time but are prodigal of it." And did but young Men fill up that time with these Studies, which lies upon their Hands, which they are incumbered with, and troubled how to pass away, much might be done even so. I do not see but the Study of true Physiology, may be justly accounted a proper or Propaideia Preparative to Divinity.

But to leave that, it is a generally received Opinion, that all this visible World was created for Man; that Man is the end of the Creation, as if there were no other end of any Creature, but some way or other to be serviceable to Man. This Opinion is as old as Tully; for, saith he, in his Second Book De Nat. Deorum. Principio ipse Mundus Deorum hominumque causa factus est: quaeque in eo sunt omnia ea parata ad fructum hominum et inventa sunt. But though this be vulgarly receiv'd, yet wise Men now-a-days think otherwise. Dr. More affirms, "That Creatures are made to enjoy themselves as well as to serve us; and that it's a gross piece of Ignorance and Rusticity to think otherwise. And in another Place: "This comes only out of Pride and Ignorance, or a haughty Presumption, because we are encouraged to believe, that, in some Sense, all Things are made for Man; therefore to think that they are not at all made for themselves. But he that pronounceth this, is ignorant of the Nature of Man and the Knowledge of Things. For if a good Man be merciful to his Beast, then surely a good God is bountiful and benign, and takes Pleasure that all his Creatures enjoy themselves, that have Life and Sense, and are capable of Enjoyment.

<1717>Those Philosophers indeed, who hold Man to be the only Creature in this sublunary World, endued with Sense and Perception, and that all other Animals are meer Machines or Puppets, have some Reason to think, that all things here below were made for Man. But this Opinion seems to me too mean, and unworthy the Majesty, Wisdom and Power of God; nor can it well consist with his Veracity, instead of a Multitude of Noble Creatures, endued with Life and Sense, and spontaneous Motion, as all Mankind 'till of late Years believed, and none ever doubted of (so that it seems we are naturally made to think so) to have stocked the Earth with divers Sets of Automata, without all Sense and Perception, being wholly acted from without, by the Impulse of external Objects.

But be this so, there are infinite other Creatures without this Earth, which no considerate Man can think, were made only for Man, and have no other use. For my part I cannot believe, that all the Things in the World were so made for Man, that they have no other use. <1691>For it is<1717>For it seems to me highly absurd and unreasonable, to think that Bodies of such vast Magnitude as the fix'd Stars were only made to twinkle to us; nay, a multitude of them there are, that do not so much as twinkle, being either by Reason of their Distance or of their Smalness, altogether Invisible to the naked Eye, and only discoverable by a Telescope; and it is likely, perfecter Telescopes than we yet have, may bring to light many more; and who knows, how many lie out of the Ken of the best Telescope that can possibly be made?

And I believe there are many Species in Nature, even in this sublunary World, which were never yet taken Notice of by Man, and consequently of no Use to him, which yet we are not to think were created in vain; but may be found out by, and of Use to those who shall live after us in future Ages. But though in this Sense it be not true, that all Things were made for Man; yet thus far it is, that all the Creatures in the World may be some way or other Useful to us, at least to exercise our Wits and

Understandings, in considering and contemplating of them, and So afford us Subject of admiring and glorifying their and our Maker.

Seeing then, we do believe, and assert, that all Things were in some Sence made for us, we are thereby oblig'd to make Use of them for those Purposes for which they serve us, else we frustrate this End of their Creation. Now some of them serve only to exercise our Minds: Many others there be, which might probably serve us to good Purpose, whose Uses are not discovered, nor are they ever like to be, without Pains and Industry. True it is, many of the greatest Inventions <**130> have been accidentally stumbled upon, but not by Men, Supine and Careless, but busie and inquisitive. Some Reproach methinks it is to Learned Men, that there should be so many Animals in the World, whose outward shape is not yet taken Notice of; or describ'd, much less their Way of Generation, Food, Manners, Uses, observed.

<1717>The Scripture, Psalm 148 calls upon "The Sun, Moon, and Stars; Fire and Hail, Snow and Vapour; stormy Winds and Tempests, Mountains and all Hills; fruitful Trees, and all Cedars; Beasts and all Cattle; creeping Things and flying Fowl, etc. to praise the Lord. How can that be? Can senseless and inanimate Things praise God? Such as are the Sun, and Moon, and Stars. And although Beasts be advanced higher to some Degree of Sense and Perception; yet being void of Reason and Understanding, they know nothing of the Causes of Things, or of the Author and Maker of themselves, and other Creatures. All that they are capable of doing, in reference to the praising of God, is (as I said before) by affording Matter or Subject of praising him, to rational and intelligent Beings. So the Psalmist, Psalm 19.1. "The Heavens declare the Glory of God, and the Firmament sheweth his handywork. And therefore the Psalmist, when he calls upon Sun, and Moon, and Stars, to praise God, doth in effect call upon Men and Angels, and other rational Beings, to consider those great Effects of the Divine Power and Wisdom, their vast Dimensions, their regular Motions and Periods, their admirable Disposition and Order, their eminent Ends and Uses in illuminating and enlivening the Planets, and other Bodies about them, and their Inhabitants, by their comfortable and cherishing Light, Heat, and Influences, and to give God the Glory of his Power, in making such great and illustrious Bodies, and of his Wisdom and Goodness in so placing and disposing of them, so moving them regularly and constantly, without clashing or interfering one with another, and enduing them with such excellent Virtues and Properties as to render them so serviceable and beneficial to Man, and all other creatures about them.

The like may be said of Fire, Hail, Snow, and other Elements and Meteors, of Trees, and other Vegetables, of Beasts, Birds, Insects, and all Animals, when they are commanded to praise God, which they cannot do by themselves; Man is commanded to consider them partieularly, to Observe and take Notice of their curious Structure, Ends, and Uses, and give God the Praise of his Wisdom and other Attributes therein manifested. And therefore those who have Leisure, Opportunity, and Abilities, to contemplate and consider any of these Creatures, if they do it not, do as it were rob God of some part of his Glory, in neglecting or slighting so eminent a Subject of it, and wherein they might have discovered so much Art, Wisdom, and Contrivance.

And it is particularly remarkable, that the Divine Author of this Psalm, amongst other Creatures, calls upon Insects also to praise God; which is as much as to say, ye Sons of Men, neglect none of his Works, those which seem most vile and contemptible; there is Praise belongs to him for them. Think not that any Thing he hath vouchsafed to create, is unworthy thy Cognizance, to be slighted by thee. It is Pride and Arrogance, or Ignorance and Folly in thee so to think. There is a greater depth of Art and Skill in the Structure of the meanest Insect, than thou art able for to fathom or comprehend.

<1691>If Man ought to reflect upon his Creator the Glory of all his Works, then ought he to take notice of them all, and not to think any thing unworthy of his Cognizance. And truly the Wisdom, Art...

The Wisdom Art, and Power of Almighty God, shines forth as visibly in the Structure of the Body of the minutest Insect, as in that of a Horse or Elephant: Therefore God is said to be, Maximus in minimis. We Men, esteem it a more difficult Matter, and of greater Art and Curiosity to frame a small Watch, than a large Clock: And no Man blames him who spent his whole time in the Consideration of the Nature and Works of a Bee, or thinks his Subject was too narrow. Let us not then esteem any thing contemptible or inconsiderable, or below our notice taking; for this is to derogate from the Wisdom and Art of the Creator, and to confess ourselves unworthy of those Endowments of Knowledge and Understanding which he hath bestowed on us. Do we praise Daedalus, and Architas, and Hero, and Callicrates, and Albertus Magnus, and many others which I might mention, for their Cunning in inventing, and Dexterity in framing and composing a few dead Engines or Movements, and shall we not admire and magnifie the Great DEmiargos Kosma Former of the World, who hath made so many, yea, I may say, innumerable, rare Pieces, and those too not dead ones, such as cease presently to move so soon as the Spring is down, but all living, and themselves performing their own Motions, and those so intricate and various, and requiring such a Multitude of Parts and subordinate Machines, that is is incomprehensible, what Art, and Skill, and Industry, must be employed in the framing of one of them?

<1717>I have already noted out of Dr. Hook, that to the performance of every Muscular Motion, at least in greater Animals, there are not fewer distinct Parts concerned, than many Millions of Millions. Further, from the Consideration of our own Smallness and Inconsiderableness, in respect of the Greatness and Splendor of those glorious heavenly Bodies, the Sun, Moon, and Stars, to which our Bodies bear no proportion at all, either in Magnitude or Lustre; let us with the holy Psalmist raise up our Hearts, to magnifie the Goodness of God towards us in taking such Notice of us, and making such Provision for us, and advancing us so highly above all his Works, Psalm 8.3. When I consider the Heavens, the Work of thy Fingers, the Moon and the Stars which thou hast ordained. What is Man that thou aret mindful of him, and the Son of Man that thou visitest him? For thou hast made him a little lower than the Angels, and hast crowned him with Glory and Honour, etc.

But it may be objected, that God Almighty was not so selfish and desirous of Glory, as to make the World and all the Creatures therein, only for his own honour, and to be praised by Man. To assert this, were, in Des Cartes's opinion, an absurd and childish Thing, and a resembling of God to a proud Man. It is more worthy the Deity, to attribute the Creation of the World, to the exundation and overflowing of his transcendent and infinite Goodness, which is of its own Nature, and in the very Notion of it, most free, diffusive, and communicative. To this I shall answer in two Words; First, The Testimony of Scripture makes God in all his Actions to intend and design his own Glory mainly, Prov. 16. 4. God made all things for himself . How, for himself? He hath no Need of them: he hath no Use of them. No, he made them for the Manifestation of his Power, Wisdom, and Goodness, and that he might receive from the Creatures that were able to take notice thereof, his Tribute of Praise, Psalm 50. 14. Offer unto God thanksgiving. And in the next verse, I will deliver thee, and thou shalt glorifie me. And again in the last Verse, Whoso offereth Praise, glorifieth me. So Praise is called a Sacrifice, and the Calves of the Lips, Hosea 14. 2. Esay 42. 8. I am the Lord, that is my Name, and my Glory will I not give to another. Efay 48. 11. And I will not give my Glory to another. The Scripture calls upon the heavens and Earth, and Sun and Moon, and Stars, and all other Creatures, to praise the Lord; that is, by the Mouth of Man, (as I Shewed before) who is hereby required to take notice of all these Creatures, and to admire and praise the Power, Wisdom and Goodness of God, manifested in the Creation and Designations of them.

Secondly, It is most reasonable that God Almighty should intend his own <**133> Glory: For he being infinite in all Excellencies and Perfections, and independent Upon any other Being; nothing can be said or thought of him too great, and which he may not justly challenge as is due; nay, he cannot think too highly of himself, his other Attributes being adequate to his Understanding; so that, though his Understanding be infinite, yet he understands no more than his Power can effect, because that is infinite also. And therefore it is fit and reasonable, that he should own and accept the Creatures Acknowledgments and Celebrations of those Virtues and Perfections, which he hath not received of any other, but possesseth eternally and originally of himself.

And indeed, (with Reverence be it spoken) what else can we imagine the ever Blessed Deity to delight and take Complacency in for ever; but his own infinite Excellencies and Perfections, and the Manifestations and Effects of them, the Works of the Creation, and the Sacrifices of Praise and Thanks offered up by such of his Creatures as are capable of considering those Works, and discerning the Traces and Footsteps of his Power and Wisdom appearing in the Formation of them; and moreover, whose bounden Duty it is so to do;

The Reason why Man ought not to admire himself, or seek his own Glory, is because he is a dependent Creature, and hath nothing but what he hath received, and not only dependent, but imperfect; yea, weak and impotent: And yet I do not take Humility in Man to consist in disowning or denying any Gift or Ability that is in him but in a just Valuation of such Gifts and Endowments, yet rather thinking too meanly than too highly of them; because Humane Nature is so apt to ers in running into the other Extreme, to flatter itself, and to accept those Praises that are not due to it; Pride being an Elation of Spirit upon false Grounds, or a desire and acceptance of undue honour. Otherwlse I do not see why a Man may not admit, and accept the testimonies of others, concerning any Perfection, Accomplishment, or Skill, that he is really posssessed of, yet can he not think himself to deserve any Praise or Honour for it, because both the Power and the Habit are the Gift of God: And considering that one Virtue is counter-balanced by many Vices, and one Skill or Perfection, with much Ignorance and Infirmity.

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The Second Part
The Wisdom of God manifested in the Works of the Creation.

I proceed now to select some particular Pieces of the Creation, and to consider them more distinctly.
They shall be only <**135> Two:

I. Whole Body of the Earth
II. Bodies of man. And other Animals.

First, The Body of the Earth, and therein I shall take Notice of, 1. Its Figure. 2. Its Motion. 3. The Constitution of its Parts. By Earth I here understand not the Dry Land, or the Earth contradistinguished to Water, or the Earth considered as an Element: But the whole Terraqueous Globe, composed of Earth and Water.

I. For the Figure, I could easily demonstrate it to be Spherical. That the Water, which by Reason of its fluidity should, one would think, compose it self to a Level, yet doth not so, but hath a Gibbose Superficies, may to the Eye be demonstrated upon the Sea. For when two Ships sailing contrary ways lose the sight one of another: first the Keel and Hull disappear; afterwards the Sails, and if when upon Deck you have perfectly lost sight of all, you get up to the Top of the Main-mast, you may descry it again. Now what should take away the sight of these Ships from each other but the gibbosity of the interjacent Water? The roundness of the Earth from North to South is demonstrated from the appearance of Northern Stars above the Horizon, and loss of the Southern to them that travel Northward and on the contrary, the loss of the Northern and <**136> appearance of the Southern to them that travel Southward. For were the Earth a Plain we should see exactly the same Stars where-ever we were placed on that Plain. The roundness from East to West is demonstrated from Eclipses of either of the great Luminaries. For why the same Eclipse, suppose of the Sun, which is seen to them that live more Easterly, when the Sun is elevated 6 Degrees above the Horizon, should be seen to them that live but one degree more Westerly, when the Sun is but five degrees above the Horizon, and so lower and lower proportionably to them that live more and more Westerly, ‘till at last it appear not at all, no Account can be given, but the globosity of the Earth. For were the Earth a perfect Plain, the Sun would appear Eclipsed to all that live upon that Plain, if not exactly in the same Elevation, yet pretty near it; but to be sure it would never appear to some, the Sun being elevated high above the Horizon; and not at all to others. It being clear then that the Figure of the Earth is Spherical, le us consider the Conveniencies of this Figure.

I. No Figure is so capacious as this, and consequently whose Parts are so well compacted and united, and lie so near one to another for mutual Strength. Now the Earth, which is the Basis of all Animals, and as some think of the whole Creation, ought to be firm, and stable, and solid, and as much as is possible secured from all Ruins and Concussions.

2. This Figure is most consonant and agreeable to the natural Nutus, or Tendency of all heavy Bodies. Now the Earth being such a one, and all its Parts having an equal propension, or connivency to the Center, they must needs be in greatest Rest, and most Immoveable when they are all equidistant from it. Whereas were it an Angular Body, all the Angles would be vast and steep Mountains, bearing a considerable Proportion to the whole bulk, and therefore those Parts being extremely more remote from the Center, than those about the Middle of the Plains, would consequently press very strongly thitherward; and unless the earth were made of Adamant or Marble, in Time the other parts would give way, ‘till all were levelled.

3. Were the Earth an Angular Body, and not round, all the whole Earth would be nothing else but vast Mountains, and so incommodious for Animals to live upon; for the middle Point of every Side would be nearer the Center than any other; and consequently from that Point which way soever one travelled would be up Hill, the <**138> Tendency of all heavy Bodies being perpendicularly to the Center. Besides, how much this would obstruct Commerce is easily seen: For not only the declivity of all Places would render them very difficult to be travelled over, but likewise the Middle of every Side being lower and nearer the Center, if there were any Rain, or any Rivers, must needs be filled with a Lake of Water, there

being no Way to discharge it, and possibly the Water would rise so high, as to overflow the whole Land. But, surely, there would be much more danger of the Inundation of whole Countries than now there is, all the Waters falling upon the Earth, by Reason of its declivity every Way, easily descending, down to the common Receptacle of the Sea. And these Lakes of Water being far distant one from another, there could be no Commerce between far remote Countries, but by Land.

4. A Spherical Figure is most commodious for dinetial Motion or Revolution upon its Axis; for in that, neither can the Medium at all resist the motion of the Body, because it stands not in its way, no part coming into any Space but what the precedent left, neither doth one part of the Superficies move faster than another: Whereas were it Angular, the parts about the Angles would find strong resistance from the <**139> Air, and those parts also about the Angles would move much faster than those about the middle of the Plains, being remoter from the Center than they. It remains therefore that this Figure is the most commodious for Motion.

Here I cannot but take notice of the folly and stupidity of the Epicureans, who fansied the Earth to be flat and contiguous to the Heavens on all sides, and that it descended a great way with long Roots; and that the Sun was new made every Morning, and not much bigger than it seems to the Eye, and of a flat Figure, and many other such gross Absurdities as Children among us would be ashamed of.

Secondly, I come now to speak of the Motion of the Earth. That the Earth (speaking according to Philosophical Accurateness) doth move both upon its own Poles, and in the Ecliptick, is now the received Opinion of the most learned and skilful Mathematicians. To prove the diurnal Motion of it upon its Poles, I need produce no other Argument than, First, The vast disproportion in respect of Magnitude that is between the Earth and the Heavens, and the great unlikelihood, that such an infinite number of vast Bodies should move about so inconsiderable a spot as the Earth, which in comparison with them by <**140> the concurrent Suffrages of Mathematicians of both perswasions, is a mere point, that is, next to nothing.

Secondly, The immense and incredible Celerity of the Motion of the Heavenly Bodies in the Ancient Hypothesis.

Thirdly, Of its Annual Motion in the Ecliptick, the Stations and Retrogradations of the superior Planets are a convincing Argument, there being a clear and facile Account thereof to be given from the mere Motion of the Earth in the Ecliptick; whereas in the Old Hypothesis no account can be given, but by the unreasonable Fiction of E:picycles and contrary Motions; add hereto the great unlikelihood of such an enormous Epicycle as Venus must describe about the Sun, not under the Sun, as the old Astronomers fansied. About the Sun, I say, as appears by its being hid or eclipsed by it, and by its several Phases, like the Moon. So that whosoever doth clearly understand both Hypotheses, cannot, I perswade myself, adhere to the Old and reject the New, without doing some violence to his Faculties.

Against this Opinion lie two Objections, First, That it is contrary to Sense, and the common Opinion and Belief of Mankind. Secondly, that it seemeth contrary to some Expressions in Scripture. To the first I answer that our Senses are sometimes mistaken, and what appears to them is not <**141> always in reality so as it appears. For Example: The Sun or Moon appear no bigger, at most, than a Cart-wheel, and of a flat Figure. The Earth seems to be plain: The Heavens to cover it like a Canopy, and to be contiguous to it round about: A Fire-brand nimbly moved round, appears like a Circle of Fire; and to give a parallel Instance, a Boat lying still at Anchor in a River, to him that Sails and Rows by it, seems to move apace; and when the Clouds pass nimbly under the Moon, the

Moon itself seems tc move the contrary way; And there have been whole Books written in Confutation of vulgar Errors.

Secondly, As to the Scripture, when hpeaking of these things, it accommodates itself to the common and received Opinions, and employs the usual Phrases and Forms of Speech (as all Wise Men also do, though in strictness they be of a different or contrary Opinion) without intention of delivering any thing Doctrinally concerning these Points, or confuting the contrary: And yet by those that maintain the Opinion of the Earth's motion there might a convenient Interpretation be given of such Places as seem to contradict it. Howbeit, because some pious Persons may be offended at such an Opinion, as favouring of Novelty, thinking it inconsistent <**142> with Divine Revelation, I shall not positively assert it, only propose it as an Hypothesis not altogether improbable. Supposing then, that the Earth doth move, both upon its own Poles, and in the Ecliptick about the Sun, I shall shew how admirably its Station and Motion are contrived for the conveniency of Man and other Animals: Which I cannot do more fully and clearly than Dr. More hath already done in his Antidote against Atheism, whose Words therefore I shall borrow.

First, Speaking of the Parallelism of the Axis of the Earth, he saith, I demand whether it be better to have the Axis of the Earth steady and perpetually parallel to itself, or to have it carelessy tumble this way and that way as it happens, or at least very variously and intricately? And you cannot but Answer me, it is better to have it steady and parallel. For in this lies the necessary Foundation of the Art of Navigation and Dialling. For that steady Stream of Particles, which is supposed to keep the Axis of the Earth parallel to itself, affords the Mariner both his Cynosura and his Compass. The Load-stone and the Load-star depend both upon this. The Load-stone, as I could demonstrate, were it not too great a digression; and the Load-star, because that which keeps the Axis parallel to itself, makes each of the Poles constantly respect such a Point in the Heavens as for Example, the North-Pole to point almost directly to that which we call the Pole-Star. And besides, Dialling could not be at all without this steadiness of the Axis. But both thes Arts are pleasant, and one especially of mighty Importance to Mankind. For thus there is an orderly measuring of our time for Affairs at home, and an opportunity of Traffick abroad with the most remote Nations of the World and so there is a mutual Supply of the several Commodities of all Countries, Besides the enlarging our Understandings by so ample Experience we get both of Men and Things. Wherefore if we were rationally to consult, whether the Axis of the Earth were better be held steady, and parallel to itself; or left at random, we would conclude it ought to be steady, and so we find it de Facto, though the Earth move floating in the liquid Heavens. So that appealing to our own Faculties we are to affirm, that the constant Direction of the Axis of the Earth was Estabiiahed by a Principle of Wisdom and Counsel.

Again, there being several Postures of the steady Direction of the Axis of the Earth, viz. either perpendicular to a Plain, going through the Center of the Sun, or <**144> co-incident or inclining, I demand which of all these Reason and Knowledge would make choice of. Not of a perpendicular Posture; for so both the pleasant Variety, and great Convenience of Summer and Winter; Spring and Autumn, would be lost, and for want of Accession of the Sun, these Parts of the Earth, which now bring forth Fruits, and are Habitable, would be in an incapacity of ever bringing forth any <1717>sith then, the heat could never be greater than now it is at our 10th of March, or the 11th of September, and therefore not sufficient to bring their Fruits and Grain to Maturity,</1717> and consequently could entertain no Inhabitants, and those Parts that the full heat of the Sun could reach, he plying them always alike without any annual Recession or Intermission, would at last grow tired or exhausted, or be wholly dried up, and want moisture, the Sun dissipating and casting off the Clouds Northwards and Southwalds. Besides, we observe that an orderly Vicissitude of Things, doth much more gratifie the Contemplative Property in Man.

And now in the second Place neither would Reason make choice of a co-incident position. For if the Axis thus lay in a Plain that goeth through the Center of the Sun, the Ecliptick would like a Colure or one of the Meridians, pass through the Poles of the Earth, which would put the Inhabitants of the World into a pitiful condition. For they that escape best in the Temperate Zone, would be accloyed with long Nights very tedious, no less than forty Days, and those that now never have their Night above twenty-four Hours, as Friesland Island, the further Parts of Russia and Norway, would be deprived of the Sun, above a Hundred and Thirty Days together. Ourselves in England, and the rest of the same Clime, would be closed up in Darkness no less than a Hundred or Eighty Days; and so proportionably of the Rest, both in and out of the Temperate Zones. And as for Sumnaer and Winter; though those Vicissitudes would be, yet it could not but Cause raging Diseases, to have the Sun stay so long, describing his little Circles so near the Poles, and lying so hot on the inhabitants, that had been in so long extremity of Darkness and Cold before.

It remains therefore, that the posture of the Axis of the Earth be inclining not perpendicular, not co-incident to the fore-mention'd Plain. And verily, it is not only inclining, but in so fit a Proportion, that there can be no fitter imagined to make it to the utmost Capacity, as well pleasant as habitable. For though the Course of the Sun be curbed between the Tropicks, yet are not those Parts directly subject to his perpendicular Beams, either Unhabitable, or extremely <**146> Hot, as the Ancients fansied: By the Testimony of Travellers, and particularly Sir Waltcr Raleigh, the parts under and near the Line, being as fruitful and pleasant, and fit to make a Paradise of, as any in the World. And that they are as suitable to the Nature of Man, and as convenient to live in, appear from the Longevity of the Natives; as for Instance, the Ethiopes, called by the Ancients <greek>Machrobioi</greek>; but especially in the Brazilians in America, the ordinary Term of whose Life is a Hundred Years, as is set down by Piso, a Learned Physician of Holland, who travelled thither on purpose to augmcnt Natural Knowledge, but especially what related to Physick. And rcafonable it is, that this should be so, for neither doth the Sun lie long upon them, their day being but twelve Hours, and their Night as long, to cool and refresh them, and besides they have frequent Showers, and constant Breezes, or fresh Gales of Wind from the East.

<1717>It was the Opinion of Asclepiades, as Plutarch reports, that generally the Inhabitants of Cold Countries are longer live'd than those of Hot because the cold keeps in the natural heat, as it were locking up the Pores to prevent its Evaporation; whereas in hot Regions the heat is easily dissipated, the Pores being large and open to give it way. Which opinion, because I fnd some Learned Men still to adhere to, I shall produce some further Instances out of Monsieur Rochefort's History of the Antilles Islands, to confirm the contrary, and to shew how often and easily we may be deceiv'd, if we trust to our own Ratiocinations, how plausible soever, and consult not Experience.

The ordinary Life (saith he) of our Caribbeans is an hundred and fifty years long, and sometimes more. There were some among them not long since living;, who remembred to havc seen the first Spaniards, that aborded A1nerica, who, we may thence conclude, lived to be at least 160 years old.

The Hollanders who traffick in the Molucca Islands, assure us, that the ordinary term of Life of the Natives there is one hundred and thirty years.

Vincent le Blanc tells us, that in Sumatra, Java, and the neighbouring Islands, the life of the Inhabitants is extended to 140 Years, and that in the Realm of Cassuby it reaches 150. Francis Pirara promotes the life of the Brazilians beyond the Term we have set it, v.g. to 160 years or more, and says that in Florida and Jucatan there are Men found, who pass that age. And it is said, that the French in Laudoniers Voyage into Florida, Anno. 1564. saw a certain old Man, who affirmed himself to be three hundred years old, and the Father of five Generations; "And well he might be of double that number".

Lastly, Mapheous reports, that a certain Bengalese vaunted himself to be 335 years old. So far Monsieur Rochefort. Indeed these two last Instances, being perchance singular and extra-ordinary, do not prove the point; for even among us, where the ordinary term of Life is about threescore and ten, or fourscore, there occur some rare instances of Persons, who have lived 130, 140, 150 Years and more. But the other Testimonies being general, prove it beyond contradiction; neither yet is the thing in itself improbable; for there being not so great inequality of Weather in those hot Countries, as there is in cold, the Body is kept in a more equal Temper, and not having such frequent Shocks, as are occasion'd by such Air, and often changes, and that from one cxtreme to another, holds out much longer. So we see infirm and crazy Persons, when they come to be so weak as to be fixed to their Beds, hold out many Years, some I have heard of, that have laid bed-rid 20 years: because in the Bed they are always kept in an almost equal Temper of Heat, who, had they been exposed to the excesses of Heat and Cold, would not probably have survived one.</1717>

Seeing then, this best posture which our Reason could make choice of; we see really established in Nature, we cannot but acknowledge it to be the issue of Wisdom, Counsel, and Providence. Moreover, a further Argument to evince this is, That though it cannot but be acknowledged, that if the Axis <**147> of the Earth were perpendicular to the Plane of the Ecliptick, her motion would be more easie and natural, yet notwithstanding for the Conveniences fore-mentioned, we see it is made in an inclining posture.

<1717>Another very considerable, and heretofore unobserv'd Convenience of this inclination of the Earth's Axis, Mr. Kiel affords us in his Examination of Dr. Burnet's <title>Theory of the Earth</title>, p. 69. There is (saith he) one more [besides what he had mentioned before] considerable advantage, which we reap by the present position of the Earth, which I will here insert, because I do not know that it is taken notice of by any. And it is, that by the present inclination of the Earth's Axis to the Plane of the Ecliptick, we who live beyond 45 degrees of Latitude, and stand most in need of it, have more of the Sun's heat throughout the year, than if he had shined always in the Equator, that is, if we take the sum of the Sun's actions upon us both in Summer and Winter, they are greater than its Heat would be if he moved always in the Equator or, which is the same thing, the aggregate of the Sun's heat upon us while he describes any two opposite Parallels, is greater than it would be if in those two Days he described the Equator. Whereas in the Torrid Zone, and even in the Temperate almost as far as 45 degrees of Latitude, the sum of the Sun's heat in Summer and Winter is less than it would be, were the Axis of the Earth perpendicular to the Plane of the Ecliptick. For the Demonstration of which, I refer the Reader to the Book itself.

I think (proceeds he) this Consideration can not but lead us into a transcendent admiration of the Divine Wisdom, which hath placed the Earth in such a posture as brings with it several Conveniencies beyond what we can easily discover without Study and Application: And I make no question, but if the rest of the Works of Nature were well observed, we should find several advantages which accrue to us by their present Constitution, which are far beyond the uses of them that are yet discovered; by which it will plainly appear, that God hath chosen better for us than we could have done for ourselves.</1717>

If any Man should object and say, it would be more convenient for the Inhabitants of the Earth, if the Tropicks stood at a greater Distance, and the Sun moved further Northward and Southward, for so the North and South Parts would be relieved, and not exposed to so extreme Cold, and thereby rendred uninhabitable as now they are.

To this I Answer, That this would be more inconvenient to the Inhabitants of the Earth in general, and yet would afford the North and South Parts but little more comfort; for then as much as the

Distances between the Tropicks were enlarg'd, so much would also the Arctick and Antartick Circles be enlarg'd too; and so we here in England, and so on Northerly, should not have that grateful and useful Succession of Day and Night, but proportionally to the Sun's coming towards us, so would our Days be of more than Twenty-four hours length, and according to his recess in Winter our Nights proportionable, which how great an inconvenience it would be, is easily seen. <**148>Whereas now the whole Latitude of the Earth, which hath at any time above Twenty-four hours Day, and Twenty-four hours Night, is little and inconsiderable in comparison of the whole Bulk, as lying near the Poles. And yet neither is that Part altogether unuseful, for in the Waters there live Fishes, which otherwhere are not obvious, so we know the chief Whale-fishing is in Greenland:

<1717>Yea, not only Fish, but great varieties of Water-Fowl, both whole and cloven-footed, frequent the Waters, and feed there, breeding also on the Cliffs by the Sea-side, as they do with us: The Figures and Descriptions of a great many whereof are given us by Martin in his Voyage to Spitzberg, or Greenland.</1717>

And on the Land, Bears, and Foxes, and Deer, in that most Northerly Country that was ever yet touched, and doubtless, if we shall discover further to the very North-Pole, we shall find all that Tract not to be vain, useless, or unoccupied.

Thirdly, The third and last Thing I proposed was the Constitution and Consistency of the Parts of the Earth. And first, Admirable it is that the Waters should be gathered together into such great Conceptacula, and the dry Land appears, and though we had not been assured thereof by divine Revelation, we could not in Reason but have thought such a Division and Separation, to have been the Work of Omnipotencey and infinite Wisdom and Goodness; for in this condition the Water nourishes and maintains innumerable Multitudes of various kinds of Fishes; and the dry Land supports and feeds as great variety of Plants and Animals, which have their firm Footing and Habitation: Whereas had all been Earth, all the Species of Fishes had been lost, and all those Commodities which the Water affords us; or all Water, there had been no living for Plants, or Terrestrial Animals, or Man himself; and all the Beauty, Glory, and Variety of this Inferior World had been gone, nothing being to be seen, but one uniform dark Body of Water: Or had all been mixt and made up of Water and Earth into one Body of Mud or Mire, as one would think should be most natural: For why such a Separation, as at present we find, should be made, no account can be given, but Providence. I say, had all this Globe been Mire or Mud, then could there have been no possibility for any Animals at all to have lived, excepting some few, and those very dull and inferior ones too. That therefore the Earth should be made thus, and not only so, but with so great variety of Parts, as Mountains, Plains, Vallies, Sand, Gravel, Limes Stone, Clay, Marble, Argilla, etc. which are so delectable and pleasant, and likewise so useful and convenient for the breedig, and living of various Plants and Animals; some affecting Mountains, some Plains, some Valleys, some Watery Places, some Shade, some Sun, some Clay, some Sand, some Gravel, etc. That the Earth should be so figured as to have Mountains in the Midland Parts; abounding with Springs of Water, pouring down Streams and Rivers for the Necessities and Conveniencies of the Inhabitants of the lower Countries and that the Levels and Plains should be formed with so easie a declivity as to cast off the Water and yet not render Travelling, or Tillage very difficult or laborious. These things, I say, must needs be the result of Counsel, Wisdom and Design. Especially when (as I said before) not that way which seems more ficile and obvious to Chance is chosen, but that which is more difficult and hard to be traced, when it is most convenient and proper for those nobler Ends and Designs, which were intended by its Wise Creator and Governor.

Add to all this, that the whole dry Land is, for the most part, covered over with a lovely Carpet of Green Grass, and other Herbs, of a colour not only most grateful and agreeable, but most useful and salutary to the Eye; and this also decked and adorned with great variety of Flowers of beautiful

Colours and Figures, and of most pleasant and fragrant Odours for the refreshment of our Spirits, and our innocent Delight.

<1717>As also with beautiful Shrubs, and stately Trees, affording us not only pleasant and nourishing, Fruits, many Liquors, Drugs, and good Medicines, but Timber and Utensils for all sorts of Trades, and the Conveniencies of Man. Out of many Thousands of which we will only just name a few, lest we should be tedious and too bulky. First, The Coco, or Coker-Nut-Tree, that supplies the Indians with almost whatever they stand in need of; as Bread, Water, Wine, Vinegar, Brandy, Milk, Oyl, Honey, Sugar, Needles, Thread, Linen, Cloaths, Cups, Spoons, Beesoms, Baskets, Paper, Masts for Ships, Sails, Cordage, Nails, Coverings for their Houses, etc. Which may be seen at large in the many printed Relations of Voyages and Travels to the East Indies, but most faithfully in the <title>Hortus Malabaricus, published by that immortal Patron of Natural Learning, Henry Van Rheede van Draakenstein, who has had great Commands and Employs in the Dutch Colonies.

Secondly, The Aloe Muricata vel Aculeata, which yields the Americans every thing their Necessities require, as Fences and Houses, Darts, Weapons, and other Arms, Shoes, Linen, and Clothes, Needles and Thread, Wine and Honey, besides many Utensils, for all which Hernandes, Garcililasso de la Vega, and Margrave, may be consulted.

Thirdly, The Bandura Cingalensium, called by some the Priapus Vegetabilis, at the end of whose leaves hang long Sacks or Bags, containing a pure limpid Water of great use to the Natives, when they want Rain for eight or ten Months together.

A parallel Instance to this of the Bandura, my Learned and Worthy Friend Dr. Sloane affords us in a Plant by him observed in the Island of Jamaica, and described by the Title of Viscum Caryophilloides Maximum flore tripetalo pallide luteo, semine filamentoso, which is commonly called, in that Island, Wild Pine, Philosoph.Transact. N. 251. Pag. 114. I shall not transcribe the whote Description, but only that Part of it which relates to this Particular:

"From the Root (which he had described before) arise Leaves on every side, after the manner of Leeks, or Anana's, whence the Name of Wild-Pine, or Aloes, being folded or enclosed one within another, each of which a is two Foot and an half long, and from a three Inch breadth at Beginning, or base Ends in a Point, having a very hollow, or concave, inward Side, and a round, or convex, outward one: So that by all their hollow Sides is made within a very large Preservatory, Cistern or Basin, fit to contain a pretty Quantity of Water, which in the rainy Season falls upon the utmost Parts of the spreading Leaves, which have Channels in them, conveying it down to the Cistern where it is a kept, as in a Bottle, the Leaves after they are swelled out like a bulbous Root to make the Bottle; bending inward or coming again close to the Stalk, by that means hindring the Evaporation of the Water, by the Heat of the Sun-Beams.

"In the mountainous, as well as the dry low Woods, in Scarcity of Water, this Reservatory " is not only necessary and sufficient for the Nourishment of the Plant itself, but likewise is very useful to Men, Birds, and all Sorts of Insects, whether in Scarcity of Water they come in Troops, and seldom go away without Refreshment.

"Captain Dampier in his Voyages, Vol. II. of Campeche (tell us) that these Basins made of the Leaves of the Wild Pine, will hold a Pint and half, or a Quart of Water, and that when they find these Pines, they stick their Knives into the Leaves just above the Roots, and that lets out the Water, which they catch in their Hats, as, saith he, I have done many times to my great Relief.

Fourthly, The Cinnamon-Tree of Ceylon, in whose Parts there is a wonderful Diversity: Out of the Root they get a Sort of Camphire, and its Oyl; out of the Bark of the Trunk, the true Oyl of

Cinnamon; from the Leaves, an Oyl like that of Cloves; out of the Fruit a Juniper Oyl, with a Mixture of those of Cinnamon and Cloves; besides, they boil the Berries into a Sort of Wax, out of which they make Candles, Plaisters, Unguents. Here we may take Notice of the Candle-Trees of the West Indies, out of whose Fruit, boil'd to a thick fat Consistence, are made very good Candles, many of which have been lately distributed by that most ingenious Merchant, Mr. Charles Dubois. Fifthly, The Fountain, or Dropping-Trees, in the Isles of Ferro, St. Thomas, and in Guiny, which serve the Inhabitants instead of Rain and fresh Springs: My honoured Friend Dr Tancred Robinson, in a late Letter to me, is not of Vossius's Opinion, that these Trees are of the Ferulaceous Kind, because he observes, that by the Descriptions of Eye-witnesses, and by the dry'd Sample, lent by Paludanus, to the Duke of Wirtenberg, the Leaves are quite different From those of the Ferula's, coming nearer to the Seseli Ethiopicum Salicis vel Periclymeni folio: Therefore the Doctor rather thinks them to be of the Laurel-kind, though he concludes here may be many different Sorts of these running Aqueous-Trees; because that Phaenomenon does not depend upon, or proceed from any Peculiarity of the Plant, but rather from the Place and Situation; of which he writes more at large, in a Letter printed in another Ditcourse of mine.

Sixthly, and Lastly, We will only mention the Names of some other Vegetables, which, with Eighteen of Twenty Thousand more of that Kind, do manifest to Mankind the illustrious Bounty and Providence of the Aimighty and Omniscient Creator, towards his undeserving Creatures; as the Cotton-Trees; the Manyoc, or Cassava; the Potatoe; the Jesuit's Bark-Tree; the Poppy; the Rhubarb; the Scammony; the Jalap; the Coloquintida; the China Sarfa; the Serpenatria Virginiana, or Snake-weed; the Nisi, or Genseg; the Numerose Balsam, and Gum-trees, many of which are of late muct illustrated by the great Industry and Skill of that most discerning Botanist, Dr. Leonard Plukenet.

Of what great Use all these, and innumerable other Plants, are to Mankind in the several Parts of Life, few or none can be ignorant; besides the known Uses in Curing Diseases, in Feeding and Cloathing the Poor, in Building, in Dying; in all Mechanicks there may be as many more not yet discoverd, and which may be reserv'd on purpose to exercise the Faculties bestow'd on Man, to find out what is necessary, convenient, pleasant, or profitable to him.

To sum up all in brief: This Terraqueous Globe we know is made up of two Parts,

1. A thin and fluid.

2. A firm and consistent.

The former called by the Name of Watcr; the latter, of Earth, or dry Land. The Land being the more dense and heavy Body, doth naturally descend beneath the Water, and occupy the lower Place; the Water ascends and floats above it. But we see that it is not thus: For the Land, though the more heavy, is forcibly and contrary to its Nature so elevated as to cast of the Water, and stand above it, being (as the Psalmist phrases it) Founded upon, or above the Seas, and established above the Floods, Psalm. 24. 2. And this in such manner, that not only on one side of the Globe, but on all sides, there were probably continents; and Islands raised so equally as to counterbalance one another, the Water flowing between them, and filling the hollow and depressed Places. Neither was the dry Land only raised up, and made to appear, but some Parts (which we call Mountains) were highly elevated above others; and those so dispersed and situated (as we have shewn) in the mid-land Parts, and in continued Cbains running East and West, as to render all the Earth habitable) a great Part whereof otherwise would not have been so: but the Torrid Zone must indeed have been such a Place as the Ancients fansied it, unhabitable for Heat. Let us now consider how much better it is, that the dry Land should be thus raised up, and the Globe divided almost equally between Earth and Water, than that all its Surface should be one uniform and dark Body of Water. I say

Water, because that naturally occupies the superior Place, and not Earth; for were it all Water; the whole Beauty on this inferior world were gone: There could be no such pleasant and delicious Prospects as the Earth now affords us; no Distinction and grateful Variety of Mountains and Hills, Plains and Valleys, Rivers and Pools, and Fountains; no shady Woods stored with lofty and towering Trees for Timber; lowly, and more spread ones, for Shade and Fruit: No amicable Verdure of Herbs, bespangled with an infinite variety of specious and fragrant Flowers: For those Plants that grow at the Bottom of the Sea, are for the most part of a dull, sullen and dirty Olive Colour, and bear no Flowers at all. Instead of the elegant Shapes and Colours, the Sagacity and Docility of ingenious Beasts and Birds, the musical Voices and Accents of the Aereal Choristers, there had been nothing but mute and stupid and indocile Fishes, which seem to want the very Sense of Discipline, as may be gathered from them that they are not Vocal, and that there appear in them no Organs of Hearing: It being also doubtful whether the Element they live in be capable of transmitting Sounds, the best Sense they have, even their Sight, can be but dull and imperfect; the Element of Water being Semiopake, and reflecting a good Part of the Beams of Light. The most noble and ingenious Creatures that live there, the Cetaceous Kind, being near akin to Terrestrial Animals, and breathing in the samme Element, the open Air.

Had, I say, all been Water, there had been no Place for such a Creature as Man; as we see there is no such there: There is no Business for him, no Subject to employ his Art and Faculties, and consequently there could be no Effects of them; no such things as Houses and Cities, and stately Edifices, as Gardens and Orchards, and Walls, Walks and Labyrinths, as Corn-fields, and Vineyards, and the rest of these Ornaments, wherewith the Wit and Industry of Man hath embellished the World.

These are great Things, and worthy the Care and Providence of the Creator; which whoso considereth, and doth not discern and acknowledge, must needs be as stupid as the Earth he goes upon.

But because Mountains have heen look'd upon by some as Warts, and superfluous Excrescencies, of no Use or Benefit; nay, rather as Signs and Proofs, that the present Earth is nothing else but a heap of Rubbish and Ruins, I shall reduce and demonstrate in Particulars, the great Use, Benefit, and Necessity of them.

I. They are of eminent Use for the Production and Original of Springs and Rivers. Without Hills and Mountains there could be no such Things, or at least but very few: No more than we now find in plain and level Countries; that is, so few, that it was never my Hap to see one. In Winter time indeed, we might have Torrents and Land-floods, and perhaps sometimes great Inundations, but in Summer nothing but stagnating Water, reserved in Pools and Cisterns, or drawn up out of deep Wells. But as for a great Part of the Earth (all lying within, or near the Tropicks) it would neither have Rivers, nor any Rain at all: We should consequently lose all those Conveniencies and Advantages that Rivers afford us, of Fishing, Navigation, Carriage, Driving of Mills, Engines, and many others. This end of Mountains I find assigned by Mr. Edmund Halley, a Man of great Sagacity and deep Insight into the Natures and Causes of Things, in a Discourse of his Published in the Philosoph. Transactions, Numb. 192. in these Words: This, if we may allow final Causes, fier [Hardiment, the Thing is clear, pronounce boldly without any Ifs or Ands] This seems to be one Design of the Hill, that their Ridges being placed through the midst of their Continents, might serve as it were Alembicks, to distil Fresh Water for the Use of Man and Beast; and their Heights to give a descent to those Streams, to run gently, like so many Veins of the Microcosm, to be the more beneficial to the Creation.

II. They are of great Use for the Generation, and convenient digging up of Metals and Minerals; which how necessary Instruments they are of Culture and Civility I have before shewn. These we

see are all digged out of Mountains and I doubt whether there is, or can be any Generation of them, in perfectly plain and level Countries: But if there be, yet could not such Mines, without great Pains and Charges, if at all, be wrought; the Delfs would be so flown with Waters (it being impossible to make any Addits or Soughs to drain them) that no Gins or Machines could suffice to lay and keep them dry.

III. They are useful to Mankind in affording them convenient Places for Habitation and Situations of Houses and Villages, serving as Skreens to keep of the cold and nipping Blasts of the Northern and Easterly Winds, and reflecting the benign and cherishing Sun-beams, and so rendering their Habitations both more comfortable and more chearly in Winter; and promoting the Growth of Herbs and Fruit trees, and the Maturation of their Fruits in Summer. Besides casting off the Waters, they lay the Gardens, Yards, and Avenues to the houses dry and clean; and so as well more Salutary, as more Elegant. Whereas Houses built in Plains, unless shaded with Trees, lie bleak and exposed to Wind and Weather, and all Winter are apt to be grievously annoyed with Mire and Dirt.

IV. They are very Ornamental to the Earth, affording pleasant and delightfiul Prospects, both, I. To them that look downwards from them, upon the subjacent Countries; as they must needs acknowledge, who have been but on the Downs of Sussex, and enjoyed that ravishing Prospect of the Sea on one Hand, and the Country far and wide on the other. And, 2. To those that look upwards and behold them from the Plains, and low Grounds; which what a Refreshing and Pleasure it is to the Eye, they are best able to judge who have lived in the Isle of Ely, or other level Countries, extending on all Sides further than one can ken; or have been out far at Sea, where they can see nothing but Sky and Water. That the Mountains are pleasant Objects to behold, appears, in that the very Images of them, their Draughts and Landskips, are so much esteemed.

V. They serve for the Production of great Variety of Herbs and Trees; for it is a true Observation, That Mountains do especially abound with different Species of Vegetables because of the great Diversity of Soils that are found there, every Vertex, or Eminency, almost affording new Kinds. Now these Plants serve partly for the Food and Sustenance of such Animals as are proper to the Mountains, partly for Medicinal Uses; the chief Physick herbs and Roots, and the best in their Kinds growing there: It being remarkable, That the greatest and most luxuriant Species in most Genera of Plants are Native of the Mountains: Partly also for the Exercise and Diversion of such ingenious and industrious Persons, as are delighted in searching out these natural Rarities; and observing the outward Form, Growth, Natures, and Uses, of each Species, and reflecting upon the Creator of them his due Praises and Benedictions. VI. They serve for the Harbour, Entertainment, and Maintenance of various Animals, Birds, Beasts, and Insects, that breed, feed and frequent there; for the highest Tops and Pikes of the Alps themselves, are not destitute of their Inhabitants, the Ibex, or Stein-buck, the Rupicapra, or Chamois, among Quadrupeds; the Lagopus among Birds; and I myself have observed beautiful Papilio's, and store of other Insects, upon the Tops of some of the Alpine Motmtains. Nay, the highest Ridges of many of those Mountains, serve for the Maintenance of Cattle for the Service of the Inhabitants of the Vallies: The Men there leaving their Wives, and younger Children. below, do not, without some Difficulty, clamber up the Acclivities, dragging their Kine with them, where they feed them, and milk them, and make Butter and Cheese, and do all the Daiery-work, in such sorry Hovels and Sheds as they build there to inhabit in during the Summer Months: This I myself have seen and observed in Mount Jura, not far from Geneva, which is high enough to retain Snow all the Winter.

The same they do also in the Grisons Country, which is one of the highest Parts of the Alps, travelling through which I did not set Foot off Snow for four Days Joulney, at the latter End of March. VII. Those long Ridges and Chains of lofty and topping Mountains, which run through the whole Continents East and West, (as I have elsewhere observed) Serve to stop the Evagation of the

Vapours to the North and South in hot Countries, condensing them like Alembick Heads into Water, and so by a kind of external Distillation giving Original to Springs and Rivers; and likewise by amassing, cooling, and constipating of them, turn them into Rain; by those Means rendring the fervid Regions of the Torrid Zone habitable.

This Discourse concerning the Use of Mountains, I have made use of in another Treatise <margin>The Dissolution of the World</margin>; but because it is proper to this Place, I have, with some Alterations and Enlargements, here repeated it.

I had almost forgotten that Use they are of to Mankind, in serving for Boundaries and Defences to the Territories of Kingdoms and Common-wealths.</1717>

A second Particular I have made choice of more exactly to survey and consider, is the Body of Man: Wherein I shall endeavour to discover something of the Wisdom and Goodness of God; First, by making some general Observations concerning the Body. Secondly, by running over and discoursing upon its principal Parts and Members. I. Then in general, I say, the Wisdom and Goodness of God appears in the erect Posture of the Body of Man, which is a Privilege and Advantage given to Man, above other Animals. But though this be so, yet I would not have you think, that all the Particulars I shall mention are proper only to the Body of Man, divers of them agreeing to many of the Creatures. It is not rny Business to consider only the Prerogatives of Man above other Animals, but the Endowments and Perfection which Nature hath conferred on his Body though common to them with him. Of this Erection of the Body of Man, the Ancients have taken Notice as a particular Gift and Favour of God.

<latin>Pronaq; cum spectent Animalia caetera terram, Os homini sublime dedit, coelumq; tueri Jussit, et erectos ad Sydera tollere vultus.</latin> Ovid. Metamorphoses.I.

<**152>And before him, Tully in his second Book, De Nat. Deorum.

<latin>Ad hanc providentiam naturae tam diligentem tamq; solertem adjungi multa possunt, <&egrave> quibus intelligatur quantae res hominibus <&agrave> Deo, quamq; eximiae tributae sunt, qui primum eos humo excitatos, celsos et erectos constituit, ut Deorum cognitionem caelum intuentes capere possent. Sunt enim <&egrave> terra homines, non ut incolae atq; habitatores, sed quasi spectatores superarum rerum atq; coelestium, quarum spectaculum ad nullum aliud genus animantium pertinet.</latin>

Man being the only Creature in this sublunary World, made to contemplate Heaven, it was convenient that he should have such a Figure or situs of the Parts of his Body, that he might conveniently look upwards. But to say the Truth in this respect of contemplating the Heavens, or looking upwards, I do not see what Advantage a Man hath by this Ereetion above other Animals, the Faces of most of them being more supine than ours, which are only Perpendicular to the Horizon, whereas some of theirs stand reclining. But yet two or three other Advantages we have of this Erection, which I shall here mention.

<**153> First, it is more Commodious for the sustaining of the Head, which being full of Brains, and very heavy (the Brain in Man being far larger in Proportion to the Bulk of his Body, than in any other Animal) would have been very painful and wearisome to carry, if the Neck had lain parallel or inclining to the Horizon.

Secondly, This Figure is most convenient for Prospect, and looking about one. A Man may see further before him, which is no small Advantage for avoiding Danger, and discovering whatever hc searches after. Thirdly, The Conveniency of this Site of our Bodies will more clearly appear, if we

consider what a pitiful Condition we had been in if we had been constantly necessitated to stand and walk upon all Four; Man being by the Make of his Body, of all Quadrupeds (for now I must compare him with them) the most unfit for that kind of incessus, as I shall shew anon. And besides that, we should have wanted, at least in a great Measure, the Use of out Hand, that unvaluable Instrument, without which we had wanted most of those Advantages we enjoy as reasonable Creatures, as I shall more particularly demonstrate afterwards.

But it may be perchance objected by some, that Nature did not intend this Erection of the Body, but that it is superinduced and artificial; <**154> for that Children at first creep on all Four, according to that of the Poet,

<latin>Mox Quadrupes, ritisque tulit sua membra serarum.</latin> Ovid.

To which I Answer, that there is so great an Inequality in the Length of our Legs and Arms, as would make it extremely inconvenient, if not impossible, for us to walk up on all Four, and set us almost upon our Heads; and therefore we see that Children do not creep upon their Hands and Feet, but upon their Hands and Knees; so that it is plain that Nature intended us to walk as we do, and not upon all Four.

2. I argue from the Situs, or Position of our Faces; for had we been to walk upon all Four, we had been the most prone of all Animals, our Faces being parallel to the Horizon, and looking directly downwards.

3. The Greatness and Strength of the Muscles of the Thighs and Legs above those of the Arms, is a clear Indication that they were by Nature intended for a more difficult and laborious Action, even the moving and transferring the whole Body, and that Motion to be sometimes continued for a great while together.

<**155>As for that Argument taken from the contrary Flexure of the Joints of our Arms and Leas to that of Quadrupeds, as that our Knees bend forward, whereas the same joint of their Hindlegs bends backward; and that our Arms bend backward, whereas the Knees of their Fore-legs bend forward. Although the Observation be as old as Aristotle, because I think there is a Mistake in it, in not comparing the same Joints (for the First or uppermost joint in a Quadruped's Hind-legs bends forward, as well as a Man's Knees, which Answer to it, being the uppermost Joint of our Legs; and the like mutatis mutandis may be said of the Arms) I shall not insist upon it. <1717>Another Particular which may serve to demonstrate that this erect Posture of the Body of Man was intended and designed by the Wise and Good Author of Nature, is the Fastning of the Cone of the Pericardium to the Midriff: An Account whereof I shall give the Reader out of the ingenious Dr. Tyson's Anatomy of the Orang-Outang, or Pygmie, p. 49.

Vesalius (saith he) and others make it a Peculiarity to Man, that the Pericardium, or Bag that incloses the Heart, should be fastned to the Diaphragm. Vesalius tells us, (De Corporis Humani fabrica, lib. 6. cap. 8.) <latin>Caeterum involucri mucro, et dextri ipsius lateris egregia portio Septi transversi nerveo circulo validissime amploque admodum spatio connascitur, quod Hominibus est peculiare.</latin>

The Point of the Pericardium, and a very considerable Portion of its right side, is most firmly fastned to the nervous Circle of the Midriff for a large Space, which is peculiar to Mankind.

So Blancardius Anat. reformat. cap. 2. p. 8. <latin>Homo prae caeteris Animalibus hoc peculiare habet, quod eius Pericardium Septi transversi medio semper, accrescat cum idem in Quadrupedum genere librum et aliquanto spatio ab ipso remtum sit: Man hath this peculiar to him, and different

from other Animals, that his Pericardium doth always grow to the Middle of the Midriff; whereas in the Quadruped-kind it is free and removed some Distance from it.

The Pericardium in Man is therefore thus fastned, that in Expiration it might assist the Diastole of the Diaphragm: For otherwise the Liver and Stomach being so weighty, they would draw it down too much towards the Abdomen, so that, upon the Relaxation of its Fibres in its Diastole, it would not ascend sufficiently into the Thorax, so as to cause a Subsidency of the Lungs by lessening the Cavity there.

In Quadrupeds there is no need of this Adhesion of the Pericardium to the Diaphragm; for in them, in Expiration, when the Fibres of the Diaphragm are relaxed, the Weight of the Viscera of the Abdomen will easily press the Diaphragm up into the Cavity of the Thorax, and so perform that Service. Besides, were the Pericardium fastned to the Diaphragm in Quadrupeds, it would hinder its Systole in Inspiration, or its Descent downwards upon the Contraction of its Muscular Fibres; and the more, because the Diaphragm being thus tied up, it could not then so freely force down the Weight of the Viscera, which are always pressing upon it, and consequently not sufiiciently dilate the Cavity of the Thorax, and therefore must hinder their Inspiration. Thus we see how necesary it is, that in Man, the Pericardium should be fastened to the Diaphragm, and in Quadrupeds how inconvenient it would be.

And since we find this Difference between the Hearts of Brutes and Men in this particular, how can we imaginc but that it must needs be the Effect of Wisdom and Design, and that Man was intended by Nature to walk erect, and not upon all Four, as Quadrupeds do?

</1717><1691=155> II. The Body of Man may thence be proved to be the Effect of Wisdom because there is nothing in it deficient, nothing, superfluous, nothing but hath its End and Use. So true are those Maxims we have already made use of, <latin>Natura nihil facit frustra, and Natura non abundat in superfluis, nec deficit in necessariis,</latin> no Part that we can well spare. "The Eye cannot say to the Hand, I have no need of thee, nor the Head to the Feet I have no need of you," I Cor. xii. 21. that I may usurp the Apostle's Similitude.

The Bellv cannot quarrel with the Members, nor they with the Belly for her seeming <**156> Sloth; As they provide for Meat for her, so she concocts and distributes it to them. Only it may be doubted to what use the Paps its Men should serve. I Answer, partly for Ornament, partly for a kind of Conformity between the Sexes, and partly to defend and cherish the Heart; in some they contain Milk, as in a Danish Family we read of in Bartholines Anatomical Observations. However, it follows not that they or any other Parts of the Body are useless because we are ignorant.

<1717>I have lately met with a Story in Seignior Paulo Boccone his Natural Obserrvations, printed at Bologna in Italy, 1684. well attested, concerning a Country-man, called Billardino di Billo, living in a Village belonging to the City of Nocera in Umbria, called Somareggio, whose Wife dying, and leaving a young Infant, he nourished it with his own Milk. This Man, either because in the small Village where he lived there was not a wet Nurse to be had, or because he was not able to hire one, took the Child, and applying it to his own Bosom, and putting the Nipples of his Breasts into its Mouth, invited it to suck, which the Infant did, and after divers times drawing, fetch'd some Milk; whereat the Father encouraged, continued to apply it, and so after a while it brought down the Milk so plentifully as to nourish it for many Months, till it was fit to be weaned. Hereupon my Author having proved by sufficient Authority of able Anatomists, such as Franciscus Maria Florentinus, and Marcellus Malpighius, that the Paps of Men have the same Structure and the same Vessels with those of Women, concludes, that Nature hath not given Paps to Men, either to no Purpose, or for meer Ornament, but, if Need requires, to supply the Defect of the Female, and give Suck to the Young.

</1717><1691=156>

Had we been born with a large Wen upon our Faces, or a Bavarian Poke under our Chins, or a great Bunch upon our Backs like Camels, or any the like superfluous Excrescency; which should be not only useless but troublesome, not only Stand us in no stead, but also be ill-favoured to behold, and burdensome to carry about, then we might have had some Pretence to doubt whether an intelligent and bountiful Creator had been our Architect; for had the Body been made by Chance, it must in all Likelihood have had many of these superfluous and unnecessary Parts.

But now seeing there is none of our Members but hath its Place and Use, none that w could spare, or conveniently live without were it but those we account Excrements, <**157> the Hair of our Heads, or the Nails on our Fingers ends; we must needs be mad or sottish if we can conceive any other than that an infinitely Good and Wise God was our Author and Former;

III. We may fetch an Argument of the Wisdom and Providence of God from the convenient Situation and Disposition of the Parts and Members of our Bodies: They are seated most conveniently for Use, for Ornament, and for mutual Assistance. First, for Use; so we see the Senses of such eminent Use for our Well-being, situate in the Head, as Sentinel in a Watch-Tower, to receive and convey to the Soul the Impressions of External Objects.

<latin>Sensus autem interpretes ac nuntii rerum in capite tanquam in arce mirifice ad usus necessarios et facti et collati sunt.</latin> Cicero. de Nat. Deorum. The Eye can more easily see Things at a Distance, the Ear receives Sounds from afar: How could the Eye have been better placed either for Beauty and Ornament, or for the Guidance and Direction of the whole Body. As Cicero proceeds well, <latin>Nam Oculi tanquam speculatores altissimum locum obtinent, ex quo plurima conspicientes funguntur suo munere: Et Aures quoe sonum recipere debent, qui natura in sublime fertur, recte in altis corporum partibus collocatae sunt; itemq; Nares, <**158> eo quo omnis odor ad superiora fertur, recte sursum sunt.</latin> For the Eyes, like Sentinels occupy the highest Place, from whencc seeing many things they perform their Functions: And the Ears, which are made for the Reception of sounds, which naturally are carried upwards, are righly placed in the uppermost Parts of the Body; also the Nostrils, because all Odors ascend, are fitly situate in the superior Parts.

I might instance in the other Members: How could the Hands have been more conveniently placed for all Sorts of Exercises and Works, and for the Guard and Security of the Head and principal Parts? The Heart, to dispense Life and Heat to the whole Body, viz. near the Center, and yet because it is harder for the Blood to ascend than descend, somewhat nearer the Head. It is also observable, that the Sinks of the Body are removed as far from the Nose and Eyes as may be, which Cicero takes Notice of in the fore-mentioned Place.

<latin>Ut in AEdificiis Architecti overtunt ab Oculis et Naribus Dominorum ea quae profluentia necessario essent tetri aliquid habitura, sic natura res similes procul amandavit à sensibus.

Secondly, For Ornament. What could have been better contrived, than that those Members which are Pairs, should stand by one another in equal Altitude, and <**159> answer on each Side one to another? And, Thirdly, For mutual Assistance. We have before shewed how the Eye stands most conveniently for guiding the Hand, and the Hand for defending the Eye; and the like might be said of the other Parts, they are so situate to afford Direction and Help one to another. This will appear more clearly, if we imagine any of the Members situate in contrary Place or Positions; Had a Man's Arms been fitted only to bend backwards behind him; or his Leg only to move backwards, what Direction could his Eyes then have afforded him in Working or Walking? Or how could he then have fed himself? Nay, had one Arm been made to bend forward, and the other directly backward, we

had then lost half the Use of them since they could not have assisted one the other in any Action. Take the Eyes, or any other of the Organs of Sense, and see if you can find any so convenient a Seat for them in the whole Body, as that they now possess.

IV. From the ample Provision that is made for the Defence and Security of the principal Parts: Those are, I . The Heart; which is the Fountain of Life and Vegetation, <latin>Officina spirituum vitalium, principum et fons caloris nativi, lucerna humidi radicalis;</latin> <**160> and that I may speak with the Chymists, ipse Sol Microcosmi, the very Sun of the Microcosme or little World, in which is contained that Vital Flame or Heavenly Fire, which Prometheus is fabled to have stole from Jupiter; or as Aristotle phrases it, that <greek> Aialogon tO tOn aplanOn zoicheiO </greek>, <latin>Divinum quid respondens Elemento Stellarum</latin>. This for more Security is situate in the Center of the Trunk of the Body, covered first with its own Membrane, called Pericardium, lodged within the soft Bed of the Lungs, encompassed round with a double Fence, (1.) Of firm Bones or Ribs to bear off Blows: (2.) Of thick Muscles and Skins, Besides the Arms, conveniently placed to fence of any Violence at a Distance before it can approach to hurt it.

2. The Brain, which is the Principle of all Sense and Motion, the Fountain of the Animal Spirits, the chief Seat and Palace Royal of the Soul upon whose Security depends whatever Privilege belongs to us as Sensitive or Rational Creatures. This, I say, being the prime and immediate Organ of the Soul, from the right Constitution whereof proceeds the Quickness of Apprehension, Acuteness of Wit, Solidity of Judgment, Method and Order of Invention, Strength and Power of Memory; which if once weakened and Disordered, <**161> there follows nothing but Confusion and Disturbance in our Apprehensions, Thoughts and Judgments, is environed round about with such a potent Defence, that it must be a mighty Force indeed that is able to injure it.

1. A Skull so hard, thick, and tough, that it is almost as easy to split a Helmet of Iron as to make a Fracture in it.

2. This covered with Skin and Hair, which serve to keep it warm, being naturally a very cold Part, and also to quench and dissipate the Force of any Stroke that shall be dealt it, and retund the Edge of any Weapon.

3. And yet more than all this, there is still a thick and tough Membrane which hangs looser about it, and doth not so closely embrace it, (that they call dura mater) and in case the Skull happens to be broken, doth often preserve it from Injury and Diminution: And, lastly, a thin and fine Membrane strait and closely adhering, to keep it from quashing and shaking. <1717> The many Pairs of Nerves proceeding frorn it, and afterwards distributing and branching themselves to all the Parts of the Body, either for Nutrition or Motion, are wonderful to behold in prepared Bodies, and even in the Schemes and Figures of Dr. Mills and Vieusens. </1717>

I might `instance (3.) in the Lungs, which are so useful to us, as to Life and Sense, that the Vulgar think our Breath is our very Life and that we breathe out our Souls from thence. Suitable to which Notion, both anima and spiritus in Latin, and pneuma in Greek, are derived from Words that signify <**162> Breath and Wind: And esslare or exhalare animam signifies to die. And the old Romans used to apply Mouth to Mouth, and receive the last Gasps of their dying Friends, as if their Souls had come out that way. From hence, perhaps, might first spring that Opinion of the Vehicles of Spirits; the Vulgar, as I hinted before, conceiving that the Breath was, if not the Soul itself, yet that wherein it was wafted and carried away. These Lungs, I say, are, for their better Security and Defence, shut up in the same Cavity with the Heart.

V. In the abundant Provison that is made Against evil Accidents and Inconveniences. And the Liberality of Nature, as to this Particular, appears, 1. In that she hath given many Members, which

are of eminent Use, by Pairs, as two Eyes, two Ears, two Nostrils, two Hands, two Feet, two Breasts, [Mammae] two Reins; that so, if by any cross or unhappy Accident one should be disabled or rendred useless, the other might serve us tolerably well; whereas had a Man but one Hand, or one Eye, etc. if that were gone, all were gone, and we left in an evil Case. See then, and acknowledge the Benignity of the Deity, who hath bestowed upon us two Hands, and two Eyes, and other the like Parts, not only for our Necessity <**163> but Conveniency, so long as we en)oy them; and for our Security, in case any Miscance deprive us of one of them. 2. In that all the Vessels of the Body have many Ramifications: Which particular Branches, though they serve mainly for one Member or Muscle, yet send forth Some Twigs to the neighbouring Muscles; and so interchangeable the Branches that serve these, send to them. So that if one Branch chance to be cut off or obstructed, its Defect may, in some measure, be supplied by the Twigs that come from the neighbouring Vessels. 3. In that she hath provided so many ways to evacuate what migh be hurtful to us, or breed Diseases in our Bodies. If any thing oppress the Head, it hath a Power to free itself by Sneezing: If any thing fall into the Lungs, or if any Humour be discharg'd upon them, they have a Faculty of clearing themselves, and casting it up by Coughing: If any thing clog or burden the Stomach it hath an Ability of contracting itself, and throwing it up by Vomit. Besides these ways of Evacuation, there are Siege, Urine, Sweating, Haemorrhoigies from the Nose, and Haemorrhoidal Veins, Fluxes of Rheum. Now the Reason why Nature hath provided so many ways of Evacuation, is, because of the different Humours that are to be voided or cast out. <**164> When therefore there is a Secretion made of any noxious Humour, it is carried off by that Emunctory whose Pores are fitted to receive and transmit the minute Parts of it; if at least this Separation be made by Percolation, as we will now suppose, but not assert. Yet I doubt not but the same Humour may be cast off by divers Emunctories, as is clear in Urine and Sweat which are for the main the same Humour carried off several ways,

<1717>To this Head of Provision against Inconveniences, I shall add an Observation or two concerning Sleep.

I. Sleep being necessary to Man and other Animals for their Refreshment, and for the Reparation of that great Expence of Spirits, which is made in the day-time, by the constant Exercise of the Senses and Motions of the Muscles, that it might ease and refrexh us indeed; Nature hath provided, that tho' we lie long upon one side, we should have no Sense of Pain or Uneasiness during our Rest, no, nor when we awake. Whereas in Reason one would think, that the whole Weight of the Body pressing the Muscles and Bones on which we lie, should be very burdensome and uneasy, and create a grievous Sense of Pain; and we find by Experience that it doth so, when we lie long awake in the Night, we being not able (especially if never so little indisposed) to rest one quarter of an Hour in the same Posture without shifting of Sides, or at least etching this way and that way, more or less. How this may be effected is a great Question. To me it seems most probable, that it is done by an Inflation of the Muscles, whereby they become both soft, and yet renitent like so many Pillows, dissipating the Force of the Pressure, and so preventing or taking away the Sense of Pain. That the Muscles are in this manner inflated in time of Rest, appears to the very Eye in the Faces of Children, and may be proved from that when we Rest in our Clothes, we are fain to loosen our Garters, Shoo-Strings, and other Ligatures, to give the Spirits free Passage, else we shall experience Pain and Uneasiness in those Parts, which when we are waking we find not. The Reason of this Phaenomeon, viz. that <greek>analgEsia</greek>, or want of Pain, we experience in Sleep, during and after a long decubitus on one Side, Dr. Lister in his <title>Journey to Paris, p.113. and Dr. Jones in his Treatise of the Mysteries of Opium revealed, attribute to the Relaxation of the Nerves and Muscles in time of Sleep; and the Sense of Pain and Uneasiness when we lie awake to the Tension of them during that time. This I do not deny, but yet I think the Reason I have assigned hath a great Interest in that Rest and Easiness we enjoy when asleep.

2. Because Sleep is inconsistent with the Sense of Pain, therefore during Rest, those Nerves which convey that Motion to the Brain, which excites in the Soul a Sence of Pain, are obstructed. This I myself have had frequent Experience of, since I have been troubled with Sores on my Legs. Upon sudden awakening, finding myself at perfect Ease, and void of all Sense of Pain for a Minute's time or more, the Pain then by degrees returning, which I could attribute to nothing but the dessipating that Vapour, or uhatever else it were, which obsructed the Nerves, and giving the dolorific Motion free Passage again.

Upon sesond Thoughts, and reading what Dr. Lister and Dr. Jones have written concerning this Subject, I rather incline to believe, that the Motion causing a Sense of Pain, is convey'd to the brain by the Nerves themselves in Tension, as we see in Cords, any the least Touch at one End passes Speedily to the other when they are stretch'd, which it doth not when they are relaxed, and not by the Spirits passing through them: And on the other tide, the Unsensibleness of Pain proceeds rather from the Relaxation of the Nerves than their Obstruction. But yet this Tension of the Nerves and Muscles is owing to the Spirits flowing down into them, and distending them. </1717><1691=164>

VI. From the Constancy that is observed in the Number, Figure, Place, and Make of all the principal Parts; and from the Variety in the less. Man is always mending and altering his Works: But Nature observes the same Tenor, because her Works are so perfect, that there is no Place for Amendments; nothing that can be reprehended. The most Sagacious Men in so many Ages, have not been able to find any Flaw in these Divinely contrived and formed Machines, no Blot or Error in this great Volume of the World, as if any thing had been an imperfect Essay at the first, to use the Bishop of Chester's words: Nothing that can be altered for the better; nothing but if it were altered would be marred. This could not have been, had Man's Body been the Work of Chance, and not Council and Providence. Why should there be constantly the same Parts? Why should they retain constantly the same Places? And why should they be endued with the same Shape and Figure? Nothing so contrary as Constancy and Chance. Should I see a Man throw the same Number a thousand times together upon but three Dice, could you Persuade me that this were Accidental, and that there was no necesary Cause of it? How much more incredible then is it, that Constancy in such a Variety, such a Multiplicity of Parts, should be the Result of Chance? Neither yet can these Works be the Effects of Necessity or Fate, for then there would be the same Constancy observed in the Smaller as well as the larger Parts and Vessels; whereas there we see Nature doth ludere, as it were, sport itself; the minute Ramifications of all the Vessels, Veins, Arteries, and Nerves, infinitely varying in Individuals of the same Species, so that they are not in any two alike.

VII. The great Wisdom of the Divine Creator appears, in that there is Pleasure annexed th those Actions that are necessary for the Support and preservation of the Individuum, and the Continuation and Propagation of the Species; and not only so, but Pain to the Neglect or Forbearance of them. For the Support of the Person, <**166> it hath annex'd Pleasure to Eating and Drinking; which else, out of Laziness or Multiplicity of Business, a Man would be apt to neglect, or sometimes forget. Indeed, to be obliged to chew and swallow Meat daily for two Hours space, and to find no relish or pleasure in it, would be one of the most burdensome and ungrateful Tasks of a Man's whole Life. But because this Action is absolutely necessary, for abundant security Nature hath inserted in us a Painful sense of Hunger to put us in mind of it, and to reward our Performance hath adjoined Pleasure to it. And as for the Continuation of Kind, I need not tell you, that the Enjoyments which attend those Actions are the highest Gratifications of Sense.

VIII. The wonderful Art and Providence of the Contriver and Former of our Bodies, appears in the Multitude of Intentions he must have in the Formation of the several Parts, or the Qualifications they require, to fit them for their several Uses. <margin>Bishop of chester, Nat Rel. lib.1. c.6. </margin> Galen in his book De Formatione Foetus, "takes

notice, That there are in a humane Body above Six hundred several Muscles, and there are at least Ten several Intentions or due Qualifications to be observed in each of these; proper Figure, just Magnitude, right Disposition <**167> of its Several Ends, upper and lower, Potition of the whole, the Insertion of its proper Nerves, Veins, and Arteries, which are each of them to be duly placed; so that about the Muscles alone, no less than Six thousand several Ends or Aims are to be attended to. The Bones are reckoned to be 284. The distinct Scopes or Intentions in each of these are above 40, in all about 100,000. And thus it is in some Proportion with all the other Parts, the Skin, Ligaments, Vessels, Glandules, Humors: But more especially with the several Members of the Body, which do, in regard of the great Variety and Multitude of those several Intentions required to them, very much exceed the homogeneous Parts. And the failing in any one of these would cause Irregularity in the Body, and in many of them such as would be very notorious."

Now to imagine that such a Machine composed of so many Parts, to the right Form, Order and Motion whereof such an infinite Number of Intentions are required, could be made without the Contrivance of some Wise Agent, must needs be irrational in the highest Degree.

<1717>This wonderful Mechanism of humane Bodies, next to viewing the Life, may be seen at large in the excellent Figures of Spigelius and Bidloo; their Situation, Order, Connexion and Manner of separating them, in Lyserus his Cult. Anatom. The almost infinite Ramifications, and Inosculations of all the several sorts of Vessels, the Structures of the Glands, and other Organs, may easily be detected by Glasses, and trac'd by blowing in of Air, and drawing them, or by injecting through peculiar Syringes, melted Wax, or Quicksilver; the Operations whereof may be learnt out of Swammerdam, Caspar Bartholine, and Antonio Nuck.

IX. Another Argument of Wisdom and Design in Contrivance of the Body of Man, and other Animals, is the Fitting of some Parts to divers Offices and Uses, whereby Nature doth (as the Proverb is) <latin>Una fidelia duos parietes dealbare</latin>; Stop two Gaps with onc Bush. So, for Instance, the Tongue serves not only for Tasting, but also to assist the Mastication of the Meat and Deglutition, by turning it about, and menaging it in the Mouth, to gather up the Food in Man by licking; in the Dog and Cat-kind by lapping; in Kine, by plucking up the Grass: Particularly in Man, it is of admirable Use for the Formation of Words and Speaking.

The Diaphragm and Muscles of the Abdomen, or lower Belly, are of Use, not only for Respiration, but also for compressing the Intestines, and forcing the Chyle into the lacteal Veins, and likewise out of the said Veins into the thoracick Chanel: And here, to note that by the way, appears the Use of a common receptacle of Chyle, that by the Motion of the Muscles of Respiration, it being pressed upon, the Chyle might with more facility be impelled into the foremention'd Duct. Besides, this Action of Respiration and Motion of the said Diaphragm and Muscles, may serve also for the Comminution and Concoction of the Meat in the Stomach (as some, not without Reason, think) by their constant Agitation and Motion upwards and downwards, resembling the pounding or braying of Materials in a Mortar.

And to instance in no more, the muscular Contraction and Pulse of the Heart serves not only for the Circulation of the Blood, but also for for the more perfect Mixture of its Parts, preserving its due Crasis and Fluidity, and incorporating the Chyle and other Juices it receives with it.

X. The Wisdom and Goodness too of the Divine Former of our Bodies appears in the Nourishment of them: For that Food which is of a wholesome Juice, and proper to nourish and preserve them in a healthful State, is both pleasant to the Taste, and grateful and agreeable to the Stomach, and continues to be so till our Hunger and Thirst be well appeased, and then begins to be less pleasant, and at last even nauseous and loathsome. The full stomach loathes the Honey-comb.

On the other side, that which is unwholsome and unfit for Nourishment, or destructive of Health, is also unpleasant to the Taste, and ungrateful and disagreeable to the Stomach, and that more or less according as it is more or less improper or noxious. And though there be some sorts of Food less Pleasant to the Taste, which by Use may be rendred grateful; yet to Persons that are in Health, and in no necessity of using such Viands, I think it were better to abstain from them, and follow Nature in eating such Things as are agreeable to their Palate and Stomach: For such unpleasant Diet must needs alter the Temper of the Body, before it can become acceptable; and doubtless for the worse. I might add hereto, that even Pain, which is the most grievous and afflictive thing that we are sensible of, is of great use to us. God hath annexed a Sense of Pain to all Diseases and Harms of the Body inward and outward, (and there is no Pain but proceeds from some Harm or Disease) to be an effectual Spur to excite and quicken us to seek for speedy Help or Remedy; and hath so order'd it, that ae the Disease heals, so the Pain abates. Neither doth Pain provoke us only to seek ease and Relief when we labour under it, but also makes us careful to avoid for the future all such things as are productive of it; that is, such things as are hurtful to our Bodies, and destructive of the Health and Well-being of them, which also are, for the most part, prohibited by God, and so sinful and injurious to our Souls.

So we see what Care the Divine Providence hath taken, and what effectual Means it hath used for the Healing of our Diseases, and the maintenance and Preservation of our Health. This is the true Reason of Pain: Howbeit, I will not deny, but that God doth sometimes Himself immediately inflict Diseases, even upon his own Children, for many good Considerations which I shall not here enumerate. Neither shall I mention the Uses that Parents and Masters make of it, for the correcting their Children and Servants, or Magistrates for the punishing of Malefactors, they being beyond my Scope; only I cannot but take Notice, that it is a <greek>posuchrEson</greek> a thing of manifold Uses, and necessary for the Government both of Commonwcalths and Families. </1717>

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XI. Some fetch an Argument of Providence from the Variety of Lineaments in the Faces of Men, which is such, that there are not two Faces in the World absolutely alike; which is somewhat strange, since all the Parts are in Species the same. Were Nature a blind Architect, I see not but the Faces of some Men might be as like, as Eggs laid by the same Hen or Bullets cast in the same Mould, or Drops of Water out of the same Bucket. This Particular I find taken notice of by Pliny in his Seventh Book, Cap. I. in these Words: <latin>Iam in facie vultuque nostro, cum sint decem aut paulo plura membra, nullas duas in tot millibus hominum indiscretas effigies existere, quod Ars nulla in paucis numero praestet affectando;</latin> to which among other things, he thus prefaces, <latin>Naturae vero rerum vis atque majestas in omnibus momentis fide caret.</latin>

Though this at first may seem to be a Matter of small Moment, yet, if duly considered, will appear to be of mighty Importance in Humane Affairs: For should there be an undiscernible Similitude between divers Men, what Confusion and Disturbance would necessarily follow? What Uncertainty in all Sales and Conveyances, in all Bargains and Contracts? What Frauds and Cheats, and suborning of Witnesses? What <**169> a Subversion of Trade and Commerce? What Hazard in all Judicial Proceedings? In all Assaults and Batteries, in all Murders and Assassinations, in Thefts and Robberies, what Security would there be to Malefactors? Who could swear that such and such were the Persons that commited the Facts, though they saw them never so clearly? Many other Inconveniencies might be instanced in: So that we see this is no contemptible Argument of the Wildom and Goodness of God.

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Neither is the Difference of Voices less considerable for the distinguishing of Sexes and particular Persons, and Individuals of all Animals, than that of Faces; as Dr. Cockburn makes out, Essay, etc. Part II. Pag.68. etc. Nay, in some cases more; for hereby Persons in the dark, and those that are blind, may know and distinguish one another, which is of great Importance to them; for otherwise they might be most grossly cheated and abused.

Farther we may add out of the same Author, p. 71 "And to no other Cause than the Wise Providence of God can be referred the no less strange Diversity of Handwritings. Common Experience shews, that though Hundreds and Thousands were taught by one Master, and one and the same Form of Writing, yet they should all write differently: Whether Men write Court or Roman Hand, or any other; there is some thing peculiar in every one's Writing, which distinguisheth it. Some, indeed, can counterfeit another's Character and Subscription; but the Instances are rare; nor is it done without Pains and Trouble: Nay, the most expert and skilful cannot write much so exactly like, as that it cannot be known, whether it be Genuine or Counterfeit. And if the Providence of God did not so order it, what Cheats and Forgeries too would daily be committed, which would not only justle private Men out of their Rights, but also unhinge States and Governments, and turn all into Confusion? The Diversity of Handwritings is of mighty great Use to the Peacc of the World; it prevents Fraud, and secures Mens Property; it obligeth the Living and Present to Honesty and Faithfulness; it importeth the Mind of the Absent, and sheweth the Will of the Dead, which ought to be sacredly observed. And what is so very Useful, is not the Effect of any humane Concert. Men did not of themselves agree to it, they are only carried to it by the secret Providence of God, who understandeth and mindeth what is for the Good and Interest of Mankind in general, and of every particular Person.

Add farther to all this, That whereas there are Several Parts peculiar to Brutes, which are wanting in Man; as for Example, the seventh or suspensory Muscle of the Eye, the nictating Membrane, the strong Aponeuroses on the sides of the Neck, called by some Packwax, it is

very remarkable, that these Parts are of eminent and constant Use to them, as I shall particularly shew hereafter, but to Man would have been altogether useless and superfluous.</1717><1691 page=169>

I have done with my general Observations. I proceed now more accurately and minutely to consider some particular Parts or Members of the Body; and First, the Hcad, because it was to contain a large Brain made of the most capacious Figure, as near as could be to a Spherical; upon this grows the Hair; which, though it be esteemed an Excrement, is of great Use (as I shewed before) to cherish and keep warm the Brain, and to quench the Force of any Stroke that might otherwise endanger the Skull. It serves also to disburden the Brain of a great deal of superfluous Moisture wherewith it abounds. <1691> and for a graceful ornament to the Face.</1691>

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I find it remark'd by Marchetti, a famous Anatomist in Padua, that the Cause of Baldness in Men is the Dryness of the Brain, and its shrinking from the Cranium or Skull; he having observ'd, that in bald Persons, under the bald part, there was always a Vacuity or empty Space between the Skull and the Brain. And, Lastly, to name no more, it serves also for a graceful Ornament to the Face, which our present Age is sensible enough of, bestowing so much Money upon false Hair and Periwigs.</1717>

Secondly, Another Member which I shall more particularly treat of; is the Eye, a Part <**170> so artificially composed, and commodiously situate as nothing can be contrived better for Use, Ornament or Security, nothing to Advantage added thereto, or altered therein. Of the Beauty of the

Eye I shall say little, leaving that to Poets and Orators; that it is a very pleasant and lovely Object to behold, if we consider the Figure, Colours and Splendor of it, is the least that I can say. The Soul, as it is more immediately and strongly moved and affected by this Part than any other, so doth it manifest all its Passions and Perturbations by this.

As the Eyes are the Windows to let in the Species of all Exterior Objeets into the dark Cells of the Brain, for the Informlation of the soul; so are they flaming Torches to reveal to those Abroad, how the soul within is moved or affected. These Representations made by the Impressions of External Objects upon the Eye, are the most clear, lively and distinct of any others. Now to this Use and Purpose of informing us what is Abroad round about us in this aspectable World, we shall find this Structure and Mechanism of the Eye, and every Part thereof; so well fitted and adapted, as not the least Curiosity can be added:

For, first of all, the Humours and Tunicles are purely transparent, to let in the Light and <**171> Colours unfolded and unsophisticated by any inward Tincture. It is usually said by the Peripateticks, that the Crystalline Humour of the Eye (which they ineptly fancied to be the immediate Organ of Vision, wherein all the Species of Extemal Objects were terminated) is without all Colour, because its Office was to discern all Colours, or at least, to receive the Species of several Colours, and convey them to the common Sense. Now if itself had been coloured, it would have transmitted all visible Objects tinctured with the same Colour; as we see whatever is beheld through a coloured Glass, appears of the Same Colour with the Glass; and to those that have the Jaundice, or the like Suffusion of Eyes, Objects appear of that same Colour wherewith their Eyes are infected. This they say, is in a great Measure true, although they are much mistaken about the Organ and Manner of Vision, and the Uses of the Humours and Membranes of the Eye. Two Reasons therefore may be assigned, why all the Membranes and Humours of the Eye are perfectly pellucid, and void of Colour. First, for the Clearness. Secondly, For the Distinctness of Vision.

I. The Clearness; for had the Tunicles and Humours of the Eye, all, or any of them been colorate, many of the Rays proceeding <**172> from the visible Object, would have been stopt and suffocated before they could come to the bottom of the Eye, where the formal Organ of Vision is situate; for it is a most certain Rule, how much any Body hath of Colour, so much hath it of Opacity, and by so much the more unfit it is to transmit the Species.

Secondly, For the Distinctness of Vision; for, as I said before, and the Peripateticks observe well, were the Humours of the Eye tinctured with any Colour, they would refund that that Colour upon the Object, and so it would not be represented to the soul, as in itself it is. So we see, that through a coloured Glass things appear as well more dim and obscure, as tinctured with the Colour thereof.

Secondly, The Parts of the Eye are made convex, and especially the Crystalline Humour, which is of a lenticular Figure, convex on both sides; that, by the Refractions there made, there might be a Direction of many Rays coming from one Point in the Object viz. as many as the Pupil can receive, to one Point Answerable in the Bottom of the Eye, without which the Sense would be very obscure, and also confused.

There would be as much Difference in the Clearness and Distinction of Vision, were the outward Surface of the Tunica Cornea plain, and <**173> the Crystalline Humour removed; as between the Picture received on a white Paper in a dark Room through an open or empty Hole, and the same received through a Hole furnished with an exactly polished lenticular Crystal; which, how great it is, any one, that hath but seen this Experiment made, knows well enough. Indeed, this Experiment doth very much explain the Manner of Vision; the Hole answering to the Pupil of the Eye, the Crystalline Humour to the lenticular Glass, the dark Room to the Cavity, containing the vitreous Humour, and the white Paper to the Tunica Retina.

Thirdly, The Uveous Coat, or Iris of the Eye, hath a musculous Power, and can dilate and contract that round Hole in it, called the Pupil, or Sight of the Eye. It contracts it for the excluding superfluous Light, and preserving the Eye from being injured by too vehement and lucid an Object, and again dilate it for the apprehending Objects more remote, or placed in a fainter Light; <latin>tam miro artificio (saith Scheiner) quam munifica naturae largitate.</latin>

If any one desires to make Experiment of these Particulars, he may, following Scheiner and Des Cartes their directions, take a Child, and setting a Candle before him, bid him look upon it, and he shall observe his Pupil contract itself <**174> very much, to exclude the Light, with the Brightness whereof it would otherwise be dazzled and offended; as we are, when after we have been some time in the dark, a bright Light is suddenly brought in and set before us, till the Pupils of our Eyes have gradually contracted themselves: Let the Candle be withdrawn, or removed aside, he shall observe the Child's Pupil by Degrees to dilate itself. Or let him take a Bead, or the like Object, and holding it near the Eye, command the Child to look at it, the Pupil will contract much when the Object is near; but let it be withdrawn to a greater Distance in the same light, and he shall observe the Pupil to be much enlarged.

Fourthly, The Uveous Coat, and also the Inside of the Choroides, are blacken'd like the Walls of a Tennis-Court, that the Rays may be there suffocated and suppressed, and not reflected backwards to confound the Sight: And it' any be, by the Retiform Coat, reflected, they are soon choaked in the black Inside of the Uvea. Whereas were they reflected to and fro, there could be no distinct Vision: As we see the Light admitted into the dark Room we even now spake of obliterates the Species which before were seen upon the white Cloath or Paper.

<**175> Fifthly, because the Rays from a nearer, and from a more remote Object, do not meet just in the same Distance behind the Crystalline Humour (as may easily be observed in Lenticular Glass, where the Point or Concourse of the Rays from a nearer Objeet is at a greater Distance behind the Glass, and from a farther at a lesser) therefore the Ciliary Processes, or rather the Ligaments observed in the Inside of the Sclerotick Tunicles of the Eye, by a late ingenious Anatomist, do serve instead of a Muscle, by their Contraction to alter the Figure of the Eye, and make it broader; and consequently draw the Retina nearer to the Crystalline Humour; and by their Relaxation suffer it to return to its natural Distance, according to the Exigency of the Object, in respect of Distance or Propinquity: And besides, possibly the Ciliary Proceisses may, by their Constriction or Relaxation, render the Crystalline itself more gibbose or plain; and with the Help of the Muscles, a little alter the Figure of the whole Eye for the same Reason.

To what I have said might be added that the retiform Tunicle is whitish, for the better and more true Reception of the Species of Things. That there being a Distance necessarily required for the Collection of the Rays receiv'd by the Pupil, viz. those that proceed from one Point <**176> of the Object to one Point again in the Bottom of the Eye, the Retina must needs be set at a Distance from the Crystalline Humour: And therefore, Nature hath provided a large Room, and filled it with the pellucid vitreous Humour most fit for that Purpose.

I must not omit a notable Observation concerning the Place of the Insertion of the Optick Nerve into the Bulb of the Eye, and the Reason of it; which I owe to that learned Mathematician Petcr Herigon; <latin>Nervus Opticus (saith lie in his Optica) ad latus ponitur, ne pars imaginis in eius foramen incidens pictura careat</latin>. The Optick Nerve is not situate directly behind the Eye, but on one side, lest that Part of the Image that falls upon the Hole of the Optick Nerve, should want its Picture. This I do not conceive to be the true Reason ofthis Situation; for even now as it is situate, that Part of the Object, whose Rays fall upon the Center or Hole of the Optick Nerve, wants its Picture, as we find by Experiences that Part not being seen by us, though we heed it not:

But the Reason is, because if the Optick Axis should fall upon this Center (as it would do, were the Nerve seated just behind the Eye) this great Inconvenience would follow, that the middle Point of every Object <**177> we viewed would be invisible, or there would a dark Spot appear in the midst of it. Thus we see the admirable Wisdom of Nature in thus placing the Optick Nerve in respect of the Eye; which he that did not consider or understand, would be apt to think more inconveniently situate for Vision than if it had been right behind.

Another Thing also concerning Vision is most remarkable, that though there be a Decussation of the Rays in the Pupil of the Eye, and so the Image of the Object in the Retina, or Bottom of the Eye, be inverted, yet doth not the Object appear inverted, but in its right or natural Posture. The Reason whereof is, because the Visual Rays coming in streight Lines, by those Points of the Sensory or Retina which they touch, affect the common Sense or Soul, according to their Direction. That is, signifie to it, that those several Parts of the Object from whence they proceed, lie in streight Lines, (Point for Point) drawn through the Pupil to the several Points of the Sensory where they terminate, and which they press upon. whereupon the Soul must needs conceive the Object, not an inverted, but a right Posture; and that the Nerves are naturally made, not only to inform the soul of External Objects which press upon them, but also of <**178> the Situation of such Objects, is clear, because if the Eyes be distorted, the Object, will we, nill we, will appear double: so if the fore and middle Fingers be cross'd, and a round Body put between them, and moved, it will seem to be two; the Reason is, because in that Posture of the Fingers the Body touches the Outsides of them, which in their natural Sight are distant one from another, and their Nerves made to signifie to the soul Bodies separate and distant in like manner, two Fingers lying between them. And tho' our Reason, by the Help of our Sight, corrects this Error, yet cannot we but fancy it to be so.

Neither is the aqueous Humour, as some may supinely imagine, altogether useless or unprofitable as to Vision, because by its Help the Uvea Tunica is sustained, which else would fall flat upon the Crystalline Humour; and fluid it must be to give way to the Contraction and Dilatation of the Uveous: And because the outermost Coat of the Eye might chance to be wouncled or pricked, and this Humour being fluid let out, therefore Nature hath made Provision speedily to repair it again in such a Case, <1717> by the help of certain Water-pipes, or Lymphae-ducts inserted into the Bulb of the Eye, proceeding from Glandules design'd by Nature to separate this Water from the Blood for that use. Antonius Nuck affirms, that if the Eye of an Animal be prick'd, and the aqueous Humour squeez'd out, in ten Hours Space the said Humour and Sight shall be restored to the Eye, if at least the Creature be kept in a dark Place. And that he did publickly demonstrate the same in the Anatomical Theatre at Leyden, in a Dog, out of whose Eye being wounded the aqueous Humour did so copiously flow, that the Membranes appeared flacid, and yet in six Hours Space the Bulb of the Eye was again replete with its Humour, and that without the Application of any Medicines. Antonius Nuck de Ductu novo salivali, etc.</1717>

Moreover, it is remarkable, that the Cornea Tunica [horny or pellucid Coat of the Eye] doth not lie in the same superficies <**179> with the white of the Eye, but riseth up, as it were a Hillock above its Convexity, and is of an Hyperbolical or Parabolical Figure: so that though the Eye seems to be perfectly round, in Reality it is not so, but the Iris thereof is protuberant above the White; and the Reason is, because that if the Cornea tunica, or Crysalline Humour, had been concentrical to the Sclerodes, the Eye could not have admitted a whole Hemisphere at one View, <latin>et sic Animalis incolumitati in multis rebus minus cautum esset</latin>, as Scheiner well observes. In many Things there had not been sufficient Caution or Care taken for the Animal's Safety.

And now (that I may use the Words of a late Author of our own <margin> Dr More, Antidote against Atheism</margin> the Eye is already so perfect, that I believe the Reason of a Man would easilly have rested here, and admired at his own Contrivance. For he being able to move his whole Body upward and downward, and on every Side, might have unawares thought himself sufficiently well

provided for; but Nature hath added Muscles also to the Eyes, that no Perfection might be wanting: For we have often occasion to move our Eyes, our Head being unmoved, as in reading and viewing more particularly an Object set before us, by transferring the Axes of our Eyes all <**180> over it: And that this may be done with the more ease and Accuracy, she hath furnished this Organ with no less than six Muscles, to move it upward, downward, to the Right and Left, obliquely and round about.

I shall now consider what Provision is made for the Defence and Security of this most excellent and useful Part.

First, the Eyes are sunk in a convenient Valley, latent utiliter, and are encompassed round with eminent Parts, as with a Rampart <latin> et excelsis undique partibus sepiuntur, </latin> <margin>De Natur. Rerum l.2 Cicero </margin> so are defended from the strokes of any flat or broad Bodies. Above stand the Eye-Brows, to keep of any thing from running down upon them, as Drops of Sweat from the Forehead, or Dust, or the like. <latin>Superiora superciliis obducta sudorem à capite et fronte defluentum repellunt. Cicero. Then follow the Eye-lids, which fence them from any sudden and lesser Stripes. These also round the Edges are fortified with stiff Bristles, as it were Pallisadoes, against the Incursions of importunate Animals, serving partly as a Fan to Strike away Flies or Gnats, or any other troublesome Insect; and partly to keep off Superfluous Light. <latin>Munit eq; sunt palpebrae tanquam vallo siquid incideret repelleretur. <**181> Idem ibid.

And because it was necessary that Man and other Animals should sleep, which could not be so well done if the Light came in by the Windows of the Eyes, therefore hath Nature provided these Curtains to be then drawn to keep it out.

And because the outward Coat of the Eye ought to be pellucid to transmit the Light, which if the Eyes should always stand open, would be apt to grow dry and shrink, and lose their Diaphaneity, therefore are the Eyelids so contrived, as often to wink, that so they may as it were glaze and varnish them over with the Moisture they contain, there being Glandules on purpose to separate a Humour for that Use, and withal wipe off whatever Dust or Filth may stick to them: And this, lest they should hinder the Sight, they do with the greatest Celerity. Cicero hath taken Notice, that they are made very soft, lest they should hurt the Sight. <latin> Mollisimae tactu ne loederent aciem, aptissime factoe et ad claudendas pupillas ne quid incideret, et ad aperiendas, idq; providit ut identidem fieri posset maxima cum celeritate.</latin>

Secondly, If we consider the Bulb or Ball of the Eye, the exterior Membrane or Coat thereof is made thick, tough and strong, that it is a very hard Matter to make a Rupture in it, and besides so slippery, that it eludes the Force of any Stroke, to which also its globular Figure gives it a very great Advantage. <**182>

Lastly, because for the Guidance and Direction of the Body in Walking, and any Exercise, it is necessary the Eye should be uncovered, and exposed to the Air at all times and in all Weathers, therefore the most wise Author of Nature hath provided for it a hot Bed of Fat, which fills up the Interstices of the Muscles; and besides made it more patient and less sensible of Cold, than our other Parts and tho' I cannot say with Cicero, absolutely free from Danger or Harm by that Enemy, yet least obnoxious to the Injuries thereof of any Part, and not at all, unless it be immoderate and extreme.

To all this I might add the Convenience of the Situation of the Eye in respect of its Proximity to the Brain, the Seat of_Apprehension and Common Sense: Whereas had it been further removed, the Optick Nerves had been liable to many more Dangers and Inconveniencies than now they are.

Seeing then the Eye is composed of so great Variety of Parts, all conspiring to the Use of Vision, whereof some are absolutely necessary others very useful and convenient, none idle or superfluous; and which is remarkable, many of them of a different Figure and Consistency from any others in the Body besides, as being transparent, which it was absolutely nccessary they should be, to transmit <**183> the Rays of Light: Who can but believe that this Organ was designed and made Purposely for the Use for which it serves?

Neither is it to be esteemed any Defect or Imperfection in the Eyes of Man, that they want the seventh Muscle, or the nictating Membrane, which the Eyes of many other Animals are furnished withal; for though they be very useful, and in a manner necessary to them, considering their manner of living, yet they are not so to Man. To such Beasts as feed upon Grass and other Herbs, and therefore are forced to hold their Eyes long in a hanging Posture, and to look downwards for the choosing and gathering of their Food, the Seventh or Suspensory Muscle is very useful, to enable them to do so without much Pain or Weariness; yet to Man, who doth not, nor hath any Occasion, indeed cannot hold his Head, or look long downwards, it would be useless and superfluous.

As for the nictating Membrane, or Periophthalmium, which all Birds, and I think most Quadrupeds, are furnished with, I have been long in doubt what the Use of it might be; and have sometimes thought it was for the more abundant Defence and Security of the Eye; but then I was puzzled to give any tolerable Account, why Nature should be more solicitous <**184> for the Preservation of the Eyes of Brutes than Men, and in this respect also to be a Step-Mother to the most noble Creature.

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But the honourable Author <margin> Boyle, Of Final Causes, ch. 2, p. 53,54</margin> formerly mention'd, gives a probable Account why Frogs anal Birds are furnished with such a Membrane. Frogs, because being Amphibious Animals, designed to pass their Lives in watery places, which for the most part abound with Sedges, and other Plants endowed with sharp Edges or Points; and the progressive Motion of this Animal being to be made not by Walking, but by Leaping, if his Eyes were not provided of such a Sheath, he must either Shut them, and so leap blindly, and by consequence dangerously, or by leaving them open run a Venture to have the Cornea cut, prick'd, or otherwise offended by the Edges or Points of the Plants, or what may fall from them upon the Animal's Eye: Whereas this Membrane (being something transparent as well as Strong) is like a kind of Spectacle that covers the Eye without taking away the Sight. Birds are likewise furnished with it because being destinated to fly among the Branches of Trees and Bushes, their Prickles, Twigs, Leaves, or other Parts, would be apt otherwise to wound or offend their Eyes.

But yet still we are to seek why it is given <**185> to other Quadrupeds, whose Eyes are in no such Danger.

Thirdly, The Ear, another Organ of Sense, how admirable it is contrived for the receiving and conveying of sounds? First, There is the outward Ear or Auricula, made hollow and contracted by Degrees to draw the sound inward, to take in as much as may be of it, as we use a funnel to pour Liquor into any Vessel. And therefore if the Auricula be cut clear off, the Hearing is much impaired, and almost quite marred, as hath been by Experience found.

From the Auricula is extended a small, long, round Hole, inward into the Head, to intend the Motion, and so augment the force of the Sound, as we see in a shooting Trunk, the longer it is to a certain Limit, the swifter and more forcibly the Air passes in it, and drives the Pellet. At the End of this Hole is a Membrane, fastned to a round bony Limb, and stretched like the Head of a Drum, and

therefore by Anatomists called also Tympanum, to receive the Impulse of the sound, and to Vibrate or quaver according to its reciprocal Motions or Vibrations; the small Ear-bones being at the End fastned to the Tympanum, and furnished with a Muscle, serve for the Tension of that Membrane, or the Relaxaticn of it according to the Exigency <**186> of the Animal, it being Stretch'd to the utmost when it would hearken diligently to a lower or more distant sound.

Behind the Drum are several Vaults and Anfractuose Cavities in the Ear-Bone, filled only with what Naturalists call the Implanted Air; so to intend the least sound imaginable, that the Sense might be affected wth it, as we see in subterraneous Caves and Vaults, how the sound is redoubled, and what a great Report it makes, however moderate it be: And because it was for the Behoof of the Animal, that upon any sudden Accident it might be awakened out of its fleep, therefore were there no Shuts or Stopples made for the Ears, that so any loud or sharp Noise might awaken it, as also a soft and gentle Voice or Murmur provoke it to sleep.

Now the Ears, for the Benefit and Conveniencies of the Animal, being always to stand open, because there was some Danger that Insects might creep in thereat and eating their way through the Tympanum harbour in the Cavities behind it; therefore hath Nature loricated or plaistred over the sides of the forementioned Hole with Ear-wax, to stop and entangle any Insect that should attempt to creep in there. But I must confess myself not sufficiently to understand the Nature of sounds to give a full and satisfactory <**187> Account of the Structure and Uses of all the Parts of the Ear. <1717>They ltX o have a mind to le r~-h into the Ctljious Anatoll;nd Use of this Part, may consult Monsieur da Verx y.</1717>

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Fourthly, The next Part I shall take notice of shall be the Teeth; concerning which I find Seven Observations in the honourable Mr. Boyle's Treatise of Final Causes, which I shall briefly recapitulate, and add one or two more.

1. That the Teeth alone, among the Bones continue to grow in Length during a Man's whole Life, as appears by the unsightly Length of one Tooth, when its Opposite happens to fall, or be pulled out; which was most providently design'd to repair the Waste that is daily made of them by the frequent Attrition in Mastication. Here, by the by, I might advise Men to be careful how they attempt to cure this Blemish, by filing or cutting off the Head of such an overgrown Tooth, lest that befall them which happened to a certain Nun in Padua, who, upon cutting of a Tooth in that manner, was presently convulsed, and fell into an Epilepsy, as Bartholine in his Anatomy reports.

II. That that Part of the Teeth which is extant above the Gums, is naked, and not invested with that sensible membrane called Periosteum, wherewith the other Bones are covered. <**188>

III. That the Teeth are of a closer and harder substmce than the rest of the Bones, for the more easy Breaking and Comminution of the more solid Aliments, and that they might be more durable, and not so soon worn down by grinding the Food.

IV. That for the nourishng and cherishing these so necessary Bones, the All wise Author of Things has admirably contrived an unseen Cavity in each side of the Jaw-bone, in which greater Channel are lodged an Artery, a Vein, and a Nerve, which through lesser Cavities, as it were through Gutters, send their twigs to each particular Tooth. V. Because Infants were for a considerable time to feed upon Milk, which needs no Chewing, and lest Teeth thould hurt the tender Nipples of the Nurse, Nature hath deferred the production of them for many Months in a humane foetus, whereas those of divers other Animals, which are reduced to seek betimes Food that needs Mastication, are born with them.

VI. The different Figure and Shape of the Teeth is remarkable. That the Fore-Teeth should be formed broad, and with a thin and sharp Edge, like Chizzels, to cut off and take away a morsel from any solid Food, called therefore Incisores. The next one on each side, stronger, and deeper rooted, and <**189> more pointed, called therefore Canini, in English Eye-Teeth, to tear the more tough rnd resisting sort of Aliments. The rest called Jaw-Teeth or Grinders, in Latin, Molares, are made flat and broad atop, and withal somewhat uneven and rugged that by their Knobs and little Cavities they may the better retain, grind, and commix the Aliments.

VII. because the Operations to be performed by the Teeth, oftentimes require a considerable Firmness and Strength, partly in the Teeth themselves, partly in the Instlruments which move the lower Jaw, which alone is moveable, Nature hath provided this with Strong Muscles, to make it bear forcibly against the upper Jaw.

And thus not only placed each Tooth in a distinct Cavity of the Jaw-bone, as it were in a close, strong, and deep socket, but has furnished the several sorts of Teeth with Hold-fasts suitable to the Stress, that by Reason of their different Offices they are to be put to. And therefore, whereas the Cutters and Eyeteeth have usually but one Root, which in these last named, is wont to be very long; the Grinders, that are employed to crack Nuts, Stones of Fruit, Bones, or other hard Bodies, are furnished with three Roots, and in the upper jaw often with four, because these are pendulous, and the Substance of the Jaw somewhat softer. <**190>

VIII. The Situation of the Teeth is most convenient, viz. the Molares or Grinders behind, nearest the Center of Motion, because there is a greater Strength or Force required to chew the Meat, than to bite a Piece, and the Cuttcrs before, that they may be ready to cut off a Morsel from any solid Food, to be transmitted to the Grinders.

IX. It is remarkable, that the Jaw in Men, and such Animals as are furnished with Grinders, hath an oblique or transverse Motion, which is necessary for Chewing and Comminution of the Meat; which it is observed not to have in those Animals that want the Molares. Now if (as Galen saith) he that shall marshal a Company but of 32 Men in due Order is commended for a skilful and industrious Person, shall we not admire Nature whicn hath so skilfully ranked and disposed this Quire of our Teeth?

Fifthly, The Tongue is no less admirable for the Contexture and manifold Uses of it. First, It is the Organ of Tasting; for being of a spungey Substance, the small Particles of our Meat and Drink being mingled with the Saliva, easily insinuate themselves into the Pores of it, and so do either gratefully affect it, or harshly grate upon it, accordingly as they are figured and moved; and <**191> hereby we discern what is convenient or inconvenient for our Nourishment. It helps us likewise in the Chewing and Swallowing of our meat: And, Lastly, It is the main Instrument of Speaking, a Quality so peculiar to Man, that no Beast coud ever attain to it. And although Birds have been taught to form some Words, yet they have been but a few, and those learnt with great Difficulty; but what is the Chief, the Birds understand not the Meaning of them, nor use them as signs of Things, or their own Conceptions of them; though they may use them as Expresions of their Passions: As Parrots having been used to be fed at the Prolation of certain Words, rnay afterwards, when they are hungry, pronounce the same. For this Des Cartes makes his main Argument, to prove, that Brutes have no Cogitation, because the highest of them could never be brought to signify their Thoughts or Conceptions by any artificial Signs, either Words, or Gestures, (which, if they had any, they would, in all likelihood, be forward enough to do) whereas all Men, both Fools and Mutes, make use of Words or other Signs to express their Thoughlts, about any Subjects that present themselves; which Signs also have no reference to any of their Passions. Whereas the Signs that Brute <**192> Animals may be taught to use, are no other than such as are the Motions of some of their Passions, Fear,

Hope, Joy, etc. Hence some of the Jewish Rabbins did not so absurdly define a Man Animal loquens, a speaking Creature.

Having had occasion just now to mention the Saliva, or Spittle, I am put in mind of the eminent Use of this Humour, which is commonly taken for an Excrement. because a great Part of our Food is dry; therefore Nature hath provided several Glandules to separate this Juice from the Blood, and no less than four <1717>Pair of</1717> Channels to convey it into the Mouth, which are of late Invention, and called by Anatomists Ductus Salivales, through which the Saliva distilling continually, serves well to macerate and temper our Meat, and make it fit to be chewed and swallowed. If a copious Moisture did not, by these Conduit-Pipes, incessantly flow down into the Mouths of Horses and Kine, how were it possible they should for a long time to, ether grind and swallow such dry Meat as Hay and Straw? Moreover, it is useful not only in the Mouth, but in the Stomach too, to promote Concoction <1717>, as we have already noted</1717>.

Sixthly, To the Mouth succeeds the Windpipe, no less wonderful in its Conformation. For because continual Respiration is necessary for the Support of our Lives, it is made <**203 193-202 not pages> with annulary Cartilages to keep it constantly open, and that the Sides of it may not flag and fall together. And lest when we swallow, our Meat or Drink should fall in there, and obstruct it, it hath a strong Shut or Valve, called Epiglottis, to cover it close, and stop it when we swallow: For the more convenient bending of our Necks, it is not made of one entire continual Cartilage, but of many annular ones join'd together by strong Membranes, which Membranes are mtuscular, compounded of streight and circular Fibres, for the more effiectual Contraction of the Wind-Pipe in any strong or violent Expiration or Coughing. And lest the Asperity or Hardness of these Cartilages should hurt the Oesophagus, or Gullet, which is tender, and of a skinny Substance, or hinder the Swallowing of our Meat, therefore these annulary Gristles are not made round, or entire Circles; but where the Gullet touches the Wind-Pipe, there to fill up the Circle, is only a soft Membrane, which may easily give Way to the Dilation of the Gullet. And to demonstrate that this was designedly done for this End and Use, so soon as the Wind-Pipe enters the Lungs, its Cartilages are no longer deficient, but perfect Circles or Rings, because there was no necessity they should be so, but ie was more convenient they should be entire. <**204>

Lastly, For the various Modulation of the Voice the Upper end of the Wind-Pipe is endued with several Cartilages and Muscles, to contract or dilate it, as we would have our Voice Flat or Sharp; and, moreover, the whole is continually moistned with a glutinous Humour issuing out of the small Glandules that are upon its inner Coat, to fence it against the Sharp Air received in, or Breath forced out; yet is it of quick and tender Sense, that it may be easily provoked to cast out by Coughing, whatever may fall into it from without, or be discharged into it from within.

<1717>It is also very remarkable which Caspar Bartholine hath observed in the Gullet, that where it perforateth the Midriff; the carneous Fibres of that Muscular Part are inflected and arcuate, as it were a Spincter embracing and closing it fast, by a great Providence of Nature, lest, in the perpetual Motion of the said Midriff, the upper Orifice of the Stomach should gape, and cast out the Victuals as fast as it received it.</1717>

Seventhly, The Heart, which hath been always esteemed, and really is, one of the principal Parts of' the Body, the <latin>primum vivens, et ultimum moriens</latin> <1717>the First that quickens and the Last that dies,</1717> by its incessant Motion distributing the Blood, the Vehicle of Life, and with it the Vital Heat and Spirits, throughout the whole Body, whereby it doth continually irrigate, nourish, and keep hot and supple all the Members. Is it not admirable, that from this Fountain of Life and Heat, there should be Channels and Conduit-Pipes, to every, even the least and most remote, Part of the Body; just as if from one Water-house, there should be Pipes conveying the Water to every House in a Town, and to every Room in each House; <**205> or from

one Fountain in a Garden, there should be little Channels or Dikies cut to every Bed, and every Plant growing therein, as we have seen more than once done beyond the Seas.

I confess, the Heart seems not to be designed to so noble an Use as is generally believed, that is, to be the Fountain or Conservatory of the vital Flame, and to inspire the Blood therewith; (for the Lungs serve rather for the Accension, or maintaining that Flame, the Blood receiving there from the Air those Particles which are one Part of the Pabulum or Fewel thereof, and so impregnated, running back to the Heart) but to serve as a Machine to receive the Blood from the Veins, and to force it out by the Arteries through the whole Body, as a Syringe doth any Liquor, though not by the same Artifice: And yet this is no ignoble Use, the Continuance of the Circulation of the Blood being indispensably necessary for the quickening and enlivening of all the Members of the Body, and supplying of Matter to the Brain, for the Preparation of the Animal Spirits, the Instruments of all Sense and Motion.

Now for this Use of receiving and pumping out of the Blood, the Heart is admirably contrived. For, First, being a Muscular Part, the Sides of it are compos'd of two Orders of <**206> Fibres, running circularly or spirally from Base to Tip, contrarily one to the other, and so being drawn or contracted contrary-ways, do violently constringe and straiten the Ventricles, and strongly force out the Blood, as we have formerly intimated.

Then the Vessels we call Arteries, which carry from the Heart to the several Parts, have Valves which open outwards like Trap-doors, and give the Blood a free Passage out of the Heart, but will not suffer it to return back again thither; and the Veins, which bring it back from the several Members to the Heart, have Valves or Trap-doors which open inwards, so as to give way unto the Blood to run into the Heart, but prevent it from running back again that way. Besides, the Arteries consist of a quadruple Coat, the Third of which is made up of Annular or Orbicular Carneous Fibres to a good Thickness, and is of a Muscular Nature, after every Pulse of the Heart, serving to contract the Vessel successively with incredible Celerity; so by a kind of peristaltick Motion, impelling che Blood onwards to the capillary Extremities, and through the Muscles, with great Force and Swiftness.

So the Pulse of the Arteries is not only caused by the Pulsation of the Heart, driving the Blood through them, in manner of a Wave or Flush, as Des Cartes <**207> and others, would have it; but by the Coats of the Arteries themselves, which the Experiments of a certain Lovain Physician <margin>Cartes Epist. Vol.1 Ep.77 & Seq. </margin> (the first whereof is Galen's) do, in my Opinion, make good against him.

First, saith he, "if you slit the Artery, and thrust into it a Pipe, so big as to fill the Cavity of it, and cast a strait Ligature upon that Part of the Artery containing the Pipe, and so bind it fast to the Pipe; notwithstanding, the Blood hath free Passage through the Pipe, yet will not the Artery beat below the Ligature; but do but take of the Ligature, it will commence again to beat immediately. But because one might be ready to reply to this Experiment, that the reason why when bound it did not beat, was, becauce the Current of the Blood being straitned by the Pipe, when beneath the Pipe it came to have more Liberty, was not sufficient to stretch the Coat of the Artery, and so cause a Pulse; but when the Ligature was taken of it might flow between the enclosed Tube, and the Coat of the Artery: Therefore he adds another, which clearly evinces, that this could not be the Reason, but that it is something flowing down the Coats of the Artery that causes the Pulse: That is, if you straiten the Artery never so much, provided the Sides of it do not quite meet, and stop all Passage <**208> of the Blood, the Vessel will, notwithstanding, continue still to beat below or beyond the Coarctation. so we see some Physicians, both Ancients, (as Galen) and Modern, were of Opinion, that the Pulse of the Arteries was owing to their Coats; though the first, that I know of,

who observed the third Coat of an Artery to be a muscular Body, composed of annular Fibres, was Dr. Willis.

This Mention of the perstaltick Motion, puts me in mind of an ocular Demonstration of it, in the Gullet of Kine when they chew the Cud, which I have often beheld with Pleasure. For, after they have swallowed one Morsel, if you look stedfastly upon their Throat, you will soon see another ascend, and run pretty swiftly all along the Throat up to the Mouth, which it could not do, unless it were impelled by the successive Contraction, or peristaltick Motion of the Gullet, continually following it. And it is remarkable, that these ruminant Creatures have a Power by the imperium of their Wills, of directing this peristaltick Motion upwards or downwards.

I shall add no more concerning the Heart, but that it, and the Brain, do mutuas opera tradere, enable one another to work: For, First, the Brain cannot itself live, unless it receive continual Supplies of Blood from the Heart, but less can it <**209> perform its Functions of preparing and distributing the Animal Spirits; nor the Heart pulse, unless it receives Spirits, or something else that descends from the Brain by the Nerves. For do but cut asunder the Nerves that go from the Brain to the Heart, the Motion thereof, in most perfect and hot Creatures, ceaseth immediately. which Part began this Round is the Question.

<1717>I find, in the Philosophical Transactions Numb. 280. some notable Observations of the famous Anatomist Mr. William Cowper concerning the Artifice of Nature, in regulating the Motion of the Blood in the Veins and Arteries to assist and promote it in the one, and moderate it in the other, which I shall give you in his own Words:

"As the Arteries, (saith he) are known to export the Blood, so the Veins to carry it back again to the Heart; but having already described their Extremities, we come now to the large Trunks of the Veins, and here, as in the Arteries, we find the common Practice of Nature, in disposimg the Branches of Veins to discharge the refluent Blood into the next adjacent Trunk, and so on to the Heart. As the Arteries afford abundance of Instances of Checks given to the Velocity of the Current of Blood through several Parts, so the Veins supply us with as many Artifices, to assist its regular Return to the Heart, as well as favour those Contrivances in the Arteries.

The carotid, vertebral, and splenick Arteries, are not only variously contorted, but also here and there dilated to moderate the Motion of the Blood; so the Veins that correspond to those Arteries are also variously dilated. The Beginnings of the internal Jugulars have a bulbous Cavity, which are diverticula to the refluent Blood, in the Sinus's of the dura Mater, lest it should descend too fast into the Jugulars. The like has been taken Notice of by Dr. Lower, in the Vertebral Sinus's. The Splenick Vein has divers Cells opening into it, near its Extremities in Humane hodies; but in Quadrupeds, the Cells open into the Trunks of the Splenick Veins.

The Spermatick Veins do more than equal the Length of the Arteries of the Testes in Men; their various Divisions, and several Inosculations, and their Valves are admirably contrived to suspend the Weight of the Blood, in order to discharge it into the larger Trunks of the Veins; and were it not that the refluent Blood from the Testes, is a Pondus to the influent Blood from the Arteries, and still lessens its Current in the Testes, these Spermatick Veins, like those of other Parts, might have discharged the Blood into the next adjacent Trunk.

Who can avoid Surprize at the Art of Nature, in contriving the Veins, that bring Part of the refluent Blood from the lower Parts of the Body, when they consider the Necessity of placing the Humane Heart, as well as that of most quadrupeds, so far from the Center of the Body towards its upper Part. It is for that End neceery, that the large Trunks of the Veins and Arteries should not associate each other. For if all the Blood sent to the lower Parts, by the descending Trunk of the Aorta,

should return to the Heart again by one single Trunk, (as it is sent out from thence) the Weight of so much Blood in the ascending Trunks of the vena Cava, would oppose all the Force the Heart could give it from the Arteries, and hinder its Ascent. For this Reason the vena Azygos, or fine Pari, is contrived to convey the B!ood sent to the Muscles of the Back and Thorax, into the descending Trunk of the vena Cava above the Heart. Hence it's evident, that more Blood comes into the Heart by the descending or upper Trunk of the vena Cava, than pases out by the ascending Trun of the Aorta. Nor does the Quantity of Blood convey'd to the Heart by the superior Trunk of the Cava, seem, without some other Design in Nature besides transporting it thither, to free the inserior Trunk from its Weight. But perhaps it was necesary so much Blood should be ready there to join with the Chyle, for its better Mixture, before it reaches the right Auricle of the Heart. So far Mr. Cowper. </1717>

Eighthly, The next Part I shall treat of shall be the Hand, this <greek>organon organOn</greek> or superlative Instrument, which serves us for such a multitude of Uses, as it is not easy to enumerate; whereto, if we consider the Make and Structure of it, we shall find it wonderfully adapted. First, It is divided into four Fingers bending forward, and one opposite to them bending backwards, and of greater Strength than any of them singly, which we call the Thumb, to join with them severally, or united; whereby it is fitted to lay hold of Objects of any Size or Quantity.

The least Things, as any small single Seed, are taken up by the thumb and Fore-finger; those a little greater by the Thumb and two Fingers, which also we chiefly employ to manage the Needle in sowing, and the Pen in Writing: When we would take up a greater Quantity of any Thing, we make use of the Thumb, and <**210> all the Fingers. Sometimes we use one Finger only, as in pointing at any Thing, picking Things out of Holes, or long and narrow Vessels; sometimes all severally at one time, as in stopping the Strings when we play upon any musical Instruments.

Secondly, The Fingers are strengthened with several Bones, jointed together for Motion, and furnished with several Muscles and Tendons, like so many Pullies to bend them circularly forwards; which is most convenient for the firm holding, and griping of any Object: Which of how great, constant, and necessary Use it is in pulling or drawing, but especially in taking up, and retaining any sort of Tool or Instrument to work withal, in Husbandry, and all mechanick Arts, is so obvious to every Man's Observation, that I need not spend Time to instance in Particulars: Moreover, the several Fingers are furnished with several Muscles, to extend and open the Hand and to move to the Right and Left: And so this Division and Motion of the Fingers doth not hinder, but that the whole Hand may be employed, as if it were all of a Piece; as we see it is, either expanded, as in striking out, smoothing and folding up of Cloaths, and some mechanick Uses; or contracted, as in Fighting, Kneading of Dough, and the like.

It is also notable, <**211> and indeed wonderful, that the Tendons, bending the middle joint of the Fingers, should be perforated to give Passage to the Tendons of the Muscles which draw the uppermost joints, and all bound down close to the Bone with strong Fillets, lest they should start up, and hinder the Hand in its Work, standing like so many Bow-strings.

Thirdly, The Fingers ends are strengthened with Nails, as we fortify the Ends of our Staves or Forks with Iron-Hoops or Ferules; which Nails serve not only for Defence, but for Ornament and many Uses. The Skin upon our Fingers ends is thin, and of most exquisite Sense, to help us judge of any Thing we handle. If now I thould go about to reckon up the several Uses of this Instrument, Time should sooner fail me than Matter.

By the Help of this we do all our Works, we build ourselves Houses to dwell in; we make ourselves Garments to wear; we plow and sow our Grounds with Corn, dress and cultivate our Vineyards, Gardens, and Orchards, gather and lay up our Grain, and Fruits, we prepare and make ready our

Victuals: Spinning, Weaving, Painting, Carving, Engraving, and that Divinely invented Art of Writing, whereby we transmit our own Thoughts to Posterity, and converse with, and participate the Observations <*212> and Inventions of them that are long ago Dead, all

performed performed by this. This is the only Instrument for all Arts whatsoever; no Improvement to be made of any Experimental Knowledge without it. Hence (as Aristotle saith well) they do amiss that complain, that Man is worse dealt with by Nature than other Crestures; whereas, they have some Hair, some Shells, some Wool, some Feathers, some Scales, to defend them selves from the Injuries of the Weather: Man alone is born Naked, and without all Covering; whereas, they have natural Weapons to defend themselves, and offend their Enemies, some Horns, some Hoofs, some Teeth, some Talons, some Claws, some Spurs and Beaks; Man hath none of all these, but is weak, and feeble, and unarmed sent into the World.

Why, a Hand, with Reason to use it, supplies the Uses of all these, that's both a Horn, and a Hoof; and a Talon, and a Tusk, etc. because it enables us to use weapons of these, and other Fashions, as Swords, and Spears, and Guns. Besides, this Advantage a Man hath of them, that whereas they cannot at Pleasure change their Coverings, or lay asde their Weapons, or make use of others as Occasion serves, but must abide Winter and Summer, Night and Day, with the same Cloathing on their Backs, <**213> and sleep with their Weapons upon them; a Man can alter his Cloathing according to the Exigency of the Weather, go warm in Winter, and cool in Summer, cover up himself hot in the Night, and lay aside his Cloaths in the Day, and put on or off more or fewer, according
as his Work and Exercise is: And can, as Occasion requires, make use of divers sorts of Weapons, and Choice of such at all Turns, as are most proper and convenient; whereby we are enabled to subdue and rule over all other Creatures; and use for our own Behoof those Qualities wherein they excel, as the Strength of the Ox, the Valour and Swiftness of the Horse, the Sagacity and Vigilancy of the Dog, and so make them as it were our own.

Had we wanted this Member in our Bodies, we must have lived the Life of Brutes without House or Shelter, but what the Woods and Rocks would have afforded; without Cloaths or Covering; without Corn, or Wine, or Oil, or any other Drink but Water; without the Warmth and Comfort, or other Uses of Fire, and so without any artificial bak'd, boil'd, or roast Meats; but must have scrambled with the wild Beasts for Crabs, and Nuts, and Acorns, and such other Things as the Earth puts forth of her own Accord. We had laid open and exposed <**214> to Injuries, and had been unable to resist or defend ourselves against almost the weakest Creature.

The remaining Parts I shall but briefly run over;

That the Back-bone should be divided into so many Vertebres for commodious bending, and not be one entire rigid Bone, which being of that Length would have been often in Danger of snapping in sunder:

<1717>That it should be made tapering in the Form of a Pillar, the lower Vertebres being the broadest and largest, and the Superior in order, lesser and lesser; for the greater Firmness and Stability of the Trunk of the Body: </1717>

That the several Vertebres should be so elegantly and artificially compacted and joined together, that they are as Strong and firm, as if they were but one Bone: That they should be all perforated in the Middle with a large Hole for the Spinal Marrow or Pith to pass along; and each Particular have a Hole on each Side to transmit the Nerves to the Muscles of the Body, to convey both Sense and Motion:

<1717>That by Reason of the forementioned close Connexion of the Vertebres, it should be so formed, as not to admit any great Flexture or Recess from a Right Line, any Angular, but only a moderate Circular Bending; lest the Spinal Pith should be compressed, and so the free Intercourse or Passage of the Spirits to and fro be stop'd.

One Observation relating to the Motion of the Bones in their Articulations, I shall here add, That is, the Care that is taken, and the Provision that is made, for the easy and expediate Motion of them; their being to that Purpose a twofold Liquor prepared for the Inunction and Lubrification of their Heads or Ends, I. An Oily one, furnished by the Marrow: 2. A Mucilaginous, supplied by certain Glandules seated in the Articulations, both which together make up the most apt and proper Mixture for this Use and End that can be invented or thought upon. For not only both the Ingredients are of a lubricating Nature; but there is this Advantage gained from their Composition, that they do mutually improve one another: For the Mucilage adds to the Lubricity of the Oil, and the Oil preserves the Mucilage from Inspissation, and contracting the Consistency of a Gelly: Now this Inunction is useful, indeed necesary, for three Ends chiefly.

1. For the facilitating of Motion. For tho' the Ends of the Bones are very smooth, yet were they dry, they could not with that Readiness and ease, nay, not without great Difficulty, yield to and obey the Plucks and Attractions of the Motory Muscles; as we see Clocks and Jacks, though the Screws and Teeth of the Wheels and Nuts be never so smooth and polish'd, yet if they be not oil'd, will hardly move, tho' you clog them with never so much Weight; but if you apply but a little Oil, they presently whirl about very swiftly with the tenth Part of the Force.

2. For preserving the Ends of the Bones from an Incalescency, which, they being hard and solid Bodies, would necessarily contract from a swift and long continuing Motion; such as that, of Running, or Mowing, or Threshing, or Sawing, and the like, if they immediately touched and rubbed against one another with that Force they must needs do; especially in running, the whole Weight of the Body bearing upon the Joints of the Thighs and Knees: So we see in the Wheels of Waggons or Coaches, the Hollows of the Naves, by their swift Rotations on the Ends of the Axle-trees, produce a Heat, sometimes so intense, as to set them on fire, to prevent which, they stand in need to be frequently anointed or besmear'd with a Mixture of Grease and Tar, imitating the forementioned natural Composition of Oil and Mucilage. Nay, Bodies softer a great deal than Metals, contract a great Heat by Attrition; as is evident from those black circular Lines we see on Boxes, Dishes, and other turned Vessels of Wood, which are the Effects of Ignition, caused by the Pressure of an edged Stick upon the Vessel turned nimbly in the Lathe. And if there had not been a Provision in the Joints against such a preternatural Incalescence upon their violent Motion, this would have made a slothful World, and confin'd us to Leisurely and deliberate Movements, when there were the most urgent and hasty Occasions to quicken us.

3. For the preventing of Attrition, and wearing down the Ends of the Bones by their Motion, and rubbing one against another, which is so violent and lasting sometimes, that it is a Wonder any Inunction should suffice, to secure their Heads from Wasting and Consumption. I have often seen the Tops of the Teeth which are of a harder Substance than the rest of the Bones) worn off by Mastication, in Persons who have lost most of their Grinders, and been compelled constantly to make use of three or four only in chewing, so low, that at last the inward Marrow and Nerve lay bare, and they could no longer, for Pain, make use of them. So that had there not been this Provision made for the anointing the Bones, the curious Workmanship of Nature in adapting them so exactly one to another, as was most fit for the easy Performance of all those Motions to which they were destined, would not suffice for Use: But the stirring Part of Mankind would soon find themselves fitter for an Hospital, than for Action, and the Pursuit of Business.

These Observations I acknowledge myself to have borrowed of a late ingenious Writer of Osteology <margin>Mr Clopton Havers</margin> who thus concludes his Discourse upon this Subject. And here we cannot avoid the Notice of the visible Footsteps of an infnite Reason, which as they are deeply impressed upon the Universe, so more especially on the sensible Parts of it in those rational Contrivances which are found in Animals: And we can never sufficiently admire the Wisdom and Providence of our great Creator, who has given all Parts in these animated Beings, not only such a Structure as renders them fit for their necessary Motions, and designed Functions, but withal the Benefit and Advantage of whatever may preserve them, or facilitate their Action.

Moreover, the Artifice of Nature is wonderful in the Construction of the Bones that are to support the Body, and to bear great Burdens, or to be employed in strong Exercises, they being made hollow, for Lightness and Stiffness. For, we have before noted, a Body that is hollow may be demonstrated to be more rigid and inflexible, than a solid one of the same Substance and Weight. so that here is Provision made for the Stiffness and Lightness of the Bones. But the Ribs, which are not to bear any great Weight, or to be strongly exercised, but only to fence the Breast, have no Cavity in them, and towards the fore Part or Breast are broad and thin, that so they might bend and give way without Danger of Fracture; when bent returning by their elastick Property to their Figure again. Yet is not the Hollow of the Bones altogether useless, but serves to contain the Marrow; which supplies an Oil for the Maintaining and Inunction of the Bones and Ligaments, and so facilitating their Motion in the Articulations; and particularly which we mentioned not before) of the Ligaments, preserving them from Dryness and Rigidity, and keeping them supple and flexible, and ready to comply with all the Motions and Postures of that moveable Part to which they appertain: And lastly, to secure them from Disrupption, which, as strong as they are, they would be in some Danger of, upon a great and suddain Stretch or Contortion, if they were dry, etc. See more to this Purpose in the Treatise fore-quoted, p. 183.

</1717> That whereas the Breast is encompassed with Ribs, the Belly is left free; that it might give way to the Motion of the Midriff in Respiration; and to the necessary Reception of Meat and Drink; as also for the convenient Bending of the Body; and in Females, for that extraordinary Extension that is requisite in the Time of their Pregnancy. <**215>

<1717>That the Lungs should be made up of such innumerable Air-Pipes and Vesicles interwoven wlth Blood-Vessels in order to purify, ferment, or supply the sanguineous Mass with Nitro-Aerial Particles, which rush in by their Elastick Power upon the Muscular Extension of the Thorax, and so feed the Vital Flame and Spirits; for upon oberucting this Communication, all is presently extinct, no Circulation, no Motion, no Heat, nor any Sign of Life remains.</1717>

That the Stomach should be membranous and capable of Dilatation and Contraction, according to the Quantity of Meat contained in it, that it should be situate under the Liver which by its Heat might cherish it, and contribute to Concoction: That it should be endued with an acid <1717>or mandulous</1717> Ferment or some corruptive Quality for so speedy a Dissolution of the Meat, and Preparation of Chyle that after Concoction it should have an Ability of contracting itself, and turning out the Meat. <1717>That the Guts should immediately receive it from the Phylorous, farther elaborate, prepare, and separate it, driving by their Peristaltick Motion the Chyle into the Lacteals, and the excrementitious Parts to the Podex, from whence there is no Regress, unless when the Valve of the Colon is torn and relax'd: But for the curious Structure of these Parts, see more in Kerkringius, Glisson, Willis, and Peyes. </1717>

That the Bladder should be made of a membranous Substance, and so extremely dilatable for receiving and containing the Urine, till Opportunity of emptying it; that it should have Shuts for the Ends of the Ureters so artificially contrived as to give the Urine free Entrance, but to ltop all Passge backward, so that they will not transmit the Wind, though it be strongly blown and forced in.

That the Liver should continually separate the Choler from the Blood, and empty it into the Intestines, where there is good Use for its not only to provoke Dejection, but also to attenuate the Chyle, and render it so subtle and fluid, as to enter in at the Orifices of the Lacteous Veins. <**216>

<1717>That in the Kidneys there should be such innumerable little Siphons or Tubes conveying the Urinose Particles to the Pelvis and Ureters, first discover'd by Bellini, and illustrated by Malpighy; that indeed all the Glands of the Body should be Congeries of various sorts of Vessels cur'd, circumgyrated, and complicated together, whereby they give the Blood time to stop and separate through the Pores of the Capillary Vessels into the Secretory ones, which afterwards all exonerate themselves into one common Ductus; as may be seen in the Works of Dr. Wharton, Graaf, Bartholine, Rudback, Bilsius, Malpighi, Nuck, and others. That the Glands should separate such Variety of Humours, all different in Colour, Taste, Smell, and other Qualities.</1717>

Finally, That all the Bones, and all the Muscles, and all the Vesels of the Body should be so admirably contrived, and adapted, and compacted together for their several Motions and Uses, and that most Geometrically, according to the strictest Rules of Mechanicks; that if in the whole Body

you change the Figure, Situation and Conjunction but of one Part, if you diminish or increase the Bulk and Magnitude: In fine, if you endeavour any Innovation or Alteration, you marr and Spoil, instead of Mending. How can all these Things put together, but beget Wonder and Astonishment?

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In the Muscles alone there seems to be more Geometry, than in all the artificial Engines in the World; and therefore the different Motions of Animals, are a Subject fit only for the great Mathematicians to handle; amongst whom, Steno, Dr. Croon, and above all, Alphonso Borelli, have made their Essays tolvards it.</1717>

That under one Skin there should be such infinite Variety of Parts, variously mingled, hard with soft, fluid with fix'd, solid with hollow, those in Rest with those in Motion; some with Cavities, as Mortesses to receive, others with Tenons to fit those Cavities; all these so pack'd and thrust so close together, that there is no unnecessary Vacuity in the whole Body, and yet so far from clashing or interfering one with another, or hindring each others Motions, that they do all friendly Conspire, all help and assist mutually one the other, all concurr in one general End and Design, the Good and Preservation of the Whole, are certainly Arguments and Effects of Infinite Wisdom and Counsel; so <**217> that he must needs be worse than mad that can find in his Heart to imagine all these to be casual and fortuitous, or not provided and designed by a most Wise and Intelligent Cause.

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Every Part is cloath'd, join'd togethet, and corroborated by Membranes, which upon several Occasions (as Extravasations of Humours, Compressions or Obstructions of Vessels) are capable of a prodigious Extension, as we see in the Hydatides of the Female Testicles or Ovaries, in Hydropical Tumors of the Lymphaeducts, of the Scrotum and Peritonaeum, out of the last of which alone twenty and even forty Gallons of Water have been drawn by a Paracentesis, or Tapping, for which we have the undoubted Authority of Tulpius, Meekren, Pechlin, Blasius, and other Medical Writers. What vast Sacks and Bags are necessary to contain such a Collection of Water, which seems to issue from the Lymphaeducts, either delacerated or obstructed, and exonerating themselves into the Foldings, or between the Duplicatures of the Membranes?

Those Parts which one would think were of little Use in the Body, serving chiefly to fill up empty Spaces, as the Fat, if examined strictly, will be found very beneficial and serviceable to it. I. To cherish and keep it warm, by hindring the Evaporation of the hot Streams of Blood, as Cloaths keep us warm in Winter, by reflecting and doubling the Heat.

2. To nourish and maintain the Body for some Time when Food is wanting, serving as Fewel to preserve and continue the natural Heat of the Blood, which requires an oily or sulphureous Pabulum, as well as Fire. Hence, upon long Abstinence and Fasting, the Body grows lean. Hence also some Beasts, as the Marmotto, or Mus Alpinus, a Creature as big or bigger than a Rabbet, which absconds all Winter, doth (as Hildanus tells us) live upon its own Fat. For in the Autumn, when it shuts itself up in its Hole which it digs with its Feet like a Rabbet, making a Nest with Hay or Straw, to lodge ltself warm) it is very fat; [Hildanus took out above a Pound and a half of Fat between the Skin and Muscles, and a Pound out of the Abdomen] but on the contrary in the Spring-time when it comes forth again, very lean, as the Hunters experience in those they then take.

3. The Internal Fat serves for the Defence and Security of the Vessels, that they might lie soft, and be safely convey'd in their Passage, wherefore it is especially gathered about them.

By what Pores, or Passages, or Vessels, the Fat is separated from the Blood when it is redundant, and again absorpt into it when it is deficient, is a Matter of curious Enquiry, and worthy to be industriously sought out by the most sagacious and dextrous Anatomists. The Vessels whereunto it is received, and wherein contained, are by the Microscope detected to be Bladders, and those doubtless perforated and pervious one into another; and though for their excessive Subtlety and Thinness they appear not in a lean Body, yet seem to have been primitively formed and provided by Nature to receive the Fat upon Occasion. Why the Fat is collected chiefly about some particular Parts and Vessels, and not others; as for Example, the Reins and the Caul, I easily consent with Galen and others, the Reason to be the cherishing and keeping warm of those Parts

upon which such Vessels are spread; so the Caul serves for the warming the lower Belly, like an Apron or Piece of Woolen Cloth. Hence a certain Gladiator, whose Caul Galen cut out, was so liable to suffer from the Cold, that he was constrained to keep his Belly constantly covered with Wool. For the Intestines containing a great deal of Food, thereto undergo its last Concoction, and no Vessels of Blood penetrating it, and flowing through it to keep it warm, they had need be defended from the Injuries of the external Air, by outward Coverings. Why there should be such copious Fat gathered about the Reins to enclose them, is not so easy to discern: But surely there is a great and constant Heat required there for the Separation of the Urine from the Blood; the constant Separation and Excretion whereof, is necessary for the Preservation of Life. And we see, if the Blood be in any Degree chill'd, the Secretion of Urine is in a great Measure stop't, and the Serum cast upon the Glandules of the Mouth and Throat. And if the Blood be extraordinarily heated by Exercise, or other wise, it casts off its Serum plentifully by Sweat, which may be effected by the swift Motion of the Blood through the Glandules of the Skin, where its plentiful Streams being strengthen'd and constipated into a Liquor, force their way through those Emunctories, which at other times transmit only insensible Vapors.

Some such Effect may be wrought upon the Blood, by the Heat of the Kidneys. Certain it is, that the Humours, excerned by Sweat and Urine, are near a-kin, if not the same; and therefore it is worthy the Consideration, whether there might not be some Use made of Sweating in a Suppression of Urine. But I digress too far.

I shall only add to this Particular, That because the Design of Nature in collecting Fat in these Places, is for the forementioned Use; it hath, for the effecting thereof, fitted the Vessels there with Pores or Passages proper for the Separation and Transmission of it.</1717> I should now

proceed to treat of the Generation and Formation of the Foetus in the Womb, but that is a Subject too difficult for me to handle; the Body of Man and other Animals being formed in the dark Recesses of the Matrix, or as the Psalmist phrases it, Psalm CXXXIX. 14. "made in secret, and curiosly wrought in the lowest Parts of the Earth." This Work is so admirable and unaccountable, that neither the Atheists nor Mechanick Philosophers have attempted to declare the Manner and Process of it; but have (as I noted before) very cautiously and prudently broke off thels Systems of Natural Philosophy here, and left this Point untouch'd; and those Accounts which some of them have attempted to give of the Formation of a few of the Parts, are so excessively absurd and ridiculous, that they need no other Confutation than ha, ha, he.

And I have already farther shewn, that to me it seems impossible that Matter divided into as minute and subtle Parts as you will, or can imagine, and those moved according to what Catholick laws soever can be devised, <**218> should without the Presidency and Direction of some intelligent Agent, by the meer Agitation of a gentle Heat, run itself into such a curious Machine, as the Body of Man is.

Yet must it be confess'd, that the Seed of Animals is admirably qualified to be fashioned and formed by the Plastick Nature into an Organical Body, containing the Principles or component Particles of all the several homogeneous Parts thereof; for indeed every Part of the Body seems to club and contribute to the Seed, else why should parents that are born Blind or Deaf, or that want a Finger, or any other Part, or have one superfluous, sometimes generate Children that have the same Defects or Imperfections; and yet (which is wonderful) nothing of the Body or grosser Matter of the Seed comes near the first Principle of the Foetus, or in some so much as enters the Womb, but only some contagious Vapour, or subtle Effluviums thereof; <1717> which seems to animate the Gemma or Cicatricula of the Egg contain'd in the Female Ovary, before it passes through the Tubes, or Cornua, into the Uterus. How far the Animalcules observ'd in the Seed of Males, may contribute to Generation, I leave to the more sagacious Philosophers to enquire, and shall here content myself with referring the Reader to the several Letters publish'd by Mr. Lewenhoek.

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But to what shall we attribute the Foetus its Likeness to the Parents, or omitting them to the precedent Progenitors, as I have observ'd some Parents that have been both black Hair'd to have generated most red Hair'd Children because their Ancestor's Hair hath been of that Colour; or why are Twins so <**220> often extremely alike? Whether is this owing to the Efficient, or to the Matter?

Those Effluvia we spake of in the Male Seed, as subtle as they are, yet have they a great, if not the greatest Stroke in Generation, as is clearly demonstrable in a Mule, which doth more resemble the Male Parant, that is the Ass, than the Female or Horse. But now, why such different Species should not only mingle together, but also generate an Animal, and yet that that hybridous Production should not again generate, and so a new Race be carried on, but Nature should stop here, and proceed no farther, is to me a Mystery, and unaccountable.

One thing relating to Generation I cannot omit; that is, the Construction of a Set of Temporary Parts, (like Scaffolds in a Building) to serve a present End, which are afterwards laid aside, afford a strong Argument of Counsel and Design. Now for the Use of the Young during its Enclosure in the Womb, there are several Parts formed, as the Membranes inveloping it, called the Secundines, the Umbilical Vessels, one Vein and two Arteries; the Urachus, to convey the Urine out of the Bladder, and the placenta uterina; Part whereof fall away at the Birth, as the Secundines and Placenta, others degenerate into Ligaments, as the Urachus, and <**220> part of the Umbilical Vein: besides which, because the Foetus during its Abode in the Womb, hath no Use of Respiration by the Lungs, the Biood doth not all, I may say not the greatest Part of it, flow through them; but there are two

Passages or Channels contrived, one called the Foramen Ovale, by which Part of the Blood brought by the Vena Cava, passeth immediately into the Left Ventricle of the Heart, without entring the Right at all; the other is a large Arterial Chanel passing from the pulmonary Artery immediately into the Aorta, or great Artery which likewise derives Part of the Blood thither; without running at all into the Lungs: These two are closed up soon after the Child is born, when it breathes no more (as I may so say) by the Placenta Uterina, but Respiration by the Lungs is needful for it.

It is here to be noted, that though the Lungs be formed so soon as the other Parts, yet during the Abode of the Foetus in the Womb, they lie by as useless. In like manner I have observed, that in ruminating Creatures, the three foremost Stomachs, not only during the Continuance of the Young in the Womb, but so long as it is fed with Milk, are unemployed and useless, the Milk passing immediately into the fourth. <**221>

Another Observation I shall add concerning Generation, which is of some moment, because it takes away some Concessions of Naturalists that give countenance to the Atheists fictitious and ridiculous Account of the first production of Mankind, and other Animals, viz. that all sorts of Insects, yea, and some Quadrupeds too, as Frogs and Mice, arc produced spontaneously. My Observation and Affirmation is, that there is no such thing in Nsture, as AEquivocal or Spontaneous Generation, but that all Animals, as well small as great, not excluding the vilest and most contemptible insect, are generated by Animal Parents of the same Species with themselves; that Noble Italian Vertuoso, Francisco Redi, having experimented, that no

putrified Flesh (which one would think were the most likely of any thing) will of itself, if all Insects be carefully kept from it, produce any: The same Experiment, I remember, Dr. Wilkins, late Bishop of Chester, told me, had been made by some of the Royal Society. No Instance against this Opinion doth so much puzzle me, as Worms bred in the Intestines of Man, and other Animals. But Seeing the round Worms do manifestly generate, and probably the other Kinds too, it's likely they come originally from Seed, which how it was <**222> brought into the Guts, may afierwards possibly be discovered.

Moreover, I am inclinable to believe, that all Plants too, that themselves produce Seed, which are all but some very imperfects ones, which scarce deserve the Name of Plants) come of Seeds themselves. For that great Naturalist Malpighius, to make Experiment whether Earth would of itself put forth Plants, took some purposely digged out of a deep place, and put it into a Glass-Vessel, the Top whereof he covered with Silk many times doubled, and strained over it, which would admit the Water and Air to pass through, but exclude the least Seed that might be wafted by the Wind; the Event was that no Plant at all sprang up in it; Nor need we wonder how in a Ditch, Bank, or Grass-Plat, newly dig'd, or in the Fen-Banks in the Isle of ElY, Mustard should abundantly Spring up, where, in the Memory of Man, none hath been known to grow, for it might come of Seed wnich had lain there more than a Man's Age. some of the Ancients mentioning some Seeds that retain thoir Fecundity Forty Years.

<1717>

And I have found in a Paper received from a Friend, but whom I have forgotten, That Melon-Seeds, after Thirty Years, are best for raising of Melons. As for the Mustard that sprung up in the Isle of Ely, though there had never been any in that Country, yet might it laave been brought down in the Chanels by the Floods, and so being thown up the Banks, together with the Earth, might germinate and grow there.

And, indeed, a Spontaneous Generation of Antmals and Plants, upon due Examination will be found to be nothing less than a Creation of thern. For after the Matter was made, and the Sea and dry

Land separated, how is the Creation of Plants and Animals described but by a commanding, that is, effectually causing the Waters and Earth to produce their several Kinds without any Seed? Now Creation being the Work of Omnipotency, and incommunicable to any Creature, it must be beyond the Power of Nature or natural Agents, to produce things after that manner. And as for God Almighty, He is said to have rested from His Work of Creation after the Seventh Day. But if there be any Spontaneous Generation there was nothing done at the Creation, but what is daily done; for the Earth and Water produc'd Animals then without Seed, and so they do still.

Because some, I understand, have been offended at my consident Denial of all Spontaneous Generation, accounting it too bold and groundless, I shall a little enlarge upon it, and give my Reasons, in order to their Satisfaction.

First, then, I say, such a Spontaneous Generation seems to me to be nothing less than a Creation. For, Creation being not only a Production of a Thing out of Nothing, but also out of indisposed Matter, as may be clearly inserred from the Scripture, and is agreed by all Divines; this Spontaneous Generation, being such a Production, wherein doth it differs from Creation? Or, what did God Almighty do at the first Creation of Animals and Plants, more than what (if this be true) we see every day done? To me, I must consess, it seems almost demonstrable, that whatever Agent can introduce a Form into indisposed Matter, or dispose the Matter in an instant, must be superior to any natural one, not to say Omnipotent.

Secondly, Those who have with the greatest Diligence and Application considered and searched into this Matter, as those eminent Virtuosi, Marcellus Malpighius, Franciscus Redi, John Swammerdam, Lewenhoek, and many others, are unanimously of this Opinion, save

that Franc. Redi would except such Insects as are bred in Galls, and some other Excrescencies of Plants. Now their Authority weighs more with me, than the general Vogue, or the concurrent Suffrages of a thousand others who never examined the thing so carefully and circumspectly as they have done, but run away with the Cry of the common Herd of Philosophers.

First of all, Dr. Swammerdam, who hath been, to the best Purpose of any Man I know of, busied in searching out and observing the Nsture of all Insects in general; all in general I say (for as to one particular Insect, to wit, the Silk-Worm, I must except Signior Malpighy; and to one genus of them, to wit, Spiders, Dr. Lister; in his general History of Insects, written in Low Dutch, and translated into French, p. 47. hath these Words, <french>Nous disons, qu'il ne fait dans toute la nature aucune generation par accident, &c.</french> We affirm, that there is not in all Nature any accidental [or Spontaneous] Generation, but all come by Propagation; wherein Chance hath not the least Part or Interest. And in p.159. speaking of the Generation of Insects out of Plants, in Contradiction I suppose to Signior Redi, he saith, <french>Nous croyons absolument, &c.</french> We do absolutely believe that it is not possible to prove by Experience, that any Insects are engendred out of Plants: But on the contrary, we are very well informed and assured, that these little Animals are not Shut up in or enclosed there for any other Reason than to draw thence their Nourishment. It's true indeed, that by a certain, constant, and immutable Order of Nature, we see many sorts of Insects affixed to particular Species of Plants and Fruits, to which the respective Kinds fasten themselves as it were by Instinct. But we are to know, that they all come of the Seed of Animalcules of their own Kind, that were before laid there. For these Insects do thrust their Seed or Eggs so deep into the Plants, that they come to be afterwards as it were united with them, and the Aperture or Orifice by which they entred, quite closed up, and obliterated; the Eggs being hatched and nourished within. We have often found the Eggs of Insects so deeply sunk into the tender Buds of Trees, that without hurting of them it was impossible to draw them out. Many Instances he produces in several sorts of Insects making their way into Plants, which, though they be well worth the reading, are too long to transcribe.

Secondly, That Great and Sagacious Naturalist, and most Accurate Examiner of these things, Signior Malpighy, in his Treatise of Galls, under which Name he comprehends all Preternatural and Morbose Tumors and Excrescencies of Plants, doth demonstrate in particular, that all such Warts, Tumors, and Excrescencies, where any Insects are found, are excited or raised up either by some Venenose Liquor, which together with their Eggs, such Insects shed upon the Leaves, or Buds, or Fruits of Plants, or boring with their Terebrae, instill into the very Pulp of such Buds or Fruits; or by the contagious Vapor of the very Eggs themselves producing a Mortification or Syderation in the Parts of Plants on which they are laid; or lastly, by the Grubs or Maggots hatch'd of the Eggs laid there, making their way with their Teeth into the Buds, Leaves, or Fruit, or even the Wood itself, of such Plants on which their Eggs were laid.

So at last he concludes, <latin>Erunt itaque Gallae et reliqui plantarum tumores morbosae excrescentiae, vi depositi ovi à turbata plantarum compage, et vitiato humorum motu excitatae, quibus inclusa ova et animalcula velut in utero foventur et augentur, donec manifestatis firmatisquc propriis partibus, quasi exoriantur novam exoptantia auram.</latin> We conclude therefore, that Galls, and other Tumors of Plants, are nothing else but Morbose Excrescencies, raised up by the Force of the Eggs there laid, disturbing the Vegetation and temper of the Plants, and perverting the Motion of their Humours and Juices; wherein the enclosed Eggs and Animalcules are cherished, nourished, and augmented, till their proper Parts being manifested, explicated, and hardned, or strengthned, they are as it were new-born, affecting to come forth into the open Air. In the same Treatise he describes the hollow Instrument, (Terebra he calls it, and we may English it Piercer) wherewith many Flies are provided, proceeding from the Womb, with which they perforate the Tegument of Leaves, Fruits, or Buds, and through the hollow of it inject their Eggs into the Holes or Wounds which they have made, where, in process of Time, they are hatch'd and nourished. This he beheld one of these Insects doing, with his own Eyes, in the Bud of an Oak; the manner whereof he describes, p. 47. which I shall not transcribe, only take Notice, that when he had taken off the Insects, he found in the Leaf very little and Diaphanous Eggs, exactly like to those which yet remained in the Tubes of the Fly's Womb. He adds farther, that it is probable, that there may be Eggs hidden in divers Parts of Plants, whereof no Footstep doth outwardly appear, but the Plant remains as entire, and thrives as well as if there were no Insect there: Nay, that some may be hidden and cherished in dry Places, (not wanting any Humour to feed them) as in Sear-Wood, yeas in Earthen-Vessels, and Marbles themselves.

Indeed to me it seems unreasonable, that Plants being of a lower Form or Order of Being, should produce Animals; for either they must do it out of indisposed Matter, and then such Production would amount to a Creation, or else they must prepare a fit Matter, which is to act beyond their Strength, there being required to the Preparation of the Sperm of Animals a great Apparatus of Vessels, and many Secretions, Concoctions, Reflexions, Digestions and Circulations of the Matter, before it can be rectified and exalted into so noble a Liquor: And Besides, there must be an Egg, too; for we know <latin>ex ovo omnia,</latin> to the Perfection whereof; there are as many Vessels, and as long a Process required. Now in Plants there are no such Vessels, and consequently no such Preparation of Eggs or Sperm, which are the necessary Principles of Animals.

Thirdly, that worthy Author of our own Country, I mean Dr. Lister, in his Notes Upon Geodartius Insect. Numb. 16. p. 47. hath these Words, <latin>Non enim inducor ut credam, hoc, vel aliud quodvis Animal, modo quodam spontaneo è Planta produci, et alii causae cuicunque originem suam debere quam Parenti Animali;</latin> i.e. I cannot be perruaded or induced to believe, that this or any other Animal is (or can be) produced out of a Plant in a spontaneous Manner, or doth owe its Original to any other Cause whatever, than an Animal Parent of its own Kind. And in his third Note upon Insect. Numb. 49. these, <latin>Quoad spontaneam Erucae hujus aliorumque Insectorum generationem pro parte negativa jam sententiam meam tradidi, &c.</latin>

As to the Spontaneous Generation of this Eruca, and other Insects, I have already delivered my Opinion for the Ncgative. This is most certain, that these Cossi are produced of Eggs laid by Animal Parents. It is also alike clear, that these diminutive Caterpillars are able by Degrees to piercc or bore their way inio a Tree which very small Holes, after they are fullly entred, do perchance grow together, and quite disappear; at least become so small that they are not to be discerned, unless by Lynceus's Eyes. Add moreover, that perchance they undergo no Transformation, but continue under the Vizzard of [Erucae] Caterpillars for many Years, which doth very well accord with my Observations. Moreover, that this Caterpillar [Eruca] is propagated by Animal Parents, to wit, Butterflies, after the common Origination of all Caterpillars. In all this I fully consent with the Doctor; only crave leave to differ in his attributing to them the Name of Cossi, which were accounted by the Ancients of a delicate Morsel, and fed for the Table; for I take those to have been the Hexapods, from which the greater sort of Beetles come; for that that sort of Hexapods are at this Day eaten in our American Plantations, as I am informed by my good Friend Dr. Hans

Sloane, who also presented me with a Glass of them, preserved in Spirit of Wine.

Having lately had an Opportunity more curiously to view and examine the great flesh-colour'd, thin-hair'd English Caterpillar, which is so like that sent me by Dr. Sloane, that it differs little but in Magnitude, which may be owing to the Climate,) I observed that it had a Power of drawing its eight hind Legs or Stumps so far up in its Body, that they did altogether disappear, so that the Creature seemed to want them, and of thrusting them out again at Pleasure: Whereupon I conjectured, That that Insect of Jamaica sent me by the Dodor, which I took to be the Cossus or Hexapod, previous to some large Beetle) had likewise the same Power of drawing up its hind Legs; so that though to Appearance it wanted them yet really it did not so, but had only drawn them up, and hid them in its Body, when it was immersed in the Spirit of Wine, and consequently was not the Hexapod of a Beetle, but an Eruca, like to, or indeed specifically the same with that of our own Country by me observed; and being eaten at this Day by the Inhabitants of Jamaica, in all likelihood the same with the Cossus of the ancient Romans, which was fed for the Table, as Pliny assures us: Especially, if we consider, that Dr. Lister found this Eruca in the Body of an Oak newly cut down, and sawed in Pieces; on which Tree, Pliny saith, they feed. Thus much I thought fit to add to Dr. Lister, and do the Truth right, by retracting my former Conjecture concerning the Cossi.

3. My third Argument against Spontaneous Generation, is, because there are no Arguments or Experiments, which the Patrons of it do or can produce, which do clearly evince it. For the general and vulgar Opinion, that the Heads of Children, or the Bodies of those that do not change their Linen, but wear that which is sweaty and sordid, breeds Lice; or that Cheese of itself breeds Mites or Maggots, I deny, and look upon it as a great Error and Mistake; and do affirm, that all such Creatures are bred of Eggs laid in such sordid Places by some wandring Louse, or Mite, or Maggot. For such Places being most proper for the Hatching and Exclusion of their Eggs, and for the Maintenance of their Young, Nature hath endued them with a wonderful Acuteness of Scent and Sagacity, whereby they can, though far distant, find out, and make towards them. And even Lice and Mites themselves, as now as they seem to be, can, to my knowledge, in no long time march a considerable way to find out a convenient Harbour for themselves.

Here, by the by, I cannot but look upon the Strange Instinct of this noisome and troublesome Creature the Louse, of searching out foul and nasty Cloaths to harbour and breed in, as an Effect of Divine Providence, designed to deterr Men and Women from Sluttishness and Sordidness, and to provoke them to Cleanliness and Neatness. God himself hateth Uncleanliness, and turns away from it, as appears by Deut. cap. xxiii. ver. 12, 13, 14. But if God requires, and is Pleased with bodily Cleanliness, much more is he so with the Pureness of the Mind. Blessed are the pure in Heart, for they shall see God, Matth. v. 10.

As for the Generation of Insects out of putrid Matter, the Experiments of Franciscus Redi, and some of our own Virtuosi, give me sufficient Reason to reject it. I did but just now mention the quick Scent that Insects have, and the great Sagacity in finding out a proper and convenient Harbour or Matrix, to cherish and hatch their Eggs, and feed their Young: They are so acted and directed by Nature, as to cast their Eggs in such Places as are most accommodate for the Exclusion of their Young, and where there is Food ready for them as soon as they be hatch'd: Nay, it is a very hard matter to keep off such Insects from shedding their Seed in such proper Places. Indeed, if an Insect may be thus equivocally generated, why not sometimes a Bird? a Quadruped, a Man, or even an Universe? Or, why no new Species of Animal now and then? As my learned Friend Dr. Tancred Robinson very well argues in his Letters: For there is as much Art shewn in the Formation of those, as of these.

A fourth and most effectual Argument against Spontaneous Generation, is, that there are no new Species produced, which would certainly now and then, nay, very often happen, were there any such thing. For in such pretended Generations, the Generant or Active Principle is supposed to be the Sun, which being an inanimate Body, cannot act otherwise than by his Heat; which Heat can only put the Particles of the passive Principle into Motion. The passive Principle is putrid Matter; the Particles whereof cannot be conceived to differ in any thing, but Figure, Magnitude, and Gravity. Now the Heat putting these Particles in Motion, may indeed gather together those which are homogeneous, or of the same Nature, and separate those that are heterogeneous, or of a different; but that it should so situate, place, and connect them, as we see in the Bodies of Animals, is altogether inconceivable; which, if it could, yet that it should always run them into such a Machine as is alreadv extant, and not often into some new-fashioned one, such as was never seen before, no Reason can be assign'd or imagined. This the Epicurean Poet Lucretius was so sensible of, that he saw a Necessity of granting Seeds or Principles to determine the Species. For (saith he) if all sorts of Principles could be connected,

<latin>Vulgo fieri portenta videres,

Semiferas hominum species existere, et altos

Interdum ramos egigni corpore vivo;

Multaque connecti terrestria membra marinis;

Tum flammam retro spirantes ore chimaeras

Pascere naturam per terras omniparenteis

Quorum nil fieri manifestum est, omnia quando

Seminibus certis, certa genetrice, creata

Conservare genus crescentia posse videmus, &c.</latin>

That is, Thence would rise

Vast Monsters, Nature's great Absurdities;

some thing half Beast, half Man, and some would grow

Tall Trees above, and Animals below;

Some join’d of Fish, and Beasts, and every where

Frightful Chimaera’s breathing Flames appear.

But since we see no such, and Things arise

From certain Seeds of certain Shape and Size,

And keep their Kind as they increase and grow;

There’s some fix’t Reason why it should be so.

The raining of Frogs and their Generation in the Clouds, though it be attested by many and great Authors, I look upon as utterly false and ridiculous. It seems to me no more likely, that Frogs should be engender’d in the Clouds, than Spanish Gennets begotten by the Wind; for that hath good Authors too. And he that can swallow the raining of Frogs hath made a fair Step towards believing, that it may rain Calves also; for we read, that one fell out of the Clouds in Avicen’s Time. Nor do they much help the matter, who say, that those Frogs that appear sometimes in great Multitudes after a Shower, are not indeed engendred in the Clouds, but coagulated of a certain sort of Dust, commixt and fermented with Rain-water; to which Hypothesis Fromondus adheres.

But let us a little consider the Generation of Frogs in a natural Way.

1. There are two different Sexes, which must concur to their Generation. 2. There is in both a great Apparatus of Spermatick Vessels, wherein the nobler and more spirituous Part of the Blood, is by many Digestions, Concoctions, Reflexions, and Circulations, exalted into that generous Liquor we call Sperm; and likewise for the preparing of the Eggs. 3. There must be a Copulation of the Sexes, which I rather mention, because it is the most remarkable in this, that ever I observed in any Animal. For they continue in complexu Venereo, at least a Month indefinitely; the Male all that while resting on the Back of the Female, clipping and embracing ller wlth his Legs about the Neck and Body, and holding her so fast, that if you take him out of the Water, he will rather bear her whole Weight, than let her go. This I observed in a couple, kept on Purpose in a Vesel of Water, by my Learned and Worthy Friend Mr. John Nid, Fellow of Tribity College, long since deceased. After this, the Spawn must be cast into Water, where the Eggs lie in the midst of a copious Gelly, which serves them for their first Nourishment for a considerable while. And at last, the Result of all is not a perfect Frog, but a Tadpole without any Feet, and having a long Tail to swim withall; in which Form it continues a long time, till the Limbs be grown out, and the Tail fallen away, before it arrives at the Perfection of a Frog.

Now, if Frogs can be generated spontaneously in the Clouds out of Vapour, or upon the Earth out of Dust and Rain-Water, what needs all this a-do? To what purpose is there such an Apparatus of Vessels for the Elaboration of the Sperm and Eggs; such a tedious Process of Generation and Nutrition? This is but an idle Pomp. The Sun (for he is supposed to be the equivocal Generant or Efficient by these Philosophers) could have dilpatch’d the Business in a trice: Give him but a little Vapour, or a little dry Duft and Rain-Water, he will produce you a quick Frog, nay, a whole Army of them, perfectly form’d, and fit for all the Functions of Life in three Minutes, nay, in the hundredth Part of one Minute, else must some of those Frogs that were generated in the Clouds fall down half-formed and imperfect, which I never heard they did; and the Process of Generation have been observed in the Product;on of Frogs out of Dust and Rain-Water, which no Man ever pretended to mark or discern. But that there can be no Frogs generated in the Clouds, may farther be made appear, 1. From the extreme Cold of the middle Region of the Air; where the Vapours are turned

into Clouds, which is not at all propitious to Generation. For did not so great Men as Aristotle and Erasmus report it, I could hardly be induced to believe that there could be one Species of Insects generated in Snow 2. Because, if there were any Animals engender'd in the Clouds, they must needs be maimed and dashed in Pieces by the fall, at least such as fell in the High-ways, and upon the Roofs of Houses; whereas we read not of any such broken or imperfect Frogs found any where. This Last Argument was sufficient to drive off the Learned Fromondus from the Belief of their Generation in the Clouds; but the Matter of Fact he takes for granted, I mean the Spontaneous Generation of Frogs out of Dust and Rain-Water, from an Observation or Experiment of his own at the Gates of Tournay in Flanders, to the Sight of which Spectacle, he called his Friends who were there present, that they might admire it with him. A sudden Shower (saith he) falling spon the very dry Dust, there suddenly appeared such an Army of little Frogs, leaping about every where upon the dry Land, that there was almost nothing else to be seen. They were also of one Magnitude and Colour; ncither did it appear out of what lurking Places [Latibula] so many Myriads could creep out, and suddenly discover themselves upon the dry and dusty soil, which they hate. But having the Reverence due to so great a Man, I doubt not but they did all creep out of their Holes and Coverts, invited by the agreeable Vapour of the Rain-Water. This, however unlikely it may seem, is a thousand Times more probable than their instantaneous and undiscernible Generation out of a little dry Dust and Rain-Water, which also cannot have any time to mix and ferment together, which is the Hypothesis he adheres to. Nay, I affirm, that it is not at all improbable; for he that shall walk out in Summer-Nights, when it begins to grow dark, may observe such a Multitude of great Toads and Frogs crawling about in the High-ways, Paths and Avenues to Houses, Yards and Walks of Gardens and Orchards, that he will wonder whence they came, or where they lurk'd all the Winter, and all the Day-time, for that then it's a rare thing to find one.

To which add, That in such Frogs as we are speaking of, Monsieur Perault hath, upon Dissection, often found the Stomach full of Meat, and the Intestines of Excrement; whence he justly concludes, That they were not then first formed, but only appeared of a sudden; which is no great wonder, since upon a Shower; after a Drought, Earth-Worms and Land-Snails innumerable come out of their lurking Places in like manner.

In Confirmation of what I have here written against the Spontaneous Generation of Frogs, either in the Clouds out of Vapour, or on the Earth out of Dust and Rain-Water commix'd; endeavouring to prove, by Force of Argument, that there is no such thing, I have lately received from my Learned and Ingenious Friend Mr. William Derham, Rector of Upmister, near Rumford in Essex, a Relation parallel to that of Fromondus, concerning the sudden Appearance of a vast Number of Frogs after a Shower or two of Rain marching cross a sandy way, that before the Rain was very dusty; and giving an Account, where in all Likelihood they were generated by Animal Parents of their own Kind, and whence they did proceed. The whole Narrative I shall give the Reader in his own Words.

"Some Years ago, as I was riding forth one Afternoon in Berks, I happened upon a prodigious Multitude creeping cross the way. It was a standy soil, and the Way had been full of Dust, by Reason of a dry Season that then was. But an Hour or two before a refreshing fragrant Shower or two of Rain had laid the Dust. Whereupon, what I had heard or rcad of the Raining of Frogs immediately came to my Thoughts, as it easily might do, there being probably as good Reason then for me, as I believe any ever had before, to conclude, that these came from the Clouds, or were instantaneously generated. But being prepossessed with the contrary Opinion, viz. that there was no equivocal generation, I was very curious in enquiring whence this vast Colony might probably come: and upon searching, I found two or three Acres of Land cover'd with this black Regiment, and that they all marched the same Way towards some Woods, Ditches, and such like cool Places in their Front, and from large Ponds in their Rear. I traced them backwards, even to the very Side of one of the Ponds. These Ponds in spawning time always used to abound much with Frogs, whose Croaking I have heard at a considerable Distance; and a great deal of Spawn I have found there.

From these Circumstances I concluded, that this vast Colomy was bred in those Ponds from whenceward they steered their Course: That after their Incubation (if I may so call it) or Hatch ing by the Sun, and their having pass'd their Tadpole-state; they had lived (till that Time of their Migration) in the Waters, or rather on the Shore, among the Flags, Rushes, and long Grass: But now being invited out by the refreshing Showers, then newly fallen, which made the Earth cool and moist for their March, that they left their old Latibula, where perhaps they had secured all their proper Food, and were now in Pursuit of Food, or a more convenient Habitation.

This I think not only reasonable to be concluded, but withall so easy to have been discovered by any inquisitive Observer, who in former Times met with the like Appearance, that I cannot but admire that such sagacious Philosophers, a Aristotle, Pliny, and many others since, should ever imaagine Frogs to fall down the Clouds, or be any way instantaneously, or spontaneously generated; especially considering how openly they act their Coition, produce Spawn, this Spawn Tadpoles, and Tadpoles Frogs.

Neither in Frogs only, but also in many other Creatures, as Lice, Flesh-Flies, Silk-Worms, and other Papilios, an uniform regular Generation was very obvious, which is an argument to me of a strange Pre-possession of fancy in the Ages since Aristotle, not to say of Carelessness and Sloth, so far Mr. Derham.

In like manner, doubtless Fromondus, had he made a diligent search, might have found out the Place where those Myriads of Frogs, observed by him about the Gates of Tournay, were generated, and whence they did proceed.

As for the Worms and other Animals bred in the Intestines of Man and Beast, I have declared my self not to be satisfied of the Ways and Means how their Seeds corme to be conveyed into those Places; but yet, that their Generation is Analogous to that of other Creatures of those Kinds, I doubt not. The Constancy to their Species; their exact Agreement and perpetual Similitude in the Shape and Figure of their Bodies, and all their Parts; their Consistence, Temper, Motion, and other Accidents, are to me little less than a Demonstration, that they are not the Effects of Chance, but the Products of a settled and spermatick Principle. I am at present, 'till better informed, of Opinion, that their Eggs are swallowed with the Meat we eat; and I am the rather induced to think so, because Children in their first Infancy, and as long as they are constantly confined to a Milk Diet, are seldom troubled with them.

After this was written, I received a Letter from my often remembred ingenious Friend Dr. Tancred Robinson, referring to this Matter, part whereof I shall transcribe, as being very pertinent, instructive, and consonant to my own Thoughts;

"I think it may be proved that the vast Variety of Worms found in almost all the Parts of different Animals, as well Terrestrial as Aquatick, are taken into their respective Bodies by Meats and Drinks, and there either lie still for some time, or else grow and alter by Change of Place and Food, [not specifically, but accidentally, in Magnitude, Colour, Figure of some Parts, or the like.] We know as yet but little of the numerous Insects bred in Water, or indeed of those in Roots, Leaves, Buds, Flowers, Fruits, and Seeds, which we are continually swallowing; and these too all vary according to Climate; [That is, the same Species of Roots, Leaves, etc. do in different Climater produce many different Species of Insects, tho' some there be common to all;] the long slender Worms, as small as Hairs, that breed between the Skin and the Flesh in the Isle of Ormuz, and in India, which are generally twisted out upon Sticks or Rowlers, and often break in the Operation, are without doubt taken in by the Water they drink in those Regions, as I could prove by many and good Experiments, had I time. They who have Leisure, may find them in the Collections of Voyages and Travels,

especially in Monsieur Thevenot. By this Explication we may give a better Account of the Vomitings up of Tadpoles, Snails, and other Animals, recorded in Medical Histories, than by any Hypothesis of Equivocal Generation: As to Insects found in stinking Flesh, or rotten Vegetables, I could never observe or find any of them different frgo1; thofie Parent Insects, which hover about or feed upon such Bodies.

If any shall object the infinite Multitudes of Animalcules discovered in Pepper-Water, and desire an Account of their Generation; to him, I shall say, that it is probable, that some few of these Animals may be floating in all Waters, and that finding the Particles of Pepper swimming in the Water, very proper for the cherishing and excluding of their Eggs, by Reason of their Heat, or some other unknown and specifick Quality, they may fasten their Eggs to them, and so there may be a sudden Breed of infinite Swarms of then . But these being not to be discerned by the most piercing and Lyncean sight, without the Assistance of a Microscope, I leave the Manner of their Generation to future Discovery.

No less difficult is it to give an Account of the Original of such Insects as are found and seem to be bred in the Bodies of others of different Kinds. Out of the Sides and Back of the most common Caterpillar, which feeds upon Cabbage, Cole-wort, and Turnep-Leaves, which we have described in the Catalogue of Cambridge-Plants, we have seen creep out small Maggots, to the Number sometimes of Threescore, or more; which so soon as ever they came forth, began to weave themselves silken Cases of a yellow shining Colour, wherein they changed, and, after some Time, came out thence in the Form of small Flies with four Wings; for a full Description and History whereof, I shall refer the Reader to the forementioned Catalogue. The like I have also observed in other Caterpillars of a different Kind, which have produced no lesser Number of Maggots, that in like manner immediately made themselves up in Cases. Others, instead of changing into Aurelia's, as in the usual Process of Nature they ought to do, have turned into one, two, three, or more Flesh-Fly Cases, at least contained such Cases within them, out of which, after a while, were excluded Flesh-Flies. Other Caterpillars, as that called the solitaty Maggot, found in the dry Heads of Teasel, by a dubious Metamorphosis, sometimes changed into the Aurelia of a Butterfly, sometimes into a Fly-Case. You'll say, How comes this to pass? Must we not here necessarily have Recourse to a spontaneous Generation? I Answer, No: The most that can be inserred from hence is, a Transmutation of Species; one Insect may, instead of generating another of its own Kind, beget one or more of a different. But I can by no means grant this. I do believe that these Flies do either cast their Eggs upon the very Bodies of the forementioned Caterpillars, or upon the Leaves on which they feed, all in a String; which there hatching, eat their Way into the Body, where they are nourished till they be come to their full Growth. Or it may be, the Fly may with the hollow and sharp Tube of her Womb punch and perforate the very Skin of the Eruca, and cast her Eggs into its Body. So the Ichneumon will convey her Eggs into Caterpillars

The Discovery of the Manner of the Generation of these sorts of Insects I earnestly recommend to all ingenious Naturalists, as a Matter of great Moment. For if this Point be but cleared, and it be demonstrated that all Creatures are generated univocally by Parents of their own Kind, and that there is no such thing as Spontaneous Generation in the World, one main Prop and Support of Atheism is taken away, and their strongest Hold demolished: they cannot then exemplify their foolish Hypothesis of the Generation of Man and other Animals at first, by the Like of Frogs and Insects at this present Day.

It will be farther objected, that there have live Toads been found in the midst of Timber Trees; nay, of Stones, when they have been sawn asunder.

To this I Answer, that I am not fully satisfied of the Matter of Fact. I am so well acquainted with the Credulity of the Vulgar, and the Delight they, and many of the better Sort too, have in telling of

Wonders and strange Things, that I must have a Thing well attested, before I can give a firm Assent to it.

Since the Writing hereof, the Truth of these Relations of live Toads found in the midst of Stones, hath been confirmed to me by sufficient and credible Eye-witnesses, who have seen them taken out. so that there is no doubt of the Matter of Fact.

But yet, suppose it be true, it may be accounted for. Those Animals, when young and little, finding in the Stone some small Hole reaching to the Middle of it, might, as their Nature is, creep into it, as a fit Latibulum for the Winter, and grow there too big to return back by the Passage by which they enter'd, and so continue imprisoned therein for many Years; a little Air, by Reason of the Coldness of the Creature, and its Lying torpid there, sufficing it for Respiration, and the Humour of the Stone, by Reason it lay immoveable, and spent not, for Nourishment. And I do believe, that if those who found such Toads, had diligently searched, they might have discovered and traced the Way whereby they enter'd in, or some Footsteps of it. Or else there might fall down into the lapideous Matter before it was concrete into a Stone some small Toad, (or some Toad Spawn) which being not able to extricate itself and get out again, might remain there imprisoned till the Matter about it were condensed and compacted into a Stone. But however it came there, I dare considently affirm, it was not there spontaneously generated. For else, either there was such a Cavity in the Stone before the Toad was generated; which is altogether improbable, and Gratis Dictum, asserted without any Ground; or the Toad was generated in the solid Stone, which is more unlikely than the other, in that the soft Body of so small a Creature should extend itself in such a Prison, and overcome the Strength and Resistance of such a great and ponderous Mass of solid Stone.

And whereas the Assertors of Equivocal Generation were wont to pretend the Imperfection of there Animals, as a Ground to facililtate the Belief of their Spontaneous Generation; I do affirm, that they are as perfect in their Kind, and as much Art shewn in the Formation of them, as of the greatest; nay more too, in the Judgment of that great Wit and Natural Historian Pliny <margin>Lib 11 cap 2</margin>. <latin>In magnis siquidem corporibus, (saith he) aut certe majoribus facilis officina sequaci materia fuit; in his tam parvis atque tam nullis, quae ratio, quanta vis, quam inextricabilis perfectio?</latin> In the greater Bodies the Forge was easy, the Matter being ductile and sequacious, obedient to the Hand and Stroke of the Artificer; apt to be drawn, formed or moulded into such Shapes and Machines, even by clumsy Fingers: But in the Formation of these, such diminutive Things, such Nothings, what Cunning and Curiosity! What Force and Strength was requisite, there being in them such inextricable Perfection!

To what Proofs or Examples of Spontaneous Generation may be brought from Insects bred in the Fruits or Excrescencies of Plants, I have already made Answer in my second Particular, which contains the Testimonies of our best modern Naturalists concerning these Things.

In my Denial of the Spontaneous Generation of Plants, I am not so consident and peremptory; but yet there are the same Objections and Arguments against it, as against that of Animals, viz. because it would be a Production out of indisposed Matter, and consequently a Creation: Or if it be said, there is disposed Matter, prepared by the Earth, or Sun, the Heat, or whatever other Agent you can assign; I reply, this is to make a thing act beyond its Strength, that is, an inserior Nature which hath nothing of Life in it, to prepare Matter for a superior, which hath some Degree of Life; and for the Preparation of which, it hath no convenient Vessels or Instruments. If it could do so, what need of all that apparatus of Vessels, Preparation of Seed, and, as I also suppose, Distinction of Masculine and Feminine that we see in Plants? I demand farther, whether any of the Patrons of Spontaneous Generation in Plants, did ever see any Herbs or Trees, except those of the Grass-leaved Tribe, come up without two Seed-Leaves; which if they never did or could, it is to me a great Argument that they came all of Seed; there being no Reason else, why they should at first

produce two Seed-Leaves different from the Subsequent. And if all these Species which are far the greatest Number) come from Seed, there is not the least reason to think that any of the rest come up spontaneously. And this, with what have written before, may suffice concerning this Point.

Whereas I have often written in many Places that such and such Plants are spontaneous, or come up spontaneously; I mean no more by that Expression, but that they were not planted or sown there industriously by Man.

Having spoken of the Body of Man, and the Uses of its Several Parts and Members, I shall add some other Observations, giving an Account of the particular Structure, Actions and Uses of some Parts, either common to whole Kinds of Animals, or proper to some particular Species different from those of Man and of the Reason of some Instincts and Actions of Brutes.

First of all, The Manner of Respiration, and the Organs serving thereto in various Animals, are accommodated to their Temper of Body, and their Place and Manner of living; of which I have observed in more perfecot Animals three Difeerences. 1. The hotter Animals, which require abundance of Spirits for their various Motions and Exercises, are provided with Lungs, which indefinently draw in and expell the Air alternately without Intermission, and have a Heart furnished with two Ventricles, because to maintain the Blood in that Degree of Heat, which is requisite to the Performance of the Actions of all the Muscles, there is abundance of Air necessary. I shall not now take notice of the Difference that is between the Lungs of Quadrupeds and Birds, how the one are fixed and immoveable, the other loose and moveable; the one perforated, transmitting the Air into large Bladders, the other enclosed with a Membrane.

It is here worth the Notice taking, that many Animals of this Kind, both Birds and Quadrupeds, will endure and bear up against the extremest Rigor of Cold that our Country is exposed to. Horsc, Kine and Sheep, as I have experienced, will lie abroad in the open Air upon the cold Ground during our long Winter-Nights, in the sharpest and severest Frosts that ever happened with us, without any Harm or Prejudice at all; whereas one would think, that at least the Extremities of their Members should be bitten, benummed and mortified thereby. Considering with myself by what Means they were enabled to do this, and to abide and resist the Cold, it occurr'd to my Thoughts, that the Extremities of their Toes were fenc'd with Hoofs, which in good Measure secured them: But the main thing was that the Cold is, as it were its own Antidote; for the Air being fully charged and sated with nitrous, or some other sort of Particles which are the great Efficients of Cold, and no less also the Pabulum of Fire) when inspired, doth by means of them cause a great Accension and Heat in the Blood (as we see Fewel burns rashly in such Weather) and so enable it to resist the Impressions of the Cold for so short a time as its more nimble Circulation exposes it thereto, before it comes to another Heating. From hence may an Account be given, why the Inhabitants of hot Countries may endure longer Fasting and Hunger, than those of colder; and those seemingly prodigious, and to us scarce credible, Stories of the Fastings and Abstinence of the Egyptian Monks be render'd probable.

2. Other Animals, which are of a colder Temper, and made to endure a long Inedia or Fasting, and to lie in their Holes almost torpid all Winter, as all Kinds of Serpents and Lizards have indeed Lungs, but do not incessantly breathe, or when they have drawn in the Air, necessarily expire it again, but can retain it at their Pleasure, and live without Respiration whole Days together, as was long since experimented by Sir Thomas Brown, M.D. in a Frog tied by the Foot under Water for that Purpose by him. This Order of Creatures have but one Ventricle in their Heartss and the whole Blood doth not so often circulate through the Lungs, as it doth through the rest of the Body. This manner of Breathing is sufficient to maintain in them that Degree of Heat which is suitable to their Nature and Manner of Living. For to our Touch they are always cold even in Summer-time, and therefore some will then put Snakes into their Bosom to cool them.

3. Fishes, which were to live and converse always in a cold Element, the Water, and therefore were to have a Temper not excelling in Heat, becaute otherwise the constant immediate Contract of the Water (unless some extraordinary Provision were made) could not have been supported by them, that they might not be nessitated continually to be coming up to the Top of the Water to draw in the Air, and for many other Reasons that might be alleged, perform their Respiration under Water by the Gills, by which they can receive no more Air than is dispersed in the Pores of the Water; which is sufficient to preserve their Bodies in that Temper of Heat that is suitable to their Nature, and the Place wherein they live. These also have but one Ventricle in their Hearts.

But now, though this be thus, the great and most wise God, as it were, purposely to demonstrate, that he is not by any Condition or Quality of Place necessarily determined to one Manner of Respiration, or one Temper of Body in Fishes; he hath endued the Bodies of some of that Tribe of Aquatick Creatures wlth Lungs like viviparous Quadrupeds, and two Ventricles of the Heart, and an Ability of Breathing like them, by drawing in and letting out the open Air; so contriving their Bodies, as to maintain, in the midst of the cold Water, a Degree of Heat Answerable to that of the forementioned Quadrupeds.

Another remarkable thing relating to Respiration, is the keeping the Hole or Passage between the Arteria venoaa and Vena cava, called Foramen ovale, open in some amphibious Quadrupeds, viz. the Phoca or Vitulus marinus, called in the English, Sea-Calf and Seal; and, as is generally held, the Beaver too. We have already given the Reason of the twofold Communication of the great Blood-Vesels in the Foetus or Young, so long as it continues in the Womb: The one between the two Veins entring the Heart, by a Hole or Window; the other between the two Arteries, by an Arterial Chanel, extended from the Pulmonary Artery to the Aorta, or great Artery which was, in brief, to divert the Blood from the Lungs. The same Reason for keeping open this Floramen ovale, there is, in these amphibious Creatures; For, 1. The Lungs probably being not extended, but emptied of Air when they abide long under water, and flacid, it is not easy for the whole Blood every Circulation to make its way through them. 2. To maintain that Degree of Heat and Motion in the Blood, as is sufficient for them while they are under Water, there is not so much Air required, as is when they are above: The Blood then moving but gently, as doth that of the Foetus in the Womb.

Farther, in reference to Respiration, it is observed by the Parisian Academists, that some amphibious Quadrupeds, particularly the Sea-Calf or Seal, hath his Epiglottis extraordinarily large in proportion to other Animals, it extending half an Inch in Length beyond the Glottis to cover it. I believe the Beazer hath the like Epiglottir, exactly clothing the Larynx or Glottis, and hindring all Influx of Water; because in one dissected by Wepferus, that suffocated itself in the Water, there was not a drop of Water found in the Lungs. It is probable (say they) that this is done more exactly to close the Entrance of the Aspera Arteria, or Wind-Pipe, when the Animal eats his Prey at the Bottom of the Sea, and to hinder the Water from running into his Lungs. An Elephant (as is observed by Dr. Moulins, I think, in the Anatomy of that Creature) hath no Epiglottis at all, there being no danger of any thing falling into their Lungs fron eating or drinking, seeing there is no Communication between the Oesophagus and it. For he thus describes the Oesophagus or Gullet: The Tongue of this Creature (saith he) had this peculiar in it, that the Passage to the Ventricle was through it; for there was a Hole near the

Root of it, and exaetly in the middle of that Part; which Hole was the Beginning of the Oesophagus. There was no Communication between this and the Passage into the Lungs, contrary to what we may observe in Men, in all Quadrupeds and Fowl, that ever I had opportunity to dissect. For the Membrana pituitaria anterior reached to the very Root of the Tongue below the Oesophagus, and so quite stopped the Passage of the Air into the Mouth. But though there be no danger of Meat or Drink falling into the Lungs, yet were they not sufficiently secured from small Animals creeping in

there: For though, to supply in some measure the Want of an Epiglottis by lessening the Glottis, there grew to the Outside of the Cartilages, called Arytenoides, another capable of Motion up and down, by the help of some Muscles that were implanted in it, strong on both sides of the aspera Arteria, but on the Under-side, opposite to that of the Oesophagus very limber, wanting about two Inches and a half of coming round the aforesaid Cartilages on the Upper-side, or the next to the Oesophagus. Yet did not this Cartilage so shut up the way against them, but that even a Mouse creeping up his Proboscis might get into his Lungs and so stifle him. Whence we may guess as the Reason, why the Elephant is afraid of a Mouse: And, therefore, to avoid this Danaer, this Creature [the Elephant, which this Author described] was observed always when he slept to keep his Trunk [Proboscis] so close to the Ground, that nothing but air could get in between them. This is a strange Sagacity and Providence in this Animal, or else an admirable Instinct.

Again, The Parisian Academists observe of the Sea-Tortoise, that the Cleft of the Glottis was strait and close: Which exact Enclosure, I do rather believe, is to prevent the Water from entring into the Wind-Pipe, when the Tortoises are under Water, than to assist the Effect of the Compression of the Air in the Lungs as they would have it. For they make the main Reason of Respiration, and Use of the Lungs in this Creature, to be, to take in and retain Air; by the Compression and Dilatation whereof, made by the Muscles, it can raise or sink itself in the Water, as need requires; though I do not exclude this. But if this be the main Use of the Lungs and Respiration in this Animal, what is it in Land-Animals, which have a like Conformation of Lungs, and Manner of Respiration, as the Camelion, Serpents, and Lizards?

But before I dismiss the Tortoise, I shall add two notable Observations concerning him, borrowed of the said French Academists, which seem to argue something of Reason in him, and more than a bare Instinct. The first is in the Land-Tortoise; and it is his manner of turning himself, and getting upon his Feet again when he is cast upon his Back, which they describe in these Words: At the great Aperture of the Shell before, there was at the Top a raised Border, to grant more liberty to the Neck and Head, for lifting themselves upwards. And this Inflexion of the Neck is of great Use to the Tortoises. For it serves them to turn again, when they are upon their Backs. And their Industry upon this Account is very admirable. We have observed in a living Tortoise, that being turned upon its Back, and not being able to make use of its Paws for the returning of itself, because they could not only bend towards the Belly, it could help itself only by its Neck and Head, which is turned sometimes on one side, sometimes on the other, by pushing against the Gtound, to rock itself as in a Cradle, to find out the side towards which the Inequality of the Ground might more easily permit it to rowl its Shell. For when it had found it, it made all its Endeavours on that Side.

The Second is in the Sea-Tortoise as follows: Aristotle and Pliny have remarked, that when Tortoises have been a long time upon the Water during a Calm, it happens that their Shell being dried in the Sun, they are easily taken by the Fishermen; by Reason they cannot plunge into the Water nimbly enough, being become too light. This shews what Equality there ought to be in their Aequilibrium, seeing so little a Change as this, which may happen by the sole Drying of the Shell, is capable of making it useless. This easiness to be taken at such a time, these Academists do not referr meerly to the Lightness of this Creature's Body, (for he could easily let Air enough out of his Lungs to render it heavier than the Water, and so enable himself to sink) but to a wonderful Sagacity and Caution of this Animal. For (say they) it is probable that the Tortoise, which is always carefu1 to keep himself in this AEquilibrium, so as other Animals are to keep themselves on their Legs, in this case, by the same Instinct, dares not let the Air out of his Lungs, to acquire a Weight which might make him speedily to sink; because he fears that his Shell being wet, it should become so heavy, that he being sunk to the bottom of the Water might never have Power afterwards to re-ascend. If this may be the Reason why he exposes himself to the Danger of being taken at such a time, rather than he will descend suddenly to the bottom, it is clear, that he is endued with an admirable Providence and Foresight, and a Power of Augmentation.

That Nature doth really Design the Preservation and Security of the more infirm Creatures, by the defensive Armor that it hath given to some of them, together with Skill to use it, is, I think, demonstrable in the common Hedge-hog or Urchin, and one Species of Tatou or Armadillo. The Hedge-hog hath his Back-sides and Flanks thick set with strong and sharp Prickles, and besides, by the help of a Muscle, given him for that purpose, is enabled to contract himself into a Globular Figure, and so to withdraw, enclose and hide his whole Under-Part, Head, Belly, and Legs, which, for the Necessities and Conveniencies of Life, must be left destitute of this Armor) within his Covert or Thicket of Prickles; so that Dogs, or other rapacious Creatures, cannot lay hold upon him, or bite him, without wounding their own Noses and Mouths. The Muscle, whereby he is enabled to draw himself thus together, and gather up his whole Body like a Ball, the Parisian Acadcmists describe to be a distinct Carnose Muscle, extended from the Ossa innominata to the Ear and Nose, running along the Back-bone, without being fastened thereto. Olaus Borrichius, in the Danick Transactions, makes it to be an almost circular Muscle, embracing the Panniculus carnosus) of a wonderful Fabrick, variously extending its Laciniae or Processes to the Feet, Tail, and Head of the Creature.

The other Creature, which doth thus contract and draw up itself into a Globular or Oval Figure for its Defence, is the second sort of Tatou or Armadillo, largely described by Marcgrave, lib. 6. cap. 9. by the Name of Tatu apara, which is covered on its Back and Sides with a strong scaly Crust or Shell, of a hard or bony Substance, jointed like Armor, or the Scales of the Tale of a Lobster, by four transverse Commissures in the middle of the Body, connected by tough Membranes. When it sleeps, (as it doth for the most part in the Day-time, going forth to feed in the Night) or when one goes about to lay hold on it, gathering up its fore and hind Legs as it were to one Point, and drawing its Ears with its Head inward, and bringing its Tail to its Head, by Reason of the fore-mentioned Commissures, it bends its Back so far, till its Head comes to touch its hind Part, and so with Armor gathers itself into a round Ball, the lateral Extremities of the Shell touching one another, and enclosing the Body on the Sides, and the fore and hind Parts coming so near together; that there is nothing to be seen, but the Armature of the Head and Tail, which, like Doors, shut up the Hole, which the Shells of the Body left open. This it performs by the Action of a notable Muscle on each Side, of a great Length, having the Form of the Letter X, made up of many Fibres, decussating one another long ways; by the help whereof, it can contract its Shell, and hold it contracted with such a mighty Force, that he must be a Srong Man indeed that is able to open it.

Had such a Muscle as this, and such an Ability of Contraction been given to any Creature that was covered with soft Hair or Fur, there might have been some Pretence to fancy, that this was accidental and not designed: But seeing there is not one Instance of this Kind in Nature, it must be great Stupidity to believe it, an Impudence to assert it. Neither will the Atheists usual <greek>krEsphugatov</greek>, or Refuge, That there were indeed at first such Creatures produc'd; but being obnoxious to those that were strong, and rapacious, they were by degrees destroyed, and the Race lost, here help them out: because such a Muscle and Faculty of using it to that Purpose, might as likely have fallen to the Lot or Chance of a strong and generous Creature, which others dared not approach to hurt, who might, for his own Disport, have thus contracted himself into a Ball, of which Kind we find none.

I have before nnentioned the Use assigned by the Honourable Mr. Boyle, of famous Memory, lately deceas'd, to the Periophthalmium, or nectating Membrane in Brutes, wherein I could not fully acqusesce as to some Quadrupeds, which were in no danger of having their Eyes harmed by Bushes, and Prickles, or Twigs of Trees; since the Writing whereof, I have met with a different Account of the Use of that Membrane, in the Anatomical Description of several Creatures dissected by the Royal Academy of Sciences at Paris, Englished by Mr. Alexander Pitfield, p.249 in the Description of the Cassowar. Our Opinion (say those Academists) is, that the Membrane serves to clean the Cornea, and to hinder, that by drying, it grow no less transparent.; Man and the Ape, which are the

sole Animals wherein we have not found this Eye-lid, have not wanted this Provision for the cleaning of their Eyes, because that they have Hands, wtth which they may, by rubbing their Eye-lids, express the Humidity which they contain, and which they let out thro' the ductus lachrymalis which is known by Experience, when the Sight is darkned, or when the Eyes suffer any Pain or Itching: For these Accidents do cease, when the Eyes are rubbed.

But the Direction has distinctly discovered to us the Organs which do particularly serve for this Use, and which are otherwise in Birds, than in Man, where the Ductus passes not beyond the Glandula lachrymalis. For in Birds it goes beyond; and penetrating above half way on the internal Eye-lid, it is opened underneath upon the Eye: Which is evidently done to spread a Liquor over the whole Cornea, when this Eye-lid passes and repasses; as we observ'd it to do every moment.

The Artifice and Contrivance of Nature, for the extending and withdrawing of this Curtain of the Periophthalmium in Birds, is admirable; but it is difficult so to express it in Words, as to render it intelligible to the Reader; for a multitude of Words doth rather obscure than illustrate, they being a Burden to the Memory, and the first apt to be forgotten, before we come to the last. So that he that uses many Words for the explaining any Subject, doth, like the Cuttle-Fish, hide himself; for the most part, in his own Ink. And in the Description of the Figure, and Manner of the Extension and Contraction of this Membrane, the Parisian Academists are constrained to use so many Words, that I am afraid few Readers Patience and Attention will last so long, as to comprehend and carry it away: Yet because it is so evident and irrefragable a Proof of Wisdom and Design, I could not omit it. Their Words are these, The Particularities of the admirable Structure of this Eye-lid, are such things as do distinctly discover the Wisdom of Nature, among a thousand others, of which we perceive not the Contrivance, because we understand them only by the Effects, of which we know not the Causes; but we here treat of a Machine, all the Parts whereof are visible, and which need only to be look'd upon, to discover the Reason of its Motion and Action.

This Internal Eye-lid in Birds is a Membranous Part, which is extended over the Cornea, when it is drawn upon it like a Curtain, by a little Cord or Tendon; and which is drawn back again into the great Corner of the Eye, to uncover the Cornea, by the Means of the very strong Ligaments that it has, and which, in drawing it back towards its Origine, do fold it up. It made a Triangle when extended, and it had the Figure of a Crescent when folded up. Its Basis which is its Origine) was toward the great Corner of the Eye, at the Edge of the great Circle, which the Sclerotica forms when it is flatted before, making an Angle with its anterior Part, that is, the Cornea) which is raised like a Hill upon it. The Basis, which is the Part immoveable, and fastned to the Edge of the Sclerotica, did take up more than a third Part of the Circumference of the great Circle of the Sclerotica: The side of the Triangle, which is toward the little Corner of the Eye, and is moveable, was reinforced with a Border, which supplies the place of the Tarsus, and which is black in most Quadrupeds. This side of the Eye-lid is that which is drawn back into the Corner of the Eye, by the Action of the Fibres of the whole Eye-lid, which parting from its Origine, proceed to join themselves to its Tarsus.

To extend this Eye-lid over the Cornea, there were two Muscles that were seen, when six were taken away, which serv'd to the Motion of the whole Eye. We found that the greatest of these two Muscles has its Origine at the very Edge of the great Circle of the Sclerotica, towards the great Corner, from whence the Eye-lid takes irs Original. It is very fleshly in its Beginning, which is a large Basis, from whence coming insensibly to contract itself by passing under the Globe of the Eye, like as the Eye-lid passes over it, it approaches the Optick Nerve, where it produces a Tendon round and slender, so that it passes through the Tendon of the other Muscle, which serves for a Pully, and which hinders it from pressing the Optick Nerve upon which it is bent, and makes an Angle, to pass through it to the upper Part of the Eye; and coming out from underneath the Eye to insert itself at the Corner of the Membrane, which makes the Internal Eye-lid. This second Muscle hath its Original

at the same Circle of the Sclerotica, but opposite to the first towards the little Corner of the Eye, and passing under the Eye like the other, goes to meet it, and embraces its Tendon, as has been declared.

The Action of these two Muscles is, in respect to the first, to draw by the means of its Cord or Tendon the Corner of the Internal Eye-lid, and to extend it over the Cornea. As to the second Muscle, its Acrion is by making its Tendon to approach towards its Origine, to hinder the Cord of the first Muscle which it embraces, from hurting the Optick Nerve; but its principal Use is, to assist the Action of the first Muscle. And ‘tis herein that the Mechanism is marvellous in this Structure, which makes that these two Muscles joined together, do draw much farther than if it had but one for the Inflection of the Cord of the first Muscle, which causes it to make an Angle on the Optick Nerve, is made only for this End: And a single Muscle with a strait Tendon, had been sufficient, if it had Power to draw far enough. But the Traction which must make the Eyelid extend over the whole Cornea, being necessarily great, it could not be done but by a very long Muscle, and such a Muscle not being able to be lodg’d in the Eye all its Length, there was no better Way to supply the Action of a long Muscle, than by that of two indifferent ones, and by bending one of them, to give it the greater Length in a little Space. Thus far the Academists, who themselves reflecting on the Length and Obscurity of this Description, tell us, that the Inspection of the Figure, wil1 serve greatly to the Understanding of it, which the Novelty of the Thing renders obscure in itself; and so I fear it will be to most Readers; howbeit in such a Work as this, I ought not by any means, as I said before, to leave out such a notable Instance, wherein Contrivance and Design do so clearly and undeniably appear.

The same Academists, as I remember, tell us, that they have found by Experience, that the aqueous Humour of the Eye will not freeze; which is very admirable, seeing it hath the Perspicuity and Fluidity of common Water, and hath not been taken Notice of; so far as I have heard, to have any eminent Quality discoverable, either by Taste or Smell; so that it must be of some Singular and Ethereal Nature: And deserves to be examined and annalized by the curious Naturalists of our Times.

The Providence of Nature is wonderful in a Camel, or Dromedary, both in the Structure of his Body, and in the Provision that is made for the Sustenance of it. Concerning the first, I shall instance only in the Make of his Foot, the Sole whereof, as the Parisian Academists do observe, is flat and broad, being very fleshy, and covered only with a thick, soft, and somewhat callous Skin, but very fit and proper to travel in sandy Places; such as are the Desarts of Africk and Asia. We thought (say they) that this Skin was like a living Sole, which wore not with the Swiftness and the Continuance of the March, for which this Animal is almost indefatigable. And it may be this softness of the Foot, which yields and fits itself to the Ruggedness and Uneavenness of the Roads, does render the Feet less capable of being worn, than if they were more solid. As to the Second, the Provision that is made for their Sustenance in their continued Travels over sandy Desarts, the same Academists observe, That at the Top of the second Ventricle (for they are ruminant Creatures, and have four Stomachs) there were several square Holes, which were the Orifices of about twenty Cavities, made like Sacks placed between the two Membranes, which do compose the Substance of this Ventricle. The View of these Sacks made us to think, that they might well be the Reservatories, where Pliny says, that Camels do a long time keep the Water, which they drink in great Abundance when they meet with it, to supply the Wants which they may have thereof in the dry Desarts, wherein they are used to travel; and where it is said, that those that do guide them, are sometimes forced, by Extremity of Thirst, to open their Bellies, in which they do find Water.

That such an Animal as this, so patient of long thirst, should be bred in such droughty and parched Countries, where it is of such eminent Use for travelling over those dry and sandy Desarts, where no

Water is to be had sometimes in two or three Days Journey, no candid and considerable Person but must needs acknowledge to be an Effect of Providence and Design.

Such Animals as feed naturally upon Flesh, both Quadrupeds and Birds, because such kind of Food is high and rank, do qualify it, the one by swallowing the Hair or Fur of the Beasts they prey upon, the other by devouring some Part of the Feathers of the Birds they gorge themselves with, not electively, but because they cannot, or will not, take the Pains fully to plume them. And therefore the Parisian Academists do rationally refer the Death of one cf the Lions whom they dissected to the Feeding of him with too succulent and delicate Meat. For (say they) we know, that some time before his Death he was several Months without going out of his Den and that it was hard to make him eat. That for this Reason some Remedies were prescribed to him, and among others the eating only the Flesh of young Animals, and those alive. And that those which look'd to the Bears of the Park of Vicennes, to make this Food more delicate, did use a Method very extraordinary; which was, they flead Lambs alive, and thus made him eat several; which at the first revived him, creating in him an Appetite, and making him brisk. But it is probable that this Food engender'd too much Blood, and which was too subtile for an Animal to whom Nature had not given the Industry of fleaing those which he eat. It being credible, that the Hair, Wool, Feathers and Scales, which all Animals of Prey do swallow, are a reasonable and necessary corrective, to prevent their Greediness from filling themselves with too succulent a Food.

Though I have declared in the Beginning of this Work, that the Means whereby cartilaginous Fishes raise and sink themselves in the Water, and rest and abide in what Depth they Please, is not yet certainly known; yet I shall propound a Conjectcure concerning it, which was first suggested to me by Mr. Peter Dent, late Physician in Cambridge, viz. that it is by the help of Water which they take in and let out by two Holes in the lower Part of their Abdomen, or Belly, near the Vent) or not far off it. The Flesh of this sort of Fish being lax and spungey, and nothing so firm, solid and weighty, as that of the Bony Fishes; and there being a good Quantity of Air contained in the Cavity of their Abdomen, they cannot sink in the Water, without letting in some of it by these Holes (the Orifices whereof are opened and shut at Pleasure by the help of Muscles provided for that purpose) into the Hollow of their Bellies, whereby they preponderate the Water; and descend; and when they would ascend by a Compression wrought by the Muscles of the Abdomen they force out the Water again, or at least so much of it as may suffice to give that Degree of Levity they need or desire. If it be found, by Experience, that the Bodies of these Fishes, without this Ballast would naturally float in the Water, and that they do really admit Water into their Bellies, then this Conjecture may have some Probability or Truth in it, otherwise not.

Upon the Contemplation and Consideration of those various Ways and Contrivances which Nature (I mean the Divine Wisdom) hath made use of for preparing the Chyle, separating the nutritious Juice from the grosser Parts of the Aliment, and the several Humours and Spirits from the Blood, I cannot but admire her great Wisdom, Art and Curiosity. For she hath not only employed all those Methods and Devices, which Chymists have either learned by Imitation of her, or invented of themselves, for annalizing of Bodies, separating their Parts, the pure from the impure, and extracting their Spirits, etc. as Maceration in the first Stomach or Paunch of ruminating Creatures, and in the Craws of Birds; Comminution by grinding in the Mouths of viviparous Quadrupeds, and in the Gizzards of Poultry; Fermentation in the Stomachs of most Terrestrial, and all Aquatick Animals; Expression and Squeezing, in the Omasus of ruminant Quadrupeds, and in the Intestines of all Creatures, by the Motion of the Midriff, and other Muscles of the Belly, forcing the Chyle out of the Faeces, or Excrements, into the Lacteal Veins; Straining, or Percolation, by all the Viscera of the Body; which use but as so many Colanders to separate several Juices from the Blood: And, lastly, Digestion and Circulation, in the Spermatick Parts and Vessels, and perhaps also in the Brain. I say, it hath not only made use of these Operations, but it hath quite out-done the Chymists, effecting that by a gentle Heat, which they cannot perform without great Stress of Fire. As for Instance, in the

Stomach of a Dog, preparing a Liquor that dissolves Bones; and in the Bodies of some Insects, a Liquor which seems to be as highly acid and corrosive, as Oil of Vitriol, or Spirit of Nitre, viz. that which is instilled into the Blood when they sting. It is an Experiment I have met with in some Books, and made myself, that if you put Blue-Bottles or other blue Flowers into an Ant-Hill, they will presently be stained with red: The Reason which these Authors render not) is because the Ants thrust in their Stings into the Flowers, and instil into or drop upon them a small Mite of their stinging Liquor, which hath the same Effect that Oil of Vitriol would have in changing their Colour, which is a Sign that both Liquors are of the same Nature.

Casper Bartholine hath observed, that where the Gullet perforates the Midriff, the carneous Fibres of that muscular Part are inflected and arcuate, as it were a Sphincter embracing and closing it fast, by a great Providence of Nature, lest in the perpetual Motion of the Diaphragm, the upper Orifice of the Stomach should gape, and cast out the Victuals as fast as it received it. And Peyesus thinks he hath Observed, that in ruminating Creatures the Connection of the Gullet with the Diaphragm is far straiter and stronger than in Man and other Animals, to the end that there should not be more than one Morsel forced out at once. For that external Sphincter inhibits a too great Dilatation of the Gullet, and doth as it were measure out the Morsels, and fit them to the Capacity of the Oesophagus.

I shall conclude with a notable Relation of Galen's, lib. 6. de locis effectis, cap. 6. concerning a Kid taken by him alive out of the Dam's Belly, and nourished and brought up.

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'H diaplasasa te kai teleiOsasa phusis eirgasato chOris didaskalias epi oikeian energeian erchesthai; kai basanon ge tQtQ megizEn epoiEsamEn pote threpsas epiphon, aneu tQ Theasasthai pote tEn kuEsasan; aigas gar egEumonas anatemOn heneka tOn ezEtEmenOn theOrEmatOn tois anatomikois andrasi peri tEs kata to kuQmenon oikonomias, heurOn pote gennaion to embruon, apelusa men tEs mEtras hOsper eiOthamen; harpasas de prin theasasthai tEn kuEsasan eis oikon men tina komisas katethEka, pollamen echonta lekania; to men oivQ, to de elaiQ, to de melitos, to de galaktos, E allQ tinos hugrQ plEres, ouk oliga d'alla tOn DEmEtriOn karpOn, hOsper de kai tOn akrodruOn; etheasametha de to embruon ekeino, prOton men badizon tois posin, hOsper akEkoOs heneka badiseOs echein ta skelE; deuteron de aposeiomenon tEn ek tEs mEtras hugrotEta, kai triton epi tQtO kusamenon heni tOn podOn tEn pleuran, eit' osmOmenon eidomen auto tOn keimenOn kata ton oikon hekazQ, hOs de pantOn Osmato tQ galaktos aperophEsen, en hO kai anekragamen hapantes, enargOs horOntes hoper hIppokratEs ephE, phuseis zOOn adidaktoi. Kai toinun kai anethrepsamEn ekeino to eriphion, eidomen te prospheromenon huzeron Q to gala monon, alla kai alla tina tOn keimenOn; ontos de tQ kairQ kath' hon exErethE tEs metros ho eriphos, eggus tEs eiarinEs hisEmerias, meta duo tQ mEnas eisekomisamEn autO malakQs akremonas thamnOn te kai phutOn, hOn palin kai autOn osmEsamenon hapantOn, enion men eutheOs apezE, tinOn de ExiOse geusasthai, kai geusa eniOn epi tEn edOdEn etrapeto tOn kai tais megalais aixi sunEthOn edesmatOn. Alla tQto men isOs mikron; ekeino de mega. Ta gar phulla kai tQs malakQs akremonas apophagOn katepien, eit' oligou huzeron epi to mErukazein hEken, ho palin theasamenoi pantes aneboEsan ekplagnetes epi tais tOn zOOn dunamesi; mega men gar E kai to peinEsan dia te tQ somatos kai tOn odontOn prospheresthai tEn edOdEn; all' hote to katapothen eis tEn gazera prOton men anapherein eis to soma prosEken, epeita leainein en autO massOmenon en chronO pollO, kai meta tauta katapinein mEketi eis tEn autEn koilian, all' eis heteran, hikanOs hEmin ephaineto thaumasion einai; PararOsi de polloi ta toiauta tEs phuseOs erga, mona ta xena theamata thaumazontes.

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Nature forming, fashioning and perfecting the Parts of the Body; hath so brought it to pass, that they would of themselves, without any teaching, set about and perform their proper Actions: And of this I once made a great Experimcnt, bringing up a Kid without ever seeing its Dam. For dissecting some Goats great with Young, to resolve some Questions mnde by Anatomists, concerning the Oeconomy of Nature in the Formation of the Foetus in the Womb; and finding a brisk Embryon, [young one] I loosed it from the Matrix after our usual manner, and snatching it away, before it saw its Dam, I brought it into a certain Room; having many Vessels full, some of Wine, some of Oil, some of Honey, some of Milk, or some other Liquor; and others, not a few, filled with all forts of Grain, as also with several Fruits, and there laid it. This Embryon we saw first of all getting up on its Feet and walking, as if it had heard, that its Legs were given it for that purpose; next Shaking of the Slime it was besmeared with from the Womb; and moreover, thirdly, scratching its Side with one of his Feet; then we saw it smelling to every one of those Things that were put in the Room; and when it had smelt to them all, it supped up the Milk; whereupon we all for Admiration cried out, seeing clearly the Truth of what Hypocrates saith, that the Natures and Actions of Animals are not taught, (but by Instinct). Hereupon I nourished and reared this Kid, and observed it afterwards not only to eat Milk, but some other things that stood by it. And the Time when this Kid was taken out of the Womb being about the Vernal Equinox, after some two Months were brought into it the tender Sprouts of Shrubs and Plants, and it again smelling of all of them, instantly refused some, but was Pleased to taste others, and after it had tasted, began to eat of such are are the usual Food of Goats. Perchance this may seem a small thing, but what I shall now relate is great. For eating the Leaves and tender Sprouts, it swallowed them down, and then a whilc after it began to chew the Cud; which all that saw cried out again with Admiration, being astonished at the Instincts and natural Faculties of Animals. For it was a great thing that when the Creature was hungry, it should take in the Food by the Mouth, and chew it with its Teeth; but that it should bring up again into the Mouth that which it had swallowed down into its Stomach; and chewing it there a long time, it should grind and smooth it, afterwards swallow it again, not into the same Stomach, but into another, seemed to us wonderful indeed. But many neglect such Works of Nature, admiring only strange and unusual Sights." So far Galen.

This pleasant and admirable Story, should one consider all the Particulars of it; and endeavour to give an Account of them, as also all the Inserences that might be drawn from it, one might fill a whole Volume with Comments upon it. All that I shall at present say is this, That in all this Oeconomy, and these Actions, Counsel and Design doth so clearly appear, that he must needs be very stupid that doth not discem it, or impudent, that can deny it. I might add, That there seems to be something more than can be performed by meer Mechanism in the Election this Creature made of its Food: For before it would eat of any, it smelt to all the Liquors before it, and when it had done so, betook itself to the Milk, and devoured that. He doth not say that the Milk was the last Liquor it smelt to, or that when it had once smelt to that, it presently drank it up. The like also he saith of all the Sprouts and Branches of Plants that were laid before it. By the by, we may take Notice of one thing very remarkable, that this Kid of its own Accord drank Milk, after the manner it had done in the womb; whereas had it once drawn by the Nipple, it would hardly have sipp'd the Milk. And therefore in weaning young Creatures, the best Way is never to let them suck the Paps at all, for then they will drink up Milk without any Difficulty; whereas, if they have Suck'd, some will very hardly, others, by no means, be brought, to drink. But how do the Young with such Facility come to take the Nipple, and to suck at it, which they had never before used to do? Here we must have Recourse to Natural Instinct, and the Direction of some Superiour Cause.

Notice hath been already taken in an 0bservation communicated by my Learned Friend Dr. Tancred Robinpon, of the Providence of Nature in so forming the Membranes of the Body, as to be capable of a prodigious Dilatation and Extension; which is of great Use in some Diseases; for Example, the Dropsy, to continue Life for some time, till Remedy may be had; and if not, to give Time to prepare for Death. But the Wisdom and Design of this Texture doth in no Instance more clearly appear, than

in the Necessity of it for the Womb in the Time of Gestation. For were not the Womb in Women, which, during Virginity, is not bigger than a small Purse, almost infinitely Dilatable, and also the Peritoneum, not to mention the Skin, and the Cuticula; how were it possible it should contain the Child, nay sometimes Twins, with all their Appurtenances, the Secundines, the Placenta, the Liquor or Waters, and what else is necessary for the Defence, Nutrition, Respiration, and soft and convenient Lodging of them, till they come to their due Perfeetion and Maturity for Exclusion? How could the Child have room to grow there to his Bigness, and stir and turn himself as is requisite? Add hereto another Observation of Blasius's, particularly relating to this Subject: He hath observed, that the Vessels of the interiou glandulous Substance of the Womb are strangely contorted and reflected with Turnings and Meanders, that they might not be too much strained, but their Folds being extended and abolished, they might accommodate themselves without Danger of Rupture to the necessary Extension of the Uterine Substance at that Time.

Another remarkable Proof of Council, and Design may be fetch'd from the Formation of the veins and arteries near the heart, which I meet with in Dr. Lower's Treatise De Corde. Just before the Entrance of the Right Auricle of the heart, (saith he) to wit, where the ascending Trunk of the Vena Cava meeting with the descending, is ready to empty itself into the said right auricle, there occurrs in it a very remarkable Knob or Bunch [Tuberculum] raised up from the subjacent Fat, by the Interposition whereof the Blood falling down by the dessending Vein, is diverted into the Auricle, which otherwise encountring and bearing upon that of the ascendent Trunk, would very much hinder and retard the Motion of it upward towards the Heart: And because in an erect Site and Figure of the Body there is a greater and more eminent Danger of such an Accident, therefore the Vena Cava in Mankind hath this Tubercle far greater, and more extant than it is in Brutes, so that if you thrust your finger into either Trunk, you can hardly find Passage or Admittance into the other.

But in Quadrupeds, as in Sheep, Dogs, Horse, Kine, in which the Course of the Blood from either Extreme of the Body is more equal, and, as it were, in a plainer Level, and because the Heart, by Reason of its Bulk and Weight, hanging downwards, both Trunks of the Vena Cava have some little Declivity towards it, there is no need of so great a Bar and Diversion in them; yet are they not altogether devoid of it.

Moreover, lest the Blood here in its Conflux should make a Kind of Flood and Whirlpool, whilst the Auricle being contracted doth not give it free Ingress, therefore, in this place, the Vena Cava in great Animals, as well Man as Quadrupeds, is round-about Musculous; as well that it may be restrain'd and kept within its due Limits of Extension, as that it may more vigorously, and strongly urge and impel the Blood into the Cavity of the Auricle. Besides, there is no less Providence and Caution used, that the Blood, when it is forcibly cast out of the Left Ventricle of the Heart, be not unequally distributed to the superior or inseriour Parts. For whereas this Gate or Orifice of the Heart opens right upwards, if that Channel, which receives the first Impulse of the Blood, did lead in a strait Line up to the Region of the Head, it could not be, but that it must be poured too swiftly upon the Brain, and so the inseriour Parts of the Body must needs be defrauded of their vital Liquor and Aliment. Which Inconvenience, that the divine Architect of the Body might wholly obviate and avoid, in Animals whose Hearts are more strongly moved; he so artificially contrived the Trunk of the Aorta, which is next the Heart, that the Blood runs not directly into the Axillary and Carotide Arteries, but doth as it were fetch a Compass: For in the middle Space between the Ventricle and those Arteries, it is very much inflected or bent; whence it comes to pass, that that crooked Angle sustains the Force and first Stroke of the ejected Blood, and directs the greatest Torrent of it towards the descending Trunk of the Aorta, which otherwise would rush too forcibly into the superiour Branches thereof, distending them immoderately, and soon oppress and burden the Head. so gar Dr. Lowther.

To elude or evade the Force of all these Instances, and innumerable others, which might be produced, to demonstrate, that the Bodies of Men and all other Animals were the Effects of the Wisdom and Power of an intelligent and almighty Agent, and the Several Parts and Members of them designed to the Uses to which now they serve, the Atheist hath one Subterfuge, in which he most consides, viz. That all these Uses of Parts are no more than what is necessary to the very Existence of the Things to whom they belong: And what Things made Uses, and not Uses Things.

<latin>Nil ideo natum est in corpore ut uti Possemus, sed quod natum est id procreat usum.</latin> Saith Lucretius, Lib. 4.

And having Instanced in several Members, he concludes,

<latin>Omnia denique membra Ante fuere, ut opinor, eorum quam fuit usus.</latin>

I shall give you their Sense, together with the Confutation of it in Dr. Bentley's Words, borrowed out of his Fifth Lecrure, &c.

"These Things (say the Atheists) are mistaken for Tokens of Skill and Contrivance, whereas they are but necessary Consequences of the present existence of those Creatures to which they belong: For he that supposeth any Animals to subsist, doth, by that very Supposition, allow them every Member and Faculty that are necessary to Subsistence. And, therefore, unless we can prove a priori, and independent on this Usefulness, now that Things are once supposed to have existed and propagated; that among almost infinite Trials and Essays at the Beginning of Things, among Millions of monstrous Shapes and imperfect Formations, a few such Animals as now exist could not possibly be produced, these After-Considerations are of very little Moment: because, if such Animals could in that way possibly be formed, as might live, and move, and propagate their Beings, all this admired and applauded Usefulness of their several Fabricks is but a necessary Condition and Consequence of their Existence and Propagation.

This is the last Pretence and Sophistry of the Atheists against the Proposition in my Text, [Acts xvii 27] That we received our Life and Being from a Divine Wisdom and Power. And as they cannot justly accuse me of concealing or baulking their Grand Objection, so, I beiieve, these following Considerations will give them no Reason to boast that it cannot receive a just and satisfactory Answer.

(1.) First, therefore, we affirm that we can prove, and have done it already by Arguments a priori, which is the Challenge of the Atheists) that these Animals that now exist, could not possibly have been formed at first by Millions of Trials. For seeing they allow by their very Hypothessis, (and without standing to that Courtesy, we have proved it before) that there can be no casual or spontaneous Motion of the Particles of Matter; it will follow, that every single Monster, among so many supposed Myriads, must have been mechanically and necessarily formed, according to the known Laws of Motion, and the Temperament and Quality of the Matter it was made of. Which is sufficient, that no such Monsters were or could have been formed. For to denominate them even Monsters, they must have had some rude Kind of Organical Bodies, some Stamina of Life, though never so clumsy, some system of Parts, compounded of solids and Liquids, that executed (though but bunglingly) their peculiar Motions and Functions. But we have lately shewn it impossible for Nature, unassisted, to constitute such Bodies, whose Structure is against the Law of specifick Gravity. So that she could not make the least Endeavour towards the producing of a Monster, or of any thing that hath more Vital and Organical Parts than we find in a Rock of Marble, or a Fountain of Water. And again, though we should not contend with them about their Monsters and Abortions, yet seeing that they suppose, even the perfect Animals, that are still in Being, to have been formed mechanically among the rest, and only add some Millions of Monsters to the Reckoning. They are

liable to all the Difficulties in the former Explication, and are expressly refuted through the whole preceding Sermon, where it is abundantly shewn, that a spontaneous Production is against the Catholick Laws of Motion, and against Matter of Fact, a Thing without Example, not only in Man and the nobler Animals, but in the Smallest of Insects, and the Vilest of Weeds: Though the Fertility of the Earth cannot be said to have been impaired since the Beginning of the World.

(2.) Secondly, We may observe, that this Evasion of the Atheist is fitted only to elude such Arguments of divine Wisdom as are taken from Things necessary to the Conservation of the Animal, as the Faculties of Sight, and Motion, and Nutrition, and the like; because such usefulness is indeed included in a general Supposition of the Existence of that Animal, but it miserably fails him against other Reasons, from such Members and Powers of the Body as are not necessary absolutely to Living and Propagating, but only much conduce to our better Subsistence and happier Condition. So the most obvious Contemplation of the Frame of our Bodies, as that we all have double Sensories, two Eyes, two Ears, two Nostrils, is an effectual Confutation of this Atheistical Sophism. For a double Organ of these Senses is not at all comprehended in the Notion of bare Existence; one of them being sufficient to have preserved Life, and continued the Species, as common Experience witnesseth. Nay, even the very Nails of our Fingers are an infallible Token of Design and Contrivance; for they are useful and convenient to give Strength and Firmness to those Parts in the various Functions they are put to; and to defend the numerous Nerves and Tendons that are under them, which have a most exquisite Sense of Pain, and without that native Armour would continually be exposed to it. It is manifest, therefore, that there was a Contrivance and Foresight of the Usefulness of Nails, antecedent to their Formation.

For the old stale Pretence of the Atheists, that Things were first made fortuitously, and afterwards their Usefulness was observed or discovered, can have no Place here; unless Nails were either absolutely requisite to the Existence of Mankind, or were found only in some Individuals, or some Nations of Men, and so might be ascribed to Necessity upon one Account, or to Fortune upon another. But from the Atheists Supposition, that among the infinite Diversity of the first Terrestrial Productions, there were Animals of all imaginable Shapes and Structrures of Body, all of which survived and multiplied, that by Reason of their Make and Fabrick could possibly do so, it necessarily follows, that we should now have some Nations without Nails upon their Fingers, others with one Eye only, as the Poets describe the Cyclopes in Sicily, and the Arimaspi in Scythia; others with one Ear, or with one Nostril, or indeed without any Organ of Smelling, because that Sense is not necessary to Man's Subsistence; others destitute of the Use of Language, seeing that Mutes also may live. One People would have the Feet of Goats, as the feigned Saytrs and Panisci: Another would resemble the Head of Jupiter Ammon, or the horned Statues of Bacchus; the Scipodes and Enotocetae, and other monstrous Nations, would be no longer Fables, but real Instances in Nature: And, in a Word, all the ridiculous and extravagant Shapes the can be imagined, all the Fancies and Whimsies of Poets and Painters, and AEgyptian Idolaters, if so be they are consistent with Life and Propagation, would be now actually in being if our Atheists Notion were true: Which therefore may deservedly pass for a meer Dream and an Error, till they Please to make new discoveries in the Terra incognita, and bring along with them some Savages of all these fabulous and monstrous Configuratious. Thus far Dr. Bentley, who adds four Considerations more to confute this Fancy, ex abundanti, granting the Atheist all the absurd Suppositions he can make. For which, though they be very well worth the reading, yet being too long to transcribe, I refer the Reader to the Sermon itself.

I shall now farther prove by a notable Instance, that Uses made Things, that is to say, that some things were made designedly and on purpose for such an Use as they serve to; and that is, the Tendrels or Claspers of Plants, because they are given only to such Species as have weak and infirm Stalks, and cannot raise up, or support themselves by their own Strength. We see not so much as one Tree, or Shrub, or Herb, that hath a firm and strong Stem, and that is able to mount up and

stand alone without Assistance, furnished with them. Whereas, had they been, without Design, scattered (as I may say) indifferently and carelessy among Plants, it could not possibly have happened, but among so many thousand Spccies, they must have fallen to the Lot of some few, at least, some one of the Strong, and not only of the Weak. The same hath been proved by the Instance of the Power given to the Hedgebog and Armadillo, of contracting their Bodies into a globular Figure, and so hiding and securing their tender and unarmed Parts.

2. I shall prove by another eminent Instance, that Things did not make uses, because there is a sort of Creatures which have all the Parts and Organs which are fitted for a certain Action, and employed for the Exercise of it by another sort; and yet make no use of them for that Purpose: That is, the Ape-kind. The Parisian Academists, in their Anatomy of some Animals of this Kind, tell us, that the Muscles of the Os Hyoides, Tongue, Larynx, and Pharynx, which do most serve to articulate a Word, were wholly like to those of Man, and a great deal more than those of the Hand; which, nevertheress, the Ape, which speaks not, uses with as much Perfection as a Man. Which demonstrates, that Speech is an Action more peculiar to Man, and which more distinguishes him from Brutes, than the Hand, which Anaxagoras, Aristotle, and Galen, have thought to be the Organ, which Nature has given to Man, as to the wisest of all Animals; for want perhaps of this Reflexion: For the Ape is found provided by Nature of all those marvellous Organs of Speech, with so much Exactness, that the very three small Muscles, which do take their Rise from the Apothesis Styloides, are not wanting, although this Apothesis be extremely small. This Particularity does likewise shew, that there is no Reason to think, that Agents do perform such and such Actions, because they are found with Organs proper thereunto: For, according to these Philosophers, Apes should speak, seeing that they have all the Instruments necessary for Speech. All this is confirmed and approved by the learned and accurate Dr. Tyson, in his Anatorny of the Orang Outrang, or Pigmy, he finding in the Animal he describ'd, which was of the Ape-kind) the whole Structure of the Larynx and Os Hyoides exactly as 'tis in Man. And the Reflexion which the Parisians make upon their Observation of these and the neighbouring Parts, he thinks very just and valuable and adds farther; that this is not the only Instance, which may justify such an Inserence, though he thinks it so strong an one, as the AtheiSts can never Answer.

It is farther considerable, and adds to the Weight of this Instance, that though Birds have been taught to imitate Humane Voice, and to pronounce Words, yea Sentences, yet Quadrupeds never; though they have Organs far more fit for that Purpose, and some of them, viz. Dogs, and Horses, converse almost perpetually with Men; and others, as Apes, are given naturally to imitate Mens Actions; as if Providence had designed purposely to confute this fond Conceit of the Atheists, by denying them the Power to make use of these Organs of Speech, which, whether they understand what they said or not, they otherwise might and would have done in Imitation of Man, and that to greater Perfection than Birds do, or are capable of doing.

Farther, to prove that those nobler Faculties of the Soul, Reason, and Understanding, cannot be produced by Matter organized, but must have a higher Principle, he <margin>Dr. Tyson</margin> thus argues; "It is an Observation of Vesalius's, that the Brain of Man, in respect of his Body, is much larger than what is to be met with in any other Animals, exceeding in Bigness three Oxes Brains; whence he insers, that as Animals excel in the Largeness of the Brain, so they do likewise in the principal Faculties of the soul; which Inserence the Doctor cannot allow.

It is (saith he) a generally received Opinion, that the Brain is the immediate Seat of the soul itself, whence one wrould be apt to think, that seeing there is so great a Disparity hetween the soul of a Man and a Brute, the Organ, in which it is placed, should be very different too; yet, by comparing the Brain of our Pigmy [the Orang-Outrang, or Wild-Man] with that of a Man, and with the greatest Exactness of observing each Part in both, it was very surprizing to me to find so great a

Resemblance of the one to the other, as nothing could be more; and that in Proportion to its Body, its Brain was also as large as a Man's.

Since therefore (he proceeds) the Brain of our Pigmy does in all respects so exactly resemble a Man's, I might here make the same reflexion the Parisians did upon the Organs of Speech, that there is no Reason to think, that Agents do perform such and such Actions, because they are found with Organs proper thereunto; for then our Pigmy might be really a Man. The Organs in Animal Bodies, are only a regular Compages of Pipes and Vessels for the Fluids to pass thro', and are passive. What actuates them, are the Humours and Fluids: And Animal Life consists in their due and regular Motion in this organical Body. But those nobler Faculties in the Mind of Man, must certainly havc a higher Principle, as Matter organized could never produce them: For why else, where the Organ is the same, should not the Action be the same too?

Object. Some may here object and arg;ue, if the Body of Man be thus perfect, why did God make any othes Animals? For the most perfect Being the best, an infinitely good Agent, which wants neither Wisdom nor Power, should (one would think) only produce the most perfect.

Answer. To which I Answer, 1. That according to this Argumentation, one might inser that God must produce but one kind of Creature, and that the most Perfect that he is able, which is impossible: For he being Infinite in all Perfection, cannot act <latin>ad extremum virium,</latin> unless he could produce an Infinite Creature, that is, another God, which is a Contradiction: But whatever he makes, must want Degrees of Infinite Perfection, of which he could sttill (if he pleased) add more and more to it.

2. The inseriour Creatures are perfect in their Order and Degree, wanting no Quality or Perfection that is necessary or due to their Nature and Condition, their Place and Manner of Living. Now, why God might not make several subordinate Ranks and Degrees of Creatures, they being good, I see no Reason.

3. These several Ranks and Degrees of Creatures are subservient one to another; and the most of them serviceable, and all, some way or other, useful to Man; so that he could not well have been without them.

4. God made these several Orders and Degrees, and in each Degree so many Varieties of Creatures, for the Manifestation and Displaying of his Infinite Power and Wisdom. For we have shewn before, by a familiar Instance, that there is more Art and Wisdom shewn in contriving and forming, a Multitude of different Kinds of Engines, than in one only.

5. Yet do I not think, that he made all these Creatures to no other End, but to be Serviceable to Man, but also to Partake themselves of his overflowing Goodness, and to enjoy their own Beings. If we admit all other creatures in this inseriour World besides Man, to be meer Machines, or Automata, to have no Life, no Sense, or Perception of any Thing, then, I consess, this Reason is out of doors; for being uncapable of Pleasure or Pain, they can have no Enjoyment. Upon this account, also among others, I am less inclinable to that Opinion.

I should now proceed to Answer some Objections which might be made against the Wisdom and Goodness of God in the Contrivance and Governance of the World, and all Creatures therein contained. But that is too great and difficult a Task for my Weakness, and would take up more Time than I have at present to spare, were I qualified for it, and besides swell this Volume to too great a Bulk. Only I shall say something to one Particular, which was suggested to me by a Learned and Pious Friend <margin>Mr. Robert Burscough of Totness, in Devon</margin>.

Objection. A wise Agent acts for Ends. Now what End can there be of creating such a vast Multitude of Insects, as the World is fill'd with; most of which seems to be useless, and some also noxious and pernicious to Man, and other Creatures?

Answer. To this I shall answer,

1. As to the Multitude of species or Kinds.

2. As to the Number of Individuals in each Kind.

First, As to the Multitude of Species, which we must needs acknowledge to be exceeding great, they being not fewer, perchance more, than 20000). I answer, there were so many made,

1. To manifest and display the Riches of the Power and Wisdom of God, Psalm civ 24 "The Earth is full of thy Riches; so is this great and wide Sea, wherein are Things creeping innumerable, &c." We should be apt to think too meanly of those Attributes of our Creator should we ever be able to come to an End of all his Works, even in this Sublunary World. And therefore, I believe, never any Man yet did, never any Man shall, so long as the World endures, by his utmost Industry, attain to the Knowledge of all the Species of Nature. Hitherto we have been so far from it, that in Vegetables, the Number of those which have been discovered this last Age, hath far exceeded that of all those which were known before. So true is that we quoted before out of Seneca

<latin>Pusilla rer ejZ 1nundus, ni/i in eo qaod q~rat omlir, 7nundlls habeat. The World is so richly furnished and provided, that Man need not fear want of Employment, should he live to the Age of Methuselah, or ten times as long. But of this, having touched it already, I shall add no more.

2. Another reason why so many Kinds of Creatures were made, might be to exercise the contemplative Faculty of Man; which is in nothing so much pleas'd, as in Variety of Objects. We soon grow weary of one Study; and if all the Objects of the World could be comprehended by us, we should, with Alexander, think the World too little for us, and grow weary of running in a Round of seeing the same Things. New Objects afford us great Delight, especially if found out by our own Industry. I remember Clusius saith of himself, "That upon the Discovery of a new Plant, he did not less rejoice, than if he had found a rich Treasure." Thus God is pleased, by reserving Things to be found out by our Pains and Industry, to provide us Employment most delightful and agreeable to our Natures and Inclinations.

3. Many of these Creatures may be useful to us, whose Uses are not yet discovered, but reserved for the Generations to come, as the Uses of some we now know are but of late Invention, and were unknown to our Forefathers. And this must needs be so, because, as I said before, the World is too great for any Man, or Generation of Men, by his, or their utmcst Endeavours, to discover and find out all its Store and Furniture, all its Riches and Treasures.

Secondly, As to the Multitude of Individuals in each Kind of Insect. I answer,

1. It is designed to secure the Continuance and Perpetuity of the several Species; which, if they did not multiply exceedingly, scarce any of them could escape the Ravine of so many Enemies as continually assault and prey upon them, but would endanger to be quite destroyed and lost out of the World.

2. This vast Multitude of Insects is useful to Mankind, if not immediately, yet mediately. It cannot be denied, that Birds are of great Use to us; their Flesh according us a good Part of our Food, and that the most delicate too, and their other Parts Physick, not excepting their very Excrements.

Their Feathers serve to stuff our Beds and Pillows, yielding us soft and warm Lodging, which is no small Convenience and Comtort to us, especially in these Northern Pats of the World. Some of them have also been always employed by Military Men in Plumes, to adorn their Crests, and render them formidable to their Enemies. Their Wings and Quills are made use of for Writing-Pens, and to brush and cleanse our Rooms, and their Furniture. Besides, by their melodious Accents they gratify our Ears; by their beautiful Shapes and Colours, they delight our Eyes, being very ornamental to the World, and rendring the Country where the Hedges and Woods are full of them, very pleasant and chearly, which without them would be no less lonely and melancholy. Not to mention the Exercise, Diversion, and Recreation, which some of them give us.

Now Insects supply Land-Birds the chiefest Part of their Sustenance: some, as the entire Genus of Swallows, living wholly upon them, as I could easily make out, did any Man deny or doubt of it: And not Swallows alone, but also Wood-peckers, if not wholly, yet chiefly; and all other sorts of Birds partly, especially in Winter-time, when Insects are their main Support, as appears by dissecting their Stomachs.

As for young Birds, which are brought up in the Nest by the old, they are fed chiefly, if not solely, by Insects. And therefore for the time when Birds for the most part breed in the Spring, when there are Multitudes of Caterpillars to be found on all Trees and Hedaes. Moreover, it is very remarkable, that of many such Birds, as when grown up, feed almost wholly upon Grain, the voung ones are nourished by Insects. For Example, Pheasants and Partridges, Which are well known to be granivorous Birds, the Young live only or mostly upon Ants Eggs. Now Birds, being of a hot Nature, are very voracious Creatures, and eat abundantly, and therefore there had need be an infinite Number of Insects produced for their Sustenance. Neither do Birds alone, but many sorts of Fishes feed upon Insects, as is well known to Anglers, who bait their Hooks with them. Nay, which is more strange, divers Quadrupeds feed upon Insects, and some live wholly upon them, as two sorts of Tamunduus upon Ants, which therefore are called in English Ant-Bears; the Camelion upon Flies; the Mole upon Earth-Worms: The Badger also lives chiefly upon Beetles, Worms, and other Insects.

Here we may take Notice by the way, That because so many Creatures live upon Ants and their Egggs, Providencc hath so ordered it, that they should be the most numerous of any Tribe of Insects that we know.

Conformable to this Particular, is the Reason my ingenious and inquisitive Friend Mr. Derham, before remembred, hath given of the Production of such innumerable Multitudes of some Aquatick Insects.

I have often thought, (saith he) that there was some more than ordinary Use in the Creation for such Insects as are vastly numerous; such as the Pulices Aquatici, which are in such Swarms, as to discolour the Waters, and many others: And therefore I have bent my Enquiries to find out the Uses of such Creatures; wherein I have so far succeeded, as to discover, that those vastly small Animalcula, not to be seen without a Microscope, with which the Waters are replete, serve for Food to some others of the small Insects of the Waters, particularly to the Nympha culicaria [Hirsuta it may be called] figured in Swammerdam. For viewing that Nympha one Day, to observe the Motion of its Mouth, and for what Purpose it is in such continual Motion; whether as Fish to get Air, or to suck in Food, or both, I could plainly perceive the Creature to suck in many of these most minute Animalcula, that were swimming briskly about in the Water. Neither yet do these Animalcules serve only for Food to such Nymphae, but also to another to me anonymous Insect of the Waters, of a dark Colour; cleft as it were in sunder, and scarce so big as the smallest Pin's Head. These Insects hunt these Animalcules, and other small Creatures that occur in the Water, and devour them: And I am apt to think, although I have not yet Seen it, that the Pulex aquaticus arborescens liveth upon

these or more minute and tender Animalcules, and that it is to catch them that it so leaps in the Water.

This to me seems a wonderfu! Work of God, to provide for the minutest Creatures of the Waters, Food proper for them, that is, minute and tender, and fit for their Organs of Swallowing.

As for noxious Insects, why there should be so many of them produced, if it be demanded,

I answer, 1. That many that are noxious to us, are salutary to other Creatures; and some that are Poison to us, are Food to them. So we see the Poultry-kind feed upon Spiders. Nay, there is scarce any noxious Insect, but one Bird or other eats it, either for Food or Physick. For many, nay, most of those Creatures, whose Bite or Sting is poisonous, may safely be taken entire into the Stomach. And therefore it is no wonder, that not only the Ibis of Egypt, but evcn Storks and Peacocks prey upon and destroy all sorts of Serpents, as well as Locusts and Catcrpillars.

2. Some of the most venomous and pernicious of Insects afford us noble Medicines, as Scorpions, Spiders, and Cantharides.

3. These Insects seldom make use of their offensive Weapons, unless assaulted or provoked in their own Defence, or to revenge an Injury. Let them but alone, and annoy them not, nor disturb their Young, and unless accidentally, you shall seldom suffer by them.

Lastly, God is Pleased sometimes to make use of them as Scourges, to chaitize or punish wicked Persons or Nations, as he did Herod, and the Egyptians. No Creature so mean and contemptible, but God can, when he Pleases, produce such Armies of them as no humane Force is able to conquer or deptroy, but they shall of a sudden consume and devour up all the Fruits of the Earth, and whatever might serve for the Sustenance of Man, as Locusts have often been observed for to do.

Did these Creatures serve for no other Use, as they do many; yet those that make them an Objection against the Wisdom of God, may (as Dr. Cockburn well notes) as well upbraid the Prudence and Policy of a State for keeping Forces, which generally are made up of very rude and insolent people, which yet are necessary, either to suppress Rebellions, or punish Rebels, and other Disorderly and vicious Persons, and keep the World in quset.</1717>

From that Part of this Discourse which relates to the Body of Man, I shall make these Practical Inferences.

Inference 1. First, Let us give Thanks to Almighty God for the Perfection and Integrity of our Bodies. It would not be amiss to put it into the Eucharistical part of our daily Devotions: "We praise Thee, O God, for the due Number, Shape, and Use of our Limbs and Senses; and in general, of all the parts of our Bodies; we bless thee for the sound and healthful Constitution of them Psalm C. "It is thou that hast made us and not we ourselves; in thy Book were all our Members written."<1717>

The Formation of the Body is the Work of God, and the whole Process thereof attributed to him, Psalm CXXIX. 13,14,15. /1717>

The Mother that bears the Child in her Wmb, is not conscious to any thing that is done there; she understands no more how the Infant is formed, than itself doth. But if God hath bestowed upon us any peculiar Gift or Endowment, wherein we excell others, as Strength, or Beauty, or Activity, we ought to give him special Thanks for it, but not to think the better of ourselves therefore, or despisc them that want it.

Now, because these bodily Perfections, being common Blesings, we are apt not at all to consider them, or not to set a just Value on them; and because the Worth of Things <**224> is best discerned by their Want, it would be useful sometimes to imagine or suppose ourselves, by some Accident, to be deprived of one of our Limbs or Senses, as a Hand, or a Foot, or an Eye; for then we cannot but be Sensible, that we should be in worse Condition than now we are, and that we should soon find a Difference between two Hands and one Hand, two Eyes and one Eye, and that two excell one as much in Worth as they do in Number; and yet, if we could spare the Use of the lost Part, the Deformity and Unsightliness of such a Defect in the Body, would alone be very grievous to us. Again, which is less, suppose we only, that our Bodies want of their just Magnitude, or that they, or any of our Members are crooked or distorted, or disproportionate to the rest, either in Excess or Defect; nay, which is least of all, that the due Motion of any one Part be perverted, as, but of the Eyes in Squinting, the Eye-Lids in Twinkling, the Tongue in Stammering, these Things are such Blemishes and Offences to us, by making us Gazing-Stocks to others, and Objecs of their Scorn or Derision, that we could be conten to part with a good Part of our Estates to repair such Defeets, or heal such Infirmities.

These Things considered, and duly weighed, would surely <**225> be a great and effectual Motive to excite in us Gratitude for this Integrity of our Bodies, and to esteem it no small Blessing, I say, a Blessing and Favour of God to us; for some there be that want it, and why might not we have been of that Number? God was no way obliged to bestow it upon us!

And as we are to give Thanks for the Integrity of our Body, so are we likewise for the Health of it, and the sound Temper and Constitution of all its Parts and Humours; Health being the principal Blessing of this Life, without which we cannot enjoy, or take Comfort in any thing besides.

Neither are we to give Thanks alone for the first Collation of these Benefits, but also for their Preservation and Continuance. God preserves our Souls in Life, and defends us from Dangers and sad Accidents, which do so beset us on every side, that the greatest Circumspection in the World could not secure us, did not his good Providence continually watch over us. We may be said to walk and converse in the midst of Snares; besides, did we but duly consider the Make and Frame of our Bodies, what a Multitude of minute Parts and Vessels there are in them, and how an Obstruction in one redounds to the Prejudice of the whole, <**226> we could not but wonder how so curious an Engine as Man’s Body could be kept in tune one Hour, as we use it, much less hold out so many Years? How it were possible it should endure such Hardships, such Blows, so many Shocks and Concussions, nay, such Violences and Outrages as are offered it by our frequent Excesses, and not be disordered and rendered useless; and acknowledge the transcendent Art and Skill of him who put it together, as to render it thus firm and durable.

Inference 2. Secondly, Have a care thou dost not by any vicious Practice deface, marr, or destroy the Workmanship of God. So use this Body as to preserve the Form and Comeliness, the Health and Vigour of it.

1. For the Form and Beauty of the Body, which Mankind generally is fond enough of; and which must be acknowledged to be a Natural Endowment and Blessing of God, a thing desirable, which all Men take Complacency in; which renders Persons gracious and acceptable in the Eyes of others; of which yet we do not observe, that Brute Beasts take any Notice at all: Of this I shall observe, that outward Beauty is a Sign of inward; and that handsome Persons are naturally well inclined, till they do either debauch themselves, or are corrupted by others; and then with their Manners they marr their Beauty too. For a Man may observe, and easily discern, that as Persons are better or worse inclined, the very Air of their Visage will alter much; and that vicious Courses, "defacing the inward Pulchritude of the soul, do change even the outward Countenance into an abborr’d Hue <margin> Dr. More.</margin>: As is evident in the Vices of Intemperance and Anger, and may, by sagacious

Persons, be observed in others also. No better Cosmeticks than a severe Temperance and Purity, a real and unaffected Modesty and Humility, a gracious Temper and Calmness of Spirit, a Sincere and Universal Charity. No true Beauty without the Signatures of these Graces in the very Countenance. They, therefore, who through the contrary Vices do deface and blot out this natural Character and Impress, and do Violence to their own Inclinations, that sacrifice this Jewel to their Lusts, that reject this Gift of God, and undervalue the Favour of Man, aggravate their Sin and Misery, and purchase Hell at somewhat a dearer Rate than others do. And those that have but a mean Portion of this Gift, are the more obliged by vertuous Practice, not only to preserve, but to improve it. Virtue, (as Cicero observes) if it could be seen with Corporeal Eyes, admirabiles sui Amores excitaret</latin>; it would excite a wonderful Love of itself. By the Signatures it there impresses, it is in some Measure visible in the Faces of those that practise it, and so must needs impart a Beauty and Amiableness to them.

Diogenes Laertius, in the Life of Socrates, tells us, that that Philosopher was wont to advise young Men, <greek>suneches katoptrizesthai </greek>, often to behold themselves in their Looking Glasses or Mirrors. Grammercy, Socrates, that is good Counsel indeed! Will our young Gentlemen and Ladies be ready to say, we like it very well, and we practise accordingly? And it seems we are injuriously taxed and reprehended by Divines, for spending so much time between a Comb and a Glass. Be not over-hasty; take what remains along with you: Mark the End for which the Philosopher exhorts this, <greek>hin ei men kaloi eien, axioi gignointo, ei d'aischroi paideia tEn duseideian epikaluptoien</greek>, That if they be handsomc, they might approve themselves worthy of their form; but if they be otherwise, they mlay by Discipline and Institution hide their Deformity, And so by their virtuous Behaviour compensate the Hardness of their Favour, and by the Pulchritude of their souls, make up what is wanting in the Beauty of their Bodies. And truly, I believe, a virtuous soul hath Influence upon its Vehicle, and adds a Lustre even to the outward Man, shining forth in the very Face.

2. So use the Body, as to preserve the Health and Vigour, and consequently produce the Life of it. These are things that all Men covet. No more effectual Means for the Maintenance and Preservation of them, than a regular and virtuous Life. That Health is impaired by Vice, daily Experience sufficiently evinceth. I need not spend Time to prove, what no Man doth or can deny. And as for Length of Days, we find by the same Experience, that intemperate and disorderly Persons are, for the most part, Short-liv'd: Moreover, immoderate Cares and Anxiety are observedsuddenly to bring gray Hairs upon Men, which are usually the Signs and Forerunners of Death. And, therefore, the way to live long, must needs be in all Points to use our Bodies, so as is most agreeable to the Rules of Temperance, and Purity, and right Reason. Every Violence offered to it, weakens and impairs it, and renders it less durable and lasting. One Means there is, which Physicians take Notice of, as very effectual for the Preservation of Health, which I cannot here omit, that is, a quset and chearful Mind, not afflicted with violent Passions, or distracted with immoderate Cares; for these have a great and ill Influence upon the Body. Now, how a Man can have a quset and chearful Mind under a great Burthen and Load of Guilt, I know not, unless he be very Ignorant, or have a seared Conscience. It concerns us, therefore, even upon this Account, to be careful of our Conversations, and to keep our Consciences void of Offence, both toward God, and toward Men.

Inser. 3. Thirdly, Did God make the Body? Let him have the Service of it, Rom. xii. 1. "I beseech you, Brethren, by the Mercies of God, that you present your Bodies a living Sacrifice, Holy, acceptable unto God, which is your reasonable Service. How we should do that, St. Chrysostom tells us in his Commentary upon this Place, <greek>, etc. Let the Eye behold no evil thing, and it is madc a Sacrifice; let the Tongue speak no filthy Word, and it becomes an Oblation: Let the Hand do no unlawful action, and you render it a Holocaust. Yet it was not enough thus to restrain them from Evil; but they must also be cmployed and exercised in doing that which is good: the Hand in giving

Alms, the Tongue in blessing them that curse us and despitefully use us, the Ear in hearkening to divine Lectures and Discourses,

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1 Cor. vi. 20. "Glorify God in yaus Body, or with your Body, and in your Spirits, which are God's"; and that not by Redemption only, of which the Apostle there speaks, but by Creation also. Rom. vi. 13. "Neither yield ye your Members as Instruments of Unrighteousness unto Sin, but as Instruments of Righteoujness unto God." And again, ver. 19. "Even so now yield your Members Servants of Righteousness unto Holiness." I shall Instance in two Members, which are especially to be guarded and restrained from Evil, and employed in the Service of God. <**227>

First, The Eye. We must turn away our Eyes from beholding Vanity, as David prayed God would his, Psalm. cxix. 37. We must "make a Covenant with our Eyes", as Job did, Job xxxi. 1. These are the windows that let in exteriour Objects to the soul: By these the Heart is affected; this way Sin entered first into the World. Our first Parent saw, that the Tree and its Fruit was pleasant to the Eyes, and so was invited to take and eat it. There are four Sins especially for which the Eye is noted, as either discovering themselves in the Eyes, or whose Temptations enter in by, and so give Denomination to the Eye.

1. There is a proud Eye, Prov. xix. 13. "Therc is a Generation, O how lofty are their Eyes! And their Eye-lids are lifted up", Chap. vi. 17. A proud Look is reckoned the First of those Things that God hates, Psalm. xviii. 27 "God (the Psalmist saith) will bring down proud or high Looks, Psalm. ci. 5. "Him that hath a high Look and a proud Heart (saith David) I will not suffer." And in Psalm. cxxxi. 1. he saith of himself, that "his Heart is not haughty, nor his Eyes lofty". By which Places it appeareth that Pride sheweth forth itself in the Eyes especially, and that they are, as it were, the Seat or Throne of it. <**228>

2. There is a wanton Eye, which the Prophet Isaish speaks of in his third Chapter, at the 16th Verse, Because the Daughters of Jerusalem walk with stretched-out Necks, and wanton Eyes. The Apostle Peter, in his Second Epistle, ii. 24. mentions "Eyes full of Adultery"; For by these Casements enter in such Objects, as may provoke and stir up adulterous Thoughts in the Mind, as they did in David's; and likewise impure Thoughts conceived in the Heart, may discover themselves by the Motions of the Eye. And, therefore, in this respect we should do well, with holy Job, to make a Covenant with our Eyes; not to gaze upon any Objects which may tempt us to any inordinate Appetite or Desire. For our Saviour tells us, it were better to pluck out our right eye, than that it should be an offence to us: Which I suppose refers to this Matter, because it immediately follows those Words, "He that looketh upon a Woman to lust after her, hath already committed Adultery with her in his Heart."

3. There is a covetous Eye. By Covetousness, I understand, not only a Desiring what is another Man's, which is forbidden in the Tenth Commandment, but also an inordinate Desire of Riches, which the Apostle John seems to understand in his First Epistle, ii. 16. "by the Lust of the Eye". And Covetousness may well be called the Lust of the Eye, because, 1. The Temptation or tempting Object enters by the Eye. So the seeing the Wedge of Gold, and Babylonian Garment, stirred up the covetous Desire in Achan. 2. Because all the Fruit a Man reaps of Riches, more than will furnish his Necessities and Conveniencies, is the Feeding of his Eye, or the Pleasure he takes in the beholding of them, Eccles. v. 11. "When Goods increase, &c. what Good is there to the Owners thereof, saving the Beholding them with their Eyes? "

4. There is an envious Eye, which, by our Saviour, is called an evil Eye, Matth. xx. 15; "Is thine Eye evil because I am good? " That is, enviest thou thy Brother, because I am kind to him. And, vii. 22. One of those evil Things which proceed out of the Heart and defile a Man, is an evil Eye. Envy is a

repining at the Prosperity or good of another, or Anger and Displeasure at any Good of another which we want, or any Advantage another hath above us. As in the Parable of the Labourers in the Vineyard, those that came in first envied the last, not because they received more than they but because they received equal Wages for less Time. Those that are subject to this Vice cannot endure to see another Man thrive, and are apt to think his Condition better than theirs when indeed it is not. <**230>

Let us then so govern our Eyes, that we discover by them none of these Vices. Let the Humility and Purity of our Minds appear even in our outward Looks. Let neither Pride nor Lust manifest themselves in the Posture or Motions of our eyes. Let us have a care, that these Members be neither the Inlets nor Outlets of any of the fore-mentioned Vices; that they neither give Admitsion to the Temptation, nor be expressive of the Conception of them. Let us employ them in reading the Word of God, and other Books, for the Increase of our Knowledge, and Direction of our Practice; in diligently viewing and contemplating the Works of the Creation, that we may discern and admire the Footsteps of the Divine Wisdom easily to be traced in the Formation, Disposition, and Designations of them. Let us take notice of any extraordinary Events and Effects of God's Providence towards ourselves or others, Personal or National: That as they are the issues of his Mercy or Justice, they may stir up suitable Affections in us of Thankfulness or Fear. Let those sad and miserable objects that present themselves to our Sights move us to Pity and Commiseration: And let our Eyes sometimes be exercised in Weeping for the Miseries and Calamities of others, but especially for our own and their Sins. <**231>

Secondly, Another Member I shall mention is the Tongue, which, as it is the chiet Instrument of Speech, so it may be well or ill employed in the Exercise of that Action, and therefore stands in need of Direction and Restraint. I remember I once heard from an ingenious Anatomist of Padua this Observation, That there are but two Members in the Body that have a natural Bridle, both which do very much need it; the Tongue, and another I shall not name. The Signification whereof may be, that they are not to be let loose, but diligently curbed and held in. <*1717> That the Tongue needs a Bridle, you will readily grant, if you read what the Apostle? hath written of it, CZ~np sii. 6. Xxe Tongue is a Fire, # Wcrlhl of lzliquit.y: Sa is the Lozlg;?zze among our Rlemberr, that it defleth the.Je whole Body, and retteth on f7;e the Coue^0e of Nature, and is Jbet on Fire of Hell. FoF every Kind of Beaser, and of Birds) and of Seepents, and of TzJings in the Sea, is tamed, and hath been tanted of Mankind; but the Tongue cas1 7z0 Man tame; it is an tinruly Evil, full of deadly Poison. </1717>

For the better Government of the Tongue, I shall note some Vices of Speech, which must carefully be avoided. First of all, Loquacity, or Garrulity. This the Contrivance of our Mouths suggests to us. Our Tongues are fenced and guarded with a double Wall, or Mound of Lips and Teeth, that our Words might not rashly and unadvisedly slip out. Then Nature hath furnished us with two Ears, and but one Tongue, to intimate, that we must hear twice so much as we speak. Why Loquacity is to be avoided, the Wise Man gives us a sufficient Reason, Prov. x. 19. "In the multitude of Words there wanteth not Sin." And, Eccles. v. 7. "In many Words there are divers vanities." To which we may add another, of great Force <**232> with most Men, viz. That it hath been always esteemed an Effect and Argument of Folly, Eccles. v. 3. "A Fool's Voice is known by multitude of Words." And on the contrary, to be of few Words is a sign of Wisdom and he that is wise enough to be silent, though a Fool, may pass undiscovered. Besides all this, a talkative Person must needs be impertinent, and speak many idle Words, and so render himself burthensome and odious to Company; and may perchance run himself upon great Inconveniencies, by blabbing out his own or others Secrets; for a Word once uttered, fugit irrevocabile, is irrevocable, whatever the Consequence of it be. Great need, therefore, have we to set a Watch over our Mouthr, and to keep the Door of our Lips, <1717> Psalm cxli. 3. </1717> and not suffer our Tongues <greek> <margin>runs before the understanding or wit</margin> as Socrates phraseth it

Secondly, Lying, or false Speaking. There is difference between Mentiri and Mendacium dicere, that is, Lying, and speaking of an Untruth, or thing that is false. Mentiri, is contra mentem ire, which though it be no good Etymology of the Word, is a good Notion of the Thing; that is, to go against one's Mind, or speak what one does not think. <greek>, as Homer expresses it, to conceal one thing in the Mind, and speak another with the <**233> Tongue. Hence a Man may speak an Untruth, and yet not lye, when he thinks he speaks the Truth; and on the contrary, may speak what is materially true, and yet lye, when he speaks what he thinks not to be True. The Tongue was made to be the Index of the Mind, Speech the Interpreter of Thought; therefore there ought to be a perfect Harmony and Agreement between these two. so that Lying is a great Abuse of Speech, and a perverting the very End of it, which was to communicate our thoughts one to another. It hath also an ill Principle, for the most part proceeding either from Baseness of Spirit, or Cowardice, as in them that have comnlitted a Fault and deny it, for fear of Punishment or Rebuke: <1717> And, therefore, the ancient Persians, as Xenophon tells us in his Kup8 7: . made it one of the three T hings they diligently taught thels Claildren; which lrrere ~XtEVE~V, Zx2to5evErvs xa' aaas veiv- To Hide, to Shoot, and to Jpeak the 7rzsth: </1717> Or from Covetousness, as in Tradesmen, who falsly commend their Commodities, that they may vend them for a greater Price; or from Vanity and Vain Glory, in them who falsly boast of any Quality or Action of their own. It is odious both to God and Man. To God, Prov. vi. 17. "A Lying Tongue" is one of those six or seven Things that are an "Abomination to Him". To Men, as Homer witnesseth in the Verse preceding the fore-quoted.

<greek> <**234> "He that tells Lies is as hateful to me, as the Gates of Hell or Death." -

The Practice of Lying is a Diabolical Exercise, and they that use it are the Devil's Children, as our Saviour tells us, John viii. 44. "Ye are of your Father the Devil, &c. for he is a Lyar, and the Father of it." And, lastly, it is a Sin that excludes out of Heaven, and depresses the soul into Hell, Rev. xxi. 8. "All Liars shall have their part in the Lake which burns with Fire and Brimstone, which is the second Death."

Thirdly, another Vice or Abuse of Speech, or vicious Action to which the Tongue is Instrumental, is slandering; that is, raising a false Report of any Man tending to his Defamation. This might have been comprehended under the former Head, being but a Kind of Lying proceeding from Enmity or Ill-Will. It is a very great Injury to our Neighbour; Mens Reputation being as dear to them as Life itself: so that it is grown to be a Proverb among the Vulgar, "Take away my good Name and take away tny Life." And that which enhances this Injury, is that it is irreparable. We cannot, by any contrary Declaration clear the Innocency of our Neighbour, as wholly to extirpate the preconceived Opinion out of the Minds of those to whom our Confession comes; and many will remain whom the Calumny hath <**235> reach'd, to whom the Vindication probably will not extend; the Pravity of Man's Nature being more apt to spread and divulge an ill Report, than to stop and silence it. I might Instance in Flattering of others, and boasting of ourselves for two Abuses of Speech; but they may both be referred to Lying, the one to Please others, and puff them up with self-Conceit, and a false Opinion, that they have some excellent Quality or Endowment, which they want, or have not in such a Degree, or that they are better thought of by others, than indeed they are, and more honoured: The other, to gain more Honour than is due to ourselves <1691 to them>.

<1717> Neither yet is it Boasting only of what we have not, but also what we have, condemned and disallowed by God and Men, as being contrary to that Humility and Modesy that ought to be in us, Prov. xxvii, 2. "Let another Man praise thee, and not thine own Mouth; a Stranger, and not thine own Lips." And moralists proceed so far as to censure all unnecessary <greek>periautologia</greek>, that is, Talking of a Man's self. </1717>

Fourthly, obscene and impure Words are another vicious Effect of the Tongue. Those are principally the <greek>sarko logoi</greek>, rotten Speeches the Apostle speaks of, Eph. v. 29. Such as chaste Ears abhor, which tend only to the depraving and corrupting the Hearers: and are to be studiously and carefully avoided by all that pretend to Christianity, Eph. v. 3. "But Fornication, and all Uncleanness, let it not be once named among you."

Fifthly, Cursing, and railing or reviling Words, are also a great Abuse of Speech, and outrageous Effects and Expressions of Malice and Wickedness, Psalm. x. 7. The Psalmist makes it part of the Character of a wicked <**236> Man, that "His Mouth is full of Cursing." Which Passage we have quoted by the Apostle, Rom. iii. 14. "Whose Mouth is full of cursing and Bitterness."

Sixthly, Swearing, and irreverently using the Name of God in common Discourse and Converse, is another Abuse of the Tongue; to which I might add vehement Asseverations upon slight and trivial occasions. I do not deny, but in a Matter of Weight and Moment, wlaich will bear out such Attestation, and where Belief will not be obtained without them, and yet it may much import the Hearer or Speaker that his Words be believed, or where the Hearer would not otherwise think the Matter so momentous or important as indeed it is, Protestations and Asseverations, yea, Oaths may lawfully be used. But to call God to witness to an Untruth or a Lye perhaps, or to appeal to Him on every trivial Occasion, in common Discourse, customarily, without any Consideration of what we say, is one of the highest Indignities and Affronts that can be offered him, being a Sin to which there is no Temptation: For it is so far from gaining Belief, (which is the only Thing that can with any shew of Reason be pleaded for it) that it rather creates Diffidence and Distrust. For as <latin>"multa fidem promissa levant", so "multa Juramenta"</latin> <**237> too; it being become a Proverb, "He that will Swear will Lie." And good Reason there is for it, for he that scruples not the Breach of one of God’s Commands, is not likely to make Conscience of the Violation of another.

Lastly, (For I will name no more) Scurrilous Words, Scoffing, and Jeering, Flouting and Taunting, are to be censured as Vicious Abuses of Speech.

This Scoffing and Derision proceeds from Contempt, and that of all Injuries Men do most impatiently bear; nothing offends more or wounds deeper: And, therefore, what greater Violation of that general Rule of Christian Practice, "to do to others as we would they should do unto us?" This Injury of being derided, the Psalmist himself complains of, Psalm lxix. 11,12. "I became a Proverb to them. They that sit in the Gate, speak against me, and I was the song of the Drunkards." And, Psalm xxxv. 15. according to the Church Translation, "The very Abjects came together against me unawares, making Mows at me, and ceased not"; and the Prophet Jeremy, Jer. xx. 7. "I am in Derision daily, every one mocketh me." And though there may be some Wit shewn in Scoffing and Jesting upon others, yet is it a practice inconsistent with true Wisdom. The Scorner and the Wise Man are frequently <**238> opposed in Scripture, Prov. ix. 8. and Chap. xiii. 1. etc. It is a Proverbial Saying, "The greatest Clerks are not always the wisest men". I think the Saying might as often be verified of the greatest Wits. Scorning, in that Gradation in the first Psalm, is set down as the highest Step of Wickededness. And Solomon tells us, "That judgments are prepared for the Scorners".

You will say to me, How then must our Tongues be employed; I answer,

1. In Praises and Thanksgiving unto Ged, Psalm xxxv. 28. "And my tonhue shall speak of thy Righteousness and of thy Praises all the day long". Parallel whereto, is verse 24 of Psalm lxxi. Indeed, the Book of Psalms is, in a great Measure, but an Exercise of, or Exhortation for this Duty.

2. We must exercise our Tongues in talking of all his wondrous Works; Psalm cxl. 5,6. "I will speak of the glorious Honour of thy Majesty, and of thy wondrous Works".

3. In Prayer to God.

4. In Confession of Him, and his Religion, and publickly owning it before Men, whatever the Hazard be.

5. In Teaching, Instructing, and Counselling of others.

6. In Exhorting them.

7. In Comforting them that need it.

8. In Reproving them. All which Particulars I might enlarge upon; but because they come in here only as they refer to the Tongue, <**239> it may suffice to have mentioned them summarily.

Thirdly, Let us hence learn duly to prize and value our Souls. Is the Body such a rare Piece, what then is the Soul? The Body is but the Husk or Shell, the soul is the Kernel; the Body is but the Cask, the Soul the precious Liquor contained in it; the Body is But the Cabinet, the Soul the Jewel; the Body is but the Ship or Vessel, the Soul the Pilot; the Body is but the Tabernacle, and a poor Clay Tabernacle or Cottage too, the Soul the Inhabitant; the Body is but the Machine or Engine, the Soul that <greek>, that actuates and quickens it; the Body is but the dark Lantern, the Soul or Spirit is the Candle of the Lord that burns in it: And seeing there is such Difference between the Soul and the Body in respect of Excellency, surely our better Part challenges our greater Care and Diligence to make Provision for it. Bodily Provision is but half Provision, it is but for one Part of a Man, and that the meaner and more ignoble too, if we consider only the Time of this life; but if we consider a future Estate of endless Duration after this Life, then Bodily Provision will appear to be, I do not say quarter Provision, but no Provision at all in Comparison; there being no Proportion <**240> between so short a Period of Time, and the infinite Ages of Eternity. Let us not then be so foolish, as to employ all our Thoughts, and bestow all our Time and Pains about cherishing, accommodating and gratifying our Bodies, in "making Provision for the Flesh to Assist the Lust thereof", as the Apostle phraseth it; and suffer our souls to lie by neglected, in a miserable, and poor, and blind, and naked Condition. Some Philosophers will not allow the Body to be an essential Part of Man, but only the Vessel or Vehicle of the soul; <latin>Anima cuiusque est quisque</latin>: The soul is the Man. Though I would not be so unequal to it, yet I must needs acknowledge it to be but an inferiour Part: It is therefore so to be treated, so dieted and provided, as to render it most calm and compliant with the soul, most tractable and obsequious to the Dictates of Reason; not so pampered and indulged, as to encourage it to cast its Rider, and to take the Reins into its own Hand, and usurp Dominion over the better Part, the <greek>to hEg??</greek>, to sink and depress it into a sordid Compliance with its own Lusts, <latin>Atque assigere humi Divinae particulam aurae</latin>.

This is our Duty, but alas what is our Practice? Our great Partiality towards our Bodies, and Neglect of our souls, shews <**241> clearly which Part we prefer. We are careful enough of wounding or maiming our Bodies, but we make bold to lash and wound our Souls daily; for every Sin we commit, being contrary to its Nature, is a real Stripe, yea a mortal Wound to the soul, and we shall find it to be so, if our Consciences be once awakened to feel the Sting and Smart of it. We are industrious enough to preserve our Bodies from Slavery and Thraldom, but we make nothing of suffering our souls to be Slaves and Drudges to our Lusts, and to live in the vilest Bondage to the most degenerate of Creatures, the devil: We are thrifty and provident enough not to part with anything that may be serviceable to our Bodies under a good Consideration, and we so esteem them, as that we will part with all we have for the Life of them; but we make little Account of what is most beneficial to our souls, the means of Grace and Salvation, the Word of God and Duties of his Worship and Service; nay, we can be content to sell our souls themselves for a Trifle, for a Thing of

nothing, yea for what is worse than nothing, the Satisfying of an inordinate and unreasonable Appetite or Passion. We highly esteem and stand much upon our Nobility, our Birth and Breeding, though we derive nothing <**242> from our Ancestors but our Bodies and Corporeal Qualities; and it is useful so far to value and improve this Advantage, as to provoke us to imitate the good Examples of our Progenitors, not to degenerate from them, nor to do any thing unworthy of our Breeding; and yet the divine Original of our Souls, which are Beams from the Father of Light, and the immediate Offpring of God himself, <greek>, hath little Influence upon us to engage us to walk worthily of our Extraction, and to do nothing that is Base or ignoble, and unsuitable to the Dignity of our Birth.

You will say, how shall we manifest our Care of our Souls? What shall we do for them? I Answer, the same we do for our Bodies.

First, We feed our Bodies, our Souls are also to be fed: The Food of the Soul is Knowledge, especially Knowledge in the Things of God, and the Things that concern its Eternal Peace and Happiness; the Doctrine of Christianity, the Word of God read and preached, 1 Pet. ii. 2. "As new born Babes desire the sincere Milk of the Word, that ye may grow thereby" Heb. v. 12. The Apostle speaks both of Milk and of strong Meat. Milk he there calls the Principles of the Doctrine of Christ: And again, 1 Cor. ii. 3. "I have fed you with Milk and <**243> not with Meat, for hitherto ye were not able to bear it". So we see in the Apostles Phrase, Feeding of the Flock, is Teaching and Intructing of them. Knowledge is the Foundation of Practice; it is impossible to do God's Will before we know it; the Word must be received into an honest and good heart and understood, before any Fruit can be brought forth.

Secondly, We heal and cure our Bodies, when they are inwardly sick, or outwardly harmed: Sin is the Sickness of the Soul, Matth. ix. 12. "They that be whole need not a Physician, but they that be sick", saith our Saviour by way of Similitude, which he explains in the next Verse, "I am come not to call the Righteous, but Sinners to Repentance." For the Cure of this Disease, an humble, serious, hearty Repentance, is the only Physick; not to expiate the guilt of it, but to qualify us to partake of the Benefit of that Atonement which our Saviour Christ hath made, by the Sacrifice of Himself, and restore us to the Favour of God, which we had forfeited, it being as much as in us lies an Undoing again what we have done.

Thirdly, We cloath and adorn our Bodies, <1717> indeed too much Time and too many Thoughts we bestow upon that; </1717> our Souls also are to be cloathed with holy and Virtuous Habits, and adorned with good Works, 1 Pet. v. 5. "Be ye cloathed <**244> with Humility"; And in the same Epistle, Chap. ii. 2. he exhorts Women to "adorn themselves, not with that outward adorning of plaiting the Hair, and of wearing Gold", etc. but with "the Ornament of a meek and quiet Spirit, which is in the Sight of God of great Price". And in Rev. xix. 8. The Righteousness of the Saints" is called "fine Linen". And the Saints are said to be "cloathed in white Raiment", Matth. xxiii. 11. Works of Righteousness, and a Conversation becoming the Gospel, is called "a wedding Garment", Coloss iii. 10. "Put on the new Man". And again, "Put on therefore as the Elect of God, Bowels of Mercy, Meekness", &c. On the contrary vicious Habits and sinful Actions are compared to Filthy Garments. So, Zech. iii. 3. "Joshua" the High-Priest is said to be "cloathed with filthy Garments"; which in the next Verse are interpreted his Iniquities, either Personal, or of the People whom he represented, "I have caused thy Iniquity to pass from thec, and will cloath thee with Change of Raiment".

Fourthly, We arm and defend our Bodies. And our Souls have as much Need of Armour as they: For the Life of a Christian is a continual Warfare; and we have potent and vigilant Enemies to encounter withal; the Devil, the World, and this corrupt Flesh we carry about with us. We <**244> had need, therefore, to take to us the Christian Panoply, to "Put on the whole armour of God, that we may withstand in the evil day, and having done all may stand; having our Loins girt with Truth,

and having the breast-plate of righteousness, and our feet shod with the preparation of the Gospel of Peace. Above all taking the shield of Faith, and for an Helmet, the Hope of Salvation, and the Sword of the Spirit, which is the Word of God", Eph. vi. 13,14, etc.

He that with his Christian Armour manfully fights against and repels the Temptations and Assaults of his Spiritual Enemies; he that keeps his Garments pure, and his Conscience void of Offence towards God and towards Man, shall enjoy perfect Peace here, and Assurance for ever. Tacitus saith of the Finns, a Northern People, that they were <latin>securi adversus homines, securi adversus Deos</latin>. They need not fear what God or Man could do to them, because they were in as bad a Condition as could consist with living in the World: They could not be banished into a worse Country, nor put into worse Circumstances than they were in already. I might say of the Man that keeps a good Conscience, that he is secure against God and Man; not in that Sense the Finni were; but secure of any Evil befalling him, from either. <**246> God can do him no Harm, not for want of Power, but for want of Will, which is regulated by his Truth and Justice. He is also secure in respect of Men, because he is under the Protection of the Almighty: And if any there be that would do him harm, they shall either be restrained by the Divine Providence, or if they be permitted to injure him, it shall tend only to the Exercise and Improvement of his Faith and Patience, and enhancing his future Reward at that great Day, when the Almighty shall dispense Aureolae to those Champions who have signalized their Valour and Fidelity by Heroick Actions, or patient Sufferings of unworthy Things for his Sake.

3. A good Conscience not only secures a Man from God and Men, but from himself too. "There is no Peace to the Wicked", saith my God, no inward Peace. Such a Man is at Odds with himself. For the Commandments of God being agreeable to the Nature of Man, and perfectly conformable to the Dictates of right Reason; Man’s judgment gives Sentence with the Divine Law, and condemns him when he violates any of them; and so the Sinner becomes an <latin> Heautontimorumenos </latin>, a Tormentor of himself. <latin>Prima est haec ultio, quod se Judice nemo nocens absolvitur </latin>; No guilt.y Person is absolved at his own Tribunal, himself being Judge. <**247>

Neither let any profligate Person, who hath bidden Defiance to his Conscience, and is at War with himself; think to take Sanctuary in Atheism, and because it imports him highly there should be no God, stoutly deny that there is any. For First, supposing that the Existence of a Deity were not demonstrably or infallibly proved, (as it most certainly is,) yet he cannot be sure of the contrary, that there is none. "For no Man can be sure of a pure Negative, namely, that such a thing is no, unless he will either pretend to have a certain knowledge of all Things that are or may be, than which nothing can be more monstrously and ridiculously arrogant; or else, unless he be be sure that the Being of what he denies doth imply a Contradiction; for which there is not the least Colour in this Case." The true Notion of God consisting in this. "That he is a Being of all possible Perfection", That I may borrow my Lord Bishop of Chester’s Words, in his Discourse of Natural Religion, page 94.

Now, if he be not sure there is no Deity, he cannot be without some Suepicion and Fear that there may be one.

"Secondly, If there should be a Deity, so Holy and Just and Powerful as is supposed, what Vengeance and Indignation <**248> may such vile miscreants and rebels expect, who have made it their Business to banish Him out of the World, who is the great Creator and Governour of it; to undermine his Being, and eradicate all Notions of Him out of their own and other Mens Minds; to provoke his Creatures and Vassals to a Contempt of him, a sleighting of his Fear and Worship, as being but such imaginary Chimaeras, as are fit only to keep Fools in awe. Certainly as this is the highest Provocation that any Man can be guilty of, so shall it be punish’d with the forest Vengeance."

Now a slender Suspicion of the Existence of a Being, the Denial whereof is of so sad Consequence, must needs disturb the Atheist's Thoughts, and fill him with Fears, and qualify and allay all his Pleasiures and Enjoyments, and render him miserable even in this Life.

"But on the other side, he that believes and owns a God, if there should be none, is in no danger of any bad Consequent. For all the inconvenience of this Belief will be, that he may be hereby occasioned to tye himself up to some needless Restraints during this short time of his Life, wherein notwithstanding there is, as to the present, much Peace, Quiet, and Safety: And, as to the future, his Error shall die with him, there being none to call him to an Accouut for his Miaake." Thus far the Bishop.

To which I shall add, that he not only suffers no Damage, but reaps a considerable Benefit from this Mistake; for during this Life he enjoys a pleasant Dream or Fancy of a future blessed Estate, with the Thoughts and Expectation whereof, he solaces himself and agreeably entertains his Time; and is in no Danger of being ever awakened out of it, and convinced of his Error and Folly, Death making a full End of him.

FINIS.

May 1692
Richard Bentley (Associate of Scientist Robert Boyle)
A Confutation Of Atheism From The Structure And Origin Of Human Bodies

PART I.
That they should seek the Lord, if haply they might feel after him, and find him; though he be not far from every one of us: for in him we live, and move, and have our being.

I HAVE said enough in my last to shew the fitness and pertinency of the Apostle's discourse to the persons he addressed to; whereby it sufficiently appears that he was no babbler, as some of the Athenian rabble reproached him; not a busy prating fellow; as in another language they say, in a like mode of expression; that that he did not talk at random, but was thoroughly acquainted with the several humours and opinions of his auditors. And, as Moses was learned in all the wisdom of the Egyptians, so it is manifest from this chapter alone, if nothing else had been now extant, that St. Paul was a great master in all the learning of the Greeks. One thing further I shall observe from the words of the text, before I enter upon the subject which I proposed; that it requires some industry and consideration to find out the being of God; we must seek the Lord, and feel after him, before we can find him by the light of nature. The search indeed is not very tedious nor difficult; he is not far from every one of us: for in him we live, and move, and have our being. The consideration of our mind and understanding, which is an incorporeal substance independent from matter; and the contemplation of our own bodies, which have all the stamps and characters of excellent contrivance; these alone, though we look upon nothing abroad, do very easily and proximately guide us to the wise Author of all things. But however, as we see in our text, some thoughts and meditation are necessary to it; and a man may possibly be so stupid, or wilfully ignorant or perverse, as not to have God in all his thoughts, or to say in his heart, There is none.

And this being observed, we have an effectual answer to that cavil of the Atheists, who make it an objection against the being of God, that they do not discover him without any application, in spite of their corrupt wills and debauched understandings. If, say they, such a God, as we are told of, had created and formed us, surely he would have left upon our minds a native and indelible inscription of himself, whereby we must needs have felt him, even without seeking, and believed in him whether we would or no. So that these Atheists, being conscious to themselves that they are

void of such belief, which, they say, if God was, would actually and necessarily be in them, do bring their own wicked doubting and denying of God as evidence against his existence; and make their very infidelity an argument for itself. To which we reply, that God hath endowed mankind with powers and abilities, which we call natural light, and reason, and common sense; by the due use of which we cannot miss of the discovery of his being; and this is sufficient. But, as to that original notion and proposition, God Is, which the Atheist pretends should have been actually imprinted on us, antecedently to all use of our faculties; We may affirm, that the absence of such a notion doth not give the least presumption against the truth of religion; because, though God be supposed to be, yet that notion distinct from our faculties would not be requisite; nor is it asserted by religion. First, it would not be requisite; because, without any such primitive impression, we can easily attain to the knowledge of the Deity by the sole use of our natural reason. And again, such an impression would have rendered the belief of a God irresistible and necessary, and thereby have bereaved it of all that is good and acceptable in it. For as the taking away the freedom of human will, and making us mere machines under fatal ties and impulses, would destroy the very nature of moral virtue; so likewise, as to faith, there would be nothing worthy of praise and recompense in it, if there were left no possibility of doubting and denying. And secondly, such a radical truth, God Is, springing up together with the essence of the soul, and previous to all other thoughts, is not asserted by religion. No such thing, that I know of, is affirmed or suggested by the Scriptures. There are several topics there used against the atheism and idolatry of the Heathens; such as the visible marks of divine wisdom and goodness in the works of the creation, the vital union of souls with matter, and the admirable structure of animate bodies, and the like: but, if our Apostle had asserted such an anticipating principle engraven upon our souls before all exercise of reason, what did he talk of seeking the Lord, if haply they might feel after him, and find him? since, if the knowledge of him was in that manner innate and perpetual, there would be no occasion of seeking, nor any hap or hazard in the finding. Such an inscription would be self-evident without reasoning or study, and could not fail constantly to exert its energy in their minds. What did he talk of the unknown God, and ignorantly worshipping f when, if such an original signature were always inherent in their hearts, God could not be unknown to, or ignorantly worshipped by any. That primary proposition would have been clear, and distinct, and efficacious, and universal in the minds of men. St. Paul therefore, it appears, had no apprehension of such a first notion, nor made use of it for an argument; which (since whosoever hath it, must needs know that he hath it) if it be not believed before by the adversary, is false; and, if it be believed, is superfluous; and is of so frail and brittle a texture, that, whereas other arguments are not answered by bare denying without contrary proof, the mere doubting and disbelieving of this must be granted to *be ipso facto* the breaking and confuting of it. Thus much therefore we have proved against the Atheists; that such an original irresistible notion is neither
other requisite upon supposition of a Deity, nor is pretended to by religion; so that neither the absence of it is any argument against the being of God, nor a supposed false assertion of it an objection against the Scripture. It is enough that all are furnished with such natural powers and capacities, that if they seriously reflect, if they seek the Lord with meditation and study, they cannot fail of finding and discovering him: whereby God is not left without witness, but the Atheist without excuse. And now I haste to the second«proposition deduced from the text, and to the argument of the present discourse, that the original structure of human bodies, whereby they are fitted to live, and move, and be vitally informed by the soul, is unquestionably the workmanship of a most wise, and powerful, and beneficent Maker.

First, it is allowed and acknowledged by all parties, that the bodies of men and other animals are excellently well fitted for life, and motion, and sensation; and the several parts of them well adapted and accommodated to their particular functions. The eye is very proper and meet for seeing, the tongue for tasting and speaking, the hand for holding and lifting, and ten thousand operations beside: and so for the inward parts; the lungs are suitable for respiration, the stomach for concoction, the lacteous vessels for the reception of the chyle, the heart for the distribution of

the blood to all the parts of the body. This is matter of fact, and beyond all dispute; and in effect is no more than to say, that animals are animals; for, if they were deprived of these qualifications, they could not be so. This therefore is not the matter in question between us and the Atheists: but the controversy is here. We, when we consider so many constituent parts in the bodies of men, all admirably compacted into so noble an engine; in each of the very fingers, for example, there are bones, and gristles, and ligaments, and membranes, and muscles, and tendons, and nerves, and arteries, and veins, and stein, and cuticle, and nail; together with marrow, and fat, and blood, and other nutritious juices; and all those solid parts of a determinate size, and figure, and texture, and situation; and each of them made up of myriads of little fibres and filaments, not discoverable by the naked eye; I say, when we consider how innumerable parts must constitute so small a member as the finger, we cannot look upon it or the whole body, wherein appears so much fitness, and use, and subserviency to infinite functions, any otherwise than as the effect of contrivance and skill, and consequently the workmanship of a most intelligent and beneficent cent Being. And though now the propagation . of mankind be in a settled method of nature, which is the instrument of God, yet we affirm that the first production of mankind was by the immediate power of the almighty Author of nature; and that all succeeding generations of men are the progeny of one primitive couple. This is a religious man's account of the frame and origination of himself. Now the Atheists agree with us, as to the fitness of man's body and its several parts to their various operations and functions, (for that is visible and past all contradiction,) but they vehemently oppose, and horribly dread the thought, that this usefulness of the parts and the whole should first arise from wisdom and design. So that here will be the point in debate, and the subject of our present undertaking; whether this acknowledged fitness of human bodies must be attributed, as we say, to a wise and good God; or, as the Atheists aver, to dead senseless matter. They have contrived several tricks and b methods of deceit, one repugnant to another, to evade, if possible, this most cogent proof of a Deity; all which I will propose and refute: and I hope to make it appear, that here, as indeed every where, but here certainly, in the great dramatic poem of nature, is *dignus Deo vindice nodus*, a necessity of introducing a God.

And first, I will answer what exceptions they can have against our account: and secondly, I will confute all the reasons and explications they can give of their own.

1. First, I will answer what exceptions they can have against our account of the production of mankind. And they may object, that the body itself, though pretty good in its kind and upon their hypothesis, nevertheless doth not look like the workmanship of so great a Master as is pretended by us: that infinite Wisdom and Goodness and Power would have bestowed upon us more senses than five, or at least these five in a much higher perfection; that we could never have come out of the hands of the Almighty so subject to numerous diseases, so obnoxious to violent deaths; and, at best, of such a short and transitory life. They can no more ascribe so sorry an effect to an omniscient cause, than some ordinary piece of clock-work with a very few motions and uses, and those continually out of order, and quickly at an end, to the best artist of the age. But to this we reply: first, as to the five senses, it would be rash indeed to affirm, that God, if he had pleased, could not have endued us with more. But thus much we may aver, that though the power of God be infinite and perfect, yet the capacities of matter are within limits and bounds. Why then doth the Atheist suspect that there may possibly be any more ways of sensation than what we have already? Hath he an idea, or notion, or discovery of any more? So far from that, that he cannot make any addition or progress in those very senses he hath, further than they themselves have informed him. He cannot imagine one new colour, or taste, or smell, beside those that have actually fallen under his senses. Much less can he that is destitute of an entire sense, have any idea or representation of it; as one that is born deaf hath no notion of sounds; or blind, of colours and light. If then the Atheist can have no imagination of more senses than five, why doth he suppose that a body is capable of more? If we had double or triple as many, there might still be the same suspicion for a greater number without end; and the objection therefore in both cases is equally unreasonable and

groundless. Secondly, we affirm, that our senses have that degree of perfection which is most fit and suitable to our estate and condition. For, though the eye were so piercing as to descry even opake and' little objects some hundreds of leagues off, even that improvement of our sight would do us little service; it would be terminated by neighbouring hills and woods; or in the largest and evenest plain by the very convexity of the earth; unless we could always inhabit the tops of mountains and cliffs, or had wings too to fly aloft, when we had a mind to take a prospect. And if mankind had had wings, (as perhaps some extravagant Atheist may think us deficient in that,) all the world must have consented to clip them; or else human race had been extinct before this time, nothing upon that supposition being safe from murder and rapine. Or, if the eye were so acute as to rival the finest microscopes, and to discern the smallest hair upon the leg of a gnat, it would be a curse and not a blessing to us; it would make all things appear rugged and deformed; the most finely polished crystal would be uneven and rough; the sight of our ourselves would affright us; the smoothest skin would be beset all over with ragged scales, and bristly hairs t and besides, we could not see at one view above what is now the space of an inch, and it would take a considerable time to survey the then mountainous bulk of our own bodies. Such a faculty of sight, so disproportioned to our other senses and to the objects about us, would be very little better than blindness itself. And again, God hath furnished us with invention and industry, so that by optical glasses we can more than supply that imaginary defect of our own eyes, and discover more remote and minute bodies with that assistance, than perhaps the most whimsical Atheist would desire to do without it. So likewise if our sense of hearing were exalted proportionally to the former, what a miserable condition would mankind be in! What whisper could be low enough, but many would overhear it? What affairs, that most require it, could be transacted with secrecy? And whither could we retire from perpetual humming and buzzing? Every breath of wind would incommode and disturb us: we should have no quiet or sleep in the silentest nights and most solitary places; and we must inevitably be struck deaf or dead with the noise of a clap of thunder. And the like inconveniences would follow if the sense of feeling was advanced to such a degree as the Atheist requires. How could we sustain the pressure of our very clothes in such a condition; much less carry burdens, and provide for conveniences of life? We could not bear the assault of an insect, or a feather, or a puff of air without pain. There are examples now of wounded persons, that have roared for anguish and torment at the discharge of ordnance, though at a very great distance: what insupportable torture then should we be under upon a like concussion in the air, when all the whole body would have the tenderness of a wound! wound! In a word, all the changes and emendations that the Atheists would make in our senses, are so far from being improvements, that they would prove the utter ruin and extirpation of mankind.

But perhaps they may have better success in their complaints about the distempers of the body, and the shortness of life. We do not wonder indeed that the Atheist mould lay a mighty stress upon this objection: for, to a man that places all his happiness in the indolency and pleasure of body, what can be more terrible than pain, or a fit of sickness? nothing but death alone, the most dreadful thing in the world. When an Atheist reflects upon death, his very hope is despair; and it is the crown and top of his wishes, that it may prove his utter dissolution and destruction. No question, if an Atheist had had the making of himself, he would have framed a constitution that could have kept pace with his insatiable lust, been invincible by gluttony and intemperance, and have held out vigorous a thousand years in a perpetual debauch. But we answer; first, in the words of St. Paul: c Nay but, O man, who art thou that repliest against, Gods shall the thing formed say to him that formed it, Why hast thou made me thus? We do adore and magnify his most holy name for his undeserved mercy towards us, that he made us the chief of the visible creation; and freely acquit his goodness from any imputation of unkindness, that he has placed us no higher. Secondly, religion gives us a very good account of the present infirmity of our bodies. Man at his first origin was a vessel of honour, when he came first out of the hands of the potter, endued with all imaginable perfections of the animal nature, . till by disobedience and sin diseases and death came first into the world. Thirdly, the distempers of the body are not so formidable to a religious man as

they are to an Atheist: he hath a quite different judgment and apprehension about them; he is willing to believe, that our present condition is better for us in the issue, than that uninterrupted health and security that the Atheist desires; which would strongly tempt us to forget God, and the concerns of a better life. Whereas now he receives a fit of sickness, as the kind chastisement and discipline of his heavenly father, to wean his affections from the world, where he is but as on a journey; and to fix his thoughts and desires on things above, where his country and his dwelling is: that, where he hath placed his treasure and concerns, there his heart may be also. fourthly, most of the distempers that are incident to us are of our own making, the effects of abused plenty, and luxury, and mutt not be charged upon our Maker; who out of the abundant riches of his compassion hath provided for us a store of excellent medicines, to alleviate in a great measure those very evils which we bring upon ourselves. And now we are come to the last objection of the Atheist, that life is too short. Alas for him, what pity it is that he cannot wallow immortally in his sensual pleasures! But, if his life were many whole ages longer than it is, he would still make the same complaint, for eternity, and that is the thing he trembles at, is every whit as long, after a thousand years as after fifty. But religion gives us a better prospect, and makes us look beyond the gloomy regions of death with comfort and delight: when this corruptible shall put on incorruption, and this mortal put on immortality, we are so far from repining at God that he hath not extended the period of our lives to the longevity of the antediluvians, that we give him thanks for contracting the days of our trial, and receiving us more maturely into those everlasting habitations above, that he hath prepared for us.

And now that I have answered all the Atheists' exceptions against our account of the production of mankind, I come in the next place to examine all the reasons and explications they can give of their own.

The Atheists upon this occasion are divided into sects, and (which is the mark and character of error) are at variance and repugnancy with each other and with themselves. Some of them will have mankind to have been thus from all eternity. But the rest do not approve of infinite successions, but are positive for a beginning; and they also are subdivided into three parties: the first ascribe the origin of men to the influence of the stars upon some extraordinary conjunction or aspect: others again reject all astrology; and some of these mechanically produce mankind, at the very first experiment, by the action of the Sun upon, duly prepared matter: but others are of opinion, that after infinite blundering and miscarrying, our bodies at last came into this figure by mere chance and accident. There is no Atheist in the world, that reasons about his infidelity, (which, God knows, most of them never do,) but he takes one of these four methods. I will refute them every one in the same order that I have named them: the two former in the present discourse, reserving the others for another occasion.

And first, the opinion of those Atheists, that will have mankind and other animals to have subsisted eternally in infinite generations already past, will be found to be flat nonsense and contradiction to itself, and repugnant also to matter of fact. First, it is contradiction to itself. Infinite generations of men, they say, are already past and gone. But whatsoever is now past, was once actually present; so that each of those infinite generations was once in its turn actually present: therefore all except one generation were once future and not in being, which destroys the very supposition: for either that one generation must itself have been infinite, which is nonsense; or it was the finite beginning of infinite generations between itself and us, that is infinity terminated at both ends, which is nonsense as before. Again, infinite past generations of men have been once actually present: there may be some one man suppose then, that was at infinite distance from us now; therefore that man's son likewise, forty years younger suppose than his father, was either at infinite distance from us, or at finite: if that son too was at infinite distance from us, then one infinite is longer by forty years than another; which is absurd: if at finite, then forty years added to finite makes it infinite, which is as absurd as the other. And again, the number of men that are already dead and gone is infinite, as they say: but the number of the eyes of those men must

necessarily be twice as much as that of the men themselves, and that of the fingers ten times as much, and that of the hairs of their heads thousands of times. So that we have here one infinite number twice, ten times, and thousands of times as great as another, which is contradiction again. Thus we see it is impossible in itself that any successive duration should be actually and positively infinite, or have infinite successions already gone and past. Neither can these difficulties be applied to the eternal duration of God Almighty. For, though we cannot comprehend eternity and infinity, yet we understand what they are not. And something, we are sure, must have existed from all eternity; because all things could not emerge and start out of nothing. So that if this preexistent eternity is not compatible with a successive duration, as we clearly and distinctly perceive that it is not; then it remains, that some Being, though infinitely above our finite comprehensions, must have an identical, invariable continuance from all eternity; which Being is no other than God. For, as his nature is perfect and immutable without the least shadow of change, so his eternal duration is permanent and indivisible, not measurable by time and motion, nor to be computed by number of successive moments: one day with the Lord is as a thousand years, and a thousand years as one day.

And, secondly, this opinion of infinite generation is repugnant likewise to matter of fact. It is a truth beyond opposition, that the universal species of mankind hath had a gradual increase, notwithstanding what war, and famine, and pestilence, and floods, and conflagrations, and the religious profession of celibacy, and other causes, may at certain periods of time have interrupted and retarded it. This is manifest from the history of the Jewish nation, from the account of the Roman census, e and registers of our own country, where the proportions of births to burials is found upon observation to be yearly as fifty to forty. Now if mankind do increase, though never so slowly, but one couple suppose in an age, it is enough to evince the falsehood of infinite generations already expired. For though an Atheist should contend, that there were ten thousand million couple of mankind now in being, (that we may allow him multitude enough,) it is but going back so many ages, and we descend to a single original pair. And it is all one in respect of eternal duration yet behind, whether we begin the world so many millions of ages ago, or date it from the late æra of about six thousand years. And moreover this recent beginning of the world is further established from the known original of empires and kingdoms, and the invention of arts and sciences: whereas, if infinite ages of mankind had already preceded, there could nothing have been left to be invented or improved by the successful industry and curiosity of our own. The circulation of the blood, and the weight and soring of the air, (which is as it were the vital pulse and the great circulation of nature, and of more importance in all physiology than any one invention since the beginning of science,) had never lain hid so many myriads of generations, and been reserved for a late happy discovery by two great luminaries of this island. I know the Atheist may endeavour to evade this by supposing, that, though mankind have been from everlasting, and have perpetually increased by generation, yet at certain great periods there may be universal deluges, which may not wholly extinguish mankind, (for, they will say, there is not water enough in nature for that,) but may cover the earth to such a height, that none but a few mountaineers may escape, enough to continue human race; and yet, being illiterate rustics, (as mountaineers always are,) they can preserve no memoirs of former times, nor propagate any sciences or arts; and so the world must needs be thought by posterity to have begun at such periods. But to this I answer, first, that upon this supposition there must have been infinite deluges already past: for if ever this Atheist admits of a first deluge, he is in the same noose that he was. For then he must assert, that there were infinite generations and an infinite increase of mankind before that first deluge; and then the earth could not receive them, but the infinite bodies of men must occupy an infinite space, and then all the matter of the universe must be human body: and many other absurdities will follow, absurdities as infinite as the generations he talks of. But, if he says, that there have been infinite deluges heretofore, this is impossibility again; for all that I said before against the notion of infinite past generations, is alike applicable to this. Secondly, such universal deluges (since the Deity is now excluded) must be produced in a natural way; and therefore gradually, and not in an instant; and therefore (because the tops of mountains, they say, are never overflown) the civilized people may

escape thither out of villages and cities; and consequently, against the Atheist, arts, and sciences, and histories, may be preserved, and derived to the succeeding world. Thirdly, let us imagine the whole terraqueous globe with its atmosphere about it; what is there here that can naturally effect an universal deluge? If you would drown one country or continent with rains and inundations, you must borrow your vapour and water from some other part of the globe. You can never overflow all at a time. If the atmosphere itself was reduced into water, as some think it possible, it would not make an orb above thirty-two foot deep, which would soon be swallowed up by the cavity of the sea, and the depressed parts of the earth, and be a very feeble attempt towards an universal deluge. But then what immense weight is there above, that must overcome the expansive force of the air, and compress it into near the thousandth part of the room that it now takes up? We, that acknowledge a God Almighty, can give an account of one deluge, by saying it was miraculous; but it would be strange to see an Atheist have recourse to a miracle; and that not once only, but upon infinite occasions. But perhaps they may endeavour to prove the possibility of such a natural deluge by borrowing an ingenious notion, and pretending, that the face of nature may be now quite changed from what it was; and that formerly the whole collection of waters might be an orbicular abyss, arched over with an exterior crust or shell of earth, and that the breaking and fall of this crust might naturally make a deluge. I will allow the Atheist all the fair play in the world. Let us suppose the fall of this imaginary crust. First, it seems to be impossible but that all the inhabitants of this crust must be dashed to pieces in its ruins: so that this very notion brings us to the necessity of a new production of men; to evade which it is introduced by the Atheist. Again, if such a crust naturally fell, then it had in its own constitution a tendency towards a fall; that is, it was more likely and inclinable to fall this thousand years, than the last. But, if the crust was always gradually nearer and nearer to falling; that plainly evinces, that it had not endured eternally before its fall. For, let them assign any imaginable period for its falling, how could it have held out till then (according to the supposition) the unmeasurable duration of infinite ages before? And again, such a crust could fall but once; for what architect can an Atheist suppose to rebuild a new arch out of the ruins of the other? But I have shewn. before that this Atheist hath need of infinite deluges to effect his design; and therefore I will leave him to contrive how to make infinite crusts one upon the back of another, and now proceed to examine, in the second place, the astrological explication of the origin of men.

II. If you ask one of this party, what evidence he is able to produce for the truth of his art, he may perhaps offer some physical reasons for a general influence of the stars upon terrestrial bodies: but, as astrology is considered to be a system of rules and propositions, he will not pretend to give any reason of it a priori; but resolves all that into tradition from the Chaldeans and Egyptians, who first learnt it by long observation, and transmitted it down to posterity; and that now it is daily confirmed, by events which are experienced to answer the predictions. This is all that can be said for astrology as an art. So that the whole credibility of this planetary production of mankind must depend upon observation. But are they able to shew among all the Chaldaic observations for four hundred and seventy thousand years (as they pretended) any tradition of such a production? So far from that, that the Chaldeans believed the world and mankind to have been from everlasting, which opinion I have refuted before. Neither can the Egyptian wizards with their long catalogue of dynasties, and observations for innumerable years, supply the Atheists with one instance of such a creation. Where are the fragments of Petosiris and Necepso, that may countenance this assertion? I believe, if they had had any example of men born out of the soil, they would rather have ascribed it to the fruitful mud of the f Nile (as they did the breeding of frogs, and mice* and monsters) than to the efficacy of stars. But, with the leave of these fortunetellers, did the stars do this feat once only, which gave beginning to human race or have they frequently done so, and may do it again? If frequently, why is not this rule delivered in Ptolemy and Albumazar? If once only, at the beginning, then how Came it to be discovered? Who were there then in the world to observe the births of those first men, and calculate their nativities, as they sprawled out of ditches? Those sons of earth were very wise children, if they themselves knew that the stars were their fathers: unless we are to

imagine that they understood the planets and the zodiac by instinct, and fell to drawing schemes of their own horoscopes in the same dust they sprung out of? s For my part, I can have no great veneration for Chaldaic antiquity, when I see they could not discover in so many thousand years that the Moon was an opaque body, and received her light from the Sun. But, suppose their observations had been never so accurate, it could add no authority to modern astrology, which is borrowed from the Greeks. It is well known that Berosu, or his scholars, now modelled and adapted the Babylonian doctrines to the Grecian mythology. The supposed influences of Aries and Taurus, for example, have a manifest relation to the Grecian stories of the ram that carried Phrixus, and the bull that carried Europa. Now which of these is the copy, and which the original? Were the fables taken from the influences., or the influences from the fables? the poetical fables more ancient than all records of history; or the astrological influences, that were not known to the Greeks till after Alexander the Great? But, without question, those fabulous tales had been many a time told and sung to lull children asleep, before ever Berosus set up his, intelligence-office at Cos. And the same may be said of all the other constellations. First, poetry had filled the skies with asterisms and histories belonging to them; and then astrology devises the feigned virtues and influences of each, from some property of the image, or allusion to the story. And the same trifling futility appears in their twelve signs of the zodiac, and their mutual relations and aspects.

Why no more aspects than diametrically opposite, and such as make equilateral figures? Why are the masculine and feminine, the fiery and airy, and watery and earthly signs all placed at such regular distances? Were the virtues of the stars disposed in that order and rank on purpose only to make a pretty diagram upon paper? But the atheistical astrologer is doubly pressed with this absurdity. For, if there was no counsel at the making of the world, how came the asterisms of the same nature and energies to be so harmoniously placed at regular intervals? and how could all the stars of one asterism agree and conspire together to constitute an universal? Why does not every single star shed a separate influence; and have aspects with other stars of their own constellation? But what need there many words? as if the late discoveries of the celestial bodies had not plainly detected the imposture of astrology? The planet Saturn is found to have a great ring that encircles him, and five lesser planets that move about him, as the Moon doth about the earth: and Jupiter hath four satellites, which by their interposition between him and us make some hundreds of eclipses every year. Now the whole tribe of astrologers, that never dreamed of these planets, have always declared, that when. Jupiter and Saturn come about again to any given point, they exert (considered singly by themselves) the same influence as before. But it is now manifest, that when either of them return to the same point, the planets about them, that must make up an united influence with them, have a different situation in respect of us and each other from what they had the time before; and consequently the joint influence must be perpetually varied, and never be reducible to any rules and observations. Or, if the influences be conveyed hither distinct, yet sometimes some of the little planets will eclipse the great one at any given point; and by that means intercept and obstruct the influence. I cannot now insist on many other arguments deducible from the late improvements of astronomy, and the truth of the Copernican system; for, if the earth be not the centre of the planetary motions, what must become then of the present astrology, which is wholly adapted to that vulgar hypothesis? And yet nevertheless, when they lay under such wretched mistakes for many myriads of years, if we are willing to believe them, they would all along, as now, appeal to experience and event for the confirmation of their doctrines. That is the invincible demonstration of the verity of the science. And indeed, as to their predictions, I think our astrologers may assume to themselves that infallible oracle of Tiresias.

There is but a true and a false in any telling of fortune; and a man that never hits on the right side, cannot be called a bad guesser, but must miss out of design, and be notably skilful at lighting on the wrong. And were there not formerly as great pretensions to it from the superstitious observation of the entrails of cows, of the flying of vultures, and the pecking of chickens? Nay, the

old augurs and soothsayers had better reason to profess the art of divining, than the modern astrological Atheist; for they supposed there were some dæmons, that directed the indications. So likewise the Chaldean and Egyptian astrologers were much more excusable than he. It was the religion of their countries to worship the stars, as we know from unquestionable authority. They believed them intelligent beings, and no other than very Gods; and therefore had some reason to suspect that they might govern human affairs. The influence of the stars was in their apprehensions no less than divine power. But an Atheist, that believes the planets to be dark, solid, and senseless bodies, like the brute earth he treads on; and the fixed stars and the Sun to be inanimate balls of fire; what reasons can he advance for the credit of such influences? he acknowledged nothing besides matter and motion; so that all, that he can conceive to be transmitted hither from the stars, must needs be performed either by mechanism or accident; either of which is wholly unaccountable, and the latter irreconcileable to any art or system of science. But, if both were allowed the Atheist, yet, as to any production of mankind, they will be again refuted in my following discourse. I can preserve a due esteem for some great men of the last age, before the mechanical philosophy was revived, though they were too much addicted to this nugatory art. When occult quality, and sympathy and antipathy, were admitted for satisfactory explications of things, even wise and virtuous men might swallow down any opinion that was countenanced by antiquity. But, at this time of day, when all the general powers and capacities of matter are so clearly understood, he must be very ridiculous himself that doth not deride and explode the antiquated folly. But we may see the miserable shifts that some men are put to, when that which was first founded upon, and afterward supported by idolatry, is now become the tottering sanctuary of Atheism: if the stars be no deities, astrology is groundless: and if the stars be deities, why is the astrologer an Atheist? He may easily be no Christian; and it is difficult indeed to be both at once: because, as I have said before, idolatry is at the bottom; and, by submitting human actions and inclinations to the influence of the stars, they destroy the very essence of moral virtue and the efficacy of divine grace: and therefore astrology was justly condemned by the; ancient Fathers and Christian Emperors. An astrologer, I say, may very easily be no Christian; he may be an idolater or a pagan: but I could hardly think astrology- to be compatible with rank atheism, if I could suppose any great gifts of nature to be in that person who is either an Atheist or an astrologer. But, let him be what he will, he is not able to do much hurt by his reasons and example; for religion itself, according to his principles, is derived from the stars. And he owns, it is not any just exceptions he hath taken against it, but it is his destiny and fate: it is Saturn in the ninth house, and not judgment and deliberation, that made him an Atheist.

PART II.

That they should seek the Lord, if haply they might feel after him, and find him; though he be not far from every one of us: for in him we live, and move, and have our being.

the former part of this enquiry I have examined and refuted two atheistical notions opposed to the great doctrine of the text, that we owe our living and being to the power of God: the one of the Aristotelian Atheists, who, to avoid the difficulties of the first production of mankind without the intervention of almighty wisdom and power, will have the race to have thus continued without beginning, by an eternal succession of infinite past generations; which assertion hath been detected to be mere nonsense, and contradictory to itself: the other of the astrological undertakers, that would raise men like vegetables out of some flat and slimy soil well digested by the kindly heat of the Sun, and impregnated with the influence of the stars upon some remarkable and periodical conjunctions: which opinion hath been vamped up of late by Cardan and Cesalpinus, and other newsmongers from the flues: a pretence as groundless and silly, as the dreaming one iro critics of Artemidorus and Astrampfychus, or the modern chiromancy and divinations of gypsies.

I proceed now to the two remaining paradoxes of such sects of Atheists, as laying aside astrology and the unintelligible influence of heavenly bodies, except that which proceeds from their gravity,

and heat, and light, do either produce mankind mechanically and necessarily from certain connections of natural causes; or more dully and supinely, though altogether as reasonably, resolve the whole business into the unaccountable shuffles and tumults of matter, which they call chance and accident. But at present I shall only take an account of the supposed production of human bodies by mechanism and necessity.

The mechanical or corpuscular philosophy, though peradventure the oldest as well as the best in the world, had lain buried for many ages in contempt and oblivion, till it was happily restored and cultivated anew by some excellent wits of the present age. But it principally owes its re-establishment and lustre to Mr. Boyle, that honourable person of ever-blessed memory, who hath not only shewn its usefulness in physiology above the vulgar doctrines of real qualities and substantial forms, but likewise its great serviceableness to religion itself. And I think it hath been competently proved in a former discourse, how friendly it is to the immateriality of human souls, and consequently to the existence of a supreme spiritual Being. And I may have occasion hereafter to shew further, that all the powers of mechanism are entirely dependent on the Deity, and do afford a solid argument for the reality of his nature. So far am I from the apprehension of any great feats that this mechanical Atheist can do against religion. For, if we consider the phenomena of the material world with a due and serious attention, we shall plainly perceive, that its present frame and system and all the established laws of nature are constituted and preserved by gravitation alone. That is the powerful cement, which holds together this magnificent structure of the world; which stretcheth the north over the empty space, and hangeth the earth upon nothing; if we may transfer the words of Job from the first and real cause to the secondary agent. Without gravity the whole universe, if we suppose an undetermined power of motion infused into matter, would have been a confused chaos, without beauty or order, and never stable and permanent in any condition. Now it may be proved, in its due place, that this gravity, the great basis of all mechanism, is not itself mechanical; but the immediate fiat and finger of God, and the execution of the divine law; and that bodies have not the power of tending towards a centre, either from other bodies or from themselves: which at once, if it be proved, will undermine and ruin all the towers and batteries that the Atheists have raised against heaven. For, if no compound body in the visible world can subsist and continue without gravity, and if gravity do immediately flow from a divine power and energy; it will avail them nothing, though they should be able to explain all the particular effects, even the origination of animals, by mechanical principles. But however at present I will forbear to urge this against the Atheist. For, though I should allow him, that this catholic principle of gravitation is essential to matter without introducing a God; yet I will defy him to shew, how a human body could be at first produced naturally, according to the present system of things, and the mechanical affections of matter.,> And because this Atheist professeth to believe as much as we; that the first production of mankind was in a quite different manner from the present and ordinary method of nature, and yet affirms nevertheless, that that was natural too; which seems at the first fight to be little less than a contradiction; it should lie upon him to make out, how matter by undirected motion could at first necessarily fall, without ever erring or miscarrying, into such a curious formation of human bodies; a thing, that by his own confession it was never able to do since, or at least hath not done for some thousands of years: he should declare to us what shape and contexture matter then had, which it cannot have now: how it came to be altered by long course of time, so that living men can no longer be produced out of putrefaction in the primary way; and yet the species of mankind, that now consists of and is nourished by matter so altered, should continue to be the same as it was from the beginning. He should undertake to explain to us the first steps and the whole progress of such a formation; at least, by way of hypothesis, how it naturally might have been, though he affirm not that it was actually so. Whether he hath a new notion peculiar to himself about that production, or takes up with some old one, that is ready at hand: whether that most witty conceit of Anaximander, that the first men and all animals were bred in some warm moisture, inclosed in crustaceous skins, as if they were various kinds of crabfish and lobsters; and so continued till they arrived at perfect age, when their shelly prisons growing dry

and breaking made way for their liberty: or the no less ingenious opinion of the great Empedocles, that mother earth first brought forth vast numbers of legs, and arms, and heads, and the other members of the body, scattered and distinct, and all at their full growth; which coming together and cementing, (as the pieces of snakes and lizards are said to do, if one cuts them asunder,) and so configuring themselves into human shape, made lusty proper men of thirty years age in an instant: or rather the divine doctrine of Epicurus and the d Egyptians, that there first grew up a sort of wombs, that had their roots in the earth, and attracted thence a kind of milk for the nourishment of the inclosed sœtus; which at the time of maturity broke through those membranes, and shifted for themselves. I say, he ought to acquaint us which of these he is for, or bring a new explication of his own, and not require us to prove the negative, that a spontaneous production of mankind, neither warranted by example, nor defended by reason, nevertheless may not possibly have been true. This is a very unreasonable demand, and we might justly put him off with such an answer as this; that there are several things, which all men in their wits do disbelieve, and yet none but madmen will go about to disprove. But, to shew him how much we endeavour to satisfy and oblige him, I will venture once for his sake to incur the censure of some persons for being elaborately trifling; for, with respect to the most of mankind, such wretched absurdities are more wisely contemned than confuted; and to give them a serious answer, may only make them look more considerable.

First then, I take it for granted by him, that there were the same laws of motion, and the like general fabric of the earth, sea, and atmosphere, at the beginning of mankind, as there are at this day. For if any laws at first were once settled and constituted: like those of the Medes and Persians, they are never to be reversed. To violate and infringe them, is the same as what we call miracle; and doth not sound very philosophically out of . the mouth of an Atheist. He must allow therefore, that bodies were endowed with the same affections and tendencies then as ever since; and that, if an e axe head be supposed to float upon water, which is specifically much lighter than it, it had been supernatural at that time, as well as in the days of Elisha. And this is all I desire him to acknowledge at present. So that he may admit of those arguments as valid and conclusive against his hypothesis, that are fairly drawn from the present powers of matter, and the visible constitution of the world.

Now that we may come to the point; all matter is either fluid or solid, in a large acceptation of the words, that they may comprehend even all the middle degrees between extreme fixedness and coherency, and the most rapid intestine motion of the particles of bodies. Now the most cavilling Atheist must allow, that a solid inanimate body, while it remains in that slate, where there is none or a very small and inconsiderable change of texture, is wholly incapable of a vital production. So that the first human body, without parents and without creator, if such an one ever was, must have naturally been produced in and constituted by a fluid. And, because this Atheist goes mechanically to work, the universal laws of fluids must have been rigidly observed during the whole process of the formation. f Now this is a catholic rule of statics; that if any body be bulk for bulk heavier than a fluid, it will (ink to the bottom of that fluid; and, if lighter, it will float upon it; having part of itself extant, and part immersed to such a determinate depth, as that so much of the fluid as is equal in bulk to the immersed part be equal in gravity to the whole: and consequently, if several portions of one and the same fluid have a different specific gravity, the heavier will always (in a free vessel) be gradually the lower; unless violently shaken and blended together by external concussion. But that cannot be in our present case. For I am unwilling to affront this Atheist so much, as to suppose him to believe, that the first organical body might possibly be effected in some fluid portion of matter, while its heterogeneous parts were jumbled and confounded together by a storm, or hurricane, or earthquake. To be sure he will rather have the primitive man to be produced by a long process in a kind of digesting balneum, where all the heavier lees may have time to subside, and a due (Equilibrium be maintained, not disturbed by any such rude and violent shocks, that would ruffle and break all the little stamina of the cmbryon, if it were a making

before. Now, because all the parts of an undisturbed fluid are either of equal gravity, or gradually placed and storied according to the differences of it; any concretion, that can be supposed, to be naturally and mechanically made in such a fluid, must have a like structure of its several parts; that is, either be all over of a similar gravity, or have the more ponderous parts nearer to its basis. But there need no more concessions than this to extinguish these supposed firstborn of nature in their very formation. For, suppose a human body to be a forming in such a fluid in any imaginable posture, it will never be reconcileable to this hydrostatical law. There will be always something lighter beneath, and something heavier above; because bone, or what is then the stuff and rudiments of bone, the heaviest in specie, will be ever in the midst. Now what can make the heavier particles of bone ascend above the lighter ones of flesh, or depress these below those, against the tendency of their own nature? This would be wholly as miraculous, as the swimming of iron in water at the command of Elisha; and as impossible to be, as that the lead of an edifice should naturally and spontaneously mount up to the roof, while lighter materials employ themselves beneath it: or that a statue, like that in Nebuchadnezzar's vision, whose head was of fine and most ponderous gold, and his feet of lighter materials, iron and clay, should mechanically erect itself upon them for its basis.

Secondly, because this Atheist goes mechanically to work, he will not offer to affirm, that all the parts of the embryon could according to his explication be formed at a time. This would be a supernatural thing, and an effectual refutation of his own principles. For, the corpuscles of matter having no consciousness of one another's acting, (at least before or during the formation; as will be allowed by that very Atheist, that attributes reason and perception to them when the formation is finished,) they could not consent and make a compact together to carry on the work in several places at once; and one party of them be forming the brain, while another is modelling the heart, and a third delineating the veins. No, there must be, according to mechanism, a successive and gradual operation: some few particles must first be united together, and so by apposition and mutual connection still more and more by degrees, till the whole system be completed;- and a fermentation must be excited in some assignable place, which may expand itself by its elastical power, and break through where it meets with the weakest resistance; and so, by that so simple and mechanical action, may excavate all the various ducts and ventricles of the body. This is the only general account, as mean as it appears to be, that this machine of an Atheist can give of that fearful and wonderful production. Now, to confute these pretences, first, there is that visible harmony and symmetry in a human body, such a mutual communication of every vessel and member of it, as gives an internal evidence that it was not formed successively, and patched up by piece-meal. So uniform and orderly a system with innumerable motions and functions, all so placed and constituted as never to interfere and clash one with another, and disturb the economy of the whole, must needs be ascribed to an intelligent artist; and to such an artist, as did not begin the matter unprepared, and at a venture; and, when he was put to a stand, paused and hesitated which way he should proceed; but he had first in his comprehensive intellect a complete idea and model of the whole organical body, before he entered upon the work. But, secondly, if they affirm, that mere matter by its mechanical affections, without any design or direction, could form the body by steps and degrees; what member then do they pitch upon for the foundation and cause of all the rest? Let them shew us the beginning of this circle, and the first wheel of this perpetual motion. Did the blood first exist, antecedent to the formation of the heart? But that is to set the effect before the cause; because all the blood, that we know of, is made in and by the heart, having the quite different form and qualities of style before it comes thither. Must the heart then have been formed and constituted before the blood was in being? But here again, the substance of the heart itself is most certainly made and nourished by the blood, which is conveyed to it by the coronary arteries. And thus it is through the whole system of the body; every member doth mutually sustain and supply one another; and all are coetaneous, because none of them can subsist alone. But they will say, g that a little ferment first making a cavity, which became the left ventricle of the heart, did thence farther expand itself, and thereby delineate all the arteries of the body. Now, if such a

slight and sorry business as that could produce an organical body, one might reasonably expect, that now and then a dead lump of dough might be leavened into an animal: for there a like ferment makes notable tumours and ventricles, besides long and small channels, which may pass tolerably well for arteries and veins. But, I pray, in this supposed mechanical formation, when the ferment was expanded to the extremities of the arteries, if it still had any elastical force remaining, why did it not go on and break through the receptacle, as other ferment must be allowed to have done, at the mouth and the nostrils? There was as yet no membranous formed, that might stop and repel it. Or, if the force of it was spent, and did not wheel about and return, what mechanical cause then mail we assign for the veins? for this ferment is there supposed to have proceeded from the small capillary extremities of them to the great vein and the heart; otherwise it made valves, which would have stopped its own passage. And why did that ferment, that at first dispersed itself from the great artery into infinite little ramifications, take a quite contrary method in the making of the veins, where innumerable little rivulets have their confluence into the great vein, the common channel of the blood? Are such opposite motions both equally mechanical, when in both cases the matter was under the same modification? And again, when the first ferment is excited, and forms the left ventricle of the heart, if the fluid matter be uniform and of a similar texture, and therefore on all sides equally resist the expansion, then the cavity must continue one, dilated more and more till the expansive force and the uniform resistance be reduced to an equality, and so nothing at all can be formed by this ferment but a single round bubble. And moreover this bubble, (if that could make a heart,) by reason of its comparative levity to the fluid that encloses it, would necessarily ascend to the top; and consequently we should never find the heart in the midst of the breast. But, if the fluid be supposed to consist of heterogeneous particles, then we cannot conceive how those dissimilar parts should have a like situation in two several fluids when the ferment begins. So that upon this supposition there could be no species of animals, nor any similitude between them: one would have its lungs where another hath its liver, and all the other members preposterously placed; there could not be a like configuration of parts in any two individuals. And again, what is that which determines the growth of all living creatures? What principles of mechanism are sufficient to explain it? Why do not all animals continually increase in bigness during the whole space of their lives, as it is reported of the crocodile? What sets a bound to their stature and dimensions? Or, if--we suppose a bound and ne plus ultra to be mechanically fixed: but then, why so great a variety in the bulk of the several kinds? Why also such constancy observed in that manifold variety? For, as some of the largest trees have seeds no bigger or even less than some diminutive plants, and yet every seed is a perfect plant with trunk and branches and leaves enclosed in a shell; h so the first embryon of an ant is supposed by inquisitive naturalists to be as big as that of an elephant, and to promise as fair at its primitive formation for as spacious a body: which nevertheless by an immutable decree can never arrive to the millionth part of the other's bulk. And what modification of the first liquid matter can vary so much as to make one embryon capable of so prodigiously vast augmentation, while another is confined to the minuteness of an insect? Is not this manifestly a divine sanction, that hath fixed and determined the shape, the stature, the appetites, and the duration of all creatures in the world? Hither must we have recourse in that great and mysterious affair of an organical formation: and I profess that I cannot discern one step in the whole, that is agreeable to the natural laws of motion.

If we consider the heart, which is supposed to be the first principle of motion and life, and d/vide it by our imagination into its constituent parts, its arteries, and veins, and nerves, and tendons, and membranes, and innumerable little fibres, that these secondary parts do consist of, we shall find nothing here singular, but what is in any other muscle of the body. It is only the site and posture of these several parts, and the configuration of the whole, that give it the form and functions of a heart. Now why should the first single fibres in the formation of the heart be peculiarly drawn in spiral lines, when the fibres of all other muscles are made by a transverse rectilinear motion? What could determine the fluid matter into that odd and singular figure, when as yet no other member is supposed to be formed, that might direct the course of that fluid matter? Let mechanism here

make an experiment of its power, and produce a spiral and turbinated motion of the whole moved body without an external director. When all the organs are once framed by a supernatural and divine principle, we do willingly admit of mechanism in many functions of the body; but, that the organs themselves should be mechanically formed, we conceive it to be impossible and utterly inexplicable. And, if any Atheist will give a clear and philosophical account of the things that are here touched upon, he may then hear of many more, and perhaps more difficult, than these; which their unfitness for a popular auditory, and the remaining parts of my subject that press forward to be treated of, oblige me now to omit.

But, as the Atheist, when he is put to it to explain, how any motion of dead matter can beget thought and perception, will endeavour to defend his baffled impiety with the instance of brutes, which he calls thinking machines; so will he now also appeal from the arbitration of reason in the case of animal productions to example and matter of fact. He will declaim to us about the admirable structure of the bodies of insects; that they have all the vital parts, which the largest of quadrupeds, and even man himself can boast of; and yet they are the easy and obvious products of unintelligent nature, that spontaneously and mechanically forms them out of putrefied carcases and the warm moisture of the soil; and (which is mightily to his purpose) the insects, so begotten without parents, have nevertheless fit organs of generation and difference of sex, and can propagate their own kinds, as if themselves had been begotten so too: and that if mother earth, in this her barrenness and decrepitness of age, can procreate such swarms of curious engines, which not only themselves enjoy their portion of life, but by a most wonderful instinct impart it to many more, and continue their species; might she not in the flower of her youth, while she was succulent and fertile, have produced horses and elephants and even mankind itself, the largest and perfectest animals as easily as in this parched and steril condition she can make a frog or an insect? Thus, he thinks, he hath made out from example and analogy, that at the beginning of things every species of animals might spring mechanically out of the soil without an intelligent Creator. And indeed there is no one thing in the world, which hath given so much countenance and shadow of possibility to the notion of atheism, as this unfortunate mistake about the equivocal generation of insects: and, as the oldest remains of atheistical writings are full of this comparison, so it is the main refuge of those, that in this and the last age have had the folly and impudence to appear in so wretched a cause.

Now to this last subterfuge of the mechanical Atheists we can occur several ways. And at present we affirm, first, *ex abundanti,* that, though we should allow them the spontaneous production of some minute animals, yet a like primitive origination of mankind could not hence be concluded; because they first tacitly suppose, that there is an universal decay of moisture and fertility in the earth. And they cannot avoid the necessity of so doing: for, if the soil be as fruitful now as it was in the beginning, why would it not produce men, and the nobler kind of beasts in our days too, if ever it did so? So that, if that supposition be evinced to be erroneous and groundless, all the arguments that they build upon it will be subverted at once. Now what more easily refuted, than that old vulgar assertion of an universal drought and exsiccation of the earth? as if the Sun could evaporate the least drop of its moisture, so that it should never descend again, but be attracted and elevated quite out of the atmosphere? It is now a matter agreed and allowed by all competent judges, that every particle of matter is endowed with a principle of gravity, whereby it would descend to the centre, if it were not repelled upward by heavier bodies. So that the smallest corpuscle of vapour, if we suppose it to be exhaled to the top of the atmosphere, thence it must come down again, or at least must there remain incumbent upon others; for there is either nothing or nothing heavier above it to protrude it any higher; neither can it spontaneously mount any more against the tendency of its nature. And, lest some ignorant Atheist should suspect that peradventure there may be no such top of the atmosphere, but that it may be continued on to the Sun or to indefinite space; he must vouchsafe to be instructed, that the whole weight of any column of the atmosphere, and likewise the specific gravity of its basis, are. certainly known by many

experiments; and that by this computation (even making allowance for its gradually larger expansion, the higher we go) the very top of, any pillar of air is not one hundred miles distant from the surface of the earth. So that hence it is manifest, that the whole terraqueous globe with its atmosphere cannot naturally have lost the least particle of moisture since the foundation of the world. But still they may insist, that, although the whole globe cannot be deprived of any of its moisture, yet the habitable earth may have been perpetually the drier, seeing it is assiduously drained and exhausted by the seas. But to this we reply, that the very contrary is demonstrable; that the longer the world shall continue, the moister the whole aggregate of the land will be. For (to take no notice of the supply of its moisture by rains and snow and dews and condensation of vapours, and perhaps by subterraneous passages) the tops of mountains and hills will be continually warned down by the rains, and the channels of rivers corroded by the streams; and the mud that is thereby conveyed into the sea will raise its bottom the higher; and consequently the declivity of rivers will be so much the less; and therefore the continents will be the less drained, and will gradually increase in humidity from the first period of their duration to the final consummation of all things; if the successive production of plants and animals, which are all made up of and nourished by water, and perhaps never return to water again, do not keep things at a poise; or if the divine power do not interpose and change the settled course and order of nature.

But let us allow their supposition, that the total of the dry land may have been robbed of some of its moisture which it had at its first constitution; yet still there are some parts of the earth sufficiently soaked and watered to produce men and animals now, if ever they did at all. For do not the Nile, and the Niger, and the Ganges, and the Menam, make yearly inundations in our days, as they have formerly done? And are not the countries so overflown still situate between the tropics under the direct and most vigorous rays of the Sun, the very place where these mechanical Atheists lay the scene of that great transaction? so that, if mankind had ever sprung naturally out of the soil, the experiment would succeed now every year in Æthiopia and Siam, where are all the requisite qualifications that ever have been for such a production. And again, if there hath been such a gradual diminution of the generative faculty of the earth, that it hath dwindled from nobler animals to puny mice and insects; why was there not the like decay in the production of vegetables? We should have lost by this time the whole species of oaks and cedars and the other tall and lofty sons of the forest, and have found nothing but dwarfish shrubs and creeping moss and despicable mushrooms. Or, if they deny the present spontaneous production of larger plants, and confine the earth to as pigmy births in the vegetable kingdom, as they do in the other, yet surely in such a supposed universal decay of nature, even mankind itself, that is now nourished (though not produced) by the earth, must have degenerated in stature and strength in every generation. And yet we have certain demonstration from the Egyptian mummies, and Roman urns and rings, and measures and edifices, and many other antiquities, that human stature is not diminished at all for the last two thousand years. Now, if the decay has not been constant and gradual, there has been no decay at all; or at least no natural one, nor what may be accounted for by this mechanical Atheist. I conclude therefore, that, although we should allow the spontaneous production of insects, yet no argument can be deduced from thence for a like origination of mankind.

But, secondly, we affirm, that no insect or animal did ever proceed equivocally from putrefaction, unless in miraculous cases, as in Egypt by the divine judgments, but all are generated from parents of their own kind, male and female; a discovery of that great importance, that perhaps few inventions of this age can pretend to equal usefulness and merit; and which alone is sufficient (if the vices of men did not captivate their reason) to explode and exterminate rank Atheism out of the world. For, if all animals be propagated by generation from parents of their own species, and there be no instance in nature of even a gnat or a mite either now or in former ages spontaneously produced; how came there to be such animals in being, and whence could they proceed? There is no need of much study and deliberation about it: for either they have existed eternally by infinite successions already gone and past, 1 which is in its very notion absurd and impossible; or their

origin must be ascribed to a supernatural and divine power, that formed and created them. Now, to prove our assertion about the seminal production of all living creatures, that we may not repeat the reasons which we have offered before against the first mechanical formation of human bodies, which are equally valid against the spontaneous origin of the minutest insects; we appeal to observation and experiment, which carry the strongest conviction with them, and make the most sensible and lasting impressions. For, whereas it hath been the general tradition and belief, that maggots and flies breed in putrefied carcases, and particularly bees come from oxen, and hornets from horses, and scorpions from crabfish, &c. all this is now found to be fable and mistake. That sagacious and learned naturalist, 1 Francisco Redi, made innumerable trials with the putrid flesh of all sorts of beasts and fowls, and fishes and serpents, with corrupted cheese, and herbs, and fruits, and even insects themselves; and he constantly found, that all those kinds of putrefaction did only afford a nest and aliment for the eggs and young of those insects that he admitted to come there, but produced no animal of themselves by a spontaneous formation: for, when he suffered those things to putrefy in hermetically sealed glasses, and vessels close covered with paper; and not only so, lest the exclusion of the air might be supposed to hinder the experiment, but in vessels covered with fine lawn, so as to admit the air and keep out the insects; no living thing was ever produced there, though he exposed them to the action of the Sun, in the warm climate of Florence, and in the kindest season of the year. Even flies crushed and corrupted, when enclosed in such vessels, did never procreate a new fly; though there, if in any case, one would have expected that success- And when the vessels were open, and the insects had free access to the aliment within them, he diligently observed, that no other species were produced, but of such as he saw go in and feed, and deposit their eggs there; which they would readily do in all putrefaction, even in a mucilage of bruised spiders, where worms were soon hatched out of such eggs, and quickly changed into flies of the same kind with their parents. And was not that a surprising transformation indeed, if, according to the vulgar opinion, those dead and corrupted spiders spontaneously changed into flies? And thus far we are obliged to the diligence of Redi: from whence we may conclude, that no dead flesh, nor herbs, nor other putrefied bodies, nor any thing that hath not then actually either a vegetable or animal life, can prodace any insect. And if we should allow, as he did, that every animal and plant doth naturally rally breed and nourish by its substance some peculiar insect, yet the Atheist could make no advantage of this concession as to a like origination of mankind. For surely it is beyond even an Atheist's credulity and impudence, to think that the first men might proceed out of the galls and tumors of leaves of trees, as some maggots and flies are supposed to do now; or might grow upon trees, as the story goes about barnacles; or perhaps might be the lice of some vast prodigious animals, whose species is now extinct. But, though we suppose him guilty of such an extravagant folly, he will only shift the difficulty, and not wholly remove it; for we shall still expect an account of the spontaneous formation of those mountainous kind of animals and men-bearing trees. And, as to the worms that are bred in the intestines and other inward parts of living creatures, their production is not material to our present enquiry, till some Atheist do affirm, that his own ancestors had such an original. I say, if we should allow this concession of Redi, it Would do no service to our adversaries: but even here also they are defeated by the happy curiosity of m Malpighi and others, who observed and discovered, that each of those tumors and excrescences of plants, out of which generally issues a fly or a worm, are at first made by such insects, which wound the tender buds with a long hollow trunk, and deposit an egg in the hole with a sharp corroding liquor, which causeth a swelling in the leaf, and so closeth the orifice: and within this tumor the worm is hatched, and receives its aliment, till it hath eat its way through. Neither need we recur to an equivocal production of vermin in the phthiriasis and in Herod's disease, who was eaten of worms, or maggots. Those horrible distempers are always accompanied with putrefying ulcers; and it hath been observed by the most accurate ° Levvenhoeck, that lice and flies, which have a most wonderful instinct and acuteness of sense to find out convenient places for the hatching and nourishment of their young, do mightily endeavour to lay their eggs upon sores; and that one will lay above a hundred eggs, and may naturally increase to some hundreds of thousands in a quarter of a year: which gives a full and satisfactory account of the phœnomena of those

diseases. And whereas it is said, Exod. xvi. ver. 20. that some of the Israelites left of the manna until the morning, and it bred worms and flank; which an Atheist may make an objection, as either against us, or against the truth of the Scriptures: I understand it no otherwise, than that the manna was fly-blown. It was then the month of October, which in that southern climate, after the preceding autumnal rains, doth afford a favourable season and copious nutriment for infinite swarms of insects. Neither do I ascribe it to a miraculous power, that some of the manna should breed worms, but that all the rest should be preserved sound and untainted. And, if any one shall rigidly urge from that passage the literal expression of breeding, he must allow Moses to speak in the language of the vulgar in common affairs of life. We do now generally believe the Copernican system; yet I suppose upon ordinary occasions we shall still use the popular terms of sun-rise and sun-set, and not introduce a new pedantic description of them from the motion of the earth. And then, as to the vulgar opinion, that frogs are made in the clouds, and brought down by the rains, it may be thus easily refuted: for at that very instant, when they are supposed to descend, you may find by dissection not only their stomachs full of meat, but their intestines full of excrement; so that they had lurked before in the day-time in holes and bushes and grass, and were then invited abroad by the freshness of a shower.

And by this time we may understand, what credit and authority those old stories ought to have about the monstrous productions in Egypt after the inundation of the Nile, of mice and frogs and serpents, half flesh and half mud; nay, of the legs, and arms, and other limbs of men; altogether as true as what is seriously related by P Helmont, that foul linen, stopped in a vessel that hath wheat in it, will in twenty-one days time turn the wheat into mice: which one may guess to have been the philosophy and information of some housewife, who had not so carefully covered her wheat but that the mice could come at it, and were there taken napping, just when they had made an end of their cheer. Corn is so innocent from this calumny of breeding of mice, that it doth not produce the very weevils that live in it and consume it; the whole course of whose generation and periodical changes hath been curiously observed and described by the ingenious Lewenhoeck. And, moreover, that we may deprive the Atheist of all hopes and pretensions of argument from this baffled opinion of equivocal insects, we will acquaint him from the most accurate observations of Swammerdam, that even the supposed change of worms into flies is no real transmutation; but that most of those members, which at last become visible to the eye, are existent at the beginning, artificially complicated together, and covered with membranes and tunicles, which are afterwards stript off and laid aside: and all the rest of that process is no more surprising than the eruption of horns in some brutes, or of teeth and beard in men at certain periods of age. And, as we have established our assertion of the seminal production of all kinds of animals, so likewise we affirm, that the meanest plant cannot be raised without seed by any formative power residing in the soil. To which assertion we are encouraged, first, from the known seeds of all vegetables, one or two only excepted, that are left to future discovery; which seeds by the help of microscopes are all found to be real and perfect plants, with leaves and trunk curiously folded up and enclosed in the cortex; nay, one single grain of wheat, or barley, or rye, shall contain four or five distinct plants under one common tunicle; a very convincing argument of the providence and goodness of God, that those vegetables, that were appointed to be the chief sustenance of mankind, should have that multiplied fecundity above any others. And, secondly, by that famous, experiment of Malpighi, who a long time enclosed a quantity of earth in a vessel, secured by a fine cloth from the small imperceptible seeds of plants that are blown about with the winds; and had this success of his curiosity, to be the first happy discoverer of this noble and important truth, that no species of plants can be produced out of earth without a preexistent seed; and consequently they were all created and raised at the beginning of things by the almighty gardener, God blessed for ever. And, lastly, as to those various and elegant shells, that are dug up in continents, and embodied in stones and rocks at a vast distance from any sea; which this Atheist may possibly alledge for an instance of a plastic faculty of nature; it is now generally agreed by the most diligent inquirers about them, that they are no sportful productions of the soil, as was ' formerly believed, but that all did once

belong to real and living fishes; since each of them exactly resembles some shell of the seas, both in its outward lineaments, and inward texture, and specific gravity, and all other properties: which therefore are so far from being subservient to Atheists in their audacious attempts against God and religion, that they rather afford an experimental confirmation of the universal deluge.

And thus we have competently shewn, that every species of living creatures, every small insect, and even the herbs of the field, give a casting vote against Atheism, and declare the necessity of a supernatural formation. If the earth in its first constitution had been left to itself, what horrid deformity and desolation had for ever overspread its face! Not one living inhabitant would be found on all its spacious surface; not so much as a worm in the bowels of it, nor one single fish in the vast bosom of the sea; not a mantle of grass or moss to cover and conceal the nakedness of nature. An eternal sterility must have possessed the world, where all things had been fixed and fastened everlastingly with the adamantine chains of specific gravity; if the Almighty had not spoken and said, Let the earth bring forth grass, the herb yielding feed, and the fruit-tree yielding fruit after its kind; and it was so. It was God that then created the first seminal forms of all animals and vegetables, that commanded the waters to bring forth abundantly, and the earth to produce living creatures after their kind; that made man in his own image after his own likeness; that by the efficacy of his first blessing made him be fruitful and multiply, and replenish the earth; by whose alone power and conservation we all live, and move, and have our being.

May the same most glorious God of His in finite mercy grant, that, as we have sought the Lord, and felt after him, and found him in these works of his creation; so now that tee have known God, we may glorify him as God, both now and for evermore. Amen.

The Third And Last Part
That they Jhouldseek the Lord, if haply they might feel after him, and find him; though he be not far from every one of us: for in him we live, and move, and have our being.

In my former discourses I have endeavoured to prove, that human race was neither (1) from everlasting without beginning; nor (2) owes its beginning to the influence of heavenly bodies; nor (3) to what they call nature, that is, the necessary and mechanical motions of dead senseless matter. I proceed now to examine the fourth and last plea of the enemies to religion and their own souls, that mankind came accidentally into the world, and hath its life and motion and being by mere chance and fortune.

We need not much wonder, that this last opinion mould obtain almost universally among the Atheists of these times. For, whereas the other require some small stock of philosophy to understand or maintain them, this account is so easy and compendious, that it needs none at all; and consequently is the more proper and agreeable to the great industry and capacity of the most numerous party of them. For what more easy to say, than that all the bodies of the first animals and plants were muffled into their several forms and structures fortuitously; that is, these Atheists know not how, nor will trouble themselves to endeavour to know? For that is the meaning of chance; and yet this is all that they say, or can say to the great matter in question. And indeed this little is enough in all reason; and, could they impose on the rest of mankind, as easily as delude themselves, with a notion, that chance can effect a thing; it would be the most expedite and effectual means to make their cause victorious over virtue and religion. For, if you once allow them such an acceptation of chance, you have precluded yourself, they think, from any more reasoning and objecting against them. The mechanical Atheist, though you grant him his laws of mechanism, is nevertheless inextricably puzzled and baffled with the first formation of animals: for he must undertake to determine all the various motions and figures and positions and combinations of his atoms; and to demonstrate, that such a quantity of motion, impressed upon particles so shaped and situated, will necessarily range and dispose them into the form and frame of an organical body: an

attempt as difficult and unpromising of success, as if he himself should make the essay to produce some new kinds of animals out of such senseless materials, or to rebuild the moving and living fabric out of its dust in the grave. But the Atheist that we are now to deal with, if you do but concede to him that fortune may be an agent, presumes himself safe and invulnerable, secure above the reach of any further disputes. For, if you proceed to ask questions, and bid him assign the proper causes and determinate manner of that fortuitous formation, you thereby deny him what you granted before, and take away the very hypothesis and the nature of chance; which supposeth that no certain cause or manner of it can possibly be assigned. And as the stupidity of some libertines, that demand a sight of a spirit or human soul to convince them of its existence, hath been frequently and deservedly exposed; because whatsoever maybe the object of our sight, must not be a soul or spirit, but an opaque body; so this Atheist would tax us of the like nonsense and contradiction, if, after he hath named to us fortune or chance, we should expect from him any particular and distinct account of the origin of mankind: because it is the very essence and notion of his chance, to be wholly unaccountable: and, if an account could be given of it, it would then no longer be chance but mechanism, or a necessary production of certain effects from certain causes according to the universal laws of motion. Thus we are to know, that if once we admit of fortune in the formation of mankind, there is no further enquiry to be made, no more difficulties to be solved, and no account to be demanded. And who then can admire, if the inviting easiness and compendiousness of this assertion should so dazzle the eyes of our Atheist, that he overlooks those gross absurdities, that are so conspicuous in it?

(l) For, first, if this Atheist would have his chance or fortune to be a real and substantial agent; as the vulgar seem to have commonly apprehended, some making it a divinity, others they do not conceive what; he is doubly more stupid and more supinely ignorant than those vulgar; in that he assumes such a notion of fortune, as, besides its being erroneous, is inconsistent with his atheism. For since, according to the Atheists, the whole universe is corpus et inane, body and nothing else; this chance, if it do really and physically effect any thing, must itself be body also. And what a numerous train of absurdities do attend such an assertion! too visible and obvious to deserve to be here insisted on. For indeed it is no less than flat contradiction to itself. For, if this chance be supposed to be a body, it must then be a part of the common mass of matter; and consequently be subject to the universal and necessary laws of motion: and therefore it cannot be chance, but true mechanism and nature.

(2) But, secondly, if he forbear to call chance a real agent, and is content to have it only a result or event; since all matter or some portion of it may be naturally exempt from these supposed mechanical laws, and be endowed with a power of spontaneous or fortuitous motion; which power, when it is exerted, must produce an effect properly casual, and therefore might constitute the first animate bodies accidentally, against the supposed natural tendency of the particles of those bodies: even this second assertion is contrary to common sense, as well as common observation. For how can he conceive, that any parcel of dead matter can spontaneously divert and decline itself from the line of its motion, without a new impulse from external bodies? If it can intrinsecally stir itself, and either commence its motion or alter its course, it must have a principle of self-activity, which is life and sense. a But sense I have proved formerly to be incompatible with mere bodies, even those of the most compound and elaborate textures; much more with single atoms or solid particles of matter, that having no intestine motion of parts are destitute of the first foundation and capacity of life. And moreover, though these particles should be supposed to have this internal principle of sense, it would still be repugnant to the notion of chance: because their motions would not then be casual, but voluntary; not by chance, but choice and design. And again, we appeal to observation, whether anv bodies have such a power of fortuitous motion. We should surely have experiment of it in the effects of nature and art: no body would retain the same constant and uniform weight according to its bulk and substance; but would vary perpetually, as that spontaneous power of motion mould determine its present tendency. All the various machines,

and utensils would now and then play odd pranks and capricio's quite contrary to their proper structures, and designs of the artificers. Whereas, on the contrary, all bodies are observed to have always a certain and determinate motion according to the degrees of their external impulse, and their inward principle of gravitation, and the resistance of the bodies they occur with: which therefore is without error exactly foreseen and computed by sagacious artists. And, if ever dead matter mould deviate from this motion, it could not proceed from itself, but a supernatural agent; and ought not to be called a chance, but a miracle.

For chance is but a mere name, and really nothing in itself; a conception of our own minds, and only a compendious way of speaking, whereby we would express, that such effects as are commonly attributed to chance were verily produced by their true and proper causes, but without their designing to produce them. And in any event called casual, if you take away the real and physical causes, there remains nothing but a simple negation of the agents intending such an event: which negation being no real entity, but a conception only of man's intellect wholly extrinsecal to the action, can have no title to a share in the production. As in that famous example, (which Plutarch b says is the only one, where fortune is related to have done a thing artificially,) when a painter having finished the picture of a horse, excepting the loose froth about his mouth and his bridle; and, after many unsuccessful essays despairing to do that to his satisfaction, in a great rage threw his sponge at it, all besmeared, as it was, with the colours; which fortunately hitting upon the right place, by one bold stroke of chance most exactly supplied the want of skill in the artist: even here it is manifest, that considering the quantity and determination of the motion, that was impressed by the painter's hand upon the sponge, and resistance of the air; the sponge did mechanically and unavoidably move in that particular line of motion, and so necessarily hit upon that part of the picture; and all the paint that it left there was as certainly placed by true natural causes, as any one stroke of the pencil in the whole piece. So that this strange effect of the sponge was fortuitous only with respect to the painter, because he did not design nor foresee such an effect; but in itself, as to its real causes, it was necessary and natural. In a word, the true notion of fortune {pis Tvxris) denoteth no more, than the ignorance of such an event in some knowing agent concerned about it. So that it owes its very being to human understanding, and without relation to that is really nothing. How absurd then and ridiculous is the Atheist, that would make this fortune the cause of the formation of mankind; whereas manifestly there could be no such thing or notion in the world as fortune, till human nature was actually formed? It was man that first made fortune, and not fortune that produced man. For, since fortune in its proper acceptation supposeth the ignorance of something, in a subject capable of knowledge; if you take away mankind, such a notion hath no existence, neither with relation to inanimate bodies that can be conscious of nothing, nor to an omniscient God that can be ignorant of nothing. And so likewise the adequate meaning of chance (as it is distinguished from fortune; in that the latter is understood to befal only rational agents, but chance to be among inanimate bodies) is a bare negation, that signifies no more than this, that any effect among such bodies ascribed to chance, is really produced by physical agents, according to the established Ws of motion, but without their consciousness of concurring to the production, and without their intention of such an effect. So that chance, in its true sense, is all one with nature; and both words are used promiscuously by some ancient writers, to express the same thing. And we must be wary, lest we ascribe any real subsistence or personality to this nature or chance; for it is merely a notional and imaginary thing; an abstract universal, which is properly nothing; a conception of our own making, occasioned by our reflecting upon the settled course of things; denoting only thus much, that all those bodies move and act according to their essential properties and qualities without any consciousness or intention of so doing. So that in this genuine acceptation of chance here is nothing supposed that can supersede the known laws of natural motion: and thus to attribute the formation of mankind to chance, is all one with the former atheistical assertion-, that ascribes it to nature or mechanism: and consequently it hath received a prolix and sufficient refutation in my preceding discourse.

(3) But thirdly, it is likely that our Atheist may willingly renounce the doctrine of chance as a thing differing from nature, and may allow it to be the same thing, and that too noreal and substantial agent, but only an abstract intellectual notion: but still he hath another expedient in reserve, which is a middle and safe way between the former rigorous mechanism and the extravagancies of fortuitous motion: viz. that at the beginning all things, it is true, proceeded necessarily and fatally according to the mechanical powers and affections of matter: but nevertheless the several kinds of animals were not formed at the first trial and effort without one error or miscarriage; (as strict mechanism would suppose;) but there was an immense variety of ferments, and tumors, and excrescences of the soil, pregnant and big with fœtus's of all imaginable shapes and structures of body: millions of which were utterly incapable of life and motion, being the molœ, as it were, and the abortions of mother earth: and many of those that had life and powers to preserve their own individuals, yet wanted the due means of propagation, and therefore could not transmit their species to the following ages: and that those few only, that we now find in being, did happen (for he cannot exprese it but by the characters of a chance) to have all the parts necessary not only for their own lives, but for the continuation of their kinds. This is the favourite opinion among the Atheists, and therefore did fatally perish soon after their birth. And thus, when we insist on other like arguments of divine wisdom in the frame of animate bodies; as the artificial position of many myriads of valves, all so situate as to give a free passage to the blood and other humours in their due channels and courses, but not permit them to regurgitate and disturb the great circulation and economy of life; as the spiral, and not annulary, fibres of the intestines for the better exercise of their functions; as the provident furnishing of temporary parts for the fœtus during the time of gestation, which are afterwards laid aside; as the' strange sagacity of little insects in choosing sit places for the exclusion of their eggs, and for the provision of proper food, when the young ones are hatched and need it; as the ardent or natural affection in those animals most plausible of all; by which they think they may elude that most formidable argument for the being of God, from the admirable contrivance of organical bodies and the exquisite fitness of their several parts for those ends and uses they are put to, and seem to have been designed for. For, say they, since those innumerable instances of blunder and deformity were quickly removed out of knowledge and being; it is plain that no animals ought now to be found, but such as have due organs necessary for their own nourishment and increase of their kinds: so that this boasted usefulness of parts, which makes men attribute their origination to an intelligent and wise agent, .is really no argument at all; because it follows also from the Atheist's assertion. For, since some animals are actually preserved in being till now, they must needs all of them have those parts that are of use and necessity: but that at first was only a lucky hit without skill or design, and ever since is a necessary condition of their continuation. And so for instance, when they are urged with the admirable frame and structure of the eye; which consists of so great a variety of parts, all excellently adapted to the uses of vision; that (to omit mathematical considerations, with relation to optics) hath its many coats and humours transparent and colourless, lest it should tinge and sophisticate the light that it lets in, by a natural jaundice; that hath its pupil so constituted, as to admit of contraction and dilatation according to the differing degrees of light, and the exigencies of seeing; that hath eyelids so commodiously placed, to cleanse the ball from dust, to shed necessary moisture upon it through numerous glandules, and to be drawn over it like a curtain for the convenience of sleep; that hath a thousand more beauties in its figure and texture never studied nor admired enough: they will briskly reply, that they willingly concede all that can be said in the commendation of so noble a member; yet notwithstanding they cannot admit for good reasoning, He that formed the eye, shall not he see? For it was blind nature alone, or matter mechanically moved without consciousness or direction, that made this curious organ of vision. For the short of the matter is this: this elegant structure of the eye is no more than is necessary to life; and consequently is included in the very suppositions of any animals living and continuing till now; though those be but the very few that at the beginning had the good fortune to have eyes, among many millions of monsters that were destitute of them, and animals, whose offspring cannot at first procure their own sustenance, but must infallibly perish, if not fed by the parents; as the untaught instincts and impresses upon every

species, directing them without imitation or deliberation to the ready knowledge of proper food, to one and the best way of their preservation and defence, and to the never failing propagation of their own kind: whatever considerations of this nature you propose to this Atheist, as indeed such instances are innumerable, all evidently setting forth the Almighty's wisdom and goodness to such as are able to judge, and will judge impartially; he hath this one subterfuge from them all, that these things are mistaken for tokens of skill and contrivance, though they be but necessary consequences of the present existence of those creatures. For he that supposeth any animals to subsist, doth by that very supposition allow them every member and faculty that are necessary to subsistence; such as are those we have just now enumerated. And therefore, unless we can prove a priori and independent of this usefulness, now that things are once supposed to have existed and propagated; that among almost infinite trials and essays at the beginning of things, among millions of monstrous shapes and imperfect formations, a few such animals, as now exist, could not possibly be produced; these after-considerations are of very little moment: because if such animals could in that way possibly be formed, as might live, and move, and propagate their beings; all this admired and applauded usefulness of their several fabrics is but a necessary condition and consequence of their existence and propagation.

This is the last pretence and sophistry of the Atheists against the proposition in my text, that we received our life and being from a divine wisdom and power. And, as they cannot not justly accuse me of any ways concealing or balking their grand objection; so I believe these following considerations will give them no reason to boast, that it cannot receive a just and satisfactory answer.

(l.) First, therefore, we affirm that we can prove, and have done it already by arguments a priori, (which is the challenge of the Atheists,) that these animals, that now exist, could not possibly have been formed at first by millions of trials. For, since they allow by their very hypothesis (and without standing to their courtesy we have proved it before) that there can be no casual or spontaneous motion of the particles of matter; it will follow that every single monster among so many supposed g myriads must have been mechanically and necessarily formed according to the known laws of motion, and the temperament and quality of the matter that it was made of. Which is sufficient to evince, that no such monsters were or could have been formed. For, to denominate them even monsters, they must have had some rude kind of organical bodies; some Jiamina of life, though never so clumsy; some system of parts compounded of solids and liquids, that executed, though but bunglingly, their peculiar motions and functions. But we have lately shewn it impossible for nature unassisted to constitute such bodies, whose structure is against the law of specific gravity. So that she could not make the least endeavour towards the producing of a monster; or of any thing that hath more vital and organical parts, than we find in a rock of marble or a fountain of water. And again, though we should not contend with them about their monsters and abortions; yet since they suppose even the perfect, animals, that are still in being, to have been formed mechanically among the rest, and only add some millions of monsters to the reckoning; they are liable to all the difficulties in the former explication, and are expressly refuted through the whole preceding sermon: where it is abundantly shewn, that a spontaneous production is against the catholic laws of motion, and against matter of fact: a thing without example, not only in man and the nobler animals, but in the smallest of insects and the vilest of weeds: though the fertility of the earth cannot be said to have been impaired since the beginning of the world.

(2.) Secondly, we may observe that this evasion of the Atheist is fitted only to elude such arguments of divine wisdom, as are taken from things necessary to the conservation of the animal, as the faculties of sight, and motion, and nutrition, and the like; because such usefulness is indeed included in a general supposition of the existence of that animal: but it miserably fails him against other reasons from such members and powers of the body, as are not necessary absolutely to living and propagating, but only much conduce to our better subsistence and happier condition. So the

most obvious contemplation of the frame of our bodies; as that we all have double sensories, two eyes, two ears, two nostrils, is an effectual confutation of this atheistical sophism. For a double organ of these senses is not at all comprehended in the notion of bare existence; one of them being sufficient to have preserved life, and kept up the species; as common experience is a witness. Nay, even the very nails of our fingers are an infallible token of design and contrivance: for they are useful and convenient to give strength and firmness to those parts in the various functions they are put to; and to defend the numerous nerves and tendons that are under them, which have a most exquisite sense of pain, and without that native armour would continually be exposed to it: and jet who will say, that nails are absolutely necessary to human life, and are concluded in the supposition of simple existence? It is manifest therefore, that there was a contrivance and foresight of the usefulness of nails antecedent

dent to their formation. For the old stale pretence of the Atheists, h that things were first made fortuitously, and afterwards their usefulness was observed or discovered, can have no place here; unless nails were either absolutely requisite to the existence of mankind, or were found only in some individuals or some nations of men, and so might be ascribed to necessity upon one account, or to fortune upon the other. But, from the Atheist's supposition, that, among the infinite diversity of the first terrestrial productions, there were animals of all imaginable shapes and structures of body, all of which survived and multiplied, that by reason of their make and fabric could possibly do so; it necessarily follows, that we should now have some nations without nails upon their fingers; others with one eye only, as the poets describe the Cyclopes in Sicily, and the Arimaspi in Scythia; others with one ear, or one nostril, or indeed without any organ of smelling, because that sense is not necessary to man's subsistence; others destitute of the use of language, since mutes also may live: one people would have the feet of goats, as the feigned Satyrs and Panisci; another would resemble the head of Jupiter Ammon, or the horned statues of Bacchus: the ' Sciapodes, and Enotocœtæ, and other monstrous nations would no longer be fables, but real instances in nature: and, in a word, all the ridiculous and extravagant shapes that can be imagined, all the fancies and whimsies of poets, and painters, and Egyptian idolaters, if so be they are consistent with life and propagation, would be now actually in being, if our Atheist's notion were true: which therefore may deservedly pass for a mere dream and an error, till they please to make new discoveries in terra incognita, and bring along with them some savages of all these fabulous and monstrous configurations.

(3.) But, thirdly, that we may proceed yet further with the Atheist, and convince him, that not only his principle is absurd, but his consequences also as absurdly deduced from it; we will allow him an uncertain extravagant chance against the natural laws of motion r though not forgetting that that notion hath been refuted before, and therefore this concession is wholly ex abundanti. I say then, that though there were really such a thing as this chance or fortune, yet nevertheless it Would be extremely absurd to ascribe the formation of human bodies to a cast of this chance. For let us consider the very bodies themselves. Here are confessedly all the marks and characters of design in their structure that can be required, though one suppose a divine Author had made them: here is nothing in the work itself, unworthy of so great a Master: here are no internal arguments from the subject against the truth of that supposition. Have we then any capacity to judge and distinguish what is the effect of chance, and what is made by art and wisdom? when a medal is dug out of the ground, with some Roman Emperor's image upon it, and an inscription that agrees to his titles' and history, and an impress upon the reverse relating to some memorable occurrence in his life; can we be sure, that this medal was really coined by an artificer, or is but a product of the soil from whence it was taken, that might casually or naturally receive that texture and figure; as many kinds of fossils are very oddly and elegantly shaped according to the modification of their constituent salts, or the cavities they were formed in? Is it a matter of doubt and controversy, whether the pillar of Trajan or Antoninus, the ruins of Persepolis, or the late temple of Minerva, were the designs and works of architecture; or perhaps might originally exist so, or be raised up in an

earthquake by subterraneous vapour? Do not -we all think ourselves infallibly certain, that this or that very commodious house must needs have been built by human art; though perhaps a natural cave in U rock may have something not much unlike to parlours or chambers? And yet he 'must be a mere idiot, that cannot discern more strokes and characters of workmanship in the structure of an animal (in an human body especially) than in the most elegant medal or edifice in the world. They will ' „ believe the first parents of mankind to have been fortuitously formed without wisdom or art; and that for this sorry reason, because it is not simply impossible but that they may have been formed so. And who can demonstrate (if chance be once admitted of) but that possibly all the inscriptions and other remains of antiquity may be mere lusus naturœ, and not works of human artifice? If this be good reasoning, let us no longer make any pretences' to judgment or a faculty of discerning between things probable and improbable; for, except flat contradictions, we may upon equal reasons believe all things or nothing at all. And do the Atheists thus argue in common matters of life? Would they have mankind lie idle, and lay aside all care of provisions by agriculture or commerce, because possibly the dissolution of the world may happen the next moment? Had Dinocrates really carved mount Athos into a statue of Alexander the Great, and had the memory of the fact been obliterated by some accident, who could afterwards have proved it impossible but that it might casually have been formed so? For every mountain must hare some determinate figure, and why then not an human one, as possibly as another? And yet I suppose none could have seriously believed so, upon this bare account of possibility. It is an opinion that generally obtains among philosophers, that there is but one common matter, which is diversified by accidents; and the same numerical quantity of it, by variation of texture, may constitute successively all kinds of bodies in the world. So that it is not absolutely impossible, but that, if you take any other matter of equal weight and substance with the body of a man, you may blend it so long till it be muffled into human shape and an organical structure. But who is he so abandoned to sottish credulity, as to think, upon that principle, that a clod of earth in a sack may ever by eternal making receive the fabric of man's body? And yet this is very near akin; nay, it is exactly parallel to the reasoning of Atheists about fortuitous production. If mere possibility be a good foundation for belief; even Lucian's true history may be true upon that account, and 1 Palæphatus's tales may be credible in spite of the title.

It hath been excellently well urged in this Case, both by ancients and moderns, that to attribute such admirable structures to blind fortune or chance, is no less than to suppose, that, if innumerable figures of the twenty-four letters be cast abroad at random, they might Constitute in due order the whole mÆneis of Virgil or the Annales of Ennius. Now the Atheists may pretend to elude this comparison; as if the case was hot fairly stated. For herein we first make an idea of a particular poem; and then demand, if chance can possibly describe that: and so we conceive man's body thus actually formed, and then affirm that it exceeds the power of Chance to constitute a being like that: which, they may say, is to expect imitation from chance, and not simple production. But at the first beginning of things there was no copy to be followed, nor any preexistent form of human bodies to be imitated: so that, to put the case fairly, we should strip our minds and fancies from any particular notion and idea of a living body or a poem; and then we shall Understand, that what shape and structure soever should be at first casually formed, so that it could live and propagate, might be man; and whatsoever should result from the strewing of those loose letters, that made any sense and measures, might be the poem we seek for.

To which we reply, that if we should allow them, that there was no preexistent idea of human nature, till it was actually formed, (for the idea of man in the divine intellect must hot now be considered,) yet because they declare, that great multitudes of each species of animals did fortuitously emerge out of the n soil in distant countries and climates; what could that be less than imitation in blind Chance, to make many individuals of one species so exactly alike? Nay, though they should now, to cross us and evade the force of the argument, desert their ancient doctrine, and derive all sorts of animals from single originals of each kind, which should be the common

parents of all the race; yet surely even in this account they must necessarily allow two at least, male and female, in every species: which chance could neither make so very nearly alike, without copying and imitation: nor so usefully differing, without contrivance and wisdom. So that, let them take whether they will, if they deduce all animals from single pairs of a fort, even to make the second of a pair, is to write after a copy; it is, in the former comparison, by the casting of loose letters to compose the preexistent particular poem of Enftius. But, if they make numerous sons and daughters of earth among every species of creatures, as all their authors have supposed, this is not only, as was said before, to believe a monkey may once scribble the Leviathan of Hobbes, but may do the same frequently by an habitual kind of chance.

Let us consider, how next to impossible it is, that chance (if there were such a thing) should in such an immense variety of parts in an animal twice hit upon the same structure, so as to make a male and female.- Let us resume the former instance of the twenty-four letters thrown at random upon the ground. It is a mathematical demonstration, that these twenty-four^ do admit of so many changes in their order, "that they may make such a long roll of differently ranged alphabets, not two of which are alike, that they could not all be exhausted, though a million million of writers should each write above a thousand alphabets a day for the space of a million million of years. What strength of imagination can extend itself to embrace and comprehend such a prodigious diversity? And it is as infallibly certain, that suppose any particular order I of the alphabet be assigned, and the twenty-four letters be cast at a venture, so as to fall in a line; it is so many million of millions odds to one against any single throw, that the assigned order will not be cast. Let us now j suppose, there be only a thousand constituent I members in the body of a man, (that we may I take few enough,) it is plain that the different I position and situation of these thousand parts Would make so many differing compounds and distinct species of animals. And if only twenty-four parts, as before, may be so multifariously placed and ordered as to make many millions °f millions of differing rows; in the supposition of a thousand parts, how immense must that capacity of variation be! even beyond all thought and denomination, to be expressed °nly in mute figures, whose multiplied powers are beyond the narrowness of language, and drown the imagination in astonishment and confusion: especially, if we observe, that the variety of the alphabet considered above was in mere longitude only; but the thousand parts of our bodies may be diversified by situation in all the dimensions of solid bodies; which multiplies all over and over again, and overwhelms the fancy in a new abyss of unfathomable number. Now it is demonstratively certain, that it is all this odds to one, against any particular trial, that no one man could by casual production be framed like another; (as the Atheists suppose thousands to be in several regions of the earth;) and I think it is rather more odds than less, that no one female could be added to a male, inasmuch as that most necessary difference of sex is a higher token of divine wisdom and skill, above all the power of fortuitous hits, than the very similitude of both sexes in the other parts of the body. And again, we must consider, that the vast imparity of this odds against the accidental likeness of two casual formations is never lessened and diminished by trying and casting. It is above a hundred to one against any particular throw, that you do not cast any given set of faces with four cubical dice, because there are so many several combinations of the six faces of four dice. Now, after you have cast all the hundred trials but one, it is still as much odds at the last remaining time, as it was at the first: for blind insensible chance cannot grow cunning by many experiments; neither have the preceding casts any influence upon those that come after. So that if this chance of the Atheists should have essayed in vain to make a species for a million million of ages, it is still as many millions odds against that formation, as it was at the first moment in the beginning of things. How incredible is it therefore, that it should hit upon two productions alike, P within so short duration of the world, according to the doctrine of our Atheists? How much more, that it should do so within the compass of a hundred years, and of a small tract of ground, so that this male and female might come together? If any Atheist can be induced to stake his soul for a wager, against such an inexhaustible disproportion; let him never hereafter accuse others of easiness and credulity.

(4.) But, fourthly, we will still make more ample concessions, and suppose with the Atheist, that his chance has actually formed all animals in their terrestrial wombs. Let us see now, how he will preserve them to maturity of birth. What climate will he cherish them in, that they be not inevitably destroyed by moisture or cold? Where is that equability of nine months warmth to be found? that uniform warmth, which is so necessary even in the incubation of birds, much more in the time of gestation of viviparous animals. I know, his party have placed this great scene in 1 Egypt, or somewhere between the two tropics. Now, not to mention the cool of the nights, which alone would destroy the conceptions; it is known that all those countries have either incessant rains every year for whole months together, or are quite laid under water by floods from the higher grounds; which would certainly corrupt and putrefy all the teeming wombs of the earth, and extinguish the whole brood of embryom by untimely abortions.

(5.) But, fifthly, we will still be more obliging to this Atheist, and grant him his petition, that nature may bring forth the young infants vitally into the world. Let us see now what sustenance, what nurses he hath provided for them. If we consider the present constitution of nature, we must affirm, that most species must have been lost for want of fostering and feeding. It is a great mistake, that man only comes weak and helpless into the world; whereas it is apparent, that excepting fish and insects, (and not all of them neither,) there are very few or no creatures, that can provide for themselves at first without the assistance of parents. So that unless they suppose mother earth to be a great animal, and to have nurtured up her young offspring with a conscious tenderness and providential care, there is no possible help for it, but they must have been doubly starved both with hunger and cold.

(6.) But, sixthly, we will be yet more civil to this Atheist, and forgive him this difficulty also. Let us suppose the first animals maintained themselves with food, though we cannot tell how. But then what security hath he made for the preservation of human race from the jaws of ravenous beasts? The divine writers have acquainted us, that God at the beginning gave mankind dominion (an impressed awe and authority) r over every living thing that moveth upon the earth. But in the Atheist's hypothesis there are no imaginable means of defence: for it is manifest, that so many beasts of prey, lions, tigers, wolves, and the like, being of the same age with man, and arriving at the top of their strength in one year or two, must needs have worried and devoured those forlorn brats of our Atheists, even before they were weaned from the * foramina terræ, or at least in a short time after; since all the carnivorous animals should have multiplied exceedingly by several generations, before those children that escaped at first could come to the age of puberty. So that men would always lefl'en, and their enemies always increase.

But some of them will here pretend, that Epicurus was out in this matter; and that they were not born mere infants out of those wombs of the earth, but men at their full growth, and in the prime of their strength. But, I pray, what mould hinder those grown lusty infants from breaking sooner those membranes that involved them; as the shell of the egg is broken by the bird, and the amnion by the fœtus f Were the membranes so thick and tough, that the fœtus must stay there till he had teeth to eat through them, as young maggots do through a gall? But let us answer these fools according to their folly. Let us grant, that they were born with beards, and in the full time of manhood. They are not yet in a better condition; here are still many enemies against few, many species against one; and those enemies speedily multiplying in the second and third and much lower generations; whereas the sons of the first men must have a tedious time of childhood and adolescence, before they can either themselves assist their parents, or encourage them with new hopes of posterity. And we must consider withal, that (in the notion of atheism) those savages were not then, what civilized mankind is now; but mutum et turpe pecus, without language, without mutual society, without arms of offence, without houses or fortifications; an obvious and exposed

prey to the ravage of devouring beasts; a most sorry and miserable plantation towards the peopling of a world.

And now, that I have followed the Atheists through so many dark mazes of error and extravagance, having to my knowledge omitted nothing on their side that looks like a difficulty, nor proposed any thing in reply but what I myself really believe to be a just and solid answer; I shall here close up the Apostle's argument of the existence of God from the consideration of human nature. And I appeal to all sober and impartial judges of what hath been delivered, whether those noble faculties of our souls may be only a mere sound and echo from the clashing of senseless atoms, or rather indubitably must proceed from a spiritual substance of a heavenly and divine extraction? Whether these admirable fabrics of our bodies shall be ascribed to the fatal motions or fortuitous shufflings of blind matter; or rather, beyond controversy, to the wisdom and contrivance of the almighty Author of all things,

A Confutation Of Atheism From The Origin And Frame Of The World

Part I.
That' ye should turn from these 'vanities unto the living God, who made heaven and earth, and the sea, and all things that are therein: who in times past suffered all nations to walk in their own ways, Nevertheless, he left not himself without witness, in that he did good, and gave us rain from heaven, and fruitful seasons, filling our hearts with food and gladness.

the arguments that can be brought, or can be demanded, for the existence of God, may, perhaps not absurdly, be reduced to three general heads: the first of which will include all the proofs from the vital and intelligent portions of the universe, the organical bodies of the various animals, and the immaterial souls of men. Which living and understanding substances, as they make incomparably the most considerable and noble part of the naturally known and visible creation; so they do the most clearly and cogently demonstrate to philosophical enquirers the necessary self-existence, and omnipotent power, and unsearchable wisdom, and boundless beneficence of their Maker. This first topic therefore was very fitly and divinely made use of by our Apostle in his conference with philosophers and that inquisitive people of Athens: the latter aspending their time in nothing else, hut either to tell or hear some new thing; and the other, in nothing, but to call in question the most evident truths that were delivered and received of old. And these arguments we have hitherto pursued in their utmost latitude and extent. So that now we shall proceed to the second head, or the proofs of a Deity from the inanimate part of the world; since even natural reason, as well as holy Scripture, assures us, b that the heavens declare the glory of God, and the firmament sheweth his handy-work; that he made the earth by his power, he hath established the World by his wisdom, and hath stretched out the heaven by his wider/landing; d that he commanded, and they were created; he hath also established them for ever and ever; e he covereth the heaven with clouds, he prepareth rain for the earth, f he croiuneth the year with his goodness.

These reasons for God's existence, from the frame and system of the world, as they are equally true with the former, so they have always been more popular and plausible to the illiterate part of mankind; insomuch as the s Epicureans, and some others, have observed, that men's contemplating the most ample arch of the firmament, the innumerable multitude of the stars, the regular rising and setting of the sun, the periodical and constant vicissitudes of day and night, and seasons of the year, and the other affections of meteors and heavenly bodies, was the principal and almost only ground and occasion that the notion of a God came first into the world: making no mention of the former proof from the frame of human nature, that in God we live, and move, and have our being. Which argument being so natural and internal to mankind, doth nevertheless (I know not how) seem more remote and obscure to the generality of men; who are readier to fetch a reason from the

immense distance of the starry heavens and the outmost walls of the world, than seek one at home, within themselves, in their own faculties and constitutions. So that hence we may perceive how prudently that was waved, and the second here insisted on by St. Paul to the rude and simple semi-barbarians of Lycaonia: he left not himself without witness, in that he did good, and gave us rain from heaven, and fruitful seasons, filling our hearts with food and gladness. Which words we shall now interpret in a large and free acceptation; so that this second theme may comprehend all the brute inanimate matter of the universe, as the former comprised all visible creatures in the world, that have understanding, or sense, or vegetable life. These two arguments are the voices of nature, the unanimous suffrages of all real beings and substances created, that are naturally knowable without revelation. And if, lastly, in the third place, we can evince the divine existence from the adjuncts and circumstances of human life; if we find in all ages, in all civilized nations, an universal belief and worship of a divinity; if we find many unquestionable records of supernatural and miraculous effects; if we find many faithful relations of prophecies punctually accomplished; of prophecies so well attested, above the suspicion of falsehood; so remote, and particular, and unlikely to come to pass, beyond the possibility of good guessing, or the mere foresight of human wisdom; if we find a most warrantable tradition, that at sundry times and in divers manners Godspake unto mankind by his Prophets, and by his Son, and his Apostles, who have delivered to us in sacred writings a clearer revelation of his divine nature and will: if, I say, this third topic from human testimony be found agreeable to the standing vote and attestation of nature, what further proofs can be demanded or desired? What fuller evidence can our adversaries require, since all the classes j of known beings are summoned to appear? Would they have us bring more witnesses than the all of the world? and will they not stand to the grand verdict and determination of the universe? They are incurable infidels, that persist to deny a Deity; when all creatures in the ' World, as well spiritual as corporeal, all from human race to the lowest of insects, from the cedar of Libanon to the moss upon the wall, from the vast globes of the sun and planets to the smallest particles of dust, do declare their absolute dependence upon the first author and fountain of all being, and motion, and life, the only eternal and self-existent God; with whom inhabit all majesty, and wisdom, and goodness, for ever and ever.

But, before I enter upon this argument from the origin and frame of the world; it will not be amiss to premise some particulars that may serve for an illustration of the text, and be a proper introduction to the following discourses.

As the Apostles, Barnabas and Paul, were preaching the Gospel at Lystra, a city of Lycaonia in Asia the Less, among the rest of their auditors there was a lame cripple from his birth, whom Paul commanded with a loud voice, to stand upright on his feet; and immediately by a miraculous energy he leaped and walked. Let us compare the present circumstances with those of my former text, and observe the remarkable difference in the Apostle's proceedings. No question but there were several cripples at Athens, so very large and populous a city; and, if that could be dubious, I might add, that the very climate disposed the inhabitants to impotency in the feet, according to the words of Lucretius; which it is probable he transcribed from Epicurus, a Gargettian and native of Athens, and therefore an unquestionable evidence in a matter of this nature. Neither is it likely that all the Athenian cripples should escape the sight of St. Paul, k since he disputed there in the market daily with them that met him. How comes it to pass then, that we do not hear of a like miracle in that city; which one would think might have greatly conduced to the Apostle's design, and have converted, or at least confuted and put to silence, the Epicureans and Stoics? But it is not difficult to give an account of this seeming disparity, if we attend to the qualifications of the lame person at Lystra; whom Paul stedfastly beholding, and 1 perceiving that he had Faith to be healed, said with a loud voice, Stand upright on thy feet. This is the necessary condition that was always required by our Saviour and his Apostles: And Jesus said unto the blind man, Receive thy sight, thy Faith hath saved thee; and to the woman that had the issue of blood, Daughter, be of good comfort; thy Faith hath made thee whole: go in peace. It was want of Faith in our Saviour's

countrymen, which hindered him from shedding among them the salutary emanations of his divine virtue: °And he did not many mighty works there, because of their unbelief There were many diseased persons in his own country, but very few that were rightly disposed for a supernatural cure. St. Mark hath a very observable expression upon the same occasion: And he Could do no mighty works there, save that he laid his hands upon a few sick folk, and healed them. We read in St. Luke, ch. v. 17. And the Power of the Lord was present to heal them. And, chap. vi. ver. 19. And the whole multitude sought to touch him: for there went virtue (2vmy.is) out of him, and healed them all. Now since they are words of the same root and signification, shall we so interpret the Evangelist, as if our Saviour had not power to work miracles among his unbelieving countrymen? This is the passage which that impious and impure Atheist Lucilio Vanino singled out for his text in his pretended and mock apology for the Christian religion; wickedly insinuating, as if the prodigies of Christ were mere impostures and acted by confederacy: and therefore, where the spectators were incredulous, and consequently watchful and suspicious, and not easily imposed on, he Could do no mighty work there; there his arm was shortened, and his power and virtue too feeble for such supernatural effects. But the gross absurdity of this suggestion is no less conspicuous than the villainous blasphemy of it. For, can it be credible to any rational person, that St. Mark could have that meaning? that he mould tax his Lord and Saviour, whom he knew to be God Almighty, with deficiency of power? He could do no mighty works; that is, he would do none, because of their unbelief. There is a frequent change of those words in all languages of the world. And we may appeal with r St. Chrysostom to the common custom of speech, whatever country we live in. This therefore is the genuine sense of that expression; Christ would not heal their infirmities, because of the hardness and slowness of their hearts, in that they believed him not. And I think there is not one instance in all the history of the New Testament of a miracle done for any one's sake, that did not believe Jesus to be a good person, and sent from God; and had not a disposition of heart fit to receive his doctrine. s For to believe he was the Messias and Son of God, was not then absolutely necessary, nor rigidly exacted; the most signal of the prophecies being not yet fulfilled by him, till his passion and resurrection. But, as I said, to obtain a miracle from him, it was necessary to believe him a good person, and sent from God. * Herod therefore hoped in vain to have seen some miracle done by him: u and when the Pharisees fought of him a sign from heaven, tempting him, they received this disappointing answer, Verily I say unto you, There shall no sign be given to this generation. And we may observe in the Gospels, that where the persons themselves were incapable of actual faith; yet the friends and relations of those dead that were raised again to life, of those lunatics and demoniacs that were restored to their right minds, were such as sought after him and believed on him. And, as to the healing of Malchus's ear, it was a peculiar and extraordinary case: for, though the person was wholly unworthy of so gracious a cure, yet in the account of the meek Lamb of God it was a kind of injury done to him by the fervidness of St. Peter, who knew not yet what spirit he was of, and that his Master's kingdom was not of this world. But, besides this obvious meaning of the words of the Evangelist, there may perhaps be a sublimer sense couched under the expression. For in the divine nature will and can ave frequently the selfsame thing; and freedom and necessity, that are opposites here below, do in heaven above most amicably agree and join hands together. And this is not a restraint or impotency, but the royal prerogative of the most absolute King of Kings; that he wills to do nothing but what he can, and that he can do nothing which is repugnant to his divine wisdom and essential goodness. God cannot do what is unjust, nor say what is untrue, nor promise with a mind to deceive. Our Saviour therefore could do no mighty work in a country of unbelievers, because it was not fit and reasonable. And so we may say of our Apostle, who was acted by the Spirit of God; that he could do no miracle at Athens, and that because of their unbelief. There is a very sad and melancholy account of the success of his stay there. Howbeit Certain men clave unto him, and believed; a more diminutive expression, than if they had been called a few. And we do not find, that he ever visited this city again, as he did several others, where there were a competent number of disciples. And indeed if we consider the genius and condition of the Athenians at that time, how vicious and corrupt they were; how conceited of their own wit, and science, and politeness, as if they had invented corn and oil, and

distributed them to the world; a and had first taught civility, and learning; and religion, and laws to the rest of mankind; how they were puffed up with the fulsome flatteries of their philosophers, and sophists, and poets of the stage; we cannot much wonder, that they should so little regard an unknown stranger, that preached unto them an unknown God.

I am aware of an objection, that, for ought we can now affirm, St. Paul might have done several miracles at Athens, though they be not related by St. Luke. I confess I am far from asserting, that all the b miracles of our Saviour are recorded in the Gospels, or of his Apostles in the Acts. But nevertheless, in the present circumstances, I think we may conjecture, that, if any prodigy and wonder had been performed by our Apostle among those curious and pragmatical Athenians, it would have had such a consequence, as might have deserved some place in sacred history, as well as this before us at Lystra; c where, when the people saw what Paul had done, they lift up their voices, faying in the speech of Lycaonia, The gods are come down to us in the likeness of men; and the priests came with oxen and garlands, and would have sacrificed to them, as to Jupiter and Mercurius. That this was a common opinion among the Gentiles, that the gods sometimes assumed human shape, and conversed upon earth as strangers and travellers, must needs be well known to any one that ever looks into the ancient poets. Even the vagabond life of Apollonius Tyanensis shall be called by a bigoted sophist, a peregrination of a god among men. And when the Lystrians say, gods in the shape of men, they mean not, that the gods had other figure than human even in heaven itself, (for that was the received doctrine of most of the vulgar heathen, and of some sects of philosophers too,) but that they, who in their own nature were of a more august stature and glorious visage, had now contracted and debased themselves into the narrower dimensions and meaner aspects of mortal men. Now, when the Apostles heard of this intended sacrifice, they rent their clothes, and ran in among the people, crying out, &c. St. Chrysostom upon this place hath a very odd exposition. He enquires why Paul and Barnabas do now at last reprove the people, when the priest and victims were even at the gates; and not presently, when they lift up their voice, and called them gods: for which he assigns this reason, sthat because they spoke in the Lycaonian tongue, the Apostles did not then understand them; but now they perceived their meaning by the oxen and the garlands. Indeed it is very probable, that the Lycaonian language was very different from the Greek, as we may gather from Gephorus, and Strabo that cites him, who make almost all the inland nations of Asia Minor to be barbarians; and from Stephanus Byzantius, who acquaints us, that a juniper-tree, was called in the speech of the Lycaonians. But, notwithstanding we can by no means allow that the great Apostle of the Gentiles should be ignorant of that language; he that so solemnly affirms of himself, I thank my God, I speak with tongues more than you all; and at the first effusion of this heavenly gift, k the dwellers in Cappadocia, in Pontus and Ajia, Phrygia and Pamphylia, (some of them near neighbours to the Lycaonians,) heard the Apostles speak in their several tongues the wonderful works of God. And how could these two Apostles have preached the Gospel to the 'Lystrians, if they did not use the common language of the country? And to what purpose did they cry out and speak to them, if the hearers could not apprehend? or how could they by those nsayings refrain the people from sacrificing, if what they said was not intelligible? But it will be asked, why then were the Apostles so stow and backward in reclaiming them? and what can be answered to the query of St. Chrysostom? When I consider the circumstances and nature of this affair, I am persuaded they did not hear that discourse of the people. For I can hardly conceive, that men under such apprehensions as the Lystrians then were, in the dread presence and under the very nod of the almighty Jupiter, not an idol of wood or stone, but the real and very God, (as the °Athenians made their compliment to Demetrius Poliorcetes, should exclaim in his sight and hearing: this, I say, seems not probable nor natural; nor is it affirmed in the text: but they might buzz and whisper it one to another, and silently withdrawing from the presence of the Apostles, they then lift up their voices, and noised it about the city. So that Paul and Barnabas were but just then informed of their idolatrous design, when they rent their clothes, and ran in among them, and expostulated with them; Sirs, why do ye these things? We also are men of like passions with you; mortal men like yourselves, as it is judiciously rendered in the ancient Latin version; otherwise the

antithesis is not so plain: for the heathen theology made even the gods themselves subject to human passions and appetites, to anger, sorrow, lust, hunger, wounds, lameness, &c. s and exempted them from nothing but death and old age: and we preach unto you, that ye should turn from these vanities (i. e. idols) unto the living God, which made heaven, and earth, and the sea, and all things that are therein: who in times past suffered all nations to walk in their own ways: not all nations, but all the heathen, (the word Heathen comes from s3-vri,) all the Gentiles, distinguished guislaed from the Jews, as the same words are translated Rom. xv. 11. and 2 Tim. iv. 17. and ought to have been so, Rom. i. 5. and xvi. 26. but much more in our text, which, according to the present version, seems to carry a very obscure, if not erroneous meaning; but by a true interpretation is very easy and intelligible: that hitherto God had suffered all the Gentiles to walk in their own ways; and excepting the Jews only, whom he chose for his own people, and prescribed them a law, he permitted the rest of mankind to walk by the mere light of nature without the assistance of revelation r but that now, in the fulness of time, he had even to the Gentiles also sent salvation, and opened the door of faith, and granted repentance unto life. So that these words of our: Apostle are exactly coincident with that remarkable passage in his discourse to the Athenians: And the (past) times of this ignorance. (of the Gentile world) God winked at,, .(at. x overlooked;) but now commandeth all men every where to repent. And nevertheless, says our text, even in that gloomy state of heathenism, he left not himself without witness, in that he did good, always doing good from heaven, (y which seems to be the real genuine punctuation, and is authorized by the Syriac interpreters,) and gave us rain and fruitful seasons, filling our hearts with food and gladness. Even the very Gentiles might feel after him and find him; since the admirable frame of heaven, and earth, and sea, and the munificent provision of food and sustenance for his creatures, did competently set forth his eternal power and Godhead; so that stupid idolaters and profane Atheists were then and always without excuse.

Our adversaries have used the same methods to elude the present argument from the frame of the world, as they have done to evade the former from the origin of mankind. Some have maintained, that this world hath thus existed from all eternity in its present form and condition; but others say, that the forms of particular worlds are generable and corruptible; so that our present system cannot have sustained an infinite duration already gone and expired: but however, say they, body in general, the common basis and matter of all worlds and beings, is self-existent and eternal; which being naturally divided into innumerable little particles or atoms, eternally endued with an ingenite and inseparable power of moreadtion, by their omnifarious concursions, and combinations, and coalitions, produce successively (or at once, if matter be infinite) an infinite number of worlds; and amongst the rest there arose this visible complex system of heaven and earth. And thus far they do agree; but then they differ about the cause and mode of the production of worlds, some ascribing it to fortune, and others to mechanism or nature. It is true, the astrological Atheists will give us no trouble in the present dispute; because they cannot form a peculiar hypothesis here, as they have done before about the origination of animals. For though some of them are so vain and senseless, as to pretend to a ihema mundi, a calculated scheme of the nativity of our world; yet it exceeds even, their absurdity, to suppose the zodiac and planets to be efficient of, and antecedent to themselves; or to exert any influences before they were in being. So that, to refute all possible explications that the Atheists have or can propose, I shall proceed in this following method:

I. First, I will prove it impossible that the primary parts of our world, the sun and the planets, with their regular motions and revolutions, should have subsisted eternally in the present or a like frame and condition.

II. Secondly, I will shew, that matter abstractly and absolutely considered, cannot have subsisted eternally; or, if it has, yet motion cannot have coexisted eternally with it, as an inherent property and essential attribute of the Atheist's god, Matter.

III. Thirdly, though universal matter should have endured from everlasting, divided into infinite particles in the Epicurean way; and though motion should have been coeval and coeternal with it; yet those particles or atoms could never of themselves by omnifarious kinds of motion, whether fortuitous or mechanical, have fallen or been disposed into this or a like visible system.

IV. And, fourthly, a posteriori, that the order and beauty of the inanimate parts of the world, the discernible ends and final causes of them, or a meliority above what was necessary to be, do evince by a reflex argument, that it is the product and workmanship, not of blind mechanism or blinder chance, but of an intelligent and benign Agent; who by his excellent wisdom made the heavens and earth, and gives rain and fruitful seasons for the service of man.

I shall speak to the two first propositions in my present discourse; reserving the latter for other opportunities. I. First, therefore: that the present or a like frame of the world hath not subsisted from everlasting. We will readily concede, that a thing may be truly eternal, though its duration be terminated at one end. For so we affirm human souls to be immortal and eternal, there was a time when they were nothing; and therefore their infinite duration will always be bounded at one extreme by that first beginning of existence. So that, for ought appears as yet, the revolutions of the earth and other planets about the fun, though they be limited at one end by the present revolution, may nevertheless have been infinite and eternal without any beginning. But then we must consider, that this duration of human souls is only potentially infinite. For their eternity consists only in an endless capacity of continuance without ever ceasing to be, w a boundless futurity that can never be exhausted, or all of it be past and present. But their duration can never be positively and actually eternal; because it is most manifest, that ˚o moment can ever be assigned, wherein it shall be true, that such a soul hath then actually sustained an infinite duration. For that supposed infinite duration will by the very supposition be limited at two extremes, though never & remote asunder, and consequently must needs ^ finite. Wherefore the true nature and notion of a soul's eternity is this: that the future moments of its duration can never be all past and present, but still there will be a futurity and- potentiality of more for ever and ever. So that we evidently perceive from this instance, that whatever successive duration shall be bounded at one end, and be all past and present, for that reason must be finite. Which necessarily evinceth, that the present or a like world can never have been eternal; or that there cannot have been infinite past revolutions of a planet about a sun. For this supposed infinity is terminate at one extreme by the pre" sent revolution, and all the other revolutions are confessedly past; so that the whole duration is bounded at one end, and all past and present; and therefore cannot have been infinite, by what was proved before. And this will shew us the vast difference between the false successive eternity backwards, and the real one to come. For, consider the present revolution of the earth, as the bound and confine of them both. God Almighty, if he so pleaseth, may continue this motion to perpetuity in infinite revolutions to come; because futurity is inexhaustible, and can never be all spent or run out by past and present moments. But then, if we look backwards from this present revolution, we may apprehend the impossibility of infinite revolutions on that side; because all are already past, and so were once actually present, and consequently are finite, by the argument before. For surely we cannot conceive a preteriteness (if I may say so) still backwards in infinitum, that never was present; as we can an endless futurity, that never will be present. So that though one is potentially infinite; yet nevertheless the other is actually finite. And this reasoning doth necessarily conclude against the past infinite duration of all successive motion and mutable beings: but it doth not at all affect the eternal existence of God, in whose invariable nature there is no past or future; who is omnipresent not only as to space, but as to duration, and, with respect to such omnipresence, it is certain and manifest, that succession and motion are mere impossibilities, and repugnant in the very terms.

And, secondly, though what hath been now said hath given us so clear a view of the nature of successive duration, as to make more arguments needless; yet I shall here briefly shew, how our

adversaries' hypothesis without any outward opposition destroys and confutes itself. For let us suppose infinite revolutions of the earth about the sun to be already gone and expired; 1 take it to be self-evident, that, if none of those past revolutions has been infinite ages ago, all the revolutions put together cannot make the duration of infinite ages: it follows therefore from this supposition, that there may be some one assignable revolution among them, that was at an infinite distance from the present. But it is self-evident likewise, that no one past revolution could be infinitely distant from the present: for then an infinite or unbounded duration may be bounded at two extremes by two annual revolutions, which is absurd and a contradiction. And again, upon the same supposition of an eternal past duration of the world, and of infinite annual revolutions of the earth about the sun; I would ask concerning the monthly revolutions of the moon about the earth, or the diurnal ones of the earth upon its own axis, both which by the very hypothesis are coeval with the former; whether these also have been finite or infinite? Not finite to be sure; because then a finite number would be greater than an infinite, as 12 or 365 are more than an unit. Nor infinite neither; for then two or three infinites would exceed one another; as a year exceeds a month, or both exceed a day. So that both ways the supposition is repugnant and impossible. the known plantations of most countries, from the recent invention of letters and arts, &c. do conclude as forcibly against the eternity of the world, as against infinite generations of human race. For if the present frame of the earth be supposed eternal; by the same notion they make mankind to have been coeternal with it. For otherwise this eternal earth, after she had been eternally barren and desolate, must at last have spontaneously produced mankind, without new cause from without, or any alteration in her own texture: which is so gross an absurdity, that even no Atheist hath yet affirmed it. So that it evidently follows, since mankind had a beginning, that the present form of the earth, and therefore the whole system of the world, had a beginning also.

And, thirdly, the arguments already used, from the gradual increase of mankind, from which being proved and established; we are now enabled to give answers to some bold queries and objections of Atheists; that since God is described as a being infinitely powerful and perfectly good; and that these attributes were essential to him from all eternity; why did he not by his power, for the more ample communication of his goodness, create the world from eternity, if he created it at all? or at least many millions of ages ago before this short span of duration of five or six thousand years? To the first we reply, that since we have discovered an internal and natural impossibility that a successive duration mould be actually eternal; it is to us a flat contradiction, that the world mould have been created from everlasting. And therefore it is no affront to the divine omnipotence, if by reason of the formal incapacity and repugnancy of the thing we conceive that the world could not possibly have been made from all eternity, even by God himself. Which gives an answer to the second question, Why created so lately? For, if it could not be created from eternity, there can no instant be assigned for its creation in time, though never so many myriads and missions of years since, but the same query may be put, Why but now, and Why so late? for even before that remoter period God was eternally existent, and might have made the world as many myriads of ages still backwards before that: and consequently this objection is absurd and unreasonable. For else, if it was good and allowable, it would eternally hinder God from exerting his creative power, because he could never make a world so early, at any given moment; but it may truly be said he could have created it sooner. Or if they think there may be a soonest instant of possible creation; yet, since all instants have an equal pretence to it in human apprehension, why may not this recent production of the world, according to sacred authority, be supposed to be that soonest? At least it may make that claim to it that cannot be baffled by their arguments, which equally conclude against all claims, against any conceivable beginning of the world.

And so when they profanely ask, Why did not this supposed Deity, if he really made the heavens, make them boundless and immense, a fit and honourable mansion for an infinite and incomprehensible being; or at least vastly more ample and magnificent than this narrow cottage of a world? we may make them this answer: First, it seems impossible and a contradiction, that a

created world should be infinite; because it is the nature of quantity and motion, that they can never be actually and positively infinite: they have a power indeed and a capacity of being increased without end; sq as no quantity can be assigned so vast, but still a larger may be imagined; no motion so swift or languid, but a greater velocity or slowness may still be conceived; no positive duration of it so long, than which a longer may not be supposed; but even that very power hinders them from being actually infinite. From whence, secondly, it follows, that though the world was a million of times more spacious and ample than even astronomy supposes it, or yet another million bigger than that, and so on in infinite progression; yet still they might make the same exception world without end. For since God Almighty can do all that is possible, and quantity hath always a possibility of being enlarged more and more; he could never create so ample a world, but still it would be true, that he could have made a bigger-; the fecundity of his creative power never growing barren, nor ever to be exhausted. Now what may always be an exception against all possible worlds, can never be a just one against any whatsoever.

And when they scoffingly demand, Why would this imaginary Omnipotence make such mean pieces of workmanship? What man indigent and impotent thing is his principal creature man! Would not boundless beneficence have communicated his divine perfections in the most eminent degrees? they may receive this reply; that we are far from such arrogance, as to pretend to the highest dignity, and be the chief of the whole creation: we believe an invisible world, and a scale of spiritual beings all nobler than ourselves: nor yet are we so low and base as their atheism would depress us; not walking statues of clay, not the sons of brute earth, whose final inheritance is death' and corruption: we carry the image of God in us, a rational and immortal soul; and, though we be now indigent and feeble, yet we aspire after eternal happiness, and firmly expect a great exaltation of all our natural powers. But whatsoever was or can be made, whether angels or archangels, cherubims or seraphims, whether thrones or dominions, or principalities or powers, all the glorious host of heaven, must needs be finite, and imperfect, and dependent creatures: and God out of the exceeding greatness of his power is still able, without end, to create higher classes of beings. For where can we put a stop to the efficacy of the Almighty? or what can we assign for the highest of all possible finite perfections? There can be no such thing as an almost infinite; there can be nothing next or second to an omnipotent God; as the heathen poet said excellently well of the supposed father of gods and men. The infinite distance between the Creator and the noblest of all creatures can never be measured nor exhausted by endless addition of finite degrees. So that no actual creature can ever be the most perfect of all possible creation. Which shews the folly of this query, that might always be demanded, let things be as they will; that would impiously and absurdly attempt to tie the arm of omnipotence from doing any thing at all, because it can never do its utmost.

II. I proceed now to the second proportion, that neither matter universally and abstractly considered, nor motion as its attribute and property, can have existed from all eternity. And to this I shall speak the more briefly; not only because it is an abstruse and metaphysical speculation, but because it is of far less moment and consequence than the rest: since without this we can evince the existence of God from the origin and frame of the universe. For if the present or a like system of the world cannot possibly have been eternal; band if without God it could neither naturally nor fortuitously emerge out of a chaos; c we must necessarily have recourse to a Deity, as the contriver and maker of heaven and earth; whether we suppose he created them out of nothing, or had the materials ready eternally to his hand. But nevertheless, because we are verily persuaded of the truth of this article, we shall briefly assign some reasons of our belief in these following particulars.

First, It is a thing possible, that matter may have been produced out of nothing. It is urged as an universal maxim, that nothing can proceed from nothing. Now this we readily allow; and yet it will prove nothing against the possibility of creation. For, when they say, no thing from nothing, they must so understand it, as excluding all causes, both material and efficient. In which sense it is most

evidently and infallibly true; being equivalent to this proposition, that nothing can make itself; or, nothing cannot bring its no-self out of nonentity into something. Which only expresses thus much, that matter did not produce itself, or, that all substances did not emerge out of an universal nothing. Now, who ever talked at that rate? We do not say, the world was created from nothing and by nothing; we assert an eternal God to have been the efficient cause of it. So that a creation of the world out of nothing by something, and by that something that includes in its nature a necessary existence and perfection of power, is certainly no contradiction, nor opposes that common maxim. Whence it manifestly follows, that since God may do any thing that implies not a contradiction; if there be such an essence as God, he may have created matter out of nothing, that is, have given an existence to matter, which had no being before.

And, secondly, It is very probable, that matter has been actually created out of nothing. In a former discourse we have proved sufficiently, that human souls are not mere modification of matter, but real and spiritual substances, that have as true an existence as our very bodies themselves. Now, no man, as I conceive, can seriously think that his own soul hath existed from all eternity. He cannot believe the stuff or materials of his soul to have been eternal, and the soul to have been made up of them at the time of his conception. For a human soul is no compound being; it is not made of particles, as our bodies are; but it is one simple homogeneous essence: neither can he think, that the personality of his soul, with its faculties inherent in it, has existed eternally; this is against common sense, and it needs no refutation. Nay, though a man could be so extravagant as to hold this assertion, that his soul, his personal self, has been from everlasting; yet even this in the issue would be destructive to atheism, since it supposes an eternal Being, endued with understanding and wisdom. We will take it then as a thing confessed, that the immaterial souls of men have been produced out of nothing. But if God hath actually created those intelligent substances that have such nobility and excellency of being above brute senseless matter; it is pervicaciousness to deny that he created matter also: unless they will say, necessary existence is included in the very essence and idea of matter.

But matter doth not include in its nature a necessity of existence. For human souls, as is proved before, have been actually created, and consequently have not necessary existence included in their essence. Now can any man believe, that his spiritual soul, that understands,, and judges, and invents; endowed with those p divine faculties of sense, memory, and reason; hath a dependent and precarious being created and preserved by another; while the particles of this dead ink and paper have been necessarily eternal and uncreated? It is against natural reason; and no one, while he contemplates an individual body, can discern that necessity of its existence. But men have been taught to believe, that extension or space, and. body are both the selfsame thing. So that because they cannot imagine, how space can either begin or cease to exist; they presently conclude, that extended infinite matter must needs be eternal. eBut I shall fully prove hereafter, that body and space or distance are quite different things, and that a vacuity is interspersed among the particles of matter, and such a one as hath a vastly larger extension than all the matter of the universe. Which now being supposed, they ought to abstract their imagination from that false infinite extension, and conceive one particle of matter, surrounded on all sides with vacuity, and contiguous to no other body. And whereas formerly they fancied an immense boundless space, as an homogeneous one; which great individual they believed might deserve the attribute of necessary existence: let them now please to imagine one solitary atom, that hath no dependence on the rest of the world; and is no more sustained in being by other matter, than it could be created by it; and then I would aslc the question, whether this poor atom, sluggish and unactive as it is, doth involve necessity of existence, the first and highest of all perfections, in its particular nature and notion? I dare presume for the negative in the judgments of all serious men. fAnd I observe the Epicureans take much pains to convince us, that in natural connections and dissolutions, atoms are not reduced to nothing; which surely would be needless* if the very idea of atoms imported self-existence. And yet if one atom do not include so much in its notion and essence; all atoms put together, that is, all

the matter of the universe cannot include it. So that upon the whole matter, since creation is no contradiction; since God hath certainly created nobler substances than matter; and since matter is not necessarily eternal; it is most reasonable to believe, that the eternal and self-existent God created the material world, and produced it out of nothing.

And then as to the last proposition, that motion as an attribute or property of matter cannot have been from eternity. That we may wave some metaphysical arguments, which demonstrate that local motion cannot be positively eternal; we shall only observe in two words, that if matter be not essentially eternal, as we have shewed before; much less can motion be, that is but the adjunct and accident of it. Nay, though we should concede an eternity to matter; yet why must motion be coeval with it? which is not only not inherent and essential to matter, but may be produced and destroyed at the pleasure of free agents; both which are flatly repugnant to an eternal and necessary duration. I am aware how some have asserted, that the same quantity of motion is always kept up in the world; which may seem to favour the opinion of its infinite duration: but that assertion doth solely depend upon an absolute plenum; which being refuted in my next discourse, it will then appear how absurd and false that conceit is, about the same quantity of motion; how easily disproved from that power in human souls to excite motion when they please, and from the gradual increase of men and other animals, and many arguments besides. Therefore let this also be concluded, that motion has not been eternal in an infinite past duration: which was the last thing to be proved.

PART II.

That ye should turn from these vanities unto the living God, who made heaven and earth, and the sea, and all things that are therein: who in times past suffered all nations to walk in their own ways. Nevertheless, he left not himself without witness, in that he did good, and gave us rain from heaven, and fruitful seasons, fitting our hearts with food and gladness.

When we first entered upon this topic, the demonstration of God's existence from the origin and frame of the world, we offered to prove four propositions.

I, That this present system of heaven and earth cannot possibly have subsisted from all eternity.

II. That matter considered generally, and abstractly from any particular form and concretion, cannot possibly have been eternal: or, if matter could be so; yet motion cannot have coexisted with it eternally, as an inherent property and essential attribute of matter. These two we have already established in the preceding discourse; we shall now shew, in the third place,

III. That, though we should allow the Atheists, that matter and motion may have been from everlasting; yet if (as they now suppose) there were once no sun, nor stars, nor earth, nor planets, but the particles that now constitute them were diffused in the mundane space in manner of a chaos without any concretion or coalition; those dispersed particles could never of themselves by any kind of natural motion, whether called fortuitous or mechanical, have convened into this present or any other like frame of heaven and earth.

1. And first, as to that ordinary cant of illiterate and puny Atheists, the fortuitous or casual concourse of atoms, that compendious and easy dispatch of the most important and difficult affair, the formation of a world; (besides that in our next undertaking it will be refuted all along;) I shall now briefly dispatch it, from what hath been formerly said concerning the true notions of fortune and chance. Whereby it is evident, that in the atheistical hypothesis of the world's production, fortuitous and mechanical must be the selfsame thing. Because fortune is no real entity nor physical essence, but a mere relative signification, denoting only this; that such a thing said to fall

out by fortune was really effected by material and necessary causes; but the person, with regard to whom it is called fortuitous, was ignorant of those causes or their tendencies, and did not design or foresee such an effect. This is the only allowable and genuine notion of the word fortune. But thus to affirm, that the world was made fortuitously, is as much as to say, that before the world was made, there was some intelligent agent or spectator, who designing to do something else, or expecting that something else would be done with the materials of the world, there were some occult and unknown motions and tendencies in matter, which mechanically formed the world beside his designer expectation. Now the Atheists, we may presume, will be loth to assert a fortuitous formation in this proper sense and meaning; whereby they will make understanding to be older than heaven and earth. Or if they should so assert it; yet, unless they will affirm that the intelligent agent did dispose and direct the inanimate matter, (which is what we would bring them to,) they must still leave their atoms to their mechanical affections; not able to make one step toward the production of a world beyond the necessary laws of motion. It is plain then, that fortune, as to the matter before us, is but a synonymous word with nature and necessity. It remains that we examine the adequate meaning of ^chance; which properly signifies, that all events called casual, among inanimate bodies, are mechanically and naturally produced according to the determinate figures, and textures, and motions of those bodies; with this negation only, that those inanimate bodies are not conscious of their own operations, nor contrive and cast about how to bring such events to pass. So that thus to say, that the world was made casually by the concourse of atoms, is no more than to affirm, that the atoms composed the world mechanically and fatally; only they were not sensible of it, nor studied and considered about so noble an undertaking. For if atoms formed the world according to the essential properties of bulk, figure, and motion, they formed it mechanically; and if they formed it mechanically without perception and design, they formed it casually. So that this negation of consciousness being all that the notion of chance can add to that of mechanism; we, that do not dispute this matter with the Atheists, nor believe that atoms ever acted by counsel and thought, may have leave to consider the several names of fortune, and chance, and nature, and mechanism, as one and the same hypothesis. Wherefore once for all to overthrow all possible explications which Atheists have or may assign for the formation of the world, we will undertake to evince this following proposition:

2. That the atoms or particles which now constitute heaven and earth, being once separate and diffused in the mundane space, like the supposed chaos, could never, without a God, by their mechanical affections, have convened into this present frame of things, or any other like it.

Which that we may perform with the greater clearness and conviction, it will be necessary, in a discourse about the formation of the world, to give you a brief account of some of the most principal and systematical phœnomena that occur in the world now that it is formed.

(l.) The most considerable phœnomenon belonging to terrestrial bodies is the general action of gravitation, whereby all known bodies in the vicinity of the earth do tend and press towards its center; not only such as are sensibly and evidently heavy, but even those that are comparatively the lightest, and even in their proper place, and natural elements; (as they usually speak;) as air gravitates even in air, and water in water. This hath been demonstrated and experimentally proved beyond contradiction, by several ingenious persons of the present age, but by none so perspicuously, and copiously, and accurately, as by the c honourable Founder of this Lecture, in his incomparable Treatises of the Air and Hydrostatics.

(2.) Now this is the constant property of gravitation, that the weight of all bodies around the earth is ever proportional to the quantity of their matter: as for instance, a pound weight (examined hydrostatically) of all kinds of bodies^ though of the most different forms and textures, doth always contain an equal quantity of solid mass or corporeal substance. This is the ancient doctrine of the d Epicurean physiology, then and since very probably indeed, but yet precariously asserted: but it is

lately demonstrated and put beyond controversy by that very excellent and divine theorist e Mr. Isaac Newton, to whose most admirable sagacity and industry we shall frequently be obliged in this and the following discourse.

I will not entertain this auditory with an account of the demonstration; but referring the curious to the book itself for full satisfaction, I shall now proceed and build upon it as a truth solidly established, that all bodies weigh according to their matter; provided only that the compared bodies be at equal distances from the center toward which they weigh, Because the further they are removed from the center, the lighter they are; decreasing gradually and uniformly in weight, in a duplicate proportion to the increase of the distance.

(3.) Now since gravity is found proportional to the quantity of matter, there is a manifest necessity of admitting a vacuum, another principal doctrine of the atomical philosophy. Because if there were every where an absolute plenitude and density without any empty pores and interstices between the particles of bodies, then all bodies of equal dimensions would contain an equal quantity of matter; and consequently, as we have shewed before, would be equally ponderous: so that gold, copper, stone, wood, &c. would have all the same specific weight; which experience assures us they have not: neither would any of them descend in the air, as we all see they do; because, if all space was full, even the air would be as dense and specifically as heavy as they. If it be said, that, though the difference of specific gravity may proceed from variety of texture, the lighter bodies being of a more loose and porous composition, and the heavier more dense and compact; yet an ethereal subtile matter, which is in a perpetual motion, may penetrate and pervade the minutest and inmost cavities of the closest bodies, and adapting itself to the figure of every pore, may adequately fill them; and so prevent all vacuity, without increasing the weight. To this we answer, that that subtile matter itself must be of the same substance and nature with all other matter, and therefore it also must weigh proportionally to its bulk; and as much of it as at any time is comprehended within the pores of a particular body must gravitate jointly with that body; so that if the presence of this ethereal matter made an absolute fulness, all bodies of equal dimensions would be equally heavy: which being refuted by experience, it necessarily follows, that there is a vacuity; and that (notwithstanding some little objections full of cavil and sophistry) mete and simple extension or space hath a quite different nature and notion from real body and impenetrable substance.

(4.) This therefore being established; in the next place, it is of great consequence to our present enquiry, if we can make a computation, how great is the whole sum of the void spaces in our system, and what proportion it bears to the corporeal substance. By many and accurate trials it manifestly appears, that refined gold, the most ponderous of known bodies, (though even that must be allowed to be porous too, because it is dissoluble in mercury, and aqua regis, and other chymical liquors; and because it is naturally a thing impossible, that the figures and sizes of its constituent particles should be so justly adapted, as to touch one another in every point,) I say, gold is in specific weight to common water as 19 to 1; and water to common air as 850 to 1: so that gold is to air as 16150 to 1. Whence it clearly appears, seeing matter and gravity are always commensurate, that (though we should allow the texture of gold to be entirely close without any vacuity) the ordinary air in which we live and respire is of so thin a composition, that 16149 parts of its dimensions are mere emptiness and nothing; and the remaining one only material and real substance. But if gold itself be admitted, as it must be, for a porous concrete, the proportion of void to body in the texture of common air will be so much the greater. And thus it is in the lowest and densest region of the air near the surface of the earth, where the whole mass of air is in a state of violent compression, the inferior being pressed and constipated by the weight of all the incumbent. But, since the air is now certainly known to consist of s elastic or springy particles, that have a continual tendency and endeavour to expand and display themselves; and the dimensions, to which they expand themselves, to be reciprocally as the compression; it follows, that the higher

you ascend in it, where it is less and less compressed by the superior air, the more and more it is rarefied. So that at the height of a few miles from the surface of the earth, it is computed to have some million parts of empty space in its texture for one of solid matter. And at the height of one terrestrial semi-diameter (not above four thousand miles) the ether is of that wonderful tenuity, h that, by an exact calculation, if a small sphere of common air of one inch diameter (already 16149 parts nothing) should be further expanded to the thinness of that ether, it would more than take up the vast orb of Saturn, which is many million million million times bigger than the whole globe of the earth. And yet, the higher you ascend above that region, the rarefaction still gradually increases without stop or limit: so that, in a word, the whole concave of the firmament, except the sun and planets and their atmospheres, may be considered as a mere void. Let us allow then, that all the matter of the system of our sun may be 50000 times as much as the whole mass of the earth; and we appeal to astronomy, if we are not liberal enough and even prodigal in this concession. And let us suppose further, that the whole globe of the earth is entirely solid and compact without any void interstices; notwithstanding what hath been shewed before, as to the texture of gold itself. Now, though we have made such ample allowances, we shall find, notwithstanding, that the void space of our system is immensely bigger than all its corporeal mass. For, to proceed upon our supposition, that all the matter within the firmament is 50000 times bigger than the solid globe of the earth; if we assume the diameter of the orbis magnus (wherein the earth moves about the sun) to be only 7000 times as big as the diameter of the earth, (though the latest and most accurate observations make it thrice 7000,) and the diameter of the firmament to be only 100000 times as long as the diameter of the orbis magnus, (though it cannot possibly be less than that, but may be vastly and unspeakably bigger,) we must pronounce, after such large concessions on that side, and such great abatements on ours, that the sum of empty spaces within the concave of the firmament is 6860 million million million times bigger than all the matter contained in it.

Now from hence we are enabled to form a right conception and imagination of the supposed chaos, and then we may proceed to determine the controversy with more certainty and satisfaction, whether a world like the present could possibly without a divine influence be formed in it, or no?

1. And first, because every fixed star is supposed by astronomers to be of the same nature with our sun; and each may very possibly have planets about them, though by reason of their vast distance they be invisible to us; we will assume this reasonable supposition, that the same proportion of void space to matter, which is found in our sun's region within the sphere of the fixed stars, may competently well hold in the whole mundane space. I am aware, that in this computation we must not assign the whole capacity of that sphere for the region of our sun; but allow half of its diameter for the radii of the several regions of the next fixed stars: so that diminishing our former number, as this last consideration requires, we may safely affirm from certain and demonstrated principles, that the empty space of our solar region (comprehending half of the diameter of the firmament) is 8575 hundred thousand million million times more ample than all the corporeal substance in it. And we may fairly suppose, that the same proportion may hold through the whole extent of the universe.

2. And secondly, as to the state or condition of matter before the world was a making, which is compendiously expressed by the word chaos; they must either suppose, that the matter of our solar system was evenly or well-nigh evenly diffused through the region of the sun, which would represent a particular chaos: or that all matter universally was so spread through the whole mundane space, which would truly exhibit a general chaos; no part of the universe being rarer or denser than another. And this is agreeable to the ancient description of chaos, that 5 the heavens and earth had one form, one texture and constitution; which could not be, unless all the mundane matter were uniformly and evenly diffused. It is indifferent to our dispute, whether they suppose it to have continued a long time or very little in the state of diffusion. For, if there were but one

single moment in all past eternity, when matter was so diffused, we shall plainly and fully prove, that it could never have convened afterwards into the present frame and order of things.

3. It is evident from what we have newly proved, that in the supposition of such a chaos or such an even diffusion either of the whole mundane matter, or that of our system, (for it matters not which they assume,) every single particle would have a sphere of void space around it 8575 hundred thousand million million times bigger than the dimensions of that particle. Nay, further, though the proportion already appear so immense; yet every single particle would really be surrounded with a void sphere eight times as capacious as that newly mentioned; its diameter being compounded of the diameter of the proper sphere, and the semi-diameters of the contiguous spheres of the neighbouring particles. From whence it appears, that every particle (supposing them globular or not very oblong) would be above nine million times their own length from any other particle. And moreover, in the whole surface of this void sphere there can only twelve particles be evenly placed, as the hypothesis requires; that is, at equal distances from the central one and from each other: so that if the matter of our system or of the universe was equally dispersed, like the supposed chaos, the result and issue would be, not only that every atom would be many million times its own length distant from any other; but, if any one should be moved mechanically (without direction or attraction) to the limit of that distance, it is above a hundred million millions odds to an unit, that it would not strike upon any other atom, but glide through an empty interval without any contact.

4. It is true, that while I calculate these measures, I suppose all the particles of matter to be at absolute rest among themselves, and situated in an exact and mathematical evenness; neither of which is likely to be allowed by our adversaries, who not admitting the former, but asserting the eternity of motion, will consequently deny the latter also: because, in the very moment that motion is admitted in the chaos, such an exact evenness cannot possibly be preserved. But this I do, not to draw any argument against them from the universal rest or accurately equal diffusion of matter; but only that I may better demonstrate the great rarity and tenuity of their imaginary chaos, and reduce it to computation: which computation will hold with exactness enough, though we allow the particles of the chaos to be variously moved, and to differ something in size, and figure, and situation. For if some particles mould approach nearer each other than in the former proportion; with respect to some other particles they would be as much remoter. So that, notwithstanding a small diversity of their positions and distances, the whole aggregate of matter, as long as it retained the name and nature of chaos, would retain well-nigh an uniform tenuity of texture, and may be considered as an homogeneous fluid: as several portions of the same sort of water are reckoned to be of the same specific gravity; though it be naturally impossible that every particle and pore of it, considered geometrically, should have equal sizes and dimensions.

We have now represented the true scheme and condition of the chaos; how all the particles would be disunited; and what vast intervals of empty space would lie between each. To form a system therefore, it is necessary that these squandered atoms mould convene and unite into great and compact masses, like the bodies of the earth and planets* Without such a coalition the diffused chaos must have continued and reigned to all eternity. But could particles so widely dispersed combine into that closeness of texture? Our adversaries can have only these two ways of accounting for it.

First, By the common motion of matter, proceeding from external impulse and conflict, (without attraction,) by which every body moves uniformly in a direct line, according to the determination of the impelling force. For, they may say, the atoms of the chaos being variously moved, according to this catholic law, must needs knock and interfere; by which means some that have convenient figures for mutual coherence might chance to stick together, and others might join to those, and so by degrees such huge masses might be formed, as afterwards became suns and planets: or there

might arise some vertiginous motion or whirlpools in the matter of the chaos, whereby the atoms might be thrust and crowded to the middle of those whirlpools, and there constipate one another into great solid globes, such as now appear in the world.

Or, secondly, by mutual gravitation or attraction. For they may assert, that matter hath inherently and essentially such an internal energy, whereby it incessantly tends to unite itself to all other matter; so that several particles, placed in a void space, at any distance whatsoever, would without any external impulse spontaneously convene and unite together. And thus, Q the atoms of the chaos, though never so widely diffused, might by this innate property of attraction soon assemble themselves into great spherical masses, and constitute systems like the present heaven and earth.

This is all that can be proposed by Atheists, as an efficient cause of the world. For as to the Epicurean theory, of atoms descending down an infinite space by an inherent principle of gravitation, which tends not toward other matter, but toward a vacuum or nothing; and verging from the perpendicular, * no body knows why, nor when, nor where; it is such miserable absurd stuff, so repugnant to itself, and so contrary to the known phenomena of nature, though it contented supine unthinking Atheists for a thousand years together, that we will not now honour it with a special refutation. But what it hath common with the other explications, we will fully confute together with them in these three propositions.

(l.) That by common motion (without attraction) the dissevered particles of the chaos could never make the world; could never convene into such great compact masses, as the planets now are; nor either acquire or continue such motions as the planets now have.

{2.) That such a mutual gravitation ot spontaneous attraction can neither be inherent and essential to matter; nor ever supervene to it, unless impressed and infused into it by a divine power.

(3.) That though we should allow such attraction to be natural and essential to all matter; yet the atoms of a chaoi could never so convene by it, as to form the present system: or, if they could form it, it could neither acquire such motions, n'6f continue permanent in this state without the power and providence? 6f a divine being.

(1.) And first, that by common motion the1 matter of chaos could never convene into such masses as the planets now are. Any man, that considers the spacious void intervals of tire chaos, how immense they are in proportion to the built of the atoms, wist hardly induce himself to believe, that particles so widely disseminated could ever throng and crowd one another into-a close and compact texture. He will rather conclude, that those few that should happen to them, might' rebound after the collision; or, if they adhered, yet by the next conflict with other atoms might be separated again; and so on in an eternal vicissitude of fast and loose, without ever consociating into the huge condense bodies of planets; some of whose particles upon- this supposition must have travelled many millions of leagues through the gloomy regions of chaos, to place themselves where they now are. But then how rarely would there be any clashing at all; how very rarely in comparison to the number of atoms! The whole multitude of them, generally speaking, might freely move and rove for ever with very little occurring or interfering. Let us conceive two of the nearest particles according to our former calculation; or rather let us try the same proportions in another example, that will come easier to the imagination. Let us suppose two ships, fitted with durable timber and rigging, but without pilot or mariners, to be placed in the vast Atlantic or the Pacific Ocean, as far asunder as may be; how many thousand years might expire, before those solitary vessels should happen to strike one against the other!

But let us imagine the space yet more ample, even the whole face of the earth to be covered with sea, and the two ships to be placed in the opposite poles; might not they now move long enough without any danger of clashing? And yet I find, that the two nearest atoms in our evenly diffused chaos have ten thousand times less proportion to the two void circular planes around them, than our two ships would have to the whole surface of the deluge. Let us assume then another deluge ten thousand times larger than Noah's; is it not now utterly incredible, that our two vessels, placed there antipodes to each other, should ever happen to concur? And yet let me add; that the ships would move in one and the same surface; and consequently must needs encounter, when they either advance towards one another in direct lines, or meet in the intersection of cross ones; but the atoms may not only fly side-ways, but over likewise and under each other: which makes it many million times more improbable that they should interfere than the ships, even in the last and unlikeliest instance. But they may say, though the odds indeed be unspeakable that the atoms do not convene in any set number of trials, yet in an infinite succession of them may not such a combination possibly happen? But let them consider, b that the improbability of casual hits is never diminished by repetition of trials; they are as unlikely to fall out at the thousandth as at the first. So that in a matter of mere chance, when there is so many millions odds against any assignable experiment, it is in vain to expect it should ever succeed, even in endless duration.

But though we should concede it to be simply possible, that the matter of chaos might convene into great masses, like planets; yet it is absolutely impossible that those masses should acquire such revolutions about the sun. Let us suppose any one of those masses to be the present earth. Now the annual revolution of the earth must proceed (in this hypothesis) either from the sum and result of the several motions of all the particles that formed the earth, or from a new impulse from some external matter, after it was formed. The former is apparently absurd, because the particles that formed the round earth must needs convene from all points and quarters towards the middle, and would generally tend toward its centre; which would make the whole compound to rest in a poise: or at least that overplus of motion, which the particles of one hemisphere could have above the other, would be very small and inconsiderable; too feeble and languid to propel so vast and ponderous a body with that prodigious velocity. And secondly, it is impossible that any external matter should impel that compound mass, after it was formed. It is manifest, that nothing else could impel it, unless the ethereal matter be supposed to be carried about the sun like a vortex or whirlpool, as a vehicle to convey it and the rest of the planets. But this is refuted from what we have shewn above, that those spaces, of the ether may be reckoned a mere void, the whole quantity of their matter scarce amounting to the weight of a grain. It is refuted also from matter of fact in the motion of comets; which, as often as they are visible to us, are in the region of our planets, and there are observed to move, some in quite contrary courses to theirs, and some, in cross and oblique ones, in planes inclined to the plane of the ecliptic in all kinds of angles: which firmly evinces, that ^ the regions of the ether are empty and free, and neither assist nor resist the revolutions of planets. But moreover there could not possibly arise in the chaos any vortices or whirlpools at all; either to form the globes of the planets, or to revolve them when formed. It is acknowledged by all, that inanimate unactive matter moves always in a straight line, nor ever reflects in an angle, nor bends in a circle, (which is a continual reflection,) unless either by some external impulse that may divert it from the direct motion, or by an intrinsic principle of gravity or attraction that may make it describe a curve line about the attracting body. But this latter cause is not now supposed; and the former could never beget whirlpools in a chaos of so great a laxity and thinness. For it is matter of certain experience, and universally allowed, that all bodies moved circularly have a perpetual endeavour to recede from the centre, and every moment -would fly out in right lines, if they were not violently restrained and kept in by contiguous matter. But there is no such restraint in the supposed chaos, no want of empty room there; no possibility of effecting one single revolution in way of a vortex, which necessarily requires (if attraction be not supposed) either an absolute fulness of matter, or a pretty close constipation and mutual contact of its particles.

And for the same reason it is evident, that the planets could not continue their revolutions about the sun, though they could possibly acquire them. For, to drive and carry the planets in such orbs as they now describe, that ethereal matter must be compact and dense, as dense as the very planets themselves; otherwise they would certainly fly out in spiral lines to the very circumference of the vortex. But we have often inculcated, that the wide tracts of the ether may be reputed as a mere extended void. So that there is nothing (in this hypothesis) that can retain and bind the planets in their orbs for one single moment; but they would immediately desert them and the neighbourhood of the sun, and vanish away in tangents to their several circles into the abyss of mundane space.

(2.) Secondly, We affirm, that mutual gravitation, or spontaneous attraction, cannot pos sibly be innate and essential to matter. By attraction we do not here understand what is properly, though vulgarly, called so in the operations of drawing, sucking, pumping, &c. which is really pulsion and trusion; and belongs to that common motion, which we have already shewn to be insufficient for the formation of a world. But we now mean (as we have explained it before) such a power and quality, whereby all parcels of matter would mutually attract or mutually tend and press to all others; so that, for instance, two distant atoms in vacuo would spontaneously convene together without the impulse of external bodies.

Now, first, we say, if our Atheists suppose this power to be inherent and essential to matter, they overthrow their own hypothesis; there could never be a chaos at all upon these terms; but the present form of our system must have continued from all eternity, against their own supposition, and what we .have proved in our last. d For, if they affirm that there might be a chaos notwithstanding innate gravity, then let them assign any period though never so remote, when the diffused matter might convene. They must confess, that before that assigned period matter had existed, eternally, inseparably endued with this principle of attraction; and yet had never attracted nor convened before, in that infinite duration: which is so monstrous an absurdity, as even they will blush to be charged with. But some perhaps may imagine, that a have its original; as that former had from another, and so on; new systems having grown out of old ones in infinite vicissitudes from all past eternity. But we say, that in the supposition of innate gravity no system at all could be dissolved: for how is it possible, that the matter of solid masses like earth, and planets, and stars, should fly up from their centres against its inherent principle of mutual attraction, and diffuse itself in a chaos? This is absurder than the other: that only supposed innate gravity not to be exerted; this makes it to be defeated, and to act contrary to its own nature. So that upon all accounts this essential power of gravitation or attraction is irreconcileable with the Atheist's own doctrine of a chaos.

And, secondly, it is repugnant to common sense and reason. It is utterly inconceivable, that inanimate brute matter, without the mediation of some immaterial being, should operate upon and affect other matter without mutual contact; that distant bodies should act upon each other through a vacuum, without the intervention of something else, by and through which the action may be conveyed from one to the other. We will not obscure and perplex with multitude of words what is so clear and evident by its own light, and must needs be allowed by all that have competent use of thinking, and are initiated into, I do not say the mysteries, but the plainest principles of philosophy. Now mutual gravitation or attraction, in our present acception of the words, is the same thing with this; it is an operation, or virtue, or influence of distant bodies upon each other through an empty interval, without any effluvia, or exhalations, or other corporeal medium to convey and transmit it. This power therefore cannot be innate and essential to matter. And, if it be not essential, it is consequently most manifest, since it doth not depend upon motion or rest, or figure or position of parts, which are all the ways that matter can diversify itself, that it could never supervene to it, unless impressed and infused into it by an immaterial and divine power.

We have proved, that a power of mutual gravitation, without contact or impulse, can in nowise be attributed to mere matter; or, if it could, we shall presently shew, that it would be wholly unable to form the world out of a chaos. What then if it be made appear, that there is really such a power of gravity, which cannot be ascribed to mere matter, perpetually acting in the constitution of the present system? This would be a new and invincible argument for the being of God; being a direct and positive proof, that an immaterial living mind doth inform and actuate the dead matter, and support the frame of the world. I will lay before you some certain phenomena of nature, and leave it to your consideration from what principle they can proceed. It is demonstrated, that the sun, moon, and all the planets do reciprocally gravitate one toward another: that the gravitating power of each of them is exactly proportional to their matter, and arises from the several gravitations or attractions of all the. individual particles that compose the whole mass: that all matter near the surface of the earth (and so in all the planets) doth not only gravitate downwards, but upwards also, and sideways, and toward all imaginable points; though the tendency downward be predominant and alone discernible, because of the greatness and nearness of the attracting body, the earth: that every particle of the whole system doth attract and is attracted by all the rest, all operating upon all: that this universal attraction or gravitation is an incessant, regular, and uniform action by certain and established laws according to quantity of matter and longitude of distance: that it cannot be destroyed, nor impaired, nor augmented by any thing, neither by motion or rest, nor situation nor posture, nor alteration of form, nor diversity of medium: that it is not a magnetical power, nor the effect of a vortical motion; those common attempts towards the explication of gravity: e these things, I say, are fully demonstrated as matters of fact, by that very ingenious author, whom we cited before. Now how is it possible that these things should be effected by any material and mechanical agent? We have evinced, that mere matter cannot operate upon matter without mutual contact. It remains then, that these phenomena are produced either by the intervention of air or ether or other such medium, that communicates the impulse from one body to another; or by effluvia and spirits, that are emitted from the one, and pervene to the other. We can conceive no other way of performing them mechanically. But what impulse or agitation can be propagated through the ether, from one particle entombed and wedged in the very centre of the earth, to another in the centre of Saturn? Yet even those two particles do reciprocally affect each other with the same force and vigour, as they would do at the same distance in any other situation imaginable. And because the impulse from this particle is not directed to that only, but to all the rest in the universe; to all quarters and regions, at once invariably and incessantly: to do this mechanically, the same physical point of matter must move all manner of ways equally and constantly in the same iristant and moment; which is flatly impossible. But, if this particle cannot propagate such motion, much less can it send out effluvia to all points Without intermission or variation; such multitudes of effluvia as to lay hold on every atom in the universe without missing of one. Nay, every single particle of the very effluvia (since they also attract and gravitate) must in this supposition emit other secondary effluvia all the world over; and those others still emit more, and so in infinitum. Now, if these things be repugnant to human reason, we have great reason to affirm, that universal gravitation, a thing certainly existent in nature, is above all mechanism and material causes, and proceeds from a higher principle, a divine energy and impression.

(£.) Thirdly, we affirm, that, though we should allow that reciprocal attraction is essential to matter, yet the atoms of a chaos could never so convene by it, as to form the present,; system; system; or, if they could form it, yet it could neither acquire these revolutions, nor subsist in the present condition, without the conservation and providence of a divine Being.

1. For first, if the matter of the universe, and consequently the space through which it i» diffused, be supposed to be finite, (and I think it might be demonstrated to be so, but that we have already exceeded the just measures of a sermon,) then, since every single particle hath an innate gravitation toward all others, proportionated by matter and distance; it evidently appears, that the outward atoms of the chaos would necessarily tend inwards, and descend from all quarters toward

the middle of the whole space: for, in respect to every atom, there would lie through the middle the greatest quantity of matter and the most vigorous attraction; and those atoms would there form and constitute one huge spherical mass, which would be the only body in the universe. It is plain therefore, that upon this supposition the matter of the chaos could never compose such divided and different masses, as the stars and planets of the present world.

But, allowing our adversaries that the planets might be composed; yet however they could not possibly acquire such revolutions in circular 6rbs; or (which is all one to our present purpose) in ellipses very little eccentric.

For let them assign any place where the planets were formed. Was it nearer to the sun than the present distances are? But that is notoriously absurd; for then they must have ascended from the place of their formation, against the essential property of mutual attraction. Or, were each formed in the same orbs in which they now move? But then they must have moved from the point of rest, in an horizontal line, without any inclination or descent. Now there is no natural cause, neither innate gravity nor impulse of external matter, that could beget such a motion: for gravity alone must have carried them downwards to the vicinity of the sun. And, that the ambient ether is too liquid and empty to impel them horizontally with that prodigious celerity, we have sufficiently proved before. Or, were they made in some higher regions of the heavens, and from thence descended by their essential gravity, till they all arrived at their respective orbs; each with its present degree of velocity, acquired by the fall? But then why did they not continue their descent till they were contiguous to the sun, whither both mutual attraction and impetus carried them? What natural agent could turn them aside; could impel them so strongly with a transverse side-blow against that tremendous weight and rapidity, when whole planets were a falling? But if we should suppose, that by some cross attraction or other they might acquire an obliquity of descent, so as to miss the body of the sun, and to fall on one side of it? Then indeed the force of their fall would carry them quite beyond it; and so they might fetch a compass about it, and then return and ascend by the same steps and degrees of motion and velocity with which they descended before. Such an eccentric motion as this, much after the manner that comets revolve about the sun, they might possibly acquire by their innate principle of gravity; but circular revolutions, in concentric orbs about the sun or other central body, could in nowise be attained without the power of the divine arm. For the case of the planetary motion is this. Let us Conceive all the planets to be formed or constituted with their centres in their several orbs; and at once to be impressed on them this gravitating energy toward all other matter, and a transverse impulse of a just quantity in each, projecting them directly in tangents to those orbs. The compound motion, which arises from this gravitation and projection together, describes the present revolutions of the primary planets about the sun, and of the secondary about those; the gravity prohibiting, that they cannot recede from the centres of their motions; and the transverse impulse withholding, that they cannot approach to them. Now although gravity could be innate, (which we have proved that it cannot be,) yet certainly this projected, this transverse and violent motion can only be ascribed to the right hand of the most high God, creator of heaven and earth,

But, finally, if we should grant them, that these circular revolutions could be naturally attained; or, if they will, that this very individual world in its present posture and motion was actually formed out of chaos by mechanical causes; yet it requires a divine power and providence to have preserved it so long in the present state and condition. For what are the causes that preserve the system of our sun and his planets, so that the planets continue to move in the same orbs, neither receding from the sun, nor approaching nearer to him? We have shewn, that a transverse impulse, impressed upon the planets, retains them in their several orbs, that they are not drawn down toward the sun. And again, their gravitating powers so incline them towards the sun, that they are not carried upwards beyond their due distance from him. These two great agents, a transverse impulse, and gravity, are the secondary causes, under God, that maintain the system of sun and planets. Gravity

we understand to be a constant energy or faculty, perpetually acting by certain measures and naturally inviolable laws: we say, a faculty and power; for we cannot conceive that the act of gravitation of this present moment can propagate itself, or produce that of the next. But the transverse impulse we conceive to have been one single act. For, by reason of the inactivity of matter, and its inability to change its present state either of moving or resting, that transverse motion would from, one single impulse continue for ever equal and uniform, unless changed by the resistance of recurring bodies, or by a gravitating power. So that the planets, since they move horizontally (whereby gravity doth not alter their swiftness) and through the liquid and unresisting spaces of the heavens, (where either no bodies at all or inconsiderable ones do occur,) may preserve the same velocity which the first impulse impressed upon them, not only for five or six thousand years, but many millions of millions. It appears then, that if there was but one vast sun in the universe, and all the rest were planets revolving around him in concentric orbs at convenient distances, such a system as that would very long endure, could it but naturally have a principle of mutual attraction, and be once actually put into circular motions. But the frame of the present world hath a quite different structure: here is an innumerable multitude of fixed stars or suns; all which being made up of the same common matter, mutt be supposed to be equally endued with a power of gravitation. For, if all have not such a power, what is it that could make that difference between bodies of the same sort*? Nothing surely but a Deity could have so arbitrarily endued our sun and planets with a power of gravity not essential to matter; while all the fixed stars, that are so many suns, have nothing of that power. If the fixed stars then are supposed to have no power of gravitation, it is a plain proof of a divine Being. And it is as plain a proof of a divine Being, if they have the power of gravitation. For since they are neither revolved about a common centre, nor have any transverse impulse, what is there else to restrain them from approaching toward each other, as their gravitating power incites them? What natural cause can overcome nature itself? What is it that holds and keeps them in fixed stations and intervals against an incessant and inherent tendency to desert them? Nothing could hinder but that the outward stars, with their systems of planets, must necessarily have descended toward the middlemost system of the universe, whither all would be the most strongly attracted from all parts of a finite space. It is evident therefore, that the present frame of sun and fixed stars could not possibly subsist without the providence of that al the now fixed stars could not be fixed, but would naturally convene together, and confound system with system; because, all mutually attracting, every one would move whither it was most powerfully drawn. This, they may say, is indubitable in the case of a finite world, where some systems must needs be outmost, and therefore be drawn toward the middle: but, when infinite systems succeed one another through an infinite space, and none is either inward or outward; may not all the systems be situated in an accurate poise; and, because equally attracted on all sides, remain fixed and unmoved? But to this we reply; that unless the very mathematical centre of gravity of every system be placed and fixed in the very mathematical centre of the attractive power of all the rest, they cannot be evenly attracted on all sides, but must preponderate some way or other. Now he, that considers what a mathematical centre is, and that quantity is infinitely divisible, will never be persuaded that such an universal equilibrium, arising from the coincidence of infinite centres, can naturally be acquired or maintained. If they say, that, upon the supposition of infinite matter, every system would be infinitely, and therefore equally attracted on all sides; and consequently would rest in an exact equilibrium, be the centre of its gravity in what mighty Deity, who spake the word and they were made; who commanded and they were created; who hath made them fast for ever and ever, and hath given them a law, which stall not be broken.

2. And, secondly, in the supposition of an hisnite chaos, it is hard indeed to determine what would follow in this imaginary case from an innate principle of gravity. But, to hasten to a conclusion, we will grant for the present, that the diffused matter might convene into an infinite number of great masses at great distances from one another, like the stars and planets of this visible part of the world. But then it is impossible, that the planets should naturally attain these circular revolutions,

either by principle of gravitation, or by impulse of ambient bodies. It is plain, here is no difference as to this; whether the world be infinite, or finite: so that the same arguments, that we have used before, may be equally urged in this supposition. And though we should concede, that these revolutions might be acquired, and that all were settled and constituted in the present state and posture of things; yet, we say, the continuance of this frame and order, for so long a duration as the known ages of the world, must necessarily infer the existence of God. For, though the universe was infinite position soever: this will overthrow their very hypothesis. For at this rate in an infinite chaos nothing at all could be formed; no particles could convene by mutual attraction; because every one there must have infinite matter around it, and therefore must rest for ever, being evenly balanced between infinite attractions. Even the planets upon this principle must gravitate no more toward the sun, than any other way; so that they would not revolve in curve lines, but fly away in direct tangents, till they struck against other planets or stars in some remote regions of the infinite space. An equal attraction on all sides of all matter is just equal to no attraction at all: and, by this means, all the motion in the universe must proceed from external impulse alone; which we have proved before to be an incompetent cause for the formation of a world.

And now, O thou almighty and eternal Creator, g having considered the heavens, the work of thy fingers, the moon and the stars which thou hast ordained, with all the company of heaven we laud and magnify thy glorious name; evermore praising thee and saying, Holy, holy, holy, Lord God of hosts, heaven and earth are full of thy glory. Glory be to thee, O Lord most high. A

PART III.

That ye should turn from these vanities unto the living God, who made heaven and earth, and the sea, and all things that are therein: who in times past suffered all nations to walk in their own ways. Nevertheless, he left not himself without witness, in that he did good, and gave us rain from heaven, and fruitful seasons, filling our hearts with food and gladness.

Having abundantly proved in our last exercise, that the frame of the present world could neither be made nor preserved without the power of God, we shall now consider the structure and motions of our own system, if any characters of divine wisdom and goodness may be discoverable by us. And even at the ' first and general view it very evidently appears to us (which is our fourth and last Proposition) that the order and beauty of the systematical parts of the world, the discernible ends and final causes of them, the meliority above what was necessary to be, do evince by a reflex argument, that it could not be produced by mechanism or chance, but by an intelligent and benign agent, that by his excellent wisdom made the heavens.

But, before we engage in this disquisition, we must offer one necessary caution; that we need not nor do not confine and determine the purposes of God in creating all mundane bodies, merely to human ends and uses. Not that we believe it laborious and painful to Omnipotence to create a world out of nothing; or more laborious to create a great world, than a small one: so as we might think it disagreeable to the majesty and tranquillity of the divine nature to take so much pains for our sakes. Nor do we count it any absurdity, that such a vast and immense universe should be made for the sole use of such mean and unworthy creatures as the children of men. For, if we consider the dignity of an intelligent being, and put that in the scales against brute inanimate matter, we may affirm, without overvaluing human nature, that the soul of one virtuous and religious man is of greater worth and excellency than the sun and his planets, and all the stars in the world. If therefore it could appear, that all the mundane bodies are someway conducible to the service of man; if all were as beneficial to us, as the polar stars were formerly for navigation; as the moon is for the flowing and ebbing of tides, by which an inestimable advantage accrues to the world; for her officious courtesy in long winter nights, especially to the more northern nations, who, in a continual night it may be of a whole month, are so pretty well accommodated by the light of the moon reflected from frozen snow, that they do not much envy their antipodes a month's presence

of the sun: if all the heavenly bodies were thus serviceable to us, we should not be backward to assign their usefulness to mankind, as the sole end of their creation. But we dare not undertake to shew, what advantage is brought to us by those innumerable stars in the galaxy and other parts of the firmament, not discernible by naked eyes, and yet each many thousand times bigger than the whole body of the earth. If you say they beget in us a great idea and veneration .of the mighty author and governor of such stupendous bodies, and excite and elevate our minds to, his adoration and. praise; you say very truly and well: But would it not raise in us a higher apprehension of the infinite majesty and boundless beneficence of God, to suppose that those remote and vast bodies were formed, not merely upon our account, to be peeped at through an optic glass, but for different ends and nobler purposes? And yet who will deny, but that there are great multitudes of lucid stars even beyond the reach of the best telescopes; and that every visible star may have opake planets revolve about them, which we cannot discover? Now, if they were not created for our sakes, it is certain and evident, that they were not made for their own. For matter hath no life nor perception, is not conscious of its own existence, nor capable of happiness, nor gives the sacrifice of praise and worship to the author of its being. It remains therefore, that all bodies were formed for the sake of intelligent minds: and as the earth was principally designed for the being and service and contemplation of men, why may not all other planets be created for the like uses, each for their own inhabitants which have life and understanding? If any man will indulge himself in this speculation, he need not quarrel with revealed religion upon such an account. The holy Scriptures do not forbid him to suppose as great a multitude of systems, and as much inhabited, as he pleases. It is true, there is no mention in Moses's narrative of the creation, of any people in other planets: but it plainly appears, that the sacred historian doth only treat of the origins of terrestrial animals: he hath given us no account of God's creating the angels; and yet the same author, in the ensuing parts of the Pentateuch, makes not unfrequent mention of the angels of God. Neither need we be solicitous about the condition of those planetary people, nor raise frivolous disputes, how far they may participate in the miseries of Adam's fall, or in the benefits of Christ's incarnation. As if, because they are supposed to be rational, they must needs be concluded to be men f For what is man? not a reasonable animal merely, for that is not an adequate and distinguishing definition; but a rational mind of such particular faculties, united to an organical body of such a certain structure and form, in such peculiar laws of connection between the operations and affections of the mind and the motions of the body. Now, God Almighty, by the inexhausted fecundity of his creative power, may have made innumerable orders and classes of rational minds; some in their natural perfections higher than human souls, others inferior. But a mind of superior or meaner capacities than human would constitute a different species, though united to a human body in the same laws of connection; and a mind of human capacities would make another species, if united to a different body in different laws of connection. For this sympathetical union of a rational soul with matter, so as to produce a vital communication between them, is an arbitrary institution of the divine wisdom: there is no reason nor foundation in the separate natures of either substance, why any motion in the body mould produce any sensation at all in the soul; or why this motion should produce that particular sensation, rather than any other. God therefore may have joined immaterial souls, even of the same class and capacities in their separate state, to other kind of bodies, and in other laws of union; and from those different laws of union there will arise quite different affections, and natures, and species of the compound beings. So that we ought not upon any account to conclude, that if there be rational inhabitants in the Moon, or Mars, or any unknown planets of other systems, they must therefore have human nature, or be involved in the circumstances of our world. And thus much was necessary to be here inculcated, (which will obviate and preclude the most considerable objections >of our adversaries,) that we do not determine the final causes and usefulness of the systematical parts of the world, merely as they have respect to the exigencies or conveniences of human life.

Let us now turn our thoughts and imaginations to the frame of our system, if there we may trace any visible footsteps of divine wisdom and beneficence. But we are all liable to many mistakes by

the prejudices of childhood and youth, which few of us ever correct by a serious scrutiny in our riper years, and a contemplation of the phœnomena of nature in their causes and beginnings. What; we have always seen to be done in one constant and uniform manner, we are apt to imagine there was but that one way of doing it, and it could not be otherwise. This is a great error and impediment in a disquisition of this nature; to remedy which, we ought to consider every thing as not yet in being, and then diligently examine if it must needs have been at all, or what other ways it might have been as possibly as the present; and if we find a greater good and utility in the present constitution, than would have accrued either from the total privation of it, or from other frames and structures that might as possibly have been as it; we may then reasonably conclude, that the present constitution proceeded, neither from the necessity of material causes, nor the blind shuffles of an imaginary chance, but from an intelligent and good Being, that formed it that particular way out of choice and design. And especially, if this usefulness be conspicuous not in one or a few instances only, but in a long train and series of things, this will give us a firm and infallible assurance, that we have not passed a wrong judgment.

I. Let us proceed therefore by this excellent rule in the contemplation of our system; It is evident that all the planets receive heat and light from the body of the sun. Our own earth in particular would be barren and desolate, a dead dark lump of clay, without the benign influence of the solar rays; which, without question, is true of all the other planets. It is good therefore, that there should be a sun, to warm and cherish the seeds of plants, and excite them to vegetation; to impart an uninterrupted light to all parts of this system for the subsistence of animals. But how came the sun to be luminous? not from the necessity of natural causes, or the constitution of the heavens. All the planets might have moved about him in the fame orbs, and the same degrees of velocity, as now; and yet the sun might have been an opake and cold body like them. For, as the six primary planets revolve about him, so the secondary ones are moved about them; the Moon about the earth, the satellites about Jupiter, and others about Saturn; the one as regularly as the other, in the same sesqui-lateral proportion of the times of their periodical revolutions to the semi-diameters of their orbs. So that, though we suppose the present existence and conservation of the system, yet the Sun might have been a body without light or heat, of the same kind with the earth, and Jupiter, and Saturn. But then what horrid darkness and desolation must have reigned in the world! It had been unfit for the divine purposes in creating vegetable, and sensitive, and rational creatures. It was therefore the contrivance and choice of a wife and good Being, that the central Sun mould be a lucid body, to communicate warmth, and light, and life to the planets around him.

II. We have shewed in our last, that the concentric revolutions of the planets about the Sun proceed from a compound motion; a gravitation towards the Sun, which is a constant energy infused into matter by the Author of all things, and a projected transverse impulse in tangents to their several orbs, that was impressed at first by the divine arm, and will carrv them around till the end of the world. But now, admitting that gravity may be essential to matter, and that a transverse impulse might be acquired too by natural causes; yet, to make all the planets move about the Sun in circular orbs, there must be given to each a determinate impulse; these present particular degrees of velocity which they now have, in proportion to their distances from the Sun and to the quantity of the solar matter. For had the velocities of the several planets been greater or less than they are now, at the same distances from the Sun; or had their a distances from the Sun, or the quantity of the Sun's matter, and consequently his attractive power, been greater or less than they are now, with the same velocities; they would not have revolved in concentric circles as they do, but have moved in hyperbolas, or in ellipses very eccentric. The same may be said of the velocities of the secondary planets with respect to their distances from the centres of their orbs, and to the quantities of the matter of those central bodies. Now that all these distances, and motions, and quantities of matter should be so accurately and harmoniously adjusted in this great variety of our system, is above the fortuitous hits of blind material causes, and must certainly flow from that eternal fountain of wisdom, the Creator of heaven and earth, who always acts geometrically, by

just and adequate numbers, and weights, and measures. And let us examine it further by our critical rule: Are the present revolutions in circular orbs more beneficial than the other would be? If the planets had moved in those lines above-named, sometimes they would have approached to the Sun as near as the orb of Mercury, and sometimes have exorbitated beyond the distance of Saturn; and some have quite left the Sun without ever returning. Now the very constitution of a planet would be corrupted and destroyed by such a change of the interval between it and the Sun; no living thing could have endured such unspeakable excesses of heat and cold; all the animals of our earth must inevitably have perished, or rather never have been. So that as sure as it is k good, very good, that human nature should exist; so certain it is that the circular revolutions of the earth, (and planets,) rather than those other motions, which might as possibly have been, do declare not only the power of God, but his wisdom and goodness.

III. It is manifest, by our last discourse, that the ethereal spaces are perfectly fluid; they neither assist nor retard, neither guide nor divert the revolutions of the planets, which roll through those regions as free and unresisted as if they moved in a vacuum: so that any of them might as possibly have moved in opposite courses to the present, and in planes crossing the plane of the ecliptic in any kind of angles. Now, if the system had been fortuitously formed by the convening matter of a chaos, how is it conceivable that all the planets, both primary and secondary, should revolve the same way, from the west to the east, and that in the same plane too, without any considerable variation? No natural and necessary cause could so determine their motions; and it is millions of millions of millions odds to an unit in such a cast of a chance. Such an apt and regular harmony, such an admirable order and beauty must deservedly be ascribed to divine art and conduct: especially if we consider, that the smallest planets are situated nearest the Sun and each other; whereas Jupiter and Saturn, that are vastly greater than the rest, and have many satellites about them, are wisely removed to the extreme regions of the system, and placed a£ an immense distance one from the other. For even now at this wide interval they are observed in their conjunctions to disturb one another's motions a little by their gravitating powers: but if such vast masses of matter had been situated much nearer to the Sun, or to each other, (as they might as easily have been, for any mechanical or fortuitous agent,) they must necessarily have caused a considerable disturbance and disorder in the whole system.

IV. But let us consider the particular situation of our earth, and its distance from the sun. It is now placed so conveniently, that plants thrive and flourish in it, and animals live; this is matter of fact, and beyond all dispute. But how came it to pass at the beginning; that the earth moved in its present orb? We have shewn before, that if gravity and a projected motion be fitly proportioned, any planet would freely revolve at any assignable distance within the space of the whole system. Was it mere chance then, or divine counsel and choice, that constituted the earth in its present situation? To know this; we will enquire if this particular distance from the Sun be better for our earth and its creatures, than a greater or less would have been. We may be mathematically certain, that the heat of the Sun is according to the density of the sun-beams, and is reciprocally proportional to the square of the distance from the body of the Sun. 1 Now by this calculation, suppose the earth should be removed and placed nearer to the Sun, and revolve for instance in the orbit of Mercury; there the whole ocean would even boil with extremity of heat, and be all exhaled into vapours; all plants and animals would be scorched and consumed in that fiery furnace. But suppose the earth should be carried to the great distance of Saturn; there the whole globe would be one frigid zone; the deepest seas under the very equator would be frozen to the bottom; there would be no life, no germination, nor any thing that comes now under our knowledge or senses. It was much better therefore, that the earth should move where it does, than in a much greater or less interval from the body of the Sun. And if you place it at any other distance, either less or more than Saturn or Mercury, you will still alter it for the worse proportionally to the change. It was situated therefore where it is by the wisdom of some voluntary agent, and not by the blind motions of fortune or fate. If any one should think with himself, how then can any animal at all live in

Mercury and Saturn in such intense degrees of heat and cold? let him only consider, that the matter of each planet may have a different density, and texture, and form, which will dispose and qualify it to be acted on by greater or less degrees of heat according to their several situations; and that the laws of vegetation, and life, and sustenance, and propagation, are the arbitrary pleasure of God, and may vary in all planets according to the divine appointment and the exigencies of things, in manners incomprehensible to our imaginations. It is enough for our purpose to discern the tokens of wisdom in the placing of our earth; if its present constitution would be spoiled and destroyed, if we could not wear flesh and blood, if we could not have human nature at those different distances.

V. We have all learnt from the doctrine of the sphere, that the earth revolves with a double motion. For, while it is carried around the sun in the orbis magnus once a year, it perpetually wheels about its own axis once in a day and a night; so that in twenty-four hours space it hath turned all the parts of the equinoctial to the rays of the sun. Now the uses of this vertiginous motion are very conspicuous; for this is it that gives day and night successively over the face of the whole earth, and makes it habitable all around. Without this diurnal rotation one hemisphere would lie dead and torpid in perpetual darkness and frost, and the best part of the other would be burnt up and depopulated by so permanent a heat. It is better therefore, that the earth should often move about its own centre, and make these useful vicissitudes of night and day, than expose always the same side to the action of the sun. But how came it to be so moved? Not from any necessity of the laws of motion, or the system of the heavens: it might annually have compassed the sun, and yet have always turned the lame hemisphere towards it. This is matter of fact and experiment in the motion of the moon; which is carried about the earth in the very same manner as the earth about the sun, and yet always shews the same face to us. She indeed, notwithstanding this, turns all her globe to the sun by moving in her menstrual orb, and enjoys night and day alternately, one day of hers being equal to about fourteen days and nights of ours. But, should the earth move in the same manner about the sun as the moon does about the earth, one half of it could never see the day, but must eternally be condemned to solitude and darkness. That the earth therefore frequently revolves about its own centre, is another eminent token of the divine wisdom and goodness.

VI. But let us compare the mutual proportion of these diurnal and annual revolutions; for they are distinct from one another, and have a different degree of velocity. The earth rolls once about its axis in a natural day: in which time all the parts of the equator tor move something more than three of the earth's diameters; which makes about 1100 in the space of a year. But within the same space of a-year the centre of the earth is carried above fifty times as far once round the orbis magnus, whose wideness we now assume to be 20000 terrestrial diameters. So that the annual motion is more than fifty times swifter than the diurnal rotation, though we measure the latter from the equator, where the celerity is the greatest. But it must needs be acknowledged, since the earth revolves not upon a material and rugged, but a geometrical plane, that the proportions of the diurnal and annual motions may be varied in innumerable degrees; any of which might have happened as probably as the present. What was it then that prescribed this particular celerity to each motion; this proportion and temperament between them both? Let us examine it by our former rule, if there be any meliority in the present constitution; if any considerable change would be for the worse. We will suppose then, that the annual motion is accelerated doubly; so that a periodical revolution would be performed in six months. Such a change would be pernicious; not only because the earth could not move in a circular orb, which we have considered before; but because, the seasons being then twice as short as they are now, the cold winter would overtake us before our corn and fruits could possibly be ripe. But shall this motion be as much retarded, and the seasons lengthened in the fame proportion? This too would be as fatal as the other; for in most countries the earth would be so parched and effete by the drought of the summer, that it would afford still but one harvest, as it doth at the present; which then would not be a sufficient store for the consumption of a year, that would be twice as long as now. But let us suppose, that the diurnal

rotation be either considerably swifter or slower. And first, let it be retarded; so as to make (for example) but twelve circuits in a year: then every day and night would be as long as thirty are now, not so fitly proportioned neither to the common affairs of life, nor to the exigencies of sleep and sustenance in a constitution of flesh and blood. But, let it then be accelerated, and wheel a thousand times about its centre, while the centre describes one circle about the sun: then an equinoctial day would consist but of four hours, which would be an inconvenient change to the inhabitants of the earth; such hasty nights as those would give very unwelcome interruptions to our labours and journeys and other transactions of the world. It is better therefore, that the diurnal and annual motions should be so proportioned as they are. Let it therefore be ascribed to the transcendent wisdom and benignity of that God, who hath made all things very good, and loveth all things that he hath made.

VII. But let us consider, not the quantity and proportion only, but the mode also of this diurnal motion. You must conceive an imaginary plane, which, passing through the centres of the sun and the earth, extends itself on all sides as far as the firmament: this plane is called the ecliptic; and, in this, the centre of the earth is perpetually carried without any deviation. But then the axis of the earth, about which its diurnal rotation is made, is not erect to this plane of the ecliptic, but inclines toward it from the perpendiculum, in an angle of twenty-three degrees and a half. Now, why is the axis of the earth in this particular posture, rather than any other? Did it happen by chance, or proceed from design? To determine this question, let us see, as we have done before, if this be more beneficial to us than any other constitution. We all know, from the very elements of astronomy, that this inclined position of the axis, which keeps always the same direction and a constant parallelism to itself, is the sole cause of these grateful and needful vicissitudes of the four seasons of the year, and the variation in length of days. If we take away the inclination, it would absolutely undo these northern nations; the sun would never come nearer us than he doth now on the tenth of March or twelfth of September. But would we rather part with the parallelism? Let us suppose then, that the axis of the earth keeps always the same inclination toward the body of the sun: this indeed would cause a variety of days, and nights, and seasons on the earth; but then every particular country would have always the same diversity of day and night, and the same constitution of season without any alteration: some would always have long nights and short days, others again perpetually long days and short nights; one .climate would be scorched and sweltered with everlasting dogdays, while an eternal December blasted another: this surely is not quite so good as the present order of seasons. But, shall the axis rather observe no constant inclination to any thing, but vary and waver at uncertain times and places? This would be a happy constitution indeed. There could be no health, no life, nor subsistence in such an irregular system; by those surprising nods of the pole we might be tossed backward or forward in a moment from January to June; nay, possibly, from the January of Greenland to the June of Abyssinia. It is better therefore, upon all accounts, that the axis mould be continued in its present posture and direction: so that this also is a signal character of divine wisdom and goodness.

But, because several have imagined, that this true posture of the axis is a most unfortunate and pernicious thing; that, if the poles had been erect to the plane of the ecliptic, all mankind would have enjoyed a very paradise upon earth, a perpetual spring, an eternal calm and serenity, and the longevity of Methuselah without pains or diseases; we are obliged to consider it a little further. And first, as to the universal and perpetual spring, it is a mere poetical fancy, and (bating the equality of days and nights, which is a thing of small value) as to the other properties of a spring, it is naturally impossible, being repugnant to the very form of the globe: for, to those people that dwell under 'or near the equator, this spring would be a most pestilent and insupportable summer; and as for those countries that are nearer the poles, in which number are our own and the most considerable nations of the world, a perpetual spring will not do their business; they must have longer days, a nearer approach of the sun, and a less obliquity Of his rays; they must have a summer and a harvest time too, to ripen their grain, and fruits, and vines, or else they must bid an

eternal adieu to the very best of their sustenance. It is plain, that the centre of the earth must move all along in the orbis magnus; whether we suppose a perpetual equinox, or an oblique position of the axis. So that the whole globe would continue in the same distance from the sun, and receive the same quantity of heat from him in a year or any assignable time, in either hypothesis. Though the axis then had been perpendicular, yet take the whole year about, and the earth would have had the same measure of heat that it has now. So that here lies the question, whether is more beneficial, that the inhabitants of the earth should have the yearly quantity of heat distributed equally every day, or so disposed as it is; a greater share of it in summer, and in winter a less? It must needs be allowed, that the temperate zones have no heat to spare in summer; it is very well if it be sufficient for the maturation of fruits. Now, this being granted, it is as certain and manifest, that an even distribution of the yearly heat would never have brought those fruits to maturity, as this is a known and familiar experiment, that such a quantity of fewel all kindled at once will cause water to boil, which being lighted gradually and successively will never be able to do it. It is clear therefore, that in the constitution of a perpetual equinox the best part of the globe would be desolate and useless; and, as to that little that could be inhabited, there is no reason to expect, that it would constantly enjoy that admired calm mid serenity. If the assertion were true, yet some perhaps may think, that such a felicity, as would make navigation impossible, is. not much to be envied. But it is altogether precarious, and has no necessary foundation neither upon reason nor experience. For the winds and rains and other affections of the atmosphere do not solely depend (as that assertion supposeth) upon the course of the sun; but partly, and perhaps most frequently, upon steams and exhalations from subterraneous heat; upon the positions of the moon, the situations of seas, or mountains, or lakes, or woods, and many other unknown or uncertain causes. So that, though the course of the sun should be invariable, and never swerve from the equator; yet the temperament of the air would be mutable nevertheless, according to the absence or presence, or various mixture of the other causes. The ancient philosophers, for many ages together, unanimously taught, that the torrid zone was not habitable.. The reasons that they went upon were very specious and probable, till the experience of these latter ages evinced them to be erroneous. They argued from celestial causes only, the constant vicinity of the sun, and the directness of his rays; never suspecting, that the body of the earth had so great an efficiency in the changes of the air; and that then could be the coldest and rainiest season, the winter of the year, when the sun was the nearest of all, and steered directly over men's heads. Which is. warning sufficient to deter any man from expecting such eternal serenity and halcyon days from an incompetent and partial a cause, as the constant course of the sun in the equinoctial circle. What general condition and temperament of air would follow upon that supposition we cannot possibly define; for it is not caused by certain and regular motions, nor subject to mathematical calculations. But, if we may make a conjecture from the present constitution, we shall hardly wish for a perpetual equinox to save the charges of weather-glasses: for, it is very well known, that the months of March and September, the two equinoxes of our year, are the most windy and tempestuous, the most unsettled and unequable of seasons in most countries of the world. Now, if this notion of an uniform calm and serenity be false or precarious, then even the last supposed advantage, the constant health and longevity of men, must be given up also, as a groundless conceit: for this (according to the assertors themselves) doth solely, as an effect of nature, depend upon the other. Nay, further, though we should allow them their perpetual calm and equability of heat, they will never be able to prove, that therefore men would be so vivacious as they would have us believe. Nay, perhaps the contrary may be inferred, if we may argue from present experience: for the inhabitants of the torrid zone, who suffer the least and shortest recesses of the sun, and are within one step and degree of a perpetual equinox, are not only shorter lived (generally speaking) than other nations nearer the poles; but inferior to them in strength, and stature, and courage, and in all the capacities of the mind. It appears therefore, that the gradual vicissitudes of heat and cold are so far from shortening the thread of man's life, or impairing his intellectual faculties, that very probably they both prolong the one in some measure, and exalt and advance the other. So that still we do profess to adore the divine wisdom and goodness for this variety of seasons, for n seed-time

and harvest, and cold and heat, and summer and winter. VIII. Come we now to consider the atmosphere, and the exterior frame and face of the globe, if we may find any tracks and footsteps of wisdom in the constitution of them. I need not now inform you, that the air is a thin fluid body, endued with elasticity or springiness, and capable of condensation and rarefaction; 0 and, should it be much more expanded or condensed than it naturally is, no animals could live and breathe: it is probable also that the vapours could not be duly raised and supported in it; which at once would deprive the earth of all its ornament and glory, of all its living inhabitants and vegetables too. But it is certainly known and demonstrated, that the condensation and expansion of any portion of the air is always proportional to the weight and pressure incumbent upon it: so that if the atmosphere had been either much greater or less than it is, as it might easily have been, it would have had in its lowest region on the surface of the earth a much greater density or tenuity of texture, and consequently have been unserviceable for vegetation and life. It must needs therefore be an intelligent Being that could so justly adapt it to those excellent purposes. It is concluded by astronomers, that the atmosphere of the moon hath no clouds nor rains, but a perpetual and uniform serenity; because nothing discoverable in the lunar surface is ever covered and absconded from us by the interposition of any clouds or mists, but such as rise from our own globe. Now, if the atmosphere of our earth had been of such a constitution, there could nothing, that now grows or breathes in it, have been formed or preserved; human nature must have been quite obliterated out of the works of creation. If our air had not been a springy elastical body, no animal could have exercised the very function of respiration; and yet the ends and uses of respiration are not served by that springiness, but by some other unknown and singular quality. Tor the air, that in exhausted receivers of air-pumps is exhaled from minerals, and flesh, and fruits, and liquors, is as true and genuine as to elasticity and density, or rarefaction, as that we respire in; and yet this factitious air is so far from being fit to be breathed in, that it kills animals in a moment, even sooner than the very absence of all air, than a vacuum itself. All which do infer the most admirable providence of the Author of nature, who foreknew the necessity of rains and dews to the present structure of plants,

IX. In the next place let us consider the ample provision of waters, those inexhausted treasures of the ocean: q and, though some have grudged the great share that it takes of the surface of the earth, yet we shall propose this too as a conspicuous mark and character of the wisdom of God. For that we may not now say, that the vast Atlantic ocean is really greater riches, and of more worth to the world, than if it was changed into a fifth continent; and that the dry land is as yet much too big for its inhabitants; and that, before they shall want room by increasing and multiplying, there may be new heavens and a new earth: we dare venture to affirm, that these copious stores of waters are no more than necessary for the present constitution of our globe. For, is not the whole substance of all vegetables mere modified water? and consequently of all animals too; all which either feed upon vegetables, or prey upon one another. Is not an immense quantity of it continually exhaled by the sun, to fill the atmosphere with vapours and clouds, and feed the plants of the earth with the balm of dews, and the fatness of showers? It seems incredible at first hearing, that all the blood in our bodies should circulate in a trice, in a very few minutes; but, I believe it would be more surprising, if we knew the short and swift periods of the great circulation of water, that vital blood of the earth, which composeth and nourisheth all things. If we could but compute that prodigious mass of it that is daily thrown into the channel of the sea from all the rivers of the world; we should then know and admire how much is perpetually evaporated and cast again upon the continents to supply those innumerable streams. And indeed hence we may discover, not only the use and necessity, but the cause too of the vastness of the ocean. I never yet heard of any nation that complained they had too broad, or too deep, or too many rivers; or wished they were either smaller or fewer; they understand better than so, how to value and esteem those inestimable gifts of nature. Now, supposing that the multitude and largeness of rivers ought to continue as great as now, we can easily prove that the extent of the ocean could be no less than it is. For it is evident and necessary, (if we follow the most fair and probable hypothesis, that the

origin of fountains is from vapours and rain,) that the receptacle, ©f waters, into which the mouths of all those rivers must empty themselves, ought to have so spacious a surface, that as much water may he continually brushed off by the winds and exhaled by the sun, as (besides what falls again in showers upon its own surface) is brought into it by all the rivers. Now the surface of the ocean is just so wide, and no wider: for, if more was evaporated than returns into it again, the sea would become less; if less was evaporated, it would grow bigger. So that, because since the memory of all ages it hath continued at a stand without considerable variation; and if it hath gained ground upon one country, hath lost as much in another; it must consequently be exactly proportioned to the present constitution of rivers. How rash therefore and vain are those busy projectors in speculation, that imagine they could recover to the world many new and noble countries, in the most happy and temperate climates, without any damage to the old ones, could this same mass of the ocean be lodged and circumscribed in a much deeper channel, and within narrower shores! For, by how much they would diminish the present extent of the sea, so much they would impair the fertility, and fountains, and rivers of the earth; because the quantity of vapours, that must be exhaled to supply all these, would be lessened proportionally to the bounds of the ocean; for the vapours are not to be measured from the bulk of the water, but from the space of the surface. So that this also doth infer the superlative wisdom and goodness of God, that he hath treasured up the waters in so deep and spacious a storehouse, r the place that he hath founded and appointed for them.

X. S But some men are out of love with the features and mien of our earth; they do not like this rugged and irregular surface, these precipices and valleys, and the gaping channel of the ocean. This with them is deformity, and rather carries the face of a ruin, or a rude and indigested lump of atoms that casually convened so, than a work of divine artifice. They would have the vast body of a planet to be as elegant and round as a factitious globe represents it; to be every where smooth and equable, and as plain as the Elysian fields. Let us examine what weighty reasons they have to disparage the present constitution of nature in so injurious a manner. Why, if we suppose the ocean to be dry, and that we look down upon the empty channel from some higher region of the air, how horrid, and ghastly, and unnatural would it look! Now, admitting this supposition, let us suppose too that the soil of this dry channel were covered with grass and trees in manner of the continent, and then see what would follow. If a man could be carried asleep and placed in the very middle of this dry ocean, it must be allowed that he could not distinguish it from the inhabited earth. For if the bottom should be unequal, with shelves, and rocks, and precipices, and gulfs; these, being now apparaled with a vesture of plants, would only resemble the mountains and valleys that he was accustomed to before. But very probably he would wake in a large and smooth plain: for though the bottom of the sea were gradually inclined and sloping from the shore to the middle, yet the additional acclivity, above what a level would seem to have, would be imperceptible in so short a prospect as he could take of it: so that, to make this man sensible what a deep cavity he was placed in, he must be carried so high in the air till he could see at one view the whole breadth of the channel, and so compare the depression of the middle with the elevation of the banks. But then a very small skill in mathematics is enough to instruct us, that, before he could arrive to that distance from the earth, all the inequality .of surface would be lost to his view: the wide ocean would appear to him like an even and uniform plane, (uniform as to its level, though not as to light and shade,) though every rock of the sea was as high as the Pico of Teneriss. But, though we should grant that the dry gulf of the ocean would appear vastly hollow and horrible from the top of a high cloud, yet what a way of reasoning is this from the freaks of imagination, and impossible suppositions? Is the sea ever likely to be evaporated by the sun, or to be emptied with buckets? Why then must we fancy this impossible dryness; and then upon that fictitious account calumniate nature, as deformed and ruinous, and unworthy of a divine Author? Is there then any physical deformity in the fabric of a human body, because our imagination can strip it of its muscles and stein, and shew us the scragged and knotty backbone, the gaping and ghastly jaws, and all the skeleton underneath? We have shewed before, that the sea could not be much narrower than it is, without a great loss to the world: and must we now have an ocean of mere flats and shallows, to

the utter ruin of navigation, for fear our heads should turn giddy at the imagination of gaping abysses and unfathomable gulfs? But however, they may say, the sea-shores at least might have been even and uniform, not crooked and broken as they are into innumerable angles, and creeks, and inlets, and bays, without beauty or order, which carry the marks more of chance and confusion, than of the production of a wise Creator. And would not this be a fine bargain indeed? to part with all our commodious ports and harbours, which the greater the inlet is are so much the better, for the imaginary pleasure of an open and straight shore without any retreat or shelter from the winds; which would make the sea of no use at all as to navigation and commerce. But what apology can we make for the horrid deformity of rocks and crags, of naked and broken cliffs, of long ridges of barren mountains, in the convenientest latitudes for habitation and fertility, could but those rude heaps of rubbish and ruins be removed out of the way? We have one general and - sufficient answer for all seeming defects or disorders in the constitution of land or sea; that we do not contend to have the earth pass for a paradise, or to make a very heaven of our globe; we reckon it only as the land of our peregrination, and aspire after la better, and a celestial country. It is enough, if it be so framed and constituted, that by a careful contemplation of it we have great reason to acknowledge and adore the divine wisdom and benignity of its Author. But, to wave this general reply, let the objectors consider, that these supposed irregularities must necessarily come to pass from the established laws of " mechanism and the ordinary course of nature. For, supposing the existence of sea and mountains, if the banks of that sea must never be jagged and torn by the impetuous assaults or the silent underminings of waves; if violent rains and tempests must not warn down the earth and gravel from the tops of some of those mountains, and expose their naked ribs to the face of the sun; if the seeds of subterraneous minerals must not ferment, and sometimes cause earthquakes and furious eruptions of volcanos, and tumble down broken rocks, and lay them in confusion; then either all things must have been overruled miraculously by the immediate interposition of God, without any mechanical affections or settled laws of nature, or else the body of the earth must have been as fixed as gold, or as hard as adamant, and wholly unfit for human habitation. u So that if it was good in the sight of God, that the present plants and animals, and human souls united to flesh and blood, should be upon this earth under a settled constitution of nature; these supposed inconveniences, as they were foreseen and permitted by the Author of that nature, as necessary consequences of such a constitution, so they cannot infer the least imperfection in his wisdom and goodness: and to murmur at them is as unreasonable as to complain that he hath made us men and not angels; that he hath placed us upon this planet, and not upon some other, in this or another system, which may be thought better than ours. Let them also consider, that this objected deformity is in our imaginations only, and not really in things themselves. There is no universal reason (I mean such as is not confined to human fancy, but will reach through the whole intellectual universe) that a figure by us called regular, which hath equal sides and angles, is absolutely more beautiful than any irregular one. AH pulchritude is relative; and all bodies are truly and physically beautiful under all possible shapes and proportions, that are good in their kind, that are fit for their proper uses and ends of their natures. We ought not then to believe, that the banks of the ocean are really deformed, because they have not the form of a regular bulwark; nor that the . mountains are out of shape, because they are not exact pyramids or cones; nor that the stars are unskilfully placed, because they are not all situated at uniform distance. These are not natural irregularities, but with respect; to our fancies only; nor are they incommodious to the true uses of life and the designs of man's being on the earth. And let them further consider, that these ranges of barren mountains, by condensing the vapours, and producing rains, and fountains, and rivers, give the very plains and valleys themselves that fertility they boast of; that those hills and mountains supply us and the stock of nature with a great variety of excellent plants. If there were no inequalities in the surface of the earth, nor in the seasons of the year, we mould lose a considerable share of the vegetable kingdom: for all plants will not grow in an uniform level and the same temper of soil, nor with the same degree of heat. Nay, let them lastly consider, that to those hills and mountains we are obliged for all our metals, and with them for all the conveniences and comforts of life. To deprive us of metals is to make us mere savages;

to change our corn or rice for the old Arcadian diet, our houses and cities for dens and caves, and our clothing for skins of beasts; it is to bereave us of all arts and sciences* of history and letters; nay, 'of revealed religion too, that inestimable favour of heaven: for, without the benefit of letters, the whole Gospel would be a mere tradition and old cabbala, without certainty, without authority. Who would part with these solid and substantial blessings for the little fantastical pleasantness of a smooth uniform convexity and rotundity of a globe? And yet the misfortune of it is, that the pleasant view of their imaginary globe, as well as the deformed spectacle of our true one, is founded upon impossible suppositions. For that equal convexity could never be seen and enjoyed by any man living. The inhabitants of such an earth could have only the short prospect of a little circular plane about three miles around them; though neither woods, nor hedges, nor artificial banks should intercept it: which little too would appear to have an acclivity on all sides from the spectators; so that every man would have the displeasure of fancying himself the lowest, and that he always dwelt and moved in a bottom. Nay, considering that in such a constitution of the earth they could have no means nor instruments of mathematical knowledge, there is great reason to believe, that the period of the final dissolution might overtake them, ere they would have known or had any suspicion that they walked upon a round ball. Must we therefore, to make this convexity of the earth discernible to the eye, suppose a man to be lifted up a great height in the air, that he may have a very spacious horizon under one view? But then again, because of the distance, the convexity and gibbousness would vanish away; he would only see below him a great circular flat, as level, to his thinking, as the face of the moon. Are there then such ravishing charms in a dull unvaried flat, to make a sufficient compensation for the chief things of the ancient mountains, and for the precious things of the lasting hills P Nay, we appeal to the sentence of mankind, if a land of hills and valleys has not more pleasure too and beauty than an uniform flat? which flat, if ever it may be said to be very delightful, is then only, when it is viewed from the top of a hill. y What were the Tempe of Thessaly, so celebrated in ancient story for their unparalleled pleasantness, but a vale divided with a river and terminated with hills? Are not all the descriptions of poets embellished with such ideas, when they would represent any places of superlative delight, any blissful seats of the muses or the nymphs, any sacred habitations of gods or goddesses? They will never admit that a wide flat can be pleasant, no not in the very Elysian fields; but these too must be diversified with depressed valleys and swelling ascents. They cannot imagine a even paradise to be a place of pleasure, nor heaven itself to be heaven without them. Let this therefore be another argument of the divine wisdom and goodness, that the surface of the earth is not uniformly convex, (as many think it would naturally have been, if mechanically formed by a chaos,) but distinguished with mountains and valleys, and furrowed from pole to pole with the deep channel of the sea; and that it is better that it should be so.

Flow'rs worthy of paradise, which not nice, art
In beds and curious knots, but nature boon
Pour'd forth profuse on hill, and dale, and plain.
Paradise Lost, book It.

For earth hath this variety from heaven
Of pleasure situate in hill and dale.
Paradise Lost, book vi.

Give me leave to make one short inference from what has been said, which shall finish this present discourse, and with it our task for the year. We have clearly discovered many final causes and characters of wisdom and contrivance in the frame of the inanimate the world; as well as in the organical fabric of the bodies of animals. Now, from hence ariseth a new and invincible argument, that the present frame of the world hath not existed from all eternity. For such an usefulness of things, or a fitness of means to ends, as neither proceeds from the necessity of their beings, nor can happen to them by chance, doth necessarily infer that there was an intelligent Being, which

was the author and contriver of that usefulness. 0 We have formerly demonstrated, that the body of a man, which consists of an incomprehensible variety of parts, all admirably fitted for their peculiar functions and the conservation of the whole, could no more be formed fortuitously than the Æneis of Virgil, or any other long poem with good sense and just measures, could be composed by the casual combinations of letters. Now, to pursue this comparison; as it is utterly impossible to be believed, that such a poem may have been eternal, transcribed from copy to copy without any first author and original; so it is equally incredible and impossible, that the fabric of human bodies, which hath such excellent and divine artifice, and, if I may so say, such good sense and true syntax and harmonious measures in its constitution, should be propagated and transcribed from father to son without a first parent and creator of it. An eternal usefulness of things, an eternal good sense, cannot possibly be conceived without an eternal wisdom and understanding. But that can be no other than that eternal and omnipotent God; d that by wisdom hath founded the earth, and by understanding hath established the heavens: to whom be all honour, and glory, and praise, and adoration, from henceforth and for evermore. Amen.

1744

Pierre Louis Maupertius (1698 – 1759)

Assessment of the Proofs of God's Existence that are Based on the Marvels of Nature (Not a friend of Natural Theologians; Rejects Teleology and discounts effectiveness of Argument from Design)

Whether we stay locked up in our own thoughts, or venture out to survey the marvels of the universe, we find so many arguments for the existence of an all-powerful and all-wise Being, that we don't need to increase their number; rather, we should distill them down to a few solid proofs. We should at least examine the strengths and weaknesses of each argument, to give each one its proper weight; for one can do no greater damage to Truth than to base it on false reasoning.

I will not consider here arguments based on an infinite Being, arguments that seem to prove that an infinitely perfect Being must exist; for that idea is so sublime that, from our finite vantage point, we cannot find a reliable foundation upon which to build reasoned arguments.

I also will not consider the argument that the unanimity of all human beings that God exists is itself a proof of God's existence, a proof that seemed strong to that Philosopher of ancient Rome (Cicero, Tuscul., I. 13). Aside from the question of whether all human beings do indeed believe in God's existence, this argument would be refuted by only a handful of people who thought differently from all other inhabitants of the Earth. Even those who believe in Him have widely different conceptions of God, which prevents us from exploiting the general agreement about God's existence as an argument.

Finally, I will not consider the argument for God's existence from the intelligence that we have within, from the sparks of wisdom and power observed in finite beings, sparks that presumably originate from a source immense and eternal.

All these arguments seem strong to me, but they are not the type I wish to consider here.

Of those who have applied themselves to studying the Universe, several have found traces of the wisdom and power of Him who governs it. The more the field of physics has progressed, the more arguments we find for His existence. However, some have been confused by the character of the Divinity revealed in Nature, while others, almost religiously zealous, have given too much weight to some arguments, considering them proofs when they were not.

Perhaps the rigor of logic may be sometimes relaxed to reach a useful but uncertain conclusion, when it lacks sufficient confirmation. However, the arguments for God's existence are sufficiently strong and sufficiently many that we can assess them rigorously to determine which arguments are the most certain.

I will not pause to consider the arguments for a supreme Being that the ancients derived from the beauty, order and arrangement of the universe, such as those related by Cicero (Tuscul. I. 28, 29) and Aristotle (De Nat. Deor. II. 37, 38). They knew too little of Nature to be in a position to admire it. Rather, I consider the arguments of a philosopher who made such grand discoveries that he could well judge the truly marvellous in Nature, and whose reasoning was more precise than that of the others.

Newton was moved most of all by arguments derived from the study of the universe, although his deep-thinking mind derived other arguments as well.

This great man believed (Opticks III. Book. Query 31) that the motion of celestial bodies demonstrated the existence of Him that governs them. Six planets — Mercury, Venus, Earth, Mars, Jupiter and Saturn — revolve about the Sun. All the planets rotate in the same direction in orbits that are more-or-less concentric. (Nevertheless, there are other bodies, the comets, that follow totally different orbits, moving in all directions and in every region of Heaven.) Newton believed that such uniformity of motion could only result from the will of a Supreme Being.

Newton also found strong arguments in less exalted objects. For him, the obvious similarity in the construction of animals, their organization and suitability for their purpose, were convincing arguments for the existence of an all-powerful and all-wise Creator (Theol Astron. de Derham, Theol. Phys. du meme, Theol. des Insectes de Lesser).

A host of physicists following Newton have found arguments for God in astronomical bodies, in insects, in plants and even in water (Theol. de l'Eau de Fabricius).

Let us not disguise the weakness of these arguments; indeed, to better understand the abuse which some have made of proofs of God's existence, let us critique even arguments as strong as those of Newton.

Newton states that the uniform motion of the planets reveals an Intelligent Designer, that it is not possible that a soulless universe could make them rotate in the same direction and in concentric orbits.

Newton could also have added that all of these planets move in the same plane. All of their orbits are contained within a solid angle that is the 17th part of a sphere. Taking the plane of the Earth's orbit as a reference, the random probability that five other orbits would fall within the same solid angle is $\left(\frac{1}{17} \right)^{5}$, i.e., 1419856 to 1 against.

Thus, thinking as Newton did (i.e., that all celestial bodies are attracted to the sun and move through empty space), it is extremely improbable that the six planets would move as they do. However, the probability is not zero and, hence, the uniformity of planetary motion is not a necessary proof of an Intelligent Designer.

There is another consideration. The two alternatives, Intelligent Design versus pure chance, are based on our inability to find a physical cause for the uniformity of planetary motion within Newton's system. However, other philosophers have hypothesized a fluid that transports the planets or at least regulates their motion; if true, that might explain the uniformity of planetary motion

(rather than an Intelligent Designer or pure chance) and would be no more proof of God's existence than any other motion imposed on matter.

I don't know whether Newton's argument based on the construction of animals is much better. A proof based on the similarity of many animals would seem to be refuted by the infinite variety observed in others. Without comparing their most basic parts, how shall we assess the similarity of an eagle with a fly, a stag with a slug, a whale with an oyster? Other philosophers have argued for God's existence from the variety of forms and I don't know which argument has a better basis.

The argument based on the suitability of the different animal parts for their needs seems more solid. Feet seem to be made for walking, wings for flying, eyes for seeing, mouths for eating and other parts for reproducing their kin. All these things seem to feature intelligent design in their construction. This argument carried as much weight with the ancients as it did with Newton. In vain, the greatest opponent of Providence (Lucretius, Book IV) argued that the usage of these organs was not by design but a consequence of their construction, that the eyes, ears, tongue, etc. formed by chance and that animals merely exploited them to see, to hear, to speak, etc.

But perhaps it is not miraculous that suitable organs are found in species that actually exist, since they help those animals to survive. One might argue that Chance has produced a countless number of individual animals, of which a few were constructed so that they could meet their own needs; the vast number of other individual animals perished since their parts were not suitable for survival. Animals without mouths cannot live; those lacking organs of generation cannot reproduce themselves. The few animals that have survived are those with well-ordered parts suited to survival; thus, the animals that we see today are but the smallest part of those produced by a soulless universe.

Almost all of the modern authors that consider physics and natural history merely extend the old arguments of the organization of animals and plants, pushing them into ever finer details of Nature. To avoid the vulgar, gory details, I mention only one author who argues for God from the folds in the skin of the rhinoceros. The skin of that animal is so thick and hard that, without such folds, it would be unable to move. Doesn't it demean the great truth of God's existence, if it must be proven by such arguments? And what shall we say to the author who argues against Providence from the fact that the tortoise's shell has neither joints nor folds? The reasoning seems the same as the rhinoceros-skin argument, with the same weight. Let us leave such trifling arguments to those who haven't learned to laugh at them yet.

Another type of philosopher goes to the other extreme. Finding all too few traces of intelligent design in Nature, he disregards all final causes and believes that world formed itself as it is from pure matter and its motion. The first type sees an Intelligent Designer everywhere; the other sees Him nowhere, believing rather that a soulless mechanics was able to form bodies as sophisticated as animals and plants and to bring about all the wonders of the universe (Descartes, Princip. L'Homme de Descartes).

It is interesting to note that Newton was not impressed by Descartes' great argument for God's existence derived from the idea of a perfect Being, nor by other metaphysical arguments that we have mentioned; yet Newton's own arguments for God's existence from the uniformity and suitability of different parts of the universe would not have seemed like proofs to Descartes.

It has to be admitted that these "proofs" have been abused; some give the arguments more weight than they deserve, whereas others multiply them too much. The bodies of animals and plants are machines too sophisticated for our understanding; their smallest parts escape our notice and we are too ignorant of their usage and purpose that we can presume to judge how much wisdom and power

went into their construction. Some of these machines seem highly perfected, whereas others seem like coarse sketches. Many parts seem useless or even harmful based on our present knowledge, unless we assume in advance that they were sent into the world by an all-wise and all-powerful Being.

Finding traces of order and suitability in the construction of animals may lead us to unsettling conclusions. The snake, which neither walks nor flies, could not evade the pursuit of other animals if it had not been blessed with such flexibility that it slithers faster than many animals can walk. It would die of cold in winter, except that it's long and pointed form suits it to tunnel underground; it would be hurt by its continual slithering or passing into the hole where it hides, were it not for its smooth and scaly skin. Is not the snake something wonderful? Yet these wonders only help to preserve an animal that kills human beings. "Oh!" one replies, "you don't know the utility of snakes. They appear to be necessary in the universe; they must contain some excellent remedy of which we are presently unaware. Therefore, let us be silent or, at least, not be surprised by the beautiful mechanisms in animals that seem harmful."

The writings of naturalists are full of such reasonings. Follow the development of a fly or an ant, and you will find the wonders of Providence in the insect's eggs, in how it feeds its children, in how it seals itself in a chrysalis and re-emerges after metamorphosis. All these wonders serve to produce an insect that bothers human beings, an insect that will be eaten by a bird, or get caught in a spider's net.

Even though some people may find proofs of God's existence in these examples, others may be reinforced in their skepticism.

Even the greatest of spirits, respected for their piety as well as their enlightenment (P. Malebranche, Medit. Chret. & Metaph., Medit. VII), cannot deny that the suitability and order observed in the universe is not so perfect as to be a proof of an all-wise and all-powerful Being. Evils of every type, the disorder, the vices, the grief: these are hard to reconcile with a world governed by an all-wise and all-powerful Ruler.

One might argue, "Consider the Earth, covered mostly by water or by sharp rocks, icy regions and burning sands. Consider the habits of those who live there, how they lie, steal, and murder; vice is more common than virtue everywhere. Many of those miserable people are despairing, troubled by gout, stones and other diseases that make their life unbearable; almost everyone is vexed by sorrow and disappointments."

Several philosophers seem to have had this perspective and, forgetting all the beauties in the universe, sought to justify God for having created such imperfections. In particular, to shield God's wisdom from criticism, some philosophers seem to diminish His power, saying that God made the world as good as it could be made (Leibnitz, Theod. II. part. N. 224,225), i.e., that of all possible worlds, this one is the best, despite its faults. Other philosophers preserve His power at the expense of His wisdom, saying that God could have made a better world than this, but it would've required a more complicated mechanism and that He had the mechanism more in mind than the perfection of the work (Malebranche, Medit. Chret. & Metaph. VII). They give the example of a painter who thinks that a circle drawn by hand shows his skill more than one drawn with a compass, never considering that instruments can help in making figures more complex and regular.

These arguments are not satisfying, but neither can they be soundly refuted. Still, a true philosopher should neither be dazzled by the order and suitability of the parts of the universe, nor seek to grasp things that lie beyond Nature. Despite the disorder observed in Nature, one finds enough traces of the wisdom and power of its Author that one cannot fail to recognize Him.

I will not discuss another type of philosopher who refuses to recognize any evil in Nature: Everything that is, is good. (Pope, Essai sur l'homme).

This proposition is untenable unless we assume beforehand the existence of an all-powerful and all-wise Being. If we derive this proposition from that assumption, it is a simple act of faith. Although it seems to honor the supreme Intelligence, it also seems like just submission to necessity. It is more a consolation for our sorrows, than praise for our happiness.

Let me return to the arguments based on the study of Nature.

Those who have reviewed such arguments have not examined their strength nor scope. Many things in the universe suggest that it is governed by a blind power. On all sides, we see consequences of effects leading to some destination; but this does not prove intelligent design. We must rather seek signs of God's wisdom in the goals of His designs; wonderful skill in execution cannot compensate for a senseless undertaking. Skill applied senselessly is not admirable; one would blame the builder all the more if he used skill to construct a machine that was useless or even dangerous.

How does it help to wonder at the regularity of the planets, how they rotate in the same direction, in almost the same plane, and in orbits that are almost geometrically similar, if we cannot see why it is better that they move thus and not otherwise? All those poisonous plants and deadly animals are produced and preserved so carefully by Nature -- how can we recognize from them the wisdom and kindness of Him who created them? If we found only such things in Nature, it might well be the work of demons.

Truly our perspective is limited to where we are; we cannot see far enough to appreciate the order and interconnectedness of things. If we could, we would undoubtedly find the marks of God's wisdom as well as His intelligence in its execution. But, given our limitations, let us not confuse the two attributes. For although an infinite intelligence necessarily brings with it wisdom, a finite intelligence may yet lack wisdom; and there is as much evidence showing that the universe is a soulless machine, as showing it to be the work of an Intelligent Designer.

[edit] II. Need to Identify Proofs of God's Existence in the General Laws of Nature; In particular, the Laws Governing Motion's Conservation, Distribution and Destruction are Based on the Attributes of a Supreme Intelligence

We should not seek the supreme Being in little details, in the parts of the universe of whose relationships we know too little; rather, we should seek Him in universal phenomena that allow no exception and whose simplicity is entirely exposed to our view.

Admittedly, such research is more difficult than studying an insect, a flower, or similar things that Nature offers to our eyes every moment. But we can be aided in our difficult march by a guide, one who is sure-footed although he has not yet gone where we would like to go.

Until now, the goals of mathematics have rarely gone beyond coarse needs of the body and useless speculations of the spirit. The truths that it has uncovered are mostly those relating to dimensions and numbers. One should not be deceived by philosophical works that pretend to be mathematical, but are merely dubious and murky metaphysics. Just because a philosopher can recite the words lemma, theorem and corollary doesn't mean that his work has the certainty of mathematics. That

certainty does not derive from big words, or even from the method used by geometers, but rather from the utter simplicity of the objects considered by mathematics.

Let us see whether we can find a better use for mathematics. Mathematical arguments for God's existence would have the obvious certainty characteristic of geometrical truths. Those who doubt metaphysical reasoning would believe a mathematical argument more readily, whereas those exposed to the usual arguments would find mathematical arguments more elevating and precise.

Therefore, let us not stop at simple speculation about the marvels of Nature. The organization of animals, the precise and many parts of insects, the enormous sizes and distances and revolutions of astronomical bodies, such arguments are better suited to amaze our mind than to clarify it. The supreme Being is everywhere; but He is not equally visible everywhere. Let us seek Him in the simplest things, in the most fundamental laws of Nature, in the universal rules by which movement is conserved, distributed or destroyed; and let us not seek Him in phenomena that are merely complex consequences of these laws.

I could have started from mathematical laws that are confirmed by experience, and tried to show how they reflect the wisdom and power of the supreme Being. But those laws can be uncertain since they are often not based on rigorous proofs or purely geometrical hypotheses. Therefore, I considered it more certain and useful to deduce mathematical laws from the attributes of an all-powerful and all-wise Being. If those derived laws are actually found in the universe, then the proof that this Being exists (and created those laws) is more certain.

But, one might object, what if the laws of motion and equilibrium are a necessary consequence of the nature of matter, and contain no arbitrariness? Wouldn't it be wrong to ascribe to Providence something that is absolutely necessary?

If it is true that the laws of motion and equilibrium are indeed absolutely necessary consequences of the nature of matter, that proves all the more the perfection of the supreme Being. Everything is so arranged that the blind logic of mathematics executes the will of the most enlightened and free Mind.

Certain philosophers of antiquity held that movement does not exist. An overly subtle use of their minds denied the evidence of their own senses. The difficulties they had in conceiving how a body could move, made them deny that bodies moved or even could move. Without delving into the arguments upon which they tried to base their opinion, we note that one cannot deny motion except by arguments that deny the reality of objects outside ourselves, arguments that reduce the universe to us, and all phenomena to our perceptions.

It is true that we know motion only through our senses; but how many things do we know otherwise? The motive force (i.e., the ability of a moving body to move other bodies) is just terminology filling in for understanding and has no meaning beyond the results of phenomena. It is only mental habit that prevents us from realizing how miraculous it is that motion can be passed from one body to another. Once our eyes have opened, nothing is so striking. For those who have never thought about it, it doesn't seem mysterious; by contrast, those who have meditated on it may despair of ever understanding it.

Imagine someone who had never touched a body and had never seen them collide, but who had some experience with mixing colors, and let this person see a blue body moving towards a yellow body. If asked about what would happen when the two bodies collided, he might say that the blue body would turn green when it hit the yellow body. But would he guess that the two bodies would join together and move at a common speed? or that one body would transfer part of its motion to

the other so that it moves in the same direction at a different speed? or that it would be reflected in the opposite direction? I don't think it would be possible to guess these things.

We have experienced the impenetrability of a material body, we have proven to ourselves that a certain force is required to change its motion, we have seen that the collision of two bodies causes them to stop or be reflected or displace a resting body or, more generally, change their speed. Yet how do such changes occur? What is this power that bodies seem to have to act on one another?

We observe that some particles of matter are in motion, while others are at rest. Hence, motion is not an essential property of matter; rather, it is a state in which matter may find itself — or not. We see only that material bodies can extract motion from each other.

The material particles moving in Nature received their motion from an external cause that is unknown hitherto. The particles are themselves indifferent to motion or rest; if at rest, they stay so, whereas moving bodies continue to move until something changes their motion. When a moving particle of matter encounters another particle at rest, it passes on some or all of its motion. Every collision of two bodies (whether one is at rest and the other moves, or both are moving) is accompanied by a change in motion. The impact causes this change; it would be absurd to say that a particle moves another particle, given that it can't even move itself.

To identify the original cause of motion, the greatest philosopher of antiquity resorted to a Prime Mover, itself unmovable and indivisible. A modern philosopher has not only recognized God as the author of all motion of material particles, but also argued that God's direct intervention is continually necessary for every change and redistribution of motion. Not being able to understand how bodies can move other bodies, he denied that they did and concluded that when bodies hit or press on other bodies, it is God who makes them move; their impact is nothing but a prompting for God to move them.

These philosophers assign the cause of motion to God because they don't know where else to put it; they resort to an immaterial Being, since they can't imagine that matter should have the power to produce, distribute and destroy motion. But it's important to realize that all the laws of motion and equilibrium should be based on a suitable principle, if we are to use them to prove God's existence, regardless of whether bodies can act directly on each other, or whether they use some other interaction as yet poorly understood.

The simplest law of Nature is that of equilibrium, which has been known for many centuries; but until now, it has seemed to have no connection to the laws of motion, which was much more difficult to discover.

Research into motion was not to the liking (or perhaps not within the scope) of the ancients, so that we may consider it as a completely new science. How could the ancients have discovered the laws of motion, given that some philosophers reduced all their speculations about motion to sophistic disputes, whereas others denied that motion existed at all?

More industrious and sensible philosophers judged only that it would be difficult to understand the principles of motion, and invented reasons to despair of ever knowing them, as an excuse to get out of doing experiments.

A true philosopher does not engage in vain disputes about the nature of motion; rather, he wishes to know the laws by which it is distributed, conserved or destroyed, knowing that such laws are the basis for all natural philosophy.

The great Descartes, boldest of the philosophers, sought such laws, but was mistaken. However, time brought the subject of mechanics to a kind of maturity and those laws, unknown for centuries, were developed suddenly in several places at once. Huygens, Wallis and Wren discovered them at the same time. Many mathematicians after them have confirmed these laws, although they arrived at these laws by different routes.

Nevertheless, although mathematicians agree today on the more complicated case, they do not agree on the simpler case. Everyone agrees about the distribution of motion in the collision of perfectly elastic bodies, but not in the collision of perfectly inelastic bodies; some even believe that the distribution of motion cannot be calculated in the latter case. This embarrassing failure has caused some to deny the existence and even the possibility of perfectly inelastic bodies, claiming that bodies believed to perfectly inelastic are actually elastic bodies whose hardness prevents us from seeing the deformation and recovery of its shape.

These people point to experiments on bodies commonly called "hard" and "undeformable" showing that these bodies are actually deformable and elastic. For example, when spheres made of ivory, or maple wood, or glass collide, they seem to have deformed during the collision, only to recover their shape immediately afterwards. This may be seen by painting one of the spheres with a color that comes off and stains the other sphere; the size of the stain after the collision shows that the spheres were flattened during the collision, although no trace of the deformation remains afterwards.

These people then add metaphysical arguments to these arguments. They require that every process in Nature take a certain time, and obey a law of continuity. They object that when a perfectly inelastic body collides with an impassable barrier, its speed must go to zero instantly, without passing through any intermediate values; or its speed instantly is transformed into its opposite, without passing through zero.

But I confess, I don't feel the force of this argument. I don't think we know enough of the means by which motion can be produced or destroyed to say whether it must follow the law of continuity. If you assume that speed must change by degrees, doesn't it change discontinuously between degrees? Even imperceptible discontinuous changes would violate the law of continuity as much as the sudden destruction of the universe.

The experiments suggest that it is easy to confuse hardness with elasticity, but they do not show that all hard bodies are elastic. On the contrary, those who have considered the impenetrability of bodies suggest that perfect inelasticity is a necessary consequence of matter. Most bodies are deformable because they are made up of particles that can move relative to each other when stress is applied; however, the fundamental particles, the elements that make up all other bodies, these must be bodies that are perfectly inelastic, undeformable and unchangeable.

The more one considers elasticity, the more it seems to require that the elastic body have parts that can move relative to one another under stress.

Hence, it seems more reasonable to assert that the fundamental particles of matter are perfectly hard, rather than to pretend that perfectly hard bodies do not exist in Nature. Nevertheless, I do not know whether our present knowledge allows us to make either assertion definitely. However, one of the main reasons for denying that perfectly hard bodies exist was that we were unable to derive the laws of motion transfer for hard bodies.

Descartes agreed that perfectly hard bodies exist, and believed to have discovered the laws of their motion. It started from a principle that seems reasonable, namely, that total momentum is

conserved in Nature. Unfortunately, he derived false laws, because his initial principle, the conservation of total momentum, is not true.

The philosophers who followed Descartes noted another conservation law: that of kinetic energy, which is one-half times the mass times the speed squared. These philosophers did not derive their laws of motion from this conservation law, but rather the reverse; they derived the conservation law from their laws of motion. However, since kinetic energy is conserved only for perfectly elastic bodies, that reinforced them in their belief that only elastic bodies exist in Nature.

Momentum is conserved only in special cases, and kinetic energy is conserved only for certain types of bodies. Neither one represents a universal principle, a general law of motion.

If one studies these principles and the reasoning their authors used, it is surprising that they ever were able to derive them; one suspects that they worked backwards from experience, rather than deducing them from basic principles. Those who argue most rigorously recognize that the principle used to derive the collision laws for elastic bodies would not be applicable to perfectly inelastic bodies. Moreover, the laws of mechanical equilibrium are independent of the conservation laws used to derive laws for collisions of elastic and inelastic bodies.

After so many great men have worked on this subject, I almost do not dare to say that I have discovered the universal principle upon which all these laws are based, a principle that covers both elastic and inelastic collisions and describes the motion and equilibrium of all material bodies.

This is the principle of least action, a principle so wise and so worthy of the supreme Being, and intrinsic to all natural phenomena; one observes it at work not only in every change, but also in every constancy that Nature exhibits. In the collision of bodies, motion is distributed such that the quantity of action is as small as possible, given that the collision occurs. At equilibrium, the bodies are arranged such that, if they were to undergo a small movement, the quantity of action would be smallest.

The laws of motion and equilibrium derived from this principle are exactly those observed in Nature. We may admire the applications of this principle in all phenomena: the movement of animals, the growth of plants, the revolutions of the planets, all is consequences of this principle. The spectacle of the universe seems all the more grand and beautiful and worthy of its Author, when one considers that it is all derived from a small number of laws laid down most wisely. Only thus can we gain a fitting idea of the power and wisdom of the supreme Being, not from some small part of creation for which we know neither the construction, usage nor its relationship to other parts. What satisfaction for the human spirit in contemplating these laws of motion and equilibrium for all bodies in the universe, and in finding within them proof of the existence of Him who governs the universe!

1754
Hermann Samuel Reimarus, professor at Hamburg
Teleogical Proof
Principal Truths of Natural Religion, Essay 5

But what shall we say of the chamois and mountain goat? No cliff too high or too steep for them to ascend, and thence to make the most astonishing leaps to some other point hanging in the abyss. Who has given them that exact estimation of the distance, so that they neither overleap nor fall short of the mark? Who has taught them to break the fall with their horns when they make a long leap downwards? Who has instructed them that it was within their power to whirl over backwards in

mid-air in such an unnatural fashion, and still preserve the equilibrium of their bodies? Who has made them so courageous and daring that they shrink at no abyss, fear no fall, but, like the elements, trust themselves to their untried skill?

Is there not a marvellous diversity of wise contrivances which all minister to one grand purpose, — the propagation and perpetuation of the species of animals? In what school of life have animals acquired so many artful expedients and devices? Or how is it that each one has chosen that which was most suitable and brought it to perfection? Do not say Nature has taught them: that expression has no meaning. ... I should become tedious if I touched upon all the modes of propagation of the various orders, — with what art and circumspection birds construct nests beforehand for their eggs and young; with what foresight insects deposit their eggs, sometimes in a lump when the young are gregarious, sometimes, on the contrary, scattering them one by one, gluing them fast here, shoving them in yonder, wherever their offspring will find its natural element and proper nutriment, although the mother may not be at all accustomed to that element or nutriment, and gives herself not the slightest concern alxsut her eggs after they are laid; how fishes seek the fresh and shallow waters when they spawn, and deposit the roe among the reeds at the water's edge, or in a shallow nest at the bottom; bow some aquatic animals and birds lay their eggs in the bare sand, to be hatched by the sun, while others keep them warm and hatch them in nests, and then most tenderly cherish their young, feeding them from their own crops, or bringing food to them; how among bees, wasps, and ants neither father nor mother, but the sterile females, busy themselves with the nursing and feeding of the young; to make no mention of many other expedients and contrivances of animals which contribute to the preservation, defence, pleasure, and welfare of themselves or their species. A man must be very perverse if he will not see that these things are so contrived for a wise purpose, and that they have their origin in an infinite mind and will.

1775
John Wesley
A Compendium of Natural Philosophy
A Survey of the Wisdom of God in the Creation: A Compendium of Natural Philosophy in Two Volumes by John Wesley

"These are thy glorious works, Parent of good, Almighty! Thine this universal frame, Thus wond'rous fair! Thyself how wond'rous then."

Milton

Preface

But I cannot find such a treatise as this in any modern, any more than ancient language. And I am certain there is none such in the English tongue. What comes nearest to it, of any thing I have seen, is Mr. Ray's " Wisdom of God in the Creation ;" Dr. Derhani's "Physico and Astro-Theology ;" Niewentyt's "Religious Philosopher;" Mather's "Christian Philosopher," and "Nature Delineated." But none of these, single, answers the design. And who will be at the pains to extract the substance of them all, and add the later discoveries, of which they had little knowledge, and therefore could take but little notice This is a desideratum still; and one that a lover of mankind would rejoice to see even tolerably supplied.

I am thoroughly sensible, there are many who have far more ability, as well as leisure, for such a work, than me. But as none of them undertake it, I have myself made some little attempt in the

ensuing volumes. Herein following Mr. Derham's plan, I divide the work into text and notes. [So it was in the first edition. Many of' these are now taken into the text.] The text is in great measure translated from the Latin work of John Francis Buddœus, the late celebrated professor of philosophy, in the university of Jena, in Germany. But I have found occasion to retrench, enlarge, or alter every chapter, and almost every section. So that it is now, I believe, not only pure, containing nothing false or uncertain; but as full as any tract can be expected to be, which is comprised in so narrow a compass: and, likewise plain, clear, and intelligible to one of a tolerable understanding. The notes contain the sum of what is most valuable, in the above named writers: to which are added the choisest discoveries both of our own, and of the foreign societies. These likewise, I trust, are as plain and clear, as the nature of the things spoken will allow: although some of them, I know, will not be understood by an unlearned, or inattentive reader.

Mean time I must apprise the reader, that I have sometimes a little digressed, by reciting both uncommon appearances of nature, and uncommon instances of art: and yet this is not properly a digression, from the main design I have in view. For surely in these appearances also, the wisdom of God is displayed : even that manifold wisdom, which is able to answer the same ends by so various means. And those surprising instances of art do likewise reflect glory upon Him, whose spirit in man giveth that wisdom, whose inspiration teacheth understanding.

It will be easily observed, that I endeavr throughout, not to account for things; but only to describe them. I undertake barely to set down what appears in nature; not the cause of those appearances. The facts lie within the reach of our senses and understanding; the causes arc more remote. That things are so, we know with certainty: but why they are so, we know not. In many cases we cannot know; and the more we enquire, the more we are perplexed and entangled. God " hath so done his works," that we may admire and adore : but " we cannot search them out to perfection."

And does nothing open to us another prospect although one we do not care to dwell upon. Does not the same survey of the creation, which shews us the wisdom of God, shew the astonishing ignorance, and short-sighted-ness of man For when we have finished our survey, what do we know How inconceivably little! Is not every thinking man constrained to cry out, "and is this all Do all the, boasted discoveries of so enlightened an age, amount to no more than this " Vain man would be wise ! But with how little success does he attempt it How small a part do we know even of the things that encompass us on every side I mean as to the very fact: for as to the reasons of almost every thing which we see, hear, or eel, after all our researches and disquisitions, they are hid in impenetrable darkness.

I trust, therefore, the following sheets may. in some degree, answer both these important purposes. It may be a means, on the one hand, of humbling the pride of man, by shewing that he is surrounded on every side, with things which he can no more account for, than for immensity or eternity: and it may serve on the other, to display the amazing power, wisdom, and goodness of the great Creator; to warm our hearts, and to fill our mouths with wonder, love and praise!

JOHN WESLEY
MARCH 25, 1775

I HAD finished the additions which I designed to make to the System of Natural Philosophy, before I saw Dr. Goldsmith's " History of the Earth and Animated Nature." I had not read over the first volume of this, when I almost repented of having wrote any thing on the head. It seemed to me,

that had he published this but a few years sooner, my design would have been quite superseded: since the subject had fallen into the hands of one, who had both greater abilities, and more leisure for the work. It cannot be denied, that he is a fine writer. He was a person of strong judgment, of a lively imagination, and a master of language; both of the beauty and strength of the English tongue.

Yet I could not altogether approve of this, that it seemed the design of the author, to say all he could upon every article; rather than all he should say. Hence arose his numerous and large digressions, making no inconsiderable part of his work. Hence his minute description of cows, horses, dogs; of cocks, hens, and pigeons, and of abundance of animals equally known to every man, woman and child: descriptions that are of little or no use, and no more entertaining than useful: at least useful only t the bookseller, by swelling the bulk, and consequently the price of his book.

Indeed this, the price of it, must ever remain a weighty objection to many readers. They cannot afford to purchase eight volumes, at six or seven shillings a volume. Ten or fifteen shillings they may possibly afford, for five or six smaller volumes;, especially when they contain all that is curious, or useful, in the far more costly work. Nay, I hope considerably more than all; as I have con-suited abundance of authors, and taken abundance of passages from them, whom, I apprehend, the doctor had not seen, I have another objection to this ingenious book: I doubt, some parts of it are not true. The author indeed has corrected many vulgar errors; but has, I fear, adopted others in their place. Many times he exposes the credulity of other writers: but does he not sometimes fall under the same imputation As where he terms presumption, to deny the existence of Bishop Pontopedan's cracken, and the sea-serpent: the one a mile across, the other raising himself out of the water, higher than the main mast of a man of war! Could one who made the least scruple of rejecting these gross absurdities, accuse other writers of credulity

Mean time the accounts which he has given of many animals, being taken from the best, and latest authorities, are both more accurate, and more to be depended on, than any which had been published before. Many of these I have inserted in their places (only contracting thirty or forty pages into four or five); often in the room of those, which were less accurate, and probably, less authentic: as also several of his beautiful remarks, such as directly tended to illustrate that great truth, "0 Lord, how manifold are thy works! In wisdom hast thou made them all !"

Introduction - Of The Gradual Improvement Of Natural Philosophy

1. NATURAL PHILOSOPHY treats both of God himself, and of his creatures, visible and invisible. Of these I purpose to speak in such a manner, as to ascend from the consideration of man, through all the orders of things, as they are farther and farther removed from us, to God the centre of all knowlege. (I mean, of visible things ;—of the invisible world we cannot know much, while we dwell in houses of clay.) Thus speculative philosophy ascends from man to God; practical, decends from God to man.

2. The most ancient nations, the Egyptians and Hebrews in particular, philosophized much concerning God, and concerning Genii, good or evil spirits, of an order superior to man. What they taught concerning the visible world, related chiefly to its origin, the changes it was to undergo, and its final dissolution. But on all these heads they only delivered to their posterity, what they had received from their forefathers.

3. Among the Greeks, Thales Milesius and his followers, applied themselves, with great industry, to discover, with the best helps they had, the material causes, of' natural things. They were succeeded by others, who more curiously searched into the structure of natural bodies. Here the

foundation of natural history was laid, in various observations on plants, animals, and other things. And herein the endeavors of Aristotle, and Theophrastus in particular, are to be commended. Yet in other respects, Aristotle did not promote, but rather obstruct the knowlege of nature: for he made philosophy as unintelligible, by his abstract and metaphysical notions, as Plato, Pythagoras and others did, by their ideas, numbers and symbols.

4. In succeeding times, when the four Greek sects, the Platonic, Peripatetic, Epicurean, and Stoic divided the western world between them, the Platonists almost confined themselves and their opinions to the subject of divinity; the Peripatetics regarded little but logic; the Stoics little but moral philosophy; and the Epicureans had small concern about any, being immersed in sensual pleasures: so that none of them made any considerable improvement in any branch of natural philosophy.

5. When the utter barbarism which followed, was a little dispelled, Aristotle began to reign. His followers (the school-men, as they were called) might have improved natural philosophy, if (like their master) they had diligently cultivated the knowledge of nature, and searched out the properties of particular things. But it was their misfortune, to neglect what was commendable in him, and to follow only what was blame-worthy; so as to obscure and pollute all philosophy, with abstract, idle, vain speculations. Yet some of them, after the Arabians had introduced the knowlege of chemistry into Europe, were wise above the age they lived in; and penetrated so far into the secret recesses of nature, as scarcely to escape the suspicion of magic. Such were Roger Bacon and Albertus Magnus.'

6. After the revival of learning, as all other branches of philosophy, so this in. particular received new light. And none was more serviceable herein than lord Bacon: who, well understanding the defects of the school-philosophy, incited all lovers of natural philosophy to a diligent search into natural history. And he himself led the way, by many experiments and observations. " ' . .

7. After this, not single persons only, but whole societies applied themselves carefully to make experiments; that having accurately observed the structure and properties of each body, they might the more safely judge of its nature. And the advantages, which have arisen from hence, manifestly appear from the memoirs of the royal society at London; of the academy of sciences at Paris; and those of the same kind in Germany, as well as several other parts of Europe.

8. To mention but a few of the late discoveries in each branch of natural philosophy. With regard to the structure of a human body, how many things have modern anatomists discovered, which were either little understood by the ancients, or wholly unknown to them Such, for instance, is the circulation of the blood, discovered by Dr. William Harvey, whose "Anatomic Exercitations," concerning it were first published in the year 1628. Such were the lacteal veins, discovered first in brutes, by Casper Asellius, of Cremona; and soon after in men. Such the thoracic duct, and receptacle of the chyle, observed first by Dr. John Pecquet, of Paris, whereby the whole course of the blood is now clearly understood.

9. Dr. Harvey improved natural philosophy, by another 'no less eminent discovery: for he was the first of the moderns that shewed all animals to be generated from eggs. That the ancients knew and taught this, (Orpheus in particular) cannot reasonably be doubted. But as the knowledge of it was entirely lost, to revive was the same thing as to invent it. It is obvious, how great a light this pours upon that dark subject, with regard to the generation of men, as well as of other animals.

10. Another remarkable discovery in the last century, was that, of the transfusion of the blood. The blood of a young, lively, healthy animal was transfused, by means of a small, silver tube, properly adjusted into the veins of another, which was old, weak, and sickly. And the effect amazed all the

beholders. When the experiment was tried before several of the royal society, a feeble, worn-out dog, ready to die with age, and hardly able to trail his legs after him, was no sooner filled with young blood, than he leaped up as from sleep, shook himself, and ran up and down, as lively and active as a puppy. In France the experiment has been made upon men, and with as surprising success. What pity, that so important an experiment should ever fall into disuse! That it is not still repeated upon proper occasions ! Especially where all other means fail.

11. It cannot be denied, that physicians have signally improved this branch of philosophy, as they have continual opportunities of making new discoveries in the human body. In diseases themselves, the wonderful wisdom of the Author of nature appears: and by means of them many hidden recesses of the human frame are unexpectedly discovered. The powers of medicine also variously exerting themselves, lay open many secrets of nature.

12. And how many things in all bodies, as well as in the human, which eluded all the art and industry of the ancients, have the moderns discovered by the help of microscopes Although these are not properly a modern invention: it being certain, something of this kind was in use many hundred years ago. There are several works of great antiquity still extant; the beauties of which cannot even be discerned, much less could they have been wrought, by the finest naked eye, which ever was in the world. Such is that seal, now in the cabinet of the king of France, allowed to be at least fifteen hundred years old, six-tenths of an inch long, and four broad, which to the naked eye presents only a confused groupe, but surveyed with a microscope, distinctly exhibits trees, a river, a boat, and sixteen or seventeen persons.

13. Now whatever assists us in searching out the structure of a human body, equally helps us to find out the nature and properties of other animals. Hence in these likewise we have received great light, from anatomical and microscopical observations. Those especially who have bestowed their whole time and thoughts on one kind of animals (as Dr. ‘Willoughby, on fishes, Dr. Swammerdam, of Amsterdam, on insects), have illustrated to a surprising degree, the subjects on which they wrote.

14. Many have diligently searched into the nature of plants; particularly Mr. Ray, who has not only ranged them in a new method, but also wrote an elaborate history of them. Others have described, with equal diligence, either plants in general, or those of a particular country. And others have shewn die like industry in finding out and explaining the nature of stones, metals, minerals, and other fossils.

15. Nor is it strange that the moderns have penetrated farther into the recesses of nature than the ancients, considering the advantages they have received, from the art of’ chemistry. Not that this is an invention of later ages: it was in some measure known long ago. But as this art has been cultivated in our age, with far greater accuracy than ever, so by this means many properties of’ natural bodies have been discovered; of fossils in particular.

16. But none of these have so much engaged the study of the learned, or so well deserved it, as the load-stone. Its attractive force was known to the ancients, and the origin of that discovery is recorded by Pliny. But it does not appear that they knew of its pointing to the pole, or of the use of the compass. This (the compass) was invented by John Goia, in the year 1300. But it has since been observed, that the magnetic needle seldom points exactly to the pole; but varies from it some degrees to the east or west, in a fixt and regular order. .

17. Nearly related to the nature of fossils is glass, which was well known to the ancients, being mentioned by Plutarch and Lucian among the Greeks, by Lucretius, Pliny, and others among the Latins. Yet the art of making glass has been since their times abundantly improved. One branch of

this is, the art of making burning-glasses, which are now brought to so great perfection, as either to melt or reduce to ashes the most solid bodies, in a few moments. If these were known to the ancients at all (which may reasonably be doubted), yet the art was wholly lost for many ages, and not recovered till of late years.

18. Later ages have likewise made many discoveries with regard to earth, water, fire, and air: the last of which, AIR, though it he of so fine a texture as to be wholly invisible, yet producing such amazing effects, has excited the most diligent enquiries of the curious. Nor does any part of philosophy afford a wider field for experiments and discoveries. The weight of it we can ascertain by that curious instrument, the barometer, invented by Torricellius; the degrees of heat and cold, by the thermometer. By the air-pump (invented by Otto Gucrick, mayor of Magdeburg) the air is drawn out of any bodies, or more largely thrown into them. And hereby many effects are produced, which deserve our diligent consideration.

19. With regard to WATER, the discoveries of later times are numerous and important. Such are the (living-bell, invented by George Sinclair; the diving-machine of Alphonso Borelli, a kind of boat, which is so contrived as to be navigated under water; and the art of making salt-water fresh, which is now done with little expense, so far that the saitness is taken away, and it is fit for almost all uses.

20. The nature and properties of FIRE also have been accurately traced in late ages: for which new occasion was given by the invention of gun-powder, by Berthold Schwartz, in the fourteenth century. Aurum fulminans, a yet later invention, goes off with a louder explosion than gun-powder. Other bodies there are, which do not burn, yet emit light. Such is the Bononian stone, which, placed in the dark, diffuses light like a burning coal. It is well known that the preparation called phosphorus, has the same property.

21. Various theories of the EARTH have lately appeared. But they are no more than ingenious conjectures. The same may be said of the systems of the universe, a few particulars excepted. The Ptolemaic system, which supposes the earth to be the centre of the universe, is now deservedly exploded: since Copernicus has revived that of Pythagoras, which was probably received by most of the ancients. Tycho Brahe’s, which jumbles both together, is too complex and intricate, and contrary to that beautiful simplicity, conspicuous in all the works of nature.

22. The telescope (invented by Galileo) has discovered many stars unknown to the ancients, together with the nature and motion of the planets, both primary and secondary. By this also have been discovered the spots of the sun, the inequality of the surface of the moon, the nature of the galaxy, or milky-way, and many other particulars relating to the heavens.

23. With regard to body in general, it is commonly supposed, that our age has a vast advantage over antiquity, by having found out new principles and new hypotheses, whereby we can accQuflt for all the secrets of nature. But this will bear a dispute. For beside that the chief of our hypotheses, are not new, but known long ago, the learned have hitherto very little profited by all their hypotheses. And in truth, all their disquisitions touching the causes of natural bodies, terminate in mere conjectures: one whereof is often more probable than another; but none admits of any solid proof.

24. What remains of natural philosophy, is, the doctrine concerning God and spirits. But in the tracing of this we can neither depend upon reason nor experiment. Whatsoever men know or can know concerning them, must be drawn from the oracles of God. Here therefore we are to look for no new improvements; but to stand in the good old paths : to content ourselves with what God has been pleased to reveal; with the faith once delivered to the saints."

Part I - Of Man

Chapter 1 - Of the Structure of the Human Body

1. As man ought to know himself best, we begin our treatise here. And first, let us contemplate the human body. The parts of this are either solid or fluid. Those of the solid, of which the rest are formed, are termed similar parts. Such as fibres, bones, membranes, ligaments, arteries, veins, lymphatic vessels, nerves, flesh, muscles, tendons: and those general coverings of the body, the cuticle, the skin, fat, and the paniculus carnosus.

2. A FIBRE is a kind of slender thread, of which all the other parts of the body are woven: according to the difference of which, the substance of the fibres is different also.

Earth, as an element, is a solid, opaque, angular, friable substance, of such small volatile particles, that it readily diffuses itself through air and water, and resides invisibly in them. And earth eagerly imbibing both air and water, by their means forms the permanent basis and growth of all mineral, vegetable, and animal bodies.

These earthly particles have their connexion and power of cohesion, not from themselves, or a mere contact, but from the intermediate glue placed betwixt them.

That this glue is composed of oil, combined with water, by the vital attrision in animals, appears from the chemical analysis of bones and hair; from the jelly ‘of bones, ivory, and horns; and from the nature of our aliments themselves. Nor is there any kind of glue that .could more powerfully join the parts of animals, as we experience in fish-glue, and that of joiners or cabinet makers.

Earthly particles then cohering longitudinally, and tied together by an intervening cohesive glue, compose one of the least or most simple fibres; such as we have a knowledge of rather from reason than sense.

The finest microscopes have been hitherto insufficient to lead us to a sight of the smallest moving and nervous fibrils, and still less can we ever expect from them, to get any sensible idea of the mechanism by which sensation and motion are effected.

But the least fibres which appear to the sight, are of two kinds.

Of these two kinds of fibres, as we shall presently see, we may distinguish the former by the title of filamentary, and the latter of membranous.

* The first kind of these fibres is lineal, namely, such a form as makes their length considerably large in proportion to their breadth; and which, by disposing of the elementary particles in a right line, must of course lay them generally parallel with the neighbouring or contiguous fibres. Examples of such fibres we see in the bones, and most easily in those of a foetus; and Jikewise in the tendons, ligaments and muscles; only we must here always remember, that the eye never reaches to the smallest fibres, but to larger ones made up of the smallest, and like to them in slenderness, placed together in a rectilineal course. That these are not different from the smallest fibres, we are persuaded by the most accurate microscopes of Muyses and Lewenloeck; by which the muscular fibres, divided even to the last, appear similar to the larger, till, at length, they . seem mere lines, like spiders threads.

The second kind of fibres are those winch are conjoined with a breadth frequently larger than their length. From what has been said, we may admire nature no less for her wise economy than simplicity, in thus forming all that variety of parts we see in an animal, from one simple mass of clay or slimy matter, compounded of earth and glue; from whence the body is not only augmented from a single point in the ovum to its full growth and stature; but like the timbers of a ship, is also every day repaired during life, till at length, not two jots of the old or first materials remain. This renovation of parts is made slower in some constitutions, and in some organs, than in others. How quickly the animal humours, with the hair, nails, &c. are renewed, every one knows: and we may venture to say, that once in three years the change is universal; at the end of which time, though a man remains the same identical person, he is not the same matter.

3. But we proceed from these simple fibres, to the next least compounded solid which they compose; viz. the cellular web-like. substance. This is made up partly of the simple fibres, and partly by an infinite number of little plates or' scales, which, joined in various directions, intercept small cells and web-like spaces; and by extending round every, even the least moving solid parts of the body, conjoins them altogether in such a manner as not only sustains, but allows them a free and ample motion.

The extension of this substance, not only with the skin round the whole body, but also round every viscus or organ, and round every individual moving fibre or vessel of them, into the cavities of the bones, and even the substance of the brain and its medulla, is a modern and wonderful discovery. This substance, in its ultimate state being composed of simple membranes, when compacted and convoluted, gives birth to the least or most simple vessels, which again reflected through plates of the same substance compacted together, make compound and vascular membranes; to the consideration of which we next proceed.

Out of this cellular substance compacted by a concretion of the membranous plates or partitions, and pressed together by the force of the incumbent muscles, and distending fluids, arise other broad and flat plates or skins in various parts of the body; which being generally disposed in one and the same direction, seem to have a better right to the name of membrane than the former; and these being convoluted into cones and cylinders, pervaded by a flux of some juice or liquors brought to them; put on the name of vessels, or else being extended round some space that is in a plane, parrallel to itself, we call it a tunic or coat.

This cellular substance in the human body, is found throughout the whole; wherever any vessel or moving muscular fibre can be traced, and this without the least exception, that I know of, in any part whatever. flut so far as we can trace, it hardly ever admits of any fat into the cells; which are rather moistened by a watery vapour, somewhat oily, exhaled out of the arteries and received again into the veins.

Its plates or scales are still more loose and open where it divides the muscles and all their fibres (even to the ultimate fibre); and likewise where it surrounds and sustains the least vessels with their free motion. That within the cavities of the bones is also made up of boney plates, with membranous ones intermixed; and lastly, it is the most loose and open of all, round the surface of the body on all sides, betwixt the muscles and the skin.

Through this cellular substance the small vessels are spread, and ramified in all parts of the body; from whose arterial extremities the fat is deposited into the cells, and afterwards absorbed by the venal orifices. This passage from the arteries, into the adipose cells, is so free and short, that there must needs be very large mouths by which they open, and by which they give admittance to injected mercury, air, or water. The oily fat, in this substance, is separated and expelled from the artery; not by any long ducts, but by transuding on all sides through the whole extent of the vessel.

How quickly it is collected from the arteries, appears from the speedy renovation of it, by a returning fatness after acute diseases.

With regard to the sponge-like communications of this substance, it is remarkable, the intervals or spaces betwixt the plates or scales that make up their sides in the cellular membrane, are every where open, and form one continuous cavity throughout the whole body.

That out of this substance, joined with vessels, nerves, muscular and tendinous fibres (a great part of all which are before formed of this substance only), all the viscera, all the muscles and glands, with their ligaments arid capsules, are entirely composed; and that only from the different length, tension, quantity or proportion of this, the diversity of our glands, and viscera arises; and lastly, that this alone makes up by far the greatest part of the whole body, we are certain, if the whole be not formed out of the cellular filaments, of this kind.

4. The hardest part of the body, white and void of sense, is termed a BONE- The bones are covered with a thin skin, called the periosteum, extremely sensible.

The bones consist of thin plates, lying one upon another ; and these again, of fibres running lengthways; some to the extremity of the bone, some not so far. Yet none of them terminate there; but are continued transversely, and as it were arched, the fibres of one side meeting and uniting with those of the other, and this at each extremity.

These plates are differently disposed in different bones: in those that have a large cavity, they are contiguous on each side,. and very closely united. In those whose cavities are small, many of the inner plates arc distant from each other; having little long cells between them. In bones whose plates are contiguous, there are pores through and between them (beside those for the blood-vessels). The first pierce them transversely, from the cavity to the external surface of each plate. The second run lengthways between . the plates, and diffuse an oil with which they are supplied by the transverse pores.

The bones are generally bigger at each end than in the middle, that the joints may be firm, and the bones not so easily dis-located. But to strengthen the middle of the bone, the fibres there are more closely compacted. Likewise, the bone, being large and hollow, is not so easily broke, as if it had been solid and smaller : for of two bones of equal length and equal number of fibres, that is stronger which has the larger diameter.

The blood-vessels usually enter the ends of the bones; the arteries at one end, the veins at the other. The medullary vessels commonly enter the sides of the bone, and that obliquely.

The marrow is covered with a membrane, wherein are inclosed little bags. In these' bags are glandulous bladders, serving both to screen the marrow from the blood, and to receive it. Both these and the bags have passages into each other, whereby the marrow has free course. It. passes first through the transverse pores of the first internal plate into the longitudinal ones. Thence it proceeds into other transverse pores, when it alters its course again, and exsudes farther. Thus it passes alternately through and between the plates, till it is diffused throughout. In this manner it is diffused through bones, whose plates are contiguous. But where the plates are at a distance, the small cells contain glands, which directly supply the plates with marrow.

The marrow not only serves to keep the substance of the bone moist, but to lubricate the joints, and to hinder the ends of the bone, from being worn or over-heated with motion. It also moistens the ligaments, which tie them to each other: as do likewise the glands found in all the joints. The back-bone hath these two things peculiarly remarkable: I. Its different articulations from the other

joints of the body. For here most of the Joints are fiat, and withal guarded with asperities and hollows, made for catching and holding; so as firmly to lock and keep the joints from luxations, but withal to afford them such a motion, as is necessary for the incurvations of the body. 2. The difference of its own joints in the neck, back and loins. In the neck the two upper vertebra, are curiously made, and jointed (different from' the rest) for the commodious and easy bending and turning the head every way. In the thorax, and back, the joints are more close and firm; and in the loins more lax and pliant; also the knobs and sockets are turned a quite contrary way, to answer the' occasions, the body hath to bend more there, than higher in the back. 'So that its structure is the very best that can be contrived; for' had it been all bone, we could have had no motion in our body; had it been two or three bones articulated for motion, the medulla spinalis must have been necessarily bruised at every angle or joint; besides, time whole would not have been so pliable, for the several postures we have occasion to put ourselves in. if it had been made of several bones without intervening cartilages, we should have had no more use of it, than if it had been but one bone. If each vertebra had had its own distinct cartilage, it might have been easily dislocated. And lastly, the oblique processes of each superior and inferior 'vertebra, keep time middle one, that it can neither be thrust backwards nor forwards to compress the medulla spinalis

The pelvis made in the belly by time ilium, ossa coxendicia, and pubis, is larger in a female than in a male skeleton, that there may be more room for the laying of the viscera and fatus. So the cartilage bracing the two sharebones, is twice thicker and laxer in women than in men. As also is the cartilage that ties time os sacrum to its vertebra; and all, to give way to the passage of the foetus. -.

Another considerable difference is, in the cartilaginous production of the seven long ribs, whereby they are braced to the breastbone. These are harder and firmer in' women than in men ; the better to support the weight of the breasts, the sucking infants, &c.

It is remarkable in the joints, and a manifest act of caution and design, 1. That although the motion of the limbs be circular, yet the centre of that motion is not in a point, but an ample sperficies. In a point, the bones would wear and penetrate one another, and the joints would be exceeding weak. But the joint consisting of two large superficies, concave and convex, some furrowed and ridged, some like a ball and socket, and all lubricated with an oily substance; they are incomparably prepared both for motion and strength. 2. That time bones next the joints are not spungy, as their extremities commonly are, nor hard and brittle; but capped with a strong, tough, smooth, cartilaginous substance, serving both for strength and motion.

For affording this oily matter there are glandules very commodiously placed near the joints, so as not to suffer too great compression by the motion of time neighbouring bones, and yet to receive a due pressure, to cause a sufficient emission of the oil into the joints. Another thing considerable is, that time excretory ducts of the mucilaginous glands have some length in their passage from the glands to their mouths; which is a good contrivance, to prevent their mouth being oppressed by the mucilage, and also to hinder the too plentiful effusion thereof, but yet to afford a due expressure of it at all times, and on all occasions; particularly in -violent and long-continued motions of the joints, when there is a greater than ordinary expense of it.

That the nourishment .taken, is continually conveyed through, the bones, as well as the flesh, appears from an easy experiment. Mix red liquor with the 'food of any animal, and in a short time the bones are died red. When madder root was mixed with the food of a cock, which died after sixteen days, all his bones were red, the internal parts as well as the external. And the most solid parts were the most deeply tinctured; in swine, the teeth above all' the rest.

5. Annexed to the bones are the CARTILAGES, white, flexible and smooth; most of which in process of time become bones, hard and quite void of sense.

A cartilage is an elastic substance, uniformly compact and somewhat transparent, harder and more brittle than a ligament, softer than a bone. It is covered with a fine membrane, folded over the bone, from where the ligament is inserted. Every joint is inserted with a membrane, which forms a complete bag, and covers every thing within the articulation. The blood-vessels are so small, that they do not admit the red globules, and are demonstrable only in very young subjects. All round the neck of the bone, there are numerous arteries and veins which spread into smaller branches, and communicate with each other. These divide into still smaller branches on the adjoining surface, as they run toward the centre of the cartilage. We can seldom trace them into its substance, because they end abruptly, at time edge of the cartilage. The larger vessels plunge in by numberless small holes, and disperse themselves into branches between the cartilage and bone. From these again there arise many short, but small twigs, which shoot toward the outward surface, This distribution of time blood-vessels is very peculiar, and calculated for obviating great inconveniences. Had they run on the outward surface, the pressure and motion of the two cartilages must have occasioned frequent obstructions and inflammations. But by creeping round the cartilaginous brim, where there is little friction, or under the cartilage, where there is none, they are perfectly well defended from all such accidents.

Cartilages are admirably contrived for all the purposes of motion. By their uniform surface they move one upon another with ease: by their soft, smooth and slippery surface, mutual abrasion is prevented. By their flexibility, the contiguous surfaces are constantly adapted to each other. By their elasticity, the violence of any shock, which might happen in running, jumping, or the like, is broken; which must have been extremely pernicious, if the hard surfaces of bones had been immediately contiguous. ‘The cartilaginous fibres appear calculated chiefly for this last advantage.. To conclude, the insensibility of these cartilages, is less wisely designed, that by this means the necessary motions of the body may be performed without pain.

6. The various parts of the body. are clothed with MEMBRANES, which are whitish tunicles, extremely thin and flexible, composed of fibres interwoven with each other, as a piece of cloth is of threads. They are fastened together by a kind of cartilages, which are termed ‘ligaments. -

7. An ARTERY is a hollow canal, composed of fibres closely twisted together, which conveys the blood from the cavity of the heart to all the, parts of the body. All the arteries spring from two, the aorta or great artery, and the pulmonary artery. The latter conveys time blood from the right ventricle of the heart, through the lungs, into the left ventricle. ‘The former conveys it from the left, to all other parts of the body.

The arteries ordinarily Consist of three COATS or membranes. The, outermost has been generally thought to be composed of fine blood-vessels. The second is muscular, and made of firm and strong circular, or rather spiral fibres: of which there are more or fewer strata, as the artery is larger or smaller. These fibres are extremely elastic. The inmost coat is a fine dense, transparent membrane, containing the blood, which otherwise would easily ooze through the spiral fibre,

On a more accurate examination it has been found, that the outermost coat of all arteries is a cellular substance, composed of’ fine, pellucid membranes, which may be stretched, even suddenly to a great extent without breaking. And they as suddenly collapse, when that stretching force is removed. These cells contain an oily liquor which their coats secern from the branches of the artery that are spread over them, This cellular substance of the arteries serves to connect them with the surrounding part, without hindering their actions or motions. It gives a safe passage to the

vessels of their other coats, and supplies oil for lubricating them. There is also another cellular substance, between the membranes and the muscular coat.

All the arteries begin with a larger trunk, and grow less and less till they are no longer seen by the naked eye. Hence they are continued till, they inosculate with the veins, and so form one uninterrupted channel.

They appear white, because their coats are of so dense a contexture, that the blood is not visible through them. This proceeding from wider to narrower canals, is continually obstructed in its passage. But being pushed ‘on from behind, it distends the coats, and causes that leaping motion called the PULSE. By this, as well as by their whiteness, arteries arc distinguished from veins.

The pulse of a. healthy person, rising in the morning, beats 65 in a minute; but after the fatigue of the day, it will in the evening beat 80 in that time’ and again, by the night’s rest or sleep, it will become less frequent, till in the morning you will find it return to 65. For the voluntary motions of the muscles, and actions of the external and internal senses, urge the venal blood on to the heart, which, being thereby oftener stimulated, makes more frequent contractions. This is the cause of those paroxysms or fits of increase, observable in all fevers towards the evening. For sleep not only retards the motion of the blood, but of all the other humours and actions in the body.

It is one Of the curious observations of Dr. Hales, that the pulse is quicker in small animals. He found the pulse of a horse slower by half than in a man, viz. 32 only in a minute; whereas in a dog, the pulse beat 97 in that time. And this we see is conformable to the blood’s heat, measured by the mercurial thermometer of Fahrenheit's scale, For the blood in oxen, horses, and other large animals at rest, being five or six degrees cooler than in us, will not rise to our heat, but by labour; whereas, dogs, cats, and fowls, are five or six degrees hotter than we (viz, about 102); and the latter, when sitting or brooding on their eggs for young, are still four or’ five degrees hotter, viz. 107 or 108, which is commonly the heat of our blood in the fit of an ague; where it is observable, that during the greatest sense of cold chill, time blood is three or four degrees hotter than in health, after which it gains four or five degrees more in the height of the hot fit, viz. 104 or 105 degrees; but in ardent fevers, where the pulse beats 140, the heat of blood will still be four or five degrees higher, viz. 110; i. e. two or three degrees more than equal to a brooding hen.

The pulse is more quick in children, and becomes slower in persons as they grow older. Time salient point of an OVUM beats 134 in a minute. New born infants have their pulse 120, and from thence down to old age it grows slower, to 60 in a minute. A feverish pulse begins at 96 per minute; it is excessive at 130 or 140, which is the number of the pulse with which a person dies. The pulse beats slower in winter, and quicker in summer, by about ten strokes per minute; and under the torrid zone, it grows quicker, to 120.

8. A VEIN is a hollow canal, which receives the blood from the artery, and conveys it back to the heart. The chief veins are. three, the vena cava, which pours the blood through a wide passage into the right ventricle of . the heart; the pulmonary vein, which in like manner’ pours it into the left ventricle; and the vena porta, which does not, like the two former, end in a large. trunk; but spreads itself at each extremity into numerous’ branches.

In the cavity of the veins, there. are certain thin tunicles, which are termed VALVES. These, during the regular motion of the blood, lie close to the side of the inner coat: but in case of any obstruction, recede from it and close the passage, to prevent the blood’s falling back.

9. The LYMPHATIC VESSELS are small canals full of valves, consisting of a thin, transparent tunic, which convey an extremely clear liquid into the mass of blood. Probably these' (as well as the veins) and all the other vessels, are only continuations of the arteries.

It has been lately discovered, that the lymphatic vessels have two coats; betwixt which there are innumerable fine filaments, containing a nutricious juice, which is conveyed into all parts of the body, by a motion from the centre to the circumference, and returns through the inner pipes, of the same watery vessels. But this juice when returning, is no more water or dew, but ferment; and the vessels may be termed ferment-vessels. This ferment is conveyed into the blood, by a motion from the circumference to the centre.

The lymphatics carry their dewy particles through the glandules, which lie between the two coats. Jim the lowermost end of these glandules, the ferment-vessels take their rise. Most of the juice of the lymphatic-vessels is discharged between the coats of the veins, arteries, and vessels, in the mesentery; to be conveyed into all parts of the body, both internal and external. Even in bearing females, the fruit is not nourished by blood, but by this nutricious juice: the remaining part of which, is transmitted into time blood through the thoracic duct and jugular veins. -

10. A NERVE is a whitish, round, slender body, arising from the brain, which is supposed to convey the animal spirits to all parts of the body. What these spirits are, none can shew: nay, we are not sure they have any being. For none can certainly tell, whether the nerves are hollow canals, or only solid threads, enclosed in proper integuments.

11. The fibrous, soft, reddish part of the body is termed FLESH. All fleshy fibres are hollow, and divided through their whole length into little caverns, wherein the blood is detained, as occasion requires.

12. A GLAND is a soft and spungy body, which separates some particular liquid from the blood. The larger glands contain arteries, veins, and lymphatic vessels: but the glands of the intestines are nly the tops of the arteries.

There is a kind of DOWN in the cavity of every gland, which probably does the office of a filter, and is that whereby a particular humour is separated from the blood.

The structure of time down-vessel is different according to the different purposes of nature. Sometimes the liquor filtrated through it, falls drop by drop on a membrane, to which one end of the vessel is fastened, as where it is designed only to moisten the part. Sometimes many of these down-vessels spread over the inner surface of a membranous cell, into which they all pour their liquor, which is discharged at a small orifice.

These vessels are often of a great length, though they take up little room, being wound over one another, sometimes in a single knot, and sometimes in several, enclosed in a common membrane. And hence is the distinction of glands into conglobate and conglomerate.

A conglobate gland is a little, smooth body, wrapt up in a fine, double skin; with only an artery and nerve passing in, and a vein and excretory duct going out.

A conglomerate gland is an irregular assemblage of several simple glands, which are tied together and wrapt up under one common membrane.

13. A MUSCLE is a bundle of fibres joined and fastened together, with their proper veins, arteries and nerves. It is divided into little cells by transverse fibres, parrallel to each one, whereby it may

be contracted and shortened, or relaxed and lengthened again. ‘ Its extreme parts arc more closely compacted,, which we term tendons. By these time muscles are connected with the neighbouring parts. A muscle generally consists of three parts: the upper, termed the head, the middle, termed the belly, and the lower part, or tail.

Every muscle is divisible into smaller muscles, and those into other still smaller; and so on, beyond all imagination. The last and smallest parts are muscular fibres. But there is no assignable point in any muscle, wherein there is not some nerve. And here all the nerves disappear (in other parts their extremities expand into membranes). It is therefore probable that the muscular fibres, are only the nervous continued.

14. The CUTICLE, or SCARF-SKIN, is an extremely thin and transparent membrane, void of sense, and covering the skin all over, sticking fast to its surface, to which it is also tied by the vessels that feed it. It consists of several layers of exceeding small scales, which cover one another where it is thick, But in the lips, where it is extremely thin, they little more than touch one another.

In some creatures (as fishes), these scales are only the excretory ducts of the’ glands of the skin. In others, those glands have their proper ducts, opening between the scales.

It is supposed, there arc in one scale 500 excretory ducts, and. and that a grain of sand will cover 250 scales. If so, a grain of sand will cover 125,000 of our pores.

The cuticle serves to defend the nerves of the skin, both front the air, which would dry and make them less sensible, and from rough and hard bodies, which would make a painful impression on the naked nerve.

Negroes have a skin between the cuticle and the true skin. They are born white; but the middle skin, in a little time, turns black, and gives that colour to the whole body.

But who can account for the following case Sir Charles Wager had a boy about eleven years old, who was born in Virginia, of negro parents. Till he was three years old, he was like other black children. He then, without any distemper, began to have little white specks upon his neck and breast. These increased with his years, both in number and bigness, so that from the tipper part of his neck, quite down to his knees, he was dappled with white spots, some of them broader than the’ palm of a man’s hand. They were wonderfully white, equal to the skin of the fairest lady, only somewhat paler. His face, arms and legs were perfectly black. He was exceedingly active, sprightly, and more ingenious, than. is common among that generation.

Perhaps the following fact is no less difficult to be accounted for: A negro woman, cook to colonel Barnes, in Maryland, about forty years of age, remarkably healthy, had her skin as dark as that of the most swarthy African. But that part of it next her finger nails, about fifteen years ago, became white. Her mouth soon underwent the same change, which has since gradually extended over the whole body. At present, four parts in five of her skin are white, smooth and transparent, as in a fair European, elegantly shewing the ramifications of the subjacent bloodvessels. The other parts daily lose their blackness, and partake of the prevailing colour. The neck and back retain most of their pristine hue; the head, face, breast, legs and arms are all white. Her face and breast, when anger or shame has been excited in her, have been observed immediately to glow with blushes. This is the naked fact; but upon what principles of philosophy can we account for it ‘

The SKIN covers almost all, the whole body, and is formed of whitish fibres, intermixt with mumberless ‘branches of nerves, veins and arteries. On its surface are many furrows, or indented lines, having generally hairs on each side, and pores, or little holes of various sizes, serving for the

transpiration of superfluous particles. Under the skin lie the subcutaneous glands, which are supposed' to transmit through the pores an insensible steam, commonly believed to be of the same kind with what, when sensibly thrown out, is called sweat.

The PORES in our hands and feet are very remarkable. Survey with a glass the palm of your hand, well washed, and you may perceive innumerable little ridges, of equal bigness and distance, every where running parallel with each other: these are very observable on the ends and first joints of the fingers and thumb, and near its root, a little above the wrist.

On these ridges stand the pores, all in even rows. Through a good glass every pore looks like a fountain. The sweat may be seen to stand therein, as clear as rock water. The ridges are so placed, that they may better suit with the use and motion of the hand: those on the lower side of each triangle, to the bending in of the fingers: those on the other two sides, and on the elliptic ridges, to the pressure of the hand or fingers' ends, against any body, requiring them to yield to the right and left.

The pores are placed on these ridges, not in the furrows between them, that their structure may be less liable to be injured by compression, whereby the furrows only are dilated or contracted: the ridges constantly maintaining themselves; and so the pores are unaltered. For' the same reason the pores are very large, that they may be the better preserved; though the skin be never so much compressed and condensed, by the constant labour of the hand: and so those on the feet, that they may be preserved, notwithstanding the compression of the skin, by the weight of the whole body.

Through the pores there continually transudes a subtle vapour from every point of the body, being what redounds of the aliment, comminuted to the highest degree, and sent to repair every particle of it. And the matter thus evacuated is more than is thrown out by all the Other passages together.

A person of middle age found what he perspired was five eighths of the food taken in: so that there remained only three eighths for nourishment and all other evacuations. He observed also that so much is perspired in one day, as passes by stool in fourteen; and more particularly, that in a night's time about sixteen ounces are usually thrown out by urine, four by stool, and about forty by insensible perspiration.

If a. man eats and drinks eight pounds in a day, five pounds of it pass by perspiration: namely, about one pound within five hours after eating (perspiration being least of all soon after eating); from the fifth to the twelfth hour, about three pounds; and from the twelfth to the sixteenth, scarcely , half a pound. Exercise increases perspiration much; but it is naturally less in women than men.

While this steam flows from our body, it constantly imbibes a supply of moisture from the air, which serves to keep all its parts soft, pliant and fit for motion. Hence, from the greater moisture of the air, we perspire less in winter than in summer, and in rainy weather than in fair. Live, therefore, if possible, in a clean house, arid in a pure, dry air.

This inhalation is very considerable. Dr. Keil found his body to have imbibed in one night eighteen ounces of moisture. And on a sudden change of weather from dry to wet, the inspiration sometimes exceeds the expiration: there being absorbent veins, which accompany the numberless arteries from which the perspiration is discharged. To time matter thus imbibed, not the obstruction of the pores, he ascribes what we term a COLD-Sweating cures this, by throwing out the noxious matter which was imbibed before.

The cutaneous vessels both exhaling and inhaling, are capable of contraction and relaxation, by the power of the nerves. This appears from the effects of the passions, which if joyful, increase the circulation, and relax the exhaling vessels. Those passions, on the contrary, which are sorrowful, and retard the circulation, contract the exhaling vessels, as appears from the dryness and corrugation of the skin, like a goose-skin after frights; and from a diarrhoea caused by fear. But the same affections seem to open the inhaling vessels; whence the variolus or pestilential contagions are easily contracted by fear.

Time benefits of insensible perspiration are so great, that life cannot be preserved without it. And the subtilty, equability and plenty of wlmt we perspire, are the grand symptoms of health.

But how little do we know even of our own frame! It has hitherto passed as an unquestionable truth, that the same matter which passes by insensible perspiration, passing in great quantities, is sweat. Whereas an ingenious physician, Dr. Rogers, has found by numerous experiments, that a person perspires abundantly less, when he sweats, than when he does not: that one who perspires twenty-four ounces in seven hours sleep, if he sweats, does not perspire above six. This he tried many times, and never found it to fail. Whence he infers, 1. That it is not the same matter which is evacuated by insensible perspiration and by sweat: 2. That it is not evacuated through the same pores: 3. That the sweat-pores are abundantly larger and fewer, than those which serve insensible perspiration: 4. That sweat greatly hinders that perspiration, both by covering those pores with a clammy liquor, and by constringing them so that they cannot open; which must be the case, when the sweat-pores are dilated. What a field does this open!

Some queries proposed concerning perspiration, by an ingenious writer, seem to deserve a serious consideration. 1. " Why do carnivorous animals sweat so little A fox hunted almost to death never sweats. 2. Why do those which feed on vegetables perspire so much Horses and cows for example. We may often see them involved in a cloud of their own vapours, yea, almost covered with froth. 3. Flow can animals, whose natural food is vegetables, be kept alive and in health, in very cold climates, by purely animal food Cows in Iceland and Norway, are fed in winter upon fish-bones." I would beg leave to ask, 4. Do the sweat-pores only, imbibe Or those also, which serve for insensible perspiration

15. FAT, a whitish, oily substance, void of sense, is secreted from the blood, and lodged in small, oval, membranous bags, which shoot out of the arteries. It is found in various parts, but chiefly under the skin, where, unless a man be emaciated, it runs co-extended with the skin over most parts of the body.

Fat is secerned from the arterial blood by the ADIPOSE GLANDS, and transmitted again from the membranous cells to the blood through the veins. It seems to be a portion of the blood coagulated by the nitrous air mixed with it in the lungs. Artificial fat is made, by mixing, for some days, oil of olives with spirit of nitre. Hence divers animals grow fat in frosty weather, the air then abounding with nitre.

The uses of the fat are various; as to facilitate the motions of the muscles in all the parts, lessen their attrition against each other, and prevent a stiffness or rigidity; it fills up the intermediate spaces between the muscles in such a manner, with the cavities about many of the viscera, that it readily yields to their motions, and yet supports them when at rest; it serves as a stratum or bed to conduct and defend the vessels in their course to all parts ; it gives an uniform extension to the skin, and serving as a cushion to ease the weight of the body in many parts, at the same time it renders the whole of a comely, agreeable shape: it probably, by returning and mixing with many of the humours; abates their acrimony; it has a principal share in forming the matter of the bile, and by transuding through the cartilaginous incrustations of the bones, it mWes with the articular

liniment or synovia; also by exhaling in a living person from the mesentery, mesocolon, omentum, and round time kidnies, it lubricates the surfaces of the viscera with an oily, emollient vapour, and by interposing betwixt their integuments, prevents their growing one to another.

Yet too much fat is a real disease, which hinders the motion of the lungs, entangles the most active particles of the blood, and naturally creates dulness and heaviness. You may cure this, by following three plain rules eat and drink little ; sleep little work much.

16 The fourth general integument is the PANNICULUS cARNOsus, which in some parts is of a fleshy substance; in others, a mere membrane, lying just under the fat.

17. The dissimilar parts arc composed of the similar. The chief of these is the HEAD. The cavity of time SKULL is nearly filled with a soft substance, termed in general, time BRAIN. But this is properly that part of it which lies forward. The hinder part, considerably smaller, is called the cerebellum. Under both, but chiefly the latter, and springing from the internal substance of both, is the medulla oblongata.

The skull is divided into two plates, one laid over the other. Between these is a spongeous substance, made of bony fibres detached from each plate. Hereby the skull is made not only lighter, but far less liable to fractures.

The skull is covered with a membrane called the PERICRANIUM. This has several holes, which give passage to the spinal marrow, the nerves, arteries and veins. But these fill them so nicely, that nothing can pass into or out of the head, but through these vessels, It is round,, that it may contain the more; but a little depressed and longish, advancing out behind, and flatted Qf the sides, which contributes to the enlargement of the sight and hearing.

It is divided into pieces by four sutures. This makes it less liable to break, gives passage to the membranes of the pericranium, and vent to the matter of insensible perspiration.

18. All these are involved in two membranes, the inner, called pia mater, extremely thin; and time outer, called dura mater, considerably harder and thicker. Where they involve the cerebellum, there is interposed between them the arachnoides, a very subtle arid transparent membrane, which descend ing through the hinder part of the skull, together with them involves the whole spinal marrow.

19. The outer part of the brain, called the cortex or bark,' is of an ashy or greyish colour. It is formed from the minute branches of the neighbouring arteries, which being wove together in the pia mater, enclose the inner part, ordinarily to the thickness of about half an inch.

It consists, therefore of innumerable little glands, contiguous to each other (supposed to secern the animal spirits), which are of themselves oval; but by their mutual pressure become angular, and run waving with each other.

The inner part, called th medulla, is white, and terminates in another medullary substance, very white and hard, called the corflus callosum. The medulla is thought to consist of fine tubes, which when collected into little bundles, and covered with membranes, are termed nerves.

20. To trace this a little farther. From every point of he outer brain arise minute fibres, which in their progress uniting together, are easily perceptible. These constitute the substance of the inner brain, and of the spinal marrow. In their farther progress they are distinguished by coats, detached

from the two membranes of the brain, into several bundles called NERVES, resembling so many horse-tails, each wrapt up in a double tunic.

Several of these part from time rest, in the brain itself, of which there are ten pair; one on each side. From the spinal marrow there arise thirty pair more. All these, while within the skull or the spine, are pulpous; but afterwards harden, acquire a coat, and spread through the smallest points of the solid parts of the body. Their coats are every where furnished with bloodvessels, lymphatics, and vesicles of a very tight texture, which serve to collect, strengthen, and contract their fibres. And if we consider, 1. The great bulk of the brain, cerebellum, and spinal marrow, whereof the whole substance goes to constitute nerves, being continued into, and ending in them: 2. The great number of nerves distributed hence, throughout the whole body: 3. That the brain and spinal marrow are the basis of an embryo, whence the other parts are afterwards formed; and lastly, that there is scarce any part of the body which does not feel or move; it may seem not altogether improbable, that all the solid parts of the body, are woven out of nervous fibres, and wholly consist of them.

21. The brain is divided into four ventricles. Near the rise of the fourth there is a round hole, over which is suspended the pineal gland, so called from its resembling the shape of a pine apple. It is furnished with veins and arteries, and enclosed in a thin membrane, derived from the Jzia mater. Des Cartes imagined this to be the seat of the soul; but without any solid reason. Nor has any one yet been able to discover, what is the use of it. Is it such a reservoir of blood for extraordinary occasions, as some imagine the spleen to be

The brain is abundantly bigger in proportion in man than in other animals. In other animals, it is commonly biggest, cteria /zari bus, in those that have most sagacity.

There are in the brain multitudes of Vessels, SO extremely small, that if a globule of blood (a million of which exceed not a grain of sand in bigness) were divided into 500 parts, those parts would be too large to pass through them. And these vessels are as large in the brain of a sparrow as in that of an ox. Nor is there any difference between the brain of a large animal and a small, but that one contains far more of these vessels than the other. But the globules of the fluid passing through them arc in all animals of the same size.

The outer part of a turkey’s brain is a very clear and transparent, oily matter. Innumerable fine blood-vessels are spread through every part of this. And if a small part is cut, there flows out a small globule of pellucid fluid.

The brain is not absolutely necessary to animal life. Infants have been born, and lived some time without any. We have an authentic account from Paris, of a child that survived the birth four days, not only without a brain, but even a head: instead of which it had a mass of flesh, somewhat like liver. In 1673, a child was born alive without any brain, cerebellum, or medulla oblongata; the skull being solid: nor had it any communication with the spinal marrow. Mr. du Verney took out the brain and cerebellum of a pigeon: yet it lived and walked about. Mons. Chirac took out the brain of a dog; yet he lived. On taking out the cerebellum, he seemed dead; but revived when he blew into the lungs, and continued alive an hour. Nay, there are many instances of insects living a long time, after their head is cut off. Hence it appears, that the spinal marrow alone may, for a season, suffice both for life, sensation and motion.

Are there distinct provisions for the vital or spontaneous, and for the animal or voluntary actions And does the cerebellum furnish the heart, and other vital organs, with nerves, while the brain supplies the nerves, which go out to the organs of sense and voluntary motion This is an elegant system, but is every where confuted by anatomy. From the cerebellum, time fifth pair of nerves is

manifestly produced; but this goes to the tongue, to the muscles of the outward ear, of the eye, and of the nose, which are parts, all of them either moved by the will, or else destined to sensation. Again, from one and the same nerve there are vital branches sent to the heart and lungs, and others that arc animal and voluntary to the larynx, or sensitive in the stomach. Lastly, the repeated accounts of injuries to the cerebellum, being so speedily fatal, are not altogether true; for that both wounds and scirrhosities of this part have been sustained without any fatality ,to the patient, may be affirmed by certain experience.

22. The EYES next offer themselves to our observation, guarded by the eye-lids, eye-lashes, and eye-brows. The eyelids consist of the cuticle, the skin, a thin expansion of the fianniculus carnosus, and an inward coat. A palisade of short, but stiff hairs grows out of their cartilaginous edge, both to break the too fierce impression of the rays of light, and to prevent any thing from getting into the eye, when open. These hairs only grow to a convenient length, and their points stand out of the way; those of the upper eye-lids being bent upward, and those of the lower, downward. Mean time the eye-brows hinder sweat, or any thing else which might be hurtful, from f ailing down from the forehead.

Both time eye-lids are moveable; but chiefly the upper. Animals which have hard eyes, as lobsters, need none, and therefore have no eye-lids. But most brutes have an additional eye-lid, called the nictitating membrane, which draws like a curtain, to wipe off what might incommode the eye. The monkey indeed has it not, as being furnished with hands like a man.

23. The eye can move upward, downward, to either side, and round, either toward the right or left. For these six motions, six muscles are allotted, which spread their tendons far' into the eye. At each inner corner of the eye, there is a gland with two or three ducts, which opening on the inner surface of the eye.. lid, keep the eye-ball moist, to facilitate its motion. By these glands, tears also are secerned. The eye is connected with the surrounding bones by the tunica adnata, commonly called the white of the eye: in the midst of which is a large hole for the tunica cornea, through which the iris and pupil appear. The whole ball of the eye rises from the optic nerve, and is formed of three coats, propagated from it, and as many humours: two of which, have each a coat of its own also. The eye therefore has five coats in all: three common, and two to contain their several humours.

24. The outermost coat, proceeding from the dura mater, and surrounding the whole eye, is termed the sclerotica: the fore-part of it being transparent like horn, is thence stiled the cornea. This is more convex than the rest of the eye. It is composed of several parallel plates, which are nourished by many blood-vessels; but so fine as not to hinder the smallest rays of light. It has an exquisite sense, that on the least touch of any thing, the tears may be expressed, to wash off any filth, which by adhering to it might render it dim or cloudy. The rest of the scierotica is opaque, and of the same colour with the dura mater.

The second coat is called the uvea. It is much thinner than 'the former, though thicker than the pia mater, from which it proceeds. In time forepart of it is a round hole, which with the chrystalline humour interposed, constitutes the pupil, surrounded by the iris, so named from its supposed resemblance to time colours of the rainbow. The third and inmost coat is termed the retina. It is extremely thin and soft, and darker-coloured than time lower part of the optic nerve, of which it is a continuation.

"If it be questioned," says Dr. Hailer, "whether the object is painted upon time retina, or upon time choroides; we answer, this late supposition is inconsistent with known observation, by which the retina is evidently a most sensible expansion of the nerve, while the choroides has only a few nerves, with small vessels, which are certainly blind. It is also opposed by the great variety of the

choroides in different animals, while the constant uniformity of the retina is equally remarkable; to which add the black membrane, that is interposed between time retina and choroides, in some kinds of fish. Finally, anatomy demonstrates, that the choroides is seated in the blind part of the eye, but is itself of a white colour."

25. The AQUEOIJS HUMOUR, resembling the colour and consistence of Water, lies in the forepart of the eye, just behind the cornea; its interior surface is convex; the other, a little concave. Whence this humour is derived we cannot tell'; but its source must be plentiful: for if the coat containing it be so wounded that all the humour runs out, it needs only to keep the eye close for a season, and the wound will heal, and the humour recruit.

Indeed an eminent Italian affirms, that he has slit the pupil of divers animals, and squeezed out all the humours, and has afterwards restored them perfectly to sight; nay, that the eyes of many, instead of being damaged thereby, seemed more lively and vigorous than before.

The second humour, termed, improperly enough, the chrystalline, consists of many thousand filaments, tending from the circumference to the' centre, and closely woven together. It is a little convex before, and more behind. It serves to refract the rays of light, so that they may meet and form an image, on the bottom of the eye. It is set in the forepart of the vitreous humour', like a diamond in its collet, and is retained there by a membrane that surrounds it, thence called its apsula. It is toward the outside like a jelly; but toward the centre as hard as salt. Time figure of tire outer part is varied by a ligament annext, which can make it either more or less convex, or move it to or from the retina. And this is absolutely necessary in order to distinct vision: for as the rays of distant objects diverge less than those of nearer objects, the chrystalline must either be made less convex, or be set farther from the retina.

When dried, it appears to consist of a vast number of thin, round scales, one upon another, 2000 of which have been counted in one chrystalline. Each of these consists of a single fibre, wound this way and that, in a stupendous manner, so as to run several courses, and meet in as many centres, and yet not interfere or cross in any place.

The third, which is termed the VITREOUS HUMOUR, is not unlike melted glass. It is covered with an exceeding thin coat. The forepart is concave, as receiving the chrystalline; the other side is convex.

The whole apparatus of the eye tends to this, that there be produced in the bottom of it, a distinct collection of all the rays, which proceeding from any point of an object, penetrate the chrystalline humour, that so an image of that object may be painted there. In order to this, the rays striking on the cornea, are reflected toward the perpendicular, and thus directed through the pupil to the chrystalline. Mean time the iris, contracting or dilating the pupil, admits fewer or more rays, as the object is more or less vivid.

Now the flatter the cornea is, the fewer rays does it collect and transmit to the chrystalline, and those more diverging. The rounder it is, the more rays does it collect and transmit, and those more converging. It is too flat In old men; it is too round in them that are short sight-sighted. Time rays transmitted through the pupil to the chrystalline humour, are there refracted anew, collected and rendered converging, and those that come from the same point, are thrown in one point on the bottom of the eye. But if the chrystalline be too dense, the focus, or point wherein they unite, will be too near; if that be not dense enough, it will be too remote. And this is another cause of short-sighted.. ness, or the contrary defect.

In all vision both the eyes are used at once. And both together (as any one will find upon trial) behold an object in another situation than either of them apart would do. Hence, a gentleman who

had one of his eyes struck out, for some months after was apt to mistake the situation of things; and when he attempted to pour liquors into phials, often poured them quite beside the neck of the phials.

Two eyes greatly contribute, if not to distinct, at least to extensive vision. When an object is placed at a moderate distance, by the means of both eyes to see a larger share of it than we possibly could with one; the right eye seeing a greater portion of its right side, and the left eye of its correspondent side. Thus both eyes in some measure see round the object; and it is this that gives it in nature, that bold relieve, or swelling, with which it appears; and which no painting, how exquisite soever, can attain to. The ‘painter must be contented with shading on a flat surface; but the eyes, in observing nature, do not behold’ the shading only, but a part of the figure also, that lies behind those very shadings, which gives it that swelling, which painters can never fully imitate.

There is another defect, which either of the eyes, taken singly, would have, but which is corrected, by having the organ double. In either eye there is a point, which has no vision, so that if one of them only is employed in seeing, there is a part of time object to which it is always totally blind. This is that part of the optic nerve where its vein and artery run: that point of the object that is painted there, must continue unseen. To be convinced of this, we have only to try a very easy experiment. If we take three black patches, and stick them upon a white wall, about a foot distant from each other, each about as high as the eye that is to observe them; then retiring six or seven feet back, and shutting one eye, by trying sometime, we shall find, that while we distinctly behold the black spots that are to the right and left, that which is in the middle remains totally unseen. When we bring that part of the eye, where the optic artery runs, to fall upon the object, it will become invisible. This defect, in either eye, is corrected by both, since the part of the object that is unseen by one, will be distinctly perceived by the other.

The form of the eye is the most commodious which can be imagined. It is fitest both to contain the humours within, and to receive the images of objects from. without. Was it square, or of any multangular form, some of its parts would lie too far off, and some too nigh those lenticular humours, which by their refractions cause vision. But by means of this form, the humours are fitly placed to perform their office of refraction, and the little darkened cell neatly adapted to receive the image of the object.

Again: as it is necessary for the eye to move various ways, in order to adjust itself to various objects; soby this figure it is well prepared for such motions, and can %Ixh ease direct itself as occasion requires.

No less commodious is the situation of the eye: in the most eminent part of the body, and near the most sensible part, the brain. By its eminence in the body, it can take in the more objects: and by ‘its situation in the head, beside its nearness to the brain, it is most conveniently placed for defence and security. In the hand it might have been more ready for service: but to how many dangers would it. have been exposed The same may be said, as to its site in any other part but where it is. But the head is a part that seems contrived and made, chiefly for the use of the principle senses.

Some odd circumstances relative to the eyes, are related by a physician in the “Philosophical Transactions.”

“A person had no visible disease in his eyes, yet could not see, unless he squeezed his nose with his fingers, or saddled it with narrow spectacles, and then he saw very well.

“A maid, 23 years old, could see very well, but no colour besides white or black. She could sometimes, in the greatest darkness, see to read almost a quarter of an hour.

“A saddler’s daughter had an imposthume, which broke in the corner of her eyes; and out of it there came about thirty stones, as big as small pearls.

“A young man in Suffolk, about twenty years of age, has. all the day a clear and strong sight. But when twilight comes, he is quite blind; nor can he see any thing at all, either by fire-light or candle-light. No glasses give him any help. He has been thus, ever since he can remember. This cloudiness comes gradually upon him, like a mist, as day-light declines. It is just the same, both in summer and winter, and at all times of the moon.

“When I was about sixty my sight was so decayed, that I could not distinguish men from women. I received no help from any glasses, till I took spectacles with the largest circles. Close to the upper. semicircle on both sides, I cut the bone, and taking out the glasses, put black Spanish leather, taper-wise, into the emptied circles. These took in my whole eye at the wider end, and through the nai’rower end I can read the smallest print. Into this end I can only put my little finger, not quite to the first joint. But they may be made wider or narrower, and longer or shorter, as best fits every eye.

“At first I could not bear them above two hours at a time: now I can use them above twelve hours in twenty-four. And they prove a great help to those who are purblind, who have weak eyes, or decayed with age. But for’ the purblind they must be made shorter: longer for eyes. decayed with age.

“Instead of leather, they may be made of paper, coloured black and pasted on; and with inner folds to be drawn out, from one inch to three.”

In some men the iris has a faculty of darting out light. Dr. Willis mentions one, who, after drinking wine plentifully, could see to read in the darkest night. And Pliny records of Tiberias Cesar, that if he waked in the night, he could see every thing for awhile, as in the broad day-light. Dr. Briggs gives a parallel instance of a gentleman in Bedfordshire.

We find various substitutes for the use of the eyes, in many blind persons. In. some the defect has been supplied, by an excellent gift of remembering what they had seen; in some by ft delicate sense of smelling; in others, by a fine sense of hearing. So Richard Clutterbuck, of Redborough, in Gloucestershire, who was stone-blind, had so curious an ear, that he could hear the fine sand of an hour-glass fall. In some it has been supplied by an exquisite sense of feeling: so that the same Richard Clutter-buck was able to perform all sorts of curious works. lie could not only take a watch in pieces, and set it together again, but could also make all sorts of stringed instruments ol music. He likewise played on them by notes cut in their usual form, and set upon protuberant lines on the wood. Yet even this hardly came up to the skill of Van Eyck, the organist of Utrecht, who, though he had been blind from two years old, played on all sorts of instruments,

Others have been able to take a face by the touch, and mould it in wax with the utmost exactness: as was the blind sculptor, who thus took the likeness of the duke de Bracciano, and made a marble statue of king Charles the first, extremely well.

26. But more than all this, some persons have been able ‘even to distinguish colours by the touch. Peter of Maestricht, though perfectly blind, distinguished by his touch the different colours of cloth. John Vermaasen, of Utrecht, did the same; judging by the different degrees of roughness which he felt.

Yet blind persons, even though they distinguish them by the touch, have no idea of visible objects. Thus the gentleman couched by Dr. Chesselden; he had no idea of distance, but imagined all the objects he saw, touched his eyes, in the same manner as those he felt did his skin.

An extract from Dr. Chesselden's account of this person, will not be unacceptable to the curious.

" This young gentleman could, in a strong light, distinguish black, white, and scarlet. Yet tire faint ideas he had of them before he was couched, did not suffice to make him know them after. He now thought scarlet the most beautiful of all colours. Of others, the most gay, were the most pleasing. But the first time he saw black, he was very uneasy; yet after awhile he was reconciled to it. When he first saw, no objects were so agreeable to him as those that were smooth and regular: although he knew not the shape of any thing, nor could distinguish one from another, either by its shape or size. Being told what those things were, whose forms he knew by feeling, he would carefully observe, that he might know them again. Thus having often forgot which was the cat and which the dog, he was ashamed to ask; but catching the cat, which he knew by feeling, he looked at her stedfastly, and said, " So, puss, I shall know you another time." He was surprised that the things or persons he liked best, did not appear most agreeable to his sight, expecting that what was most pleasing to his other senses, would be so to his sight also.

We thought he soon knew the nature of pictures; but found afterward we were mistaken: for' it was two months after the operation, before he discovered that they represented solid bodies. Even then he was no less surprised, expecting they would feel like the things they represented. He was amazed, that those parts, which by their light and shade appeared round and uneven, should feel like the rest, and asked, which was the lying sense, feeling or seeing Being shewn his father's picture, drawn in miniature, and told what it was, he acknowledged the. likeness; but asked, how it could be, that so large a face should be contained in so little room Saying, it would have seemed as impossible to him, as to put a bushel of any thing into a pint. But even blindness, he observed, had this advantage, that lie could go any where hi the dark, better than those that could see. And after' he was couched he did not lose it, but could go all about the house without a light. Every new object gave him new delight, such as he wanted words to express. He was particularly delighted when he first saw a large prospect, and called it a new kind of seeing. Being afterwards couched in his other eye, he said that objects appeared larger to this eye; though not so large as they did to the other, when it was newly couched. But looking on them with both eyes, they seemed twice as large as if he looked with that only."

27. I would beg leave to propose a few queries here, to which I have not found a satisfactory answer.

1. Why do we see things false with one eye Particularly with regard to their situation.

2. How do the two eyes compound the rays of light, so as to see right

3. Why do we not see all things double

4. Since all things are painted upside down on the bottom of the eye, why do we not see them so

28. We now proceed to the EAR, formed with exquisite wisdom, for the reception of sounds. The OUTWARD EAR consisting of an oval cartilage, externally convex, concave within, leads by various windings to tire meatus auditorius, which is first catilaginous, and then bony. It is filled with a viscid matter, called the EAR-WAX, which is supplied from the vessels placed in the skin, surrounding the meatus, to hinder any hurtful animal from creeping into tire car. The meatus is

closed within by a thin, dry, transparent membrane, affixt to a bony circle, which is called the membrana tympani. Behind it is that cavity of the os petrosum, which is termed the DRUM.

The outward ear has two parts, that which stands out from the head, called the AURICLE, and the narrow passage which enters the skull, called meatus auditorius.

The auricle is furrowed with divers winding canals, which receive and collect the various undulations of the air. They who have lost this, hear very confusedly, unless they use a trumpet, or form a cavity round the ear with their hands.

It is a wise provision, that tire substance of the auricle is cartilaginous. Had it been bone, it would have been troublesome, and might by many accidents have been broken off. If flesh, it would neither have remained expanded, nor so well have received or conveyed the sounds. Rather it would have blunted them, and retarded their progress into tire organ. But being hard, and curiously smooth and winding, sounds find an easy passage, with a regular refraction, as in a well-built arch.

It is observable, that in infants in the womb, and newly-born, the meatus auditorius is close shut up, Partly by the construction of the passage, and partly by a glutinous substance, whereby the drum is guarded against the water in the secundine, and against tire injuries of the air, as soon as the infant is born.

It is remarkable, that in the ear of most, if not all animals, where the meatus auditorius is long enough to afford harbour to EAR-WIGS, or other insects, ear-wax is constantly to be found. But in birds, whose cars are covered with feathers, and where the drum lies but a little within the skull, no car-wax is found, because none is necessary to the ears so well guarded, and so little tunnelled.

29. In this, besides a little branch of nerves, there are four little bones, two passages, and two windows. Three of those bones, from some imagined resemblance, are stiled the hammer, the anvil, and the staple: the fourth is termed, the orbicular bone. These are fastened by strong ligaments to each other, and to the neighbouring parts. The passages go from the side of the drum: one of which, termed the labyrinth, by a very winding way, carries a part of the auditory nerve to the external muscles of the head. The other passes from the bottom of the drum to the palate; whereby not only air, if needful, may be received, but the defect of hearing, in some measure supplied by speaking to the mouth,

The LABYRINTH contains, besides the entrance, three bony, semicircular cavities, and a bony canal, in the form of a screw, divided into two parts, from the top to the bottom. The labyrinth is lined throughout with a thin membrane, furnished with veins, arteries and nerves. And this membrane may not improbably be the organ of hearing.

The curious structure of the labyrinth and screw, tend to make the weakest sounds audible. Those canals, by their winding, contain large portions of the auditory nerve, upon every point of which, at once the sound being imprest, becomes audible; and by their narrowness the sounds are hindered from dilating, which. must have weakened them proportionably.

The strength of the impression is likewise increased, by the elasticity of the sides of the bony canal; which receiving the first impulses of the air, reverberate them on the auditory nerve.

The AUDITORY NERVES are distributed, one to the ear, the other to the eye, tongue, and parts adjoining. By the distribution thereof to different parts, an admirable consent is established between them. Hence it is, that most animals hearing a strange sound, erect their ears to catch it, open their eyes, and are ready with their mouth, to shriek or call for help. A farther use of this

nervous communication between the ear and the mouth, is, that the voice may correspond with the hearing, and be a kind of echo thereof: and that what is heard with one of these nerves, may readily be expressed by the help of the other.

And now, what less than an infinitely wise God, could contrive so fine an organ, and such a medium, so susceptible of every impression, that the sense of hearing hath occasion for, to empower all animals to express their meaning to each other, with endless variety Yea, what less could form such an economy as that of music is So that the medium conveys the melodious vibration of every animal voice or well-tuned instrument, and the ear receives them, to allay the perturbations, and calm and cheer the heart of man!

Though the ear be the ordinary organ of hearing, yet it is not the only one. We may hear by the teeth: for if one end of a knife be applied to a spinnet, and the other held between the teeth, the music will be distinctly heard, though the ears he ever so closely stopped. Yet this is not properly by the teeth, but by the auditory nerve which passes from the drum to the palate.

In those who are born deaf, the eyes may in some measure serve in the place of ears. Some can understand what is said, by nicely observing the lips and tongue of the speaker: and may even accustom themselves to use their own, till they learn a kind of speech. Thus a physician at Amsterdam taught several children, born deal;, to understand what was said, and to give pertinent answers.

Mr. Goddy's daughter, of Geneva, lost her hearing at two years old. Yet by observing the lips of others, she had acquired many words, whereby she would talk whole days with those that could understand her. But she knew nothing of what was said, unless she saw the mouth of the speaker: so that if they wanted to speak to her in the night, they were obliged to light a candle. Only she knew what her sister said even in the dark, by laying her hand on her mouth.

But.' many deaf persons can hear, if a loud noise be made while you speak. Dr. Willis mentions one, who, if a drum was heat in the room, could hear very clearly. So that her husband hired a drummer for his servant, and by that means conversed with her daily.

30. The NOSTRILS are made not of flesh or bone, but of cartilage, the better to be kept open, and as occasion requires, to' be dilated or contracted: for which purpose they are furnished with proper and curious muscles. The tubes therein growing narrower and narrower, lead into several little cells and winding cavities, covered with a soft coat, and provided with arteries, veins, glands, and filaments of the olfactory nerves. This therefore is without all doubt the proper organ of smelling.

And forasmuch as it is by breathing, that the odorant particles are drawn in, the laming with which the upper part of the nose is barricaded, serve two excellent purposes; partly to prevent any thing hurtful from entering the breathing passages in our sleep, for which end likewise the hairs placed at the entrance of the nostrils serve, and partly to receive the divarications of the olfactory nerves, which are here thick spread, and by this means meet the smells entering with the breath.

Each of the CARTILAGINOUS LAMIN is divided into many others, folded into a spiral line. The os cribro8um is made up of the extremities of these; the holes therein being the intervals between them. They are designed to uphold the inner tunic of the nose, which is folded round about together with these lamina that by its great expansion it may receive a greater number of the odorant particles. For the same reason, it is furnished with many small glands, which open into it, and moisten it with a slimy exsudation, fitted to entangle and detain the subtile effluvia that touch it. And not only the number, but also the length of these lamin, is of great use for the strength of

smelling. Fr this purpose most beasts, which either hunt, or distinguish their food by smell, have not their nose in the middle of their face, like a man, but prolonged to the very end.

31. The TONGUE has for its basis that forked bone, called the os gutturis. It consists of various muscles interwoven together, that it may be fit for various kinds of motion. To these are added very many small branches of nerves, which pass through time middle of it to the outside, and being gathered into little bundles constitute those papilla, which makes its surface rough and uneven. Besides these, there appear also on the surface of the tongue, certain pointed fibres, not unlike the ends of birds' claws, inclining toward the basis of it, with which are interspersed innumerable salival glands. And all these are in their several ways subservient to the sense of tasting.

It has been generally supposed, that the tongue is essentially necessary to the formation of speech. But as sure as we have been of this, it is an entire mistake. A child in Essex, sonic years ago, had her tongue entirely cut out, by reason of an incurable canker. She was then three years old. Twenty years after, it was reported, that she was able to speak. To be satisfied hereof, Mr. Benjamin Boddington, Turkey-merchant, of Ipswich, with two other gentlemen, went to. Wickham Market, where the young woman then lived, whose case they thus describe.

" We have this day been at Wickham Market, to satisfy ourselves concerning Margaret Cutting. We examined her mouth with the greatest exactness, but found no part of the tongue remaining; nor was there any uvula. The passage down the throat is a circular open hole, large enough to admit a small nutmeg.

"Notwithstanding this, she swallowed both solids and fluids, as well as we could do. and in the Same manner. Yea, and she talked as fluently as other persons do. She pronounced letters and syllables very articulately, even those which seem necesšarily to require the help of the tongue, as d, 1, t, w. She read to us in a book distinctly; she sings very prettily; nay, and she distinguishes tastes, and can tell the least difference either in taste or smell."

But is it possible to teach any one to speak, who has been deaf and dumb from his birth

It is. Dr. Wallis taught such an one to speak: Mr. Daniel Whaley, of Northampton. He was present before the royal society, May 21, 1662, and did there pronounce, distinctly enough, such words as the company proposed to him: indeed not altogether with the usual tone, yet s as easily to be understood. In a year, which was the time he stayed with Dr. Wallis, he read over great part of the English bible, and learned to express himself intelligibly in common affairs, to understand letters written to him, and to answer them. And in the presence of many foreigners, he has not only read English and Latin to them, but has pronounced the most -difficult words in their languages, which they could propose to him.

The doctor has since done' the same for Mr. Alexander Popham, a gentleman of a fair estate.

But we have an instance of dumbness cured in a .shorter time. Henry Axford, son of Henry Axford, in the Devizes, at twenty-eight years of age, perceived a hoarseness, and in about six days became quite speechles; not only unable to speak articulately, but to utter the least sound with his tongue. His cold went off, but he remained absolutely speechless; and the advice of all the neighbouring physicians did not help him.

He continued totally dumb for four years, till in July, 1 741, being at Stoke, in returning homeward at night, he fell from his horse, and was taken up and put to bed in a house on the road. He soon fell asleep, and dreamed he was fallen into a vessel of boiling wort. Struggling with all his might to

call for help, he actually did call aloud, and recovered the use of his tongue from that moment, as perfectly as ever he had it in his life.

Perhaps, therefore, there is truth in that ancient story, concerning the son of king Croesus: namely, having been dumb from his birth, he never had spoke at all, till in the battle, seeing a man ready to kill his father, his tongue was loosed, and he cried out aloud “soldier, spare the king !“

The time of cutting the teeth is usually from the seventh to the seventeenth month. It is commonly preceded by an itching of the gums, and by convulsions, fevers, and looseness: most of which symptoms happen to birds also, upon moulting or casting their feathers. The seed of the teeth is a mucous matter, like the white of an egg, contained in the cells of the jaw-bone, which grows harder and bigger till it breaks through the gum.

The part of the tooth which stands out of the gum, is covered with a peculiar substance called ENAMEL. It is composed of an infinity of little tubes, which grow on the bone by their root. If any part of this be broken off, so that the bone be left bare, it grows carious; there being no bone which will bear the air.

We may farther observe, 1. That the teeth only, of all the bones, grow in length during a man’s whole life: which is providentially designed, to repair the waste that is continually made by attrition; 2. That the teeth are the only bones which are not covered with that exquisitely sensible membrane, the perios teum; 3. That they are harder and firmer than any other bone, that they may be more durable and fit to chew the most solid aliments; 4. That for their nourishment, there is a cavity contrived in each side of the jaw-bone, in which are lodged an artery, a vein, and a nerve, which through smaller cavities send their twigs to every tooth; 5. That as infants are designed to live on milk for some months, they are so long without any teeth:

whereas animals that need them, have them sooner, and some are even born with them. 6. The different shape of the teeth is remarkable: the fore-teeth are formed broad, and with a thin and sharp edge, like chissels, to cut off a morsel from any solid food. The next, one on each side, are stronger, deeper-rooted, and more pointed, to tear tougher aliments; the rest are made fiat and broad at top, and withal somewhat uneven, that thereby they may retain, grind and mix the aliment. 7. Because biting and chewing require much strength, partly in the teeth themselves, partly in the instruments that move the lower jaw, which alone is moveable; nature has given it strong muscles, which make it bear forcibly against the upper jaw: and has not only fixt each tooth in a distinct cavity, as in a close, strong and deep socket; but has given holdfasts to the several sorts of teeth, suitable to the stress that is to be laid upon them. So whereas the cutters and eye-teeth have only one root, the grinders, designed for harder work, have three: in the upper jaw often four, because they are pendulous, and the substance of the jaw somewhat softer. 8. The situation of the teeth is most convenient. The grinders are behind, near the centre of motion, because chewing requires a considerable force: the cutters before, ready for their easier work.

32. The PALATE is of a bony substance, .a little concave, anti clothed with a thick membrane, which has the same kind of nervous papilla and small glands, that are seen in the surface of the tongue; and hence it is qualified to assist the taste as well as the speech.

It would be endless to specify the curious mechanism of all the parts that concur to form the voice; however let us note two things: 1. There are thirteen muscles provided for moving the live cartilages of the wind-pipe. 2. It is amazing that the glottis (the upper part of the wind.pipe), can so exquisitely contract or dilate itself, to form all notes. “ Suppose,” says Dr. Keil, “the greatest distance of the two sides of the glottis to be one-tenth of an inch, in sounding twelve notes, to which the voice easily reaches, this line must be divided into twelve parts, each of which gives the

aperture requisite for such a note. But if we consider the subdivision of notes into which the voice can run, the motion of the sides of the glottis is still vastly nicer: for if of two chords, sounding exactly unisons, one be shortened but the two-thousandth part of its length, a just ear will perceive the disagreement, and a good voice will sound the difference; and yet this is only the one-hundredth and ninety-sixth part of a note. But suppose the voice can divide only into a hundred parts, it follows, that the different apertures of the glottis, actually divide the tenth part of an inch, into twelve hundred parts, the effect of each of which produces a sensible alteration upon a good ear."

33. The UVULA is a round, oblong, fleshy substance, suspended near the passage from the mouth into the nostrils, and probably designed to hinder the cold air from rushing too fast into the lungs, as well as to prevent the food we swallow from regurgitating into the nostrils.

The TONSILS, or almonds of the ear, are two small glands, placed at the root of the tongue, which supply an humour, to keep the mouth and the tongue continually moist.

The WIND-PIPE is wonderful in its conformation, because con tinual respiration is necessary; it is made with annular cartilages, to keep it constantly open, that its sides may not fall together; and lest, when we swallow, any particle of food should fall in, which might cause convulsions, or even death, it has a strong shutter, or lid, called the epiglottis, which, whenever we eat or drink, falls down of itself, and covers it close, so that no crum or drop can enter. It is for the more convenient bending of our necks, that the wind-pipe is not made of one entire continued cartilage, but of many circular ones.

What is farther remarkable in these cartilages is, that all the way where they are contiguous to the gullet, they are membranous, to give an easy passage to the food; but after that, they are, some completely round, some triangular. Another thing observable is, in the wind-pipe, the cartilages run parallel to each other; but, in the lungs, the lower-parts of the superior cartilages, receive the upper parts of the inferior: hereby enabling them to contract themselves in expiration, and to dilate in inspiration.

34. The HAIRS all hollow. The root of each hair is fixt in a mucous globule, of an oval figure, which often adheres to it, when it is pulled up by the root. They are jointed like a reed or cane, and shoot out into small branches. They serve not only for a covering, but also for the excretion and expiration of an oily matter.

Every hair does properly live, and receive nourishment like the other parts. The roots do not turn white or grey in age, any sooner than the extremes; but the whole of each hair changes colour at once. Or, to speak more properly, the hairs of another colour fall off, and white ones grow in their place.

But extreme fear may turn the hair grey, or even white in a short space. So it was in that famous instance some years ago. A nobleman, in Germany, was condemned to die, and ordered for execution in the morning. During the night, in ten or twelve hours time, all his hair turned white as flax. The emperor being informed of this, said, "he has suffered enough ;" and pardoned him.

Since that time, there has been an instance of one of our own countrymen, who being ship-wrecked, saved himself on a small rock, surrounded by the sea. A boat took him off after he had stayed there four hours. But in that space his hair was turned quite white.

Perhaps a still stranger instance of this kind is related in the duke of Sully's memoirs. "Henry IV. told the marquis De ha Force, that the moment he was informed Henry the III. had published an

edict (in July, 1585), ordering all the Hugonots either to go to mass, or to abandon the kingdom in six months, his mustaches tm-ned suddenly white on that side of Ins face which he supported with his hand."

Its life is a peculiar kind, and approaches to the nature of vegetation. Hairs grow much as plants grow out of the earth, or as some plants grow upon others: from wimich they draw their nourishment, and yet each has its life distinct from the other. So hair derives its food from some juices in the body; but not from the nutricious juices. Accordingly the hair may live and grow, while the body is starved to death,

That hair may grow, merely as an excressence of the vegetable kind, appears from that memorable case recited by Mr. Hook, of a body which, having been buried forty-three years, was found in a manner wholly converted into hair. The woman was buried in a coffin of wood, and lay the lowest of three in the same grave. Time others being removed, and this coffin appearing, it was observed that much hair came though the clefts of it; on removing the lid, the whole appeared a very surprising sight. There was time whole figure of the corpse, exhibiting time eyes, mouth, ears, and every part. But. from the crown of the head, even to the sole of the foot, it was covered over with a very thick set hair; long, and much curled, The people, amazed at this appearance, went to touch the corpse; but the shape fell away, as it was handled, leaving only a quantity of shapeless hair; but neither flesh nor bones, only a small part of the great toe of the right foot.

Each hair consists of several smaller ones, wrapt up in one common covering. They send out branches at the joints. The root lies pretty deep in the skin: and by this they imbibe their proper nourishment, from the adjacent humours. Their extremes also split into two or three branches, especially if they are very dry, or too long. So that what appears a single hair to the naked eye, to the microscope appears a brush. They are grey on the fore part of the head first, particularly about the temples: the back part affords them nourisimment longer. For the same reason they fall from the crown of time head first. Their thickness depends on the size of the pores they issue from: if these are small, the hair is fine, If the pores be straight, the hairs are straight; if oblique or sinuous, the hairs are curled.

All hairs appear round. But the microscope discovers some of them to be square, others triangular; which diversity of figures arises merely from the diversity of the pores. Their length depends on the quantity of homours proper to feed them, and their colour on the quality. And hence the colour usually differs in the different stages of life.

The hair of a' mouse is a transparent tube, with a pith of small fibres convolved, running in some hairs spirally, in some transversely, in others from top to bottom.

The NAILS are of the nature and fabric of the cuticle, like which, they are also insensible, and renewable, after being cut or fallen off. They are placed upon the backs of the ends of the fingers and toes, which they support to make a due resistance in the apprehension of objects, having the nervous papillary bodies, that serve the organ of touch, placed under their lower surface. They arise with a square root, intermixed with the periosteum, a little before the last joints, from betwixt the outer and inner stratum of the skin, and, passing on soft, go out by a lunar cleft in the external plate of the skin, where the cuticle returns back, and enters into a close adhesion with the root of the nail, together with which it is extended as an outer covering.

35. We proceed to the middle cavity of the body. Herein the principal part is the HEART, consisting of a strong tendon, extended obliquely from the basis or broader part, to the cone, into which ,the fleshy fibres are inserted, in an elegant series, with a spiral bending, one half opposite to, and crossing the other: by which means the grand muscle is admirably fitted both to receive and to

propel time blood. It has two great cavities, usually termed the vENTRICLES of the heart. They are divided from each other by an intermediate part called the septurn, constituted by the same fibres, which is convex on the side next the right ventricle, and concave on time other. The vena cava is inserted in time .right ventricle, and two inches from its insertion, divides into time upper and lower. The former brings the blood into it from tile upper; the latter, from the lower parts of the body. The PULMONARY ARTERY carries the blood from that ventricle into the lungs, which the PULMONARY VEIN brings from thence into the left ventricle. At the upper side of these veins, ,there is added to each ventricle, a kind of purse called the AURICLE, which is a hollow muscle of the same structure as the heart, in order to stay the blood, that it pour not too violently into the ventricle. Before the orifices of the veins of the heart, there are triangular valves', and semilunar in the orifices of the arteries, to hinder the reflux of time blood, from the ventricles into the veins, and from the arteries into the ventricles In a healthy person, the heart contracts little less than five thousand times in an hour.

36. The heart is covered with a fine membrane; and near the base of it, on the outside, there is a little fat, probably designed to facilitate its motion. It is placed near the middle of the breast; only its cone inclines a little to the left: It hangs by its base on veins and arteries, communicating with all parts of the body. The other part of it is loose in the PERICARDIUM, that it may be the more commodiously' constringed arid dilated. The pericardium is a kind of membrane, that like a kind of purse, loosely encloses the heart. The shape of it is suited to that of the heart, and it contains a thin, saltish, reddish humour, exuding from the arteries.

The brain has an alternate contraction and dilation, answering those of the heart- It is highly probable, the weight of time atmosphere is the counterpoise to the contractile force of the heart. That of the brain being not near so strong, does not need so strong a counterpoise.

In the basis of the heart, in some animals, there is a bone frequently found. Such an one was found in the heart of pope Urban. Probably it was only the tendons of the heart ossified.

Wounds of the heart are not always so immediately mortal as is generally supposed. A soldier was brought into one of the hospitals in Paris, with a wound in the upper part of the left breast. lie seemed very well for three days: but on the fourth was taken with a fever and difficulty of breathing, and died on the tenth. On 'opening the body, it was found the sword had pierced the pericardium, traversed the right ventricle of the heart in its lower part, pierced the pericardium on the opposite side, and gone through the diaphragm, and an inch deep into, the liver.

37. The heart is placed in the middle of the LUNGS, which consist of two parts, the right and left lobe. Each of these is divided into two other lobes; one of these frequently into three, sometimes into four, by fisures, sometimes deeper, sometimes shallower, running from the interior margin towards the back part. The lungs are divided into cells, which are no other than expansions of the small branches of the trachea or wind-pipe. And there is an easy passage from one branch into many cells, and again into it from them all. Time upper part of the trachea opens into the mouth; the lower, divided into two branches, shoots out into various ramifications, which are termed bronchia. And these little canals running on, constitute the lungs, whose cells are wonderfully connected together, and intermixed with numberless branches of veins and arteries.

The upper end of the trachea is called the LARYNX. At the fourth vertebre of the back, it divides and enters the lungs. Its cartilages, ranged at small and equal distances, are smaller and smaller as they approach the lungs.

These cartilages have two membranes. The external, composed of circular fibres, covers the whole trachea. That which lines it within, consists of three distinct membranes: the first woven of two

orders of fibres, part longitudinal, to shorten it by drawing the cartilages together; part circular, to contract them. Both these together, with the external membrane, assist in breathing, coughing, and varying the tone of voice. The second membrane is glandulous; and its glands opening into time cavity of the trachea, separate a liquor which moistens and defends it from the acrimony of time air. The third is a net-work of nerves, veins, and arteries.

The organs which form the voice of man, have not been accurately observed by the ancients. As the trachea bears some resemblance to a flute, they considered the voice according to the sounds of that instrument. Mr. Dodart was the first who she wed the glottis to be the chief organ in producing it, and considered it both as a string and wind instrument, far more perfect than any which art can produce.

The organs which form the various voices of other animals, are likewise worthy of our attention. Those of each species have peculiar sounds, whereby they understand each other. Wherein do these organs resemble ours and wherein do they differ

The human voice is almost wholly formed by the glottis, and various tones are produced by time various modifications of it. But all these. depend on one only: the separation and junction of its lips. This comprehends two circumstances, time one capital and primitive; time other, a consequence of it. The first is, that the lips are more and more bent, from the lowest to the highest note. The second, that the more they bend, the nearer they draw to each other. It follows from the first, that their vibrations will be more frequent, as they come nearer the highest tone, and that time voice will be exact when they are equally bent, and the reverse when unequally: which corresponds perfectly well with the nature of stringed-instruments. It follows from the second, that the higher the tone, the nearer they draw to each other. And this agrees perfectly with those wind-instruments which are governed by reeds. From these simple, and almost imperceptible variations, proceed the infinite variety of sounds.

In most quadrupeds too the glottis is the principal organ of the voice. So it is in cats, sheep, and several others. But many have something more than a glottis; as horses, asses, mules, and Swine. Some of these have also a tendinous membrane, which concurs in forming the voice. 0thers have several membranes; others a kind of bags, which in some are membranous, and in others bony. Others have both membranes .and bags. Others, lastly, have in their larynx a kind of cavity or drum, which assists them in uttering very strong and long continued notes.

All sounds are produced by a swift succession of vibrations, from the particles of sonorous bodies, which agitate the air. But the vibrations of the lips of the glottis would not suffice to produce the neighing of a horse. This begins by more or less acute interrupted tones, accompanied by quaverings, and ends by tones more or less grave, which is performed by jirks. This second part is. done by the lips of the glottis; the other chiefly by a small, elastic membrane. This is tendinous, very thin, of a triangular figure, and lies fiat on each extremity of the lips of time glottis. As it adheres but loosely to these, it can easily flutter up and down; and it is the play of the membrane up' and down which produces the acute sounds of neighing. These are more or less acute, as the membrane is more or less thin, and its adhesion more or less slack. The grave sounds that conclude the neighing, are excited by the fluttering of the thick strings which form the lips of the glottis.

The hoarse sound of the ass's voice, is not so much produced by the lips of the glottis, as by a tendinous part which adheres loosely on the aperture of a kind of drum, situate under the extremity of time lips of the glottis: above which are also found two large and thick bags, one on the right, the other on the left. Each of these has a roundish aperture, cut much like the stopple of an organ.

Such are the organs which form this amazing sound. A kind of drum is the principal; and the two bags above the lips of the glottis arc the main auxiliaries; while those lips, as plain experiments shew, contribute very little thereto. The mule's voice much resembles that of his sire, and is formed by much the same organs: the drum, of so singular a composition, being found in mules also.

There is another animal which affords us a particular disposition of the vocal organs. T his is the hog; whose shrill cries are more insupportable than his usual grunting. Yet neither are these excited by the lips of the glottis, but by the fluttering of two large membranous bags, situated on each side, above the lips of the glottis. What is most remarkable is, that each lid is cloven, almost its whole length. By this cleft each lip has a communication with the bag belonging to it; and the motions of these bags produce most of the sounds peculiar to this animal.

Though the voice of birds bears a nearer resemblance to ours, than that of quadrupeds, yet their organs have far less resemblance to ours, and contain a greater number of singularities. They, like us, have a glottis at the top of the trachea; but they have another at the bottom of it, which much contributes both to the strengthening and modifying of their voice. These have different membranes more or less fine, more or less bent, and in a variety of positions. In some birds, as in geese, there are four of these, figured and disposed like the reeds in hautboys.

With regard to the human voice, an ingenious man observes:

" Sitting in company, I chanced to take notice, that in ordinary discourse, all that is spoke, is spoken in perfect notes; and that some of the company used eighths, some fifths, and others thirds. I observed likewise of him whose speech was the most pleasing, that all the tones he used, consisted either of concords, or of such discords as made up harmony."

'Cutting the trachea was long reputed mortal: but it is now usual to open it in dangerous quinsies. This, physicians were at first encouraged to do, from the case of a Cornish gentleman, who had his wind-pipe quite cut through, and yet was cured and lived several years after.

38. In order to the admission and expulsion of the air by the lungs, it is necessary the breast should be contracted and dilated. This end is served by the bony part of the THORAX, the INTERCOSTAL muscles, and the DIAPHRAGM a broad, muscular part, reaching across the breast, and dividing the middle from the lower cavity. It runs obliquely from the aternon and ribs before, to the vertebra of the loins behind.

39. The whole thorax is covered on the inside with a firm, white membrane, called the PLEURA. It is double throughout, consisting of two folds: the innermost whereof has a smooth surface, that it may not hurt the tender substance of the lungs; the surface of the outer is rough and uneven. From the pleura rises the MEDIASTINUM, which is a double membrane, that divides the lungs and the cavity of the thorax lengthways into two parts.

40. On the slightest observation we cannot but acknowledge, the consummate wisdom wherewith the external parts of time middle cavity are formed, for beauty, as well as for the defence of the internal. This is commodiously connected with the head, by the neck. The BREAST, or fore part of the thorax, which begins at the throat, and ends at the STERNON, or breast-bone, is an admirable guard to the noblest parts. To the same end serve the SHOULDER-BLADES and the BACK-BONE, as well as to support the whole fabric.

The BREASTS consist of numberless oval glands, intermixed with globular vessels of fat. Their ducts, as they approach the nipple, unite together, till they form eight or more small pipes,

communicating with each other by cross canals, which are of great use, when some of them happen to be obstructed. These tubes are in some parts narrower, in some wider, so as to form cells, which hinder the efflux of the milk. The PAPS consist chiefly of the concurrence of these tubes, but with a glandulous substance intermixt. There are likewise joined herewith abundance of fibres, from the external teguments of the breasts, by means of which the tubes are constringed, and the motion of the milk is modified.

In virgins, the glands of the breasts are so contracted, that no blood can enter them. But when the womb swells with the foetus, and compresses the descending trunk of the great artery, the blood forces its way into them. They admit thicker and thicker serum, till after the birth, they run with a thick milk,

It is more difficult to account for the milk which some men have in considerable plenty. Thus in the year 1684, a countryman, called Billardino di Billo, living in a village near Nocoera, in Umbria, when. his wife was dead, 'took the child, and put the pies of his breasts into its mouth, invited it to suck; which the infant did, and after several times drawing, fetched some milk. After a while it brought down the milk so plentifully, as to nourish it for many months till it was weaned.

Almost as strange is the following account: " One informing me of an old woman that gave suck, I went to the house in Tottenham-court-road. Her name is Elizabeth Bryan. She is in the 68th year of her age, and has not borne a child for many years: her face is withered, her cheeks and mouth sunk in: but her breasts are full, fair, and void of wrinkles. About four years ago, her daughter was obliged to leave an infant she gave suck to, in the care of her mother. The old woman finding the child forward for want of the breast, applied it to her own. Having done this. several times, her son thought the child seemed to swallow, and begged his mother, he might try, if she had not milk; it soon appeared she had; and she then continued to suckle the child in earnest. Two year's after, her daughter had another child; on which the grandmother weaned the first, and suckled the second. Both the children are healthy, plump, and firm in flesh, and as brisk and lively as can be desired."

41. In the lower cavity first occurs the STOMACH, with the OESOPHAGUS or GULLET, which reaches to it from the mouth. The right orifice, called the zylorus, transmits the digested food to the intestines. It is narrower than the other, as being designed to transmit nothing, till it is reduced to a kind of liquid. And it goes by a long and oblique descent into the duodenum, that the chyle may not pass out, either too swiftly or too slowly.

The upper opening of the stomach, is compressed in such a manner, by the lower muscle of the diaphragm, in every inspiration, as to confine the food within the stomach, and direct it in every respiration, towards the pylorus. By this means this office of the stomach, is so closely shut, as to confine even wind or vapours within the cavity of a healthy stomach, from whence they never escape but by' a morbid affection.

The fabric of the stomach answers to that of the oesophagus, of which it is an expansion. 1. The outmost coat is from the peritoneum, of considerable strength, so as to limit the extension of the rest, and afford a support to the subjacent muscular fibres. 2. The cellular coat lies immediately under the former, whence the outer and muscular tunic closely cohere together; in this substance the larger branches of the vessels are distributed. Next in order appears, 3. the muscular coat, Here, the longitudinal fibres of the oesophagus, coming to the stomach are detached one from another in all directions.

Immediately under the muscular fibres, follows, 4. another cellular stratum, larger than the outermost, softer, more easily in'flatible, and consisting of larger vessicles than what we usually observe, even in the intestines. Within this cellular substance are spread the small vessels, which,

coming from the larger branches of the stomach, enter through its muscular coat, and spread internally after the manner of a plexus. Under this lies, 5. the nervous coat, which is thick, white, and firm, and makes up the true substance of the stomach itself; and this is again lined internally with a third cellular stratum, whose vascular net-work is much more minute than that of the former, from whence it is derived. Immediately within this lies, 6. the villous or velvet-like coat, that lines the cavity of the stomach itself, contiguous with the external cuticle, like which it is renewable, but of a soft, mucous texture, and extended into a very short pile, like that of the tongue, only less conspicuous, and folded into large plates.

42. The INTESTINES are a Continuation of the alimentary tube from the pylorus, wound together in various wreaths, yet without confusion, and to keep them in their situation, fastened together by the MESENTERY, a strong membrane, which fastens them also to the back. The intestinal duct is really but one; but because the parts of it differ in figure and use, the upper part of it, divided into the duodenum, jejunum and ileum, is termed the SMALL GUTS; the lower part, divided into the coecuin, colon and rectum, is called the GREAT GUTS. All these are full of turnings and windings, especially the small, that the more subtle part of the chyle, both through the length and narrowness of the passage, and the agitation of the intestines, may enter the lacteal veins, and pass from thence into the receptacle of the chyle.

When the intestines are separated from the mesentery, they are usually six times as long as the man. They have all a kind of vermicular motion, called the PERISTALTIC MOTION, from the stomach downwards; and are lubricated with much fat, especially the great ones, whose surface being more uneven, and their contents less fluid, they need somewhat more to make them slide easily.

Likewise from the exhaling arteries distils a thin, watery liquor, into the cavity of the intestines, not at all acid, but like' the juice of the stomach; the quantity of which liquor may be computed from the large extent of all the excretory orifices, arid from the section of the secretory artery, a larger than which, we see no where in the body.

The duodenum, so called because it is usually ten or twelve inches long, receives the gall and pancreatic juice, which are here mixt with the chyle. The jejunum is so termed, because it is generally more empty than the rest. This may be occasioned partly by its capacity, which gives a free 'passage to its contents; partly to its irritation through the bile, which falls in a little above it. It takes up almost the whole umbilical region, and is usually twelve or thirteen hands long. The ileum, situate below the navel, fills the ilia with its numerous convolutions. It, is much the longest of all the intestines, generally one and twenty. hands long. In both this and the jejunum the inner coat is much wrinkled, and lies in loose folds. They are formed, as the folds in the stomach, only by the inner coat being larger than the outer,

The first of the great guts, called the coecum, is literally inserted at the upper end of the colon. It is not perforated at the other end, but hangs to it, like the finger of a glove, and is three or four inches long. In new-born children, and in beasts it is found full of excrements; but in adults it frequently hangs like a worm. In a foetus it is doubtless a receptacle of the fces, during the time it does not discharge by stool. And may it not occasionally serve the same end in adults Perhaps in those animals wherein it is very large, it may likewise serve as a kind of second stomach. But it is not absolutely necessary. The coecum of a dog has been cut out, without any perceivable prejudice.

The colon is the largest of the great guts. It runs into various circumvolutions from the coecum to the rectum. It has many cavities, formed by two ligaments, running on each side of it, opposite to each other the whole length, and as it were guiding it at certain distances. The rectum, which reaches from the as sacrum to the anus, is usually about a hand and a halflong.

43. The LACTEAL VEINS, which are of a whitish colour, are in all the intestines, small and great, and receive the chylc by imperceptible passages, throughout the whole canal. And for this end the food remains so long in the intestines, and is carried through various windings, that whatsoever of nourishment it contains, may be expressed before it leaves the body.

44. The intestines are covered with the OMENTUM or CAWL, which is contained within the PERITONEUM, a very thin, soft, doubje membrane, and wholly consists of little bags of fat. Its use is to keep the intestines warm; to, promote their peristaltic motion by lubricating them with its oily substance: by following them in their doublings and windings, to serve them as a bolster to slide upon, and by filling up their hollows, to prevent their being too much distended by flatulencies; yet giving way to them when filled with aliments.

Under the stomach behind lies the PANCREAS, extended towards the spleen, which transmits to the intestines a liquor of the nature of spittle, helping to dissolve time food.

45. Under the diaphragm, on the right side, lies the LIVER, whence it extends over the right part of time stomach, below the sternum, toward the left, growing gradually smaller, that it may not hinder the distention of the stomach. It consists partly of gall-ducts, partly of fine ramifications of the vena porta. Tile blood contained in these, deposits oily particles in the ducts, and then returns, chiefly through the vena cava, to the heart. It is thus the BILE is secreted, for which purpose the GALL-BLADDER also is designed. This both receives and retains the bile, by which delay the power of it is greatly heightened. Part of the bile is conveyed to the intestines by the HEPATIC DUCT, which pours it into the ductus choledochus. Part goes first into the gail-bladder, thence into the ductus choledochus, and then into the duodenum.

The principal use of the bile is, to absterge and stimulate the. intestines, to assimilate crude things to things concocted, to bruise and blunt sharp and saline particles, to divide those that are coagulated: to excite appetite, to open the passages for the chyle, and where need is, act the part of a ferment.

46. The SPLEEN is an elegant net-work of numberless vessels, enclosed in a double membrane: it is placed on the left side, between the short ribs and the stomach. Some suppose it to secrete a peculiar juice, which passes with the blood through the vena porta. Others imagine it to be a kind of reservoir, wherein on extraordinary occasions, that blood may be received, which would otherwise oppress the viscera and disturb the animal functions.

47. On the muscles of the loins on each side lie the KIDNEYS, to separate from the blood that part of the serum which is superfluous, and would be hurtful were it retained in the habit. This is carried by the URETERS into the bladder, which is placed in the lowest part of the belly. What remains of tile blood is conveyed to time heart by the veins and lymphatic vessels.

The BLADDER is composed of three coats: time first is an extension of the peritoneum; time second consists of muscular fibres; the third is both glandulous and nervous, and full of wrinkles, that it may be capable of contraction and dilatation. Its glands separate a slimy matter, which defends the bladder from the acrimony of the urine. The involuntary emission of this is prevented by a small muscle which goes round time neck of the bladder.

48.We proceed to the LIMBS. The HAND, physically speaking, is divided into the ARM, the CUBIT, and the HAND, properly so called. In. this there are twelve bones, beside fifteen in the fingers, all oblong, slender, hollow, arid so fitly joined together by ligaments, so wonderfully provided with

various muscles, adapted to so many different motions, that the hand alone gives us an abundant argument of the admirable wisdom of God.

Is there any possibility, that the want of so necessary an instrument as the arm should be supplied One, would think it impossible. But it is not: such is the amazing power of God! James Walker was born in 1718, in Ireland, in the parish of Hillsborough. His mother could not be delivered, till the surgeon totally separated the arms of the child from the body. Nevertheless he lived, and in the room of his arms, had little protuberances that appeared as stumps. He grew to be six feet high, slender, and active. " He sits a saddle," says an eye-witness, " upright and firm, will ride forty miles a day to a fair, and deals in buying and selling horses, which lie dresses and curries without much apparent difficulty, holding the curry-comb between his chin and shoulders. The same way he holds the goad in driving the plough, and the spade when he' digs. lie throws a stone from the top of his foot with greater force than most men can with their hand, and seldom fails to hit his mark. He mounts a horse without any assistance, and shuffling the bridle over his head, till he gets it on his shoulders, guiding his horse with as little fear, and as much skill as most men."

49.The THIGH consists of one bone, the largest and longest in the' whole body. It is a little crooked, bending forward before, that there may be more room for the muscles. The bones of the LEG are two, distant from each other in time middle, but joined together at each end. They are nearly of the same length, but the inner is much thicker than the outer. The bones of the Foot are twelve, besides fourteen in the toes; which like those in the hands, are most aptly connected by ligaments, and fitted with muscles of various kinds, serving for equally various motions.

50.Thus far we have spoken concerning the SOLID PARTS of the body. Among the fluid are usually reckoned the ANIMAL SPIRITS, supposed to be secreted in the brain, to flow through the nerves, and to be the instruments of sense and motion.

"But are the nerves in general hollow canals, which contain a circulating fluid Or are they solid threads, which being highly elastic, vibrate variously to occasion various sensations " The latter supposition is wholly overthrown by the phenomena of wounded nerves. A nerve cut asunder does not retract its divided extremities, but becomes rather longer, extruding its medulla into a round tubercle. Again, 'were it elastic, it should be composed of hard fibres, having their extremities fixed to some firm bodies: since strings, otherwise constituted and disposed, have no elasticity. But it is evident, all nerves are soft at their origin, as well as void of tension: and some soft in every part, as the olfactory nerve, and the soft portion of the auditory nerve. Yea, they all grow soft in the viscera, the-muscles, and the sensories, before they exert their functions. Besides, some nerves are so situate, that they cannot vibrate, as those of the heart, which are fastened to the great vessels and the pericardium. Further, the influence of an irritated nerve is never propagated upwards; whereas an elastic chord communicates tremors to both ends from the point of percussion. Hence it is plain, the nerves do not act by their spring, but by the motion of their proper fluid. The extreme smallness of these canals, which no microscope can reach, is no valid objection to this: neither our inability to discern that fluid. This only proves the imperfection of our senses.

" But what is this fluid Who can tell " We may very probably conjecture, it consists of some subtle fire or ether, diffused through the whole system of nature, and acting by laws unknown to us.

51.Of the other fluids, some serve to prepare the chyle; some to thin the blood and preserve it from putrefaction. Others only remain till they can be thrown out of the body, as being useless and superfluous. All of these, but the chyle, arise from the 'blood, being secreted from it by proper glands. But as to the manner of secretion, after all the most accurate and laborious enquiries, it still remains absolutely uncertain; and every one abounds in his own sense. Some believe it depends

on the suitableness of the fluid secerned, to the shape of the secerning pores. Some lay the stress rather on the various size and diameters of those pores: others on this, that the constituent particles, suppose of the bile, from their peculiar proportion, texture and.flgure, may be more easily united to each other, than to the particles of lymph, or any other fluid.

52.The chief of all the fluids in our body, and the fountain of life, is the BLOOD. It consists of a watery serum, fibrous particles, and red globules, which last are scarce a twelfth part of it. It is generated thus. The meat and drink being digested into chyle, pass from the intestines, through the lacteal veins and the thoracic duct, into the left subclavian vein, and thence into the vena cava, where it mixes with the blood, and then circulates with it, till it is wholly assimulated.

Blood, fresh drawn, appears to the naked eye, uniform and homogenous. But when cold, it separates into two parts; the one red and fibrous, which clots together; the other thin and transparent, called SERUM, in which the former swims. The serum is in bulk three-fourths of the blood; in weight fifteen-seventeenths.

A red globule is computed to be 25000 times smaller than the smallest grain of sand. But whence arises the heat of the blood This deserves a particular enquiry.

FERMENTATION is that spontaneous, intestine motion, which by the heat of subterraneous caverns, will in a few hours so change vegetable juices (for fermentation is confined to the vegetable kingdom) as from a vapid wort quenching fire, to nourish fire, and to afford that inflammable liquor commonly called spirits.

EFFERVESCENCE arises from an intestine motion excited in Various fluids, by the mixture of other fluids, or of salts or powders of a different nature. Acids and alcalis, when mixed, cause a great ebullition, but no great heat: whereas the solution of some metals in aqua-fortis, causes intense heat, and emits flame. Aromatic oils, mixt with acid mineral spirits, kindle and burn with violent explosions.

In these cases, as there is no adventitious fire, there must be fire lying hid in one or other of the bodies.. And it is known, much air lies dormant in all bodies. It is known likewise, that fire cannot exert itself, without the help of air. It being granted then, that fire and air lie dormant in all bodies, there is only required such an action as may set at liberty the particles of air and of fire. By this action, the particles of air recover their elasticity, and putting those of fire in motion, cause heat, but not incension, unless this fire meet a proper pabulum, which pabulum is sulphur only, though differently modified, whether in the appearance of brimstone, oil, spirits, metalline sulphur, or the most inflammable of all, animal sulphur, commonly called PHOSP H 0 R US.

In fermentation, the fire and air being let loose, produce warmth, but seldom kindle, because of the water predominating. But in the effervescence, produced by the solution of metalline sulphur, they kindle and sometimes cause explosions. Aromatic oils, containing little but the sulphureous parts of the vegetables, immediately kindle and break out into flame. And phosphorus is so highly inflammable, that if it be only exposed to the air a few minutes, it kindles and flames.

Now all animals contain more or less phosphorus. Some insects constantly shine in the open air. Many sorts of fish are luminous: some quadrupeds emit light, on a very slight friction. These are proofs of phosphorous lying dormant in animal fluids: and as they all contain air likewise, let only the phosphoreal and aereal particles be brought into contact, and heat necessarily ensues-

This clearly explains the cause of animal heat: of which the heart and arteries are the occasion; not by friction, but by the intestine motion which the circulation gives to the several particles that

constitute the mass of animal fluids. As the velocity of these fluids is increased, the particles of which they consist, come oftner into contact, and the oftner the Phosphoreal and aereal meet, the more heat they produce.

But to what cause is the colour of the blood owing

Borelli took some of the red part, and washing it frequently in water, found it separable into a viscous slippery substance, consisting of colourless fibres, which rose and gathered into a scum on the top of the water, and a deep red powder, which precipitated plentifully to the bottom. Hence it appears that the redness of the blood springs from red tinging particles, as in the case of dying.

However this red colour, though generally found in the blood of land animals, is not absolutely necessary, there being some species, whose blood is white or limpid. Nay Dr. Drake let out of the median vein of a man, a pure, white blood, like milk, which, when cold, did not separate into two parts, as the red usually- does. Nor yet did it yield any skim or cream, neither turn sour as milk uses to do. Dr. Beal gives an instance of the same kind; and Dr. Lower relates one as strange. A person bled at the nose, till at length the broth he drank flowed out very little altered.

It is amazing to see, how careful Providence has been, to prevent the blood's running into concretions, which might destroy life, by the very dispositions of the vessels it is to run through. These are so contrived, as to cause the globules to come together with a brisk collision. The arteries which convey the blood from the heart to the extremities, continually lessen, as they recede from their source in consequence of which, the globuics of blood must rush with force against one another, as they are driven on impetuously. And the veins which bring it back from the extremities to the heart, enlarging all the way as they go on, while the streams of several continually run into one, each of these ingresses causes new commotions, capable, though not of dissolving that natural connexion of the red and serous particles, yet of preventing any preternatural concretions or coagulations.

53. These are the parts of which this wonderful machine is composed, which, the chemists say, consists of four sorts of matter, earth, water, salt, and sulphur, the particles of which being variously mixt together, constitute larger particles of different kinds; out of which, more loosely or closely connected, all the parts of the body, solid or fluid, are composed.

But this is far from being an accurate account. For what arc salt and sulphur but species of earth May not we then much more properly say, with the ancients, that the body is chiefly composed of earth and water, yet cannot enjoy even animal life, unless air and fire also be wrought into its frame So that at what soever time, it is deprived either of air or fire, it is an useless, lifeless clod. And yet the manner how these arc so intimately mixt, both with our fluid and solid parts, as much exceeds Our comprehension, as the manner how the soul is united to its house of clay.

That much air is wrought into the whole animal frame, appears by the following experiments. The blood of a sheep, fresh drawn, was in a wide-mouthed glass put into a receiver, and the air drawn out. After awhile, the subtle parts of the blood forced their way through the clammy ones, and seemed to boil in large clusters, some as big as nutmegs. And sometimes the expansion was so vehement, that it boiled over the glass. Some milk being put into a vessel four or five inches high, when the air was drawn out, it boiled so impetuously, as to throw up several parts out of the glass that contained it.

And to shew, that not only the blood, but the other parts of animals include air, the liver of an eel was put into a receiver, and even this apparently swelled every way, as soon as the air was withdrawn.

The air, as a fixed element in the composition of solid and fluid bodies, has been generally overlooked by philosophers, and even by the chemists, who have above all sects, gloried in their knowledge of principles or elements ; until Mr. Boyle, Sir Isaac Newton, and more especially Dr. Hales, by many experiments demonstrated, that a great part of the substance of most bodies, in several to half their weight, is a permanent or unelastic air, which being freed (either slowly, by the air-pump, putrefaction, fermentation, distillation, &c. or suddenly by explosions, fulminations, ebullitions, mixtures, &c.) from the other solid particles, assumes its elasticity, and fills an immense space, in comparison of the body from whence it came. Dr. Hales found a cubic inch of blood in distillation, afforded above 30 times its bulk of elastic air; whose particles are in effect the wedges of nature which pin and cement together the other elements, and particles of bodies, for their growth of accretion; and under other circumstances, regaining their elasticity, serve to break again those parts for the dissolution of the compound, whose matter may be, by the same instrument, again differently assembled and combined for the firming of other bodies.

54. It remains to add some reflections on the wisdom of God, displayed in the structure of the human body. And how eminently is this displayed, first, in the situation of its several parts and members They are situated most conveniently for use, for ornament, and for mutual assistance. 1. For use. The principal senses are placed in the head, as sentinels in a watch-tower. How could the eyes have been more commodiously fixt, for the guidance of the whole body The ears likewise, made for the reception of sounds, which naturally move upward, are rightly placed in time uppermost parts of the body: and so are the nostrils, as all odours ascend. Again: how could time hands have been more conveniently placed, for all sorts of exercises Or the heart, to dispense life and heat to the whole body Or tile sinks of time body, than in time most remote parts of it 2. For ornament. Not to descend to particulars, what could be better contrived than that those members which are pairs should be of equal length, and just answer one another on each side 3. For mutual assistance. So the eye stands most conveniently to guide the hand, and the hand to defend the eye. Time same may i)e said of the other parts they are all so placed, as to direct or help each other. This will clearly appear, if you suppose the position of any of them to be changed. had our arms been bent backward, what direction could our eyes have afforded us in working Or how cold we even have fed ourselves Nay, had one arm bent backward, and time other forward, half the use of them had been lost; for one could not have assisted the other in any action.,

How is His wisdom displayed, secondly, in the ample provision made for the security of the principal parts! These are, 1. The heart, the fountain of life. This lies in the centre of the trunk of the body, covered with its own membrane; the pericardium, lodged within the soft bed of the lungs, encompassed round with a double fence, both of thick muscles and skins, and of firm ribs and bones; besides time arms, conveniently placed to ward oft any violence. 2. The brain, the principle of all sense and motion, is surrounded with so strong a de fence, that it must be a mighty force indeed, which is able to injure it. The skull is so hard, thick and tough, that it is almost as firm as a helmet of iron. This is covered with skin and hair, which both keep it warm, and soften the violence of a stroke. Yet more, a thick and tough membrane hangs, loose about it, which often saves it, even when the skull is broke. And lastly, a tine membrane closely adheres, to keep it from quashing and ‘shaking.

How is it displayed, thirdly, in the abundant provision that is made against evil accidents and inconveniencies! To this end, 1. The members which are of eminent use arc in pairs. We have two eyes, ears, nostrils, hands; two feet, two breasts, two kidneys; that if one should be rendered useless, the other might serve us tolerably well: whereas had a man but one hand or eye, if that were gone, all were gone. 2. All the vessels have many ramifications, which send forth twigs to the neighbouring vessels: so that if one branch be cut or obstructed, its want may be supplied by the twigs from the neighbouring vessels.

3. Many ways are provided to evacuate, whatever might be hurtful to us. If any thing oppress the head, it can free itself by sneezing; if the lungs, they can cast it off by coughing; if any thing burden the stomach, it can contract itself, and throw it up by vomit. Beside these evacuations, there are siege, urine, sweat, and hmorhages of various kinds. 4. Whereas sleep is necessary for us in many respects, nature has provided, that though we lie long on one side, we should feel no uneasiness while we sleep; no, nor when we awake. One would think, the whole weight of the body pressing the muscles on which we lie, would be very burdensome. And we find by experience, so it is, when we lie long awake in the night. Probably this provision is made, by an inflation of the muscles, making them soft, and yet renitent, like pillows. That they are inflated during sleep, appears to the very eye, in the faces of children ; and from the common experiment, that if we sleep in our clothes, we must loosen our garters and other ligatures, otherwise we find uneasiness in those parts. 5. Because sleep is inconsistent with the sense of pain, therefore during rest, those nerves that convey the motions to the brain, which excite the sense of pain, are obstructed. " This I myself," says Mr. Ray, "have often experienced, since I have had sores on my legs. Waking suddenly, I find myself at perfect ease for awhile. Then the pain by degrees returns."

It is displayed, fourthly, in the multitude of intentions God hath in the formation of the several parts, and the multitude of qualifications they require to fit them for their several uses. Galen observes, "that there are in a human body-, above six hundred muscles. And there are at least ten several intentions in each, and as many qualifications needful: so that about the muscles alone, no less then 6000 ends are to be attended to. The bones are reckoned to be 284. The distinct intentions in teach of these are above forty: in all about a hundred thousand. And thus it is, in proportion, with all the other parts: the skin, ligaments, veins, arteries, nerves, glands, humours; but more especially with the members of the body, which as to the multitude of intentions and qualifications, far exceed the similar parts. And should one of these qualifications fail, great inconvenience would ensue."

It is displayed, fifthly, in the stature of man, so admirably well adapted to the circumstances of his existence. Had man been only a foot or two high, he had been quite disproportioned to every thing round about him. Had he been much larger, he could not well have been supplied with food: all the edible animals would not have sufficed. And had they too been proportioned larger, time surface of the earth would not have sufficed to feed them.

It is however a common opinion, and has been so ever since old Homer's time, that the people in the early ages of the world, were much larger than us. And it is true we read of some men of a surprising stature, But they were even then esteemed giants. The ordinary stature of men, is probably just the same now, as it was at the beginning. This may be gathered from the monuments still remaining, particularly the pyramids of Egypt. The cavities for bodies now visible herein, are little larger than our ordinary coffins: likewise from several embalmed bodies taken out of them, it appears, that men are of the same stature now, that they were when those pyramids were built, which is at least three thousand years ago. Eighteen hundred years ago, the emperor Augustus was five feet seven inches high: queen Elizabeth was taller by two inches, being five feet nine.

But what a paradox is it, that all men arc taller in the morning than in the evening In a young man, the difference is near an inch; try the experiment as often as you please. Does not the difference proceed from hence, that as long as the trunk of the body is in an erect posture, there is a constant pressure on the large cartilages connecting the vertebr of the spine So long they gradually contract, and consequently a man grows shorter. But they again gradually expand themselves, while we arc in a reclining posture.

As to the art of embalming, it appears from a mummy, not long since dug up in France, that this was more completely understood in the western world some ages since, than ever it was in Egypt. This mummy which was dug up at Auvergne, was an amazing instance of their skill. As some peasants were digging in a field near Rion, within about twenty-six paces of the highway, between that and the river Artier, they discovered a tomb, that was about a foot and a half beneath the surface. It was composed only of two stones; one of which formed the body of a sepulchre, and the other the cover.

This tomb was of freestone; seven feet and a half long, three feet and a half broad, and about three feet high. It was of rude workmanship; the cover had been polished, but was without figure or inscription: within this tomb was placed a leaden-coffin, four feet seven inches long, fourteen inches broad, and fifteen high. It was oblong, like a box, equally broad at both ends, and covered with a lid that fitted on like a snuff-box, without a hinge. Within this coffin was a mummy, in the most perfect preservation. The internal sides of the coffin were filled with an aromatic substance, mingled with clay. Round the mummy was wrapped a coarse cloth ; under this were two shirts, or shrouds, of the most exquisite texture; beneath these a bandage, which covered all parts of the body, like an infant in swaddling clothes ; under this general bandage there was another, which went particularly round the extremities, the hands and legs; the head was covered with two caps; the feet and hands were without any particular bandages; and the whole body was covered with an aromatic substance, an inch thick. When these were removed, and the body exposed naked to view, nothing could be more astonishing than the exact resemblance it bore to a body that had been dead a day or two before. It appeared well proportioned, except the head was rather large, and the feet small. The skin had all the pliancy, and colour of a body lately dead; the visage, however was of a brownish hue. The belly yielded to the touch; all the joints were flexible, except those of the legs and feet; the fingers stretched forth of themselves when bent inwards. The nails still continued perfect; and all the marks of the joints, both in the fingers, the palms of the hands, and the soles of the feet, remained perfectly visible. The bones of the arms and legs were soft and pliant; those of the scull preserved their rigidity; the hair which only covered the back of the head, was of a chesnut colour, and about two inches long. The pericranium at top was separated from the skull, by an incision, in order to the introducing aromatics in the place of the brain, where they were found mixed with clay. The teeth, the tongue, and the ears, were all preserved in perfect form. The intestines were not taken out of the body, but remained pliant and entire, as in a fresh subject; and the breast was made to rise and fall like a pair of bellows. The embalming preparation had a very strong and pungent smell, which the body preserved for more than a month after it was exposed to the air. If one touched either the mummy, or any part of the preparation, the hand smelt of it for several hours after. This mummy, having been exposed for some months, began to suffer some mutilations. A part of the skin of the forehead was cut off; all its teeth were drawn out, and some attempts were made to pull away the tongue. It was therefore put into a glass case, and transmitted to the king’s cabinet, at Paris.

There are many reasons to believe this to be the body of a person of the highest distinction: however no marks remain to assure us either of the quality of the person, or the time of his decease. There are only to be seen some irregular figures on the coffin: one of which represents a kind of star.

There were also some singular characters upon the bandages, which were totally defaced by those who had tore them. It should seem that it had remained for several ages in this state, since the first years immediately succeeding the interment, are usually those in which the body is most liable to decay.

On this remarkable subject, I beg leave to add an extract from a late author.

“I always apprehended that human bodies after death, if interred, or exposed to the air, without any preparation to defend them from the attacks of it, would of necessity corrupt, become offensive, and putrify. The art of embalming is very ancient, and was invented to preserve them from this inevitable consequence of death; but that they may remain unputrified for centuries without any sort of artificial aid, I have seen so incontestibly proved since my arrival at Bremen, that I imagine not the shadow of doubt can remain about it. Under the cathedral church is a vaulted apartment, supported on pillars; it is near sixty paces long, and half as many broad. The light and air arc constantly admitted into it by three windows, though it is several feet beneath the level of the ground. Here are five large oak coffers, rather than coffins, each containing a corpse. The most curious and perfect, is that of a woman. Tradition says, she was an English countess, who dying here at Bremen, ordered her body to be placed in this vault uninterred, in the apprehension that her relations would cause it to be brought over to her native country. They say it has lain here two hundred and fifty years. Though the muscular skin is totally dried in every part, yet so little are the features of the face sunk or changed, that nothing is more certain than that she was young, and even beautiful. It is a small countenance, round in its contour: the cartilage of the nose and the nostrils have undergone no alteration: her teeth are all firm in the sockets, but the lips arc drawn away from over them. The cheeks are shrunk in, but yet less than I ever remember to have seen in embalmed bodies. The hair of her head is at this time more than eighteen inches long, very thick, and so fast, that I heaved the corpse out of the coffer by it: the colour is a light brown, and I cut off a small lock, which is as fresh and glossy as that of a living person. That this lady was of high rank seems evident from the extreme fineness of the linen which covers her body. The landlord of the inn, who was with me, said, he remembered it for forty years past; during which time there is not the least perceptible alteration in it.—In another coffer is the body of a workman, who is said to have, tumbled off the church, and was killed by the fall. His features evince this most forcibly. Extreme agony is marked in them: his mouth is wide open, and his eyelids the same; the eyes are dried up. His breast is unnaturally distended, and his whole frame betrays a violent death.—A little child who died in the small-pox is still more remarkable. The marks of the pustules, which have broken the skin on his hands and head, are very discernable; though one should suppose that a body which died of such a distemper, must contain in a high degree the seeds of putrefaction.—The two other corpses arc not less extraordinary. There are in this vault likewise turkeys, hawks, weasels, and other animals, which have been hung up here, some, time immemorial, sonic very lately, and are in the most complete preservation: the skin, bills, and feathers, arc all unaltered. The magistrates do not permit that any fresh bodies be brought here. The cause of these phenome nons are doubtless the dryness of the place where they are laid. It is in vain to seek for any other.”

A repository of nearly the same kind, a late writer informs us is at a monastery, near Palermo, in Sicily. It is a long, subterranean gallery, having niches on every side, between six and seven feet high. In each of these is a human body standing erect, in its usual apparel. The face and hands are uncovered, and preserve their shape, and natural colour, only a little browner. They are fastened to the wall by the back. Some of them are believed to have been there two or three hundred years. Suppose they could remain there forever, what would it profit their former inhabitants

Another traveller gives a fuller account of them.

“This morning we went to see a celebrated convent of capu chins, about a mile without the city of Palermo; it contains nothing very remarkable, but time burial-place, which indeed is a great curiosity. This is a vast subterraneous apartment, divided into large commodious galleries, the walls on each side of which are hollowed into a variety of niches, as if intended for a great collection of statues: these niches, instead of statues, are all halled with dead bodies, set upright upon their legs, and fixed by the back to the inside of a niche. Their number is about three hundred: they are all dressed in the clothes they usually wore, and form a most respectable and venerable assembly. The skin and muscles, by a certain preparation, become as dry and hard as a piece of stock-fish;

and although many of them have been here upwards of two hundred and fifty years, yet none are reduced to skeletons; though the muscles in some are more shrunk than in others; probably because these persons had been more extenuated at the time of their death.

"Here the people of Palermo pay daily visits to their deceased friends, and recal with pleasure and regret the scenes of their past life; here they familiarize themselves with their future state, and choose the company they would wish to keep in the other world. It is a common thing to make choice of their niche, and to try if their body fits it, that no alterations may be necessary after they are dead; and sometimes by way of voluntary penance, they stand for hours in these niches.

“The bodies of the princes and first nobility are lodged in handsome chests or trunks, some of them richly adorned these are not in the shape of coffins, but all of one width, and about a foot and a half or two feet deep. The keys are kept by the nearest relations of the family, who sometimes come and drop a team’ over their departed friends.

“These visits must prove admirable lessons of humility; and they are not such objects of horror as one would imagine; they arc said, even for ages after death, to retain a strong likeness of what they were when alive: so that, as soon as you have conquered the first feelings excited by these venerable figures, you only consider this as a vast gallery of original portraits, drawn after the life, by the justest and most unprejudiced hand. It must he owned, that the colours are rather faded; and the pencil does not appear to have been the most flattering in the world; but no matter; it is the pencil of truth, and not of a mercenary, who only wants to please.

“ It might also be made of very considerable use to society: these dumb orators could give the most pathetic lectures upon pride and vanity. Whenever a fellow began to strut, or to affect the haughty, supercilious air, he should be sent to converse with his friends in the gallery ; and if their arguments did not bring him to a proper way of thinking, I would give him up as incorrigible.”

I cannot better conclude this chapter than by an extract from the late pious and ingenious Mr. Hervey, which may serve for a recapitulation of what has been said, as well as an improvement of it.

“Let us begin with the less adorned, but more solid parts, those which support, and which contain the rest. First, you have a system of bones, cast in a variety of moulds, in a variety of sizes: all strong, that they may bear up the machine, yet light, that they may not weigh us down: bored with an inward cavity to contain the moistening marrow, and perforated with fine ducts, to admit the nourishing vessels. Insensible themselves, they ate covered with a membrane, exquisitely sensible, which warns them of, and secures them from the annoyance of any hurtful friction ; and also preserves the muscles from being fretted in their action, by the hard and rough substance of the bone. They are larger at the extremities, that they may be joined more firmly, and not so easily dislocated. The manner of their articulation is truely admirable, and remarkably various: yet never varied without demonstrating some wise design, and answering sonic valuable end. Frequently when two are united, the one is nicely rounded and capped with a smooth substance; the other is scooped into a hollow of the same dimensions to receive it. And both are lubricated with an unctuous fluid, to facilitate the rotation.

The FEET compose the firmest pedestal, infinitely beyond all that statuary can accomplish, capable of altering its form, and extending its size, as different circumstances require. They likewise contain a set of the nicest springs, which help to place the body in a variety of attitudes, and qualify it for the multiplicity of motions. The undermost part of the heel, and the extremity of the sole, are shod with a tough insensible substance; a kind of natural sandal, which never wears out, never wants repair: and which prevents an undue compression of the vessels by the weight of the

body. The legs and thighs are like stately columns, so articulated that they arc commodious for walking, and yet do not obstruct the easy posture of sitting. The legs swell out towards the top with a genteel projection, and are neatly wrought off toward the bottom: a variation which lessens their bulk, while it increases their beauty.

The RIBS, turned into a regular arch, are gently moveable, for the act of respiration. They form a safe lodgement for the lungs and heart, some of the most important organs of life. The backbone is designed, not only to strengthen the body, and sustain its most capacious store-rooms, but also to bring down the continuation of the brain, usually termed the spinal marrow. It both conveys and guards this silver cord, as Solomon terms it, and by commodious outlets transmits it to all parts. Had it been only strait and hollow, it might have served these purposes. But then the loins must have been inflexible: to avoid which, it consists of very short bones, knit together by cartilages. This peculiarity of structure gives it the pliancy of an osier, with the firmness of an oak. By this means it is capable of various inflections, without bruising the soft marrow, or diminishing that strength which is necessary to support all the upper stories. Such a formation in any other of the solids, must have occasioned great inconvenience. Here it is unspeakably useful, a master-piece of creating skill.

The ARMS are exactly proportioned to each other, to preserve the equilibrium of the structure. These being the guards that defend, and the ministers that serve the whole body, are fitted for the most diversified and extensive operations: firm with bone, yet not weighty with flesh, and capable of performing all useful motions. They bend inwards and turn outwards; they move upward or downward; they wheel about in whatever direction we please. To these are added the HANDS, terminated by the fingers, not of the same length, nor of equal bigness, but in both respects different, which gives the more beauty, and far greater usefulness. Were they all flesh, they would be weak: were they one entire bone, they would be utterly inflexible; but consisting of various little bones and muscles, what shape can they not assume Being placed at the end of the arm the sphere of their action is exceedingly enlarged. Their extremities are an assemblage of fine tendinous fibres, acutely sensible: which notwithstanding are destined to almost incessant employ, and frequently among rugged objects. For this reason they are overlaid with nails, which preserve them from any painful impression.

In the hands we have a case of the finest instruments. To these we owe those beautiful statues, this melodious trumpet. By the strength of the hand the tallest firs fall, and the largest oaks descend from the mountains. Fashioned by the hand they are a floating warehouse, and carry the productions of art and nature from Britain to Japan.

The hand is the original and universal sceptre, which not only represents, but ascertains our dominion over all the elements, and over every creature. Though we have not the strength of the horse, the swiftness of the greyhound, or the quick scent of the spaniel, yet directed by the understanding, and enabled by the hand, we can as it were make them all our own. These short hands have found a way to penetrate the bowels of the earth, to touch the bottom of the sea. These feeble hands can manage the wings of the wind, arm themselves with the violence, of fire, and press into their service the forcible impetuosity of water. How greatly then are we indebted to our wise Creator, for this distinguishing, this invaluable member!

Above all is the HEAD, for the residence of the brain: ample to receive, and firm to defend it. It has a communication with all, even the remotest parts: has outlets, for dispatching couriers to all quarters, and avenues for receiving speedy intelligence, on all needful occasions. It has lodgements wherein to post centinels, for various offices: to expedite whose operations the whole turns on a curious pivot, nicely contrived to afford the largest and freest circumvolutions.

This is screened from heat, defended from cold, and at the same time beautified by the hair: a decoration so delicate, as no art can supply; so perfectly light, as no way to incumber the wearer.

While other animals are prone in their aspect,, the attitude of man is erect, which is by far the most graceful, and bespeaks superiority. It is by far the most commodious, for prosecution of all our extensive designs. It is likewise safest, less exposed to dangers, and better contrived to repel or avoid them. Does it not also remind us of our noble original, and our sublime end Our original, which was the breath of the Almighty: our end, which was the enjoyment of him in glory

Thus much for the rafters and beams of the house. Let us now survey the lodgings within. Here are LIGAMENTS, a tough and strong arrangement of fibres, to unite the several parts, and render what would be otherwise an unwieldly jumble, a well compaCte(l and self-manageable system: MEMBRANES, thin and flexible, tunicles to enwrap the fleshy parts, to connect some, and form a separation between others: ARTERIES, the rivers of our little world, that striking out as they go, into numberless small canals, visit every street, yea, every apartment in the vital city. These being wide at first, and growing narrower and narrower, check the rapidity of the blood. This thrown from the heart, dilates the arteries, and their own elastic force contracts them by which means they vibrate against the finger, and much assist both in the discovery and cure of diseases. The larger arteries, wherever the blood is forced to bend, are situate on the bending side: lest being stretched to an improper length, the circulation should be retarded. They are not, like several of the veins, near the surface, but placed at a proper depth. And hereby they arc more secure from external injuries. In those parts which are most liable to pressure, an admirable expedient takes place. The arteries inosculate with each other: breaking into a new track, they fetch a little circuit, and afterwards return into the main road. So that if any thing block up or straiten the direct passage, the current, by diverting into this new channel, eludes the impediment, flows on, and soon regains its wonted course.

The VEINS receive the blood from the arteries, and reconvey it to the heart. The pressure of the blood is not near so forcible in these as in the arteries. Therefore their texture is considerably slighter. Such an exact economist is nature, amidst all her liberality In many of these canals, the current, though widen-‘rig Continually, is obliged to push its way against the perpendicular: hereby it is exposed to the danger of falling back and overloading the vessels. To prevent this, VALVES are interposed at proper distances, which are no hindrance to the regular passage, but prevent the reflux, and facilitate the passage of the blood to the grand receptacle. But these valves are only where the blood is constrained to climb: where the ascent ceases, they cease also.

Here are GLANDS to filtrate the passing fluids: each of which is an assemblage of vessels, complicated with seeming confusion, but with perfect regularity. Each forms a secretion’ far more curious than the most admired operations of chemistry: MUSCLES, composed of the finest fibres, yet endued with incredible strength, fashioned after a variety of patterns, but all in the highest taste for elegance and conveniency. These are the instruments of motion, and at the command of the will, execute their functions quick as lightning: NERVES, surprisingly minute, which set the muscles at work, diffuse the power of sensation through the body, and upon any impression from without, give all needful intelligence to the soul: VESICLES, destined with an unctuous matter, in some places compose a soft cushion; as in the calf of the leg, whose large muscles, mixt with fat, are of singular service to those important bones. This flanks and fortifies them, like a strong bastion ; supports and cherishes them, like a soft pillow. In other places they fill up the vacuities, and smooth the inequalities of the flesh. Inwardly, they supply the machine for motion; outwardly, they render it smooth and graceful.

The SKIN, like a curious surtout, covers the whole, formed of the most delicate net-work, whose meshes are minute, and whose threads are multiplied, even to a prodigy: the meshes are so

minute, that nothing passes them, which is discernible by the eye; though they discharge, every moment, myriads and myriads of superfluous encumbrances. The threads are so multiplied, that neither the point of the smallest needle, nor the infinitely finer lance of a gnat, can pierce any part, without drawing biQod, and causing an uneasy sensation. Consequently, without wounding, by so small a puncture, both a nerve and a vein!

But a course of incessant action must exhaust the solids and waste the fluids, and unless both are properly recruited, in a short time destroy the machine. For this reason it is furnished with the organs, and endued with the powers of nutrition: TEETH the foremost, thin and sharp, to bite asunder the food; the hindermost, broad and strong, indented with small cavities, the better to grind in pieces what is transmitted to them. But in children, the formation of teeth is postponed till they have occasion for them. -

Were the teeth, like other bones, covered with the periosteum, chewing would give much pain. Were they quite naked, they would soon decay and perish. To guard against ‘both, they are overlaid with a neat ENAMEL, harder than the bone itself, which gives no pain in chewing, and yet secures them from various injuries.

The LIPS prevent the food from slipping out of the mouth, and assisted by the tongue, return it to the grinders. While they do this in conceit with the cheeks, they squeeze a thin liquor from the adjacent glands. This moistens the food sand prepares it for digestion. When the mouth is inactive, these are nearly closed: but when we speak or eat, their moisture being then necessary, is expressed as needs require.

But the food could not descend merely by its own weight, through a narrow and clammy passage into the stomach. Therefore to effect this, muscles both straight and circular are provided. The former enlarge the cavity, and give an easy admittance. The latter, closing behind the descending aliment, press it downward. But before the food enters the gullet, it must of necessity pass over the orifice of the wind-pipe: whence it is in danger of falling upon the lungs, which might occasion instant death. To obviate this, a moveable lid is placed, which when the smallest particle advances, is pulled down and shut close, but as soon as it is swallowed, is let loose and stands open. Thus the important pass is always made sure against any noxious approaches; yet always left free for the air, and open for respiration.

The food descending into the stomach, is not yet ready for the bowels. Therefore that great receiver is strong to bear, and proper to detain it, till it is wrought into the smoothest pulp imaginable. From hence it is discharged by a gentle force, and passes gradually into the intestines.

Near the entrance waits the GALL-BLADDER, ready to pour its salutary juice upon the aliment, which dissolves any thing viscid, scours the intestines, and keeps all the fine apertures clear. This bag, as the stomach fills, is pressed thereby, and then only discharges its contents. It is also furnished with a valve of a very peculiar nature, namely, of a spiral form; through which the detersive liquid cannot hastily pour, but must gently ooze. Admirable construction! which without any care of ours, gives the needful supply, and no more.

The nutriment then pursues its way through the mazes of the intestines: which by a worm-like motion protrude it and force its small particles into the lacteal vessels. These are a series of the finest strainers, ranged into countless multitudes all along time sides of the winding passage. Had this been strait or short, the food could not have resigned a sufficient quantity of its nourishing particles. Therefore it is artfully convolved, and greatly extended, that whatever passes may be sifted thoroughly. As the aliment proceeds, it is more and more drained of its flutricious juices in consequence of this, it would become hard, and pain the tender parts, but that glands are posted

in proper places, to -discharge a lubricated fluid. These. are smaller or fewer, near the stomach, because there the aliment is moist enough: whereas in the bowels, remote from the stomach, they are either multiplied or enlarged.

The C KYLE drawn off by the lacteals is carried through millions of ducts, too fine even for the microscope to discover. To this it is owing, that nothing enters the blood, but what is capable of passing through the finest vessels. It is then lodged in several commodious cells (the glands of the mesentery) and there mixt with a thin diluting lymph, which makes it more apt to flow. Hence it is conveyed to the common receptacle, and mounts through a perpendicular tube into the left subclavian vein. This tube lies contiguous to the great artery, whose strong pulsation (hives on the fluid, and enables it to ascend and unload its treasure, at the very door of the heart.

But the chyle is as yet in too crude a state, to be fit for the animal functions. Therefore It is thrown into the lungs. In the spongy cells of this amazing laboratory, it mixes with the external air, and its whole substance is made more smooth and uniform. Thus improved it enters the left ventricle of the heart, a strong, active, indefatigable muscle. The large muscles of the arm or of the thigh are soon wearied: a day’s labour, or a day's journey exhausts their strength. But time heart toils whole weeks, whole months, nay years, unwearied: is equally a stranger to intermission and fatigue. Impelled by this, part of the blood shoots upward to time head; part rolls through the whole body.

But how shall a stream, divided into myriads of channels, be brought back to its source Should any portion of it be unable to return, putrefaction, if not death, must ensue. Therefore the allwise Creator has connected the extremities of the arteries, with the beginning of the veins: so that the same force which darts the blood through the former, helps to drive it through the Latter. Thus it is reconducted to the great cistern, and there played off afresh.

Where two opposite currents would be in danger of clashing, where the streams from the vena cava and vena aacendens coincide, a fibrous excrescence interposes, which like a projecting pier, breaks the stroke of each, and throws both into their proper receptacle. Where the motion is to be speedy, the channels either forbear to wind (as in the great artery, which descends to time feet) or to lessen in their dimensions, as in every interval between all the ramifications. When the progress is to be retarded, the tubes are variously convolved, or their diameter contracted. Thus guarded, the living flood never discontinues its course, but night and day, whether we sleep or wake, still perseveres to run briskly through the arteries and return softly through the veins.

But farther: the great Creator has made us an invaluable present of the senses, to be the inlets of innumerable pleasures, and the means of the most valuable advantages.

The EYE, in its elevated station, commands the most enlarged prospects. Consisting only of fluids, enclosed within coats, it shews us all the graces and glories of nature. 1-low wonderful, that an image of the hugest mountains, and the widest landscapes should enter the small pupil! that the rays of light should paint on the optic nerve, paint in an instant of time, paint in the truest colours and exact lineaments, every species of external objects!

The eye is so tender, that the slightest touch might injure its delicate frame. It is guarded therefore with peculiar care, intrenched deep, and barricaded round with bones. As the smallest fly might incommode its polished surface, it is farther protected by two substantial curtains. In sleep, when there is no occasion for the sense, but a necessity- to guard the organ, these curtains close of their own accord. At any time they fly together as quick as thought. They are lined with an extremely fine sponge, moist with its own clew. Its brisly palisades keep out the least mote, and moderate the too strong impressions of the light.

As in our waking hours we have almost incessant need for these little orbs, they run upon the finest castors, rolling every way with the utmost ease; which circumstance, added to the flexibility of the neck, renders our two eyes as useful as a thousand.

The EAR consists of an outward porch and inner rooms. Time porch somewhat prominent from the head, is of a cartilaginoussubstance, covered with tight membranes and wrought into sinuous cavities. Thcsc, like circling hills, collect the wandering undulations of time air, and transmit them with a vigorous impulse, to the finely stretched membrane of the drum. This is expanded upon a circle of bones, over a polished, reverberating cavity. It is furnished with braces that strain or relax, as the sound is faint or strong. The hammer and the anvil, the winding labyrinth, and the sounding galleries, these and other pieces of mechanism, all instrumental to healing, are inexpressibly curious.

Amazingly exact must be time tension of the auditory nerves, since they answer the smallest tremors of the atmosphere, and distinguish their most subtle variations. These living' chords, turned by an .Almighty hand, and spread through the echoing isles, receive all the impressions of sound, and propagate them to the brain. These give existence to the charms of music, and the still nobler charms of discourse.

The eye is useless amidst the gloom of night: but the ear hears through the darkest medium. The eye is on duty only in our waking hours: but the ear is always accessible.

As there are concussions of the air, which are discernable only by the instruments of hearing, so there are odoriferous particles wafted in the air, which are perceivable only by the smell. The nostrils are wide at the bottom, that more effluvia may enter, narrow at the top, that when entered, they may act more strongly. The steams that exhale from fragrant bodies, are fine beyond imagination. Microscopes that shew thousands of animals in a drop of water, cannot bring one of these to our sight. Yet so judiciously are the olfactory nets set, that they catch the vanishing fugitives. They imbibe all the roaming perfumes of spring, and make us banquet even on the invisible dainties of nature.

Another capacity for pleasure our bountiful Creator has bestowed, by granting us the powers of TASTE. This is circumstanced in a manner so benign and wise, as to be a standing plea for temperance, which sets the finest edge on the taste, and adds the most poignant relish to its enjoyments.

And these senses are not only so many sources of delight, but a joint security to our health. They are the inspectors that examine our food, and enquire into the properties of it. For the discharge of this office they are excellently qualified, and most commodiously situate. So that nothing can gain admission, till it has past their scrutiny.

To all these, as a most necessary supplement, is added the sense of FEELING. And how happily is it tempered between the two extremes; neither too acute, nor too obtuse! Indeed all the senses are exactly adapted to the exigencies of our present state. Were they strained much higher, they would be avenues of anguish; were they much relaxt, they would be well nigh useless.

The crowning gift, which augments the benefits accruing from all the senses, is SPEECH. Speech makes me a gainer by the eyes and ears of others; by their ideas and observations. And what an admirable instrument for articulating the voice, and modifying it into speech, is the tongue This little collection of muscular fibres under the direction of the Creator, is the artificer of our words. By this we communicate the secrets of our breasts, and make our very thoughts audible. This likewise is the efficient cause of music; it is soft as the lute, or shrill as the trumpet. As the tongue

requires an easy play, it is lodged in an ample cavity. It moves under a concave roof, which gives additional vigour to the voice, as the shell of a violin to the sound of the strings.

Wonderfully wise is the regulation of voluntary and involuntary motions. The will in some cases has no power: in others she is an absolute sovereign. If she commands, the arm is stretched, the arm is closed. How easily, how Punctually are her orders obeyed! To turn the screw, or work the lever, is laborious and wearisome. But we work the vertebr of the neck, with all their appendant chambers; we advance the leg, with the whole incumbent body; we rise, we spring from the grouni, and though so great a weight is raised, we meet with no difficulty or fatigue.

That all this should be effected without any toil, by a bare act of the will, is very surprising. But that it should be done, even while we are entirely ignorant of the manner in which it is performed, is most astonishing! Who can play a single tune upon the spinnet, without learning the difference of the keys Yet the mind touches every spring of the human machine, with the most masterly skill, though she knows nothing at all of the nature of her instrument, or the process of her operations.

The eye of a rustic, who has no notion of optics, or any of its laws, shall lengthen and shorten its axis, dilate and contract its pupil, without the least hesitation, and with the utmost propriety: exactly adapting itself to the particular distance of objects, and the different degrees of light. By this means it performs some of the most curious experiments in the Newtonian philosophy, without the least knowledge of the science, or consciousness of its own dexterity!

Which shall we admire most, the multitude of organs; their finished form and faultless order; or the power which the soul exercises over them Ten thousand reins are put into her hands: and she manages all, conducts all, without the least perplexity or irregularity. Rather with a promptitude, a consistency and speed, that nothing else can equal!

So fearfully and wonderfully are we made! Made of such complicated parts, each so nicely fashioned, and all so exactly arranged; every one executing such curious functions, and many of them operating in so mysterious a manner! And since health depends on such a numerous assemblage of moving organs;. since a single secretion stopped may spoil the temperature of the fluid, a single wheel clogged may put an end to the solids; with what holy fear, should we pass the time of our sojourning here below! Trusting for continual preservation, not merely to our own care, but to the Almighty Hand, which formed the admirable machine, directs its agency, and supports its being.

Part V - Of the System of the World, Heavenly Bodies, Properties and Causes of Natural Bodies

Chapter 1 - Of the System of the World

Having considered the earth with the bodies that are therein, let us now look up to those that surround it. The world is a congeries of innumberable bodies, many of which are supposed to exceed the size of the earth: yet by reason of their distance, most of them are invisible to ‘the naked eye.

The nearest to us is the moon, which moves round the earth in less than twenty-eight days from west to east. The sun likewise seems to move from east to west, and shines successively on all parts of the globe. It appears also to us to move every year obliquely from west to east, coming twenty-three degrees and a half to the north, and then globe just as far to the south.

2. Some of the stars keep always the same distance with respect to each other and are termed fixed. Others are continually changing their situation, whence they are termed planets. Two of these, Mercury ‘and’ Venus, are frequently between the earth and the sun; of which the former being generally hid by the rays of the sun, is seldom-visible: but Venus, commonly called the evening star, is very conspicuous. The earth is never between them and the sun. They are sometimes between us and him. Sometimes the sun is interposed between us and them.

3. The upper planets are Mars, Jupiter, and Saturn. The sun is sometimes between these and the earth. But none of them is ever interposed between the earth and the sun. Mars has different appearances, like the moon, as it is differently situated, with regard to the sun whereas Jupiter and Saturn always appear with the same aspect, and have smaller planets revolving round them. All these revolve round the sun, in their several stated periods.

4. Beside these, there are another kind of stars, called comets, vulgarly, blazing stars. These do not revolve round the sun in so regular orbits as the planets. The fixed stars are above these: These have a vivid light, and always appear with the same face towards us: they seem to have a twofold motion, a slow one from east to west in as year, and a swift one round the earth with all the other stars in and twenty hours. But there are some of them which never set, namely those near the north or south pole.

5. To explain these phenomena of the heavenly bodies, various systems have been invented. The Ptolemaic supposes the earth to be fixed, in the centre of the universe, round which all the heavenly bodies move, each affixed to a solid sphere which moves with it: first the moon, then Mercury, thirdly, Venus, next the sun, filthy, Mars, then Jupiter, seventhly, Saturn. In the eighth place is the firmament or sphere of fixed stars: then the crystaline heaven, and last of all the primum mobile, which is supposed to move from east to west in twenty-four hours, whirling all the other spheres with it. But this system being in some respects obviously false, in others utterly improbable, and likewise: insufficient to account for many phenomena, is now universally exploded.

6. In the room of this, the Copernican system is now generally received, which supposes the sun to be fixed in the centre, without. any other motion, than that round his own axis. Next him is Mercury, then Venus, thirdly the Earth, (round which the moon revolves,) above the earth, Mars, then Jupiter and Saturn, with their attendant moons.

This system is extremely simple and natural, and easily accounts for most phenomena. As to the objection, that it is contrary to the testimony of our senses, it is easily answered. They who are in a ship seem to see the shore and the land moving along, although it is really the ship that moves. Yet let it move ever so swiftly, it displaces nothing, provided it moves smoothly So neither does the motion of the earth displace any thing on its surface, because it is equable and regular.

Not that Copernicus was the inventor of this system. It was in great part known long ago. Pythagoras taught, “ that the earth was carried about the sun among the stars, and by turning round its axis, caused day and night.” Yet by degrees it sunk into oblivion, till it was revived by cardinal Cusa. However, the Ptolemaic system still prevailed, till Nicholas Copernicus, a canon of Thorn, in Polish Prussia. born in the year 1473, had resolution to examine it thoroughly, and learning enough to explain and defend it. Some of the reasons on which this system is founded are, 1. This is most simple and agreeable to the whole tenure of nature: for by the motions of the earth all the phenomena of the heavens are resolved, which on any of the other hypothesis are utterly inexplicable. 2. It is more rational to suppose the earth moves round the sun, than that the huge bodies of the planets and of the sun itself, and the immense firmament of stars, should all move round the inconsiderable body of earth every four and twenty hours. 3. The earth’s moving round

the sun is agreeable to that general harmony and universal law, which all other moving bodies of the system observe, namely, that the squares of the periodical times are as the cubes of the distances. But if the sun move round the earth, that law is destroyed, and the general order and symmetry of nature interrupted; because, according to that law, the sun would be so far from revolving about the earth in 365 days, that it would require not less than 5106 years, to finish one revolution. 4. The sun is the fountain of light and heat, which it darts through the whole system, and therefore it ought to be placed, as the heart in the that so all the planets may at all times have them, in an uniform and equal manner. 5. If the sun be placed in the centre of the system we have then the rational hypothesis of the planets being all moved about the sun, by the universal law of gravity: and everything will answer to that law ; but otherwise we are wholly in the dark. 6. But we need not rely upon conjectures. We have demonstrable proofs, that the sun possesses the centre, and that the planets , move-round it, in the order above mentioned. For example: Mercury and Venus are ever observed to have two conjunctions with the sun but no opposition, which could not happen unless the orbits of those planets lay within the orbit of the earth. And in the same manner it may be demonstrated, that the orbits of Mars, Jupiter and Saturn lie without the orbit of the earth.

7.After Copernicus came Tyco Brahe, a noble Dane, who endeavoured to compound a system, of the Ptolemaic and Copernican put together; but it was quickly found by all unprejudiced judges, to be “So intricate and perplexed, that it had not many assertors even while he lived, and is now well nigh sunk into oblivion,

8. Numerous hypothesis have been formed to explain the relative situation and character of our globe, and the motions and appearances of the heavenly bodies, the greater number of which have been evidently absurd and erroneous. Some have been marked by greater degrees of ingenuity, and plausibility, than others, which have nevertheless been rejected, as science progressed to more extensive degree of developement. Besides the Ptolemaic, and the Tychonic systems, other systems were projected which had many advocates. The Semitychonic, supposed the planets to revolve round the sun, while the sun and moon revolve round the earth, as their centre of motion, but this system supposed the diurnal motion of the globe, on its own axis. In this, it differs from the Tychonic.

The Cartesian system was next introduced. This proposed a variety of vortices, or whirlpools, in the etherial regions, in which the motions of the heavenly bodies were performed, in different times, proportioned to their distances; and each planet having a particular vortex of its own, in which the motions of its satellites were performed. But this appeared equally destitute. of analogy, and fact, for support. Besides it was evident, that the irregularities in motions of the planets, could not be accounted for on this hypothesis.

The Ptolemaic system bad gained universal credit when Copernicus began to entertain doubts of its truth ; and to try if a more rational scheme could not be projected, to account for the motions of the heavenly bodies. He had recourse to every means, for information, and found from Cicero, that Nichetas, a Syracusian astronomer, had maintained the doctrine of the rotatory motion of the earth. And that Pythagoras and others of the ancients had maintained the same opinion.

From these small hints, this great genius deduced a most complete system of astronomy, capable of solving every phenomenon in a satisfactory manner, a system which has been amply confirmed by the discoveries and improvements in astronomy, since that time. Like alt important discoveries however, when they run counter to popular prejudices, this system was very much opposed, and Copernicus him self considered as a wild theorist.

But while philosophers were divided between the Ptolemaic, the Tychonic, the Cartesian. and the Copernican systems, Sir Isaac Newton stepped forward in the plenitude of genius, and like a mighty umpire, laid down the laws of nature and of motion, and by comparing all the phenomena of the heavens, found out the true system of the universe, and confirmed the Copernican system. He demonstrated by unanswerable arguments, that it could not possibly be otherwise, without the utter subversion of all the laws of nature.

It would be endless to recount all the conjectures which have been made, respecting the constituent parts of the universe. Mr. Hutchinson supposed the following divisions. 1. The darkness, or dark air, or the fine ether, in the state of stagnation. 2. The spirit, or the air in sensible motion. 3. The light, or the pure ether in motion. 4. The luminaries, comprehending the sun, moon, and stars. 5. The densities, which form the extremity of the whole system of nature: or the dense gross air, out of which the fine ether is extracted, and into which it returns. He considered that the regions of space would be naturally grosser and grosser, the farther from the sun, and that the utmost extremity would be condensed into an immoveable solid. But since the discoveries and observations of Dr. Herschell on the nebulosity of the heavens, (which we shall take a brief survey of, when treating of the fixed stars,) very different conjectures and theories have been substituted. It now appears a more probable and rational conjecture, that our solar system is but one of innumerable systems; that the universe is of infinite extension, and occupied by an infinite multitude of worlds; that the sovereignty of the Creator is not limited to a comparatively insignificant and solitary world, or system, but that it is infinite as his wisdom, and extensive as his power. By the application, and great improvement of telescopic powers, the ideas of the universe has been much enlarged-; assisted and corroborated by handmaids of philosophy, science, and analogy. And we derive new views and prospects of the constituent parts of nature, and of universe, from recent experiments, and the great improvements, and discoveries in chemical philosophy. Hence we contemplate the universe as a boundless expanse, interspersed with contiguous systems; and worlds, suspended at distances proportionate to their mutual powers of attraction, and capable or reciprocating causes and effects hence we contemplate the nebulous patches of the heavens, as so many systems, and the galaxy as a zone of systems; and hence also we contemplate the sun as the centre of its particular system, comprehending the worlds which revolve round it as their common centre.

It was formerly imagined that the sun was a globe of liquid fire, from an idea that heat travelled to us from the sun: and the conclusion was naturally deduced, that the nearer the sun, the greater the heat. But this is found to be evidently erroneous. Notwithstanding Sir Isaac Newton calculated the heat of a comet at its nearest approach to the sun, to be 2000 times hotter than red hot iron; it was evidently en the assumption, that the sun was a globe of fire, and that the intensity of the beat, was in a ratio, proportionate to the distances. But this does not correspond with experience, for it is decisively ascertained, that the most intense cold prevails, at small elevations, in a direct line between us and the sun, even in the hottest parts of the globe under the equinox; towards the summits of very high mountains, where the cold has been found so intense, that it was with difficulty, life could be supported. The like has also been experienced, in the ascent in balloons, when the aeronauts have attatned to a great height, they have experienced intense cold, even when the weather has been intensely warm, on the surface of the earth. It is further evident that heat and fire, are mere local effects, from the various changes of the atmosphere, and from the phenomenon of hail in summer, when the drops of rain coming in contact with a cold region of air, are divested of their caloric, and instead of descending in a shower of water, descend in a shower of ice'. Hence it is sufficiently apparent that the elementary matter of heat, and fire, does not travel to very great distances in the atmosphere, but that it is confined to narrow limits near the surface of the earth, that it is a subtile elementary body, which can be alternately collected, and dissipated, in a great variety .f degrees by a great variety of circumstances. And these various

effects, exactly correspond with the modern discoveries, experiments and doctrines of that subtile elementary substance, caloric.

These ideas would naturally introduce the mind, to a more connected, systematic. and rational train of reflection, on the sublime and interesting subjects of astronomy, and the philosophy connected with it. They would exhibit nature on a more extended scale of grandeur and simplicity. They would tend to harmonize the universe, and unfold the true relations of nature. They would display in more enlarged characters, and appropriate features, the universal creation, and the universal Creator. They would show that immortality was stamped on the universe; that the essential principle of all being, and of every species of being, was active, immutable, and universal. It would tend to excite in the mind of the creature reverence, gratitude and piety. And give an importance to being, even the meanest of the works of God.

Thus much premised, we shall proceed to survey the various phenomena of the heavens.

Chapter 2 - Of the Heavenly Bodies in Particular

The sun is apparently the most magnificent and splendid orb in the heavens. And the most obvious phenomena attending it, are its light, its heat, and its daily rising and setting; but although the sun appears extremely bright and splendid to the naked eye, yet he is frequently observed even through a telescope of very moderate powers, to have dark spots on his disk. These were first discovered in 1611 : and the honour of the discovery was disputed between Galileo and Scheiner a German jesuit of Ingolstadt.

There is a great variety in the magnitude of these spots. The difference is chiefly in superficial extent of length and breadth ; their depth or thickness is very small; some have been computed to be so large, as to be capable of covering the continents of Asia, and Africa, and even of the globe itself. The diameter of a spot, when near the middle of the disk is measured by comparing the time it takes in passing of a hair, laid across the telescope, with the time it takes the whole disk to pass over the same hair; it may also be measured by a micrometer. By either of these methods, we may judge how many times the diameter of the spot is contained in the diameter of the sun.

It is observed that these spots are subject to increase and diminution of their magnitude, that they are of various shapes, most of them having a deep black nucleus surrounded by a dusky cloud, whereof the inner parts near the black are a little brighter than the out-skirts. They frequently change their shapes in the manner of our clouds, though not often so suddenly: thus what is of a certain figure to-day, tomorrow, or perhaps in a few hours shall be of a different one ; one spot is sometimes broken into two or three, and sometimes two or three spots shall coalesce, and be united in one. The number of spots is very uncertain, sometimes there are a great many, sometimes very few; and sometimes none at all.

It is evident from the various appearances, that the spots are not endowed with any permanency, nor are they uniform in shape, number magnitude, or duration. Hevelius observed one that arose and vanished in 16 or 17 hours; and no one has been observed to continue longer than 70 days; in general those spots which are gradually formed, are gradually dissolved; and those which appear suddenly, are suddenly dissipated; it has been observed that when a spot disappears, the particular place which it occupied becomes brighter, on the other band those parts called faculae frequently turn to spots.

The sun when free from spots, appears equally luminous to the eye, or through coloured glasses. But through a telescope, the middle of the disk appears brighter than the out-skirts, the light

darting more directly to us from the middle than the other parts, and the faculae appear more distinctly near the sides.

The spots are not confined to one part of the sun's disk; though we have not heard of any being observed about his polar regions. They described different courses over the sun's disk, sometimes they travel in straight lines, sometimes in curves; sometimes descending from the northern to the southern part of the disk, sometimes ascending from the southern to the northern, &c. Besides these spots there are others which sometimes appear very round and black, travelling over the sun's disk in a few hours, and are totally unlike the others. These proceed from the interposition of the planets, Mercury, and Venus, between the earth and the sun. Excepting these two kinds of spots, nothing is discoverable on the surface of the sun, but he appears like an immense ocean of light.

Mr. Huygene supposed the sun to be a liquid globe, which the equal distribution of its rays, he thought was an argument for. The small inequalities upon it discovered by means of the telescope, and which has made some imagine they saw huge mountains of fire, he considered as entirely owing to the trembling motions of the vapours of our atmosphere; and that it was likewise the cause of the twinkling of the stars; and indeed it is not much to be doubted but that our vision is abundantly, more affected by the medium of our own atmosphere than we are aware of For instance, should we deviate ever so little from the old established hypothesis, that light travels in straight lines, and should it hereafter be discovered, that the motion of light, like all other motion, is elliptical, it would very materially affect our calculations of the distances, magnitudes, and appearances of the celestial bodies.

When the moon passes between the earth and the sun, so as to intercept his rays, he is said to be eclipsed. This happens only at the time of new moon, because it is then only she passes between the sun and the earth. Yet the sun is not eclipsed at every new moon, because the moon more frequently declines from a straight line between the earth and the sun, either to the north, or the south. And this is also the case when the moon passes at the opposite conjunction, when she passes to the northward or southward of the earth's shadows.

No solar eclipse can be universal, the moon being too small to overshadow the whole earth. Consequently the eclipses of the sun do not appear the same in all places, but are total in one, and partial in another. In most solar eclipses the moon is covered with a faint dawning light, which appears owing to the reflection of the light from the illuminated parts of the earth. In total eclipses, the moon's edge is seen surrounded by a pale circle of light, which is at least a probable indication. of a lunar atmosphere.

When the earth is interposed between the moon and the sun in a direct line, so as to intercept his rays upon the moon, then the moon is eclipsed. And this is only at the time of the full moon. In the midst of a lunar eclipse the moon is observed to have a faint light, which is supposed to be reflected by the' atmosphere of the earth, and that to the shadow of this it is owing, that she grows paler and dimmer before she enters into the shadow of the earth.

The interior conjunction of the planets, Mercury, and Venus, when passing over the sun's disk, are not called eclipses, but transits.

The greatest diameter of the sun as seen from the earth is 32' 36', or 883,217 miles. It is stated from observations to revolve on its own axis in 25h. 15' 16", and is computed to be 1,380,000 times larger than the earth. It has been calculated to be 97,000,000 of miles distant from our earth.

2. Mercury to our observation at least, is the nearest planet t. the sun; this planet when viewed through a telescope magnifying about 200 or 300 times, appears equally luminous throughout his whole surface, without the least spot. He exhibits the same phases with the moon, being sometimes horned, sometimes gibbous, and sometimes shining with a full face, though not entirely full, because his enlightened side is never turned directly towards us, but at all times perfectly well defined, without any ragged edge and perfectly bright.

This planet performs its entire revolution in its orbit, in 87 days, 23 hours, and 15 1/4 minutes, which of course is the length of its year. Its distance from the sun is computed to be 27,000,000 of miles, or as have computed it to be 1/4 the distance of the earth. Its greatest apparent diameter as seen. from the earth 11", or 3222 miles. 'Its diurnal rotation is unknown, it not being possible from appearance on his disk, to come at a knowledge of his rotary motion. - The inclination of his orbit to the ecliptic, is 70; its bulk is (thpnted to be of that of our earth, and its proportion of density 2-1, and its light 6-I.

3.Venus is next to Mercury, and the second interior planet it is rarely seen to shine with a full face, but has phases and changes like those of the moon, her illuminated hemisphere being constantly turned towards the sun. This planet is what is termed the morning and evening star, as she is situated in different parts of her orbit.

Dr. Herschel has published in the philosophical transactions for 1793, a long series of observations on this planet, whence he concludes, that the planet revolves about its axis, but that the period, and position of the axis are uncertain, that it has a very considerable atmosphere; that it exhibits inequalities of surface, though he could not discover much of them; owing probably to the density of its atmosphere; and that this planet instead of being smaller, is somewhat larger than the earth; though former astronomers have computed its diameter at 7687 miles, which is 275 miles less than the diameter of the earth, or its bulk of the' earth; and its diurnal rotation to be 23h. 22'. Its mean distance from the sun, is computed to be 68,000,000 of miles.

The earth as a planet, offers itself next to our contemplation, as being situated next in order in the solar system. But as it involves phenomena, and considerations abundantly more numerous and interesting than the surrounding orbs, we shall first take a brief survey of those celestial bodies, which occupy the remoter regions of space, and first of the exterior planets, Mars, Jupiter, Saturn, and Herschel.

4.Mars is the next planet; and is called an exterior planet, because it describes an orbit without the orbit of the earth. He is of a red, fiery colour, and gives a much duller light than Venus, though he sometimes equals her in size. He is not subject to the same limitations as Venus or Mercury, but appears sometimes very near the sun, and sometimes at a great distance from him. Sometimes rising when the sun sets, or setting when he rises. Mars appears gibbous when near his quadratures with the sun.

Much larger and more remarkable spots have been perceived on the disk of Mars, than on that of any other primary planet. By very accurate observations, Herschel has determined the proportion between the polar and equatorial diameters, and the length of the day of this planet. He has also given some plausible conjectures on its and atmosphere; the latter it is now satisfactorily ascertained to have, though not to so great an extent, as conjectures on former observations led astronomers to imagine.

The mean distance of Mars from the sun is computed to be 144.000,000 of miles, its diameter 1189 miles. Its diurnal rotation, 24h, 39' 22", the inclination of its orbit to the elliptic, 10 51'. Its proportion of solar light, 43. Its bulk in proportion to the earth 7/10 And its proportion of density

5. Jupiter is the next exterior planet in the solar system., He has the same general appearance with Mars, only the belts on his surface are much larger, and more permanent. The number is very variable, sometimes being only one, at other times no fewer than eight may be perceived. They are generally parallel to one another, but not always so; and their breadth is likewise variable, one belt having been observed to grow narrower, while another in its neighbourhood has increased in breadth, as if the one had flowed into the other.

The time of their continuance is also uncertain. sometimes remaining unchanged for three months together, at others, new belts have been formed in an hour or two. In some of these belts large black spots have appeared, which moved briskly over the disk from east to west, and returned in a short time, to the same place; from whence the rotation of this planet abut its axis has been determined

The figure of Jupiter is evidently an oblate spheroid, the longest diameter of his disk being to that of the shortest as 13 to 12. Ills rotation is from west to east like that of the sun, and the plane of his equator is very nearly coincident with that of his orbit ; so that there can be very little difference of seasons in that planet. His rotation has been observed to be quicker in his aphelion than his perihelion.

The most remarkable circumstances attending this planet, is his having four moons or satellites, which constantly revolve round him at different distances. These are all supposed to remove in ellipses, though the eccentricities of all of them are too small to be measured, excepting that of the fourth, and even this amounts to no more than 0,007 of its mean distance from the primary.

The periodic times and distances of these satellites, in semi-diameters of Jupiter, and in English miles, the angles under which their orbits appear, as seen from the earth, at its mean distance from Jupiter, taken from the latest and most exact observations, are ‘as follows.

No.	Perdiodic Times.	Distances		Angle of Orb.
	D h ‘ “	Semi Diam.	Miles	‘ “
1	1..18..27..34	5 2/3	266,000	3..35
2	3..13..13..42	9 1/56	423,000	6..14
3	7.. 3..42.. 36	14 5/16	676,000	7..58
4	16..16..32..9	25 3/16	1,189,000	17..30

6. Saturn sometimes appears at a vast distance from the sun shines with a very faint light; and his motion is so slow among the fixed stars that unless carefully observed, he will scarcely be thought to move at all When viewed through a good telescope, he makes a more remarkable appearance than any of the other planets. Galileo first discovered his uncommon shape, and from his discoveries and those of other astronomers, it appears that this planet is surrounded by a broad ring, the edge of which reflect little or none of the sun’s light to us; but the planes of the ring reflect the light in the same as the planet itself does: the diameter of the ring is about the diameter of the body of the planet. The ring is detached from the body of the planet in such a manner, that the distance between the innermost ‘part of the ring and its body, is equal to its breadth.

Dr. Hershel has found in the course of observation, that the ring is double, or that there are two concentric rings; also that it has a motion of rotation in its own plane, its axis of motion being the same with that of Saturn himself, and its periodical time 10h 32’ 15”. 4 but he thinks it probable,

that the concentric rings may not revolve in the same period. Their dimensions and the space between them, he states in the following proportions to each other.

Miles.

Inner diameter of the small ring, .. 146,345

Outward diameter of do. 184,393

Inner diameter of the large ring, 190,248

Outside diameter of do. 204,883

Breadth of the inner do. 20,000

Breadth of the outer do. 7,200

Breadth of the vacant space 2,839

Dr. Herschel concludes from his observations on the ring, that its structure is such, as to alLow it to remain permanently in its present state; nor does he think it at all probable, that the ring is of that changeable nature which some have imagined.

The same excellent astronomer has concluded from a series of observations on the belts of Saturn, that he revolves on his axis in 10h. 16' 0”.4, that be has a dense atmosphere, and that his polar diameter is to his equatorial as 10 to 11.

Saturn has, besides his ring, seven secondary planets or satellites revolving round him. One of them, which till lately was reckoned the fourth in order from Saturn, was discovered by Huygens, in 1655, and by means of a telescope of 100 feet long; and the others; viz. the 1st, 3d 4th., and 5th. at different times by Cassini, between 1671 and and 1684, by the help of glasses of 100 and 136 feet. The 6tband 7th have been lately discovered by Herschel, with his 40 feet reflecting telescope in 1787 and 1788. These he has called the 6th and 7th satellites, though they are nearer to Saturn than the other 5, that the names may not be mistaken with regard to former observations of them.

The periodical revolutions and distances of these satellites ex. pressed in semi-diameters of that planet, and in English miles, are as follows.

No.	Periodical Times	Distances in		Angle of Orbit
	D h ‘ “	Semi Diam.	Miles	‘ “
1	1 21 13 27	4 3/8	170,000	1 27
2	2 17 41 22	5	217,000	1 52
3	4 12 25 12	8	303,000	2 36
4	15 22 41 13	18	704,000	6 18
5	72 7 48 0	54	2,050,000	1 14
6	1 8 53 9	3 5/9	135,000	1 14
7	0 22 40 46	2 5/6	107,000	0 57

The 4 first described ellipses like those of the ring, are in the same plane: their inclination to the orbit, is from 300 to 31. The 5th describes an orbit inclined from 17 to 18 to the orbit of Saturn, his

plane lying between the ecliptic and those of the other satellites. Dr. Herschel observes that the 5th satellite turns round its axis once, exactly in the time in which it revolves round the planet Saturn. In this respect it resembles our moon, which does the same thing.

7. The Georgium Sidus, or Herschel, being more remote than Saturn, is also less known. Its apparent magnitude is so small, that it can seldom be seen by the naked eye, and even when viewed by means of the telescope, it appears only a few seconds in diameter. This planet was discovered by Dr. Herschel, in 1781; and in 1787 he likewise discovered two satellites that revolve round it. They are probably not less than Jupiter's moons, and their orbits are nearly perpendicular to the ecliptic. This is a circumstance in which they differ from the attendants of all the other planets.

Their periods of revolution and angular distances from their primary, are as follows.

No.	Periods.	Distance
	D h ' "	' "
1	8 17 1 19	0 33
2	13 11 5 1 1/3	0 44 2/9

8. Comets are another class of planets appertaining to our system, and which exhibit appearances vastly different from any of the other planets. The nucleus or star, seems much dimmer; they are to appearance surrounded with atmospheres of a prodigious size, often rising ten times higher than the nucleus, and often likewise exhibit different phases, like the moon.

What is called the head of a comet, or the round part, appears to be a solid globe, and is called the nucleus, which is easily distinguished from the atmosphere of hairy appearance.

Comets are peculiarly distinguished by a blaze or tail, also by the eccentricity of their motion. Sometimes the tail only has been seen at 'the head has been hid under the horizon, then it is termed a beam. There appears to be a relative degree of conformity peculiar shape of the atmosphere of comets, the velocity with which they move, and the extreme ellipsis in which they traverse. None of the celestial bodies have given rise to a greater degree of speculation and conjecture than the comets. Their strange appearance has in all ages been a matter of terror to the vulgar, who uniformly looked upon them as bad omens, or forerunners of war, pestilence, &c. Others less superstitious, have supposed them to be meteors formed in the upper regions of the air. After much speculation and conjecture among astronomers, Tycho Brahe restored them to their true rank in the creation, and Sir Isaac Newton at length discovered their true motion, from the observations he made on the great comet which appeared in 1680 This comet appeared to descend almost perpendicular towards the sun with a prodigious velocity; ascending again with a motion retarded as much as it had been before accelerated. It was seen in the morning by a great number of astronomers in different parts of Europe from the 4th to the 25th of November, in its way towards the sun, and in the evening, from the 12th of December to the 9th of March following. The many exact observations made on this comet, enabled Sir Isaac Newton to deter-mine, that they are a kind of planets, which move in very eccentric ellipses and this opinion is now considered as an established truth. Although the orbits of all comets are very eccentric ellipses, yet there 'are very great differences among them. Excepting the orbit of Mercury there are no great differences among those of the planets, either as to their eccentricity, or the inclination of their planes; but the planes of some comets are almost perpendicular to others, and. some of their ellipses are much wider than others. The narrowest. ellipsis of any comet hitherto observed, was that of 1680. There is also a much greater inequality in the motion of the comets, than in the planets; the velocity of the former being incomparably greater in their perihelion than in their aphelion; but the planets are but little accelerated. Hence it is apparent, that the degree of acceleration of any orb, will be

in a ratio proportionate to the degree of the ellipsis of its orbit ; for it is evident from all observation, that a body is retarded in its aphelion, in a degree corresponding to its acceleration in its perihelion distance.

It is now universally allowed that comets are opaque bodies, enlightened by the sun. Sir Isaac Newton observes that if a comet be observed, in two parts of its orbit at equal distances from the earth, but at unequal distances from the sun, it always shines brightest in that part which is nearest to the sun.

Comets are of very different magnitudes, which may be observed from their apparent diameters and brightness.

The extraordinary atmospheres, or tails of comets, have given rise to various conjectures, though it is allowed by all, that they depend on the sun some way or other, as they are always directed towards him in one undeviating position; but by what means this is effected is a subject of dispute among philosophers.

The analogy discovered by that indefatigable astronomer, Kepler between the periodical times of the planets, and their distances from the sun, takes place also in the comets. In consequence this, the mean distance of a comet from the sun, may be found by comparing its period with the time of the revolution round the sun. Thus the period of the comet which appeared in 1531, ,IeOI, I68 and 1759 being about 76 years, and whose regular return will be about the year 1835, its mean distance may be found by the following proportion. As I, the square of one year, the earth's periodical time, is to 5776, the square of 76, the comet's periodical time, so is 1,000,000, the cube of 100, the earth's mean distance from the sun, to 5,77,000,000, the cube of the comet's mean distance. The root of this last number

1794, the mean distance itself in such parts as the mean distance of the earth from the sun contains 100. If the perihelion distance of the comet 58, be taken from 3588, double the mean distance, we shall have the aphelion distance 3530, of such parts as the distance of the earth contains 100, which is a little more than 35 times the distance of the earth from the sun. By a like method, the aphelion distance of the comet of 1680, comes out 138 times the mean distance of the earth from the sun, supposing its period 575 years ; so that this comet in its aphelion goes more than 14 times the distance from the sun that Saturn does. Euler computes the orbit from three of Flamstead's observations, taken nearly together, compared with a fourth, taken at some distance from the other three, and from thence concludes the.-period to be a little more than 170 years.

9.The next celestial objects which present themselves in succession to our notice, are those innumerable orbs, which we term fixed stars: they are termed fixed, because they appear not to vary their situations in the heavens, to a spectator on the earth. Astronomers have supposed them to be so many suns, each the centre of a system of habitable worlds, similar to our solar system. The strongest argument for this, is, that the stars cannot be magnified, even by the most powerful telescope, on account of their immense distance; whence it is concluded, that they shine by their own light, and are therefore so many suns; each of which we may suppose is of equal if not superior magnitude to our own. They are situated at vastly different distances from us, as is indicated by their different magnitudes; and this supposition is necessary, to prevent any interference of the orbits of the planets, and thus there may be as great a distance between a ___ of the first magnitude and one of the second, apparently close to it, as between our globe and the fixed stars themselves.

The fixed stars, instead of being magnified by the best glasses, are ___ diminished in size, on account, as is thought, that the telescope takes off that twinkling appearance which they exhibit to

the naked eye., or more probably, that the rays being very much compounded in consequence of their immense passage, the superfluous rays are excluded by the instrument; and this is inferable from the fact, that the number of stars is prodigiously increased by the telescope, 70 stars having been counted in the single constellation Pleiades, and fewer than 2000 in that of Orion.

The late great discoveries and improvements of the celebrated Herschel have thrown new light on this subject, and shown the number of stars to be exceedingly beyond the discoveries, and even the apprehensions of the ancients. This able astronomer has shown that many which appear single to the naked eye, or through ordinary glasses, do in fact consist of two or more stars; and that the galaxy or milky way, owes its light entirely to multitudes of small stars, so close together, that the naked eye, or even ordinary telescopes cannot distinguish them.

The nebulae, or small whitish specks, discoverable by means of the telescope, in various parts of the heavens, are owing to the same cause. Former astronomers could only reckon 103 of these nebulous patches, but Herschel has discovered upwards of 1250. He has also discovered a species of them which he calls planetary nebulae, on account of their peculiar brightness, and their shining with a well defined disk.

In the philosophical transactions for 1783, Mr. Mitchell, in proposing a method to determine the distance, magnitude, &c. of the fixed stars, by the dimmution of the velocity of their light, should any such thing be discovered, supposes, that by far the greater par, if not all of them, are systems of stars, so near to each other, as probably to be liable to be affected sensibly by mutual gravitation; and that it is therefore not unlikely that the periods of the revolutions of some of these about their primaries, the smaller ones being upon this hypothesis to be considered as satellites to the other,) may at some time or other be discovered. Dr. Herschel, improving upon Mitchell's idea, of the fixed stars being collected into groups, and assisted by his own observations, aided by his extraordinary telescopic powers, has suggested a theory concerning the construction of the universe, entirely novel and singular. The opinion had long prevailed among astronomers, that our sun, besides occupying the center of the system which properly belongs to him, occupied also the center of the universe; but Dr. Herschel is of a different opinion; we shall extract some of the doctor's observations on this interesting subject.

Hitherto (says the Dr.) the siderial heavens have, not inadequately for the purpose designed, been represented by the concave surface of a sphere, in the centre of which the eye of the observer might be supposed to be placed. It is true, the various magnitudes of the fixed stars even then, plainly suggested to us, and would have better suited, the idea of an expanded firmament of three dimensions; but the observations upon which I am now going to enter, still farther illustrate and enforce the necessity of considering the heavens in this point of view. In future, therefore, we shall look upon these regions, into which we may now penetrate by means of the improved telescopes, as a naturalist regards a rich extent of ground or chain of mountains, containing strata variously inclined and directed, as well as consisting of very different materials. A surface of a globe, or a map, therefore, will but ill delineate the interior parts of the heavens."

The doctor's observations, on which this theory is founded, were made with a Newtonian reflector of 20 feet focal length, and an aperture of 18 inches. With this powerful telescope, he first began to survey the Via Lactea, and found that it completely resolved the whitish appearance into stars, which the telescopes he formerly used, had not light enough to do. The portion he first observed, was about the hand and club of Orion; in which he found, an astonishing multitude of stars, the number of which he endeavoured to estimate, by counting many fields, (or apparent spaces of the heavens, which he could see at once through his telescope,) and computing from a medium of these, how many might be contained in a given portion of the milky way. In the most vacant place to be met with in that neighbourhood, he found 63 stars: other six fields, contained 110, 66, 70, 90,

70, and 74 stars, a medium of all which gave 79 for the number of stars to each field.—Thus he found that by allowing 15’ for the diameter of his field of view, a belt of 15 long, and 2 broad, which lie had often seen pass before his telescope, in an hour’s time, could not contain less than 50,000 stars, large enough to be distinctly numbered besides which, he suspected twice as many more, which could be seen only now and then, by faint glimpses, for want of sufficient light.

The doctor’s success thus far, soon induced him to direct his attention to the nebulous parts of the heavens, of which an accurate list was published in the Connoissance de Temps for 1 783 and 1784. Most of these yielded to a Newtonian reflector of 20 feet focal distance, and 12 inches aperture, which plainly discovered them to be composed of stars, or at least to contain stars, and to show every other indication of consisting of them entirely.

“The nebulae (says he) are arranged into strata, and run on to a great length; and some of them I have been able to pursue and to guess pretty well at their form and direction. It is probable enough, that they may surround the whole starry sphere of the heavens, not unlike the milky way, which undoubtedly it nothing but a stratum of fixed stars; and as this latter immense starry bed, is not of equal breadth and lustre in every part, nor runs on in one straight direction, but is curved, and even divided into two streams, along a very considerable portion of it. We may likewise expect the greatest variety in the strata of the clusters of stars and nebulae.

“One of the nebulous beds is so rich, that in passing through a section of t in the time of only 36 minutes, no less than 31 nebulae have been detected, all distinctly visible on a fine blue sky. Their situation and shape, as well as condition, seem to denote the greatest variety imaginable. In another stratum or perhaps a branch of the former, I have often seen double and treble nebulae variously arranged; large ones with small seeming attendants ; narrow but much extended lucid nebulae or bright dashes; some of the shape of a fan resembling an electric brush issuing from a lucid point; others of a comatic shape, with a seeming nucleus in the centre, or like cloudy stars, surrounded by a nebulous atmosphere: a different sort again, contain a nebulosity of the milky kind, like that wonderful inexplicable phenomenon about Orion is while others shine with a fainter mottled kind of light, which denotes their being resolvable into stars.

“It is very probable that the great stratum called the milky way, is that in which the sun is placed, though perhaps not in the very centre of its thickness. This we gather from the appearance of the galaxy, which seems to encompass the whole heavens, as it certainly must do, if the sun is within the same. For suppose a number of stars arranged between parallel planes indefinitely every way, but at a given considerable distance from one another, and calling this a siderial stratum; an eye placed somewhere within it, will set all the stars in the direction of the planes of the stratum, projected into a great circle, which will appear lucid on account of the accumulation of the stars, while the’ rest of the heavens at the sides, will only seem to be scattered over with constellations, more or less crowded, according to the distance of the planes, or number of stars contained in the thickness or sides of the stratum. If the eye were placed somewhere without the stratum at no great distance, the appearance of the stars within it, would assume the form of one of the lesser circles of a sphere, which would be more or less contracted to the distance of the eye; and if this distance were exceedingly increased, the whole stratum might at last be drawn together into a lucid spot of any shape, according to the position, length, and height of the stratum. Let us now suppose that a branch or smaller stratum should run out from the former in a certain direction, and let it also be contained between two parallel planes, extended indefinitely onwards, but so that the eye may be placed in the great stratum, somewhere before the separating and not far from the place where the strata are still united; then will the second stratum not be projected into a bright circle like then will former, but will be seen as a lucid branch proceeding from the first, and returning to it again at a certain distance less than a semicircle. What has been instanced in parallel planes may easily be applied to strata irregularly bounded, and running in various

directions ; for their projection will of consequence vary, according to the quantities of the variations in the strata, and the distance of the eye from the same and thus any kind of curvatures, as well as various degrees of bright. ness, may he produced in the projections.

“From appearances, then, as I observed before, we may infer, the sun is most likely placed in one of the great strata of the fixed stars, and very probably not far from the place where some smaller stratum branches out from it. Such a supposition will satisfactorily and with great simplicity, account for all the phenomena of the milk way; which, according to this hypothesis, is no other than the appearance of the projection of the stars contained in this stratum, an its secondary branch. As a farther inducement to look on the galaxy in this point of view, let it be considered, that we can no longer doubt of its whitish appearance arising from the mixed lustre of the numberless stars that compose it. Now should we suppose it to be and irregular ring of stars, in the centre nearly of which we must suppose our sun to he placed, it will appear not a little extraordinary, that the sun being a fixed star like those which compose this imagined ring, should just be in the centre of such a multitude of celestial bodies without any apparent reason for this singular distinction; whereas on the other supposition, every star in this stratum, not very near the termination of its length or height, will be so placed as to have its own galaxy, with only such variations in the form and lustre of it, as it may arise from the particular situation of each star.”

A continued series of observations confirmed Dr. Herschel in these opinions; and in a succeeding paper, he has given a sketch of his ideas of the interior construction of the starry heavens.—” That the milky way (says he,) is a most extensive stratum of stars of various sizes, admits no longer of the least doubt; and that our sun is one of the heavenly bodies belonging to it, is equally evident. I have now viewed and gauged this shining zone in almost every direction, and find it composed of shining stars, whose number, by the account those gauges, constantly increases and decreases, in proportion to its apparent brightness to the naked eye.

“But in order to develope the ideas of the universe, that have been suggested by my late observations, it will be best to take the subject from a point of view at a considerable distance both of space then suppose numberless stars of various sizes and time. Let us then suppose numberless stars of various sized, scattered over an infinite space, in such a manner as to be almost divided through whole. The laws of attraction, which no doubt extend to the remotest regions of the fixed stars, will operate in such a manner most probably to produce the following remarkable effects.

1. It will frequently happen, that a star being considerably larger than its neighbouring ones, will attract them more than they will be attracted by others that are immediately around them; by which means they will be in time, as it were, condensed about a centre; or in other words form themselves into a cluster of stars of almost a globular figure, more or less regularly so according to the size and original distance of the surrounding stars. The perturbations of the mutual attractions must undoubtedly be very intricate, as we may comprehend, by considering what Sir Isaac Newton has said, (Princip. Lib i. Prob. 38. et seq.) but in order to apply this great author’s reasoning, of bodies moving in ellipses, to such as are here for a while supposed to have no other motion, than what their mutual gravity has imparted to them, we must suppose the conjugate axes of their ellipses indefinitely diminished, whereby the ellipses will become straight lines.

2. The next case which will happen almost as frequently as the former, is where a few stars, though not superior in size to the rest, may chance to be rather nearer each other than the surrounding one, for here also will be formed a prevailing attraction in the combined center of gravity of them all, which will occasion the neighbouring stars to draw together; not, indeed, so as to form a regular globular figure, but, however, in such a manner as to be condensed towards the common centre of gravity of the whole irregular cluster. And this construction admits of the utmost variety

of shapes, according to the number and situation of the stars, which first gave rise to the condensation of the rest.

3. “From the composition and repeated conjunction of both the foregoing forms, a third may be derived: when many large stars, or combined small ones, are situated in long extended, regular, or crooked hooks, or branches; for they will also draw the surrounding ones, so as to produce figures of condensed stars coarsely similar to the former, which gave rise ~o these condensations.

4. ‘We may likewise admit of still more extensive-combinations; same time a cluster of stars are farming in one part of space, there may be another collecting in a different, but perhaps not The distant quarter, which may occasion a mutual approach towards this common centre of gravity.

5. “In the last place, as a natural consequence of the former cases, there will be great cavities, or vacancies, formed by the retreat of the stars towards the various centres which attract them; so that, upon the whole, there is evidently a field of the greatest variety for the mutual and combined attractions of the heavenly bodies to exert themselves in. .

“From this theoretical view of the heavens, which has been takes from a point not less distant in time than in space, we will now retreat to our own retired station, in one of the planets attending a star in great combination with numberless others; and in order to investigate) what will be the appearance from this contracted situation, let us begin with the naked eye. The stars of the first magnitude being in all probability the nearest, will furnish us with a step to begin our scale Setting off therefore, with the distance of Sirius or Arcturus, for instance as unity, we will at present suppose, that those of the second magnitude are at double, those of the third at treble the distance, &c. Taking it for granted then, that a star of the 7th magnitude (the smallest supposed visible with the naked eye) is about 7 times as far: as one of the first, it follows, that an observer, who is inclosed in a globular cluster of stars, and not far from the centre, will never be able with the naked eye to see the end of it; for since according to the above estimation, he can only extend - his view to about 7 times the distance of Sirius, it cannot be expected that his eyes should reach the borders of a cluster, which has perhaps not less than 50 stars in depth every where around him. The whole universe to him, therefore will be comprised in a set of constellations, richly ornamented with scat-tered stars of all sizes; or, if the united brightness of a neighbouring cluster of stars should, in a remarkable clear night reach his sight, it will put on the appearance of a small, faint, whitish, nebulous cloud, not. to be perceived without the greatest attention.

“Let us suppose him placed in a much extended stratum, or branching cluster of millions of stars, such as may fall under the third form, of nebulae already considered. Here also the heavens will not only be richly scattered over with brilliant constellations, but a shining zone, or milky way will be perceived to surround the whole sphere of the heavens, owing to the combined light of those stars which are too small, that is, too remote to be seen. Our observer’s sight will be 80 confined, that he will imagine this single collection of stars, though be does not even perceive the 1000th part of them to be the whole contents of the heavens.

Allowing him now the use of a common telescope, he begins to suspect that all the milkiness of the bright path which surrounds the sphere, may be owing to stars. He perceives a few clusters of them in various parts of the heavens, and finds also, that there are a kind of nebulous patches: but still his views are not so far extended as to reach the end of the stratum in which he is situated; so that he looks upon these patches as belonging to that system, which to him seems to comprehend every celestial object. He now increases his power of vision; himself to a close observation, finds that the milky way is indeed no other than a collection of very small stars. He perceives that those objects which had been called nebulas, are evidently nothing but clusters of stars. Their number increases upon him; anti when he resolves one nebulas into stars, he discovers ten new ones which lie cannot

resolve He then forms the idea of immense strata of fixed stars, of clusters of stars, and of nebulas, till going on with such interesting observations, he now perceives that all these appearances must naturally arise from the confined situation in which we are placed. Confined it may justly be called, though in no less a space than what appeared before, to be the whole region of the fixed stars, but which now has assumed the shape of a crooked branching nebula; not indeed one of the least, but perhaps very far from being one of the most considerable, of those numberless clusters that enter into the construction of the heavens."

Herschel shows, that this theoretical view of the heavens is perfectly consistent with facts, and seems to be confirmed by a series of observations. Many hundreds of nebulas of the first and second forms are to be seen in the heavens ; and their places, he says, will hereafter be pointed out; many of the 3d form described, and instances of the 4th related; a few of the cavities mentioned in the 5th particularized, though many more have been already observed ; so that, upon the whole (says he) " I believe it will be found, that the foregoing theoretical view, with all its consequential appearances, as seen by an eye inclosed in one of the nebulas, is no other than a drawing from nature, wherein the features of the original have e been closely copied: and I hope the resemblance will not be called a bad one, when it is considered how very limited must be the pencil of an inhabitant of so small and retired a portion of the infinite system, in attempting the picture of so unbounded an extent."

The doctor having determined that the visible system of nature, by us called the Universe, consisting of all the celestial bodies, and many more than can be seen by the naked eye, is only a group of stars or suns, with their planets, constituting one of those patches called a nebula, and perhaps not one ten thousand millionth part of what is really the universe, he goes on to-delineate the figure of this vast nebula, which he is of opinion may now be done; and for this purpose, lie gives a table, calculating the distance of the stars which form its extreme boundaries, or the length of the visual ray in different parts, by the number of stars contained in the field of his telescope at different times. He then proceeds to offer some thoughts on the origin of the nebulous strata of the heavens; in doing which, he gives some hints concerning the antiquity of them.

If it were possible (says he) to distinguish between the parts of a indefinitely extended whole, the nebulae we inhabit, might be said be one that has fewer marks of antiquity, than any of the rest. explain this idea, perhaps more clearly, we should recollect, that condensation of clusters of stars, has been ascribed to gradual approach and whoever reflects on the number of ages that must hive passed before some of the clusters that are to be found in my intended catalogue of them, could be so far condensed as we find them at present will not wonder if I ascribe a certain air of youth and vigour, to very regularly scattered regions of our siderial stratum. There are moreover, in my places in it, in which, if we may judge from appearances, there is the greatest reason to believe, that the stars are drawing towards secondary centres, and will in time separate into clusters so as to occasion many subdivisions.

" Here we may surmise, that when a nebulous stratum consists chiefly of nebulas of the first and second forms, it probably owes origin to what may be called the decay of a great compound nebula of the third form ; and that the subdivisions which happened to it, it length of time occasioned all the small nebulas which sprung from it to lie in a certain range, according as they were detached from the primary one. In like manner, our system, after numbers of ages, may very possibly become divided, so as to give rise to a stratum of two or three hundred nebulas ; for it would not be difficult to point out so many beginning or gathering clusters in it. " This throws a considerable light, upon that remarkable collection of many hundreds of nebulas which are to be seen in what I have called the nebulous stratum in Coma Berenices. It appears from the extended and branching figure of our nebula, that there is room for the decomposed small nebulas, of a large, reduced, former great one, to approach nearer to us in the sides, than in any other part. Nay, possibly there

might originally be another very large joining branch,-which in time became separated by the condensation of the stars: and this may be the reason of the little remaining breadth of our, system in that very place; for, the nebulas of the Coma are brightest and most crowded just opposite to our situation, or in the pole of the system.

“As soon as this idea was suggested, I tried also the opposite pole where, accordingly, I have met with a great number of nebulas, though under a much more scattered form. Some parts of our system, indeed, seem already to have sustained greater ravages of time than others; for instance, in the body of the Scorpion, in an opening which is probably owing to this cause. It is at least 4 broad; but its height I have not yet ascertained. It is remarkable, that the 80 Nebuleuse sans Etoiles of the Connoissance des Temps; which is also on the western border of another vacancy, and has, moreover, a small miniature cluster or easily resolvable nebula, of about 2 minutes north. Following it at no very great distance.

There is a remarkable purity or clearness in the heavens, when we look out of our stratum at the sides ; that is towards Leo, Vergo, and Coma Berenices on the one band, and towards Cetus on the other;; where as the ground of the heavens becomes troubled as we approach towards the length or height of it. These troubled appearances are easily to be explained by ascribing them to some of the distant straggling stars that yield hardly light enough to be distinguished: and I have indeed, often experienced this to be the cause, by examining the spots for a long while together, when at last I generally perceived the stars which occasioned them. But, when we look towards the poles of our system, where the visual ray does not graze along the side the straggling stars will of course be very few in number; and therefore, the ground of the heavens will assume that purity which I have always observed to take place in those regions.”

The doctor here applies the name of poles to those points which are 90 distant from a circle passing along the milky way. The north poles is situated in R. As. 186 and distant from the pole of the world 58.

According to Herschel, then, the universe consists of nebulas, or innumerable collections of innumerable stars, each individual of which is a sun, not only equal, but much superior to ours: and none of the celestial bodies in our nebulas are nearer to one another, than we are to Sirius, whose distance is supposed to be not less than 400,000 times that of the sun from us, or 38 millions of millions of miles. The whole extent of the nebulas being in some places near 500 times as great, must be such, that the light of a star placed at its extreme boundary, supposing It to fly with the velocity of 12 millions of miles every minute must, have taken near 3000 years to reach us. Herschel, however is by no means of opinion that our nebula is the most considerable in the universe.

“As we are used (continues he) to call the appearance of the heavens, where it is surrounded with a bright zone, the milky way, it may not be amiss to point out some other very remarkable nebulas, which cannot well be less, but are probably much larger, than our own system; and being also extended, the inhabitants of the planets

That attend the stars which compose them, must likewise perceive the same phenomena; for which reason they may also be called milky ways. For distinction’s sake. My opinion of their size is grounded on the following observations. There are many round nebulas of the first form, of about five or six minutes in diameter, the stars of which I can see very distinctly ; and on comparing them with the visual ray calculated from some of my long gauges, that the centres of these round nebula may be 600 times the distance of Sirius from us.”

He then tells us, that the stars in such nebulae, are probably twice as much condensed as those of our system: otherwise, the centre of it could not be less than 6000 times the distance that Sirius is from us; and that it is possibly much under-rated, by supposing it only 600 times the distance of that star.

“ Some of these round nebulas (says the Dr.) have others near them, perfectly similar in form, colour, and the distribution of stars, but of only half the diameter: and the stars in them seem to he doubly crowded, and only at about half the distance from each other. They are indeed so small, as not to he visible without the utmost attention. I suppose these nebulas to be double the distance of the first.

An instance equally remarkable and instructive is, a case-, where, in the neighbourhood of two such nebulas as have been mentioned, I met with a third similar, resolvable, but much smaller and fainter nebulas, the stars of it are no longer to be perceived, but a resemblance of colour with the former two, and its diminished size and light may well permit us to place it at full twice the distance of the first. And yet the nebulosity is not of the milky kind; nor is it so much as difficulty resolvable or colourless. Now in a few of the extended nebulas, the light changes gradually, so as from the resolvable to approach to the milky kind ; which appears to me an indication, that the milky light of nebulas is owing to their much greater distance. A nebula therefore, whose light is perfectly milky cannot well be supposed to be at less than 6000 or 8000 times the distance of Sirius; and though the numbers here assumed are not to be taken otherwise, than as very coarse estimates, yet an extended nebula, which an oblique situation, where it is possibly fore-shortened by one half, two thirds, or three fourths of its length, subtends a degree or more in diameter, cannot be otherwise than a wonderful magnitude. and may well out-vie our milky way in grandeur.”

After giving an account of several remarkable nebulas, Dr. Herschel concludes thus: “Now what great length of time must be required to produce these effects (the formation of nebulas) may easily be conceived, when, in all probability, our whole system, of about 800 stars in diameter, if it were seen at such a distance, that one end of it might assume the resolvable nebulosity, would not at the other end. present us with the irresolvable, much less with the colourless and milky nebulosities.” Great indeed must be the length of time, requisite for such distant bodies to form combinations by the laws of attraction, since, according to the distances. the Dr. has assumed, the light of some of his nebulas must be 36,00(J or 48,000 years in arriving from them to us. It would be worth while-then to inquire, whether attraction is propagated in time or not, or whether it moves quicker or slower than light.

Several circumstances, however, lie says manifestly Lend to a general preservation. The indefinite extent of the siderial heavens must produce a balance, that will effectually secure all the great parts of the whole from approaching to each other. “There remains then (says he) only to see how the Particular stars belonging to separate clusters, are prevented from rushing on to their centres of attraction.” this he supposes may be done by projectile forces. “The admission of which will prove such a barrier against the seeming destructive power of attraction, as to secure from it, all the stars belonging to a cluster, if not for ever at least for millions of ages Besides, we ought perhaps to look upon such clusters, and the destruction of a star now and then in some thousands of ages, as the very means by which the whole is preserved and renewed. These clusters may be the laboratories of the universe, wherein the most salutary remedies for the decay of the whole are prepared.”

The existence of such projectile forces is rendered probable, from the apparent changes of position of certain stars, and from a comparison of the best modern observations, with the most accurate of former times, there appears to have been a real change in the places of some of them. The Bull’s Eye, Sirius, and Arcturus, are now found to be half a degree more southerly than the ancients

reckoned them, and the bright star in the shoulder of Orion, has, in Ptolemy, almost a whole degree of latitude more southerly than at present. Dr. Herschel has lately observed that the distance and position of the two stars forming the double star, in Draconis, is different from what it was in Flamstead's time. So considerable is the change of distance (for it is 16".6) that he thinks we can hardly account for it otherwise, than by admitting a proper motion in the one or other of the stars or in our solar system; most probably he says, neither of the three are at rest.

If our solar system do really change its place in absolute space, in process -of time, an apparent change in the angular distances of some of the fixed stars will appear-; and the nearest being more affected than such as are more remote, their relative positions may be seen to alter, although the stars were really immoveable. and vice versa, we may surmise, from the observed motions of the stars, that our sun with all its planets and comets, may have a motion towards some particular part of the heavens, on account of a greater quantity of matter collected in a number of stars, and their surrounding planets there situated, which may occasion a gravitation of our whole solar system towards it. On the other hand, if our system he at rest, and any of the stars really in motion, this might likewise vary their apparent position, and the more so, the nearer they are to us, or. the swifter their motions ‘are, or the more proper the direction of the motion is, to be rendered perceptible by us.

From this brief theoretical sketch, we derive an idea, which the ancient philosophy would not give us, of the amazing grandeur, magnificence, and sublimity of universal being: all the visible part of, which, is hut a mere speck, a comparatively little, branching fragment of the extended universe. And although it is impossible for us to attain to an identifying sensibility, and actual retrospect, in consequence of our limited situation, yet there is every reason to conclude, from analogy, observation, and reflection, that infinite space is thus occupied, and diversified, and that God is a God of the universe, and not merely of this little, straggling world of ours; which is but a little planet, attached to a single star, which appears somewhat eccentrized, from the -regular strata of worlds, and which we have been in the habit of contemplating, as of vast and superior magnitude.

It is a narrow, contracted, and local idea, that limits the boundaries of universal creation, to this little ball of earth, or this little solar system, of which we are a comparatively small member. The idea would appear more rational, and consistent, and more worthy of the munificent hand, that guides the stars in their courses, and grasps them in its palm, that could contemplate not only our own system, but the whole visible universe as a mere link of an infinitely extended system of being. But there is no error, the mind is more prone to, than, to substitute local, for general ideas; and to limit the boundaries of infinite being, to its own finite comprehension. Whereas, it does appear most reasonable, if we apply our mind to a right contemplation of things, and avail ourselves of the analogy of experience and fact, that nature travels on in infinitum. and is equally boundless in magnitude, and prolific in variety.

A late important discovery was made by the celebrated Dr. Bradley, astronomer royal, of the aberration of the fixed stars; this was accidentally made, while endeavouring to ascertain the parallax of be earth’s orbit. This is a variation of their situation, in relation to the plane of the earth’s axis. Mr. Molyneuz and Dr. Bradley began to observe the bright star in the head of Draco, as it passed near the zenith, with an instrument made by Mr. Graham, for the purpose of discovering the parallax, and by often repeated observations, they found the star, about the beginning of March 1726, to be 20 seconds more southerly thin at the time of the first observation. It now indeed seemed to have arrived at its utmost limit southward ; because in several trials made about this time, no sensible difference was observed in its situation. : by the middle of April it appeared to he returning back again towards the north ; and about the beginning of June, it passed about the same distance from the zenith, as it had done in December, when it was first observed. In September following it appeared 39” more northerly than it was in March, just the contrary way to which it

ought to appear by the annual parallax of the stars. This unexpected phenomenon perplexed the observers very much, and Mr. Molyneux died before the true cause of it was discovered. After this Dr. Bradley. with another instrument, more exact, and accurately adapted to the purpose, observed the appearances, not only in that, but many other stars ; and by the great regularity that appeared in a series of observations, made in ;J1 parts of the year. the doctor was full) satisfied with regard to the general laws of the phenomenon, and therefore endeavoured to find out the cause of them. He was already convinced that the apparent motion of the stars, was not owing to a mutation of the earth's axis. The next thing that offered itself was an alteration in .the direction of the plumb line, by which the instrument was constantly rectified; but this proved insufficient, as well as a trial by refraction. At last this acute astronomer found, that the phenomena in question proceeded from the progressive motion of light, and the earth's annual motion in its orbit: for he perceived, that if light was propagated in a given portion of time, the apparent place of a fix d object would not be the same when the eye is at rest, as when it is moving in any other direction, than that of the line passing through the eye and the object; and, that, when the eye is moving in different directions, the apparent place of the object would be different, from the true.

10th. The earth, or planet which we inhabit, is the third in magnitude and distance from the sun. it is computed to he 95.173,000 miles distant from the centre of its attraction, or the body of the sun; round which it revolves in the space of 365 days 5 hours and 49 minutes, or from any equinox, or solstice to the same again, but from any fixed star to the same again as seen from the sun, in 365 days 5 hours 9 minutes ; the former being the length of the tropical year, and the latter the length of the siderial. It travels at the rate of 68,000 miles every hour; a motion, which though upwards of 140 times swifter than a cannon ball, is little more than half as swift as Mercury's motion in his orbit. The diameter of the earth is 7970 miles; and by turning round on its axis every 24 hours from west to east it causes an apparent motion of all the heavenly bodies from east to west. By this rapid motion of the earth on its axis, the inhabitants about the 'equator are carried 1042 miles every hour, while those on the parallel of London are carried only about 580, besides the 68 thousand above mentioned, which is common to all places whatever

A variety of circumstances afford the clearest evidence of the globular figure of the earth. 1. When we are at sea, we may be out of sight of land, even when the land i3 near enough to be visible, if it were not hid from the eye by the convexity of the water. 2. The higher the eye, the farther will the view be extended; it is very common for sailors to go up to the top of the mast to look out, as they term it, and thence they will discover land, or ships at a much greater distance than one could do from the deck. 3. When we are on shore, the highest part of a ship is visible at the greatest distance. If a ship is going from us, out to sea, we shall continue to see the mast, after the hull or body has disappeared, and the top of the mast will continue to he seen the longest. If a ship is coming towards us, the top of the mast comes first in view, and we see more and more, till at last the hull appears 4. Several navigators, as Ferdinand Magellan, Sir Francis Drake, Lord Anson, Captain Cook, &c. have sailed round the globe; not in an exact circle, the land preventing them, but by going in and out as the shores happen to lie. 5. All the appearances of the heavens are the same, whether at land or sea. 6. Eclipses of the moon arise from the shadow of the earth, which is always circular, although the earth presents, during several hours, different portions of its surface to the moon, yet still the shadow is round. The small inequalities upon the surface of the earth, bear no kind of proportion to its magnitude, sufficient to alter the appearance of its shadow. 7. The globular figure of the earth is also inferred from the operation of level ling in which it is found necessary, to make an allowance for the difference between the apparent, and true level.

The earth's axis makes an angle of 23 1/2 with the axis of its orbit, and its position at any one time, is parallel to its position at any other time. Thus it points always to the same quarter of the heavens throughout its annual course. That the earth moves round the sun, may be proved beyond a doubt, by the following arguments.

1st. The sun is found by the most accurate observations, to be immensely larger than the earth; for his diameter, as seen by us, subtends an angle of more than 80', but it is certain, that the earth were it seen from the sun, would not subtend a greater angle than 1 7", if, therefore, the sun be formed of materials, not very much rarer than the earth, (and there is no reason to believe it is less dense,) the quantity of matter in the sun, must far exceed the whole mass of matter in all the planets; and to suppose that gravity retains all the other planets in their orbits, without affecting the earth, would be as absurd, as to suppose that six cannon bullets might be projected up to different heights in the air, and that five of them should fall to the ground, and that the sixth, though neither the highest nor the lowest, should remain suspended in the air, without falling, and the earth move round it.

There is no such thing in nature as a heavy body moving round a light one, as its centre of motion. A pebble fastened to a millstone by a string, may, by an easy impulse be made to circulate round the millstone: but no impulse could make a millstone circulate round a loose pebble; for the millstone would fly off and carry the pebble along with it. The sun is so much bigger and heavier than the earth, that, if he were moved out of his place, not only the earth, but all the planets, even if they were united in one mass, would be carried along with him, as the pebble would be with the millstone.

2. The celestial motions, on this principle become more simple and free of looped contortions, which must be supposed to occur in the other case; and which are extremely improbable, and incompatible with all that we know of motion. 3. If the earth revolve round the sun, then the analogy between the squares of the periodic times, and the cubes of the distances, will obtain in all the bodies, which circulate round a common centre ; whereas this will not be the case with the sun and moon, if both turn round the earth. Besides these, other proofs night be given: but the most complete proof of all, and which indeed amounts to a demonstration is, the aberration of the fixed stars, arising from the progressive motion of light, combined with the earth's progressive motion round the sun, a discovery made by Dr. Bradley, and one of the finest in modern astronomy.

The strongest objection, that can be urged against the earth's moving round the sun like the other planets, is that in opposite points of the earth's orbit, its axis, which always keeps a parallel direction, would point to different fixed stars; which is not found to be fact. But this objection is easily removed, by considering the immense distance of the stars, in respect to the diameter of the earth's orbit; the latter being no more than a point, when compared to the former. If we lay a ruler on the side of a table, and along the edge of the ruler, view the top of a spire at ten miles distance; then lay the ruler on the opposite side of the table, in a parallel situation to what it had before, and the spire will still appear along the edge of the ruler; because, our eyes even when assisted by the best instruments, are incapable of distinguishing so small a change at so great a distance. As the apparent places of the stars, therefore, correspond with this theory, the motion of the earth, and the motion of light are at once determined.

For by frequent observations of the eclipses of Jupiter's satellites, it is found, that light is about 8 minutes in moving from the sun to the earth. And since the earth describes about I degree, or 3800' in a day, or 1440 miles in minutes, it will describe 20" in its orbit; therefore, the velocity of light, is to the velocity of the earth in its orbit, as radius to an arch of 20", or the third part ofa minute, that is, as one to 0002929/3 or, .00009697, or as 10,300 to 1, that is, the velocity of light is I 0,300 times greater than the velocity of the earth in its orbit.

It is found that the sun, and those planets which have visible spots turn round on their own axes: for the spots in general move regular over their disks, allowing for the variations already noticed. Hence %ve may reasonably conclude, that the other planets on which we see no spots, and the

earth which is likewise a planet, have such rotations. ‘But being incapable of leaving the earth to view it at a distance, and its rotation being smooth and uniform, we can neither see it move on its axis as we do the planets, nor feel ourselves affected by its motion.

Yet there is one effect of such motion, which will enable us to judge with certainty, whether the earth revolves On its axis or not.

All globes which do not turn round their axis, will be perfect spheres, on account of the equable pressure on their surface ; especially of the fluid parts. But all globes, which turn on their axis, will be oblate spheroides; that is their surface will be higher, or farther from the centre in the equatorial than in the polar regions: for as the equatorial parts move quickest, they will recede farthest from the axis of motion and enlarge the equatorial diameter. That our earth is really of this figure, is demonstrable from the unequal vibrations of a pendulum, and the unequal length of degrees in different latitudes -Since then, the earth is higher at the equator than at the poles, the sea, which naturally runs downwards, or towards the places which are nearest the centre, would run towards the polar regions, and leave the equatorial parts dry, if the centrifugal tbrce of those parts, by which the waters were carried there, did not keep them from returning. The earth’s equatorial diameter, is 36 miles longer than its axis.

It is found that bodies near the Poles are heavier than those towards the equator, because they are nearer the earth’s centre, where the whole force of the earth’s attraction is accumulated. They are also heavier, because their contrifugal force is less, on account of their diurnal motion being slower. For both these reasons, bodies carried from the poles towards the equator, gradually loose their weight. Experiments prove, that a pendulum which vibrates seconds near the poles, vibrates slower near the equator, which shows that it is lighter, or less attracted there. To make it oscillate in the same time, it is found necessary to diminish its length. By comparing the different length of pendulums, swinging seconds at the equator and at London, it is found, that a pendulum must be 2 169/1000 lines (or 12th part of an inch) shorter at the equator than at the poles.

A person on the earth can no more be sensible of its undisturbed motion on its axis, than one in the cabin of a ship, on smooth water, can be sensible of the ship’s motion, when it turns gently and uniformly round. It is therefore no argument against the earth’s diurnal motion, that we do not feel it; nor are the apparent revolutions of the celestial bodies every day, a proof of the reality of these motions; for whether we, or they revolve, the appearance is the very same. A person looking through the cabin window of a ship, as strongly fancies the objects on land to go round, when the ship turns, as if they were actually in motion.

The other common objections against the earth’s motion on its axis, are easily answered. Some imagine, that if the earth turns eastward, as it actually does, if it turns at all, that a ball fired perpendicularly up in the air, should fall considerably westward of the place it was projected from. This objection will be found to have no weight, if we consider that the gun, and ball, both partake of the earth’s motion: and therefore, the ball being carried forward with the air, as quick as the earth and the air turn, must fall down on the same place. A stone let fall from the top of a main-mast, if it meets with no obstacle, the deck as near the foot of the mast, when the ship sails smoothly along, as when it stands still.

for those scriptural expressions which seem to contradict the earth’s motion, this general answer may be made to them all, that, the scriptures were never intended to instruct us in philosophy, or astronomy; and therefore, on those subjects, expressions are not always to be taken in the literal sense, but for. the most part, as accommodated to the common apprehension of mankind. Men of sense, in all ages, when not treating of the science purposely, have used common language, and it would be absurd to adopt any other, in addressing the majority of mankind. The annual motion of

the earth has been effectually confirmed by an argument drawn from the progressive motion of light; and from the same consideration, the truth of the diurnal motion may be completely established.

In consequence of the progressive motion of light, the apparent place of a fixed star is east of its true place, and the difference is proportional to the cosine of the stars declination; this displacement of the fixed stars has changed, because of the procession of the equinoctial points. Therefore, if the diurnal revolution of the heavens were a real motion, the whole heavens must have changed their appearance; and the respective positions of the stars must be very different now, from what they were in the time of Hipparchus. A star which is now near the vernal equinox, must have changed its apparent distance at least 50 from another elliptical star which is 60 degrees east of it. Nay it is highly probable, that no zodiacal star could be ever visible; such would have been the direction, that the rays of light must have taken, because of their own proper motion being corn-pounded with that of the star, whose velocity must have been exceedingly great,, by reason of its distance from the poles of the motion. But since no such remarkable displacement of the stars has been observed, we may conclude, that the cause which would have produced it, has no existence; and that the revolutions of the heavens is not a real, but only an apparent motion.

From the preceding select remarks and observations, we derive the following satisfactory conclusions. That the earth is a planet, moving in concert with the other planets, and like them, yielding, and exhibiting all the planetary evolutions, waxing, and waning, and revolving round its primary. That it participates in mutual relations, which are common to the system, of which it is a member. That whatever enters into the composition of the earth, is reciprocated through the system, supplied, and communicated by the current flow of attraction, from globe to globe. That this attraction, is a mutual relation. and Communication between worlds, but that it is diversified in degrees, of strength, as they are diversified in degrees of distance. Hence also we derive the physical conclusion, that two worlds cannot be suspended, and concentrated in the same orbit, or limit of attraction, but that their distances will be in an exact ratio, to the space which they are to occupy: so, that, if two worlds c could coalesce and drop. into one, for instance, the earth and .Jupiter, their new orbit would assume a mean distance, between their separate orbits, somewhere, about the orbit of Mars, and this would occur in consequence of, and in proportion to, the combined attraction of the Two spheres. Could such a phenomenon take place, the new world would immediately assume an orbit, whose distance from its centre would be in proportion to its relative quantity of attraction, to that centre: arid the new world would immediately assume, also, a rotatory motion on its axis, which would be in an exact ratio, to the proportion of its equatorial diameter, and its distance from the centre of revolving motion. Finally, we learn from this general review, that the same extensive and universal relations prevail, through the continuity of divisions, and subdivisions of worlds, and systems of worlds, as if the materials of the universe were spread out in uniform consistence, and rendered independent of the mundane laws of density, and rarefaction; gravitation, and attraction; concretion, and expansion; the general laws of motion and revolution; so that no arguments can weigh against the infinite continuity of worlds, and systems of worlds.

The different seasons which we experience, are owing to the obliquity of the axis of rotation of the earth, to the plane of the earth’s orbit. But if the axis were perpendicular to it, there could be no variety in the length of days, in whatever part of the orbit the earth was; and all seasons would be alike. Thus the obliquity of the earth’s axis, to the ecliptic, or which is the same thing of the equinoctial to the ecliptic, is the cause of the different seasons, summer, winter, spring and autumn, during the year. Without this, there could be no difference of seasons; and consequently it could not be easy to know the length of the year, without observations of the stars. For the length of the year is known from the time of observation, when the sun is in the equinoctial points ; and there being no such points to observe by, there could be no method but to observe by the position

of the stars, when the same star was again in opposition to the sun, which none but an astronomer could do.

The sun appears 47 degrees higher in the summer tropic, than it does in the winter tropic; this phenomenon may be thus represented: take a small globe that has the equinoctials and parallels drawn upon it; and placing a candle upon a table, move the globe round the candle in a circle parallel to the table, so that the axis of the equator may be oblique to that circle, and be kept always in a parallel position whilst it moves about. The candle will illuminate the globe as it is carried round, just as the sun does the earth in its orbit; and the parallels will be the same way affected with light and darkness the globe.

The opinion of astronomers, that the orbit of the earth being and the sun constantly keeping in its lower focus, which according to calculation, is, 1,617,941 miles from the middle point of the larger axis, the earth approaches twice as near, or, by computation 3,235;882 miles nearer the sun at one time of the year than at another; for the sun appearing under a larger angle in our winter than in our summer, proves that our earth approaches nearer the sun in winter, than in summer. ‘But here a very serious difficulty occurs, which they appear not to have been aware of, they did not consider in this instance, that whilst it was winter in the northern regions, it was summer in the southern regions of the earth, and that it was impossible, that the earth in 400 of north latitude, could be 3,235,832 miles nearer the sun, than the same earth in 400 of south latitude, the direct difference of which situations, would only amount to a very few miles, in proportion to the angular obliquity of the opposite points of parallel latitudes, north and south; they did not consider, that the part of the earth, which is nearest the sun, is that point on its circumference which has the sun in its zenith at meridian, and that in twelve hours time, that point of its circumference would be farthest from the sun: the angular phenomenon, on which astronomers have founded the hypothesis, vanishes at the equator, and in opposite parallels of latitude, consequently the hypothesis itself falls to the ground.

No part of the earth, can, at the same time, be farther from the sun than another, at a distance exceeding its diameter, or 7964 miles, and that point of the earth which is nearest the sun at meridian, is farthest from it at midnight. One astronomer in 40 of north latitude computes the earth to be 3 1/4 millions of miles nearer the sun, in his northern winter, than it was in his northern summer; while an astronomer, in 40 of south latitude, at the very same instant, and from the very same data, is calculating the same earth to be 3 1/2 millions of miles, farther from the sun than the northern astronomer. while the diameter of the earth itself does not extend to 8000 miles. These remarks are only intended to apply to the hypothesis, that the earth is nearer the sun in winter than in summer, they are not intended to affect, by any means the doctrine of the ellipsis of the earth’s orbit, or to deny its perihelion and aphelion distances. Nor is it intended to deny that the earth is in its perihelion in winter; but it should be recollected, that if the earth is in its perihelion in winter, it is also in its perihelion in summer; for there is no winter but there, is at the same time a summer, and it is evident, that the part where it is summer, is nearer the sun, than the part where it is winter, and this for the reasons before assigned, viz, that of the direct position, of a point of the earth’s circumference to the sun: for the position of all the parts of the earth, where it is summer, is more direct, than the parallel parts where it is winter. Besides, from the nature of an ellipsis, the earth in its complete revolution, must be twice in is aphelion, and twice in its perihelion: and the difference of time will be, half, or the earth will be alternately in its perihelion, and aphelion every six months: consequently, if the earth is in its perihelion in winter, it will also be in its perihelion in summer, for the distance of time is six months, the distance mentioned. And the northern parts of the earth, cannot be in aphelia, at the same time that the southern are in perihelia Therefore, when it is winter in the north, and summer in the south; or summer in the north, and winter in the south, then is the earth in perihelia, then, computing the distance, the earth is 3,235,882 miles nearer the sun, than, when it is in the vernal and autumnal

equinoxes: at which seasons, the atmosphere of the earth is more dilated and enlarged, than at the solstices, in consequence of the direct force of attraction, operating on the centre of its disk.

The MOON is not a primary planet, but only a satellite, Or attendant on the earth, circulating round it in 29 days, 12 hours, 44 minutes, and round the sun along with the earth in a year. The moon's dia. meter is computed at 2180 miles; and her distance from the earth's centre 240,000; the period of her revolution in her orbit is 27 days, 7 hours, 43 minutes, moving at the mean rate of 2290 miles an hour; she is stated to revolve on her axis, in exactly the same time that she moves round the earth, which is the occasion of her exhibiting always the same face to us, and consequently her day and night taken together is as long as our month.

The moon, like the earth, is an opaque globe, and shines by reflecting the light of the sun; therefore whilst that half of her, which is towards the sun is enlightened, the other half must be dark and invisible. Hence she disappears when she comes between us and the sun; because then her dark side is turned towards us. When she is gone a little way forward, we see a little of her enlightened side, which increases to our view as she advances until she comes opposite to the sun; when her whole enlightened side is towards us, and she appears a round illuminated orb, which we call the FULL MOON; her dark side being then turned away from the earth. From the full she seems to decrease gradually, as she goes through the other half of her course, showing us less of her enlightened side every day, till her next change or conjunction with the sun, when she disappears as before.

The earth being an opaque body must appear as a moon, to the inhabitants of the moon, waxing and waning regularly, but appearing 13 times as big, and affording them 13 times as much light as she does changes to us, the earth appears full to her; and when she is in her first quarter to us, the earth is in its third quarter to her, and vice versa. From these peculiar circumstances of the month, the earth is never seen at all from the side opposite to the earth; from the middle of the other half it is always seen over bead; turning round almost 30 times as quick as the moon does. From the circle which our view of the moon, only one half of the earth's side next her is seen; the other half being hid below the horizon of all places On that circle. To her inhabitants the earth appears the biggest body the universe, appearing full 13 times as big as she does to us.

It has been observed by astronomers that the axis of the moon, is so nearly perpendicular to the ecliptic, that the sun never removes sensibly from the equator; and the obliquity of her orbit, as seen from the sun, which is next to nothing, cannot cause any sensible declination. Yet her inhabitants are not destitute of means for ascertaining the length of their year, or period of her revolution round the sun: though their method must be different from ours. We know the length of our year by the return of our equinox; but the Lunarians having always equal day and night, must have recourse to another method arid we may suppose, they measure their year by observing when either of the poles of our earth begins to be enlightened, and the other to disappear, which always takes place at our equinoxes: being conveniently situated to observe any particular phenomenon attached to our globe, and which must be extremely conspicuous to them. The year is of the same absolute length to the inhabitants of the earth and moon though very different as to the number of days; we having 365,k days, and the Lunarians only 1 27/19 every day and night in the moon, being as long as 29 1/2 on the earth.

The inhabitants of the moon on the side next the earth, may find the longitude of their places, as easily as we can find the latitude of ours: for the earth being constantly or very nearly so, over one meridian of the moon, the east and west distances of places from that meridian are as easily found, as we can find our distances from the equator, by the altitude of our celestial poles.

As the sun only enlightens that half of the earth which is towards it, and leaves the opposite half in darkness, so he does the same to the moon, but with this difference, that as the earth is surrounded with a superior atmosphere, we have twilight after the sun sets, and before he rises; but the moon, (as is supposed,) having no atmosphere of her own, must have an immediate transition from the brightest sunshine to the blackest darkness.

The moon being an opaque spherical body, we can only see to part of her enlightened half, which is towards the earth. And the fore, when the moon is between us and the sun, her dark side is turn towards the earth, and she totally disappears, there being not light enough on that half to render it visible. When she comes to first octant, or has gone an eighth part of her orbit, from her conjunction, a quarter of her enlightened side is towards the earth, and appears horned. When she has gone a quarter of her orbit, in between the earth and the sun, she shows us one half of her enlightened side, and we say she is a quarter old. When she gains he third octant, by showing us more of her enlightened side, she appe gibbous. When she comes to her fourth octant, or has complete half her orbit, she is said to so in opposition to the sun; when t whole of her enlightened side is towards us, and we say it is full mo In her fifth octant, part of her dark side being towards the earth, s again appears gibbous, and is on the decrease. When she comes her sixth octant, we see just one half of her enlightened side, and s. appears half decreased, or as we say in her third quarter. In h seventh octant we only see a quarter of her enlightened side, when she again appears horned. At length having completed her course fr the sun to the sun again, she disappears; and we say it is new mo Thus in going through her first four octants, the moon continually seems to increase; and in her remaining four octants, to decree in the same proportion, having like phases at equal distances: but seen from the sun, or from Mercury, she appears always in the full.

The moon does not appear perfectly round when she is full i the highest or lowest part of her orbit, because we have not a fill view of her enlightened side at that time. When full in the higher part of her orbit, a small deficiency appears on her lower edge; a the contrary when full in the lowest part of her orbit.

It is evident, that when the moon changes to the earth, the earth in full to the moon, and vice versa. For when the moon is new to the earth, the whole enlightened side of the earth is towards the moon. And when the moon is full to the earth, its dark side is towards her Hence a new moon answers to a full earth, and a full moon to a earth. The quarters are also reversed to each other.

The position of the moon’s cusps, or a right line touching the moon’s horns, is very differently inclined to the horizon, at different hours of the same days of her age. Sometimes she stands, as it were, upright on her lower horn, and then such a line is perpindicular to the horizon: when this happens, she is in what the astronomers call the nonagesimal degree ; which is the highest point of the ecliptic. But this never happens when the moon is on the meridian, except she is at the very beginning of cancer, or Capricorn.

It appears that the moon turns round her axis in the time she goes round her orbit and that a spectator at rest without the periphery of the moon's orbit would see all her sides turned regularly towards him in that time. She turns round her axis from any star, to the same star again in 27 days 8 hours; from the sun to the sun again, in 29 1/2 days; the former is the length of her siderial day, and the latter the length of her solar day. A body moving round the sun would have a solar day in every revolution, without turning on its axis; the same as if it had at rest, and the sun moved round it: but without moving round its axis, it could never have one siderial day, because it would always keep the same side towards any particular star.

If the earth had no annual motion, the moon would go round it, so, to complete a lunation, a siderial, and a solar day, all in the same time. •But because the earth goes forward in its orbit,

while the moon goes round the earth in her orbit, the moon must go as much more than round her orbit, from change to change, in completing a solar day, as the earth has gone forward in its orbit during that time, almost a twelfth part, of a circle. If the earth had no annual motion, the moon's motion round the earth, and her track in open space, would be always the same. But as the earth and moon move round the sun, the moon's real path in the heavens, is very different from, her visible, path round the earth; the latter being in a progressive circle, and the former in a curve of different degrees of concavity ; which would always be the same, in the same parts of the heavens, if the moon performed a complete number of lunations in a year without any fraction.

To illustrate this, let the nail in the end of the axle of a chariot wheel, represent the earth. and a pin in the nave, the moon: if the body of the chariot be propped up so as to keep the wheel from touching the ground, and the wheel be then set in motion, the pin will then describe a circle both round the nail, and in the space it moves through. But if the prop be taken away, the horses put to, and the chariot driven over a l)iece of ground, which is circularly convex, the nail in the axle will describe a circular curve, and the pin in the nave will still describe a circle round the progressive nail in the axle, but not in the space through which it moves. In this case the curve described by the nail, will resemble in miniature, as much of the earth's annual path round the sun, as it describes while the moon goes as often round the earth, as the pin does round the nail: and the curve described by the pin, will have some resemblance of the moon's path during so many lunations.

Many conjectures have been formed respecting the moon's substance. Some have imagined that besides the light reflected from the sun, the moon hath also some, obscure light of her own, by which she would be visible without' being illuminated by the sun's beams; in proof of this it is urged, that during the time of even total eclipses, the moon is still visible, appearing of a dull red colour, as if obscured by a great deal of smoke. In reply to this it bath been advanced, that this is not always the case ; the moon sometimes disappearing, totally in the time of an eclipse, so as not to be described by the best glasses, while little stars of the fifth and sixth magnitudes were distinctly seen as usual: and when the moon is visible in a total eclipse a sufficient reason may be assigned for this appearance, from the refraction of the sun's rays through our atmosphere, which are reflected back on the earth, by the otherwise dark surface of the moon.

It has been a matter of much dispute, whether the moon has an atmosphere or not; the following arguments have been urged on the negative side. I. The moon constantly appears with the same brightness where there are no clouds in our atmosphere; which could not be the case, if she were surrounded with an atmosphere like ours, so variable in its density, and so frequently obscured by clouds and vapours. 2. In an appulse of the moon to a star, when she comes so near it that a part of her atmosphere is interposed between our eye and the star, refraction would cause the latter to seem to change its place; so that the body of the moon would appear to touch it later than by her own motion she would do. 3. Some philosophers are of opinion, that because there are no seas and lakes, and consequently no springs and rivers in the moon, there is therefore no atmosphere, as there is no water to be raised up in vapours.

To these arguments it has been replied. I. That the moon does not always appear with the same brightness, even when our atmosphere appears equally clear. Hevelius relates, that he has several times found i n skies perfectly clear, when even stars of the 6th and 7th magnitude were visible, that at the same altitude of the moon, and the same elongation from the earth, and with one and the same telescope, that the moon and maculae do not appear equally lucid, clear, and conspicuous at all times; but are much brighter, and more distinct at some times than at others. From the circumstances of this observation, say they, it is evident, that the reason of this phenomenon is neither in our air, in the tube, in the room, nor in the spectator's eye; but must be looked for in something existing about the moon. An additional argument is drawn from the

different appearances of the moon in total eclipses, which are supposed to be owing to the different constitutions of the lunar atmosphere.

2. To the second argument, Dr. Long replies, that Sir Isaac Newton has shown, that the weight of any body upon the moon is but a third part of what the same would be upon the earth: now the expansion of the air is reciprocally as the weight that compresses it; the air, therefore, surrounding the moon, being pressed together by a weight, or being attracted towards the centre of the moon, by a force equal only to one third of that which attracts our air towards the centre of the earth, it 'follows, that the lunar atmosphere is only one third as dense as that of the earth, which is too little to produce any sensible refraction of the stars' light. Other astronomers have contended that such refraction was sometimes very apparent. Cassini says, that he frequently observed Saturn, Jupiter and the fixed stars, to have their circular figure changed into an elliptical one, when they approached either to the moon's dark or illuminated limb, though they own, that in other occultations, no such change could be observed. With regard to the fixed stars, indeed, it has been urged, that granting the moon to have an atmosphere, of the same nature and quantity as ours, no such effect- as a diminution of light ought to take place; at least, that we could by no means he capable of perceiving it, our atmosphere is found to be so rare, at the height of 44 miles, as to be incapable of refracting the rays of light, the height is the 180th part of the earth's diameter; but since clouds are never observed higher than four miles, we must conclude that the vaporous or obscure part is only 1980the. The mean apparent diameter of the moon is 31' 29", or 1889 seconds: therefore the obscure parts of her atmosphere, when viewed from the earth, must subtend an angle of less than one second; which space is passed over by the moon in less than two seconds of time. It could hardly therefore be expected, than the nicest observation should be adequate to determine, whether the supposed observation takes place or not.

3.The third argument is necessarily inconclusive, because we know not, whether there is any water in the moon or not; nor though this' could be demonstrated, should it follow that the lunar atmosphere answers no other purpose than the raising of water into vapour. Farther, it may as well be doubted whether there is any solid matter, as fluid matter; for the presence of the one, argues the existence of the other ; nature furnishes no precedent, to justify the conclusion, that a solid body can exist, independent of a fluid state of that body all solids are concrete fluids, and all fluids are solids in solution, matter becomes solid by an abstraction of its menstruum, which being restored to it, reduces it to the fluid state; and being abstracted reduces it to the solid, besides, the admission of the doctrine, of the non-existence of a lunar atmosphere, or that of any other globe, would tend directly to destroy the doctrine of the law, and force of attraction; which, from reason and analogy, appears to be a stream, and supply, of all the elementary principles, and materials, of which a world is composed.

4.There is besides a strong argument in favour of the existence of a lunar atmosphere, taken from the appearance of a luminous ring round the moon in the time of solar eclipses ; a circumstance frequently observed by astronomers, particularly in the total eclipse of the sun in 1706; and in another total eclipse of the sun in April, 1715 When certain streaks of light were seen to dart from different places of the moon, during the time of total darkness, these were imagine to be flashes of lightning ; and hence the existence of clouds, and, vapours, and an atmosphere have been inferred. These flashes might be connected with such appearances, as Dr. Herschel, has with great probability, concluded to be volcanos, which has also been considered as a proof of the lunar atmosphere.

We have already observed, that the occultations of the fixed stars and planets, by the moon, in general happened without any kind of refraction of their light by the lunar atmosphere, the contrary, however, has sometimes, it is said, been observed, and the stars have been seen manifestly to change their shape and colour on going behind the moon's disk ; but by many this

colour has been attributed rather to the different refrangibility of the rays, in the object glass of the telescope, than to any real variation of colour in the planets and stars from appulse to the moon.

It is remarkable that the moon, during the week in which she is full about the time of harvest, rises sooner after sunsetting, than she does in any other full moon week throughout the year. By this means, she affords an immediate. supply of light after sunset, which is very beneficial for those employed in the harvest, and gathering the fruits of the earth. Hence this full moon is distinguished from all others in the year, by calling it the HARVEST-MOON.

To conceive the reason of this phenomenon, it may first be consider. ed, that the moon is always opposite to the sun when she is full, and therefore, in the harvest months, she is full in Pisces and Aries, which are opposite to Virgo and Libra, the signs occupied by the sun at the same season. Now, the signs Pisces and Aries rise in a shorter space of time than others, as is easily shown and illustrated by a celestial globe; and the same thing may be conceived from this circumstance, that in northern latitudes, the smallest angle, made by the ecliptic and the horizon, is when Aries rises at which time Libra sets ; and it is obvious, that the smaller the angle contained by the ecliptic and horizon, the greater portion of the ecliptic will rise by the earth's rotation, in a given time. Consequently when the moon is full in harvest, she rises with less difference of time, or more immediately after sunset, than at any other season of the year.

In our winter, the moon is in Pisces and Aries, about the time of her first quarter, when she rises about noon, and therefore her rising is not then noticed.

In spring, the moon is in Pisces and Aries, about the time of her change, but she then gives no light, and rises with the sun, her rising cannot be perceived.

In summer the moon is in Pisces and Aries, at the time of her last quarter, and then she does not rise till midnight, her rising usually passes unobserved. .

But in Autumn the moon is in Pisces and Aries at the time of her full, and rises soon after sunset, for several evenings successively; which makes her regular risings very conspicuous, at that time of the

All this would happen, if the moon's orbit lay in the ecliptic'; but her orbit makes with the ecliptic an angle of 50 18', and crosses it in two points, called her nodes; so that her rising when in Pisces and Aries, will sometimes not differ above an hour and 40 minutes, through a whole week ; and at other times, in the same two signs, she will differ in a week 3 1/2 hours, in the times of her rising, according to the different positions of her nodes, with respect to these signs; which positions are always changing, because the nodes go backwards through the ecliptic, in 12 years 225 days.

This revolution of the nodes, causes the harvest-moons to go through a whole course of the most advantageous and least beneficial states, with respect to the harvest every 19 years. They are most beneficial at present, in 1816, and will continue so till 1825, when the opposite period commences, and lasts to 1834 ; and again they will be most beneficial from 1835, to 1843, and so on.

12, The TIDES are found to follow periodically the course of the sun and moon, and hence it has been suspected in all ages, that the tides were somehow produced by the influence of those luminaries. Of this Pliny, Ptolemy, Macrobius, and others seem to have some knowledge. The celebrated Kepler formed some conjectures long ago, as to the true cause of the tides. "If (says he)' the earth ceased to attract the waters towards itself, all the waters in the ocean would rise and flow into the moon. The sphere of the moon's attraction extends to our earth, and draws up

the water." What Kepler only surmised, has been successfully investigated by the great Newton, and Dr. Halley from his principles. The general phenomena of the tides are as follows:

1. The sea is observed to flow for about 6 hours, from south to north gradually swelling; and after a flux of about 6 hours, it seems to rest for a quarter of an hour ; and then to ebb, or retire back again from north to south for 6 hours more. Then, after a seeming pause of about a quarter of an hour more, the sea again begins to flow ; and so on alternately.

2. Hence, the sea ebbs and flows twice a day, but falling every day later and later, by about 48 minutes, the period of a flux and reflux being on an average about 12 hours 24', and the double of each 24 hours 48', which is the period of a lunar day, or the time between the moon's passing a meridian and coming to it again, so that the sea flows as often as the moon passes the meridian, both the arch above the horizon and that below it, and ebbs as often as she passes the horizon, both on the eastern and western side. These are the most obvious appearances: the other phenomena as follows:

3. The elevation towards the moon exceeds the opposite one a lit. tie, and the quantity of the ascent of the water is diminished from the middle latitudes, towards the equator, and towards the poles.

4. The sun raises and depresses the sea twice every day, in the same manner as the moon does; but the solar tides are much less than the lunar one ; although subject to the same laws.

5 The tides which depend upon the actions of the sun and moon, are not distinguished, hut compounded; and thus they form to appearance, one united tide, which increasing and decreasing, produces 'what are called NEAP and SPRING tides.

6. In the syzygies, the elevations from the action of both luminaries concur, and the sea is more elevated; but the sea ascends less in the quadratures ; for where the water is elevated by the action of the moon, it is depressed by that of the sun, and vice versa. There. fore while the moon passes from syzygy to the quadrature, the daily elevations are continually diminished; on the contrary, they are increased, while the moon passes from the quadrature to the syzygy. At the new moon also cateris paribus the elevations are greater; and those that follow one another the same day, are more different than those at full moon.

7. The greatest elevation and depression takes place on the 2d or 3d day after the new or full moon, and they are the greater, the nearer these luminaries are to the plane of the equator ; being greatest in the syzygies, near the equinoxes.

8. The actions of the sun and moon are greater, the nearer those bodies are to the earth; and the greatest tides happen, when the sun is a little to the south of the equator ; but this does not happen regularly every year, because some variation may arise from the situation of the moon's orbit, and the distance of the syzygy from the equinox.

9. The mean force of the moon to move the fluids of our globe is to that of the sun nearly as 4 1/2 to 1; and therefore, if the action of the sun alone produces a tide of 2 feet, which it is said to do, then that of the moon will be 9 feet; from which it follows, that the spring tides will be 11 feet, and the neap tides 7 feet. But such elevations, as far exceed these, happen from the motion of the water against some obstacles, and from the sea violently entering straits, bays, or guts, where the force is riot broken till the water rises higher.

The preceding phenomena take place in the open sea, where the ocean is extended enough to be subject to those motions. But the particular situations of places, as to shores, capes, bays, &c. disturb in a considerable degree these general rules. We are now to show how these phenomena may be explained, from the principle of universal gravitation.

If the earth were -entirely fluid and quiescent, its particles, by their common gravitation to the centre would naturally form themselves into an exact sphere. If a power were to act on all the particles of this spheres with an equal force, and in parallel directions, the whole mass would be moved together, but no change would be produced on its spherical figure, and its centre would have the same motion as each particle.

Upon this hypothesis, if the motion of the earth, round the centre of gravity of the earth and moon, were destroyed, and the earth left to. the influence of its gravitation towards the moon, (and this independent of any repelling power) then the earth would fall or move straight towards the moon without changing its spherical figure.

But the fact is, that the effects of the moon's action as well as the action itself, on different parts of the earth, are not equal; those parts, by- the general laws of gravity, being most attracted, that are nearest to the moon, and those least attracted which are farthest from her; while the parts at a middle distance, are attracted by a mean degree of force; besides, all the parts are not acted upon in parallel lines, but in lines directed to a centre, on which accounts, the spherical figure of the fluid earth. must suffer some change from the action of the moon, so that in falling, as we have supposed, the nearer parts being most attracted, would fall quickest, the farther parts being least attracted, would fall slowest, and the fluid mass would be lengthened out, and take a kind of spheroidical form, or rather a conical shape.

Hence it appears, (which must be carefully observed,) that it is not the action of the moon itself but the inequalities of that action, that cause any variations of the earth from a spherical figure; and that if this action were the same on all particles, as the central parts, and operating in the same direction, no such change would ensue.

Let- us now admit the parts of the earth to gravitate towards its centre; then, as this gravitation far exceeds the action of the moon, and much more exceeds the difference of her actions on different parts of the earth, the effect of which results from the inequalities of these actions of the moon, will be only a small dimunition of the gravity of those parts of the earth, which it endeavoured in the former supposition to separate from its centre; that is those parts of the earth which are nearest to the moon, and those that are farther from her, will have their gravity 'towards the earth somewhat abated, to say nothing of the lateral parts; so that supposing the earth entirely fluid, the columns from the centre, to the nearest, and to the farthest parts must rise, till, by their greater height, they are able to balance the other columns, whose gravity is less abated by the inequalities of the moon's action, and thus the figure of the earth must still be an oblong spheroid.

Let us now consider the earth, instead of falling towards the moon by its gravity, as projected in any direction, so as to move round the centre of gravity of the earth and moon, it is evident, that in this case the several parts of the fluid earth, will still preserve their relative position, and the figure of the earth will remain the same as if it fell freely towards the moon ; that is, the earth will still assume a spheroidical form, having its longest axis directed towards the moon.

From the preceding reasoning, it appears, that the parts of the earth directly under the moon, and also the opposite parts, will have the flood or high water at the same time, while the parts at 900 distance, or where the moon appears in the horizon, wilt then have the ebb or lowest water. Hence

as the earth turns round its axis from the moon to the moon again in 24 hours 48', this oval of waters must shift with it ; and thus there will be two tides of flood and two of ebb at that time. It farther appears, that by the motion of the earth on its axis, the most elevated parts of the waters are carried beyond the moon in the direction of the rotation ; so that the water continues to rise after it has passed directly under the moon, though the immediate action of the moon there begins to decrease; arid comes not to its greatest elevation till it has got about half a quadrant farther. It continues to descend after it has passed at 90 from the point below the moon, to a like distance of half a quadrant.

The greatest elevation, therefore, is not in the line drawn through the centres of the earth and moon, nor the lowest points, where the moon appears in the horizon, but all these are removed about half a quadrant eastward from these points in a direction of the motion of rotation. Thus in open seas, where the water flows freely. the moon is passed the meridian at high water in different distances, in proportion as she is near the syzygies, or quadratures; but in narrow seas, bays, and rivers, there is no rule, high water happening in such situations, according to the distances from the regular course of the tide. If the earth was subject to no other action than that of the moon, the distance of time, from the moon's passing the meridian, till the time of high water, would be uniform; but this distance of time varies in proportion as the attractive force of the moon coincides with that of the sun. This coincidence takes place, when the moon is in her 1st and 3d quarters ; but the tides happen later in the 2d and 4th quarters; and the reason of this is obvious 'for the waters are partly raised by the action of the sun, when the action of the moon begins to exert itself upon them.

In former remarks, we only adverted to the action of the moon, in producing the tides, but it is evident, that for the very same reasons, the inequality of the sun's action, on different parts of the earth, would produce a like effect, and a like deviation from an exact spherical figure; so that in reality, there are two tides every natural day, from the action of the sun, as there are every lunar day from the action of the moon, subject to the same laws ; and the lunar tide is somewhat varied by the action of the sun, and this variation takes place. every day on account of the inequality between the natural and lunar day.

Notwithstanding the gravitation of the earth towards the sun, is much greater than its gravitation towards the moon ; yet by reason of the sun's immense distance, to which the earth's diameter bears but a small proportion, his action on the side of the earth next to him differs but little, from that, which is exerted on the side furthest from him, and it is only the inequalities in that action, which produces the solar tide : arid it should be recollected, that the earth and its satellite, the moon, gravitate together towards the sun, in one line of attraction; consequently the mutual gravitation of the earth and moon, will be in a just relation to their magnitudes and distances. However the effect of the sun is very distinctly sensible, though that of the moon is more perceptible; for by its proximity to the earth. there is a greater proportion of inequality, both in the direction of its action, and in the intensity of that action on different parts of the earth.

Hence it is easy to see that the tides must be greatest, at new and full moon, because the actions of the sun and moon are then exerted in the same directions. These are called SPRING TIDES ; whereas when the sun and moon are 90 distant, the action of the one luminary, raises the tides, just where that of the other depresses them; and thus are produced what are called TIDES. Newton has calculated these effects of the sun and moon respectively upon the tides from their attractive powers, the former he finds to be, to the force of gravity, as I to 12,868,200. And be concludes, that the force of the moon, is to that of the sun, as 44.815 to 1..

Dr.. Horsely, however, in his edition of Newton's Principia, estimates the force of the moon to that of th sun, as 50,469 to I ; and other authors have given different proportions. But Newton

computes, from his proportion that the moon may raise the waters 9 feet 1 1/3 inch, and the sun and moon together may produce an elevation of about 1 feet 3 inches, and about 12 1/4 feet, when the moon is at her nearest distance. Now this is found by observation, to he nearly the case, in the average occurrence of tide on the coasts of the open and deep ocean.

It must be observed, that the spring tides do not happen precisely at new and full moon. nor the neap tides precisely at the quarters, but a day or two after, because, as in Other cases, so in this, the effect is not greatest or least, when the immediate influence of the cause is greatest or least, for if the actions of the sun and moon were to cease, yet the titles would continue for some time; as the waves of the sea continue for some time after a storm.

The different distances of the moon from the earth, produce a sensible variation in the tides, and Newton has shown. that they increase, as the cubes of their distances decrease, so that the moon at half her distance, would produce a tide eight times greater. The moon describes a path round the earth, of an oval figure; and at her nearest distance, produces a tide sensibly greater than at her farthest distance. Hence two great spring tides never succeed each other, at the distance of 14 days, for if the moon be at her least distance at the change, and therefore produce a great spring tide, she will be at her greatest distance at the full, and therefore the spring tide will be less.

The spring tides are highest, and the neap tides lowest, about the time of the equinoxes, because, were the sun, or moon in the pole of the world, there would be no tide; for their action would raise the water at the equator, or any parallel, equally round the earth: therefore, the nearer they are to the equator, the greater will be their effect. When the sun and moon traverse the equator, the tides, which are under them, ivill traverse the greatest circle, and the waters will be put into the greatest agitation. They will also be the greater at these times, because the whole force of attraction, is concentrated on the equator, and exerted to either pole, about the middle of March, and September.

As the greatest of the two tides, happening in every diurnal revolution of the moon, is that in which the moon is nearest the zenith, or nadir, therefore, while the sun is in the northern signs, the greater of the two diurnal tides, in the northern regions, will be that arising from the moon, when above the horizon; and when the sun is in the southern signs, the greatest is that arising from the moon, when below the horizon. Thus, the evening tides in summer exceed the morning tides, and the morning tides in winter exceed the evening tides.

Such would the tides regularly be, if the earth were covered all over with the sea, to a great depth, so that the water might freely follow the influence of the sun and moon; hut, as the tides pass over shoals, and run through straights and bays of the sea, their motions become various, and their height in consequence, will depend on a great many circumstances. That the tides may have their free and full motion, the ocean in which they are produced, ought to be extended at least 90 from east to west; because that is the distance, between the greatest elevation, and the greatest depression, produced on the waters by the moon.

Hence it appears, that it is only in the great oceans, that such tides as we have described can be produced, and why in the larger Pacific ocean they exceed those in the Atlantic ocean.-Hence it may be considered as one reason why the tides are not so great in the torrid zone between Africa and America, where the ocean is narrower, as in the temperate zones on either side ; and why they are so small in islands at a great distance from the shores. It would likewise appear, that the waters cannot rise on one shore of the Atlantic ocean, without descending on the other, so that at the intermediate islands it must remain at a mean height, between its elevations on those two shores.

The tides, that enter the mouths of rivers from the ocean, are greatly retarded in their progress by the currents of the rivers. Mr. Condamine, while in South America, observed, that in the river Amazon, there were five high waters, and four intermediate low waters at once ; a similar circumstance takes place in the Hudson, in the Thames, and most long rivers.—The tide propagated in the German ocean, by the moon, when she is three hours past the meridian, takes twelve hours to reach London bridge, so, that when it is high water at the bridge, a new tide is already come to its height in the ocean, and in some intermediate place, it must be low water at the same time.

At several places, it is high water three hours before the moon comes to her meridian ; but that tide, which the moon pushes as it were before her, is only the tide opposite to, that, which was raised by her, when she was nine hours past the opposite meridian.

There are no sensible tides in the Baltic, the Mediterranean, or the Black seas ; for they communicate with the ocean, by such inlets, as are of such immense extent, that they cannot speedily receive, and empty water enough, to raise, and depress their surfaces sensibly. In the Caspian sea, the American lakes, &c. the moon's attraction is nearly the same on all parts of their surface, so that no sensible swelling can take place in their waters.

We have already observed, that the immediate cause of the tide, was the force of attraction, exerted by the action of the sun and moon, on the fluid parts of our globe. But we have hitherto restricted our observations, to the effect of this force upon our waters : it now remains to take a more extended review of the effect of this force, upon our globe generally. Not only our waters, but the whole body of our earth, is amenable to the law which governs the tides ; even animals, and vegetables are subject to its operation, and there is unquestionably a kind of ebbing and flowing of the fluids, which enter into their composition; all the particles of our earth will be liable to be affected in proportion to their capacity of expansion. Our atmosphere, particularly, will be liable to be more affected by the power of this attractive law it consists of particles so attenuated, and capable of such extreme expansion, that it must be considered as a principal agent in the production of the phenomenon of the tides. If the pressure of our atmosphere were uniform, and undeviating, on the surface of the earth, and waters, no such thing as tide, could take place ; but, in consequence of its yielding texture, it conforms itself,.' en masse, to all the impressions of attractive force ; and by its expansive, and condensive powers, it forms a due medium, between the attraction and repulsion of the earth to and from its centre. It has already been noticed, in the notes to Vol. I. page 450, that the force of attraction exerts itself ill direct lines, from the centre, to the circumference, and that the force is reciprocal, and proportional to the distance : that, in consequence of' this rectilinear impulse, certain phenomena would naturally occur; the force of attraction is exerted on a point of the circumference of the globe, and passes through in a straight line, that in this line the greatest dilatations of the atmosphere take place, and consequently the greatest elevation of the waters, and this is what we call high tides. As the earth recedes from this point, and attains to 900 distant from it, it meets with a correspondent compression, its surface being parallel with the line of attraction, consequently, its waters will be proportionally depressed, and this we Call low tide. Could the earth remain a sufficient length of time in this situation, and the force of attraction continue to be exerted upon it, these points on the equatorial circumference, being rectangular to the line of attraction, would become flatted hike the poles; hence it would appear that the particular configuration of' the globe, from a round to a spheroidal form, proceeded from two causes, viz, that of attraction, whereby its fluid parts are more immediately affected; and that of rotation, which gives spheroidity to its solid, and adhesive parts. Considering the expansive powers of our atmosphere, as a mean, whereby the earth is suspended in its orbit, at a proportionate distance from its centre of attraction, it would follow, as a natural consequence, that the bulk of our atmosphere, consists of such materials, as are capable of being compressed, and dilated beyond their equilibrium ; and that in the first instance, when it is exceedingly compressed, the centrifugal force will prevail, and it will fly off to a greater distance

from the centre of gravity. On the other hand, should the atmosphere become exceedingly dilated, the centripetal force will prevail, and the earth will be impelled towards its centre of gravity, and will approach it, until it regains its equilibrium, or exceeds it, in proportion to the impetus it had acquired, when it will again he driven back, or farther from its centre of gravity, and so on alternately, approaching to, and receding from its centre, impelled by principles, and causes coexistent with itself, with which the all-wise Creator has invested all worlds, and which we call attraction. Hence it will be readily perceived, why the earth cannot approach nearer to, or recede farther from the sun, than a certain given distance; that it will consequently be preserved and retained in its orbit, at a mean proportionate distance from the sun; that the path which it describes round the 'sun, will not be a circle, but a very eccentric ellipsis, projected in unequal curves ; and that all the particles of which it is composed will be perpetually, and uniformly responsive to its various evolutions.

It ought to be observed, that this general compression, and dilatation' of the bulk of the atmosphere, which are effected by what are termed the solar and lunar attractions, are different from those local compressions and dilatations of the various strata of the atmosphere, whence originates storms, hurricanes, whirlwinds, &c. But it is a force which is exerted on the whole broad disk of the globe, producing at once, a dilatation in the apex, and so in a straight line, through the whole diameter of the globe, comprehending the atmosphere, and which produces the high tide; and a compression in the rectangles, of the earth's diameter, which produces the low tide. The spring and neap tides, proceed from greater and less degrees of dilatation, and compression, occasioned by the different eccentric positions of the earth in its orbit.

We say the attraction of the sun, the attraction of the moon, &c. which expressions should be corrected, being apt to give an incorrect idea of the phenomenon; attraction being reciprocal between two globes, and in a ratio proportionate to their comparative diameters, magnitudes, and distances. Hence the true place of the sun is not in the centre of the system, but it revolves round the centre in common with the planets; nor is the earth the true centre of the moon's orbit, but it describe an orbit with the moon, round the common centre.

Before the time of Kepler, astronomers supposed that the planets moved in circular orbits with uniform motions. But this justly celebrated astronomer, instead of taking for granted the truth of the hypothesis of his predecessors, applied himself with diligence to make observations on the heavenly bodies, and who, from his great accuracy and sagacity, has been considered as at the head of modern reformed astronomy. After much labour and many mistakes, he at last discovered the great laws of motion, which are hence called Kepler's laws: They are as follows :—

1.The primary planets and comets describe round the sun, and the secondary planets describe round their respective primaries, areas proportional to the times.

2.The orbits described round the sun, and round the primary planets, are ellipses having the sun and the primary planets in the focus.

3.The squares, or the periodic times of planets revolving round common centres, are proportional to the cubes of their mean distances,

These laws were deduced by Kepler entirely from observation, and it is obvious, they are the very same which Sir Isaac Newton has investigated by geometrical reasoning, as the necessary consequence of a body revoking in an ellipse, by a force directed towards one of its foci.

We are therefore warranted to conclude that the planets are kept in their orbits by a force which is directed towards the sun ; that this force is reciprocal, and proportionate to their diameters that

all the planets are suspended in equilibrium from their centres, and this, by virtue of their expansive forces that though the sun attracts the earth, the earth attracts the sun, but the sun has a superior attraction, inasmuch as he is of superior magnitude. Thus, our earth being of superior magnitude to the moon, it has an attraction proportionally superior to the moon ; hence the tides are raised more by its own attraction, than by that of the moon.

To a spectator placed in the sun, all the planets would appear to describe circles annually in the heavens : for though their motions are really elliptical, the eccentricity is so small, that the difference between them and true circles is not easily perceived even on earth; and at the sun, whether great or small, it would entirely vanish.— These circles which would be apparently described among the fixed stars, are called the heliocentric circles of the planets. To a spectator in the sun, the comets though moving inn the most eccentric orbits, would also appear to describe circles in the heavens : for though their orbits are in reality very long ellipses, the planes of them extended to the heavens, would mark a great circle, of which the eye would be the centre; only as the real motion is an ellipsis, the body would appear to move much more slowly in some parts of the circle than others, and to differ excessively in magnitude.

To an inhabitant of any planet, however, the sun appears to go round in its own heliocentric circle, or to describe in the heavens, that same curve, which the planet would appear to do if seen from the sun.

The heliocentric circle of the earth is called the ecliptic ; because eclipses of the sun or moon can only happen when the latter are in or near it.

Although the sun appears to go round the earth annually in this circle, we cannot determine his place by mere inspection, as we do that of any other of the heavenly bodies ; for the fixed stars are the only marks by which we can determine the place of any of the heavenly bodies ; and the superior brightness of the sun renders them totally invisible, except in the time of a great eclipse, when his light is for a time totally obscured. But though we cannot know the place of the sun directly, it is easily found from a knowledge of those fixed stars which are opposite to him.

The LATITUDE of any planet is either heliocentric, or geocentric

The heliocentric latitude is its distance from the ecliptic as seen from the sun, and its geocentric as seen from the earth. As the orbits of the planets are inclined in different angles to the ecliptic, the heliocentric latitude of any planet, is almost always different from its geocentric latitude.

The two points where the heliocentric of any planet cuts the ecliptic, are called its nodes ; that point where it cuts the ecliptic to pass into north latitude is called the ascending node, and that to the south, the descending node. A line drawn from one node to the other, is called, the line of nodes, which is the common section of the plane of the ecliptic, and that of the planet produced on each side to the fixed stars.

A motion in the heavens, in the order of the signs of the ecliptic, as through Aries, Taurus, Gemini, &c. is called a motion in consequence; such, are the true motions of all the planets, though sometimes their apparent motions are contrary, then they are said to move in antecedence. The local zodiac, is not always invariably the same, as to the places of the several signs, though the whole always takes up the same place in the heavens, viz. 10 on each side of the ecliptic. The points where the celestial equator cuts the ecliptic, are found to have a motion in antecedence of about 50 seconds a year.

This change of place of the first point of the ecliptic, from whence the signs are counted, occasions a like change in the signs themselves which, though scarcely sensible for a few years, has now become very considerable.

The LONGITUDE of a phenomenon in the heavens, is the number of degrees counted from the first point of Aries on the ecliptic, to the place, where a circle of latitude drawn through tine phenomenon would cut the ecliptic at right angles. Every phenomenon in the heavens, whether in the zodiac or not, is thus referred to the ecliptic, by its circle of latitude, or great circle passing through the phenomenon, and cutting the ecliptic at right angles; and whatever sign the circle of latitude passes through, the phenomenon is said to have its place in that sign, though ever so far distant from it.

The common way of reckoning the longitude of a phenomenon is to take v for the first point of the ecliptic, and not to number the degrees quite round that circle, as a continued series, but to make a new beginning at the first point of every sign, and to reckon from thence only the length of 30, then the phenomenon is stated to be in such a degree and minute of such a sign: thus, 13 40'; or Mercury in the ascending node in Taurus, and so of any other. A point in the heavens is expressed, by setting down its longitude and latitude.

Every planet like the moon, is sometimes in CONJUNCTION, sometimes in OPPOSITION with the sun. Its conjunction is when the geocentric place of the planet is the same with that of the sun; though an exact and central conjunction can only take place, when the of its nodes passes through the earth, and the planet itself is in one of its nodes at the time.. It is however, termed a conjunction when the same circle of latitude passes through the sun and planet at the same time. When the geocentric place of a planet is in 90, or a quarter of a circle from the sun's place, it is said to be in quadrature or in a quartile aspect with the sun'; and these terms are use4 in a like sense when applied to any two of the heavenly bodies. Thus the sun moon, or the moon and any planets, or any two planets, may be in conjunction, opposition, or quadrature.

The inferior planets have two kinds of conjunctions with the sun one in the inferior part of their semicircles, the other in the superior part. In the former the planet is between the earth and the sun; the latter the sun is between the earth and planet. The. inferior planets can never be in opposition to the sun, nor even appear at a great distance from him. The length they go is called their elongation.

The greatest possible elongation of Mercury, or his aphelion distance, is found by astronomical observations, to be about 28 and that of Venus, about 48. The inferior planets in their elongations, are sometimes eastward and sometimes westward of the sun; in the: former case they appear in the evening, in the latter in the morning The smallness of Mercury, and his nearness to the sun, prevents him from being taken notice of; but the largeness and beauty of Venus, have made her 'celebrated in all ages as the evening and morning star..,

The planets sometimes appear to go forward, sometimes to go backwards, and sometimes to stand still. These different conditions are by astronomers called direct, retrograde, and stationary. Were they to l)e viewed, from the sun, they would always appear direct; but, when viewed from the earth, the inferior planets appear direct while moving in their upper semicircles: retrograde while moving in their lower ones, and stationary while changing from direct to retrograde, or retrograde to direct.

When the earth is in the line of nodes of an inferior planet, the, apparent motion of the former is then in a straight line, because the plane of it passes through the eye: if in a conjunction in his upper. semicircle, he passes behind the sun, if in his lower semicircle, he. passes before it, and will

then be seen by an observer on earth to pass over the sun's disk like a round and very black spot. Were the plane of his orbit coincident with the ecliptic, this appearance would be seen. every year; but by reason of the obliquity of the two planes to each'. other it is much more rare.

MERCURY however was seen in this manner November 12th, 1782,. at3 hours 44', in the afternoon; May 4th, 1786, at 6 hours 37', in the morning; December 6th, 1789, at 3 hours 5', in the afternoon. Is like manner VENUS sometimes appears like a black spot on the sun, but much more seldom than Mercury. She was thus seen first in 1639 afterward in the years 1761, and 1769; but will not again be visible in this manner till the year 1874.

An inferior planet, when in conjunction with the sun, in its inferior semicircle, is said to be in PERIGEE, and when in the other, to be in APOGEE, on account of its different distances from the earth. Their real distances from the earth when in perigee, are variable, partly owing to the eccentricities of their orbits, as well as that of the earth and partly owing to the different bodies by which they are in perigee, in different parts of their orbits. The least possible distance is, when the perigee happens at the time that the earth is in its perihelion and when the planet is in its aphelion.

The difference between the earth and inferior planets, at different times, makes a considerable variation at different times, which indeed is very observable in all the planets ; and thus, they sometimes look considerably larger than at others. This difference of magnitude in Mercury is nearly as 5 1/2 to one; and in Venus no less than 32 to I, any person unassisted by instruments, may observe an inferior planet alternately approach nearer and nearer the sun, until at last it comes into conjunction with him, and then retires farther and farther, till it is at its greatest elongation, which will be first on one side, and then on the other: but if we observe the apparent change of a place of an inferior planet, in the sphere of the heavens, its direct motions, stations and retrogradations, measuring its diameter 'frequently with the mecrometer, we shall find, by its decrease at some times, and increase at others, that its distance from us is very considerably varied.

The apparent paths of Mercury and Venus are looped curves.

As the superior planets move in larger orbits than the earth, they can only be in conjunction with the sun, when they are on that side opposite to the earth; as on the other hand they are in opposition to him when the earth is between the sun and them. They are in quadrature with him, when the geocentric places are at 90 distance from the sun.

The DIRECT MOTION of a superior planet is swifter the nearer it is to a conjunction, and slower as it approaches to a quadrature with the sun.

The RETROGRADE MOTION of a superior planet, is swifter the nearer it is to an opposition, and slower as it approaches to a quadrature with the sun.

A superior planet is in APOGEE when in conjunction with the sun, and in PERIGEE when in opposition; and every one of the superior planets, is at its least possible distance from the earth, where it is in perigee and perihelion at the same time. Their apparent diameters are variable, according to their distances, like those of the inferior planets; and this as might naturally be expected, is most remarkable in the planet MARS, who is nearest us. In his nearest approach, this planet is 25 times larger than when farthest off, Jupiter twice and a half, and Saturn once and a half. As the times of conjunction, utmost elongation, direct or retrograde motion, of the inferior planets depend on the combinations of their motions in their orbits with the motion of the earth in its orbit; any of these appearances will h€ more frequent in Mercury than in Venus, because the

former moves with a swifter motion in his orbit, and consequently, must more frequently pass through those places, where he is in conjunction, &c.

The time in which any of the inferior planets will return into a given situation, may be easily known. Compute the diurnal hello. centric motions of Venus and the earth: the difference of their motions, is the diurnal motion of Venus from the earth, or the quantity by which Venus would be seen to recede from the earth every day, by a spectator placed in the sun: thus the motion of Venus is every day about 59 minutes and 8 seconds; the difference is 37 minutes Therefore, as 37 minutes is to 360 degrees, or to 21,600 minutes, so is one day to the time wherein Venus, having left the earth, recedes from her 36O degrees; that is, to the time wherein she returns to the earth again, or the time between two conjunctions of the same kind.

The calculations of the times are here made according to mean or equable motions of the planets, and is therefore called a mean conjunction: but because Venus and the earth are really carried in elliptic orbits, in which their motions are sometimes swifter and sometimes slower, the true conjunctions may happen some days either sooner or later than what these rules will give. The time of the true conjunction is to be computed from that of the mean conjunction, in the following manner. Find by astronomical tables the place of Venus and the earth in the ecliptic, from which we shall have the distance of the two as seen from the sun ; compute also the angular motions of these two planets for any given time, suppose six hours. As this difference is to the arc between the places of Venus and the earth, at the time of a mean conjunction, so is six hours to the time between the mean conjunction and the true. This time added to, or subtracted from, the time of the mean conjunction, according as Venus is in antecedence or consequence from the earth, shows the time of the true conjunction.

As to the conjunctions, oppositions, direct, and retrograde motions, &c. of the superior planets, they depend on the combinations of their motions with that of the earth, and are more frequent in Saturn than in Jupiter, and in Jupiter than in Mars; but most frequent of all in Herschel; because the slower the motion of the planet is, the sooner the earth will overtake in so as to have it again in any given situation.

Thus suppose Saturn to be in conjunction with the sun in Aries, if he were to stand still one year, then he would again be in conjunction with the sun in Aries, but, as he goes on slowly, according to the order of the signs, about 12 degrees annually, the earth must therefore go through almost 13 degrees more than an entire revolution, so that there will be almost a year and 13 days, between any conjunction between the sun and Saturn, and the conjunction immediately following. As Jupiter moves in his orbit, with greater velocity than Saturn, the earth must have a proportionably larger space added to the year; and as Mars moves swifter still, the time between any two of his conjunctions, must be still longer. The time when any superior planet will return into any given situation, may be found by the methods already laid down for the inferior planets; and the true conjunctions, &c. may be found in the superior planets as in the inferior.

Here it is worth while to pause a few moments, and contemplate the immense scale of being, to consider the magnitudes, relations, order, and arrangement of those immense globes, which occupy the unlimited regions of space, and diffuse their lustre and beneficence around us. And,

1. None of them interfere with each other. Had the universe been the work of any but the wise Architect, there would have been many inconveniences in the situation of such a prodigious number of immense globes. Some would have been too near or too far off; some would have incommoded others. But instead of this, all the globes which fall under our notice, are set at such a due distance as not only to avoid all violent concourse, but not to shade each other, so as to hinder each others kindly influence, or to occasion noxious ones. 2. As it is one great instance of the skill of an

architect, to give due proportion to his works, so this abundantly appears in all the heavenly bodies that come under our cognizance. Curious order, and due and nice proportions are observed in their situations. The sun is placed in the centre of his system, to give all his planets heat and light. Then follow the several planets surrounding him, not scattered at all adventures, but at due distances from the sun, as well as from one another. And this is discernible, not only in the primary, but the secondary planets too: in the five moons that attend Saturn, and the four that accompany Jupiter.

The wisdom of the Creator appears, secondly, from the motions of the heavens and the earth. That these vast globes should move at all, proves some being that has power to put them in motion: seeing matter cannot move itself. And suppose them moved by the sun, the ether, or some other primary mover, still we must recur to some first cause who was able to put the mover into motion. And this could be no other than the hand of the Almighty. What farther shows both his power and wisdom, is, that those motions are not at random, or in inconvenient lines and orbs, but such as manifest the deepest counsel. That every planet should have as many and various motions, as the world and its inhabitants have occasion for, must be the work of a wise and kind, as well as omnipotent Creator.

In particular, the diurnal motion of these globes shows the wisdom of the Creator. Of what prodigious use is this Were the planets always to stand still, half of each globe would be dazzled and parched with unceasing day, and the other half wrapt in everlasting darkness Were this the case with our globe, a great part of it at least would scarce be habitable. It would neither agree with the state of man or other animals, nor of vegetables. How could the vapours be raised to supply the earth with cooling clouds and fruitful showers ‘low could the winds be excited to fan the atmosphere with their pleasant and healthful gales How could vegetables be raised up by the kindly heat of the day, and tempered by the dews arid cool of the night How could men and other animals gather their food, and perform the various labours of the day, and then under the salutary influences of the night recruit themselves with rest and sleep -

And as the diurnal, so the annual motion of the heavenly bodies, is a clear manifestation of the Creator’s wisdom : especially when we consider the different paths of their diurnal and annual motions. These lie not in a very different plane, nor in the same, but a little crossing one another: the diurnal lying in or parallel to the equator: the annual, at an inclination of twenty-three degrees and a half A glorious contrivance this for the good of our globe, and for all the rest that have the same annual motion! For were the earth’s annual motion to be always in the same plane with the diurnal, we might indeed he sometimes nearer to the sun than we now are. But we should miss of those kindly increases of day and night, which the approach of the earth to one or the other pole occasions. This is likewise the great cause of summer and winter. Indeed one cause of them is, the longer or shorter continuance of the sun above the horizon. As it continues longer in summer, it increases the heat, as much as it lengthens the day : and just the contrary in winter. But the chief cause is, the oblique or perpendicular direction of the sun’s rays. For, 1. Perpendicular rays strike on any plane with greater force than oblique. And, 2. A greater number of rays fall within the same compass, in a perpendicular than in an oblique direction.

A farther manifestation of the Creator’s wisdom we have in the perpetuity. constancy and regularity of those motions. How without an Almighty guide should those vast bodies continue their course throughout all ages How should they perform their usual stages, without the least intermission or disorder What piece of clockwork under heaven, was ever comparable to this How steadily do all these motions conspire, to answer the ends of divine Providence, to despatch the noble offices of the several globes, to comfort amid cherish every thing residing on them, by the useful change of day and night, and the several seasons of the year!

We may learn the wisdom of Cod, thirdly, from the figure of the heavenly bodies, so well suited to the motions, and to the whole state and convenience of them. And, 1. They are all nearly spherical:

I say, nearly, to allow for their difference between their polar and equatorial diameter. Now this figure is both more capacious than any other, and more agreeable to a mass in motion, each part of it being at a due distance from the centre of motion and gravity: besides, without this, there could have been no such agreeable alterations of day and night, of heat and cold. And as to our own globe, the winds could not have fanned the air, as now, but must have been greatly retarded, if not wholly stopped, by the angles and jettings out of other figures. Lastly, the waters would have had intolerable confluences; here too much, there none at all. So that instead of habitable world, far the greatest part would have been a desert, or an useless bed of waters.

And all the parts of the earth are so distributed as may best minister to their several uses. Thus, the two grand parts, the solids and fluids, instead of being jumbled into one mass, are admirably parted, and as nicely disposed of in proper places. The strata conveying sweet water in all or most parts of the world, consist of proper, pervious matter, remain distinct from the other strata, and lie at such due depths, as either to break out in fountains, or to be dug into for wells: all of which is a manifest demonstration of the concern of a Wise Agent.

And not only the planets are a demonstration of this, but the very comets also: though their motions are so far from being always the same way, that they move sometimes contrary to each other. Their planes and directions lie every way, and their orbits are exceedingly eccentrical. But this very eccentricity is an admirable contrivance of the Creator, to prevent their disturbing either the planets, or one another, by mutual attractions. By this means they have sufficient room to revolve in; and by ascending to very great heights, and spending almost all their time in the remote regions of the universe, at vast distances both from the planets and each other, they incommode neither. Whereas had they moved in the same plane with the planets, they would sometimes have come too near them: and possibly have disturbed their motions, or even dashed against them.

But what would all the planets have done, had they not been sup. plied with light and heat And what an indulgent provision of these is made even for the most distant of them See the sun, that prodigious mass of elementary matter placed in the centre of the system, to scatter his light throughout the whole, and to warm and cherish us by day: and such a noble retinue of moons and stars, attending and assisting us by night! And we see the same care of the Creator, extended to all the other planets. According to their several distances, they have proportionably a great number of moons, and Saturn a stupendous ring besides, to supply the decrease of light and heat. Who can help being amazed at such well contrived, such stately works of God! Who can partake of their beneficial influences, and not adore the wisdom and kindness of their Maker!

That he who dispenses existence at his will, should multiply, extend, enlarge, and add a kind of immensity to his works, is not properly what surprises me; at least my amazement is chiefly founded on my own extreme littleness. But what astonishes me most is to see, that notwithstanding this, my extreme littleness, he has vouchsafed to regulate his immense works, by the advantages I was to receive from them!

The heavens declare the grandeur and glory of God, from one end of the world to the other. But the sun alone affects us more than all the beauties the heavens can display to our sight: the heavens are only a. pavilion to the sun. The richly embroidered veil which seemed to bide him from us for a season, is removed when he advances. At first, he appears as a young bridegroom, coming out of his chamber. His splendour is then full of mildness, and he is easy of access. But he is commissioned to convey the heat and the life, as well as the light, every where. He darts more and

more fire as he ascends. He passes from one end of the heavens to the other. There is nothing can either be hid from his light, or subsist without his heat. And by his penetrating fires he reaches those very places which are inaccessible to his rays.

And yet we need his absence at proper intervals, no less than we do his presence. For night and sleep are so connected, that when we want repose, we generally procure a kind of artificial night. Our senses are seldom unbent, but by the removal of that which agitates them. And this is the service for which night is appointed, and which it excellently well performs. It does not come in a blunt and abrupt manner, to extinguish the light of the day, and all on a sudden to rob us of the sight of the objects we are intent on: but advances only by slow steps, and brings on darkness by degrees. It is not till after reminding us of the necessity of taking rest, that it covers the face of nature.

During the time of man's repose, night hushes every noise. It indeed suffers a few animals, whose grim aspect might scare him, to go forth, and silently seek their food. It permits, however, the animal that stands center by him, to give him notice of what concerns him. But it keeps the horse, the ox, and all his domestics fast asleep around him. it disperses the birds, and sends each to his respective abode. As it comes on, it gradually hushes the winds, to secure the lord of nature's rest. It causes his repose to be reverenced every where: the moment of which is no sooner come, but all creatures retire, and for several hours, an universal silence reigns.

Nor yet is nature's palace wholly void of light. As some may be constrained to travel by night, several flambeaus are scattered through the firmament. But these, though they prevent total darkness, yield only a gentle light. Nor ought those who then wake to be supplied with such alight, as would interrupt the repose of others.

But it is not, by its darkness only, that night is useful to us. Its coolness likewise is of use: and this increasing the spring of the air, makes it capable of working with greater activity, and giving new vigour both to the dry plants and the enfeebled animals. It is to preserve this cool, that the moon reflecting the light of the sun, gives it without any sensible heat. In vain do we collect her rays by the strongest burning glass. An admirable caution of the Divine Artificer, who has reserved for the night season, a light strong enough to remove darkness, yet too weak to alter the coolness of the air.

When man is inclined to have the benefit of this, he sees no more the prospects of the day; but night in her turn, favours him with another, that has charms to itself.

We cannot doubt but these immense globes of fire, which enlighten our night, have all their peculiar appointments, which answer, in God's purposes, the magnificence of their appearance. But who shall presume to explain, what the Almighty has thought fit to conceal The small glimpses which a few are permitted to have, being quite unknown to the bulk of mankind. It is not in the particular destination of each star, nor in the general harmony of all, that we are to look for the means of instructing man, or regulating his affections. But yet what we do see, and know concerning them, is matter for the deepest admiration. We see innumerable fires hung up in the magnificent ceiling of our abode; and the dark azure which serves them as a ground, still heightens their beauty and brightness. But their rays are dispersed through spaces so immense, that when they come to us, they are quite destitute of heat. Thus by the Creator's providence we enjoy the sight of a multititude of fiery globes, without any danger of destroying the coolness of our night, or the quiet of our repose.

The sum of what has been said, with some farther improvements, we add in the words of Mr. Hervey.

“ The earth is, in fact, a round body, though in some parts raised into hills, or sunk into vallies, in others spread out into wide ‘and immeasurable plains. For the loftiest mountains bear no more proportion to the whole surface of the ball, than a particle of dust on the astronomer’s globe, bears to its whole circumference. We may fancy that it has deep foundations, and rests on some solid basis. But it is pendant in the wide transparent ether, without any visible support either from above or beneath. It may seem to remain still and motionless: but it is continually sailing through the depths of the sky, and in the space of twelve months finishes the mighty voyage. This periodical rotation produces the seasons, and completes the year. And all the time it proceeds in its annual circle, it spins upon its own centre, and turns ‘its sides alternately to the great fountain of light. By this means the day dawns in one hemisphere, while the night succeeds in the other. Without this expedient, one part of its regions would, during half the great revolution, be scorched with excessive heat, and languish under an uninterrupted glare: while the other would be frozen to ice, and buried under dismal and destructive darkness.

“ The earth in the revolution which it performs daily on its own axis, whirls about at the rate of above a thousand miles an hour. What an amazing force must be requisite to protrude so vast a globe, and wheel it on, loaded with huge rocks and mountains, with such a prodigious degree of rapidity!

“ Mean time the sun which seems to perform its daily stages, is fixed and immoveable. It is the great axle of heaven, about which the earth and many larger orbs wheel their stated courses. And small as it seems, it is far larger than the earth : Sir Isaac Newton supposes, 900,000 times. Are we ready to cry out, how mighty is the Being who kindled such a prodigious fire! And keeps alive from age to age, such an enormous mass of flame! And yet this sun, with all its attendant planets, are but a very small part of that grand machine, the universe. Every star is really a vast globe, like the sun in size and in glory. Nay, every star, as some suppose, is not merely a world, but the centre of a magnificent system; has a retinue of worlds enlightened by its beams, and revolving round its orb: all which are lost to our sight, in immeasurable wilds of ether.

“But could you soar farther yet, could you wing your way to the highest apparent star, you would there see other skies expanded, another sun distributing his beams by day, with other stars, that gild the horrors of the alternate night: and other, perhaps nobler, systems established, through the boundless dimensions of space. Nor does the dominion of the great Sovereign, terminate even here. Even at the end of this vast tour, you would find yourself advanced no farther than the suburbs of creation: arrived only at the frontiers of the great Jehovah’s kingdom

“Think on this. When innumerable bodies, many of them more than a hundred thousand miles in diameter, are set in motion: when the orbits in which they move are extended to hundreds of millions of miles: when each has a distinct and separate spheres for finishing his vast circuit; when none is cramped, but each freely expatiates in his unbounded career: when every one is so immensely distant from the others, that they appear each to other as only so many spots of light: how astonishing is the expanse which yields room for them all, and their widely diffused operations! To what lengths did the Almighty Builder stretch his line, when he marked out the stupendous platform! I wonder at such an immeasurable extent: my. thoughts are lost in this abyss of space.

“To go one step farther still: when I contemplate those ample and amazing structures, erected in endless magnificence, over all the etherial plains: when I look on them as so many repositories of light, or fruitful abodes of life : when I remember, there are orbs vastly more remote than those which appear to our unaided sight; when I stretch my thoughts to the innumerable orders of beings, which inhabit all those spacious systems, from the highest seraph to the puny nations that tinge the plume with blue, or mantle the standing poor with green. How various are the links in this immense

chain, the gradations in this universal scale of existence ! Yet all these are the work of God's hand, and are full of his presence!

"He rounded in his palm those dreadfully large globes, which are pendulous in the vault of heaven. He kindled those astonishingly bright fires, which fill the firmament with a flood of glory. By him they are suspended in fluid ether, arid never can be shaken; by him they dispense a perpetual tide of beams, and never are exhausted.— He formed that exquisitely tine collection of tubes, that unknown multiplicity of subtle springs, which organize and actuate the frame of the minutest insect, lie bids the crimson current roll, the vital movements play, and joins together a world of wonders, even in an animated point. For there are living creatures abundantly smaller than a mite. Mr. Bradly mentions some, which by computation he found to be a thousand times less than the least visible grain of sand; at the same time he declares, that this was a bulky beinz, compared to others discovered by Mr. Lewenhock. If then we consider the several limbs. which compose such an organized particle: the different springs which actuate those limbs; the flow of spirits which put those springs in motion; the various fluids which circulate: the different secretions which must necessarily be performed; together with the proportion-able minuteness of the solids, before they arrive at their full growth: we shall see the utmost reason to own, that the Creator is greatly glorious even in his smallest works.

" To conclude this head. If the stars are magazines of fire, and immense reservoirs of light, undoubtedly they have some grand uses, suited to the magnificence of their nature. To determine what Uses, is not possible, in our present state of distance and ignorance. This however is clear, they are disposed in such a manner, as is most pleasing and serviceable to mankind. They are not placed at such an infinite remove, as to lie beyond our sight neither are they brought so near to our abode, as to annoy us with their beams."

1776
Thomas Paine
Common Sense
Revolutionary War Pamphlet

What is it we want to know? Does not the creation, the universe we behold, preach to us the existence of an Almighty power, that governs and regulates the whole? And is not the evidence that this creation holds out to our senses infinitely stronger than anything we can read in a book that any imposter might make or call the word of God? As for morality, the knowledge of it exists in every mans conscience. (In God We Trust, ed. Norman Cousins, New York, Harper and Brothers, 1958, p. 1.)

1778 (Original Publication Date)
Georges-Louis Leclerc, Comte de Buffon
Des Époques De La Nature (Epochs of Nature)
This vierson in Oeuvres Completes published in 1836

Link at Google Book:
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Comme, dans l'histoire civile, on consulte les titres, on recherche les médailles, on déchiffre les inscriptions antiques, pour déterminer les époques des révolutions humaines, et constater les dates

des événemens moraux; de même, dans l'histoire naturelle, i\ faut fouiller les archives du monde, tirer des entrailles de la terre les vieux monumens, recueillir leurs débris, et rassembler en un corps de preuves tous les indices des changemens physiques qui peuvent nous faire remonter aux différens âges de la nature. C'est le seul moyen de fixer quelques points dans l'immensité de l'espace, et de placer un certain nombre de pierres numéraires sur la route éternelle du temps. Le Sassê est comme "la distance; notre vue y écroit, et s'y perdroit de même, si l'histoire et la cbronologie n'eussent placé des fanaux, des flambeaux, aux points les plus obscurs: mais, malgré ces lumières de la tradition écrite, si l'on remonte à quelques siècles, que d'incertitudes dans les faits! que d'erreurs sur les causes des événemens! et quelle obscurité profonde n'environne pas les temps antérieurs à cette tradition! D'ailleurs elle ne nous a transmis que les gestes de quelques nations, c'est-à-dire les actes d'une très petite partie du geure humain; tout le reste des hommes est demeuré nul pour nous, nul pour la postérité; ils ne sont sortis de leur néant que pour passer comme des ombres qui ne laissent point de traces: et plût au ciel que le nombre de tous ces prétendus héros dont on a célébré les crimes ou la gloire sanguinaire fût également enseveli dans la nuit de l'oubli!

Ainsi l'histoire civile, bornée d'un côté par les ténèbres d'un temps assez voisin du nôtre, ne s'étend de l'autre qu'aux petites portions de terre qu'ont occupées successivement les peuples soigneux de leur mémoire; au lieu que l'histoire naturelle embrasse également tous les espaces, tous les temps, et n'a d'autres limites que celles de l'univers.

La nature étant contemporaine de la matière, de l'espace, et du temps, son histoire est celle de toutes les substances, de tous les lieux, de tous les âges; et quoiqu'il paroisse à la première vue que ses grands ouvrages ne s'altèrent ni ne changent, et que dans ses productions, même les plus fragiles et les plus passagères, elle se montre toujours et constamment la même, puisqu'à chaque instant ses premiers modèles reparoissent à nos yeux sous de nouvelles représentations, cependant, en l'observant de près, on s'apercevra que son cours n'est pas absolument uniforme: on reconnoitra qu'elle admet des variations sensibles, qu'elle reçoit des altérations successives, qu'elle se prête même à des combinaisons nouvelles, à des mutations de matière et de forme; qu'enfin autant elle paroit fixe dans son tout, autant elle est variable dans chacune de ses parties; et si nous l'embrassons dans toute son étendue, nous ne pourrons douter qu'elle ne soit aujourd'hui très différente de ce qu'elle étoit au commencement et de ce qu'elle est devenue dans la succession des temps: ce sont ces changemens divers que nous appelons ses époques. La nature s'est trouvée dans différens états; la surface de la terre a finis successivement des formes différentes; es cieux mêmes ont varié, et toutes les choses de l'univers physique sont, comme celles du monde moral, dans un mouvement continuel de variations successives. Par exemple, l'état dans lequel nous voyons aujourd'hui la nature est autant notre ouvrage que le sien; nous avons su la tempérer, la modifier, la plier à nos besoins, à nos désirs; nous avons sondé, cultivé, fécondé la terre: l'aspect sous lequel elle se présente est donc bien différent de celui des temps antérieurs à l'invention des arts. L'âge d'or de la morale, ou plutôt de la fable, n'étoit que l'âge de fer de la physique et de la vérité. L'homme de ce temps, encore à demi sauvage, dispersé, peu nombreux, ne sentoit pas sa puissance, ne connoissoit pas sa vraie ricbesse; le trésor de ses lumières étoit enfoui; il ignoroit la force des volontés unies, et ne se doutoit pas que, par la société et par des travaux suivis et concertés, il viendrait à bout d'imprimer ses idées sur la surface entière de l'univers.

Aussi faut-il aller chercher et voir la nature dans ces régions nouvellement découvertes, dans ces contrées de tout temps inhabitées, pour se former une idée de son état ancien; et cet ancien état est encore bien moderne en comparaison de celui où nos continens terrestres étoient couverts par les eaux, où les poissons habitoient sur nos plaines, où nos montagnes formoient les écueils des mers: combien de changemens et de différens états ont dû se succéder depuis ces temps antiques (qui cependant n'étoient pas les premiers) jusqu'aux âges de l'histoire! que de choses ensevelies! combien d événemens entièrement oubliés! que de révolutions antérieures à la mémoire des

hommes! 11 a fallu une très longue suite d'observations, il a fallu trente siècles de culture à l'esprit humain, seulement pour reconnaître l'état présent des choses. La terre n'est pas encore entièrement découverte; ce n'est que depuis peu qu'on a déterminé sa figure; ce u'est que de nos jours qu'on s'est élevé à la théorie de sa forme intérieure, et qu'on a démontré l'ordre et la disposition des matières dont elle est composée: ce n'est doue que de cet instant où l'on peut commencer à comparer la nature avec elle-même, et remonter de son état actuel et connu à quelques époques d'un état plus ancien.

Mais comme il s'agit ici de percer la nuit des temps, de reeonnoitre par l'inspection des choses actuelles l'ancienne existence des choses anéanties, et de remonter par la seule force des faits subsistans à la vérité historique des faits ensevelis; comme il s'agit, en un mot, de juger non seulement le passé moderne, mais le passé le plus ancien, par le seul présent, et que, pour nous élever jusqu'à ce point de vue, nous avons besoin 4e toutes nos forces réunies, nous emploierons trois grands moyens: i" les faits qui peuvent nous rapprocher de l'origine de la nature; «° les monumens qu'on doit regarder comme les témoins de ses premiers âges; 3° les traditions qui peuvent nous donner quelque idée des âges subséquens: après quoi nous tâcheron de lier le tout par des analogies, et de former une chaîne qui, du sommet de l'échelle d,n temps, descendra jusqu'à nous.

Premier Fait

La temps est élevée sur l'équateur et abaissée tous les pôles, dans la proportion qu'exigent les lois de la pesanteur et de la force centrifuge.

Second Fait

Le globe terrestre a une chaleur intérieure qui lui est propre, et qui est indépendante de celle que les rayons du soleil peuvent lui communiquer.

Troisième Fait

La chaleur que le soleil envoie à la terre est assez petite eu comparaison de la chaleur propre du globe terrestre; et cette chaleur envoyée par le soleil ne serait pas seule suffisante pour maintenir la nature vivante.

Quatrième Fait

Les matières qui composent le globe de la terre sont en général de la nature du, verre, et peuvent être toutes réduites en verre.

Cisquieme Fait

On trouve sur toute la surface de la terre, et même sur les montagnes, jusqu'à quinze cents et deux mille toises de hauteur, une immense quantité de coquilles et d'autres débris des productions de la mer.

Examinons d'abord si, dans ces faits que je veux employer, il n'y a rien qu'on puisse raisonnablement contester. Voyons si tous sont prouvés, ou du moins peuvent l'être; après quoi nous passerons aux inductions que l'on doit en tirer.

Le premier fait du renflement de la terre, à l'équateur et de son aplatissement aux pôles, est mathématiquement démontré et physiquement prouvé par la théorie de la gravitation et par les

expériences du pendule. Le globe terrestre a précisément la figure que prendrait un globe fluide qui tournerait sur lui-même avec la vitesse que nous connoissons au globe de la terre. Ainsi la première conséquence qui sort de ce fait incontestable c'est que la matière dont notre terre est composée étoit dans un état de fluidité au moment qu'elle a pris sa forme, et ce moment est celui où elle a commencé à tourner sur elle-même: car si la terre n'eût pas été fluide, et qu'elle eût eu la même consistance que nous lui voyons aujourd'hui, il est évident que cette matière consistante et solide n'auroit pas obéi à la loi de la force centrifuge, et que par conséquent, malgré la rapidité de son mouvement de rotation, la terre, au lieu d'être un sphéroïde renflé sur l'équateur et aplati sous les pôles, seroit au contraire une sphère exacte, et qu'elle n'auroit jamais pu prendre d'autre figure que celle d'un globe parfait, en vertu de l'attraction mutuelle de toutes les parties de la matière dont elle est composée.

Or, quoiqu'en général toute fluidité ait la chaleur pour cause, puisque l'eau même, sans la chaleur, ne formerait qu'une substance solide, nous avons deux manières différentes de concevoir la possibilité de cet état primitif de fluidité dans le globe terrestre, 'parce qu'il semble d'abord que la nature ait deux moyens pour l'opérer. Le premier est la dissolution ou même le délaiement des matières terrestres dans l'eau; et le second, leur liquéfaction par le feu. lMais l'on sait que le plus grand nombre des matières solides qui composent le globe terrestre ne sont pas dissolubles dans l'eau; et en même temps l'on voit que la quantité d'eau est si petite en comparaison de celle de la matière aride, qu'il n'est pas possible que l'une ait jamais été délayée dans l'autre. Ainsi, cet état de fluidité dans lequel s'est trouvée la masse entière de la terre n'ayant su s'opérer ni par la dissolution ni par le clairement dans l'eau, il est nécessaire que cette fluidité ait été une liquéfaction causée par le feu.

Cette juste conséquence, déjà très vraisemblable par elle-même, prend un nouveau degré de probabilité par le second fait, et devient une certitude par le troisième fait. La chaleur intérieure du globe, encore actuellement subsistante, et beaucoup plus grande que celle qui nous vient du soleil, nous démontre que cet ancien feu qu'a éprouvé le globe, n'est pas encore, à beaucoup près, entièrement dissipé: la surface de la terre est plus refroidie que son intérieur. Des expériences certaines et réitérées nous assurent que la masse entière du globe a une chaleur propre et tout-à-fait indépendante de celle du soleil: cette chaleur nous est démontrée par la comparaison de nos hivers à nos étés1; et on la reconnoit d'une manière encore plus palpable dès qu'ou pénètre au dedans de la terre; elle est constante en tous lieux pour chaque profondeur, et elle paroit augmenter à mesuré que l'on descend Mais que sont nos travaux eu comparaison de ceux qu'il faudrait faire pour reconnoitre les degrés successifs de cette chaleur intérieure dans les profondeurs du globe? Nous avons fouillé les montagnes à quelques centaines de toises pour en tirer les métaux; nous avons fait dans les plaines des puits de quelques centaines de pieds; ce sont là nos plus grandes excavations, ou plutot nos fouilles les plus profondes; elles effleurent à peine la première écorce du globe, et néanmoins la chaleur intérieure y est déjà plus sensible qu'à la surface: on doit donc présumer que si l'on pénétrait plus avant, cette chaleur serait plus grande, et que les parties voisines du centre de la terre sont plus chaudes que celles qui en sont éloignées, comme l'on voit dans un boulet rougi au feu l'incandescence se conserver dans les parties voisines du centre longtemps après que la surface a perdu cet état d'incandescence et de rougeur. Ce feu ou plutot cette chaleur intérieure de la terre est encore indiquée parles effets de l'électricité, qui convertit en éclairs lumineux cette chaleur obscure; elle nous est démontrée par la température de l'eau de la mer, laquelle, aux mêmes profondeurs, est à peu près égale à celle de l'intérieur de la terre3. Ayant plongé un thermomètre dans la mer eu différens lieux et en différens temps, il s'est trouvé que la température à, 10, 20, 3o, et 1ao brasses, étoit également de 10 degrés ou 10 degrés 3/4.,, Voyez l’histoire physique de la mer, par Marsigli, page 16.... M. de Mairan fait à ce sujet une remarque très judicieuse, c'est que « les eaux les plus chaudes, qui sont à la plus grande profondeur, doivent, comme plus légères, continuellement monter au dessus de celles qui le sont le moins; ce qui donnera à cette grande couche 11. quide du globe terrestre une température à peu

près égale, conformément aux observations de sttarsigli, excepté vers la superficie actuellement exposée aux impressions de l'air et où l'eau se gèle quelquefois avant que d'avoir eu le temps de descendre par son poids et son refroidissement. » (Dissertation sur la glace, page 6q.) D'ailleurs il est aisé de prouver que la liquidité des eaux de la mer en général ne doit point être attribuée à la puissance des rayons solaires, puisqu'il est démontré, par l'expérience, que la lumière du soleil ne pénètre qu'à six cents pieds à travers l'eau la plus limpide 4, et que par conséquent sa chaleur n'arrive peut-être pas au quart de cette épaisseur, c'est-à-dire à cent cinquante pieds 5. Ainsi toutes les eaux qui sont au dessous de cette profondeur seraient glacées sans la chaleur intérieure de la terre, qui seule peut entretenir leur liquidité. Et de même il est encore prouvé, par l'expérience, que la chaleur des rayons solaires ne pénètre pas à quinze ou vingt pieds dans la terre, puisque la glace se conserve à cette profondeur pendant les étés les plus chauds. Donc il est démontré qu'il y a au dessous du hassin de la mer, comme dans les premières couches de la terre, une émanation continuelle de chaleur qui entretient la liquidité des eaux, et produit la température de la terre; donc il existe dans son intérieur une chaleur qui lui appartient en propre, et qui est tout-à-fait indépendante de celle que le soleil peut lui communiquer.

Nous pouvons encore confirmer ce fait général par un grand nombre de faits particuliers. Tout le monde a remarqué, dans le temps des frimas, que la neige se fond dans tous les endroits où les vapeurs de l'intérieur de la terre ont une libre issue, comme sur les puits, les aqueducs recouverts, les voûtes, les citernes, etc., tandis que sur tout le reste de l'espace où la terre resserrée par la gelée intercepte ces vapeurs, la neige subsiste et se gèle au lieu de fondre. Cela seul suffiroit pour démontrer que ces émanations de l'intérieur de la terre ont un degré de chaleur très réel et sensible. Mais il est inutile de vouloir accumuler ici de nouvelles preuves d'un fait constaté par l'expérience et par les observations; il nous suffit qu'on ne puisse désormais le révoquer en doute, et qu'on reconnoisse cette chaleur intérieure de la terre comme un fait réel et général, duquel, comme des autres faits généraux delà nature, on doit déduire les effets particuliers.

Il en est de même du quatrième fait: on ne peut pas douter, d'après les preuves démonstratives que nous en avons données dans plusieurs articles de notre Théorie de la terre, que les matières dont le globe est composé ne soient de la nature du verre 1:

1. Cette vérité générale, que nous pouvons démontrer par l'expérience, a été soupçonnée par Leibnitz, philosophe dont le nom fera toujours grand honneur à l'Allemagne. « S*ane plerisque « ereditum et à sacris etiam scriptoribus insinuatum « est conditos in abdito telluris ignis thesauros.... « Adjuvant vultus, nam omnis ex fusione Scorix «vitri est Gkhus.... Talcm vero esse globi nostri « superficiem (neque enim ultra penetrare nobis (tdatum) reipsâ experimur; omnes enim terra: et « lapides igne vitrum reddunt.... nobis satis est « admoto igne omnia terrestria in Vitro niriRi. » Ipsa magna telluris ossa undzque ill2c rupes atquc « immortales silices «ùm tota fere in vitrum «béant,* le fond des minéraux, des végétaux, et des animaux, n'est qu'une matière vitrescible; car tous leurs résidus, tous leurs détrimens ultérieurs, peuvent se réduire en verre. Les matières que les chimistes ont appelées réfractaires, celles qu'ils regardent comme infusibles, parce qu'elles résistent au feu de leurs fourneaux sans se réduire en verre, peuvent néanmoins s'y réduire par l'action d'un feu plus violent. Ainsi toutes les matières qui composent le globe de la terre, du moins toutes celles qui nous sont connues, ont le verre pour hase de leur substance; et nous pouvons, en leur faisant subir la grande action du feu, les réduire toutes ultérieurement à leur premier état 2.

La liquéfaction primitive de la masse entière de la terre par le feu est donc prouvée dans toute la rigueur qu'exige la plus stricte logique: d'abord à priori, par le premier fait de son élévation sur l'équateur et de son abaissement sous les pôles; 2° ab actu, par le second et le troisième fait de la chaleur intérieure de la terre encore subsistante; 3° à posteriori, par le quatrième fait, qui nous démontre le produit de cette action du feu, c'est-à-dire le verre, dans toutes les substances

terrestres.

Mais quoique les matières qui composent le globe de la terre aient été primitivement de la nature du verre, et qu'on puisse aussi les y réduire ultérieurement, on doit cependant les distinguer et les séparer relativement aux différens états où elles se trouvent avant ce retour à leur première nature, c'est-à-dire avant leur réduction en verre par le moyen du feu. Cette considération est d'au:

qnid nisi concreta sunt ex fusis otim corporibus « et prima illa magnaque vi quam in facilem arihnc « materiam exercuit ignis natura:.... cùm igitur «omnia quai non avolent in auras, tandem fan. « dantur, et, speculorum imprnnis urentinm ope, « vitri naturam sumant, hinc facile intelligcs vitrum «esse velut Tins Rasih, et naturam ejus cauern« rum plerumque corporum larvis latere. » (G. G. Leibnitn Protogœa; Goettingx, 1749. pages 4 et 5.) (Add. Buff.)

2. J'avoue qu'il y a quelques matières que le feu de nos fourneaux ne peut réduire en verre; mais au moyen d'un bon miroir ardent ces mêmes matières s'y réduiront: ce n'est point ici le lieu de rapporter les expériences faites avec les miroirs de mon invention, dont la chaleur est assez grande pour volatiliser ou vitrifier toutes les matières exposées à leur foyer. Mais il est vrai que jusqu'à ce jour l'on n'a pas encore eu des miroirs assez puissans pour réduire en verre certaines matières du geure vitrescible, telles que le cristal de roche, le silex ou la pierre à fusil; ce n'est donc pas que ces matières ne soient par leur nature réductibles en verre comme les autres, mais seulement qu'elles exigent un feu plus violent, tant plus nécessaire ici, que seule elle peut nous indiquer en quoi diffère la formation de ces matières: on doit donc les diviser d'abord en matières vitrescibles et en matières calcinables; les premières n'éprouvant aucune action de la part du feu, à moins qu'il ne soit porté à un degré de force capable de le convertir en verre; les autres, au contraire, éprouvant à un degré bien inférieur une action qui les réduit en chaux. La quantité des substances calcaires, quoique fort considérable sur la terre, est néanmoins très petite en comparaison de la quantité des matières vitrescibles. Le cinquième fait, que nous avons mis en avant, prouve que leur formation est aussi d'un autre temps et d'un autre élément; et l'on voit évidemment que toutes les matières qui n'ont pas été produites immédiatement par l'action du feu primitif ont été formées par l'intermède de l'eau, parce que toutes sont composées de coquilles et d'autres débris des productions de la mer. Nous mettons dans la classe des. matières vitrescibles le roc vif, les quartz, les sables, les grès et granites, les ardoises, les schistes, les argiles, les métaux et minéraux métalliques: ces matières, prises ensemble, forment le vrai fonds du globe, et en composent la principale et très grande partie; toutes ont originairement été produites par le feu primitif. Le sable n'est que du verre en poudre; les argiles, des sables pourris dans l'eau; les ardoises et les schistes, des argiles desséchées et durcies; le roc vif, les grès, le granite, ne sont que des masses vitreuses ou des sables vitrescibles sous une forme concrète; les cailloux, les cristaux, les métaux et la plupart des autres minéraux, ne sont que les stillations, les exsudations, ou les sublimations de ces premières matières, qui toutes nous décèlent leur origine primitive et leur nature commune par leur aptitude à se réduire immédiatement en verre.

Mais les sables et graviers calcaires, les craies, la pierre de taille, le moellon, les marbres, les albâtres, les spaths calcaires, opaques, et transparens, toutes les matières, en un mot, qui se convertissent en chaux, ne présentent pas d'abord leur première nature: quoique originairement de verre comme toutes les autres, ces matières calcaires ont passé par des filières qui les ont dénaturées; elles ont été formes dans l'eau; toutes sont entièrement composées de madrépores, de coquilles, et de détrimens des dépouilles de ces animaux vraiment, aquatiques, qui seuls savent convertir le liquide en solide, et transformer l'eau de la mer en pierre Les marbres communs et les autres pierres calcaires sont composés de coquilles entières et de morceaux de coquilles, de madrépores, d'astroïtes, etc., dont toutes les parties sont encore évidentes ou très reconnoissables: les graviers ne sont que les débris des marbres et des pierres calcaires que l'action de l'air et des gelées détache des rochers, et l'on peut faire de la chaux avec ces graviers, comme l'on en fait avec

le marbre ou la pierre; on peut en faire aussi avec les coquilles mêmes et avec la craie et les tufs, lesquels ne sont encore que des débris, ou plutôt des détrimens de ces mêmes matières. Les albâtres, et les marbres qu'on doit leur comparer lorsqu'ils contiennent de l'albâtre, peuvent être regardés comme de grandes stalactites qui se forment aux dépens des autres marbres et des pierres communes: les spatbs calcaires se forment de même par l'exsudation ou la stillation oVns les matières calcaires, comme le cristal de roche se forme dans les matières vitrescibles. Tout cela peut se prouver par l'examen attentif des monumens de la nature.

Premiers Monumens

On trouve à la surface et à l'intérieur de la terre des coquilles et autres productions de la mer; et toutes les matières qu'on appelle calcaires sont composées de leurs détrimens.

Seconds Monumens

En examinant ces coquilles et autres productions maritimes que l'on tire de la terre en France, en Angleterre, eu Allemagne, et dans le reste de l'Europe, on reconnoit qu'une grande partie des espèces d'animaux auxquels ces dépouilles ont appartenu ne se trouvent pas dans les mers adjacentes, et que ces espèces ou ne subsistent plus ou ne se trouvent que dans les mers méridionales: de même on voit dans les ardoises et dans d'autres matières, à de grandes profondeurs, des impressions de poissons et de plantes dont aucune espèce n'appartient à notre climat, et lesquelles n'existent plus, ou ne se trouvent subsistantes que dans les climats méridionaux.

Troisièmes **Monumens**
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On trouve en Sibérie et dans les autres contrées septentrionales de l'Europe et de l'Asie des squelettes, des défenses, des 03 ossemens d'éléphant, d'hippopotame, et de rhinocéros, en assez grande quantité pour être assuré que les espèces de ces animaux, qui ne peuvent se propager aujourd'hui que dans les terres du midi, cxistoient et se propageoient autrefois dans les terres du nord; et l'on a observe que ces dépouilles d'éléphant et d'autres animaux terrestres se présentent à une assez petite profondeur, an lieu (pie les coquilles et les autres débris des productions de la mer se trouvent enfouis à de plus grandes profondeurs dans l'intérieur de la terre.

Quatrièmes Monumens

On trouve des défenses et des ossemens (l'éléphant, ainsi que des déms d'hippopotame, non seulement dans les terres du nord de noire continent, mais aussi dans celles du nord de l'Amérique, quoique les espèces de l'éléphant et de l'hippopotame n'existent point dans ce continent du Nouveau Monde.

Cinquièmes Monumens

On trouve dans le milieu des continens, dans les lieux les plus éloignés des mers, un nombre infini de coquilles dont la plupart appartiennent aux animaux de ce genre actuellement existai» dans les mers méridionales, et dont plusieurs autres n'ont aucun analogue vivant, en sorte que les espèces en patoisant perdues et détruites par des causes jusqu à présent inconnues.

En comparant ces monumens avec les faits, ou voit d'abord que le temps de la formation des matières vitrescibles est bien plus reculé que celui de la composition des substances calcaires; et il paroîl qu'on peut déjà distinguer quatre et même cinq époques dans la plus grande profondeur des

temps: la première, où la matière du globe étant en fusion par le feu, la terre a pris sa forme, et s'est élevée sur l'équateur et abaissée sous les pôles par son mouvement de rotation; la seconde, où cette matière du globe s'étant consolidée a formé les grandes masses de matières vitiescibles; la troisième, où la mer, couvrant la terre actuellement habitée, a nourri les animaux à coquille dont les dépouilles ont formé les substances calcaires; et la quatrième, où s'est faite la retraite de ces mêmes mers qui couvroient nos continens. Une cinquième époque, tout aussi clairement indiquée que les quatre premières, est celle du temps où les éléphans, les hippopotames, et les autres aninaux du midi, ont habité les terres du nord; cette époque est évidemment postérieure à la quatrième, puisque les dépouilles de ces animaux terrestres se trouvent presque à la surface de la terre, au lieu que celles des animaux marins sont, pour la plupart et dans les mêmes lieux, enfouies à de grandes profondeurs.

Quoi! dira-t-on, les éléphans et les autres animaux du midi ont autrefois habité les terres du nord? Ce fait, quelque singulier, quelque extraordinaire qu'il puisse paroitre, n'en est pas moins certain. On a trouvé et on trouve encore tous les jours en Sibérie, eu Russie, et dans les au ires contrées septentrionales de l,Europe et de l'Asie, de l'ivoire en grande quantité; ces défenses d'éléphant se tirent à quelques pieds sous terre, ou se découvrent par les eaux lorsqu'elles fout tomber les terres du bord des fleuves: on trouve ces ossemens et défenses d'éléphant en tant de lieux différais et en si grand nombre, qu'on ne peut plus se borner à dire que ce sont les dépouilles de quelques éléphans amenés par les hommes dans ces climats froids; on est maintenant forcé par les preuves réitérées de convenir que ces animaux étuient autrefois habitans naturels des contrées du nord, comme ils le sont aujourd'hui des contrées du midi; et ce qui paroit encore rendre le fait plus merveilleux, c'est-à-dire plus difficile à expliquer, c'est qu'on trouve ces dépouilles des animaux du midi de notre continent non seulement dans les provinces de notre nord, mais aussi dans les terres du Canada et des autres parties de l'Amérique septentrionale. Nous avons au Cabinet du Roi plusieurs défenses et un grand nombre d'ossemens d'éléphant trouvés en Sibérie; nous avons d'autres défenses et d'autres os d'éléphant qui ont été trouvés en France, et enfin nous avons des défenses d'éléphant et des dents d'hippopotame trouvées en Amérique dans les terres voisines de la rivière d'Ohio. Il est donc nécessaire que ces animaux, qui ne peuvent subsister et ne subsistent en effet aujourd'hui que dans les pays chauds, aient autrefois existé dans les climats du nord, et que par conséquent cette zone froide fût alors aussi chaude que l'est aujourd'hui notre zone torride; car il n'est pas possible que la forme constitutive, ou, si l'on veut, l'habitude réelle du corps des animaux, qui est ce qu'il y a de plus fixe dans la nature, ait pu changer au point de donner le tempérament durant à l'éléphant, ni de supposer que jamais ces animaux du midi, qui ont besoin d'une grande chaleur pour subsister, eussent pu vivre et se multiplier dans les terres du nord, si la température du climat eût été aussi froide qu'elle l'est aujourd'hui. M. Gmelin, qui à parcouru la Sibérie, et qui a ramassé lui-même plusieurs ossemens d'éléphant dans ces terres septentrionales, cherche à rendre raison du fait en supposant que de grandes inondations survenues dans les terres méridionales ont chassé les éléphans vers les contrées du nord, où ils auront tous péri à la fois par la rigueur du climat. Mais cette cause supposée n'est pas proportionnelle à l'effet: on a peut-être dejà tiré du nord plus d'ivoire que tous les éléphans des Indes actuellement vivans n'en pourroient fournir; on en tirera bien davantage avec le temps, lorsque ces vastes déserts du nord, qui sont à peine reconnus, seront peuplés, etque les terres en seront remuées et fouillées par les mains de l'homme. D'ailleurs, il seroit bien étrange que ces animaux eussent pris la route qui convenoit le moins à leur nature, puisque, en les supposant poussés par des inondations du midi, il leur restait deux fuites naturelles vers l'orient et vers l'occident. Et pourquoi fuir jusqu'au soixantième degré du nord, lorsqu'ils pouvoient s'arrêter en chemin, ou s'écarter à coté dans des terres plus heureuses? Et comment concevoir que, par une inondation des mers méridionales, ils aient été chassés à mille lieues dans notre continent et à plus de trois mille lieues dans l'autre? Il est impossible qu'un débordement de la mer des grandes Indes ait envoyé des éléphans en Canada ni même en Sibérie, et il est également impossible qu'ils y soient arrivés en nombre aussi grand que l'indiquent leurs dépouilles.

Etant peu satisfait de cette explication, j'ai pensé qu'on pouvoit en donner une autre plus plausible et qui s'accorde parfaitement avec ma théorie de la terre. Mais, avant de la présenter, j'observerai, pour prévenir toutes difficultés, i° que l'ivoire qu'on trouve en Sibérie et en Canada est certainement de l'ivoire d'éléphant, et non pas de l'ivoire de morse ou vache marine, comme quelques voyageurs l'ont prétendu: on trouve aussi dans les terres septentrionales de l'ivoire fossile de morse; mais il est différent de celui de l'éléphant, et il est facile de les distinguer par la comparaison de leur texture intérieure. Les défenses, les dents luichelières, les omoplates, les fémurs, et les autres ossemens trouvés dans les terres du nord, sont certainement des os d'éléphant) nous les avons comparés aux différentes parties respectives du squelette entier de l'éléphant, et l'on ne peut douter de leilr identité d'espèce. Les grosses dents carrées trouvées dans ces mêmes terres du nord, dont la face qui broie est en forme de trèfle, ont tous les caractères des dents molaires de l'hippopotame; et ces autres énormes dents dont la face qui broie est composée de grosses pointes mousses, ont appartenu à une espèce détruite aujourd'hui sur la terre, comme les grandes volutes appelées cornes d'Àmmon sont actuellement détruites dans la mer.

Les os et les défenses de ces anciens éléphans sont au moins aussi grands et aussi gros que ceux des éléphans actuels 1, auxquels nous les avons comparés; ce qui prouve que ces animaux n'habitoient pas les terres du nord par force, mais qu'ils y existaient dans leur étal de nature et de pleine liberté, puisqu'ils y avoient acquis leurs plus hautes dimensions et pris leur entier accroissement. Ainsi l'on ne peut pas supposer qu'ils y aient été transportés par les hommes; le seul état de captivité, indépendamment de la rigueur du climat, les auroit réduits au quart ou au tiers de la grandeur que nous montrent leurs dépouilles.

La grande quantité que l'on en a déjà trouvée par hasard dans ces terres presque désertes où personne ne cherche suffit pour démontrer que ce n'est ni par un seul ou plusieurs accidens ni dans un seul et même temps que quelques individus de cette espèce se sont trouvés dans ces contrées du nord, mais qu'il est de nécessité absolue que l'espèce même y ait autrefois existé, subsisté, et multiplie, comme elle existe, subsiste, et se multiplie aujourd'hui dans les contrées du midi.

Cela posé, il me semble que la question se réduit à savoir, ou plutôt consiste à chercher s'il y a ou s'il y a eu une cause qui ait pu changer la température dans les différentes parties du globe, au point que les terres du nord, aujourd'hui très froides, aient autrefois éprouvé le degré de chaleur des terres du midi.

Quelques physiciens pourroient penser que cet effet a été produit par le changement de l'obliquité de l'écliptique, parce qu'à la première vue ce changement semble indiquer que l'inclinaison de l'axe du globe n'étant pas constante, la terre a pu tourner autrefois sur un axe assez éloigné de celui sur lequel elle tourne aujourd'hui, pour que la Sibérie se fût alors trouvée sous l'équateur. Les astronomes ont observé que le changement de l'obliquité de l'écliptique est d'environ 45 secondes par siècle: donc, en supposant cette augmentation successive et constante, il ne faut que soixante siecles pour produire une différence de 45 minutes, et trois mille six cents siècles pour donner celle de 45 degrés; ce qui ramèneroit le 6oe degré de latitude au i5", c'est-à-dire les terres de la Sibérie, où les éléphants ont autrefois existé, aux terres de l'Inde où ils vivent aujourd'hui. Or il ne s'agit, dira-t-on, que d'admettre dans le passé cette longue période de temps pour rendre raison du séjour des éléphants eu Sibérie: il y a trois cent soixante mille ans que la terre tournoit sur un axe éloigné de 45 degrés de celui sur lequel elle tourne aujourd'hui; le i5e degré de latitude actuelle étoit alors le 6oG, etc.

A cela je réponds que cette idée et le moyen d'explication qui en résulte ne peuvent pas se soutenir lorsqu'on vient à les examiner: le changement de l'obliquité de l'écliptique n'est pas une diminution ou une augmentation successive et constante; ce n'est au contraire qu'une variation limitée, et qui

se fait tantôt en un sens et tantôt en un autre, laquelle par conséquent n'a jamais pu produire en aucun sens ni pour1 aucun climat cette différence de 45 degrés d'inclinaison; car la variation de l'obliquité de l'axe de la terre est causée par l'action des planètes, qui déplacent l'écliptique sans affecter l'équateur. En prenant la plus puissante de ces attractions, qui est celle de Vénus, il faudrait douze cent soixante mille ans pour qu'elle pût faire changer de 18o degrés la situation de l'écliptique sur l'orbite de Vénus, et par conséquent produire un changement de 6 degrés 47 minutes dans l'obliquité réelle de l'axe de la terre, puisque 6 degrés 47 minutes sont le double de l'inclinaison de l'orbite de Vénus. De même l'action de Jupiter ne peut, dans un espace de neuf cent trente-six mille ans, changer l'obliquité de l'écliptique que de 2 degrés 38 minutes, et encore cet effet est-il en partie compensé par le précédent; en sorte qu'il n'est pas possible que ce changement de l'obliquité de l'axe de la terre aille jamais à 6 degrés, à moins de supposer que toutes les orbites des planètes changeront elles mêmes; supposition que nous ne pouvons ni ne devons admettre, puisqu'il n'y a aucune cause qui puisse produire cet effet. Et, comme on ne peut juger du passé que par l'inspection du présent et par la vue de l'avenir, il n'est pas possible, quelque loin qu'on veuille reculer les limites du temps, de supposer que la variation de l'écliptique ait jamais pu produire une différence de plus de 6 degrés dans les climats de la terre: ainsi cette cause est tout-à-fait insuffisante, et l'explication qu'on voudrait en tirer doit être rejetée.

Mais je puis donner cette explication si difficile, et la déduire d'une cause immédiate. Nous venons de voir que le globe terrestre, lorsqu'il a pris sa forme, étoit dans un état de fluidité; et il est démontré que l'eau n'ayant pu produire la dissolution des matières terrestres, cette fluidité étoit une liquéfaction causée par le feu. Or, pour passer de ce premier état d'embrasement et de liquéfaction à celui d'une chaleur douce et tempérée, il a fallu du temps: le globe n'a pu se refroidir tout à coup au point où il est aujourd'hui. Ainsi, dans les premiers temps après sa formation, la chaleur propre de la terre étoit infiniment plus grande que celle qu'elle reçoit du soleil, puisqu'elle est encore beaucoup plus grande aujourd'hui; ensuite, ce grand feu s'étant dissipé peu à peu, le climat du pôle a éprouvé, comme dans tous les autres climats, des degrés successifs de moindre chaleur et de refroidissement. Il y a donc eu un temps et même une longue suite de temps pendant laquelle les terres du nord, après avoir brûlé comme toutes les autres, ont joui de la même chaleur dont jouissent aujourd'hui les terres du midi: par conséquent ces terres septentrionales ont pu et dû être habitées par les animaux qui habitent actuellement les terres méridionales, et auxquels cette chaleur est nécessaire. Dès lors le fait, loin d'être extraordinaire, se lie parfaitement avec les autres faits, et n'en est qu'une simple conséquence: au lieu de s'opposer à la théorie de la terre que nous avons établie, ce même fait en devient au contraire une preuve accessoire qui ne peut que la confirmer dans le point le plus obscur, c'est-à-dire lorsqu'on commence à tomber dans cette profondeur du temps où la lumière du génie semble s'éteindre, et où, faute d'observations, elle paroit ne pouvoir nous guider pour aller plus loin.

Une sixième époque, postérieure aux cinq autres, est celle de la séparation des deux continens. Il est sûr qu'ils n'étoient pas séparés dans les temps que les éléphants vivoient 'également dans les terres du nord de l'Amérique, de l'Europe, et de l'Asie: je dis également, car on trouve de même leurs ossemens en Sibérie, en Russie, et au Canada. La séparation des continens ne s'est donc faite que dans des temps postérieurs à ceux du séjour des animaux dans les terres septentrionales: mais comme l'on trouve aussi des défenses d'éléphans en Pologne, en Allemagne, en France, en Italie ', on doit en conclure qu'à mesure q.ne les terres septentrionales se refioidissoient. ces animaux se retiraient vers les contrées des zones tempérées où la chaleur du soleil et la plus grande épaisseur du globe compensoient, la perte de la chaleur intérieure de la terre; et qu'enfin ces zones s'étant aussi trop refroidies avec le temps, ils ont successivement gagné les climats de la zone torride, qui sont ceux où la chaleur intérieure s'est conservée le plus long-temps par la plus grande épaisseur du sphéroïde de la terre, et les seuls où cette chaleur, réunie avec celle du soleil, soit encore assez forte aujourd'hui pour maintenir leur nature et soutenir leur propagation.

De même ou trouve en France et dans toutes les autres parties de l'Europe, des coquilles, des squelettes, et des vertèbres d'animaux, marins qui ne peuvent subsister que dans les mers les plus méridionales. Il est donc arrivé, pour les climats de la mer, le même changement de température que pour ceux de la terre; et ce second fait, s'expliquant, comme le premier, par la même cause, parait confirmer le tout au point de lu démonstration.

Lorsque l'on compare ces anciens monumens du premier âge de la nature vivante avec ses productions actuelles, on voit évidemment que la forme constitutive de chaque animal s'est conservée la même et sans altération dans ses principales parties: le type de chaque espèce n'a point changé; le moule intérieur a conservé sa forme t n'a point varié. Quelque longue qu'on voulût imaginer la succession des temps, quelque nombre de générations qu'on admette ou qu'on suppose, les individus de chaque; guère représentent aujourd'hui les formes de ceux des deux premiers siècles, surtondans les espèces majeures, dont l'empreinte est plus ferme et la nature plus fixe; car les espèces inférieures ont, comme nous l'avons dit, éprouvé d'une manière sensible tous les effets des différentes causes de dégénération: seulement il est à remarquer au sujet de ces espèces majeures, telles que l'éléphant et l'hippopotame, qu'en comparant leurs dépouilles antiques avec celles de notre temps, en voit qu'en général ces animaux étoient alors plus grands qu'ils ne le sont aujourd'hui; la nature éloit dans sa première vigueur; la chaleur intérieure de la terre donnoit à ses productions toute la force et toute l'étendue dont elles étoient susceptibles. Il y a eu. dans ce premier âge, des géans en tous geures; les nains et les pygmées sont arrivés depuis, c'est-à-dire après le refroidissement; et si (comme d'autres monumens semblent le démontrer) il y a eu des espèces perdues, c'est-à-dire des animaux qui aient autrefois existé et qui n'existent plus, ce ne peuvent être que ceux dont la nature exigcoil une chaleur plus grande que la chaleur actuelle de la zone torride. Ces énormes dents molaires presque carrées et à grosses pointes mousses, ces grandes volutes pétrifiées dont quelques unes ont plusieurs pieds de diamètre », plusieurs autres poissons et coquillages fossiles dont on ne retrouve nulle part les analogues vivans, n'ont existé que dans les premiers temps où la terre et la mer encore chaudes devoient nourrir des animaux auxquels ce degré de chaleur étoit nécessaire, et qui ne subsistent plus aujourd'hui parce que probablement ils ont péri par le refroidissement.

Voilà donc l'ordre des temps indiqués par les faits et par les monumens; voilà six époques dans la succession des premiers âges de la nature, six espaces de durée dont les limites, quoique indéterminées, n'en sont pas moins réelles; car ces époques ne sont pas, comme celles de l'histoire civile, marquées par des points fixes, ou limitées par des siècles et d autres portions du temps que nous puissions compter et mesurer exactement: néanmoins nous pouvons les comparer entre elles, en évaluer la durée relative, et rappeler à chacune de ces périodes de durée d'autres monumens et d'autres faits qui nous indiqueront des dates contemporaines, et peut-être aussi quelques époques intermédiaires et subséquentes.

Mais avant d'aller plus loin hâtons-nous de prévenir une objection grave, qui pourroit même dégénérer en imputation. Comment accordez-vous, dira-t-on, cette haute ancienneté que vous donnez à la matière avec les traditions sacrées, qui ne donnent au monde que six ou huit mille ans? Quelque fortes que soient vos preuves, quelque fondés que soient vos raisonnemens, quelque évidens que soient vos faits, ceux qui sont rapportés dans le livre sacré ne sont-ils pas encore plus certains? Les contredire, n'est-ce pas manquer à Dieu, qui a eu la bonté de nous les révéler?

Je suis affligé toutes les fois qu'on abuse de ce grand, de ce saint nom de Dieu; je suis blessé toutes les fois que l'homme le profane, et qu'il prostitue l'idée du premier Être en la substituant à celle du fantôme de ses opinions. Plus j'ai pénétré dans le sein de la nature, plus j'ai admiré et profondément respecté son auteur: mais un respect aveugle seroit superstition; la vraie religion suppose au contraire un respect éclairé. Voyons donc, tâchons d'entendre sainement les premiers faits que l'interprète divin nous a transmis au sujet de la création; recueillons avec soin ces rayons

échappés de la lumière céleste: loin d'offusquer la vérité, ils ne peuvent qu'y ajouter un nouveau degré de splendeur.

Au Commencement Dieu Crea Le Ciel Et La Terre

Cela ne veut pas dire qu'au commencement Dieu créa le ciel et la terre tels qu'Us sont, puisqu'il est dit, immédiatement après, me la terre e'toit informe, et que le soleil, a lune, et les étoiles, ne furent placés dans le ciel qu'au quatrième jour de la création. On rendroit donc le texte contradictoire à lui-même, si l'on vouloit soutenir qu'o« commencement Dieu créa le ciel et la terre tels qu'ils sont. Ce fut dans un temps subséquent qu'il les rendit en effet tels qu'ils

sont, en donnant la forme à la matière, et en plaçant le soleil, la lune, et les étoiles, dans le ciel. Ainsi, pour entendre sainement ces premières paroles, il faut nécessairement suppléer un mot qui concilie le tout, et lire: Au commencement Dieu créa La Matière du ciel et de la terre.

Et ce commencement, ce premier temps, le plus ancien de tous, pendant lequel la matière du ciel et de la terre existoit sans forme déterminée, paroit avoir eu une longue durée; car écoutons attentivement la parole de l'interprète divin:

La Terre étoit Informe Et Toute Nue.

Les Ténèbres Couvroient La Face De L'abîme, Et L'esprit De Dleu Etoit Torté Sur Les Eaux.

La terre étoit, les ténèbres couvroient, l'esprit de Dieu étoit. Ces expressions par l'imparfait du verbe u'indiquent-elles pas que c'est pendant un long espace de temps que la terre a été informe et que les ténèbres ont couvert la face de l'abîme? Si cet état informe, si cette face ténébreuse de l'abîme, n'eussent existé qu'un jour, si même cet état n'eût pas duré long-temps, l'écrivain sacré ou se seroit autrement exprimé, ou n'auroit fait aucune mention de ce moment des ténèbres; il eût passé de la création de la matière en général à la production de ses formes particulières, et n'auroit pas fait un repos appuyé, une pause marquée, entre le premier et le second instant des ouvrages de Dieu. Je vois donc clairement que non seulement on peut, mais que même l'on doit, pour se conformer au sens du texte de l'Ecriture Sainte, regarder la création de la matière en général comme plus ancienne que les productions particulières et successives de ses différentes formes; et cela se confirme encore par la transition qui suit:

Or, Dieu Dit:

Ce mot or suppose des choses faites et des choses à faire: c'est le projet d'un nouveau dessein, c'est l'indication d'un décret pour changer l'état ancien ou actuel des choses en un nouvel état.

Que La Lumière Soit Faite, Et La Lumière Fut Faite.

Voilà la première parole de Dieu; elle est si sublime et si prompte, qu'elle nous indique assez que la production de la lumière se fit en un instant: cependant la lumière ne parut pas d'abord ni tout à coup comme un éclair universel; elle demeura pendant du temps confondue avec les ténèbres, et Dieu prit lui-même du temps pour la considérer; car, est-il dit,

Dieu Vit Que La Lumière Etoit Bonne, Et Il Sépara La Lumière D'avec Les Ténèbres.

'L'acte de la séparation de la lumière d'avec les ténèbres est donc évidemment distinct et physiquement éloigné par un espace de temps de l'acte de sa production; et ce temps, pendant lequel il plut à Dieu de la considérer pour voir qu'elle était bonne, c'est-à-dire utile à ses desseins;

ce temps, dis-je, appartient encore et doit s'ajouter à celui du chaos, qui ne commença à se débrouiller que quand la lumière fut séparée des ténèbres.

Voilà donc deux temps, voilà deux espaces de durée, que le texte sacré nous force à reconnoitre: le premier, entre la -création de la matière en général et la production de la lumière; le second, entre celle production de la lumière et sa séparation d'avec les ténèbres. Ainsi, loin de manquer à Dieu en donnant à la matière plus d'ancienneté qu'au monde tel qu'il est, c'est au contraire le respecter autant qu'il est en nous, eu conformant notre intelligence à sa parole. En effet, la lumière qui éclaire nos âmes ne vient-elle pas de Dieu? Les vérités qu'elle nous présente peuvent-elles être contradictoires avec celles qu'il nous a révélées? Il faut se souvenir que son inspiration divine a passé par les organes de l'homme; que sa parole nous a été transmise dans une langue pauvre, dénuée d'expressions précises pour les idées abstraites, en sorte que l'interprète de cette parole divine a été obligé d'employer souvent des mots dont les acceptions ne sont déterminées que par les circonstances: par exemple, le mot créer et le mot former ou faire sont employés indistinctement pour signifier la même chose ou des choses semblables, tandis que dans nos langues ces deux mots ont chacun un sens très différent et très déterminé: créer est tirer une substance du néant; former ou faire, c'est la tirer de quelque chose sous une forme nouvelle; et il paroit que le mot créer 1 appartient de préférence et peut-être uniquement au premier verset de la Genèse, dont la traduction précise en notre langue doit être: Au commencement Dieu tira du néant la matière du ciel et de la terre; et ce qui prouve que ce mot créer, ou tirer du néant, ne doit s'appliquer qu'à ces premières paroles, c'est que toute la matière du ciel et de la terre ayant été créée ou tirée du néant dès le commencement, il n'est plus possible et par conséquent plus permis de supposer de nouvelles créations de matière, puisque alors toute matière n'auroit pas été créée dès le commencement. Par conséquent l'ouvrage des six jours ne peut s'entendre que comme une formation, une production de formes tirées de la matière créée précédemment, et non pas comme d'autres créations de matières nouvelles tirées immédiatement du néant; et en effet, lorsqu'il est question de la lumière, qui est la première de ces formations ou productions tirées du sein de la matière, il est dit seulement Que la lumière soit faite, et non pas Que la lumière soit créée. Tout concourt donc à prouver que la matière ayant été créée *in principio*, ce ne fut que dans des temps subséquens qu'il plut au souverain Être de lui donner la forme, et qu'au lieu de tout créer et tout former dans le même instant, comme il l'auroit pu faire s'il eut voulu déployer toute l'étendue de sa toute-puissance, il n'a voulu au contraire qu'agir avec le temps, produire successivement, et mettre même dos repos, des intervalles considérables, entre chacun de ses ouvrages. Que pouvons-nous entendre par les six jours que l'écrivain sacré nous désigne si précisément en les comptant les uns après les autres, sinon six espaces de temps, six intervalles de durée? El ces espaces de temps indiqués par le nom de jours, faute d'antres expressions, ne peuvent avoir aucun rapport avec nos jours actuels, puisqu'il s'est passé successivement trois de ces jours avant que le soleil ait été placé dans le ciel. Il n'est donc pas possible que ces jours fussent semblables aux nôtres; et l'interprète de Dieu semble l'indiquer assez en les comptant toujours du soir au matin, au lieu que les jours solaires doivent se compter du matin au soir. Ces six jours n'étoient donc pas des jours solaires semblables aux nôtres, ni même des jours de lumière, puisqu'ils commençoient par le soir et unissoient au matin: ces jours n'étoient pas même égaux, car ils n'auroient pas été proportionnés à l'ouvrage. Ce ne sont donc que six espaces de temps: l'historien sacré ne détermine pas la durée de chacun; mais le sens de la narration semble la rendre assez longue pour que nous puissions l'étendre autant que l'exigent les vérités physiques que nous avons à démontrer. Pourquoi donc se récrier si fort sur cet emprunt du temps que nous ne faisons qu'autant que nous y sommes forcés par la connoissance démonstrative des phénomènes de la nature? Pourquoi vouloir nous refuser ce temps, puisque Dieu nous le donne par sa propre parole, et qu'elle seroit contradictoire ou inintelligible si nous n'admettions pas l'existence de ces premiers temps amérieurs à la formation du monde tel qu’il est?

A la bonne heure, que l'on dise, que l'on soutienne, même rigoureusement, que demis le dernier terme, depuis la fin des ouvrages de Dieu, c'est-à-dire depuis la création de l'homme, il ne s'est écoulé que six ou huit mille ans, parce que les différentes généalogies du geure humain depuis Adam n'en indiquent pas davantage; nous devons, cette fois, cette marque de soumission et de respect, à la plus ancienne, à la plus sacrée de toutes les traditions; nous lui devons même plus, c'est de ne jamais nous permettre de nous écarter de la lettre de cette sainte tradition que quand la lettre tue, c'est-à-dire quand elle parait directement opposée à la saine raison et à la vérité des faits de la nature: car toute raison, toute vérité, venant également de Dieu, il n'y a de différence entre les vérités qu'il nous a révélées et celles qu'il nous a permis de découvrir par nos observations et nos recherches; il n'y a, iis-je, d'autre différence que celle d'une première faveur faite gratuitement, à une seconde grâce qu'il a voulu différer et nous faite mériter par nos travaux; et c'est par cette raison que son inter prète n'a parlé aux premiers hommes, encore très ignorans, que dans le sens vulgaire, et qu'il ne s'est pas élevé au dessus de leurs connoissances, qui, bien toin d'atteindre au vrai système du monde, ne s'élendoient pas même au delà des nouons communes, fondées sur le simple rapport des sens; parce qu'en effet c'éloit au peuple qu'il falloit parler, et que la parole eût été vaine et inintelligible si elle eût été telle qu'on pourrait la prononcer aujourd'hui, puisque aujourd'hui même il n'y a qu'un petit nombre d'hommes auxquels les vérités astronomiques et physiques soient assez connues pour n'en pouvoir douter, et qui puissent en entendre le langage.

Voyons donc ce qu'étoit la physique dans ces premiers âges du monde, et ce qu'elle seroit encore si l'homme n'eût jamais étudié »a nature. On voit le ciel comme une voûte d'azur dans laquelle le soleil et la lune paraissent être les astres les plus considérables, dont le premier produit toujours la lumière du jour, et le second fait souvent celle de la nuit; on les voit paroitre ou se lever d'un côté, et disparaître ou se coucher de l'autre, après avoir fourni leur course et donné leur lumière pendant un certain espace de temps. On voit que la mer est de la même couleur que la voûte azurée, et qu'elle paroi, toucher au ciel lorsqu'on la regarde au loin. Toutes les idées du peuple sur le système du monde ne portent que sur ces Irais ou quatre notions; et quelque fausses qu'elles soient, il falloit s'y conformer pour se faire entendre.

En conséquence de ce que la mer parait dans le lointain se réunir au ciel, il étoit naturel d'imaginer qu'il existe en effet oes eaux supérieures et des eaux inférieures, dont les unes remplissent le ciel et les autres la mer, et que, pour soutenir les eaux supérieures, il falloit un firmament, c'est-à-dire un appui, une voûte solide et transparente, au travers de laquelle on aperçût l'azur de, eaux supérieures; aussi est-il dit: Que le firmament soit fait au milieu des eaux, et quil sépare les eaux d'avec les eaux. Et Dieu fit le firmament, et sépara les eaux qui étoient sous le firmament, de celles qui étoient au dessus du firmament, et Pieu donna au firmament le nom de ciel..., et à toutes les eaux rassemblées sous le firmament le nom de mer. C'est à ces mêmes idées que se rapportent les cataractes du ciel, c'est-à-dire les portes ou les fenêtres de ce firmament solide qui s'ouvrirent lorsqu'il fallut laisser tomber les eaux supérieures pour noyer fa terre. C'est encore d'après ces mêmes idées qu'il est dit que les poissons et les oiseaux ont eu une origine commune. Les poissons auront été produits par les eaux inférieures, et les oiseaux parles eaux supérieures, parce qu'ils s'approchent par leur vol de la voûtt azurée, que le vulgaire n'imagine pas être beaucoup plus élevée que les nuages. De même le peuple a toujours cru que les étoiles sont attachées comme des clou - à cette voûte solide, qu'elles sont plus petites que la lune, et infiniment plus petites que le soleil: il ne distingue pas même les planètes des étoiles fixes; et c'est par cette raison qu'il n'est fait aucune mention des planètes dans tout le récit de la création; c'est par la même raison que la lune y est regardée comme le second astre, quoique ce ue soit en effet que le plus petit de tous les corps célestes. etc.. etc.. etc.

Tout, dans le récit de Moïse, est mis à la portée de l'intelligence du peuple; tout y est représenté relativement à l'homme vulgaire, auquel il ne s'agissoit pas de démontrer le vrai système du monde, mais qu'il suffisoit d'instruire de ce qu'il devoit au Créateur, en lui montrant les effets de sa toute-

puissance comme autant de bienfaits: les vérités de la nature ne devoient paroitre qu'avec le temps, et le souverain Être se les réservoit comme le plus sûr moyen de rappeler l'homme à lui, lorsque sa foi, déclinant dans la suite des siècles, seroit devenue cbancelante; lorsque éloigné de son origine, il pourroit l'oublier; lorsqu'enfin trop accoutumé au spectacle de la nature, il n'eu seroit plus touché et viendrait à en méconnoitre l'auteur. Il étoit donc nécessaire de raffermir de temps en temps et même d'agrandir l'idée de Dieu dans l'esprit et dans le cœur de l'homme. Or, chaque découverte produit ce grand effet; chaque nouveau pas que nous faisons dans la nature nous rapproche du Créateur. Une vérité nouvelle est une espèce de miracle, l'effet en est le même, et elle ne diffère du vrai miracle qu'en ce que celui-ci est un coup d'éclat que Dieu frappe immédiatement et rarement, au lieu qu'il se sert de l'homme pour découvrir et manifester les merveilles dont il a rempli le sein de la nature; et que, comme ces merveilles s'opèrent à tout instant, qu'elles sont exposées de tout temps et pour tous les temps à sa contemplation. Dieu le rappelle incessamment à lui, non seulement par le spectacle actuel, mais encore par le développement successif de ses œuvres.

Au reste, je ne me suis permis cette interprétation des premiers versets de la Genèse (vue dans la vue d'opérer un grand bien; ce seroit de concilier à jamais la science de la nature avec celle de la théologie: elles ne peuvent, selon moi, être en contradiction qu'en apparence, et mon explication semble le démontrer. Mais si cette explication, quoique simple et très claire, paroit insuffisante et même hors de propos à quelques esprits trop strictement attachés à la lettre, je les prie de me juger par l'intention, et de considérer que mon système sur les époques de la nature étant purement hypothétique, il ne peut nuire aux vérités révélées, qui sont autant d'axiomes*immuables, indépendans de toute hypothèse, et auxquels j'ai soumis et je soumets mes pensées.

Additions De Buffon.

Il ne faut pas creuser bien avant pour ' trouver d'abord une chaleur constante et qui ne varie plus, quelle que soit la température de l'air à la surface de la terre. On sait que la liqueur du thermomètre se soutient toujours sensiblement pendant toute l'année à la même hauteur dans les caves de l'Observatoire, qui n'ont pourtant que 84 pieds ou 14 toises de profondeur depuis le rez-de-chaussée. C'est pourquoi l'on lixe à ce point la hauteur moyenne ou tempérée de notre climat. Cette chaleur se soutient encore ordinairement et à peu de chose près la même depuis une semblable profondeur de 14 ou 15 toises jusqu'à 60, 80, ou 100 toises et au delà, plus ou moins, selon les circonstances, comme on l'éprouve dans les mines; après quoi elle augmente et devient quelquefois si grande, que les ouvriers ne sauraient y tenir et y vivre, si on ne leur procurait pas quelques rafraichissemens et un nouvel air, soit par des puits de respiration, soit par des chutes d'eau.... M. de Geusanne a éprouve dans les mines de Giromagny, à trois lieues de Réfort, que le thermomètre étant porté à 5 atoises de profondeur verticale, se soutint à 10 degrés, comme dans les caves de l'Observatoire; qu'à 106 toises de profondeur il étoit à 10 degrés 1/2, qu'à *58 toises il monta à i5 degrés 1/5, et qu'à 111 toises de profondeur il s'éleva à 18 degrés 1/6. » (Dissertation sur. la glace, par M. de Mairan; Paris, *749, in-12, pages 60 et suiv.)

Plus on descend à de grandes profondeurs dans l'intérieur de la terre, dit ailleurs M. de Gensanne, plus on éprouve une chaleur sensible qui va toujours en augmentant à mesure qu'on descend plus has: cela est au point qu'à 1800 pieds de profondeur au dessous du sol du Rhin, pris à Huningue en Alsace, j'ai trouvé que la chaleur est déjà assez forte pour causer à I eau une évaporation sensible. On peut voir le détail de mes expériences à ce sujet dans la dernière édition de l'excellent Traité de la glace de feu mon illustre ami M. Dortous de Mairan. » (Histoire naturelle du Languedoc)

Tous les filons riches des mines de toute espèce, dit M. Eller, sont dans les fentes perpendiculaires de la terre, et l'on ne saurait déterminer la profondeur de ces fentes: il y en a en Allemagne où l'on

descend au delà de 600 perches (lachters) 1; à mesure que les mineurs descendent, ils rencontrent une température d'air toujours plus chaude. (Mémoire sur la génération des métaux. Académie de Berlm, année 1733.)

l'eu M. Bouguer, savant astronome de l'Académie royale des Sciences, a observé qu'avec seize morceaux de verre ordinaire dont on fait les vitres, appliqués les uns contre les autres, et faisant en iout une épaisseur de 9 lignes 1/2, la lumière passant au travers de ces seize morceaux de verre diminuoit deux cent quaraute-sept fois, c'est-à-dire qu'elle étoit deux cent quarante-sept fois plus foible qu'avant d'avoir traversé ces seize morceaux de verre. Ensuite il a placé soixante-quatorze morceaux de ce même verre à quelque distance les uns des autres dans un tuyau, pour diminuer la lumière du soleil jusqu'à extinction: cet-a-dire étoit à 5o degrés de hauteur sur l'horizon lorsqu'il ht cette expérience; et les suixante-quatorze morceaux de verre ne l'empèchoient pas de voir encore quelque apparence de son disque. Plusieurs personnes qui étoient avec lui voyoient aussi une foible lueur, qu'ils ne distinguoient qu'avec peine, et qui s'évauouissoit aussitôt que leurs yeux n'étoieut pas tout-à-fait dans l'obscurité; mais lorsqu'on eut ajouté trois morceaux de verre aux soixante-quatorze premiers, aucun des assistans ne vit plus la moindre lumière; en sorte qu'en supposant quatre-vingts morceaux de ce même verre on a l'épaisseur de verre nécessaire pour qu'il n'y ait plus aucune transparence par rapport aux vues même les plus délicates; et M. Bouguer trouve, par un calcul assez facile, que la lumière du soleil est alors rendue 900 milliards de fois plus foible: aussi toute matière transparente qui, par sa grande épaisseur, fera diminuer la lumière du soleil oo milliards de fois perdra dès lors toute sa transparence.

En appliquant cette règle à l'eau de la mer, qui de toutes les eaux est la plus limpide, M. Bouguer a trouvé que, pour perdre toute sa transparence, il faut 256 pieds d'épaisseur, attendu que, par une autre expérience, la lumière d'un flambeau avoit diminué dans le rapport de 14 à 5, en traversant 115 pouces d'épaisseur d'eau de mer contenue dans un canal de 9 pieds 7 pouces de longueur, et que, par un calcul qu'on ne peut contester, elle doit perdre toute transparence à 256 pieds. Ainsi, selon M. Bouguer, il ne doit passer aucune lumière sensible au delà de 256 pieds dans la profondeur de l'eau. (Essai d'optique sur la gradation de la lumière; Paris, 1729, in-12, page 85.)

Dépendant il me semble que ce résultai de M. Bouguer s'éloigne encore beaucoup de la réalité: il seroit à désirer qu'il eût fait ses expériences avec des masses de verre de différente épaisseur, et non pas avec des morceaux de verre mis les uns sur les autres; je suis persuadé que la lumière du soleil aurait percé une plus grande épaisseur que celle de ces quatre-vingts morceaux, qui, tous ensemble, ne forment que 47 lignes 1/2, c'est-à-dire à peu près 4 pouces: or, quoique ces morceaux dont il s'est servi fussent de verre commun, il est certain qu'une masse solide de quatre pouces d'épaisseur de ce même verre n'auroit pas entièrement intercepté la lumière du soleil, d'autant que je me suis assuré, par ma propre expérience, qu'une épaisseur de 6 pouces de verre blanc la laisse passer encore assez vivement, comme 0n le verra dans la note suivante. Je crois donc qu'on doit plus que doubler les épaisseurs données par M. Bouguer, et que la lumière du soleil pénètre au moins à 600 pieds à travers l'eau de la mer: car il y a une seconde inattention dans les expériences de ce savant physicien; c'est de n'avoir pas fait passer la lumière du soleil à travers son tuyau rempli d'eau de mer, de 9 pieds 7 pouces de longueur; il s'est coulenté d'y faire passer la lumière d'un flambeau, et il en a conclu la diminution dans le rapport de 14 à 5; or je suis persuade que cette diminution n'auroit pas été si grande sur la lumière du soleil, d'autant que celle du flambeau ne pouvoit passer qu'obliquement, au lieu que celle du soleil passant directement auroit été plus pénétrante par la seule incidence, indépendamment de sa pureté et de son intensité. Ainsi, tout bien considéré, il me paroît que, pour approcher le plus près qu'il est possible de la vérité, on doit supposer que la lumière du soleil pénètre dans le sein de la mer jusqu'à 100 toises ou 600 pieds de profondeur, et la chaleur jusqu'à i5o pieds. Ce n'est pas à dire pour cela qu'il ne passe encore au delà quelques atomes de lumière et de chaleur, mais seulement que leur effet seroit absolument insensible, et ne pourrait être reconnu par aucun de nos sens.

Je crois être assuré de cette vérité par une analogie tirée d'une expérience qui me paroit décisive: avec une loupe de verre massif de 27 pouces de diamètre sur 6 pouces d'épaisseur à son centre je me suis aperçu, en couvrant la partie du milieu, que dette loupe ne brûloit, pour ainsi dire, que par les bords jusqu'à 4 pouces d'épaisseur, et que toute la partie plus épaisse ne produisoit presque point de chaleur; ensuite ayant couvert toute cette loupe, à l'exception d'un pouce d'ouverture sur son centre, j'ai reconnu que la lumière du soleil étoit si fort affoiblie, après avoir traversé cette épaisseur de 6 pouces de verre, qu'elle ne produisoit aucun effet sur le thermomètre. Je suis donc bien fondé à présumer que cette même lumière, affoiblie par i5o pieds d'épaisseur d'eau, ne donnerait pas un degré de chaleur sensible.

La lumière que la lune réfléchit à nos yeux est certainement la lumière réfléchie du soleil; cependant cette lumière n'a point de chaleur sensible, et même, lorsqu'on la concentre au foyer d'un miroir ardent, qui augmente prodigieusement la chaleur du soleil, cette lumière réfléchie par la lune n'a point encore de chaleur sensible; et celle du soleil n'aura pas plus de chaleur, dès qu'en traversant une certaine épaisseur d'eau, elle deviendra aussi foible que celle de la lune. Je suis donc persuadé qu'en laissant passer les rayons du soleil dans un large tuyau rempli d'eau, de 5o pieds de longueur seulement, ce qui n'est que le tiers de l'épaisseur que j'ai supposée, cette lumière affoiblie ne produirait sur un thermomètre aucun effet, en supposant même la liqueur du thermomètre au degré de congélation; d'où j'ai cru pouvoir conclure que, quoique la lumière du soleil perce jusqu'à 600 pieds dans le sein de la mer, sa chaleur ne pénètre pas an quart de cette profondeur.

On peut s'en assurer par les descriptions et les dimensions qu'en a données M. Daubenton; mais, depuis ce temps, on m'a envoyé une défense entière et quelques autres morceaux d'ivoire fossile dont les dimensions excèdent de beaucoup la longueur et la grosseur ordinaires des défenses de l'éléphant; j'ai même fait chercher chez tous les marchands de Paris qui vendent de l'ivoire, on n'a trouvé aucune défense comparable à celle-ci, et il ne s'en est trouvé qu'une seule, sur un très grand nombre, égale à celles qui nous sont venues de Sibérie, dont la circonférence est de 19 pouces à la hase. Les marchands appellent ivoire cru celui qui n'a pas été dans la terre, et que l'on prend sur les éléphans vivans, ou qu'on trouve dans les forêls avec les squelettes rérens de ces animaux; et ils donnent le nom d’ivoire cuit à celui qu'on tire de la terre, et dont la qualité se dénature plus ou moins par un plus ou moins long séjour, ou par la qualité plus ou moins active des terres où il a été renfermé. La plupart des défenses qui nous sont venues du nord sont encore d'un ivoire très solide, dont on pourrait faire de beaux ouvrages: les plus grosses nous ont été envoyées par M. de l'ïsle, astronome, de l'Académie royale des Sciences; il les a recueillies dans son voyage en -Sibérie. Il n'^avoit dans tous les magasins de Paris qu'une seule défense d'ivoire cru qui eût 19 pouces de circonférence; toutes les autres éloient plus menues; cette grosse défense avoit 6 pieds r pouce de longueur, et il paroit que celles qui sont au Cabinet du Roi, et qui ont été trouvées en Sibérie, avoient plus de 6 pieds 1/2 lorsqu'elles éloient entières; mais, comme les extrémités eu sont tronquées, on ne peut en juger qu'à peu près.

Et si l'on compare les os fémurs trouvés de même dans les terres du nord, on s'assurera qu'ils sont au moins aussi longs et considérablement plus épais que ceux des éléphans actuels.

Au reste, nous avons, comme je l'ai dit, comparé exactement les os et les défenses qui nous sont venus de Sibérie aux os cl aux défenses d'un squelette d'éléphant, et nous avons reconnu évidemment que tous ces ossemens sont des dépouilles de ces animaux. Les défenses venues de Sibérie ont non seulement la figure, mais aussi la vraie structure de l'ivoire de l'éléphant, dont M. Daubenton donne la description dans les termes suivans:

Lorsqu'une défense d'éléphant est coupée transversalement, on voit au centre, ou à peu près au centre, un point noir qui est appelé le cœur; mais si la défense a été coupée à l'endroit de sa cavité, il n'y a au centre qu'un trou rond ou ovale: on aperçoit des lignes courbes qui s'étendent en sens contraire, depuis le centre à la circonférence, et qui se croisant forment de petites losanges; il y a ordinairement à la circonférence une bande étroite et circulaire; les lignes courbes se ramifient à mesure qu'elles s'éloignent du centre; et le nombre de ces lignes est d'autant plus grand, qu'elles approchent plus de la circonférence: ainsi la grandeur des losanges est presque partout à peu près la même. Leurs côtés, ou au moins leurs angles, ont une couleur plus vive que l'aire, sans doute parce que leur substance est plus compacte: la bande de la circonférence est quelquefois composée de fibres droites et transversales, qui aboutiraient au centre si elles étoient prolongées; c'est I apparence de ces lignes ei de ces points que l'on regarde comme le grain de l'ivoire: on l'aperçoit dans tous les ivoires, mais il est plus ou moins sensible dans les différentes défenses; et parmi les ivoires dont le grain est assez apurent pour qu'on leur donne le nom d'ivoire grenu, il y en a que l'on appelle ivoire à gros gravis, pour le distinguer de l'ivoire dont le grain est fin. » Voyez, dans cette Histoire naturelle, l'article de l'Éléphant, et les Mémoires de l'Académie des Sciences, année 176a.

Indépendamment de tous les morceaux qui nous ont été envoyés de Russie et de Sibérie, et que nous conservons au Cabinet du Roi, il y en a plusieurs autres dans les cabinets des particuliers de Paris; il y en a un grand nombre dans le Muséum de Pétersbourg, comme on peut le voir dans le catalogue qui en a été imprimé dès l'année 1742; il y en a de même dans le Muséum de Londres, dans celui de Copenhague, et dans quelques autres collections, en Angleterre, en Allemagne, en Italie: on a même fait plusieurs ouvrages de tour avec cet ivoire trouvé dans les terres du nord; ainsi l'on ne peut douter de la grande quantité de ces dépouilles d'éléphant en Sibérie et en Russie.

M. Pallas, savant naturaliste, a trouvé dans sou voyage en Sibérie, ces années dernières, une grande quantité d'ossemens d'éléphant, et un squelette entier de rhinocéros, qui n'étoit enfoui qu'à quelques pieds de profondeur.

On vient de découvrir des os monstrueux d'éléphant à Swijatoki, à dix-sept verstes de Pétersbourg; on les a tirés d'un terrain inondé depuis long-temps. On ne peut donc plus douter de la prodigieuse révolution qui a changé le climat, les productions, et les animaux de toutes les contrées de la terre. Ces médailles naturelles prouvent que les pays dévastés aujourd'hui par la rigueur du froid ont eu autrefois tous les avantages du midi. » (Journal de politique et de littérature, 5 janvier 1776; article de Pétersbourg.)

La découverte des squelettes et des défenses d'éléphans dans le Canada est assez récente, et j'en ai été informé des premiers par une lettre de feu M. Collins mi, membre de la Société royale de Londres; voici la traduction de cette lettre:

M. Georges Croghan nous a assurés que, dans le cours de ses voyages en 1763 et 1766, dans les contrées voisines de la rivière d'Ohio, environ à 4 milles sud-est de cette rivière, éloignée de 640 milles du fort de Quesne (que nous appelons maintenant Pitsburgh), il a vu, aux environs d'un grand marais salé, où les animaux sauvages s'assemblent en certains temps de l'année, de grands os et de grosses dents, et qu'ayant examiné cette place avec soin, il a découvert, sur un banc élevé du côté du marais, un nombre prodigieux d'os de très grands animaux, et que par la longueur et la forme de ces os et de ces défenses on doit conclure que ce sont des os d'éléphants.

Mais les grosses dents que je vous envoie, monsieur, ont été trouvées avec ces défenses; d'autres encore plus grandes que celles-ci paraissent indiquer et même démontrer qu'elles n'appartiennent pas à des éléphans. Comment concilier ce paradoxe? Ne pourrait-on pas supposer qu'il a existé autrefois un grand animal qui avoit les défenses de l'éléphant et les mâchoires de l'hippopotame? car ces grosses dents màebelières sont très différentes de celles de l'éléphant. M. Croghan pense,

d'après la grande quantité de ces différentes sortes de dents, c'est-à-dire des défenses et des dents molaires qu'il a observées dans cet endroit, qu'il y avoit au moins trente de ces animaux. Cependant les éléphans n'étoient point connus en Amérique, et probablement ils n'ont pu y être apportés d'Asie: l'impossibilité qu'ils ont à vivre dans ces contrées, à cause de la rigueur des hivers, et où cependant on trouve une si grande quantité de leurs os, fait encore un paradoxe que votre éminente sagacité doit déterminer.

M. Croghan a envoyé à Londres, au mois de février 1767, les os et les dents qu'il avoit rassemblés dans les années 1763 et 1766:

A milord Sbelburne, deux grandes défenses, dont une étoit bien entière et avoit près de 7 pieds de long (6 pied? 7 pouces de France); l'épaisseur étoit comme celle d'une défense ordinaire d'un éléphant qui auroit cette longueur.

Une mâchoire avec deux dents mâcbelières qui y teuoient, et outre cela plusieurs tres-grosses dents mâcbelières séparées.

Au docteur Franklin, i° trois défenses d'éléphant, dont une, d'environ 6 pieds de long, étoit cassée par la moitié, gâtée ou rongée au centre, et semblable à de la craie; les autres étoient très saines; le bout de l'une des deux étoit aiguisé en pointe et d'un très bel ivoire.

Une petite défense d'environ 3 pieds de long, grosse comme le bras, avec les alvéoles qui reçoivent les muscles et les tendons, qui étoient d'une couleur marron luisante, laquelle avoit l'air aussi frais que si on venoit de les tirer de la tête de l'animal.

Quatre mâchelières, dont l'une des plus grandes avoit plus de largeur et un rang de pointes de plus que celles que je vous ai envoyées. Vous pouvez être assuré que tomes celles qui ont été envoyées à milord Shelburne et à M. Franklin étoient de la même forme et avoient le même émail que celles que je mets sous vos yeux.

Le docteur Franklin a diné dernièrement avec un officier qui a rapporté de cette même place, voisine de la rivière d'Ohio, une défense plus blanche, plus luisante, plus unie que toutes les autres, et une màchelière encore plus grande que toutes celles dont je viens de faire mention. » (Lettre de M. Collinson à M. de Buffon, datée de Mill-hill, près de Londres, le 3 juillet 1767.)

Extrait du Journal du voyage de M. Crogahïf, fait sur la rivière d'Ohio, el envoyé à M. Franklin au mois de mai 1765.

Nous avons passé la grande rivière de Miame, et, le soir, nous sommes arrivés à l'endroit où l'on a trouvé des os d'élépliaus; il peut y avoir 640 milles de distance du fort Pitt. Dans la matinée, j'allai voir la grande plaee marécageuse où les animaux sauvages se rendent dans de certains temps de l'année; nous arrivâmes à cet endroit par une ronle hattue par les bœufs sauvages (bisons), éloigné d'environ 4 milles au sud-est du fleuve Ohio. Nous vîmes de nos yeux qu'il se trouve dans ces lieux une grande quantité d'ossement, les uns épars, les autres enterrés à cinq ou six pieds sous terre, que nous vimes dans l'épaisseur du banc de terre qui borde cette espèce de route. Nous trouvâmes là deux défenses de 6 pieds de longueur, que nous transportâmes à notre bord, avec d'autres os et des dents; el, l'année suivante, nous retournâmes au même endroit prendre encore un plus grand nombre d'autres défenses et d'autres dents.

Si M. de Buffon avoit des doutes et des questions à faire sur cela, je le prie, dit M; Collinson, de me les envoyer; je ferois passer sa lettre à M. Croghan, homme très honnête et éclairé, qui seroit charmé de satisfaire à ses questions. »

Ce petit Mémoire étoit joint à la lettre que je viens de citer, et à laquelle je vais ajouter l'extrait de ce que M. Collinson m'avoit écrit auparavant au sujet de ces mêmes ossemenstrouvés en Amérique:

Il y avoit à environ un mille et demi de la rivière d'Ohio six squelettes monstrueux enterrés debout, portant des défenses de 5 à 6 pieds de long, qui étoient de la forme et de la substance des défenses d'éléphans; elles avoient 3o pouces de circonférence à la racine; elles alloient en s'amincissant jusqu'à la pointe: mais on ne peut pas bien connoitre comment elles étoient jointes à la mâchoire, parce qu'elles étoient brisées eu pièces. Un fémur de ces mêmes animaux fut trouvé bien entier; il pesoit cent livres, et avoit 4 pieds 1/2 de long. Ces défenses et ces os de la cuisse font voir que l'animal étoit d'une prodigieuse grandeur. Ces faits ont été confirmés par M. Greenw00d, qui, ayant été sur les lieux, a vu les six squelettes dans le marais salé; il a de plus trouvé, dans le même lieu, de grosses dents màchelières qui ne paroissent pas appartenir à l'éléphant, mais plutôt à l'hippopotame; et il a rapporté quelques-unes de ces dents à Londres, deux entre autres qui pesoient ensemble 9 livres 1/4. Il dit que l'os de la mâchoire avoit près de 3 pieds de longueur, et qu'il étoit trop lourd pour être porté par deux hommes: il avoit mesuré l'intervalle entre l'orbite des deux yeux, qui étoit de 18 pouces. Une Angloise, faite prisonnière par les sauvages et conduite à ce marais salé, pour leur apprendre à faire du sel en faisant évaporer l'eau, a déclaré se souvenir, par une circonstance singulière, d'avoir vu ces ossemens énormes; elle racontoit que trois François qui rassoient des noix étoient tons trois assis sur un seul de ces grands os de la cuisse.

Quelque temps après m'avoir écrit ces lettres, M. Collinson lut à la Société royale de Londres deux petits Mémoires sur ce même sujet, et dans lesquels j'ai trouvé quelques faits de plus que je vais rapporter, en y joignant un mot d'explication sur les choses qui en ont besoin.

Le marais salé où l'on a trouvé des os d'éléphans, n'est qu'à 4 milles de distance des bords de la rivière d'Ohio; mais il est éloigné de plus de 700 milles de la plus prochaîne cote de la uter. Il y avoit un chemin frayé par les bœufs sauvages (Usons), assez large pour deux chariots de front, qui menoit droit à la place de ce grand marais salé, où ces animaux se rendent, aussi bien que toutes les espèces de cerfs et de chevreuils, dans une certaine saison de l'année, pour lécber la terre et boire de l'eau salée.... Les ossemens d'éléphans se trouvent sous une espèce de levée, ou plutôt sous la rive qui entoure et surmonte le marais à 5 ou 6 pieds de hauteur; on y voit un très - grand nombre d'os et de dents qui ont appartenu à quelques animaux d'une grosseur prodigieuse; il y a des défenses qui ont près de 7 pieds de longueur, et qui sont d'un très bel ivoire: on ne peut donc guère douter qu'elles n'aient appartenu à des éléphans. Mais ce qu'il y a de singulier, c'est que jusqu'ici l'on n'a trouvé parmi ces défenses aucune dent molaire ou màchelière d'éléphant, mais seulement un grand nombre de grosses dents, dont chacune porte cinq ou six pointes mousses, lesquelles ne peuvent avoir appartenu qu'à quelque animal d'une énorme grandeur; et ces grosses dents carrées n'ont point de ressemblance aux mâcbelières de l'éléphant, qui sont aplaties et quatre ou cinq fois aussi larges qu'épaisses; en sorte que ces grosses dents molaires ne ressemblent aux dents d'aucun animal connu.

Ce que dit ici M. Collinson est très vrai: ces grosses dents molaires diffèrent absolument des dents mâcbelières de l'éléphant; et en les comparant à celles de l'hippopotame, auxquelles ces grosses dents ressemblent par leur forme carrée, on verra qu'elles en diffèrent aussi par leur grosseur, étant deux, trois, et quatre fois plus volumineuses que les grosses dents des anciens hippopotames trouvées de même en Sibérie et au Canada, quoique ces dents soient elles-mêmes trois ou quatre fois plus grosses que celles des hippopotames actuellement existans. Toutes les dents que j'ai observées dans quatre tètes de ces animaux qui sont au Cabinet du Roi ont la face qui broie creusée en forme de trèfle, et celles qui ont été trouvées au Canada et en Sibérie ont ce même caractère, et n'en diffèrent que par la grandeur; mais ces énormes dents à grosses pointes mousses diffèrent

de celles de l'hippopotame creusées en trèfle, ont toujours quatre et quelquefois cinq rangs, au lieu que les plus grosses dents de l'hippopotame n'en ont que trois, comme on peut le voir en comparant les figures 4, 5 et 6 avec celles des figures 7 et 8, pl, 1. Il paroit donc certain que ces grosses dents n'ont jamais appartenu à l'éléphant ni à l'hippopotame: la différence de grandeur, quoique énorme, 11e m'empêcheroit pas de les regarder comme appartenant à cette dernière espèce, si tous les caractères de la forme étoient semblables, puisque nous connoissons, comme je viens de le dire, d'autres dents carrées, trois ou quatre fois plus grosses que celles de nos hippopotames actuels, et qui néanmoins ayant les mêmes caractères pour la forme, et particulièrement les creux eq trèfle sur la face qui broie, sont certainement des dents d'hippopotames trois fois plus grands que ceux dont nous avons les tètes; et c'est de ces grosses dents, fig. 7, qui sont vraiment des dents d'hippopotames, que j'ai parlé lorsque j'ai dit qu'il s'en trouvoit également dans les deux confinons, aussi bien que des défenses d'éléphans: mais ce qu'il y a de très - remarquable, c'est que non seulement ou a trouvé de vraies défenses d'éléphans et de vraies dents de gros hippopotames en Sibérie et au Canada, mais qu'on y a trouvé de même ces dents beaucoup plus énormes à grosses pointes mousses et à quatre rangs; je crois doue pouvoir prononcer avec fondement que cette très grande espèce d'animal est perdue.

M. le comte de Vergennes, ministre et secrétaire d'état, a eu la bonté de me donner, en 1770, la plus grosse de toutes ces dents, laquelle est représentée planche 1, fig. 1 et 2; elle pèse 11 livres 4 onces. Cette énorme deux molaire a été trouvée dans la petite Tartarie, en faisant un fossé. Il y avoit d'autres os qu'on n'a pas recueillis, et, entre autres, un os fémur dont il ne restoit que la moitié bien entière, et la cavité de cette moitié contenoit quinze pintes de Paris. M. l'abbé Chappe, de l'Académie des Sciences, nous a rapporté de Sibérie une autre dent toute pareille, mais moins grosse, et qui ne pèse que 3 livres 12 onces 1/2, fig. 4 et 5. Enfin la plus grosse de celles que M. Collinson m'avoit envoyées, et qui est représentée fig. 6, a été trouvée, avec plusieurs autres semblables, en Amérique, près de la rivière d'Ohio; et d'autres qui nous sont venues de Canada leur ressemblent parfaitement. L'on ne peut donc pas douter qu'indépendamment de l'éléphant et de l'hippopotame, dont 0n trouve également les dépouilles dans les deux continens, il n'y eût encore un autre animal commun aux deux continens, d'une grandeur supérieure à celle même des plus grands éléphans; car la forme carrée de ces énormes dents mâchelières prouve qu'elles étoient en nombre dans la mâchoire de l'animal; et quand on n'y en supposerait que six ou même quatre de chaque côté, on peut juger de l'énormité d'une lête qui aurait au moins seize dents mâchelières, pesant chacune dix ou onze livres. L'éléphant n'en a que quatre, deux de chaque coté; elles sont aplaties, elles occupent tout l'espace de la mâchoire; et ces deux dents molaires de l'éléphant fort aplaties ne surpassent que de deux pouces la largeur de la plus grosse dent carrée de l'animal inconnu, qui est du double plus épaisse que celles de l'éléphant. Ainsi tout notre porte à croire que cette ancienne espèce, qu'on doit regarder comme la première et la plus grande de tous les animaux terrestres, n'a subsisté que dans les premiers temps, et n'est pas parvenue jusqu'à nous; car un animal dont l'espèce seroit plus grande que celle de l'éléphant, ne pourrait se cacher nulle part sur la terre au point de demeurer inconnu; et d'ailleurs il est évident par la forme même de ces dents, par leur émail, et par la disposition de leurs racines, qu'elles n'ont aucun rapport aux dents des cachalots ou autres cétacés, et qu'elles ont réellement appartenu à un animal terrestre dont l'espèce étoit elus voisine de celle de l'hippopotame que 'aucune autre. Dans la suite du Mémoire que j'ai cité ci-dessus, M. Collinson dit que plusieurs personnes de la Société royale connoissent, aussi bien que lui, les défenses d'éléphans que l'on trouve tous les ans en Sibérie sur les bords du fleuve Obi et des antres rivières de cette contrée. Quel système établira-t-on, ajoute-t-il, avec quelque degré de probabilité, pour rendre raison de ces dépôts d'ossemens d'éléphans en Sibérie et en Amérique? Il finit par donner l'émunération, les dimensions, et le poids de toutes ces dents trouvées dans le marais salé de la rivière d'Ohio, dont la plus grosse dent carrée appartenoit au capitaine Ourry, et pesoit 6 livres 1/2.

Dans le second petit Mémoire de M. Collinson, lu à la Société royale de Londres, le 10 décembre 1767, il dit que, s'étant aperçu qu'une des défenses trouvées dans le marais salé avoit des stries près du gros bout, il avoit eu quelques doutes si ces stries étoient particulières ou non à l'espèce de l'éléphant; que, pour se satisfaire, il alla visiter le magasin d'un marchand qui fait commerce de dents de toute espèce,' et qu'après les avoir bien examinées, il trouva qu'il y avoit autant de défenses striées au gros bout que d'unies, et que par conséquent il ne faisoit plus aucune difficulté de prononcer que ces défenses trouvées en Amérique ne fussent semblables, à tous égards, aux défenses d'éléphans d'Afrique et d'Asie; mais, comme les grosses dents carrées trouvées dans le même lieu n'ont aucun rapport avec les dents molaires de l'éléphant, il pense que ce sont les restes de quelque animal énorme qui avoit les défenses de l'éléphant avec des dents molaires particulières à son espèce, laquelle est d'une grandeur et d'une forme différente de celle d'aucun animal connu. Voyez les Transactions philosophiques de l'année 1767.

Dès l'année 1748, M. Fabri, qui avoit fait de grandes courses dans le nord de la Louisiane et dans le sud du Canada, m'avoit informé qu'il avoit vu des tètes et des squelettes d'un animal quadrupède d'une grandeur énorme, que les sauvages appeloient le pève-aux-bœufs, et que les os fémurs de ces animaux avoient 5 et jusqu'à 6 pieds de hauteur. Peu de temps après, et avant l'année 1767, quelques personnes à Paris avoient déjà reçu quelques-unes des grosses dents de l'animal inconnu, d'autres d'hippopotames, et aussi des ossemens d'éléphans trouvés en Canada: le nombre en est trop considérable, pour qu'on puisse douter que ces animaux n'aient pas autrefois existé dans les terres septentrionales de l'Amérique, comme dans celles de l'Asie et de l'Europe.

Mais les éléphans ont aussi existé dans toutes les contrées tempérées de notre continent; j'ai fait mention des défenses trouvées en Languedoc près de Simore, et de celles trouvées à Cominges en Gascogne; je dois y ajouter la plus belle et la plus grande de toutes, qui nous a été donnée en dernier lieu pour le Cabinet du Roi par M. le duc de la Rochefoucauld, dont le zèle pour le progrès des sciences est fondé sur les gran des connoissances qu'il a acquises dans tous les geures. Il a trouve ce beau morceau en visitant, avec M. Desmarest, de l'Académie des Sciences, les campagnes aux environs de Rome. Cette défense étoit divisée en cinq fragmens, que M. le duc de la Rochefoucauld fit recueillir: l'un de ces fragmens fut soustrait par le crocheteur qui en étoit chargé, et il n'en est resté que quatre, lesquels ont environ huit pouces de diamètre; en les rapprochant, ils forment une longueur de sept pieds; et nous savons, par M. Desmarest, que le cinquième fragment, qui a été perdu, avoit près de 3 pieds: ainsi l'on peut assurer que la défense entière devoit avoir environ 10 pieds de longueur. En examinant les cassures, nous y avons reconnu tous les caractères de l'ivoire de l'éléphant; seulement cet ivoire, altéré

iiar un long séjour dans la terre, est devenu léger et friable comme les autres ivoires fossiles.

M. Tozzetli, savant naturaliste d'Italie, rapporte qu'on a trouvé, dans les vallées de l'Arno, des os d'éléphans, d'autres animaux terrestres en grande quantité, et épars çà et là dans les couches de la terre, et il dit qu'on peut conjecturer que les éléphans étoient anciennement des animaux indigènes à l'Europe, et surtout à la Toscane. (Extrait d'une lettre du docteur Tozzetti. Journal étranger, mois de décembre i"j55.)

On trouva, dit M. Colielluii, vers la fm du mois de novembre, dans un bien de campagne appartenant au marquis de Petrella, et situé à Fusigliano dans le territoire de Corinne, un morceau d'os d'éléphant incrusté, eu grande partie, d'une matière pierreuse Ce n'est pas d'aujourd'hui qu'on a trouvé de pareils os fossiles dans nos environs.

Dans le cabinet de M. Galeotto Corrazzi, il y a un autre grand morceau de défense d'éléphant pétrifié, et trouvé, ces dernières années, dans les environs de Cortone, au lieu appelé la Selva....

Ayant comparé ces fragmens d'os avec un morceau de défense d'éléphant venu depuis peu d'Asie, on a trouve qu'il y avoit entre eux une ressemblance parfaite.

M. l'abbé Mearini m'apporta, au mois d'avril dernier, une mâchoire entière d'éléphant qu'il avoit trouvée dans le district de Fa rue ta, village de ce diocèse. Cette mâchoire est pétrifiée en grande partie, et surtout des deux côtés, où l'incrustation pierreuse s'élève à la hauteur d'un pouce et a toute la dureté de la pierre.

Je dois enfin à M. Muzio Angelieri Alticozzi, gentilhomme de cette ville, un fémur presque entier d'éléphant, qu'il a découvert lui même dans un de ses biens de campaenc appelé la Rota, situé dans le territoire de Cortone. Cet os, qui est long d'une brasse de Florence, est aussi pétrifié, surtout dans l'extrémité supérieure qu'on appelle la tète... «(Lettre de M. Louis Coltell i ni, de Cortone. Journal Etranger, mois de juillet i-fit.)

La connoissance de toutes les pétrifications dont on ne trouve plus les analogues vivans, supposeroit une étude longue et une comparaison réfléchie de toutes les espèces de pétrifications qu'on a trouvées jusqu'à présent dans le sein de la terre, et cette science n'est pas fort avancée; cependant nous sommes assurés qu'il y a plusieurs de ces espèces, telles que les cornes d'ammon, les orthocératites, les pierres lenticulaires ou numismates, les bélemnites, les pierres judaïques, les anthropomorphiles, etc., qu'on ne peut rapporter à aucune espèce actuellement subsistante. Nous avons vu des cornes d'ammon pétrifiées de deux et trois pieds de diamètre, et nous avons été assurés, par des témoins dignes de foi, qu'on en a trouvé une en Champagne plus grande qu'une meule de moulin, puisqu'elle avoit 8 pieds de diamètre sur un pied d'épaisseur: on m'a même offert dans le temps de me l'envoyer; mais l'énormité de poids de cette masse, qui est d'environ huit milliers, et la grande distance de Paris, m'ont empêché d'accepter cette offre. On ne connoit pas plus les espèces d'animaux auxquels ont appartenu les dépouilles dont nous venons d'indiquer les noms; mais ces exemples, et plusieurs autres que je pourrais citer, suffisent pour prouver qu'il existoit autrefois dans la mer plusieurs espèces de coquillages et de crustacés qui ne subsistent plus. Il en est de même de quelques poissons à écailles: la plupart de ceux qu'on trouve dans les ardoises et dans certains schistes, ne ressemblent pas assez aux poissons qui nous sont connus pour qu'on puisse dire qu'ils sont de telle ou telle espèce; ceux qui sont au Cabinet du Roi, parfaitement conservés dans des masses de pierre, ne peuvent de même se rapporter précisément à nos espèces connues: il paraît donc que, dans tous les genres, la mer a autrefois nourri des animaux dont les espèces n'existent plus.

Mais, comme nous l'avons dit, nous n'avons jusqu'à présent qu'un seul exemple d'une espèce perdue dans les animaux terrestres, et il paroit que c'étoit la plus grande de toutes, sans même en excepter l'éléphant. Et puisque les exemples des espèces perdues dans les animaux terrestres sont bien plus rares que dans les animaux marins, cela ne semble-t-il pas prouver encore que la formation des premiers est postérieure à collé des derniers?

Premiere Epoque - Lorsque la terre et les planètes ont pris leur forme

Dans ce premier temps où la terre en fusion, tournant sur elle-même, a pris sa forme et s'est élevée sur l'équateur en s'abaissant sous les pôles, les autres planètes étoient dans le même état de liquéfaction, puisqu'en tournant sur elles-mêmes, elles ont pris, comme la terre, une forme renflée sur leur équateur et aplatie sous leurs pôles, et que ce renflement et cette dépression sont proportionnels à la vitesse de leur rotation. Le globe de Jupiter nous en fournit la preuve: comme il tourne beaucoup plus vite que celui de la terre, il est en conséquence bien plus élevé sur son équateur, et plus abaissé sous ses pôles; car les observations nous démontrent que les deux diamètres de cette planète différent de plus d'un treizième, tandis que ceux de la terre ne différent que d'une deux cent trentième partie: elles nous montrent aussi que dans Mars, qui tourne

près d'une fois moins vile que la terre, cette différence entre les deux diamètres n'est pas assez sensible pour ell e mesurée par les astronomes, et que dans la lune, dont le mouvement de rotation est encore bien plus lent, les deux diamètres paraissent égaux. La vitesse de la rotation des planètes est donc la seule cause de leur renflement sur l'équateur; et ce renflement, qui s'est fait en même temps que leur aplatissement sous les pôles, suppose une fluidité entière dans toute la masse de ces globes, c'est-à-dire un état de liquéfaction causé par le feu '.

D'ailleurs toutes les planètes circulant autour du soleil dans le même sens et presque dans le même plan, elles paraissent avoir été mises en mouvement par une impulsion commune et dans un même temps; leur mouvement de circulation et leur mollement de rotation sont contemporains, aussi bien que leur état de fusion ou de liquéfaction par le feu, et ces mouvemens ont nécessairement été précédés par l'impulsion qui les a produits.

Dans celles des planètes dont la masse a été frappée le plus obliquement, le mouvement de rotation a été le plus rapide, et, par cette rapidité de rotation, les premiers effets de la force centrifuge ont excédé ceux de la pesanteur: en conséquence il s'est fait dans ces masses liquides une séparation et une projection de parties à leur équateur, où cette force centrifuge est la plus grande, lesquelles parties séparées et chassées par cette force ont formé des masses concomitantes, et sont devenues des satellites qui ont dù circuler et qui circulent en effet tous dans le plan de l'équateur de la planète dout ils ont été séparés par cette cause. Les satellites des planètes se sont donc formés aux dépens de la matière de leur planète principale, comme les planètes elles-mêmes paraissent s'être formées aux dépens de la masse du soleil. Ainsi le temps de la formation des satellites est le même que celui du commencement de la rotation des planètes; c'est le moment où la matière qui les coinpose venoit de se rassembler, et ne formoit encore que des globes liquides, état dans lequel cette matière en liquéfaction pouvoit en être séparée et projetée fort aisément; car, dès que la surface de ces globes eut commencé à prendre un peu de consistance et de rigidité par le refroidissement, la matière, quoique animée de la même force centrifuge, étant retenue par celle de la cohésion, ne pouvoit plus être séparée ni projetée bors de la planète par ce même mouvement de rotation.

Comme nous ne connoissons dans la nature aucune cause de chaleur, aucun feu que celui du soleil, qui ait pu fondre ou tenir en liquéfaction la matière de la terre et des planètes, il me parait qu'en se refusant à croire que les planètes sont issues et sorties du soleil on serait au moins forcé de supposer qu'elles ont été exposées de très près aux ardeurs de cet astre de feu pour pouvoir être liquéfiées. Mais cette supposition ne serait pas encore suffisante pour expliquer l'effet, et tomberait d elle-même par une circonstance nécessaire, c'est quil faut du temps pour que le feu, quelque violent qu'il soit, pénètre les matières solides qui lui sont exposées, et un très long temps pour les liquéfier. On a vu, par les expériences qui précèdent, cme pour échauffer le corps jusqu'au degré de fusion il faut au moins la quinzième partie du temps qu'il faut pour le refroidir, et qu'attendu les grands volumes de la lerre et des autres planètes il serait de toute nécessité qu'elles eussent été pendant plusieurs milliers d'années stationnaires auprès du soleil pour recevoir le degré de chaleur nécessaire à la liquéfaction: or il est sans exemple dans l'univers qu'aucun corps, aucune planète, aucune comète, demeure stationnaire auprès du soleil, même pour un instant; au contraire, plus les comètes en approchent, et plus leur mouvement est rapide: le temps de leur péribélie est extrêmement court, et le feu de cet astre, en brûlant la surface, n'a pas le temps de pénétrer la masse des comètes qui s'en approchent le plus.

Ainsi tout concourt à prouver qu'il n'a pas suffi que la lerre et les planètes aient passé, comme certaines comètes, dans le voisinage du soleil, pour que leur liquéfaction ait pu s'y opérer; nous devons donc présumer que cette matière des planètes a autrefois appartenu au corps même du soleil, et en a été séparée, comme nous l'avons dit, par une seule et même impulsion: car les comètes qui approchent le plus du soleil ne nous pro-entend que le premier degré des grands effets

de la chaleur; elles paraissent précédées d'une vapeur enflammée lorsqu'elles s'approchent, et suivies d'une semblable vapeur lorsqu'elles s'éloignent Je cet astre. Ainsi une partie de la matière superficielle de la comète s'étend autour d'elle, et se présente à nos yeux en forme de vapeurs lumineuses qui se trouvent dans un etat d'expansion et de volatilité causé par le feu du soleil: mais le noyau, c'est-à-dire le corps même de la comète, ne paroil pas être profondément pénétré par le feu, puisqu'il n'est pas lumineux par lui-même, comme le serait néanmoins toute masse de fer, de verre, ou d'autre matière solide intimement pénétrée par cet élément; par conséquent il paroit nécessaire que la matière de la terre et des planètes, qui a été dans un état de liquéfaction, appartienne au corps même du soleil, et qu'elle fasse partie des matières en fusion qui constituent la masse de cet astre de feu.

Les planètes ont reçu leur mouvement par une seule et même impulsion, puisqu'elles circulent toutes dans le même sens et presque dans le même plan; les comètes, au contraire, qui circulent comme les planètes autour du soleil, mais dans des sens et des plans différons, paraissent avoir été mises en mouvement par des impulsions différentes. On doit donc rapporter à une seule époque le mouvement des planètes, au lieu que celui des comètes pourrait avoir été donné en différens temps. Ainsi rien ne peut nous éclairer sur l'origine du mouvement des comètes; mais nous pouvons raisonner sur celui des planètes, parce qu'elles ont entre elles des rapports communs qui indiquent assez clairement qu'elles ont été mises en mouvement par nne seule et même impulsion. Il est donc permis de chercher dans la nature la cause qui a pu produire cette grande impulsion, au lieu que nous ne pouvons guère former de raisonnemens ni même faire des recherches sur les causes du mouvement d'impulsion des comètes.

Rassemblant seulement les rapports fugitifs et les légers indices qui peuvent fournir quelques conjectures, on pourrait imaginer, pour satisfaire, quoique très imparfaitement, à la curiosité de l'esprit, que les comètes de notre système solaire ont été formées par l'explosion d'une étoile fixe ou d'un soleil voisin du nôtre, dont toutes les parties dispersées, n'ayant plus de centre ou de foyer commun, auront été forcées d'obéir à la force attractive de notre soleil, qui dès lors sera devenu le pivot et le foyer de toutes nos comètes. Nous et nos neveux n'en dirons pas davantage jusqu'à ce que, par des observations ultérieures, on parvienne à reconnoitre quelque rapport commun dans le mouvement d'impulsion des comètes; car, comme nous ne connoissons rien que par comparaison, dès que tout rapport nous manque, et qu'aucune analogie ne se présente, toute lumière fuit, et non seulement notre raison, mais même notre imagination, se trouve en défaut. Aussi,étant abstenu ci-devant de former des conjectures sur la cause du mouvement d'impulsion des comètes, j'ai cru devoir raisonner sur celle de l'impulsion des planètes; et j'ai mis en avant, non pas comme un fait réel et certain, mais seulement comme une chose possible, que la matière des planètes a été projetée hors d(i soleil par le choc d'une comète. Cette hypothèse est fondée sur ce qu'il n'y a dans la nature aucun corps en mouvement, sinon les comètes, qui puisse ou ait pu communiquer un aussi grand mouvement à d'aussi grandes masses, et en même temps sur ce que les comètes approchent quelquefois de si près du soleil, qu'il est pour ainsi dire nécessaire que quelques-unes tombent obliquement et en sillonnent la surface, en chassant devant elles les matières mises en mouvement par leur choc.

Il en est de même de la cause qui a pu produire la chaleur du soleil: il m'a paru qu'on peut la déduire des effets naturels, c'est-à-dire la trouver dans la constitution du système du monde; car le soleil ayant à supporter tout le poids, toute la force de l'action pénétrante des vastes corps qui circulent autour de lui, et ayant à souffrir en même temps l'action rapide de cette espèce de frottement intérieur dans toutes les parties de sa masse, la matière qui le compose doit être dans l'état de la plus grande division; elle a dû devenir et demeurer fluide, lumineuse, et brûlante, en raison de cette pression et de ce frottement intérieur toujours également subsistant. Les mouvemens irréguliers des taches du soleil, aussi bien que leur apparition spontanée et leur disparition, démontrent assez que cet astre est liquide, et qu'il s'élève de temps en temps à sa

surface des espèces de scories ou d'écumes, dont les unes nagent irrégulièrement sur cette matière en fusion, et dont quelques autres sont fixes pour un temps, et disparaissent, comme les premières, lorsque l'action du feu les a de nouveau divisées. On sait que c'est par le moyen de quelques-unes de ces taches fixes qu'on a déterminé la durée de la rotation du soleil en vingt-cinq jours et demi.

Or chaque comète et chaque planète forment une roue, dont les rais sont les rayons de la force attractive; le soleil est l'essieu ou le pivot commun de toutes ces différent tes roues; la comète ou la planète en est la jante mobile, et chacune contribue de tout son poids et de toute sa vitesse à l'embrasement de ce foyer général, dont le feu durera par conséquent aussi long-temps que le mouvement et la pression des vastes corps qui le produisent.

De là ne doit-on pas présumer que si l'on ne voit pas des planètes autour des étoiles fixes, ce n'est qu'à cause de leur immense éloignement? Notre vue est trop bornée, nos instrumens trop peu puissans, pour apercevoir ces astres obscurs, puisque ceux mêmes qui sont lumineux échappent à nos yeux, et que, dans le nombre infini de ces étoiles, nous ne connoîtrons jamais que celles dont nos instrumens de longue vue pourront nous rapprocher: mais l'analogie nous indique qu'étant fixes et lumineuses comme le soleil, les étoiles ont dû s'échauffer, se liquéfier, et brûler par la même cause, c'est-à-dire par la pression active des corps opaques, solides, et obscurs, qui circulent autour d'elles. Cela seul peut expliquer pourquoi il n'y a que les astres fixes qui soient lumineux, et pourquoi dans l'univers solaire tous les astres errans sont obscurs.

Et la chaleur produite par cette cause devant être en raison du nombre, de la vitesse, et de la masse des corps qui circulent autour du foyer, le feu du soleil doit être d'une ardeur ou plutôt d'une violence extrême, non seulement parce que les corps qui circulent autour de lui sont tous vastes, solides, et mus rapidement, mais encore parce qu'ils sont en grand nombre: car, indépendamment des six planètes, de leurs dix satellites, et de l'anneau de Saturne, qui tous pèsent sur le soleil et forment un volume de matière deux mille fois plus grand que celui de la terre, le nombre des comètes est plus considérable qu'on ne le croit vulgairement: elles seules ont pu suffire pour allumer le feu du soleil avant la projection des planètes, et suffiroient encore pour l'entretenir aujourd'hui. L'homme ne parviendra peut-être jamais à reconnoître les planètes qui circulent autour des étoiles fixes; mais, avec le temps, il pourra savoir au juste quel est le nombre des comètes dans le système solaire. Je regarde cette grande connoissance comme réservée à la postérité. En attendant, voici une espèce d'évaluation qui, quoique bien éloignée d'être précise, ne laissera pas de fixer les idées sur le nombre de ces corps circulant autour du soleil:

En consultant les Recueils d'observations, on voit que depuis l'an 1101 jusqu'en 1766, c'est-à-dire en six cent soixante-cinq années, il y a eu deux cent vingt-huit apparitions de comètes. Mais le nombre de ces astres errans qui ont été remarqués n'est pas . aussi grand que celui des apparitions, puis^ que la plupart, pour ne pas dire tous, font leur révolution en moins de six cent soixante-cinq ans. Prenons donc les deux comètes desquelles seules les révolutions nous sont parfaitement connues; savoir, la comète de 1680, dont la période est d'environ cinq cent soixante-quinze ans, et celle de 1759, dont la période est de soixante-seize ans. On peut croire, en attendant mieux, qu'en prenant le terme moyen, trois cent vingt-six ans, entre ces deux périodes de révolution, il y a autant de comètes dont la période excède trois cent vingt-six ans, qu'il y en a don de est moindre. Ainsi, en les réduisant toutes à trois cent vingt-six ans, chaque comète auroit paru deux fois en six cent cinquante-deux ans, et l'on auroit par conséquent à peu près quinze comètes pour deux cent vingt-huit apparitions en six cent soixante-cinq ans.

Maintenant, si l'on considère que vraisemblablement il y a plus de comètes hors de la portée de notre vue, ou échappées à l'œil des observateurs, qu'il n'y en a eu de remarquées, ce nombre croîtra peut-être de plus du triple; en sorte qu'on peut raisonnablement penser qu'il existe dans le sysleme solaire quatre ou cinq cents comètes. Et s'il en est des comètes comme des planètes, si les

plus grosses sont les plus éloignées du soleil, si les plus petites sont les seules qui en approchent d'assez près pour que nous puissions les apercevoir, quel volume immense de matière! quelle charge énorme sur le corps de cet astre! quelle pression, c'est-à-dire quel frottement intérieur dans toutes les parties de sa masse, et par conséquent quelle chaleur et quel feu produit par ce frottement!

Car, dans notre hypothèse, le soleil étoit une masse de matière eu fusion, même avant la projection des planètes; par conséquent ce feu n'avoit alors pour cause que la pression de ce grand nombre de comètes qui circuloient précédemment et circulent encore aujourd'hui autour de ce foyer commun. Si la masse ancienne du soleil a été diminuée d'un six cent cinquantième par la projection de la matière des planètes lors de leur formation, la quantité totale de la cause de son feu, c'est-à-dire de la pression totale, a été augmentée dans la proportion de la pression entière des planètes, réunie à la première pression de toutes les comètes,à l'exception de celle qui a produit l'effet de la projection, et dont la matière s'est mêlée à celle des planètes pour sortir du soleil, lequel par conséquent, après celle perte, n'en est devenu que plus brillant, plus actif, et plus propre à éclairer, échauffer, et féconder son univers.

En poussant ces inductions encore plus loin, on se persuadera aisément que les satellites qui circulent autour de leur planète principale, et qui pèsent sur elle comme les planètes pèsent sur le soleil; que ces satellites, dis-je, doivent communiquer un certain degré de chaleur à la planète autour de laquelle ils circulent: la pression et le mouvement de la lune doivent donner à la terre un degré de chaleur qui seroit plus grand si la vitesse du mouvement de circulation de la lune étoit plus grande; Jupiter, quia quatre satellites, et Saturne, qui en a cinq, avec un grand anneau, doivent. par celle seule raison, être animés d'un certain degré de chaleur. Si ces planètes tres-éloignées du soleil n'étoient pas douées comme la terre d'une chaleur intérieure, elles seraient plus que gelées, et le froid extrême que Jupiter el Saturne auraient à supporter, à cause de leur éloignement du soleil, ne pourrait être tempéré que par l'action de leurs satellites. Plus les corps circulans seront nombreux, grands, et rapides, plus le corps qui leur sert d'essieu ou de pivot s'échauffera par le frottement intime qu'ils feront subir à toutes les parties de sa masse.

Ces idées se lient parfaitement avec celles qui servent de fondement à mon. hypothèse; sur la formation des planètes; elles en sont des conséquences simples et naturelles: mais j'ai la preuve que peu de gens ont saisi les rapports et l'ensemble de ce grand système. Néanmoins y a-t-il un sujet plus élevé, plus digne d'exercer la force du génie? On m'a critiqué sans m'entendre; que puis-je répondre? sinon que tout parle à des yeux attentifs, tout est indice pour ceux qui savent voir; mais que rien n'est sensible, rien n'est clair pour le vulgaire, et même pour ce vulgaire savant qu'aveugle le préjugé. Tâchons néanmoins de rendre la vérité plus palpable; augmentons le nombre des probabilités; rendons la vraisemblance plus grande; ajoutons lumières sur lumières, en réunissant les faits, en accumulant les preuves, et laissons-nous juger ensuite sans inquiétude et sans appel: car j'ai toujours pensé qu'un homme qui écrit doit s'occuper uniquement de son sujet, et nullement de soi; qu'il est contre la bienséance de vouloir en occuper les autres, et que par conséquent les critiques personnelles doivent demeurer sans réponse.

Je conviens que les idées de ce système peuvent paraître hypothétiques, étranges, et même chimériques, à tous ceux qui, ne jugeant les choses que par le rapport de leurs sens, n'ont jamais conçu comment on sait que la terre n'est qu'une petite planète, renflée sur l'équateur et abaissée sous les pôles; à ceux qui ignorent comment on s'est assure que tous les corps rélestes pèsent, agissent, et réagissent les uns sur les autres; comment ou a pu mesurer leur grandeur, leur dis tance, leurs mouvemens, leur pesanteur, etc.: mais je suis persuadé que ces mêmes idées paraîtront simples, naturelles, et même grandes, au petit nombre de ceux qui, par des observations et des réflexions suivies, sont parvenus à connoitre les lois de l'univers, et qui, jugeant des choses par leurs propres lumières, les voient sans préjugé, telles qu'elles sont, ou telles qu'elles pourraient

être; car ces deux points de vue sont à peu près les mêmes; et celui qui regardant une horloge pour la première fois, diroit que le principe de tous ses mouvemens est un ressort, quoique ce fût un poids, ne se tromperait que pour le vulgaire, et auroit, aux yeux du philosophe, expliqué la machine.

Ce n'est donc pas que j'aie affirmé ni même positivement prétendu que noire lerre et les planètes aient été formées nécessairement et réellement par le choc d'une comète qui a projeté hors du soleil la six cent cinquantième partie de sa masse: mais ce que j'ai voulu faire entendre, et ce que je maintiens encore comme hypothèse très probable, c'est qu'une comète qui, dans son péribélie, approcherait assez près du soleil pour en effleurer et sillonner la surface, pourrait produire de pareils effets, et qu'il n'est pas impossible qu'il se forme quelque jour, de cette même manière, des planètes nouvelles, qui toutes circuleraient ensemble comme les planètes actuelles, dans le même sens, et presque dans un même plan autour du soleil; des planètes qui tourneraient sur elles-mêmes, et dont la matière étant, au sortir du soleil, dans un état de liquéfaction, obéiroit à la force centrifuge, et s'élèveroit à l'équateur en s'abaissant sous les pôles; des planètes qui pourraient de même avoir des satellites en plus ou moins grand nombre, circulant autour, d'elles dans le plan de leurs équateurs, et dont les mouvemens seraient semblables à ceux des satellites de nos planètes: en sorte que tous les phénomènes de ces planètes possibles et idéales seraient, je ne dis pas les mêmes, mais dans le même ordre, et dans des rapports semblables à ceux des phénomènes des planètes réelles. Et, pour preuve, je demande seulement que l'on considère si le mouvement de toutes les planètes, dans le même sens, et presque dans le même plan, ne suppose pas une impulsion commune j je demande s'il y a dans l'univers quelques corps, excepté les comètes, qui aient pu communiquer ce mouvement d'impulsion; je demande s'il n'est pas probable qu'il tombe de temps à autre des comètes dans le soleil, puisque celle de 1680 en a pour ainsi dire rasé la surface, et si par conséquent une telle comète, en sillonnant cette surface du soleil, ne communiqueroit pas son mouvement d'impulsion à une certaine quantité de matière qu'elle séparerait du corps du soleil, en la projetant au dehors: je demande si, dans ce torrent de matière projetée, il ne se formerait pas des globes par l'attraction mutuelle des parties, et si ces globes ne se trouveraient pas à des distances différentes, suivant la différente densité des matières, et si les plus légères ne seraient pas poussées plus loin que les plus denses par la même impulsion; je demande si la situation de tous ces globes presque dans le même plan n'indique pas assez que le torrent projeté n'étoit pas d'une largeur considérable, et qu'il n'avoit pour cause qu'une seule impulsion, puisque toutes les parties de la matière dont il étoit composé ne sont éloignées que très peu de la direction commune; je demande comment et où la matière de la terre et des planètes aurait pu se liquéfier, si elle n'eût pas résidé dans le corps même du soleil, et si l'on peut trouver une cause de cette chaleur et de cet embrasement du soleil, autre que celle de sa charge et du frottement intérieur produit par l'action de tous ces vastes corps qui circulent autour de lui; enfin je demande qu'on examine tous les rapports, que l'on suive toutes les vues, que l'on compare toutes les analogies sur lesquelles j'ai fondé mes raisonnemens, et qu'on se contente de conclure avec moi que, si Dieu l'eût permis, il se pourroit, par les seules lois de la nature, que la terre et les planètes eussent été formées de cette même manière.

Suivons donc notre objet, et, de ce temps qui a précédé les temps et s'est soustrait à notre vue, passons au premier âge de notre univers, où la terre et les planètes, ayant recu leur forme, ont pris de la consistance, et de liquides sont devenues solides. Ce changement d'état s'est fait naturellement et par le seul effet de la diminution de la chaleur: la matière qui compose le globe terrestre et les autres globes planétaires étoit en fusion lorsqu'ils ont commencé à tourner sur eux-mêmes; ils ont donc obéi, comme toute autre matière fluide, aux lois de la force centrifuge: les parties voisines de l'équateur, qui subissent le plus grand mouvement dans la rotation, se sont le plus élevées; celles qui sont voisines des pôles, où ce mouvement est moindre ou nul, se sont abaissées dans la proportion juste et précise qu'exigent les lois de la pesanteur, combinées avec celles de la force centrifuge *, et cette forme de la terre et des planètes s'est conservée jusqu'à ce

jour, et se conservera perpétuellement, quand même l'on voudrait supposer que le mouvement de rotation viendrait à s'accélérer,, parce que, la matière ayant passé de l'état de fluidité à celui de solidité, la cohésion des parties suffit seule pour maintenir la forme primordiale, et qu'il faudrait pour la changer que le mouvement de rotation prit une rapidité presque infinie, c'est-à-dire assez grande pour que l'effet de la force centrifuge devint plus grand que celui de la force de la cohérence.

Or le refroidissement de la terre et des planètes, comme celui de tous les corps chauds, a commencé par la surface: les matières eu fusion s'y sont consolidées dans un temps assez court. Dès que le grand feu dont elles étoient pénétrées s'est échappé, les parties de la matière, qu'il tenoit divisées, se sont rapprochées et réunies de plus près par leur attraction mutuelle: celles qui «voient assez de fixité pour soutenir la violence du feu ont forme des masses solides; mais celles qui, comme l'air et l'eau, se raréfient ou se volatilisent par le feu ne pouvoient faire corps avec les autres; elles en ont été séparées dans les premiers temps du refroidissement. Tous les élèmens pouvant se transmuer et se convertir, l'instant de la consolidation des matières fixes fut aussi celui de la plus grande conversion des élémens et de la production des matières volatiles: elles étoient réduites en vapeurs et de l2 terre étoit dans le rapport de 174 à 175, d'après la détermination faite par nos mathématiciens envoyés en Laponie et au Pérou; mais, comme ils ont supposé une courbe régulière à la terre, j'ai averti que cette supposition étoit hypothétique, et par conséquent je ne me suis point arrêté à cette détermination. Je pense donc qu'on doit préférer le rapport de 2-g à 23o, tel qu'il a été déterminé par Newton, d'après sa théorie et les expériences du pendule, qui me paroissent être bien plus sures que les mesures. C'est par cette raison que, dans les mémoires de la partie hypothétique, j'ai toujours supposé que le rapport des deux diamètres du sphéroïde terrestre étoit de 729 à 23o. M. le docteur Irving, qui a accompagné M. Phipps dans son voyage au nord en 177Ï, a fait des expériences très exactes sur l'accélération du pendule au 7g* degré 5o minutes, et il a trouvé que cette accéléra, trou étoit de 72 à 73 secondes eu 24 heures, d'où il conclut que le diamètre a l'équateur est à l'axe de la terre comme 212 à 211. Ce savant voyageur ajoute, avec raison, que son résultat approche de celui de Newton beaucoup plus que celui de M. de Maupertuis, qui donne le rapport de 178 a 179, et plus aussi que celui de M. Bradley, qui, d'après les observations de M. Campbell, donne le rapport de 200 à 201 pour la différence des deux diamètres de A terre. (Aild. &,ff.~)

Dispersées au loin, formant autour des planètes une espèce d'atmosphère semblable à celle du soleil; car on sait que le corps de cet astre de feu est environné d'une sphère de vapeurs qui s'étend à des distances immenses, et peut-être jusqu'à l'orbe de la terre. L'existence réelle de cette atmosphère solaire est démontrée par un phénomène qui accompagne les éclipses totales du soleil. La lune en couvre alors à nos yeux le disque tout entier; et néanmoins l'on voit encore un limbe ou grand cercle de vapeurs, dont la lumière est assez vive pour nous éclairer à peu près autant que celle de la lune: sans cela le globe terrestre serait plongé dans l'obscurité la plus profonde pendant la durée de l'éclipse totale. On a observé que cette atmosphère solaire est plus dense dans ses parties voisines du soleil, et qu'elle devient d'autant plus rare et plus transparente qu'elle s'étend et s'éloigne davantage du corps de cet astre de feu: l'on ne peut donc pas douter que le soleil ne soit environné d'une sphère de matières aqueuses, aériennes, et volatiles, que sa violente chaleur tient suspendues et reléguées à des distances immenses, et que, dans le moment de la projection des planètes, le torrent des matières fixes sorties du corps du soleil, n'ait, en traversant son atmosphère, entraîné une grande quantité de ces matières volatiles dont elle est composée; et ce sont ces mêmes matières volatiles, aqueuses, et aériennes, qui ont ensuite formé les atmosphères des planètes, lesquelles étoient semblables à l'atmosphère du soleil, tant que les planètes oui été, comme lui, dans un état de fusion ou de grande incandescence.

Toutes les planètes n'étoient donc alors que des masses de verre liquide, environnées d'une sphère de vapeurs. Tant qu'a duré cet état de fusion, et même long-temps après, les planètes étoient

lumineuses par elles-mêmes, comme le sont tous les corps en incandescence; mais, à mesure que les planètes prenaient de la consistance, elles perdoient de leur lumière: elles ne devinrent tout - à - fait obscures qu'après s'être consolidées jusqu'au centre, et long-temps après la consolidation de leur surface, comme l'on voit dans une masse de métal fondu la lumière et la rougeur subsister très longtemps après la consolidation de sa surface. Et dans ce premier temps où les planètes brilloient de leurs propres feux elles devoient lancer des rayons, jeter des étincelles, faire des explosions, et ensuite souffrir, en se refroidissant, différentes ébullitions, à mesure que 1'eau, l'air et les autres matières qui ne peuvent supporter le feu, retomboient à leur surface: la production des élémens, et ensuite leur combat, n'ont pu manquer de produire des inégalités, des aspérités, des profondeurs, des hauteurs, des cavernes à la surface el dans les premières couches de l'intérieur de ces grandes masses; et c'est à cette époque que l'on doit rapporter la formation des plus liâmes montagnes de la terre, de celles de la lune, et de toutes les aspérités ou inégalités qu'on aperçoit sur les planètes.

Représentons - nous l'état et l'aspect de noire univers dans son premier âge: toutes les planètes, nouvellement consolidées à la surface, étoient encore liquides à l'intérieur, et 1ançoient au dehors une lumière très vive; c'étoient autant de petits soleils détachés du grand, qui ne lui cédoient que par le volume, et dont la lumière et la chaleur se répandoient de même. Ce temps d'incandescence a duré tant que la planète n'a pas été consolidée jusqu'au centre, c'est-à-dire environ 2936 ans pour la terre, 644 ans pour la lune, 2127 ans pour Mercure, 113o ans pour Mars, 3596 ans pour Vénus, 5ï4o ans pour Saturne, et 9433 ans pour Jupiter.

Les satellites de ces deux grosses planètes, aussi bien que l'anneau qui environne Saturne, lesquels sont tous dans le plan de l'équateur de leur planète principale, avoient été projetés, dans le temps de la liquéfaction, par la force centrifuge de ces grosses planètes, qui tournent sur elles-mêmes avec une prodigieuse rapidité: la terre, dont la vitesse de rotation est d'environ 9000 lieues pour vingt-quatre heures, c'est-à-dire de six lieues un quart par minute, a, dans ce même temps, projete hors d'elle les parties les moins denses de son équateur, lesquelles se sont rassemblées par leur attraction mutuelle à 85000 lieues de distance, où elles ont formé le globe de la lune. Je n'avance rien ici qui ne soit confirmé par le fait, lorsque je dis que ce sont les parties les moins denses qui ont été projetées, et qu'elles l'ont été de la région de l'équateur; car l'on sait que la densité de la lune est à celle de la terre comme 702 sont à 100o, c'est-à-dire de plus d'un tiers moindre; et l'on sait aussi que la lune circule autour de la terre dans un plan qui n'est éloigné que de 23 degrés de notre équateur, et que sa distance moyenne est d'environ 85000 Heurs.

Dans Jupiter, qui tourne sur lui-même en dix heures, et dont la circonférence est onze fois plus grande que celle de la terre, et la vitesse de rotation de 16S lieues par minute, cette énorme force centrifuge a projeté un grand torrent de matière de différeras degrés de densité, dans lequel se sout formés les quatre satellites de cette grosse planète, dont l'un, aussi petit que la lune, n'est qu'à 89500 lieues de distance, c'est-à-dire presque aussi voisin de Jupiter que la lune l'est de la terre; 1e second, dont la matière étoit un peu moins dense que celle du premier, et qui est environ gros comme Mercure, s'est formé à 141800 lieues; le troisième, composé de parties encore moins denses, et qui est à peu près grand comme Mars, s'est formé à 2?5800 lieues; et enfin le quatrième, dont la matière étoit la plus légère de toutes, a été projeté encore plus loin, et ne s'est rassemblé qu'à 397877 lieues; et tous les quatre se trouvent, à très peu près, dans le plan de l'équateur de leur planète principale, et circulent dans le même sens autour d'elle '. Au reste, la matière qui compose le globe de Jupiter est elle-même beaucoup moins dense que celle de la lerre. Les planètes voisines du soleil sont les plus denses; celles qui en sont les plus éloignées sont en même temps les plus légères: la densité de la terre est à celle de Jupiter comme 1000 sont à 292; et il est à présumer que la matière qui compose ses satellites est encore moins dense que celle dont il est lui-même composé 2.

Saturne, qui probablement tourne sur lui-même encore plus vite que Jupiter, a non seulement produit cinq satellites, mais encore un anneau qui, d'après mon hypothèse, doit être parallèle à son équateur, et qui l'environne comme un pont suspendu et continu à 54000 lieues de distance: cet anneau, beaucoup pus large qu'épais, est composé d'une matière solide, opaque, et semblable à celle des satellites; il s'est trouvé dans le même état de fusion, et ensuite d'incandescence. Chacun de ces vastes corps a conservé cette chaleur primitive, en raison composée de leur épaisseur et de leur densité; en sorte que l'anneau de Saturne, qui parait être le moins épais de tous les corps célestes, est celui qui aurait perdu le premier sa chaleur propre, s'il n'eût pas tiré de très grands supplémens de chaleur de Saturne même, dont il est fort voisin; ensuite la lune et les premiers satellites de Saturne et de Jupiter, qui sont les plus petits des globes planétaires, auraient perdu leur chaleur propre, dans des temps toujours proportionnels à leur diamètre; après quoi les plus gros satellites auraient de même perdu leur chaleur, et tous seraient aujourd'hui plus refroidis que le globe de la terre, si plusieurs d'entre eux n'avoient pas reçu (te leur planète principale une chaleur immense dans les commencemens: enfin les deux grosses planètes, Saturne et Jupiter, conservent encore actuellement une très grande chaleur en comparaison de celle de leurs satellites, et même de celle du globe de la terre.

Mars, dont la durée de rotation est de vingt - quatre heures quarante minutes, et dont la circonférence n'est que treize vingt-cinquièmes de celle de la terre, tourne une fois plus lentement que le globe terrestre, sa vitesse de rotation n'étant guère que de trois lieues par minute; par conséquent sa force centrifuge a toujours été moindre de plus de moitié que celle du globe terrestre: c'est par cette raison que Mars, quoique moins dense que la terre dans le rapport de 7Îo à i00o, n'a point de satellite.

Mercure, dont la densité est à celle de la terre comme 2040 sont à 100o, n'aurait pu produire un satellite que par une force centrifuge plus que double de celle du globe de la terre; mais, quoique la durée de sa rotation n'ait pu être observée par les astronomes, il est plus que probable qu'au lieu d'être double de celle de la terre, elle est, au contraire, beaucoup moindre. Ainsi l'on peut croire avec fondement que Mercure n'a point de satellite.

Vénus pourroit en avoir un; car, étant un peu moins épaisse que la terre dans la raison de 17 à 18, et tournant un peu plus vite dans le rapport de 23 heures 20 minutes à 23 heures 56 minutes, sa vitesse est de plus de six lieues trois quarts par minute, et par conséquent sa force centrifuge d'environ un treizième plus grande que celle de la terre. Cette planète aurait donc pu produire un ou deux satellites dans le temps de sa liquéfaction, si sa densité plus grande que celle de la terre, dans la raison de 1270 à 100o, c'est-à-dire de plus de 5 contre 4, ne se fût pas opposée à la séparation et à la projection de ses parties même les plus liquides; et ce pourroit être par cette raison que Vénus n'aurait point de satellite, quoiqu'il y ait des observateurs qui prétendent en avoir aperçu un autour de cette planète.

A tous ces faits que je viens d'exposer on doit en ajouter un qui m'a été communiqué par M. Kailly, savant physicien astronome de l'Académie des Sciences. La surface de Jupiter est, comme l'on sait, sujette à des changemens sensibles, qui semblent indiquer que cette grosse planète est encore dans un état d'inconstance et de bouillonnement. Prenant donc, dans mon système de l'incandescence générale et du refroidissement des planètes, les deux extrêmes, c'est-à-dire Jupiter comme le plus gros, et la lune comme le plus petit de tous les corps planétaires, il se trouve que le premier, qui n'a pas en encore le temps de se refroidir et de prendre une consistance entière, nous présente à sa surface les effets du mouvement intérieur dont il est agité par le feu, tandis que la lune, qui, par sa petitesse, a dû se refroidir en peu de siècles, ne nous offre qu'un calme parfait, c'est-à-dire une surface qui est toujours la même, et sur laquelle l'on n'aperçoit ni mouvement ni changement. Ces deux faits, connus des astronomes, se joignent aux autres analogies que j'ai présentées sur ce sujet, et ajoutent un petit degré de plus à la probabilité de mon hypothèse.

Par la comparaison que nous avons faite de la chaleur des planètes à celle de la terre, on a vu que le temps de l'incandescence pour le globe terrestre a duré deux mille nedf cent trente-six ans; que celui de sa chaleur, au point de ne pouvoir le toucher, a été de trente-quatre mille deux cent soixante-dix ans, ce qui fait en tout trente-sept mille deux cent six ans; et que c'est là le premier moment de la naissance possible de la nature vivante. Jusqu'alors les élémens de l'air et de l'eau étoient encore confondus, et ne pouvaient se séparer ni s'appuyer sur la surface brûlante de la terre, qui les dissipoit en vapeurs; mais, dès que cette ardeur se fut attiédie, une chaleur bénigne et féconde succéda par degrés au feu dévorant qui s'opposoit à toute production, et même à l'établissement des élémens. Celui du feu, dans ce premier temps, s'étoit pour ainsi dire emparé des trois autres, aucun n'existoit à part: la terre, l'air, et l'eau, pétris de feu et confondus ensemble, n'offraient, au heu de leurs formes distinctes, qu'une masse brûlante environnée de vapeurs enflammées. Ce n'est donc qu'après trente-sept mille ans que les gens de la terre doivent dater les actes de leur monde, et compter les faits de la nature organisée.

Il faut rapporter à cette première époque ce que j'ai écrit de l'état du ciel, dans mes mémoires sur la température des planètes. Toutes, au commencement, étoient brillantes et lumineuses; chacune formoit un petit soleil ', dont la chaleur et là lumière out diminué peu à peu et se sont dissipées successivement dans le rapport des temps, que- j'ai ci-devant indique, d'après mes expériences sur le refroidissement des corps en général, dont la durée est toujours à très peu près proportionnelle à leurs diamètres et à leur densité

Les planètes, ainsi que leurs satellites, se sont donc refroidies les unes plus tôt et les autres plus tard, et, en perdant partie de leur chaleur, elles ont perdu toute leur lumière propre. Le soleil seul s'est maintenu dans sa splendeur, parce qu'il est le seul autour duquel circulent un assez grand nombre de corps pour en entretenir la lumière, la chaleur et le feu.

Mais sans insister plus long-temps sur ces objets, qui paroissent si loin de notre vue, rahaissons-la sur le seul globe de la terre. Passons à la seconde époque, c'est-à-dire au temps où la matière qui le compose, s'étant consolidée, a formé les grandes masses de matières vitrescibles.

Je dois seulement répondre à une espèce d'objection que l'on m'a dejà faite sur la trèslongue durée des temps. Pourquoi nous jeter, m'a-t-on dit, dans un espace aussi vague qu'une durée de cent soixante-huit mille ans? car, à la vue de votre tableau, la terre est âgée de soixante-quinze mille ans, et la nature vivante doit subsister encore pendant quatre-vingt-treize mille ans: est-il aisé, est-il même possible de se former une idée du tout ou des parties d'une aussi longue suite de siècles? Je n'ai d'autre réponse que l'exposition des monumens et la considération des ouvrages de la nature: j'en donnerai le détail et les dates dans les époques qui vont suivre celle-ci, et l'on verra que bien loin d'avoir augmenté sans nécessité la durée du temps, je l'ai peut-être beaucoup trop raccourcie.

Eh! pourquoi l'esprit humain semble-t-il se perdre dans l'espace de la durée plutôt que dans celui de l'étendue, ou dans la considération des mesures, des poids, et des nombres? pourquoi cent mille ans sont-ils plus difficiles à concevoir et à compter que cent mille livres de monnoie? Seroit-ce parce que la somme du temps ne peut se palper ni se réaliser en espèces visibles? ou plutot n'est-ce pas qu'étant accoutumés par notre trop courte existence à regarder cent ans comme une grosse somme de temps, nous avons peine à nous former une idée de mille ans, et ue pouvons plus nous représenter dix mille ans, ni même en concevoir cent mille? Le seul moyen est de diviser en plusieurs parties ces longues périodes de temps, de comparer par la vue de l'esprit la durée de chacune de ces parties avec les grands effets et surtout avec les constructions de la nature, se faire des aperçus sur le nombre des siècles qu'il a fallu pour produire tous les animaux à coquilles dont la terre est remplie, ensuite sur le nombre encore plus grand des siècles qui se sont écoulés pour le

transport et le dépôt de ces coquilles et de leurs détrimens, enfin sur le nombre des autres siècles subséquens, nécessaires à la pétrification et au dessèchement de ces matières; et dès lors on sentira que celle énorme durée de soixante-quinze mille ans, que j'ai comptés depuis la formation de la terre jusqu'à son état actuel, n'est pas encore assez étendue pour tous les grands ouvrages de la nature, dont la construction nous démontre qu'ils n'ont pu se faire que par une succession lente de mouvemens réglés et constans.

Pour rendre cet aperçu plus sensible, donnons un exemple; cherchons combien il a fallu de temps pour la construction d'une colline d'argile de mille toises de hauteur. Les sédimens successifs des eaux ont formé toutes les couches dont la colline est composée depuis la hase jusqu'à son sommet. Or nous pouvons juger du dépôt successif et journalier des eaux par les feuillets des ardoises; ils sont si minces qu'on peut en compter une douzaine dans une ligne d'épaisseur. Supposons donc que chaque marée dépose un sédiment d'un douzième de ligne d'épaisseur, c'est-à-dire d'un sixième de ligne chaque jour, le dépôt augmentera d'une ligne en six jours » de six lignes en trente-six jours, et par conséquent d'environ cinq pouces en un an; ce qui donne plus de quatorze mille ans pour le temps nécessaire à la composition d'une colline de glaise de mille toises de hauteur: ce temps paroitra même trop court si on le compare avec ce qui se passe sous nos yeux sur certains rivages de la mer, où elle dépose des limons et des argiles, comme sur 1rs côtes de Normandie 1; car le dépôt n'augmente qu'insensiblement et de beaucoup moins de cinq ponces par an. Et si cette colline d'argile est couronnée de rochers calcaires, la durée du temps, que je réduis à quatorze mille ans, ne doit-elle pas être augmentée de celui qui a été nécessaire pour le transport des coquillages dont la colline est surmontée? et cette durée si longue n'a-t-elle pas encore été suivie du temps nécessaire à la pétrification et au dessèchement de ces sédimens, et encore d'un temps tout aussi long pour la figuration de la colline par angles saillans et rentrans? J'ai cru devoir entrer d'avance dans ce détail, afin de démontrer qu'au lieu de reculer trop loin les limites de la durée, je les ai rapprochées autant qu'il m'a été possible, sans contredire évidemment les laits consignés dans les archives de la nature.

Seconde Époque - Lorsque La Matière, S'étant Consolidée, A Formé La Roche Intérieure Du Globe Ainsi Que Les Grandes Masses Vitrescìbles Qui Sont A Sa Surface

Os vient de voir que, dans notre hypothèse, il a dû s'écouler deux mille neuf cent trente-six ans avant (lue le globe terrestre ait pu prendre toute sa consistance, et que sa niasse entière se soit consolidée jusqu'au centre. Comparons les effets de celte consolidation du globe de la terre en fusion à ce que nous voyons arriver à une masse de métal ou de verre fondu, lorsqu'elle commence à se refroidir: il se forme à la surface de ces masses des trous, des ondes, des aspérités; et au dessous de la surface il se fait des vides, des cavités, des boursouflures, lesquelles peuvent nous représenter ici les premières inégalités qui se sont trouvées sur la surface de la terre et les cavités de son intérieur: nous aurons dès lors une idée du grand nombre de montagnes, de vallées, de cavernes, et d'anfra et nosités, qui se sont formées dès ce premier temps dans les couches extérieures de la terre. Notre comparaison est d'autant plus exacte que les montagnes les plus élevées, que je suppose de trois mille ou trois mille cinq cents toises de hauteur, ne sont, par rapport au diamètre de la terre, que ce qu'un huitième de ligne est par rapport au diamètre d'un globe de deux pieds. Ainsi ces chaînes de montagnes qui nous paraissent si prodigieuses tant par le volume que par la hauteur, ces vallées de la mer qui semblent être des abîmes de profondeur, ne sont, dans la réalité, que de légères inégalités proportionnées à la grosseur du globe, et qui ne pouvoient manquer de se former lorsqu'il prenoit sa consistances ce sont des effets naturels produits par une cause tout aussi naturelle et fort simple, c'est-à-dire par l'action du refroidissement sur les matières en fusion lorsqu'elles se consolident à la surface.

C'est alors que se sont formés les élémens par le refroidissement et pendant ses progrès: car à cette époque, et même longtemps après, tant que la chaleur excessive a duré, il s'est fait une

séparation et même une projection de toutes les parties volatiles, telles que l'eau, l'air, et les autres substances que la grande chaleur chasse au dehors, et qui ne peuvent exister que dans une région plus tempérée que ne l'étoit alors la surface de la terre. Toutes ces matières volatiles s'étendoient donc autour du globe en forme d'atmosphère à une grande distance où la chaleur étoit moins forte, tandis que les matières fixes, fondues et vitrifiées, s'étant consolidées, former en' la roche intérieure du globe et le noyau des grandes montagnes, dont les sommets, les masses intérieures, et les bases, soit eu effet composés de matières vitrescibles. Ainsi le premier établissement local des grandes chaînes de montagnes appartient à cette seconde époque, qui a précédé de plusieurs siècles celle de la formation des montagnes calcaires, lesquelles n'ont existé qu'après l'établissement des eaux, puisque leur composition suppose la production des coquillages et des autres substances (pie la mer fomente et nourrit. Tant que la surface du globe n'a pas été refroidie au point de permettre à l'eau d'y séjourner sans s'exhaler en vapeurs, toutes nos mers étoient dans l'atmosphère; elles n'ont pu touiller et s'établir sur la terre qu'au moment où sa surface s'est trouvée assez attiédie pour ne plus rejeter l'eau par une trop forte ébullition. Et ce temps de l'établissement des eaux sur ta surface du globe n'a précédé que de peu de siècles le moment où l'on auroit pu toucher cette surface sans se brûler; de sorte qu'en comptant soixante-quinze mille ans depuis la formation de la terre, et la moitié de ce temps pour son refroidissement au point de pouvoir la toucher, il s'est peut-être pas>e vingt-cinq mille des premières années avant que I eau, toujours rejetée dans l'atmosphère, ait pu s'établir à demeure sur la surface du globe; car, quoiqu'il y ait une assez grande différence entre le degré auquel l'eau chaude cesse de nous offenser et celui où elle entre en ébullition, et qu'il y ait encore une distance considérable entre ce premier degré d'ébullition et celui où elle se disperse subitement en vapeurs, on peut néanmoins assurer que cette différence de temps ne peut pas être plus grande que je l'admets ici.

Ainsi, dans ces premières vingt-cinq mille années, le globe terrestre, d'abord lumineux et chaud comme le soleil, n'a perdu que peu à peu sa lumière et son feu: son état d'incandescence a duré pendant deux mille neuf cent trente-six ans, puisqu'il a fallu ce temps pour qu'il ait été consolidé jusqu'au centre. Ensuite les matières fixes dont il est composé sont devenues encore plus fixes eu se resserrant de plus en plus par le refroidissement; elles ont pris peu à peu leur nature et leur consistance telle que nous la reconnoissons aujourd'hui dans la roche du globe et dans les hautes montagnes qui ne sont en effet composées, dans leur intérieur et jusqu'à leur sommet, que de matières de la même nature. Ainsi leur origine date de cette même époque.

C'est aussi dans les premiers trente-sept mille ans que se sont formés, par la sublimation, toutes les grandes veines et les gros filons de mines où se trouvent les métaux. Les substances métalliques ont été séparées des autres matières vitrescibles par la chaleur longue et constante qui les a sublimées et poussées de l'intérieur de la masse du globe dans toutes les éminences de sa surface, où le resserrement des matières causé par un plus prompt refroidissement laissoit des fenles et des cavités qui ont été incrustées et quelquefois remplies par ces substances métalliques que nous y trouvons aujourd'hui 1; car il faut, à l'égard de l'origine des mines, faire la même distinction que nous avons indiquée pour l'origine des matières vitrescibles et des matières calcaires, dont les premières out été produites par l'action du feu, et les autres par l'intermède de l'eau. Dans les mines métalliques, les principaux filons, ou, si l'on veut, les masses primordiales ont été produites par la fusion et par la sublimation, c'est-à-dire par l'action du feu; et les autres mines, qu'on doit regarder comme des filons secondaires et parasites, n'ont été produites que postérieurement par le moyen de l'eau. Ces filons principaux, qui semblent présenter les troncs des arbres métalliques, ayant tous été formés soit par la fusion, dans le temps du feu primitif, soit par la sublimation, dans les temps subséquens, ils se sont trouvés et se trouvent encore aujourd'hui dans les fentes perpendiculaires des hautes montagnes; tandis que c'est au pied de ces mêmes montagnes que gisent les petits filons, que l'on prendroit d'abord pour les rameaux de ces arbres métalliques, mais dont l'origine est néanmoins bien différente; car ces mines secondaires n'ont pas été formées par le feu, elles ont été produites par l'action successive de l'eau, qui, dans des temps postérieurs aux

premiers, a détaché de ces anciens filons des particules minérales, qu'elle a charriées e' déposées sous différentes formes, et toujours au dessous des filons primitifs.

Ainsi la production de ces mines secondaires étant bien plus récente que celle des mines primordiales, et supposant le concours et l'intermède de l'eau, leur formation doit, comme celle des matières calcaires, se rapporter à des époques subséquentes, c'est-à-dire au temps où la chaleur brûlante s'étant attiédie, la température de la surface de la terre a permis aux eaux de s'établir, et ensuite au temps où ces mêmes eaux ayant laissé nos continens à découvert, les vapeurs ont commencé à se condenser contre les montagnes, pour y produire des sources d'eau courante. Mais, avant ce second et ce troisième temps, il y a eu d'autres grands effets que nous devons indiquer.

Représentons-nous, s'il est possible, l'aspect qu'offroit la terre à cette seconde époque, c'est-à-dire immédiatement après que sa surface eut pris de la consistance, et avant que ta grande chaleur permit à l'eau d'y séjourner, ni même de tomber de l'atmosphère; les plaines, les montagnes, ainsi que l'intérieur du globe, étoient également et uniquement composés de matières fondues par le feu, toutes vitrifiées, toutes de la même nature. Qu'on se figure pour un instant la surface actuelle du globe, dépouillée de toutes ses mers, de toutes ses collines calcaires, ainsi que de toutes ses couches horizontales de pierre, de craie, de tuf, de terre végétale, d'argile, en un mot de toutes les matières liquides ou solides qui ont été formées ou déposées par les eaux: quelle serait cette surface après l'enlèvement de ces immenses déblais? Il ne resterait que le squelette de la terre, c'est-à-dire la roche vitrescibles qui en constitue la masse intérieure; il resterait les fentes perpendiculaires produites dans le temps de la consolidation, augmentées, élargies par le refroidissement; il resterait les métaux et les minéraux fixes, qui, séparés de la roche vitrescibles par l'action du feu, ont rempli, par fusion ou par sublimation, les fentes perpendiculaires de ces prolongemens de la roche intérieure du globe; et enfin il resterait les trous, les anfractuosités, et toutes les cavités intérieures de cette roche qui en est la base, et qui sert de soutien à toutes les matières terrestres amenées ensuite par les eaux.

Et comme ces sentes occasionnées par le refroidissement coupent et tranchent le plan vertical des montagnes non seulement de haut en has, mais de devant en arrière, ou d'un côté à l'autre, et que dans chaque montagne elles ont suivi la direction générale de sa première forme, il en a résulté que les mines, surtout celles des métaux précieux, doivent se chercher à la boussule, en suivant toujours la direction qu'indique la découverte du premier filon; car dans chaque montagne les fentes perpendiculaires qui la traversent sont à peuplés parallèles: néanmoins il n'en faut pas conclure, comme l'ont fait quelques minéralogistes, qu'on doive toujours chercher les métaux dans la même direction, par exemple sur la ligne de onze heures ou sur celle de midi; car souvent une mine de midi ou de onze heures se trouve coupée par un filon de huit ou neuf heures, etc., qui étend des rameaux sous différentes directions; et d'ailleurs on voit que, suivant la forme différente de chaque montagne, les fentes perpendiculaires la traversent, à la vérité, parallèlement entre elles, mais que leur direction, quoique commune dans le même lieu, n'a rien de commun avec la direction des fentes perpendiculaires d'une autre montagne, à moins que cette seconde montagne ne soit parallèle à la première.

Les métaux et la plupart des minéraux métalliques sont donc l'ouvrage du feu, puisqu'on ne les trouve que dans les fentes de la roche vitrescible, et que, dans ces mines primordiales, l'on ne voit jamais ni coquilles ni aucun autre débris de la mer mélangés avec elles. Les mines secondaires, qui se trouvent au contraire, et en petite quantité, dans les pierres calcaires, dans les schistes, dans les argiles, ont été formées postérieurement, aux dépens des premières et par l'intermède de l'eau. Les paillettes d'or et d'argent que quelques rivières charrient viennent certainement de ces premiers filons métalliques renfermés dans les montagnes supérieures: des particules métalliques encore plus petites et plus ténues peuvent, en se rassemblant, former de nouvelles petites mines

des mêmes métaux; mail ces mines parasites, qui prennent mille formes différentes, appartiennent, comme je l'ai dit, à des temps bien modernes en comparaison de celui de la formation des premiers filons qui ont été produits par l'action du feu primitif. L'or et l'argent, qui peuvent demeurer très long-temps en fusion sans être sensiblement altérés, se présentent souvent sous leur forme native: tous les autres métaux ne se présentent communément que sous une forme minéralisée, parce qu'ils ont été formés plus tard par la combinaison de l'air et de l'eau qui sont entrés dans leur composition. Au reste, tous les métaux sont susceptibles d'être volatilisés par le feu à différens degrés de chaleur; en sorte qu'ils se sont sublimés successivement pendant le progrès du refroidissement.

On peut penser que s'il se trouve moins de mines d'or et d'argent dans les terres septentrionales que dans les contrées du midi, c'est que communément il n'y a dans les terres du nord que de petites montagnes en comparaison de celles des pays méridionaux: la matière primitive, c'est-à-dire la roche vitreuse, dans laquelle seule se sont formés l'or et l'argent, est bien plus abondante, bien plus élevée, bien plus découverte, dans les contrées du midi. Ces métaux précieux paraissent être le produit immédiat du feu: les gangues et les autres matières qui les accompagnent dans leur mine sont elles-mêmes des matières vitrescibles; et comme les veines de ces métaux se sont formées soit par la fusion, soit par la sublimation, dans les premiers temps du refroidissement, ils se trouvent en plus grande quantité dans les hautes montagnes du midi. Les métaux moins parfaits, tels que le fer et le cuivre, qui sont moins fixes au feu, parce qu'ils contiennent des matières que le feu peut volatiliser plus aisément, se sont formés dans des temps postérieurs: aussi les trouve-t-on en bien plus grande quantité dans les pays du nord que dans ceux du midi. 11 semble même que la nature ait assigné aux différens climats du globe les différens métaux; l'or et l'argent aux régions les plus chaudes, le fer et le cuivre aux pays les plus froids, et le plomb et l'étain aux contrées tempérées: il semble de même qu'elle ait établi l'or et l'argent dans les plus hautes montagnes, le fer et le cuivre dans les montagnes médiocres, et le plomb et l'étain dans les plus basses. Il paroit encore que, quoique ces mines primordiales des différens métaux se trouvent toutes dans la roche vitrescible, celles d'or et d'argent sont quelquefois mélangées d'autres métaux; que le fer et le cuivre sont souvent accompagnes de matières oui supposent l'intermède de l'eau, ce qui semble prouver qu'ils n'ont pas été produits en même temps; et à l'égard de l'étain, du plomb, et du mercure, il y a des différences qui semblent indiquer qu'ils ont été produits dans des temps très différens. Le plomb est le pins vitrescible de tous les métaux, et l'étain l'est le moins: le mercure est le plus volatil de tous; et cependant il ne diffère de l'or, qui est le plus fixe de lous, que par le degre de feu que leur sublimation exige; car l'or, ainsi que tous les autres métaux, peuvent également être volatilisés par une plus ou moins grande chaleur. Ainsi tous les métaux ont été sublimés et volatilisés successivement pendant le progrès du refroidissement. Et comme il ne faut qu'une très légère chaleur pour volatiliser le mercure, etre une enaîeur médiocre suffit pour fondre l'étain et le plomb, ces deux métaux sont demeurés liquides et coulans bien plus long-temps que les quatre premiers; et le mercure l'est encore, parce que la chaleur actuelle de la terre est plus que suffisante pour le tenir en fusion: il ne deviendra solide que quand le globe sera refroidi d'un cinquième de plus qu'il ne l'est aujourd'hui, puisqu'il faut 197 degrés au dessous de la température actuelle de la terre pour que ce métal Oui de se consolide; ce qui fait à peu près la cinquième partie des 1000 degres au dessous de la congélation.

Le plomb, l'étam, et le mercure, ont donc coulé successivement, par leur fluidité, dans les parties les plus basses de la roche du globe, et ils ont été, comme tous les autres métaux, sublimés dans les fentes des montagnes élevées. Les matières ferrugineuses qui pouvoient supporter une très violente chaleur, sans se fondre assez pour couler, ont formé, dans les pays du nord, des amas métalliques si considérables, qu'il s'y trouve des montagnes entières de fer 1, c'est-à-dire d'une pierre vitrescible ferrugineuse, qui rend souvent soixaute-dix livres de fer par quintal: ce sont là les mines de fer primitives; elles occupent de très vastes espaces dans les contrées de notre nord; et

leur substance n'étant que du fer produit par l'action du feu, ces mines sont demeurées susceptibles de l'attraction magnétique, comme le sont toutes les matières ferrugineuses qui ont subi le feu.

L'aimant est 4e cette même nature; -ce n'est qu'une pierre ferrugineuse, dont il se trouve de grandes masses et même des montagnes dans quelques contrées, et particulièrement dans celles de notre nord 2: c'est par cette raison que l'aiguille aimantée se dirige toujours vers ces contrées, où toutes les mines de fer sont magnétiques. Le magnétisme est un effet constant de l'électricité constante, produite par la chaleur intérieure et par la rotation du globe; mais s'il dépendoit uniquement de cette cause générale, l'aiguille aimantée pointeroit toujours et partout directement au pôle: or les différentes déclinaisons suivant les différons pays, quoique sous le même parallèle, démontrent que le magnétisme particulier des montagnes de fer et d'aimant influe considérablement sur la direction de l'aiguille, puisqu'elle s'écarte plus ou moins à droite ou à gauche du pole, selon le lieu où elle se trouve, et selon la distance plus ou moins grande de ces montagnes de fer.

Mais revenons à notre objet principal, à la topographie du globe antérieure à la chute des eaux. Nous n'avons que quelques indires encore subsistans de la première forme de sa surface; les plus hautes montagnes, composées de matières vitrescibles, sont les seuls témoins de cet ancien état: elles éloient alors encore plus élevées qu'elles ne le sont aujourd'hui; car, depuis ce temps, et après l'établissement des eaux, les mouvemens de la mer, et ensuite les pluies, les vents, les gelées, les courans d'eau, la chute des torrens, enfin toutes les injures des élémens de l'air et de l'eau, et les secousses des mouvemens souterrains, n'ont pas cessé de les dégrader, de les trancher, et même d'en renverser les parties les moins solides; et nous ne pouvons douter que les vallées qui sont au pied de ces montagnes ne fussent bien plus profondes qu'elles ne le sont aujourd'hui.

Tâchons de donner un n perçu plutôt qu'une numération de ces cullnences primitives du globe. i° La chaîne des Cordilières ou des montagnes de f Amérique, qui s'étend depuis la pointe de la Terre-de-Feu jusqu'au nord du Nouveau-Mexique, et aboutit enfin à des régions septentrionales que l'on n'a pas encore reconnues. On peut regarder cette chaîne de montagnes comme continue dans une longueur de plus de 120 degrés, c'est-à-dire de trois mille lieues; car le détroit de Magellan n'est qu'une coupure accidentelle et postérieure à l'établissement local de cette chaîne dont les plus hauts sommets sont dans la contrée du Pérou, et se rabaissent à peu près également vers le nord et vers le midi: c'est donc sous l'équateur même que se trouvent les parties les plus élevées de cette chai ne primitive des plus hautes montagnes du monde; et nous observerons, comme chose remarquable, que de ce point de l'équateur cites vont en se rabaissant à peu près également vers le nord et vers le midi, et aussi qu'elles arrivent à peu prés à la même distance, c'est-à-dire à quinze cents lieues de chaque coté de l'équateur; en sorte qu'il ne reste à chaque extrémité de cette chaîne de montagnes qu'environ 3o degrés, c'est-à-dire sept cent cinquante lieues de mer ou de terre inconnue vers le pote austral, et un égal espace dont on a reconnu quelques côtes vers le pôle boréal. Cette chaîne n'est pas précisément sous le même méridien, et ne forme pas une ligne droite; elle se courbe d'abord vers l'est, depuis Bolivia jusqu'à Lima, et sa plus grande déviation se trouve sous le tropique du Capricorne; ensuite elle avance vers l'ouest, retourne à l'est, auprès de Popayán, et de là se courbe fortement vers l'ouest, depuis Panama jusqu'à Mexico; après quoi elle retourne vers l'est, depuis Mexico jusqu'à son extrémité, qui est à 3o degrés du pôle, et qui aboutit à peu près aux îles découvertes par de Ponte. En considérant la situation de cette longue suite de montagnes, on doit observer encore, comme chose très remarquable, qu'elles sont toutes bien plus voisines des mers de l'Occident que de celles de l'Orient. Les montagnes d'Afrique, dont la chaîne principale, appelée par quelques auteurs tépine du monde, est aussi fort élevée, et s'étend du sud au nord, comme celle des Cordillères en Amérique. Cette chaîne, qui forme en effet l'épine du dos le l'Afrique, commence au cap de Bonne espérance, et court presque sous le même méridien jusqu'à la mer Méditerranée, vis-à-vis la pointe de la Morée. Nous observerons encore, comme chose très remarquable, que le milieu de cette grande chaîne de montagnes, longue d'environ quinze cents

lieues, se trouve précisément sons l'éofMteur, comme le point milieu des Cordillères; en sorte qu'on ne peut guère douter que les parties les plus élevées des grandes chaînes de montagnes en Afrique et en Amérique ne se tronvent également sous l'équateur.

Dans ces deux parties dn monde, dont l'équateur traverse assez exactement les continens, tes principales montagnes sont donc dirigées du sud au nord; mais elles jettent des liranches très considérables vers l'orient et vers l'occident. L'Afrique est traversée de l'est à l'ouest par une longue suite de montagnes, depuis le cap Guardafui jusqu'au iles du cap Vert: le mont Allas la coupe aussi d'orient en occident. En Amérique, un premier rameau des Cordillères traverse les terres Magellaniques de l'est à l'ouest; un autre s'étend à peu près dans la même direction au Paraguay et dans toute la largeur du Brésil; quelques autres branches s'étendent depuis Popayan dans la Terre-Ferme, et jusque dans la Guiane: enfin, si nous suivons toujours cette grande chaîne de montagnes, il nous parait que la péninsule d'Yucatan, les iles de Cuha, de la Jamaïque, de Saint-Domingue, Porto-Rico, et toutes les Antilles, n'en sont qu'une branche, qui s'étend du sud au nord, depuis Cuha et la pointe de la Floride, jusqu'aux lacs du Canada, et de là court de l'est à l'ouest pour rejoindre l'extrémité des Cordillères, au delà des lacs Sioux. 3° Dans le grand continent de l'Europe et de l'Asie, qui non seulement n'est pas, comme ceux de l'Amérique et de l'Afrique, traversé par l'équateur, mais en est même fort éloigné, les chaînes des principales montagnes, au lieu d'être dirigées du sud au nord, le sont d'occident en orient. La plus longue de ces chaînes commence au fond de l'Espagne, gagne les Pyrénées, s'étend en France par l'Auvergne et le Vivarais, passe ensuite par les Alpes, en Allemagne, en Grèce, en Crimée, et atteint le Caucase, le Tannis, l'bnaûs, qui environnent la Perse, Cachemire, et le Mogol au nord, jusqu'au Thinet, d'où elle s'étend dans la Tartarie chinoise, et arrive vis-à-vis la terre d'Yeço. Les principales branches que jette cette chaîne principale sont dirigées du nord au sud en Arabie, jusqu'au détroit de la mer Rouge; dans l'Indostan, jusqu'au cap Comorin; du Thibet, jusqu'à la pointe de Malaca. Ces branches ne laissent pas de former des suites de montagnes particulières dont les sommets sont fort élevés. D'autre côté, cette chaîne principale jette du sud au nord quelques rameaux, qui s'étendent depuis les Alpes du Tyrol jusqu'en Pologne; ensuite, depuis le mont Caucase jusqu'en Moscovie, et depuis Cachemire jusqu'en Sibérie; et ces rameaux, qui sont du sud au nord de la chaîne principale, ne présentent pas des montagnes aussi élevées que celles des branches de cette même chaîne qui s'étendent du nord au sud. Voilà donc, à peu près, la topographie de la surface de la terre, dans le temps de notre seconde époque, immédiatement après la consolidation de la matière. Les hautes montagnes que nous venons de désigner sont les éminences primitives, c'est-à-dire les aspérités produites à la surface du globe au moment qu'il a pris sa consistance; elles doivent leur origine à l'effet du feu, et sont aussi, par cette raison, composées, dans leur intérieur et jusqu'à leurs sommets, de matières vitrescibles: toutes tiennent par leur hase à la roche intérieure du globe, qui est de même nature. Plusieurs autres éminences moins élevées ont traversé daus ce même temps et presque en tous sens, la surface de la terre; et l'on peut assurer que, dans tous les lieux où l'on trouve des montagnes de roc vif ou de toute autre matière solide et vitrescible, leur origine et leur établissement local ne peuvent être attribués qu'à l'action du feu et aux effets de la consolidation, qui ne se fait jamais saus laisser des inégalités sur la superficie de toute masse de matière fondue.

En même temps que ces causes ont produit des éminences et des profondeurs à la surface de la terre, elles ont aussi formé des boursouflures et des cavités à l'intérieur, surtout dans les couches les plus extérieures. Ainsi le globe, dès le temps de cette seconde époque, lorsqu'il eut pris sa consistance, et avant que les eaux y fussent établies, présentoit une surface hérissée de montagnes et sillonnée de vallées: mais toutes les causes subséquentes et postérieures à cette époque ont concouru à combler toutes les profondeurs extérieures, et même les cavités intérieures. Ces causes subséquentes ont aussi altéré presque partout la forme de ces inégalités primitives; celles qui ne s'élevoient qu'à une hauteur médiocre ont été, pour la plupart, recouvertes dans la suite par les scklhnens des eaux, et toutes ont été environnées à leurs hases jusqu'à de grandes hauteurs de ces mêmes sédimens. C'est par cette raison que nous n'avons d'autres témoins appareils de la première

forme de la surface de la terre que les montagnes composées de matières vitrescibles dont nous venons de faire l'énumération: cependant ces témoins sont sûrs et suffisans; car, comme les plus hauts sommets de ces premières montagnes n'ont peut-être jamais été surmontés par les eaux, ou du moins qu'ils ne l'ont été que pendant un petit temps, attendu qu'on n'y trouve aucun débris des productions marines, et qu'ils ne sont composés que de matières vitrescibles, on ne peut pas douter qu'ils ne doivent leur origine au feu, et que ces éminences, ainsi que la roche intérieure du globe, ne fassent ensemble un corps continu de même nature, c'est-à-dire de matières vitrescibles, dont la formation a précédé celle de toutes les autres matières.

En tranchant le globe par l'équateur, et comparant les deux hémisphères, on voit que celui de nos continens contient à proportion beaucoup plus de terres que l'autre; car l'Asie seule est plus grande que les parties de l'Amérique, de l'Afrique, de la Nouvelle-Hollande, et de tout ce qu'on a découvert de terres au delà. Il y avoit donc moins d'éminences et d'aspérités sur l'hémisphère austral que sur le boréal, dès le temps même de la consolidation de la terre; et si l'on considère pour un instant ce gisement général des terres et des mers, on reconnoitra que tous les continens vont en se rétrécissant du coté du midi, et qu'au contraire toutes les mers vont en s'élargissant vers ce même côté du midi. La pointe étroite de l'Amérique méridionale, celle de Californie, celle du Groenland, la pointe de l'Afrique, celle des deux presqu'iles de l'Inde, et enfin celle de la Nouvelle-Hollande, démontrent évidemment ce rétrécissement des terres et cet élargissement des mers vers les régions australes. Cela semble indiquer que la surface du globe a eu originairement de plus profondes vallées dans 1 hémisphère austral, et des éminences en plus grand nombre dans l'hémisphère boréal. Nous tirerons bientôt quelques inductions de cette disposition générale des continens et des mers.

La terre, avant d'avoir reçu les eaux, étoit donc irrégulièrement hérissée d'aspérités, de profondeurs, et d'inégalités semblables à celles que nous voyons sur un bloc de métal ou de verre fondu; elle avoit de même des boursouflures et des cavités intérieures, dont l'origine, comme celle des inégalités extérieures, ne doit être attribuée qu'aux effets de la consolidation. Les plus grandes éminences, profondeurs extérieures, et cavités intérieures, se sont trouvées dès lors, et se trouvent encore aujourd'hui sous l'équateur entre les deux tropiques, parce que cette zone de la surface du globe est la dernière qui s'est consolidée, et que c'est dans cette zone où le mouvement de rotation étant le plus rapide, il aura produit les plus grands effets; la matière en fusion s'y étant élevée plus que partout ailleurs, et s'étant refroidie la dernière, il a dû s'y former plus d'inégalités que dans toutes les autres parties du globe où le mouvement de rotation étoit plus lent, et le refroidissement plus prompt. Aussi trouve-t-on sous cette zone les plus hautes montagnes, les mers les plus entrecoupées, semées d'un nombre infini d'îles, à la vue desquelles on ne peut douter que, dès son origine, cette partie de la terre ne fût la plus irrégulière et la moins solide de toutes.

Et quoique la matière en fusion ait dû arriver également des deux pôles pour renfler l'équateur, il paroit, en comparant les deux hémisphères, que noire pôle en a un peu moins fourni que l'autre, puisqu'il y a beaucoup plus de terres et moins de mers depuis le tropique du Cancer au pôle boréal, et qu'au contraire il y a beaucoup plus dè mers et moins de terres depuis celui du Capricorne à l'autre pôle. Les plus profondes vallées se sont donc formées dans les zones froides et tempérées de l'hémisphère austral, et les terres les plus solides et les plus élevées se sont trouvées dans celles de l'hémisphère septentrional.

Le globe étoit alors, comme il l'est encore aujourd'hui, renflé sur l'équateur, d'une épaisseur de près de six lieues un quart; mais les couches superficielles de cette épaisseur y étoient, à l'intérieur, semées de cavités, et coupées à l'extérieur d'éminences et de profondeurs plus grandes que partout ailleurs: le reste du globe étoit sillonné et traversé en différens sens par des aspérités toujours moins élevées à mesure qu'elles approchoient des pôles; toutes n'étoient composées que de la même matière fondue dont est aussi composée la roche intérieure du globe; toutes doivent

leur origine à l'action du feu primitif et à la vitrification générale. Ainsi la surface de la terre, avant l'arrivée des eaux, ne présentoit que ces premières aspérités qui forment encore aujourd'hui les noyaux de nos plus hautes montagnes; celles qui étoient moins élevées ayant été dans la suite recouvertes par les sédimens des eaux et par les débris des productions de la mer, elles ne nous sont pas aussi évidemment connues que les premières: on trouve souvent des bancs calcaires au dessus des rochers de granite, de roc vif, et des autres masses de matières vitrescibles; mais l'on ne voit pas de masses de roc vif au dessus des bancs calcaires. Nous pouvons donc assurer, sans craindre de nous tromper, que la roche du globe est continue avec toutes les éminences hautes et hasses qui se trouvent être de la même nature, c'est-àdire de matières vitrescibles: ces éminences font masse avec le solide du globe; elles n'en sont que de très petits prolongemens, dont les moins élevés ont ensuite été recouverts par les scories du verre, les sables, les argiles, et tous les débris des productions de la mer amenés et déposés par les eaux dans les temps subséquens, qui font l'objet de notre troisième époque.

Additions De Buffon

Les veines métalliques, dit M. Eller, se trouvent seulement dans les endroits élevés, en une longue suite de montagnes: cette chaîne de montagnes suppose toujours pour son soutien une hase de roche dure. Tant que ce roc conserve sa continuité, il n'y a guère apparence qu'on y découvre quelques filons métalliques; mais, quand on rencontre des crevasses ou des fentes, on espère d'en découvrir. Les physiciens minéralogistes ont remarqué qu'en Allemagne la situation la plus favorable est lorsque la chaîne de montagnes s'élevant petit à petit, se dirige vers le sud-est, et qu'ayant atteint sa plus grande élévation elle descend insensiblement vers le nord-ouest.

C'est ordinairement un roc sauvage, dont l'étendue est quelquefois presque sans bornes, mais qui est fendu et entrouvert en divers endroits, qui contient les métaux quelquefois purs, mais presque toujours minéralisés: ces fentes sont tapissées pour l'ordinaire d'une terre blanche et luisante, que les mineurs appellent quartz, et qu'ils nomment spath lorsque cette terre est plus pesante, mais mollasse et feuilletée à peu près comme le talc: elle est enveloppée en dehors, vers le roc, de l'espèce de limon qui paroit fournir la nourriture à ces terres quartzeuses ou spatheuses; ces deux enveloppes sont comme la gaine ou l'étui du filon; plus il est perpendiculaire, et plus on doit en espérer; et toutes les fois que les mineurs voient que le filou est perpendiculaire, ils disent qu'il va s'ennoblir.

Les métaux sont formés dans toutes ces fentes et cavernes par une évaporation continuelle et assez violente: les vapeurs des mines démontrent cette évaporation encore subsistante; les fentes qui n'en exhalent point sont ordinairement stériles: la marque la plus sûre que les vapeurs exhalantes portent des atomes ou des molécules minérales, et qu'elles les appliquent partout aux parois des crevasses du roc, e'est cette incrustation successive qu'on remarque dans toute la circonférence de ces fentes ou de ces creux de roches, jusqu'à ce que la capacité en soit entièrement remplie et le filon solidement formé; ce qui est encore confirmé par les outils qu'on oublie dans les creux, et qu'on retrouve ensuite couverts et incrustés de la mine, plusieurs années après.

M Les fentes du roc qui fournissent une veine métallique abondante inclinent toujours ou poussent leur direction vers la perpendiculaire de la terre; à mesure que les mineurs descendent, ils rencontrent une température d'air toujours plus chaude, et quelquefois des exhalaisons si abondantes et si nuisibles à la respiration, qu'ils se trouvent forcés de se retirer au plus vite vers le puits ou vers la galerie, pour éviter la suffocation, que les parties sulfureuses et arsenicales leur causeroient à l'instant. Le soufre et l'arsenic se trouvent généralement dans toutes tes mines des quatre métaux imparfaits et de tous les demi-métaux, et c'est par eux qu'ils sont minéralisés.

Il n'y a que l'or, et quelquefois l'argent et le cuivre, qui se trouvent natifs en petite quantité; mais, pour l'ordinaire, le cuivre, le fer, le plomb, et l'étain, lorsqu'ils se tirent des filons, sont minéralisés

avec le soufre et l'arsenic. On sait, par expérience, que les métaux perdent leur forme métallique à un certain degré de chaleur relatif à chaque espèce du métal: cette destruction de la forme métallique, que subissent les quatre métaux imparfaits, nous apprend que la hase des métaux est une matière terrestre; et comme ces chaux métalliques se vitrifient à un certain degré de chaleur, ainsi que les terres calcaires, gypseuses, etc., nous ne pouvons pas douter que la terre métallique ne soit du nombre des terres vitrifiables. (Extrait du Mémoire de M. Eller sur l'origine et la génération des métaux, dans le recueil de l'Académie de Berlin, année 1753.)

- M. Lehman, célèbre chimiste, est le seul qui ait soupçonné une double origine aux mines métalliques; il distingue judicieusement les montagnes à filons des montagnes à couches. «L'or et l'argent, dit-il, ne se trouvent en masse que dans les montagnes à filons; le fer ne se trouve guère que dans les montagnes à couches: tous les morceaux ou petites parcelles d'or et d'argent qu'on trouve dans les montagnes à couches n'y sont que répandus, et ont été détachés des filons qui sont dans les montagnes supérieures et voisines de ces couches.

» L'or n'est jamais minéralisé; il se trouve toujours natif ou vierge, c'est-à-dire tout formé dans sa matrice, quoique souvent il y soit répandu en particules si déliées, qu'on chercheroit vainement à le recontioilre, même avec les meilleurs microscopes. On ne trouve point d'or dans les montagnes à couches; il est aussi assez rare qu'on y trouve de l'argent; ces deux métaux appartiennent de préférence aux montagnes à filous: ou a néanmoins trouvé quelquefois de l'argent en petits feuillets ou sous la forme de cheveux dans de l'ardoise: il est moins rai e de trouver du cuivre natif sur de l'ardoise, et communément ce cuivre natif est aussi en forme de filets ou de cheveux.

« Les mines de fer se reproduisent peu d'années après avoir été fouillées; elles ne se trouvent point dans les montagnes à filons, mais dans les montagnes à couches: on n'a point encore trouvé de fer natif dans les montagnes à couches, ou du moins c'est une chose très rare.

Quanta l'étain natif, il n'en existe point qui ait été produit par la nature sans le secours du feu; et la chose est aussi tres-douteuse pour le plomb, quoiqu'on prétende que les grains de plomb de Massel eu Silesie sont de plomb natif.

° On trouve le mercure vierge et coulant dans les couches de terre argileuses et grasses ou dans les ardoises.

« Les mines d'argent qui se trouvent dans les ardoises ne sont pas, à beaucoup près, aussi riches que celles qui se trouvent dans les montagnes à filons: ce métal ne se trouve guère qu'en particules déliées, en filets, ou en végétations, dans ces couches d'ardoLses ou de schistes, mais jamais en grosses mines; et encore faut-il que ces couches d'ardoises soient voisines des montagnes à filons. Toutes les mines d'argent qui se trouvent dans les couches ne sont pas sous une forme solide et compacte; toutes les autres mines qui contiennent de l'argent en abondance se trouvent dans les montagnes à filons. Le cuivre se trouve abondamment dans les couches d'ardoises, et quelquefois aussi dans les charbons de terre.

- L'étain est le métal qui se trouve le plus rarement répandu dans les couches. Le plomb s'y trouve plus communément: on en rencontre sous la forme de galène, attaché aux ardoises; mais on n'en trouve que très rar.-ni.iil avec les charbons de terre.

• Le fer est presque universellement répandu, et se trouve dans les couches sous un grand nombre de formes différentes.

« Le cinabre, le cohalt, le bismuth, et la calamine se trouvent aussi assez communément dans les couches. » (Lehman, tome III, pages 381 et suiv.)

« Les charbons de terre, le jayet, le succin, la terre alumineuse, ont été produits par des végétaux, et surtout par des arbres résineux qui ont été ensevelis dans le sein de la terre, et qui ont souffert une décomposition plus ou moins grande; car on trouve, au dessus des mines de charbon de terre, très souvent du bois qui n'est point du tout décomposé, et qui l'est davantage à mesure qu'il est plus enfoncé en terre. L'ardoise, qui sert de toit ou de couverture au charbon, est souvent remplie des empreintes de plantes qui accompagnent ordinairement les forêts, telles que les fougères, les capillaires, etc. Ce qu'il y a de remarquable, c'est que ces plantes dont on trou/e les empreintes sont toutes étrangères, et les bois paroissent aussi des bois étrangers. Le succin, qu'on doit regarder comme une résine végétale, renferme souvent des insectes qui, considéiés attentivement, n'appartiennent point au climat où on les rencontre présentement: enfin la terre alumineuse est tut)vent feuilletée, et ressemble à du bois, tantôt plus, tantôt moins décomposé. »(Ibid., ilid.)

«Le soufre, l'alun, le sel ammomac, se trouvent dans les couches formées par les volcans.

- Le pétrole, le naphte, indiquent un feu actuellement allumé sous la terre, qui met, pour ainsi dire, le charbon de terre en distillation: on a des exemples de ces embrasemens sonlerrains, qui n'agissent qu'en silence dans les mines de charbon de terre, en Angleterre et en Allemagne, lesquelles brûlent depuis très long-temps sans explosion; et c'est dans le voisinage de ces embrasemens souterrains qu'on trouve les eaux chaudes thermales.

« Les montagnes qui contiennent des filons ne renferment point de charbon de terre, ni des substances bitumineuses et combustibles; ces substances ne se trouvent jamais que dans les montagnes à couches. » (Note sur Lehman, par M. le haron d'Holhach, t. m, p. 435.)

- Je citerai pour exemple la mine de fer près de Taberg en Smoland, partie de l'ile de Gotbland en Suède: c'est l'une des plus remarquables de ces mines ou plutôt de ces montagnes de fer, qui toutes ont la propriété de céder à l'attraction de l'aimant, ce qui prouve qu'elles ont été formées par le feu. Cette montagne est dans un sol de sable extrêmement fin; sa hauteur est de plus de 400 pieds, et son circuit d'une lieue: elle est en entier composée d'une matière ferrugineuse très riche, et l'on y trouve même du fer natif; autre preuve qu'elle a éprouvé l'action d'un feu violent. Cette mine étant brisée montre à sa fracture de petites parties brillantes, qui tantôt se croisent et tantôt sont disposées par écailles: les petits rochers les plus voisins sont de roc pur (saxo puro). On travaille à cette mine depuis environ deux cents ans; on se sert pour l'exploiter de poudre à canon, et la montagne paroit fort peu diminuée, excepté dans les puits qui sont au pied du côté du vallon.

- Il paroil que cette mine n'a point de lits réguliers; le fer n'y est point non pins partout de la même bonté. Toute la montagne a beaucoup détentes, tantôt perpendiculaires et tantôt horizontales: elles sont toutes remplies de sable qui ne contient aucun fer; ce sable est aussi pur et de même espèce que celui des bords de la mer: on trouve quelquefois dans ce sable des os d'animaux et des cornes de cerf; ce qui prouve qu'il a été amené par les eaux, et que ce n'est qu'après la formation de la montagne de fer par le feu que les sables en ont rempli les crevasses et les fentes perpendiculaires et horizontales.

- Les masses de mine que l'on tire tombent aussitôt au pied de la montagne, au lieu que, dans les autres mines, il faut souvent tirer le minéral des entrailles de la terre; on doit concasser et griller cette mine avant de la mettre au fourneau, où on la fond avec la pierre calcaire et du charbon de bois.

- Cette colline de fer est située dans un endroit montagneux fort élevé, éloigné de la mer de près de 80 lieues: il paroil qu'elle étoit autrefois entièrement couverte de sable. (Extrait d'un article de

l'ouvrage périodique qui a pour titre: Nordisthe Beytrage-, etc. Contribution du Mord pour les progrès de la physique, des sciences, et des arts. A Allone, chez David Ifers, 1756.)

- On vient de voir, par l'exemple cité dans la note précédente, que la montagne de fer de Taberg s'élève de plus de 400 pieds au dessus de la surface de la terre. M. Gmelin, dans son Voyage en Sibérie, assure que, dans les contrées septentrionales de l'Asie, presque toutes les mines des métaux se trouvent à la surface de la terre, tandis que dans les autres pays elles se trouvent profondément ensevelies dans son intérieur. Si ce fait étoit généralement vrai, ce serait une nouvelle preuve que les métaux ont été formés par le feu primitif, et que le globe de la terre ayant moins d'épaisseur dans les parties septentrionales, ils s'y sont formés plus près de la surface que dans les contrées méridionales.

- Le même M. Gmelin a visité la grande montagne d'aimant qui se trouve en Sibérie, chez les Baschkirs: cette montagne est divisée en huit parties, séparées par des vallons: la septième de ces parties produit le meilleur aimant; le sommet de cette portion de montagne est formé d'une pierre jaunàre, qui parait tenir de la nature du jaspe. On y trouve des pierres que l'on prendrait de loin pour du grès, qui pèsent deux mille cinq cents ou trois milliers, mais qui ont toutes la vertu de l'aimant. Quoiqu'elles soient couvertes de mousse, elles ne laissent pas d'attirer le fer et l'acier, à la distance de plus d'un pouce: les cotés exposés à l'air ont la plus forte vertu magnétique, ceux qui sont enfoncés en terre en ont beaucoup moins: ces parties les plus exposées aux injures de l'air sont moins dures, et par conséquent moins propres à être armées. Un gros quartier d'aimant de la grandeur qu'on vient de dire est composé de quantité de petits quartiers d'aimant, qui opèrent en différentes directions. Pour les bien travailler, il faudrait les séparer en les sciant, afin que tout le morceau qui renferme la vertu de chaque aimant particulier conservât son intégrité; on obtiendrait vraisemblablement de cette façon des aimant d'une grande force: mais on coupe des morceaux à tout hasard, et il s'en trouve plusieurs qui ne valent rien du tout, soit parce qu'on travaille un morceau de pierre qui n'a point de vertu magnétique, ou qui n'en renferme qu'une petite portion, soit que dans un seul morceau il y ait deux ou trois aimant réunis. A la vérité, ces morceaux ont une vertu magnétique; mais, comme elle n'a pas sa direction vers un même point, il n'est pas étonnant que l'effet d'un pareil aimant soit sujet à bien des variations.

- L'aimant de cette montagne, à la réserve de celui qui est exposé à l'air, est d'une grande dureté, taché de noir, et rempli de tubérosités qui ont de petites parties anguleuses, comme on en voit souvent à la surface de la pierre sanguine, dont il ne diffère que par la couleur; mais souvent, au lieu de ces parties anguleuses, on ne voit qu'une espèce de terre d'ocre: en général, les aimans qui ont ces petites parties anguleuses ont moins de vertu que les autres. L'endroit de la montagne où sont les aimans est presque entièrement composé d'une bonne mine de fer, qu'on tire par petits morceaux entre les pierres d'aimant. Toute la section de la montagne la plus élevée renferme une pareille mine; mais plus elle s'abaisse moins elle contient de métal. Plus has, au dessous de la mine d'aimant, il y a d'autres pierres ferrugineuses, mais qui rendoient fort peu de fer, si on vouloit les faire fondre: les morceaux qu'on en tire ont la couleur de métal, et sont très lourds; ils sont inégaux en dedans, et ont presque l'air de scories: ces morceaux ressemblent assez par l'extérieur aux pierres d'aimant; mais ceux qu'on tire à huit brasses au dessus du roc n'ont plus aucune vertu. Entre ces pierres, on trouve d'autres morceaux de roc qui paroissent composés de très petites particules de fer; la pierre par elle-même est pesante, mais fort molle; les particules intérieures ressemblent à une matière brûlée, et elles n'ont que peu ou point de vertu magnétique. On trouve aussi de temps en temps un minerai brun de fer dans des couches épaisses d'un pouce; mais il rend peu de métal. (Extrait de l'Histoire générale des voyages, tome X"VIII, pages 141 et suiv.)

Il y a plusieurs autres mines d'aimant en Sibérie dans les monts Poias. A 10 lieues de la route qui mène de Catherinbourg à Solikamskaia est la montagne de Galazinski; elle a plus de vingt toises de hauteur, et c'est entièrement un rocher d'aimant, d'un brun couleur de fer dur et compacte.

A 20 lieues de Solikamskaia on trouve un aimant cubique et verdâtre; les cubes en sont d'un brillant vif: quand on les pulvérise, ils se décomposent en paillettes brillantes, couleur de feu. Au reste, on ne trouve l'aimant que dans les chaînes de montagnes dont la direction est du sud au nord. (Extrait de l'Histoire générale des voyages, tome XIX, page 472-)

Dans les terres voisines des confins de la Laponie, sur les limites de la Bothnie, à deux lieues de Cokluanda, on voit une mine de fer dans laquelle on tire des pierres d'aimant tout-à-fait bonnes.

Nous admirâmes avec bien du plaisir, dit le relateur, les effets surprenais de cette pierre, lorsqu'elle est encore dans le lieu natal: il fallut faire beaucoup de violence pour en tirer des pierres a(t-si considérables que celles que nous voulions avoir; et le marteau dont on se servoit, qui étoit de la grosseur de la cuisse, demeurait si fixe eu tombant sur le ciseau qui étoit dans la pierre, que celui qui frappoit avoit besoin de secours pour le retirer. Je voulus éprouver cela moi-même; et ayant pris une grosse pince de fer, pareille à celle dont on se sert à remuer les corps les plus pesans, et que j'avois de la peine à soutenir, je l'approchai du ciseau, qui l'attira tvec une violence extrême, et la soutenoit avec une force inconcevable. Je mis une boussole au milieu du trou où étoit la mine, et l'aiguille tournoit continuellement d'une vitesse incroyable. (OEuvres de Regnard, Paris, 1742, tomel, page 185.)

Troisième Époque - Lorsque Les Eaux Ont Couvert Nos Continens

A la date de trente ou trente-cinq mille ans de la formation des planètes, la terre se trouvoit assez attiédie pour recevoir les eaux sans les rejeter en vapeurs. Le chaos de l'atmosphère avoit commencé de se débrouiller: non seulement les eaux, mais toutes les matières volatiles que la trop grande chaleur y tenoit reléguées et suspendues, tombèrent successivement; elles remplirent toutes les profondeurs, couvrirent toutes les plaines, tous les intervalles qui se trouvoient entre les éminences de la surface du globe, et même elles surmontèrent toutes celles qui n'étoient pas excessivement élevées. On a des preuves évidentes que les mers ont couvert le continent de l'Europe jusqu'à quinze cents toises du niveau de la mer actuelle, puisqu'on trouve des coquilles et d'autres productions marines dans les Alpes et dans les Pyrénées jusqu'à cette même hauteur. On a les mêmes preuves pour les continens de l'Asie et de l'Afrique; et même dans celui de l'Amérique, où les montagnes sont plus élevées qu'eu Europe, on a trouvé des coquilles marines à plus de deux mille toises de hauteur au dessus du niveau de la mer du Sud. Il est donc certain que, dans ces premiers temps, le diamètre du globe avoit deux lieues de plus, puisqu'il étoit enveloppé d'eau jusqu'à deux mille toises de hauteur. La surface de la terre en général étoit donc beaucoup plus élevée qu'elle ne l'est aujourd'hui; et, pendant une longue suite de temps, les mers l'ont recouverte en entier, à l'exception peut-être de quelques terres très élevées et des sommets des hautes montagnes, qui seuls surmontoient cette mer universelle, dont l'élévation étoit au moins à cette hauteur où l'on cesse de trouver des coquilles: d'où l'on doit inférer que les animaux auxquels ces dépouilles ont appartenu peuvent être regardés comme les premiers habitans du globe; et cette population étoit innombrable, à en juger par l'immense quantité de leurs dépouilles et de leurs détrimens, puisque c'est de ces mêmes dépouilles et de leurs détrimens qu'ont été formées toutes les couches des pierres calcaires, des marbres, des craies, et des tufs qui composent nos collines, et qui s'étendent sur de grandes contrées dans tontes les parties de la terre.

Or, dans les commencemens de ce séjour des eaux sur la surface du globe, a'avoient elles pas un degré de chaleur que nos poissons et nos coquillages actuellement existant n'auroient pu supporter? et ne devons nous pas présumer que les premières productions d'une mer encore bouillante étoient différentes de celles qu'elle nous offre aujourd'hui? Cette grande chaleur ne pouvoit convenir qu'à d'autres natures de coquillages et de poissons; et par conséquent c'est aux premiers temps de cette époque, c'est-à-dire depuis trente jusqu'à quarante mille ans de la formation de la terre, que l'on

doit rapporter l'existence des espèces perdues dont on ne trouve nulle part les analogues vivans Ces premières espèces, maintenant anéanties, ont subsisté pendant les dix ou quinze mille ans qui ont suivi le temps auquel les eaux venoient de s'établir.

Et l'on ne doit point être étonné de c e que j'avance ici, qu'il y a eu des poissons et d'autres animaux aquatiques capables de supporter un degré de chaleur beaucoup plus grand que celui de la température actuelle de nos mers méridionales, puisqu'encore aujourd'hui nous connoissons des espères de poissons et de plantes qui vivent et végètent dans des eaux presque bouillantes, ou du moins chaudes jusqu'à 5o ou 60 degrés du thermomètre.

Mais, pour ne pas perdre le fil des grands et nombreux phénomènes que nous avons à exposer, reprenons ces temps antérieurs où les eaux, jusqu'alors réduites en vapeurs, se sont condensées, et ont commencé de tomber sur la terre brûlante, aride, desséchée, crevassée par le feu. Tâchons de nous représenter les prodigieux effets qui ont accompagné et suivi cette chute précipitée des matières volatiles, toutes séparées, combinées, sublimées, dans le temps de la consolidation, et pendant le progrès du premier refroidissement. La séparation de l'élément de l'air et de l'élément de l'eau, le choc des vents et des flots qui tomboient en tourbillons sur une terre fumante; la dépuration de l'atmosphère qu'auparavant les rayons du soleil ne pouvoient pénétrer; cette même atmosphère obscurcie de nouveau par les nuages d'une épaisse fumée; la cohobation mille fois répétée, et le bouillonnement continuel des eaux tombées et rejetées alternativement; enfin la lessive de l'air, par l'abandon des matières volatiles précédemment sublimées, qui toutes s'en séparèrent et descendirent avec plus ou moins de précipitation: quels mouvemens, quelles tempêtes ont dû précéder, accompagner, et suivre, l'établissement local de chacun de ces élémens! et ne devons-nous pas rapporter à ces premiers momens de choc et d'agitation les bouleversemens, les premières dégradations, les irruptions, et les changemens qui ont donné une seconde forme à la plus grande partie de la surface de la terre? Il est aisé de sentir que les eaux qui la couvraient alors presque tout entière, étant continuellement agitées par la rapidité de leur chute, par l'action de la lune sur l'atmosphère et sur les eaux déjà tombées, par la violence des vents, etc., auront obéi à toutes ces impulsions, et que, dans leurs mouvemens, elles auront commencé par sillonner plus à fond les vallées de la terre, par renverser les éminences les moins solides, rabaisser les crêtes des montagnes, percer leurs chaînes dans les points les plus foibles; et qu'après leur établissement ces mêmes eaux se sont ouvert des routes souterraines, qu'elles ont miné les voûtes des cavernes, les ont fait écrouler, et que par conséquent ces mêmes eaux se sont abaissées successivement pour remplir les nouvelles profondeurs qu'elles venoient de former. Les cavernes étoient l'ouvrage du feu: l'eau, dès son arrivée, a commencé par les attaquer; elle les a détruites, et continue de les détruire encore. Nous devons donc attribuer l'abaissement des eaux à l'affaissement des cavernes, comme la seule cause qui nous soit démontrée par les faits.

Voilà les premiers effets produits par la masse, par le poids, et par le volume de l'eau; mais elle en a produit d'autres par sa seule qualité: elle a saisi toutes les matières qu'elle pouvoit délayer et dissoudre; elle s'est combinée avec l'air, la terre, et le feu, pour former les acides, les sels, etc.; elle a converti les scories et les poudres du verre primitif en argiles; ensuite elle a, par son mouvement, transporté de place eu place ces mêmes scories et toutes les matières qui se trouvoient réduites en petits volumes. Il s'est donc fait dans cette seconde période, depuis trente-cinq jusqu'à cinquante mille ans, un si grand changement à la surface du globe, que la mer universelle, d'abord très élevée, s'est successivement abaissée pour remplir les profondeurs occasionnées par l'affaissement des cavernes, dont les voûl tes naturelles, sapées ou percées par l'action et le feu de ce nouvel élément, ne pouvoient plus soutenir le poids cumulé des terres et des eaux dont elles étoient chargées. A mesure qu'il se faisoit quelque grand affaissement par la rupture d'une ou de plusieurs cavernes, la surface de la terre se déprimant en ces endroits, l'eau arrivoit de toutes parts pour remplir cette nouvelle profondeur, et par conséquent la hauteur

générale des mers diminuoit d'autant; en sorte qu'étant d'abord à deux mille toises d'élévation la mer a successivement baissé jusqu'au niveau où nous la voyons aujourd'hui.

On doit présumer que les coquilles et tes autres productions marines, que l'on trouve à de grandes hauteurs au dessus du niveau actuel des mers, sont les espèces les plus anciennes de la nature; et il serait important pour l'histoire naturelle de recueillir un assez grand nombre de ces productions de la mer, qui se trouvent à cette plus grande hauteur, et de les comparer avec celles qui sont dans les terrains plus bas. Nous sommes assurés que les coquilles dont nos collines sont composées appartiennent en partie à des espèces inconnues, c'est-à-dire à des espèces doul aucune mer fréquentée ne nous offre les analogues vivans. Si jamais on fait un recueil de ces pétrifications prises à la plus grande élévation dans les montagnes, on sera peut-être en état de prononcer sur l'ancienneté plus ou moins grande des espèces relativement aux autres. Tout ce que nous pouvons en dire aujourd'hui c'est que quelques-uns des monumens qui nous démontrent l'existence de certains animaux terrestres et marins dont nous ne connoissons pas les analogues vivans, nous montrent en même temps que ces animaux étoient beaucoup plus grands qu'aucune espèce du même geure actuellement subsistante. Ces grosses dents molaires à pointes mousses, du poids de onze ou douze livres; ces cornes d'ammon, de sept à huit pieds de diamètre sur un pied d'épaisseur, dont on trouve les moules pétrifiés, sont certainement des êtres gigantesques dans le geure des animaux quadrupèdes et dans celui des coquillages. La nature étoit alors dans sa première force, et travailloit la matière organique et vivante avec une puissance plus active dans une température plus chaude: cette matière organique étoit plus divisée, moins combinée avec d'autres matières, et pouvoit se réunir et se combiner avec elle-même en plus grandes masses, pour se développer en plus grandes dimensions. Cette cause est suffisante pour rendre raison de toutes les productions gigantesques qui paraissent avoir été fréquentes dans ces premiers âges du monde.

En fécondant les mers, la nature répandoit aussi les principes de vie sur toutes les terres que l'eau n'avoit pu surmonter, ou qu'elle avoit promptement abandonnées; et ces terres, comme les mers, ne pouvoient être peuplées que d'animaux et de végétaux capables de supporter une chaleur plus grande que celle qui convient aujourd'hui à la nature vivante. Nous avons des monumens tirés du sein de la 'erre, et particulièrement du fond des minières de charbon et d'ardoise, qui nous démontrent que quelques-uns des poissons et des végétaux que ces matières contiennent ne sont pas des espèces actuellement existantes ». On peut donc croire que la population de la mer en animaux n'est pas plus ancienne que celle de la terre en végétaux: les monumens et les témoins sont plus nombreux, plus évidens pour la mer; mais ceux qui déposent pour la terre sont aussi certains, et semblent nous démontrer que ces espèces anciennes dans les animaux marins et dans les végétaux terrestres se sont anéanties, ou plutôt ont cessé de se multiplier, dès que la terre et la mer ont perdu la grande chaleur nécessaire à l'effet de leur propagation.

Les coquillages ainsi que les végétaux de ce premier temps s'étant prodigieusement multipliés pendant ce long espace de vingt mille ans, et la durée de leur vie n'étant que de peu d'années, les animaux à coquilles, les polypes des coraux, des madrépores, des astroïtes, et tous les petits animaux qui convertissent l'eau de la mer en pierre, ont, à mesure qu'ils périssoient, abandonné leurs dépouilles et leurs ouvrages aux caprices des eaux: elles auront transporté, brisé, et déposé ces dépouilles en mille et mille endroits; car c'est dans ce même temps que les mouvemens des marées et des vents réglés ont commencé de former les couches horizontales de la surface de la terre par les sédimens et le dépôt des eaux; ensuite les courons ont donné à tou tes les collines et à toutes les montagnes di médiocre hauteur des directions correspondantes; en sorte que leurs angles sallans sont toujours opposés à des angles rentrons. Nous ne répéterons pas ici ce que nous avons dit à ce sujet dans notre Théorie de la terre, et nous nous contenterons d'assurer que cette disposition générale de la surface du globe par angles correspondans, ainsi que sa composition par couches horizontales, ou également et parallèlement inclinées, démontrent évidemment que la structure et la forme de la surface actuelle de la terre ont été disposées par les eaux, et produites

par leurs sédimens. Il n'y a eu que les crêtes et les pics des plus hautes montagnes qui peut-être se sont trouvés hors d'atteinte aux eaux, ou n'en ont été surmontés que pendant un petit temps, et sur lesquels par conséquent la mer n'a point laissé d'empreintes: mais, ne pouvant les attaquer par leur sommet, elle les a prises par la hase; elle a recouvert ou miné les parties inférieures de ces montagnes primitives; elle les a environnées de nouvelles matières, ou bien elle a percé les voûtes qui les soutenoient; souvent elles les a fait pencher; enfin elle a transporté dans leurs cavités intérieures les matières combustibles provenant du détriment des végétaux, ainsi que les matières pyriteuses, bitumineuses, et minérales, pures ou mêlées de terres et de sédimens de toute espèce.

La production des argiles paroit avoir précédé celle des coquillages; car la première opération de l'eau a été de transformer les scories et les poudres de verre en argiles: aussi les lits d'argiles se sont formés quelque temps avant les bancs de pierres calcaires; et l'on voit que ces dépôts de matières argileuses ont précédé ceux des matières calcaires, car presque partout les rochers calcaires sont posés sur des glaises qui leur servent de base. Je n'avance rien ici qui ne soit démontré par l'expérience, ou confirmé par les observations; tout le monde pourra s'assurer par des procédés aisés à répéter, que le verre et le grès en poudre se convertissent en peu de temps en argile, seulement en séjournant dans l'eau 1; c'est d'après cette connoissance que j'ai dit, dans ma Théorie de la terre, que les argiles n'étoient que des sables vitrescibles décomposés et pourris. J'ajoute ici que c'est probablement à cette di composition du sable vitrescible dans l'eau qu'on doit attribuer l'origine de l'acide; car le principe acide qui se trouve dans l'argile peut être regardé comme une combinaison de terre vitrescible avec le feu, l'air, et l'eau; et c'est ce même principe acide qui est la première cause de la ductilité de l'argile et de toutes les autres matières, sans même en excepter les bitumes, les huiles, et les graisses, qui ne sont ductiles et ne communiquent de la ductilité aux autres matières que parce qu'elles contiennent des acides.

Après la chute et l'établissement des eaux bouillantes sur la surface du globe, la plus grande partie des scories de verre qui la couvraient en entier ont donc été converties en assez peu de temps en argiles: tous les mouvemens de la mer ont contribué à la prompte formation de ces mêmes argiles, en remuant et transportant les scories et les poudres de verre, et les forçant de se présenter à l'action de l'eau dans tous les sens; et, peu de temps après, les agiles formées par l'intermède et l'impression de l'eau ont successivement été transportées et déposées au dessus de la roche primitive du globe, c'est-à-dire au dessus de la masse solide de matières vitrescibles qui en fait le fond, et qui, par sa ferme consistance et sa dureté, avoit résisté à cette même action des eaux.

La décomposition des poudres et des sables vitrescibles, et la production des argiles, se sont faites en d'autant moins dé temps que l'eau étoit plus chaude: cette décomposition a contmué de se faire et se fait encore tous les jours, mais plus lentement et en bien moindre quantité; car, quoique les argiles se présentent presque partout comme enveloppant le globe, quoique souvent ces couches d'argiles aient cent et deux cents pieds d'épaisseur, quoique les rochers de pierres calcaires et toutes les collines composées de ces pierres soient ordinairement appuyés sur des couches argileuses, on trouve quelquefois au dessous de ces mêmes couches des sables vitrescibles qui n'ont pas été convertis et qui conservent le caractère de leur première origine. Il y a aussi des sables vitrescibles à la superficie de la terre et sur celle du fond des mers: mais la formation de ces sables vitrescibles qui se présentent à l'extérieur est d'un temps bien postérieur à la formation des autres sables de même nature qui se trouvent à de grandes profondeurs sous les argiles; car ces sables qui se présentent à la superficie de la terre ne sont que les détrimens des granites, des grès, et de la roche vitreuse, dont les masses forment les noyaux et les sommets des montagnes, desquelles les pluies, la gelée, et les autres agens extérieurs, ont détaché et détachent encore tous les jours de petites parties, qui sont ensuite entraînées et déposées par les eaux courantes sur la surface de la terre: on doit donc regarder comme très récente, en comparaison de l'autre, cette production des sables vitrescibles qui se présentent sur le fond de la mer ou à la superficie de la terre.

Ainsi les argiles et l'acide qu'elles contiennent ont été produits très peu de temps après l'établissement des eaux, et peu de temps avant la naissance des coquillages; car nous trouvons dans ces mêmes argiles une infinité de bélemnites, de pierres lenticulaires, de cornes d'ammon, et d'autres échantillons de ces espèces perdues dont on ne trouve nulle part les analogues vivans. J'ai trouvé moi-même dans une fouille que j'ai fait creuser à cinquante pieds de pro fondeur, au plus bas d'un petit vallon2 tout composé d'argile, et dont les collines voisines étoient aussi d'argile jusqu'à quatre-vingts pieds de hauteur; j'ai trouvé, dis-je, des bélemnites qui avoient huit pouces de long sur près d'un pouce de diamètre, et dont quelques-unes etoient attachées à une partie plate et mince comme l'est le têt des crustacés. J'y ai trouvé de même un grand nombre de cornes d'ammon pyriteuses et bronzées, et des milliers de pierres lenticulaires. Ces anciennes dépouilles étoient, comme l'on voit, enfouies dans l'argile à cent trente pieds de profondeur; car quoiqu'on n'eût creusé qu'à cinquante pieds dans cette argile au milieu du vallon, il est certain que l'épaisseur de cette argile étoit originairement de cent trente pieds, puisque les couches eu sont élevées des deux côtés à quatre-vingts pieds de hanleur au dessus: cela me fut démontré par la correspondance de ces couches et par celle des bancs de pierres calcaires qui les surmontent de chaque coté du vallon. Ces bancs calcaires ont cinquante-quatre pieds d'épaisseur, et leurs différens lits se trouvent correspondons et posés horizontalement à la même hauteur au dessus de la couche immense d'argile qui leur sert de hase et s'étend sous les collines calcaires de toute cette contrée.

Le temps de la formation des argiles a donc immédiatement suivi celui de l'établissement des eaux; le temps de la formation des premiers coquillages doit être placé quelques siècles après; et le temps du transport de leurs dépouilles a suivi presque immédiatement: il n'y a eu d'intervalle qu'autant que la nature en a mis entre la naissance et la mort de ces animaux à coquilles. Comme l'impression de l'eau convertissoit chaque jour les sables vitrescibles en argiles, et que sou mouvement les transportent de place en place, elle entrainoit en même temps les coquilles et les autres dépouilles et débris des productions marines, et déposant le tout comme des sédimens, elle a formé dès lors les couches d'argile où nous trouvons aujourd'hui ces monumens, les plus anciens de la nature organisée, dont les modèles ne subsistent plus. Ce n'est pas qu'il n'y ait aussi dans les argiles des coquilles dont l'origine est moins ancienne, et même quelques espèces que l'on peut comparer avec celles de nos mers, et mieux encore avec celles des mers méridionales; mais cela n'ajoute aucune difficulté à nos explications, car l'eau n'a pas cessé de convertir en argiles toutes les scories de verre et tous les sables vitrescibles qui se sont présentés à son action: elle a donc formé des argiles en grande quantité dès qu'elle s'est emparée de la surface de la terre: elle a continué et continue encore de produire le même effet; car la mer transporte aujourd’hui ces vases avec les dépouilles des coquillages actuelles vivans, comme ellea autrefois transporté ces mêmes vases avec les dépouilles des coquillages alors èxistans.

La formation des schistes, des ardoises, des charbons de terre, et des matières bitumineuses, date à peu près du même temps: ces matières se trouvent ordinairement dans les argiles à d'assez grandes profondeurs; elles paraissent même avoir précédé l'établissement local des dernières couches d'argile, car au dessous de cent trente pieds d'argile dont les lits contenoient des bélemnites, des cornes d'ammon, et d'autres débris des plus anciennes coquilles, j'ai trouvé des matières charbonneuses et inflammables; et l'on sait que la plupart des mines de charbon de terre sont plus ou moins surmontées par des couches de terres argileuses. Je crois même pouvoir avancer que c'est dans ces terres qu'il faut chercher les veines de charbon, desquelles la formation est un peu plus ancienne que celle des couches extérieures des terres argileuses qui les surmontent: ce qui le prouve, c'est que les veines de ces charbons de terre sont presque toujours inclinées, tandis que celles des argiles, ainsi que toutes les autres couches extérieures du globe, sont ordinairement horizontales. Ces dernières ont donc été formées par le sédiment des eaux qui s'est déposé de niveau sur une hase horizontale, tandis que les autres, puisqu'elles sont inclinées, semblent avoir été amenées par un courant sur un terrain en penle. Ces veines de charbon, qui toutes sont composées de végétaux mêlés de plus ou moins de bitume, doivent leur origine aux premiers

végétaux que la terre a formés: toutes les parties du globe qui se trouvoient élevées au dessus des eaux produisirent, dès les premiers temps, une infinité de plantes et d'arbres de toute espèce, lesquels bientôt tombant de vétusté furent entraînés par les eaux, et formèrent des dépôts de matières végétales en une infinité d'endroits; et comme les bitumes et les autres huiles terrestres paraissent provenir des substances végétales et animales, qu'en même temps l'acide provient de la décomposition du sable vitrescible par le feu, l'air, et l'eau, et qu'enfin il entre de l'acide dans la composition des bitumes, puisque avec une huile végétale et de l'acide on peut faire du bitume, il parait que les eaux se sont dès lors mêlées avec ces bitumes et s'en sont imprégnées pour toujours; et comme elles transportoient incessamment les arbres et les autres matières végétales descendues des hauteurs de la terre, ces matières végétales ont continué de se mêler avec les bitumes déjà formés des résidus des premiers végétaux; et la mer, par son mouvement et par v ses courans, les a remuées, transportées et déposées sur les éminences d'argile qu'elle avoit formées précédemment.

Les couches d'ardoises, qui contiennent aussi des végétaux et même des poissons, ont été formées de la même manière, et l'on peut en donner des exemples qui sont, pour ainsi dire, sous nos yeux. Ainsi les ardoisières et les mines de charbon ont ensuite été recouvertes par d'autres couches de terres argileuses que la mer a déposées dans des temps postérieurs: il y a même ou des intervalles considérables et des alternatives de mouvement entre l'établissement des différentes couches de charbon dans le même terrain; car on trouve souvent au dessous de la première couche de charbon une veine d’argile ou d'autre terre qui suit la même inclinaison, et ensuite on trouve assez communément une seconde couche de charbon inclinée comme la première, et souvent une troisième, également séparées l'une de l'autre par des veines de terre, et quelquefois même par des bancs de pierre calcaire, comme dans les mines de charbon du Hainaut. L'on ne peut donc pas douter que les couches les plus basses de charbon n'aient été produites, les premières, par le transport des matières végétales amenées par les eaux; et lorsque le premier dépôt d'où la mer enlevoit ces matières végétales se trouvoit épuisé, le mouvement des eaux continuoit de transporter au même lieu les terres ou les autres matières qui environnoient ce dépôt: ce sont ces terres qui forment aujourd’hui la veine intermédiaire entre les deux couches de charbon; ce qui suppose que l'eau amenoit ensuite, de quel (pi'autre dépôt, des matières végétales pour former la seconde couche de charbon. J'entends ici par couches la veine entière de charbon prise dans toute sou épaisseur, et non pas les petites couches ou feuillets dont la substance même du charbon est composée, et qui souvent sont extrêmement minces; ce sont ces mêmes feuillets, toujours parallèles entre eux, qui démontrent que ces masses de charbon ont été formées et déposées par le sédiment et même par la stillation des eaux imprégnées de bitume; et cette même forme de feuillets se trouve dans les nouveaux charbons dont les couches se forment par stillation, aux dépens des courbes les plus anciennes. Ainsi les feuillets du charbon de terre ont pris leur forme par deux causes combinées: la première est le dépôt toujours horizontal de l'eau; et la seconde, la disposition des matières végétales, qui tendent à faire des feuillets1. Au surplus, ce sont les morceaux de bois, souvent entiers, et les détrimens très reconnoissables d'autres végétaux, qui prouvent évidemment que la substance de ces charbons de terre n'est qu'un assemblage de débris de végétaux liés ensemble par des bitumes.

La seule chose qui pourrait être difficile à concevoir, c'est l'immense quantité de débris de végétaux que la composition de ces mines de charbon suppose; car elles sont très épaisses, très étendues, et se trouvent en une infinité d'endroits: mais si l'on fait attention à la production peut-être encore plus immense de végétaux qui s'est faite pendant vingt ou vingt-cinq mille ans, et si l'on pense en même temps que l'homme n'étant pas encore créé, il n'y avoit aucune destruction des végétaux par le feu, on sentira qu'ils ne pouvoient manquer d'être emportés par les eaux, et de former en mille endroits différens des couches très étendues de matière végétale. On peut se faire une idée en petit de ce qui est alors arrivé en grand: quelle énorme quantité de gros arbres certains fleuves, comme le Mississipi, n'entrainent-ils pas dans la mer! le nombre de ces arbres est si prodigieux, qu'il empêche, dans certaines saisons, la navigation de ce large fleuve: il en est de

même sur la rivière des Amazones, et sur la plupart des grands fleuves des continens déserts ou mal peuplés. On peut donc penser, par cette comparaison, que toutes les terres élevées au dessus des eaux étant dans le commencement couvertes d'arbres et d'autres végétaux que rien ne détruisoit que leur vétusté, il s'est fait, dans cette longue période de temps, des transports successifs de tous ces végétaux el de leurs détrimens, cuirai nés par les eaux courantes du haut des montagnes jusqu'aux mers. Les mêmes contrées inhabitées de l'Amérique nous en fournissent un exemple frappant: on voit à la Guiane des forêts de palmiers latanirrs de plusieurs lieues d'étendue, qui croissent dans les espèces de marais qu'on appelle des savants noyées, qui ne sont que des appendices de la mer; ces arbres, après avoir vécu leur âge, tombent de vétusté, et sont emportés par le mouvement des eaux. Les forêts plus éloignées de la mer et qui couvrent toutes les hauteurs de l'intérieur du pays,

i. Voyez l'expérience de M. de Moryeau sur une concrétion blancbe qui est devenue du charbon de terre noir et feuilleté, sont moins peuplées d'arbres sains et vigoureux que jonchées d'arbres décrépits et à demi pourris. Les voyageurs qui sont obligés de passer la nuit dans ces bois ont soin d'examiner le lieu qu'ils choisissent pour gîte, afin de reconnoitre s'il n'est environné que d'arbres solides, et s'ils ne courent pas risque d'être écrasés pendant leur sommeil par la chute de quelques arbres pourris sur pied; et la chute de ces arbres en grand nombre est très fréquente: un seul coup de vent fait souvent un abatis si considérable qu'on en entend le bruit à de très grandes distances. Ces arbres, roulant du haut des montagnes, en renversent quantité d'autres, et ils arrivent ensemble dans les lieux les plus bas, ou ils achèvent de pourrir, pour former de nouvelles couches de terre végétale; ou bien ils sont entraides par les eaux courantes dans les mers voisines, pour aller former au loin de nouvelles couches de charbon fossile.

Les détrimens des substances végétales sont donc le premier fonds des mines de charbon; ce sont des trésors que la nature semble avoir accumulés d'avance pour les besoins à venir des grandes populations. Plus les hommes se multiplieront, plus les forêts diminueront; les bois ne pouvant plus suffire à leur consommation, ils auront recours à ces immenses dépôts de matières combustibles, dont l'usage leur deviendra d'autant plus nécessaire que le globe se refroidira davantage; néanmoins ils ne les épuiseront jamais, car une seule de ces mines de charbon contient peut-être plus de matière combustible que toutes les forêts d'une vaste contrée.

L'ardoise, qu'on doit regarder comme une argile durcie, est formée par couches qui contiennent de même du bitume et des végétaux, mais en bien plus petite quantité; et en même temps elles renferment souvent des coquilles, des crustacés, et des poissons, qu'on ne peut rapporter à aucune espèce connue. Ansi l'origine des charbons et des ardoises date du même temps; la seule différence qu'il y ait entre ces deux sortes de matières, c'est que les végétaux composent la majeure partie de la substance des charbons de terre, au lieu que le fonds de la substance de l'ardoise est le même que celui de l'argile, et que les végétaux, amsi que les poissons, ne paraissent s'y trouver qu'aucidentellement et eu assez petit nombre: mais toutes deux contiennent du bitume, et sont formées par feuillets ou par couches très minces, toujours parallèles entre elles; ce qui démontre clairement qu'elles ont également été produites par les sédimens successifs d'une eau tranquille, et dont les oscillations étoient parfaitement réglées, telles que sont celles de nos marées ordinaires ou des courans constans des eaux.

Reprenant donc pour un instant tout ce que je viens d'exposer, la masse du globe terrestre, composée de verre en fusion, ne présentait d'abord que les boursouflures et les cavités irrégulières qui se forment à la superficie de toute matière liquéfiée par le feu et dont le refroidissement resserre les parties. Pendant ce temps et dans le progrès du refroidissement, les élémens se sont séparés, les liquations et les sublimations des substances métalliques et minérales se sont faites, elles ont occupé les cavités des terres élevées et les fentes perpendiculaires des montagnes; car ces poioies avancées au dessus de la surface du globe s'étant refroidies les premières, elles ont

aussi présenté aux élémens extérieurs les premières fentes produites par le resserrement de la matière qui se refroidissoit. Les métaux et les minéraux ont été poussé; par la sublimation, ou déposés par les eaux, dans toutes ces fentes, et c'est par cette raison qu'on les trouve presque toutes dans les hautes montagnes, et qu'on ne rencontre dans les terres plus basses que des mines de nouvelle formation: peu de temps après, les argiles se sont formées, les premiers coquillages et les premiers végétaux ont pris naissance; et, à mesure qu'ils ont péri, leurs dépouilles et leurs détrimens ont fait les pierres calcaires, et ceux des végétaux ont produit les bitumes et les charbons; et en même temps les eaux, par leur mouvement et par leurs sédimens, ont composé l'organisation de la surface de la terre par couches horizontales; ensuite les courans de ces mêmes eaux lui ont donné sa forme extérieure par angles saillans et rentrans; et ce n'est pas trop étendre le temps nécessaire pour toutes ces grandes opérations et ces immenses constructions de la nature, que de compter vingt mille ans depuis la naissance des premiers coquillages et des premiers végétaux: ils étutent déjà très multipliés, très nombreux, à la date de quarante-cinq mille ans de la formation de la terre; et comme les eaux, qui d'abord étoient si prodigieusement élevées, s'abaissèrent successivement et abandonnèrent les terres qu'elles surmontoient auparavant, ces terres présentèrent dès lors une surface toute jonchée de productions marines.

La durée du temps pendant lequel les eaux couvraient nos continens a été très longue; l'on n'en peut pas douter en considérant l'immense quantité de productions marines qui se trouvent jusqu'à d'assez grandes profondeurs et à de très grandes hauteurs dans toutes les parties de la terre: et combien ne devons-nous pas encore ajouter de durée à ce temps déjà si long, pour que ces mêmes productions marines aient été brisées, réduites en poudre, et transportées par le mouvement des eaux, pour former ensuite les marbres, les pierres calcaires, et les craies! Cette longue suite de siècles, cette durée de vingt mille ans, me parait encore trop courte pour la succession des effets que tous ces monumens nous démontrent.

Car il faut se représenter ici la marcbe de la nature, même se rappeler l'idée de ses moyens, A*» molécules organiques vivantes ont existé dès que les élémens d'une chaleur douce ont pu s'incorporer avec les substances qui composent les corps organisés; elles oui produit sur les parties" élevées du globe une infinité de végétaux, et dans les eaux un nombre immense de coquillages, de crustacés, et de poissons, qui se sont bientôt multipliés par la voie de la génération. Cette multiplication des végétaux et des coquillages, quelque rapide qu'on puisse la supposer, n'a pu se faire que dans un grand nombre de siècles, puisqu'elle a produit des volumes aussi prodigieux que le sont ceux de leurs détrimens. En effet, pour juger de ce qui s'est passé, il faut considérer . ce qui se passe: or ne faut-il pas bien des années pour que des huîtres qui s'amoncèlent dans quelques endroits de la mer s"y multiplient en assez grande quantité pour former une espèce de rocher? El combien n'a-t-il pas fallu de siècles pour que toute la matière calcaire de la surface du globe ait été produite? Et n'est-on pas forcé d'admettre non seulement des siècles, mais des siècles de siècles, pour que ces productions marines aient été non seulement réduites en poudre, mais transportées et déposées par les eaux, de manière à pouvoir former les craies, les marnes, les marbres, et les pierres calcaires? Et combien de siècles encore ne faut-il pas admettre pour que ces mêmes matières calcaires, nouvellement déposées par les eaux, se soient purgées de leur humidité superflue, puis sérers et durcies aju point qu'elles le sont aujourd'hui et depuis si long-temps?

Comme le globe terrestre n'est pas une sphère parfaite, qu'il est plus épais sous l'équateur que sous les pôles, et que l'action du soleil est aussi bien plus grande dans les climats méridionaux, il en résulte que les contrées polaires ont été refroidies plus tôt que celles de l'équateur. Ces parties polaires de la terre ont donc reçu les preneurs les eaux et les matières volatiles qui sont tombées de l'atmosphère: le reste de ces eaux a dû tomber ensuite sur les climats que nous appelons tempérés, et ceux de l'équateur auront été les derniers abreuvés. Il s'est passé bien des siècles avant que les parties de l'équateur aient été assez attiédies pour admettre les eaux; l'équilibre et même l'occupation des mers a donc été long-temps à se former et à s'établir, et les premières

inondations ont dû venir des deux pôles. Mais nous avons remarqué 1 que tous les continens terrestres finissent en pointe vers les régions australes: ainsi les eaux sont venues en plus grande quantité du pôle austral que du pôle boréal, d'où elles ne pouvoient que refluer et non pas arriver, <lu moins avec autant de force; sans quoi les continens auraient pris une forme toute différente de celle qu'ils nous présentent; ils se seraient élargis vers les plages australes, au lieu de se rétrécir. En effet, les contrées du pôle austral ont dû se refroidir plus vite que celles du pôle boréal, et par conséquent recevoir plus tôt les eaux de l'atmosphère, parce que le soleil fait un peu moins de séjour sur cet hémisphère austral que sur le boréal; et cette cause me paraît suffisante pour avoir déterminé le premier mouvement des eaux, et le perpétuer ensuite assez longtemps pour avoir aiguisé les pointes de tous les continens terrestres.

D'ailleurs il est certain que les deux continens n'étoient pas encore séparés vers notre nord, et que même leur séparation ne s'est faite que long-temps après l'établissement de la nature vivante dans nos climats septentrionaux, puisque les éléphans ont en même temps existé en Sibérie et au Canada; ce qui prouve invinciblement la continuité de l'Asie ou de l'Europe avec l'Amérique, tandis qu'au contraire il paraît également certain que l'Afrique étoit, dès les premiers temps, séparée de l'Amérique méridionale, puisqu'on n'a pas trouvé dans cette partie du Nouveau Monde un seul des animaux de l'ancien continent, ni aucune dépouille qui puisse indiquer qu'ils y aient autrefois existé. Il paraît que les éléphans dont on trouve les ossemens dans l'Amérique septentrionale y sont de meures confines; qu'ils n'ont pu franchir les hantes montagnes qui sont au sud de Tistlime de Panama, et qu'ils n'ont jamais pénétré dans les vastes contrées de l'Amérique méridionale: mais il est encore plus certain que les mers qui séparent l'Afrique et l'Amérique existoient avant la naissance des éléphans en Afrique; car si ces deux conlinens eussent été contigus, les animaux de Guinée se trouveraient au Brésil, et l'on eût trouvé des dépouilles de ces animaux dans l'Amérique méridionale, comme l'on en trouve dans les terres de l'Amérique septentrionale.

Ainsi, dès l'origine et dans le commencement de la naturè vivante, les terres les plus élevées du globe et les parties de notre nord ont été les premières peuplées par les espèces d'animaux terrestres auxquels la grande chaleur convient le mieux: les régions de l'équateur sont demeurées long-temps désertes, et même arides et sans mers. Les terres élevées de la Sibérie, de la Tartarie, et de plusieurs autres endroits de l'Asie, toutes relies de l'Europe qui forment la chaîne des montagnes de Galice, des Pyrénées, de l'Auvergne, des Alpes, des Apennins, de Sicile, de la Grèce, et de la Macédoine, ainsi que les monts Riphées, Rymniques, etc., ont été les premières contrées habitées, même pendant plusieurs siècles, tandis que toutes les terres moins élevées étoient encore couvertes par les eaux.

Pendant ce long espace de durée que la mer a séjourné sur nos terres, les sédimens et les dépôts des eaux ont formé les couches horizontales de la terre, les inférieures d'argiles, et les supérieures de pierres calcaires. C'est dans la mer même que s'est opérée la pétrification des marbres et des pierres: d'abord ces matières étoient molles, ayant été successivement déposées les unes sur les autres, à mesure que les eaux les amenoient et les laissoient tomber en forme de sédiment; ensuite elles se sont peu à peu durcies par la force de l'affinité de leurs parties constituantes, et enfin elles ont formé toutes les masses des rochers calcaires, qui sont composées de couches horizontales ou également inclinées, comme le sont toutes les autres matières déposées par les eaux.

C'est dès les premiers temps de cette même période de durée que se sont déposées les argiles où se trouvent les débris des anciens coquillages; et ces animaux à coquilles n'étoient pas les seuls alors existans dans la mer; car, indépendamment des coquilles, on trouve des débris de crustacés, des pointes d'oursins, des vertèbres d'étoiles, dans ces mêmes argiles; et dans les ardoises, qui ne sont que des argiles durcies et mêlées d'un peu de bitume, on trouve, ainsi que dans les schistes, des impressions entières et très bien conservées de plantes, de crustacés, et de poissons de différentes grandeurs: enfin, dans les minières de chai bon de terre, la masse entière de charbon ne paroit

composée que de débris de végétaux. Ce sont là es plus anciens monumens de la nature vivante, et les premières productions organisées tant de la mer que de la terre.

Les régions septentrionales, et les parties les plus élevées du globe, et surtout les sommets des montagnes dont nous avons fait l'énumération, et qui, pour la plupart, ne présentent aujourd'hui que des faces sèches et des sommets stériles, ont donc autrefois été des terres fécondes, et les premières où la nature se soit manifestée, parce que ces parties du globe ayant été bien plus tôt refroidies que les terres plus basses ou plus voisines de l'équateur, elles auront les premières reçu les eaux de l'atmosphère et toutes les autres matières qui pouvoient contribuer à la fécondation. Ainsi l'on peut présumer qu'avant l'établissement fixe des mers toutes les parties de la terre qui se trouvoient supérieures aux eaux ont été fécondées, et qu'elles ont dû, dès lors et dans ce temps, produire les plantes dont nous retrouvons aujourd'hui les impressions dans les ardoises, et toutes les substances végétales qui composent les charbons de terre.

Dans ce même temps où nos terres étoient couvertes par la mer, et tandis que les bancs calcaires de nos collines se formoient des détrimens de ses productions, plusieurs monumens nous indiquent qu'il se détachoit du sommet des montagnes primitives, et des autres parties découvertes du globe, une grande quantité de substances vitrescibles, lesquelles sont venues par alluvion, c'est-àdire par le transport des eaux, remplir les fentes et les autres intervalles que les masses calcaires laissoient entre elles. Ces fentes perpendiculaires, ou légèrement inclinées dans les bancs calcaires, se sont formées par le resserrement de ces matières calcaires, lorsqu'elles se sont séchées et endurcies, de la même manière que s'étoient faites précédemment les premières fentes perpendiculaires dans les montagnes vitrescibles produites par le feu, lorsque ces matières se sont resserrées par leur consolidation. Les pluies, les vents, et les autres agens extérieurs, avoient déjà détaché de ces masses autour desquelles tournent les veines de la mine, toujours accompagnées de la terre rouge, qui souvent traverse les veines de la mine ou bien est appliquée contre les parois des rochers calcaires qui la renferment. Et ce qui prouve d'une manière évidente que ces dépots de mines se sont faits par le mouvement des eaux, c'est qu'après avoir vidé les fentes et cavités qui les contiennent, on voit, à ne pouvoir s'y tromper, que les parois de ces fentes ont été usées et même polies par l'eau, et que, par conséquent, elle les a remplies et baignées pendant un assez long temps, avant n'y avoir dépose la mine de fer, les petils cailloux, le sable vitrescible, et la terre limoneuse dont ces fentes sont actuellement remplies: et l'on ne peut pas se prêter à croire que les grains de 1er se soient formés dans cette terre limoneuse depuis qu'elle a été déposée dans ces fentes de rochers; car une chose tout aussi évidente que la première s'oppose à cette idée, c'est que la quantité de mines de fer paroit surpasser de beaucoup celle de la terre limoneuse. tes grains de cette substance métallique ont, à la vérité, tous été formés dans cette même terre, qui n'a rllemême été produite que par le résidu des matières animales et végétales, dans le pmel nous démontrerons la production du fer en grains; mais cela s'est fait avant leur transport et leur dépôt dans les fentes des rochers. La terre limoneuse, les grains de fer, le sable vitrescible et les petits cailloux, ont été transportés et déposés ensemble; et si depuis il s'est forme dans cette même terre des grains de fer, ce ne peut être qu'eu petite quantité. J'ai tiré de chacune de ces mines plusieurs milliers de tonneaux; et, sans avoir mesuré exactement la quantité de terre limoneuse qu'on a laissce dans ces mêmes cavités, j'ai vu qu'elle étoit bien moins considérable que la quantité de mine de fer dans chacune.

Mais ce qui prouve encore que ces mines de fer eu grains ont été toutes amenées par le mouvement des eaux, c'est que, dans ce même canton, à trois lieues de distance, il y a une assez grande étendue de terre formant une espèce de petite plaine au dessus des collines calcaires, et aussi élevée que celles dont je viens de parler, et qu'on trouve dans ce terrain une grande quantité de mine de fer en grains qui est très différemment mélangée et autrement située: car, au lieu d'occuper les fentes perpendiculaires et les cavités intérieures calcaires, »u lieu de former un sacs perpendiculaires, cette mine de fer est au contraire déposée en nappe, c'est-à-dire par couches

horizontales, comme tous les autres sédimens des eaux; au lieu de descendre profondément comme les premières, elle s'étend presque à la surface du terrain sur une épaisseur de quelques pieds; au lieu d'être mélangée de cailloux et de sable vitrescible, elle n'est, au contraire, mêlée partout que de graviers et de sables calcaires. Elle présente de plus un phénomène remarquable: c'est un nombre prodigieux de cornes d'ammon et d'autres anciens coquillages, en sorte qu'il semble que la mine entière en soit composée, tandis que dans les huit autres mines dont j'ai parlé ci-dessus, il n'existe pas le moindre vestige de coquilles, ni même aucun fragment, aucun indice du genre calcaire, quoiqu'elles soient enfermées entre des masses de pierres entièrement calcaires. Cette autre mine, qui contient un nombre si prodigieux de débris de coquilles marines, même des plus anciennes, aura donc été transportée avec tous ces débris de coquilles par le mouvement des eaux, et déposée en forme de sédiment par couches horizontales; et les grains de fer qu'elle contient, et qui sont encore bien plus petits que ceux des premières mines, mêlées de cailloux, auront été amenés avec les coquilles mêmes. Ainsi le transport de toutes ces matières et le dépôt de toutes ces mines de fer en grains se sont faits par alluvion à peu près dans le même temps, c'est-à-dire lorsque les mers couvroient encore nos collines calcaires.

Et le sommet de toutes ces collines, ni les collines elles-mêmes, ne nous représentent plus à beaucoup près le même aspect qu'elles avoient lorsque les eaux les ont abandonnées. A peine leur forme primitive s'est-elle maintenue; leurs angles saillans et rentrans sont devenus plus obtus, leurs pentes moins rapides, leurs sommets moins élevés et plus chenus; les pluies en ont détaché et entraîné les terres: les collines se sont donc rabaissées peu à peu, et les vallons se sont en même temps remplis de ces terres entraînées par les eaux pluviales ou courantes. Qu'on se figure ce que devoit être autrefois la forme du terrain à l'aria et aux environs; d'une part sur les collines de Yaugirard jusqu'à Sèvre, ou voit des carrières de pierres calcaires remplies de coquilles pétrifiées; de l'autre côté, vers Montmartre, des collines de plâtre et de matières argileuses; et ces collines, à peu près également élevées au dessus de la Seine, ne sont aujourd'hui que d'une hauteur très médiocre; mais au fond des puits que l'on a faits à Bicètre et à l'École militaire on a trouvé des bois travaillés de main d'homme à soixante-quinze pieds de profondeur. Ainsi l'on ne peut douter que cette vallée de la Seine ne se soit remplie de plus de soixante-quinze pieds, seulement depuis que les hommes existent: et qui sait de combien les collines adjacentes ont diminué dans le même temps par l'effet des pluies, et quelle étoit l'épaisseur de terre dont elles étoient autrefois revêtues? Il en est de même de toutes les autres collines et de toutes les autres vallées; elles étoient peut-être du double plus élevées et du double plus profondes dans le temps que les eaux de la mer les ont laissées à découvert. On est même assuré que les montagnes s'abaissent encore tous les jours et que les vallées se remplissent à peu près dans la même proportion; seulement cette diminution de la hauteur des montagnes, qui ne se fait aujourd'hui que d'une manière presque insensible, s'est faite beaucoup plus vite dans les premiers temps, en raison de la plus grande rapidité de leur pente, et il faudra maintenant plusieurs milliers d'années pour que les inégalités de la surface de la terre se réduisent encore autant qu'elles l'ont fait en peu de siècles dans les premiers âges.

Mais revenons à cette époque antérieure où les eaux, après être arrivées des régions polaires, ont gagné celles de l'équateur. C'est dans ces terres de la zone torride où se sont faits les plus grands bouleversemens: pour en être convaincu, il ne faut que jeter les yeux sur un globe géographique;'on reconnoîtra que presque tout l'espace compris entre ha cercles de cette zone ne présente que les débris de continens bouleversés et d'une terre ruinée. L'immense quantité d'îles, de détroits, de hauts et de bas fonds, de bras de mer et de terre entrecoupés, prouve les nombreux affaissemens qui se sont faits dans cette vaste partie du monde. Les montagnes y sont plus élevées, les mers plus profondes, que dans tout le reste de la terre; et c'est sans doute lorsque ces grands affaissemens se sont faits dans les contrées de l'équateur que les eaux qui couvroient nos continens se sont abaissées et retirées en coulant à grands flots vers ces terres du midi. dont elles ont rempli les

profondeurs en laissant à découvert d'abord les parties les plus élevées des terres, ensuite toute la surface de nos continens.

Qu'on se représente l'immense quantité des matières de toute espèce qui ont alors été transportées par les eaux: combien de sédimens de différente nature n'ont-elles pas déposés les uns sur les autres, et combien, par conséquent, la première face de la terre n'a-t-elle pas changé par ces révolutions! D'une part, le flux et le reflux donnoient aux eaux un mouvement constant d'orient en occident; d'autre part, les alluvions venant des pôles croisoient ce mouvement, et déterminoient les efforts de la mer autant et peut-être plus vers l'équateur que vers l'occident. Combien d'irruptions particulières se sont faites alors de tous cotés! A mesure que quelque grand affaissement présentait une nouvelle profondeur, la mer s'abaissoit et les eaux couraient pour la remplir; et quoiqu'il paroisse aujourd'hui que équilibre des mers soit à peu près établi, et que toute leur action se réduise à gagner quelque terrain vers l'occident et en laisser à découvert vers l'orient, il est néanmoins très certain qu'en général les mers baissent tous les jours de plus en plus, et qu'elles baisseront encore à mesure qu'il se fera quelque nouvel affaissement, soit par l'effet des volcans et des tremblemens de terre, soit par des causes plus constantes et plus simples: car toutes les parties caverneuses de l'intérieur du globe ne sont pas encore affaissées; les volcans et les secousses des tremblemens de terre en sont une preuve démonstrative. Les eaux mineront peu à peu (es voûtes et les remparts de ces cavernes souterraines; et lorsqu'il s'en écroulera quelques-unes, la surface de la terre, se déprimant dans ces endroits, formera de nouvelles vallées dont la mer viendra s'emparer. Néanmoins, comme ces événemens, qui, dans les commencemens, devoient être très fréquens, sont actuellement assez rares, on peut croire que la terre est à peu près parvenue à un état assez tranquille pour que ses habitans n'aient plus à redouter les désastreux effets de ces grandes convulsions.

L'établissement de toutes les matières métalliques et minérales a suivi d'assez près l'établissement des eaux; celui des matières argileuses et calcaires a précédé leur retraite; la formation, la situation, la position de toutes ces dernières matières, datent du temps où la mer couvrait les confinais. Mais nous devons observer que le mouvement général des mers ayant commencé de se faire alors comme il se lait encore aujourd'hui d'orient en occident, elles ont travaillé la surface de la terre dans ce sens d'orient en occident autant et peut-être plus qu'elles ne l'avoient fait précédemment dans le sens du midi au nord. L'on n'eu doutera pas si l'on fait attention à un fait très général et très vrai: c'est que, dans tous les continens du monde, la pente des terres, à la prendre du sommet des montagnes, est toujours beaucoup plus rapide du côté de l'occident que du côté de l'orient1; cela est évident dans le continent entier de l'Amérique, où les sommets de la chaîne des Cordillères sont très voisins partout des mers de l'ouest, et sont très éloignés de la mer de l'est. La chaîne qui sépare l'Afrique dans sa longueur, et qui s'étend depuis le cap de Bonne - Espérance jusqu'aux monts de la Lune, est aussi plus voisine des mers à l'ouest qu'à l'est. Il en est de même des montagnes qui s'étendent depuis le cap Comorin dans la presqu'ile de l'Inde; elles sont bien plus près de la mer à l'orient qu'à l'occident; et si nous considérons les presqu'iles, les promontoires, les iles, et toutes les terres environnées de la mer, nous reconnoitrons partout que les pentes sont courtes et rapides vers l'occident, et qu'elles sont douces et longues vers l'orient: les revers de toutes les montagnes sont de même plus escarpés à l'ouest qu'à l'est, parce que le mouvement général des mers s'est toujours fait d'orient en occident, et qu'à mesure que les eaux se sont abaissées elles ont détruit les terres et dépouillé les revers des montagnes dam le sens de leur chute, comme l'on voit dans une cataracte les rochers dépouillés et les terres creusées par la chute continuelle de l'eau. Ainsi tous les continens terrestres ont été d'abord aiguisés en pointe vers le midi par tes eaux qui sont venues du pôle austral plus abondamment que du pôle boréal; et ensuite ils ont été tous escarpés en pente plus rapide à l'occident qu'à l'orient, dans le temps subséquent où ces mêmes eaux ont obéi au seul mouvement général qui les porte constamment d'orient en occident.

Additions De Buffon

On voit plusieurs exemples de plantes qui croissent dans les eaux thermales les plus chaudes, et M. Sonnerat a trouvé des poissons dans une eau dont la chaleur étoit si active, qu'il ne pouvoit y plonger la main. Voici l'extrait de sa relation à ce sujet: « Je trouvai, dit-il, à deux lieues de Calamha, dans l'ile de Luçon, près du village de Bailv, un ruisseau dont l'eau étoil chaude au point que le thermomètre, division de Réaumur, plongé dans ce ruisseau, à une lieue de sa source, marquoit encore 69 degrés. J'imaginois, en voyant lin pareil degré de chaleur, que toutes les productions de la nature devoient être éteintes sur les bords du ruisseau, et je fus Irès-surpris de voir trois arbrisseaux très vigoureux dont les racines trempoient dans cette eau bouillante, et dont les branches étoient environnées de sa vapeur; elle éloit si considérable, que les hirondelles qui osoient traverser ce ruisseau à la hauteur de sept ou huit pieds y tomboient sans mouvement. L'un de ces trois arbrisseaux étoit un agnus cas/us, et les deux autres des asfmlathus. Pendant mon séjour dans ce village, je ne bus d'autre eau que celle de ce ruisseau, que je faisois refroidir: son goût me parut terreux et ferrugineux. On a construit différens hains sur ce ruisseau, dont les degrés de chaleur sont proportionnés à la distance de la source. Ma surprise redoubla lorsque je vis le premier hain: des poissons nageuient dans cette eau où je ne pouvois plonger la main. Je fis tout ce qu'il me fut possible pour me procurer quelques-uns de ces poissons; mais leur agilité et la maladresse des gens du pays ne me permirent pas d'en prendre un seul. Je les examinai nageant; mais la vapeur de l'eau ne me permit pas de les distinguer assez bien pour les rapprocher de quelque geure: je les reconnus cependant pour des poissons à écailles brunes; la longueur des plus grands éloit de quatre pouces. J'ignore comment ces poissons sont parvenus dans ces hains. »

M. Sonnerai appuie son récit du témoignage de M. Prevost, commissaire de la marine, qui a parcouru avec lui l'intérieur de l'ile de Luron. Yoici comment est conçu ce témoignage:

Tous avez eu raison, monsieur, de faire part à M. de Buffon des observations que vous avez rassemblées dans le voyage que nous avons fait ensemble. Vous désirez que je confirme par écrit celle qui nous a si fort surpris dans le village de liaily, situé sur le bord de la lagune de Manille, à Los-Bagnos: je suis fâché de n'avoir point ici la noie de nos observations faites avec le thermomètre de M. de Réaumur; mais je me rappelle très bien que l'eau du petit ruisseau qui passe dans ce village pour se jeter dans le lac fit monter le mercure à 66 ou 67 degrés, quoiqu'il n'eut été plongé qu'à une lieue de sa source: les bords de ce ruisseau sont garnis d'un gazon toujours vert. Vous n'aurez sûrement pas oublié cet agnus castus que nous avons vu en fleur, dont les racines étoient mouillées de l'eau de ce ruisseau, et la tige continuellement enveloppée de la fumée qui en sortoil. Le père franciscain, curé de la paroisse de ce village, m'a aussi assuré avoir vu des poissons dans ce même ruisseau: quant à moi, je ne puis le certifier; mais j'en ai vu dans l'un des hains dont la chaleur faisoit monter le mercure à 48 et 5o degrés. Voilà ce que vous pouvez certifier avec assurance. Signe Privost. » (Poyage à la Nouvelle-Guinée, par M. Sonnerat, correspondant de l'Académie des Sciences et du Cabinet du Roi; Paris, 1776; pages 38 et sùiv.)

Je ne sache pas qu'on ait trouvé des poissons dans nos eaux thermales; mais il est certain que, dans celles mêmes qui sont les plus chaudes, le fond du terrain est tapissé de plantes. M. l'abbé Mazéas dit expressément que dans l'eau presque bouillante de la solfatare de Viterbe le fond du bassin est couvert des mêmes plantes qui croissent au fond des lacs et des marais. (Mémoires des savons étrangers, tome V, page 325.)

Les grosses dents à pointes mousses dont nous avons parlé indiquent une espèce gigantesque, relativement aux autres espèces, et même à celle de l'éléphant; mais cette espèce gigantesque n'existe plus. D'autres grosses dems, dont la face qui broie est ligurée en trèfle, comme celle des hippopotames, et qui néanmoins sont quatre fois plus grosses que celles des hippopotames actuellement subsistans, démontrent qu'il y a eu des individus très gigantesques dans l'espèce de l'hippopotame. D'énormes fémurs, plus grands et beaucoup plus épais que ceux de nos éléphans,

demontrent la même chose pour les éléphans; et nous pouvons ciler encore quelques exemples qui vont à l'appui de notre opinion sur les animaux gigantesques.

On a trouvé auprès de Rome, en 177a, une tète de bœuf pétrifiée, dont le P. Jannier a donné la description. « La longueur u front, comprise entre les deux cornes, est, dit-il, de 2 pieds 3 pouces; la distance entre les orbites des yeux, de 14 pouces; celle depuis la portion supérieure du front jusqu'à l'orbite de l'œil, de i pied 6 pouces; la circonférence d'une corne mesurée dans le bourrelet inférieur, de i pied 6 pouces; la longueur d'une corne mesurée dans doute sa courbure, de 4 pieds; la distance des sommets des cornes, de 3 pieds: l'intérieur est d'une pétrification très dure: cette tète a été trouvée dans un fonds de pouzzolane, à la profondeur de plus de ao pieds.

On voyoit, en 1768, dans la cathédrale de Strasbourg, une très grosse corne de bœuf, suspendue par une chaîne contre un pilier près du chœur; elle m'a paru excéder trois fois la grandeur ordinaire de celles des plus grands bœufs: comme elle est fort élevée, je n'ai pu en prendre les dimensions; mais je l'ai jugée d'environ 4 pieds 1/2 de longueur sur 7 à 8 pouces de diamètre au gros bout '.

Lionel Waffer rapporte qu'il a vu, au Mexique, des ossemens el des dents d'une prodigieuse grandeur; entre autres une dent de 3 pouces de large sur 4 pouces de longueur, et que les plus habiles gens du pays ayant été consultés jugèrent que la tète ne trouvoit pas avoir moins d'une aune de argeur. (Waffer, Voyage en Amérique, page 367.)

Cest peut-être la même dent dont parle le P. Acosta. « J'ai vu, dit-il, une dent molaire qui m'étonna beaucoup par son énorme grandeur, car elle étoit aussi grosse que le poing d'un homme. » Le P. Torquemado, franciscain, dit aussi qu'il a eu en son pouvoir une dent molaire deux fois aussi grosse que le poing, et qui pesoit plus de deux livres: il ajoute que, dans celle même ville de Mexico, au couvent de Saint-Augustin, il avoit vu un os fémur si grand, que l'individu auquel cet os avoit appartenu devoit avoir été haut de it à 12 coudées, c'est-à-dire 17 ou 18 pieds, et que la tète dont la dent avoit été tirée étoit aussi grosse qu'uoe de ces grandes cruches dont on se sert eu Castille pour mettre le vin.

Philippe Hernandes rapporte qu'on trouve à Tezcaco et à Tosuea plusieurs os de grandeur extraordinaire, et que, parmi ces os, il y a des dents molaires larges de 5 pouces et hautes de ro; d'où l'ou doit conjecturer que la grosseur de la tète à laquelle elles appartenoient éloit si énorme, que deux hommes auraient à peine pu l'embrasser. Don Lorenzo Boturini Benaduci dit aussi que, dans la Nouvelle-Espagne, surtout dans les hauteurs de Santa-Fé et daus le territoire de la Puebla et de Tlascallan, on trouve des os énormes et des dents molaires, dont une qu'il conservoit dans son cabinet est cent lois plus grosse que les plus grosses dents humaines. (Gigantologie espagnole, par le P. Torrubia, Journal étranger, novembre 1760.)

L'auteur de cette Gigantologie espagnole attribue ces dents énormes et ces grands os à des géans de l'espèce humaine. Mais est-il croyable qu'il y ait jamais eu des hommes dont la tète ait eu 8 à 10 pieds de circonférence? N'cst-il pas même assez étonnant que, dans l'espèce de l'hippopotame ou de l'éléphant, il y en ait eu de cette grandeur? Nous pensons donc que ces énormes dents sont de la même espèce que celles qui ont été trouvées nouvellement eu Canada sur la rivière d'Ohio, que nous avons dit appartenir à un animal inconnu dont l'espèce étoit autrefois existante en Tartarie, en Sibérie, au Canada, el s'est étendue depuis les Illinois jusqu'au Mexique. Et comme ces auteurs espagnols ne disent pas que l'on ait trouvé, dans la Nouvelle-Espagne, des défenses d'éléphans mêlées avec ces grosses dents molaires, cela nous fail présumer qu'il y avoit en effet une espèce différente de celle de l'éléphant, à laquelle ces grosses dents molaires appartenoient, laquelle est parvenue jusqu'au Mexique. Au reste, les grosses dents d'hippopotame paroissent avoir été anciennement connues; car saint Augustin dit avoir vu une dent molaire si grosse, qu'en la divisant

elle auroit fait cent dents molaires d'un homme ordinaire 2. Fulgose dit aussi qu'on a trouvé en Sicile des dents dont chacune pesoit trois livres.

M. Jobn Sommer rapporte avoir trouvé, à Chat liant, près de Cantorbery, à 17 pieds de profondeur, quelques os étrangers et monstrueux, les uns entiers, les autres rompus, et quatre dents saines et parfaites pesant chacune un peu plus d'une demi-livre, grosses à peu près comme le poing d'un homme: toutes quatre étoient des dents molaires ressemblant assez aux dents molaires de l'homme, si ce n'est par la grosseur. Il dil que Louis "Vives parle d'une dent encore plus grosse 4 qui lui fut montrée pour une dent de saint Cbristophe. Il dit aussi qu'Acosta rapporte avoir vu dans les Indes une dent semblable qui avoit été tirée de terre avec plusieurs autres os, lesquels rassemblés et arrangés représentoient un homme d'une structure prodigieuse, OU plutôt monstrueuse '. Nous aurions pu, dit judicieusement M. Sommer, juger de même des dents qu'on a tirées delà lerre auprès de Cantorbery, si l'on n'eût pas trouvé avec ces mêmes dents des os qui ne pouvoient être des os d'homme; quelques personnes qui les ont vues ont jugé que les os et les dents étoient d'un hippopotame. Deux de ces dents sont gravées dans une planche qui est à la têle du n° 27a des Transactions philosophiques.

On peut conclure de ces faits que la plupart des grands os trouvés dans le sein de la terre sont des os d'éléphans et d'hippopotames; mais il me pai oit certain, par la comparaison immédiate des énormes dents à pointes mousses avec les dens de l'éléphant et de l'hippopotame, qu'elles ont appartenu à un animal beaucoup plus gros que l'un et l'autre, el que l'espèce de ce prodigieux animal ne subsiste plus aujourd'hui.

Dans les éléphans actuellement existans, il est extrêmement rare d'en trouver dont les défenses aient six pieds de longueur. Les plus grandes sont communément de cinq pieds à cinq pieds et demi, et par conséquent l'ancien éléphant auquel a appartenu la défense de dix pieds de longueur, dont nous avons les fragmens, étoit un géant dans cette espèce, aussi bien que celui dont nous avons un fémur d'un tiers plus gros et plus grand que les fémurs des éléphans ordinaires.

Il en est de même dans l'espèce de l'hippopotame; j'ai fait arracher les deux plus grosses dents molaires de la plus grande tète d'hippopotame que nous ayons au Cabinet du Roi: l'une de ces dems pèse 1 o onces, et l'autre 9 onces 1/2. J'ai pesé ensuite deux dents, l'une trouvée en Sibérie, et l'autre au Canada; la première pèse 2 livies 12 onces, et la seconde 2 livres 2 onces. Ces anciens hippopotames étoient, comme l'on voit, bien gigantesques eu comparaison de ceux qui existent aujourd'hui.

L'exemple que nous avons cité de l'énorme téle de bœuf pétrifiée trouvée aux environs de Rome prouve aussi qu'il y a eu de prodigieux géans dans cette espèce, el nous pouvons le démontrer par plusieurs autres monumens. Nous avons au Cabinet du Roi: i° Une corne d'une belle couleur verdàlre, très lisse et bien contournée, qui est évidemment une corne de bœuf; elle porte 25 pouces de circonférence à la hase, et sa longueur est de 42 pouces; sa cavité contient u pintes 1/4 de Paris. 20 Un os de l'intérieur de la corne d'un bœuf, du poids de 7 livies; tandis que le plus grand os de nos bœufs, qui soutient la corne, ne pèse qu'une livre. Cet os a été donné pour ie Cabinet du Roi par M. le comte de Tressan, qui joint au goût et aux talens beaucoup de connaissances en histoire naturelle. 3" Deux os de l'intérieur des cornes d'un bœuf réunis par un morceau du crâne, qui ont été trouvés à 2$ pieds de profondeur dans les couches de tourbe, entre Amiens et Abbeville, et qui. m'ont été envoyés pour le Cabinet du Roi: ce morceau pèse 17 livres; ainsi chaque os de la corne, étant séparé de la portion du crâne, pèse au moins 7 livres 1/2. J'ai comparé les dimensions comme les poids de ces différens os: celui du plus gros bœuf qu'on a pu trouver à la boucherie de Paris n'avoit que i3 pouces de longueur sur 7 pouces de circonférence à la hase, tandis que des deux autres tirés du sein de la terre, l'un a 24 pouces de longueur sur 12 pouces de circonférence à la hase, et l'autre 27 pouces de longueur sur i3 de circonférence. En voilà plus qu'il

n'en faut pour démontrer que, dans l'espèce du bœuf, comme dans celles de l'hippopotame et de l'éléphant, il y a eu de prodigieux géans.

Sur cela nous observerons, avec M. Lehman, qu'on ne trouve guère des empreintes de plantes dans les mines d'ardoise, à l'exception de celles qui accompagnent les mines de charbon de terre; et qu'au contraire on ne trouve ordinairement les empreintes de poissons que dans les ardoises cuivreuses.

On a remarqué que les bancs d'ardoise chargés de poissons pétrifiés, dans le comté de Mansfeld, sont surmontés d'un banc de pierres appelées puantes; c'est une espèce d'ardoise grise, qui a tiré son origine d'une eau croupissante, dans laquelle les poissons avoient pourri avant de se pétrifier. (Lceberoth, Journal économique, juillet 1752.)

M. Hoffman, en parlant des ardoises, dit que non seulement les poissons que l'on y trouve pétrifiés ont été des créatures vivantes, mais que les couches d'ardoises n'ont été que le dépôt d'une eau fangeuse, qui, après avoir fermenté el s'être pétrifiée, s'étoit précipitée par couches très minces.

Les ardoises d'Angers, dit M. Guettard, présentent quelquefois des empreintes de plantes et de poissons qui méritent d'autan t plus d'attention, que les plantes auxquelles ces empreintes sont dues étoient des fucus de mer, et que celles des poissons représentent différens crustacés ou animaux delà classe des écrevisses, dont les empreintes sont plus rares que celles des poissons et des coquillages. Il ajoute qu'après avoir consulté plusieurs auteurs qui ont écrit sur les poissons, les écrevisses, et les crabes, il n'a rien trouvé de ressemblant aux empreintes en question, si ce n'est le pou de mer, qui y a quelques rapports, mais qui en diffère néanmoins par le nombre de ses anneaux, qui sont au nombre de treize; au lieu que les anneaux ne sont qu'au nombre de sept ou huit dans les empreintes de l'ardoise: les empreintes de poissons se trouvent communément parsemées de malière pyriteuse et blanchâtre. Une singularité, qui ne regarde pas plus les ardoises d'Angers que celles des autres pays, tombe sur la fréquence des empreintes de poissons et la rareté des coquillages dans les ardoises, tandis qu'elles sont si communes dans les pierres à chaux ordinaires. » (Mémoires de C Académie des Sciences, année 1757, page 5a.)

On peut donner des preuves démonstratives que tous les charbons de terre ne sont composés que de débris de végétaux, mêlés avec du bitume et du soufre, ou plutot de l'acide vitriolique, qui se fait sentir dans la combustion: on reconnoit les végétaux souvent en grand volume dans les couches supérieures des veines de charbon de terre; et, à mesure que l'on descend, on voit les nuances de la décomposition de ces mêmes végétaux. Il y a des espèces de charbon de terre qui ne sont que des bois fossiles: celui qui se trouve à Sainte Agnès, près Lons-le Saunier, ressemble parfaitement à des bûcbes on tronçons de sapins; on y remarque très distinctement les veines de chaque crue annuelle, ainsi que le cœur: ces tronçons ne diffèrent des sapins ordinaires qu'en ce qu'ils sont ovales sur la longueur, et que leurs veines forment autant d'ellipses concentriques. Ces bûcbes n'ont guère qu'environ un pied de tour, et leur écorce est très épaisse et fort crevassée, comme celle des vieux sapins; au lieu que les sapins ordinaires de pareille grosseur ont toujours une écorce assez lisse.

J'ai trouvé, dit M. de Gensanne, plusieurs liions de ce même charbon dans le diocèse de Montpellier: ici les tronçons sont très gros, leur tissu est très semblable à celui des châtaigniers de trois à quatre pieds de tour. Ces sortes de fossiles ne donnent au feu qu'une légère odeur d'asphalte; ils brûlent, donnent de la flamme et de la braise comme le bois; c'est ce qu'on appelle communément en France de la houille; elle se trouve fort près de la surface du terrain: ces houilles annoncent, pour l'ordinaire, du véritable charbon de terre à de plus grandes profondeurs. {Histoire naturelle du Languedoc, par M. de Gensanne, tome I, page ao.)

Ces charbons ligneux doivent être regardés comme des bois déposés dans une terre bitumineuse à laquelle est due leur qualité de charbons fossiles: on ne les trouve jamais que dans ces sortes de terres, et toujours assez près de la surface du terrain; il n'est pas même rare qu'ils forment la tète des veines d'un véritable charbon; il y en a qui, n'ayant reçu que peu de substance bitumineuse, ont conservé leurs nuances de couleur de bois. « J'en ai trouvé de cette espèce, dit M. de Gensanne, aux Cazarets, près de Saint-Jeau-de-Cucul, à quatre lieues de Montpellier; mais pour l'ordinaire la fracture de ce fossile présente une surface lisse, entièrement semblable à celle du jayet. Il y a dans le même canton, près d'Aseras, du bois fossile qui est en partie changé en une vraie pyrite blancbe ferrugineuse. La matière minérale y occupe le cœur du bois, et on y remarque très distinctement la substance ligneuse, rongée en quoi-que sorte et dissoute par l'acide minéraliseur. « {Histoire naturelle du Languedoc, tome I, page 54.)

J'avoue que je suis surpris de voir qu'après de pareilles preuves rapportées par M. de Gensanne lui-même, qui d'ailleurs est bon minéralogiste, il attribue néanmoins l'origine du charbon de terre à l'argile plus ou moins imprégnée de bitume: non seulement les faits que je viens de citer d'après lui démentent cette opinion, mais on verra, par ceux que je vais rapporter, qu'on ne doit attribuer qu'aux détrimens des végétaux mêlés de bitumes la masse entière de toutes les espèces de charbons de terre.

Je sens bien que M. de Gensanne ne regarde pas ces bois fossiles, non plus que la tourbe et même la houille, comme de véritables charbons de terre entièrement formés; et en cela je suis de son avis. Celui qu'on trouve auprès de Lons-le-Saunier a été examiné nouvellement par M. le président de Ruffey, savant académicien de Dijon. Il dit que ce bois fossile s'approcbe beaucoup de la nature des charbons de terre, mais qu'on le trouve à deux ou trois pieds de la surface . de la terre dans une étendue de deux liens sur trois à quatre pieds d'épaisseur, et que l'on reconnoit encore facilement les espèces de bois de chêne, charme, hêtre, tremble; qu'il y a du bois de corde et du fagotage; que l'écorce des bûches est bien conservée, qu'on y distingue les cercles des sèves et les coups de hache, et qu'à différentes distances on voit des amas de copeaux; qu'au reste ce charbon dans lequel le bois s'est changé est excellent pour souder le fer; que néanmoins ii répand, lorsqu'on le brûle, une odeur fétide, et qu'on en a extrait de l'alun. {Memoires de l'Académie de Djon, tome I, page 47.)

Pres du village nommé Beichlitz, à une lieue environ de la ville de Halle, on exploite deux couches composées d'une terre bitumineuse et de bois fo sile (il y a plusieurs mines de cette espèce dans le pa^s de Hesse), et celui-ci est semblable à celui que l'on trouve dans le village de Sainte-Agnès en Franche-Comté, à deux lieues de Lons-le-Saunier. Cette mine est dans le terrain de Saxe; la première couche est à trois toises et demie de profondeur perpendiculaire, et de 8 à 9 pieds d'épaisseur: pour y parvenir on traverse un sable blanc, ensuite une argile blanche et grise qui sert de toit, et qui a trois pieds d'épaisseur; on rencontre encore au dessous une bonne épaisseur tant de sable que d'argile qui recouvre la seconde couche, épaisse seulement de 3 1/2 à 4 pieds: ou a sondé beaucoup plus has sans en trouver d'autres.

Ces couches sont horizontales; mais elles plongent ou remontent à peu près comme les autres couches connues. Elles consistent en une terre brune, bitumineuse, qui est friable lorsqu'elle est sèche, et ressemble à du bois pourri. Il s'y trouve des pièces de bois de toute grosseur, qu'il faut couper à coups de hache, lorsqu'on les retire de la mine où elles sont encore mouillées. Ce bois étant sec se casse très facilement. Il est luisant dans sa cassure comme le bitume; maison v reconnoit toute l'organisation du bois. Il est moins abondant que la terre; les ouvriers le mettent à part pour leur usage.

Va boisseau ou deux quintaux de terre bitumineuse se vend dix-huit à vingt sous de France. Il y a des pyrites dans ces couches; la matière en est vitriolique; elle refleurit et blanchit à l'air: mais la

matière bitumineuse n'est pas d'un grand débit, elle ne donne qu'une chaleur foible. » (Voyages métallurgiques de M. Jars, pages 32o et suivantes.)

Tout ceci prouverait qu'en effet cette espèce de mine de bois fossile, qui se trouve si près de la surface de la terre, serait bien plus nouvelle que les mines de charbon de terre ordinaire, qui presque toutes s'enfoncent profondément: mais cela n'empêche pas que les anciennes mines de charbon n'aient été formées des débris des végétaux, puisque, dans les plus profondes, on reconnoit la substance ligneuse et plusieurs autres caractères qui n'appartiennent qu'aux végétaux; d'ailleurs on a quelques exemples de bois fossiles trouvés en grandes masses et en lits fort étendus sous des bancs de grès et sous des rochers calcaires Voyez ce que j'en ai dit à l'article des Additions sur les bois souterrains. Il n'y a donc d'antre différence entre le vrai charbon de terre et ces bois charbonifiés, que le plus ou moins de décomposition, et aussi le plus ou moins d'imprégnation par les bitumes; mais le fonds de leur substance est le même, et tous doivent également leur origine aux détrimens des végétaux.

M. Le Monnier, premier médecin ordinaire du roi, et savant botaniste, a trouvé dans le schiste ou fausse ardoise qui traverse une masse de charbon de terre en Auvergne les impressions de plusieurs espèces de fougères qui lui étoient presque toutes inconnues; il croit seulement, avoir remarqué l'impression des feuilles de l'osmonde royale, dont il dit n'avoir jamais vu qu'un seul pied dans toute l'Auvergne. (Observations d'histoire naturelle par M. Le Monnier; Paris. 1739, page t93.)

Il serait à désirer que nos botanistes fissent des observations exactes sur les impressions des plantes qui se trouvent dans les charbons de terre, dans les ardoises, et dans les schistes: il faudrait même dessiner et graver ces impressions de plantes aussi bien que celles des crustacés, des coquilles, et des poissons, que ces mines renferment; car ce ne sera qu'après ce travail qu'on pourra prononcer sur l'existence actuelle ou passée de toutes ces espèces, et même sur leur ancienneté relative. Tout ce que nous en savons aujourd'hui c'est qu'il y en a plus d'inconnues que d'autres, et que, dans celles qu'ou a voulu rapporter à des espèces bien connues, l'on a toujours trouvé des différences assez grandes pour n'être pas pleinement satisfait de la comparaison.

J'ai mis dans un vaisseau de faïence deux livres de grès en poudre, dit M. Nadault; j'ai rempli le vaisseau d'eau de fontaine distillée, de façon qu'elle surnagcoit le grès d'environ trois ou quatre doigts de hauteur; j'ai ensuite agité ce grès pendant l'espace de quelques minutes, et j'ai exposé le vaisseau eu plein air. Quelques jours après, je me suis aperçu qu'il s'étoit formé sur ce grès une couche de plus d'un quart de pouce d'épaisseur d'une terre jaunâtre très fine, très grasse, et très ductile: j'ai versé alors par inclinaison l'eau qui surnagcoit, dans un autre vaisseau, et cette terre, plus légère que le grès, s'en est séparée sans qu'il s'y soit mêlé. La quantité que j'en ai retirée par cette première lotion étoit trop considérable pour pouvoir penser que, dans un espace de temps aussi court, il eiit pu se faire une assez grande décomposition de grès pour avoir produit autant de terre: j'ai donc jugé qu'il falloit que cette terre fût déjà dans le grès dans le même état que je l'en avois retirée, et qu'il se faisoit peut-être ainsi continuellement une décomposition du grès dans sa propre mine. J'ai rempli ensuite le vaisseau de nouvelle eau distillée; j'ai agité le grès pendant quelques instans, et, trois jours après, j'ai encore trouvé sur ce grès une couche de terre de la même qualité que h première, mais plus mince de moitié. Ayant mis à part ces espèces de sécrétions; j'ai continué, pendant le cours de plus d une année, cette même opération et ces expériences que j'avois commencées dans le mois d'avril; et la quantité de terre que m'a produite ce grès a diminué peu à peu, jusqu'à ce qu'au bout de deux mois, en transvidant l'eau du vaisseau qui le contenoit, je ne trouvai plus sur le grès qu'une pellicule terreuse qui n'avoil pas une ligne d'épaisseur; mais aussi pendant tout le reste de 1 année, ët tant que le gres a été dans l'eau, cette pellicule n'a jamais manqué de se former dans l'espace de deux ou trois jours, sans augmenter ni diminuer en épaisseur, à l'exception du temps où j'ai été obligé, par rapport à la gelée, de mettre le vaisseau à couvert, qu'il m'a paru que la décomposition du gres se faisoit un peu plus lentement.

Quelque temps après avoir luis ce gros dans l'eau, j'y ai aperçu une grande quantité de paillettes brillâmes et argentées, comme le sont celles du talc, qui n'y ctoient pas auparavant, et j'ai juge que c'étoil là sou premier étal de décomposition; que ses molécules, formées de plusieurs petites couches, l'exlblioient, connue j'ai observé qu'il arrivoit au verre daus certaines circonstances, et que ces paillettes s'atténuoient ensuite peu à peu dans l'eau, jusqu'à ce que, devenues si petites qu'elles n'avoient plus assez de surface pour réfléchir la lumière, elles acquéraient la forme et les propriétés d'une véritable terre: j'ai donc amassé et mis à part toutes les sécrétions terreuses que les deux livres de grès m'ont produites pendant le cours de plus d'une annce; et lorsque cette terre a été bien sèche, elle pesoit environ cinq onces. J'ai aussi pesé le grès après l'avoir fait séchër, et il avoit diminue en pésanteur dans la même proportion, de sorte qu'il s'en étoit décompose un peu plus de la sixième partie. Toute cette terre etoit au reste de la même qualité, et les dernières sécrétions étoient aussi grasses, aussi ductiles, que les premières, et toujours d'un jaune tirant sur l'orangé: mais comme j'y apercevois encore quelques paillettes brillantes, quelques molécules de grès qui n'étoient p2s entièrement décomposées, j'ai remis cette terre avec de l'eau dans un vaisseau de verre, et je l'ai laissée exposée à l'air, sans la remuer, pendant tout un été, ajoutant de temps en temps de nouvelle eau à mesure qu'elle s'évaporait; un mois après, cette eau, a commence à se corrompre, et elle est devenue verdâtre et de mauvaise odeur: la terre paroissoit être aussi dans un état de fermentation et de putréfaction, car il s'en élevoit une grande quantité de bulles d'air; et quoiqu'elle eût conservé à sa superficie sa couleur jaunâtre, celle qui étoit au foud du vaisseau étoit brune, et cette couleur s'étendolt de jour en jour, et paroissoil plus foncée, de sorte qu'à la fin de l'été cette terre étoit devenue absolument noire. J'ai laissé évaporer l'eau sans en remettre de nouvelle dans le vaisseau; et en ayant tiré la terre, qui ressembloit assez à de l'argile grise lorsqu'elle est humectée, je l'ai fait sécher à la chaleur du feu; et lorsqu'elle a été échauffée, il m'a paru qu'elle exhaloit une odeur sulfureuse: mais ce qui m'a surpris davantage, c'est qu'à proportion qu'elle s'est desséchée là couleur noire s'est un peu effacée, et elle est devenue aussi blanche que l'argile la plus blanche; d'où on peut conjecturer que c'étoil par conséquent une matière volatile qui lui communiquoit cette couleur brune: les esprits acides n'ont fait aucune impression sur cette terre; et lui ayant fait éprouver un degré de chaleur assez violent, elle n'a point rougi comme l'argile grise, mais elle a conservé sa blancheur; de sorte qu'il me parait évident, que cette matière que m'a produite le grès, eu s'atténuant et en se décomposant dans l'eau, est une véritable argile blanche. » (Noie communiquée à M. de Buffon par M. Nadault, correspondant de l'Académie des Sciences, ancien avocat - général de la chambre des comptes de Dijon.)

Cela est évident dans le continent de l'Amérique, dont les pentes sont extrêmement rapides vers les mers de l'ouest, et dont toutes les terres s'étendent en pente douce et aboutissent presque toutes à de grandes plaines du côté de la mer à l'orient. En Europe, la ligne du sommet de la Grande-Bretagne, qui s'étend du nord au sud, est bien plus proche du bord occidental que de l'oriental de l'Océan, et par la même raison, les mers qui sont à l'occident de l'Irlande et de l'Angleterre sont plus profondes que la mer qui sépare l'Angleterre et la Hollande. La ligne du sommet de la Norwège est bien plus proche de l'Océan que de la mer Baltique. Les montagnes du sommet général de l'Europe sont bien plus haules vers l'occident que vers l'orient; et si l'on prend une partie de ce sommet depuis la Suisse jusqu'en Sibérie, il est bien plus près de la mer Baltique et de la mer Blanche qu'il tie l'est de la mer Noire et de la mer Caspienne. Les Alpes et l'Apennin régnent bien plus prés de la Méditerranée que de la mer Adriatique. La chaîne de montagnes qui sort du Tyrol, et qui s'étend en Dalmalie et Jusqu'à la pointe delà M orée, cotoie, pour ainsi dire, la mer Adriatique, tandis que les côtes orientales qui leur sont .opposées sont plus hasses. Si l'on suit en Asie- la chaîne qui S'étend depuis les Dardanelles jusqu'au détroit de Babel-Mandel, on trouve que les sommets du ihonl Taurus, du Lihan, et dé toute l'Arabie, côtoient la Méditerranée et la mer Rouge, et qu'à l'orient ce sont de vastes continens où coulent des fleuves d'un long cours, qui vont se jeter dans le golfe Persique. Le sommet des fameuses montagnes de Gatles s'approche phis des mers occidentales que des mers orientales. Le sommet qui s'élend depuis les frontières occidentales de la

Chine jusqu'à la pointe de Malaca est encore plus près de la mer d'Occident que de la mer d'Orient. En Afrique, la chaîne du mont Atlas envoie dans la mer des Canaries des fleuves moins longs que ceux qu'elle envoie dans l'intérieur du continent, et qui vont se perdre au loin dans des lacs et de grands marais. Les hautes montagnes qui sont à l'occident vers le cap Vert et dans toute la Guinée, lesquelles, après avoir tourné autour de Congo, vont gagner les monts de la Lune, et s'allongent jusqu'au cap de Bonne-Espérance,,occupent assez régulièrement le milieu de l'Afrique, On reconnaitra néanmoins, en considérant la mer à l'orient et à l'occident, que celle à l'orient est peu profonde, avec un grand nombre d'iles, taudis qu'à l'occident elle a plus de profondeur et très peu d'iles; en sorte que l'endroit le plus profond de la mer occidentale est bien plus près de cette chaîne que le plus profond des mers orientales et des Indes.

On voit donc généralement, dans tous les continens, que les points de partage sont toujours beaucoup plus près des mers de l'ouest que des mers de l'est; que les revers de ces continens sont lous allongés vers l'est, et toujours raccourcis à l'ouest; que les mers des rives occidentales sont plus profondes et bien moins semées d'iles que les orientales; et même l'on reconnoitra que, dans toutes ces mers, les côtes des iles sont toujours plus hautes et les mers qui les baignent plus profondes à l'orient qu'à l'occident.

Quatrième Époque - Lorsque Les Eaux Se Sont Retirées, Et Que Les Volcans Ont Commencé D'agir

On vient de voir que les élémens de l'air et de l'eau se sont établis par le refroidissement, et que les eaux, d'abord reléguées dans l'atmosphère par la force expansive de la chaleur, sont ensuite tombées sur les parties du globe qui étoient assez attiédies pour ne les pas rejeter en vapeurs; et ces parties sont les régions polaires et toutes les montagnes. Il y a donc eu, à I époque de trente - cinq mille ans, une vaste mer aux environs de chaque pole, et quelques lacs ou grandes mares sur les montagnes et les terres élevées qui, se trouvant refroidies au même degré que celles des pôles, pouvoient également rerevoir et conserver les eaux; ensuite, à mesure que le globe se refroidissoit, les mers des pôles, toujours alimentées et fournies par la chute des eaux de l'atmosphère, se répandoient plus loin; et les lacs ou grandes mares, également fournis par cette pluie continuelle d'autant plus abondante que l'attiédissement étoit plus grand, s'étendoient en tous sens, et formoient des bassins et de petites mers intérieures dans les parties du globe auxquelles les grandes mers des deux pôles n'avoient point encore atteint: ensuite les eaux continuant à tomber toujours avec plus d’abondance jusqu'à l'entière dépuration de l'atmosphère, elles ont gagné successivement du terrain, et sont arrivées aux contrées de l'équateur; et enfin elles oui couvert toute la surface du globe à deux mille toises de hauteur au dessus du niveau de nos mers actuelles. La terre entière étoit alors sous l'empire de la mer, à l'exception peut-être du sommet des montagnes primitives, qui n'ont été pour ainsi dire que lavées et baignées pendant le premier temps de la chute des eaux, lesquelles se sont écoulées de ces lieux élevés pour occuper les terrains inférieurs dès qu'ils se sont trouvés assez refroidis pour les admettre sans les rejeter en vapeurs.

Il s'est donc formé successivement une mer universelle, qui u'étoit interrompue et surmontée que par les sommets des montagnes d'où les premières eaux s'étoient déjà retirées en s'écoulunt dans les lieux plus bas. Ces terres élevées, ayant été travaillées les premières par le séjour et le mouvement des eaux, auront aussi été fécondées les premières; et tandis que toute la surface du globe n'étoit pour ainsi dire qu'un archipel général, la nature organisée s'établissoit sur ces montagnes: elle s'y déployoit même avec une grande énergie; car la chaleur et l'humidité, ces deux principes de toute fécondation s'y trouvoient réunis et combinés à un plus haut degré qu'ils ne le sont aujourd'hui dans aucun climat de la terre.

Or, dans ce même temps, où les terres élevées au dessus des eaux se couvraient de grands arbres et de végétaux de toute espère, la mer générale se peuploit partout de poissons et de coquillages; elle étoit aussi le réceptacle universel de tout ce qui se détachoit des terres qui la surmontoient. Les scories du verre primitif et les matières végétales ont été entraînées des éminences de la terre dans les profondeurs de la mer, sur le fond de laquelle elles ont formé les premières couches de sable vitrescible, d'argile, de schiste, et d'ardoise, ainsi que les minières de charbon, de sel, et de bitumes, qui dès lors ont imprégné toute la masse des mers. La quantité de végétaux produits et détruits dans ces premières terres est trop immense pour qu'on puisse se la représenter; car, quand nous réduirions la superficie de toutes les terres élevées alors au dessus des eaux à la centième ou même à la deux centième partie de la surface du globe, c'est-à-dire à cent trente mille lieues carrées, il est aisé de sentir combien ce vaste terrain de cent trente mille lieues superficielles a produit d'arbres et de plantes pendant quelques milliers d'années, combien leurs détrimens se sont accumulés, et dans quelle énorme quantité ils ont été entraînés et déposés sous les eaux, où ils ont formé le fonds du volume tout aussi grand des mines de charbon qui se trouvent en tant de lieux. Il eu est de même des mines de sel, de celles de fer en grains, de pyrites, et de toutes les autres substanres dans la composition desquelles il entre des acides, et dont la première formation n'a pu s'opérer qu'après la chute des eaux: ces matières auront été entraînées et déposées dans les lieux has et dans les fentes de la roche du globe, où trouvant déjà les substances minérales sublimées par la grande chaleur de la terre, elles auront formé le premier fonds de l'aliment des volcans à venir: je dis à venir, car il n'existoit aucun volcan en action avant l'établissement des eaux, et ils n'ont commencé d'agir, ou plutôt ils n'ont pu prendre une action permanente, qu'après leur abaissement: car l'on doit distinguer les volcans terrestres des volcans marins; ceux-ci ne peuveut faire que des explosions, pour ainsi dire, momentanées, parce qu'à l'instant que leur feu s'allume par l'effervescence des matières pyriteuses et combustibles, il est immédiatement éteint par l'eau qui les couvre et se précipite à îlots jusque dans leur foyer par toutes les routes que le feu s'ouvre pour en sortir. Les volcans de la terre ont au contraire une action durable et proportionnée à la quantité de matières qu'ils contiennent: ces matières ont besoin d'une certaine quantité d'eau pour entrer en effervescence; et ce n'est ensuite que par le choc d'un grand volume de feu contre un grand volume d'eau, que peuvent se produire leurs violentes éruptions; et de même qu'un volcan sous-marin ne peut agir que par instans, un volcan terrestre ne peut durer qu'autant qu'il est voisin des eaux. C'est par cette raison que tous les volcans actuellement agissans sont dans les îles ou près des côtes de la mer, et qu'on pourrait en compter cent fois plus d'éteints que d'agissans; car à mesure que les eaux, en se retirant, se sont trop éloignées du pied de ces volcans, leurs éruptions ont diminué par degrés, et enfin ont entièrement cessé, et les légères effervescences que l'eau pluviale aura pu causer dans leur ancien foyer n'auront produit d'effet sensible que par des circonstances particulières et très rares.

Les observations confirment parfaitement ce que je dis ici de l'action des volcans: tous ceux qui sont maintenant en travail sont situés près des mers; tous ceux qui sont éteints, et dont le nombre est bien plus grand, sont placés dans le milieu des terres, ou tout au moins à quelque distance de la mer; et, quoique la plupart des volcans qui subsistent paraissent appartenir aux plus hautes montagnes, il en a existé beaucoup d'autres dans les éminences de médiocre hauteur. La date de l'âge des volcans n'est donc pas partout la même: d'abord il est sûr que les premiers, c'est-à-die les plus anciens, n'ont pu acquérir une action permanente qu'après l'abaissement des eaux qui couvraient leur sommet; et ensuite il parait qu'ils ont cessé d'agir dès que ces mêmes eaux se sont trop éloignées de leur voisinage: car, je le répète, nulle puissance, à l'exception de celle d'une grande masse d'eau choquée contre un grand volume de feu, ne peut produire des mouvemens aussi prodigieux que ceux de l'éruption des volcans.

Il est vrai que nous ne voyons pas d'assez près la composition intérieure de ces terribles bouches à feu, pour pouvoir prononcer sur leurs effets en parfaite connoissance de cause; nous savons seulement que souvent il y a des communications souterraines de volcan à volcan; nous savons aussi

que, quoique le foyer de leur embrasement ne soit peut-être pas à une grande distance de leur sommet, il y a néanmoins des cavités qui descendent beaucoup plus has, et que ces cavités, dont la profondeur et l'étendue nous sont inconnues, peuvent être, en tout ou en partie, remplies des mêmes matières que celles qui sont actuellement embrasées.

D'autre part, l'électricité me parait jouer un très grand rôle dans les tremblemens de terre et dans les éruptions des volcans; je me suis convaincu par des raisons très solides, et par la comparaison que j'ai faite des expériences sur l'électricité, que le fonds de la matière électrique est la chaleur propre du globe terrestre: les émanations continuelles de cette chaleur, quoique sensibles, ne sont pas visibles, et restent sous la forme de chaleur obscure, tant qu'elles ont .leur mouvement libre et direct; mais elles produisent un feu très vif et de fortes explosions, dès qu'elles sont détournées de leur direction, ou bien accumulées par le frottement des corps. Les cavités intérieures de la terre contenant du feu, de l'air, et de l'eau, l'action de ce premier élément doit y produire des vens impétueux, des orages bruyans, et des tonnerres souterrains, dont les effets peuvent être comparés à ceux de la foudre des airs: ces effets doivent même être plus violens et plus durables par la forte résistance que la solidité de la terre oppose de tous côtés à la force électrique de ces tonnerres souterrains. Le ressort d'un air mêlé de vapeurs denses et enflammées par l'électricité, l'effort de l'eau réduite en vapeurs élastiques par le feu, toutes les antres impulsions de cette puissance électrique, soulèvent, entr'ouvrent la surface de la terre, ou du moins l'agitent par des tremblemens, dont les secousses ne ureut pas plus long-temps que le coup de la foudre intérieure qui Tes produit; et ces Secousses se renouvellent jusqu'à ce que les vapeurs expansives se soient fait une issue par quelque ouverture à la surface de la terre/ou dans le sein des mers. Aussi les éruptions des volcans et les tremblemens de terre sont précédés et accompagnés d'un bruit sourd et roulant, qui ne diffère de celui du tonnerre que par le ton sépulcral et profond que le son prend nécessairement en traversant une grande épaisseur de matière solide, lorsqu'il s'y trouve renfermé.

Cette électricité souterraine, combinée comme cause générale avec les causes particulieres de feux allumés par l'effervescence des matières pvriteues combustibles que la terre recèle en tant d'endroits, suffit à l'explication des principaux phénomènes de l'action, des volcans: par exemple, leur fover parait être assez voisin de leur sommet; mais l'orage est au dessous. Un volcan n'est qu un vaste fourneau, dont les soufflets, ou plutôt lés ventilateurs, sont placés dans les cavités inférieures, à côté et au dessous du foyer. Ce sont ces mêmes cavités, lorsqu'elles s'étendent jusqu'à la mer, qui servent de tuyaux d'inspiration pour porter en liant non seulement les vapeurs, mais les masses mêmes de l'eau et de l'air; c'est dans ce transport que se produit la foudre souterraine, qui s'annonce par des mugissemens, et n'éclate que par l'affreux vomissement des matièress qu'elle a frappées, brûlées et calcinées: des tourbillons épais d'une noire fumée ou d'une flamme lugubre, des nuages massifs de cendres et de pierres, des torrens bouillonnans de lave en fusion, roulant au loin leurs flots brùlans et destructeurs, manifestent au dehors le mouvement convulsif des entrailles de la terre.

Ces tempêtes intestines sont d'autant plus violentes qu'elles sont plus voisines des montagnes à volcan et des eaux de la mer, dont le sel et les huiles grasses augmentent encore l'activité du sen; les terres situées entre le volcan et la mer ne peuvent manquer d'éprouver des secousses fréquentes: mais pourquoi n'y a-t-il aucun endroit du mondé où l'on n'ait ressenti, même de mémoire d'homme, quelques tremblemens, quelque trépidation, causés par ces movemens intérieurs de la terre? Ils sont, à la -""té, moins violens et bien plus rares dans le milieu des continens éloignés des volcans et des mers; mais ne sont-ils pas des effets dépendant des mêmes causes? Pourquoi donc se font-ils ressentir où ces causes n'existent pas, c'est-à-dire dans les lieux où il n'y a ni mer ni volcans? La réponse est aisée: c'est qu'il y a eu des mers partout et des volcans presque partout, et que, quoique leurs éruptions aient cessé lorsque lès mers s'en sont éloignées, leur feu subsiste, et nous est démontré par les sources des huiles terrestres, par les fontaines chaudes et sulfureuses qui se trouvent fréquemment au pied des montagnes, jusque dans le milieu

des plus grands continens. Ces feux des anciens volcans, devenus plus tranquilles depuis la retraite des eaux, suffisent néanmoins pour exciter de temps en temps des mouvemens intérieurs, et produire de légères secousses dont les oscillations sont dirigées dans le sens des cavités de la terre, et peut-être dans la direction des eaux ou des veines des métaux, comme conducteurs de cette électricité souterraine.

On pourra me demander encore pourquoi tous les volcans sont situés dans les montagnes? pourquoi paraissent - ils être d'autant plus ardens que les montagnes sont plus liantes? quelle est la cause qui a pu disposer ces énormes cheminées dans l'intérieur des murs les plus solides et les plus élevés du globe? Si l'on a bien compris ce que j'ai dit au sujet des inégalités produites par le premier refroidissement, lorsque les matières en fusion se sont consolidées, on sentira que les chaînes des hautes montagnes nous représentent les plus grandes boursouflures qui se sont faites à la surface du globe dans le temps qu'il a pris sa consistance. La plupart des montagnes sont donc situées sur des cavités, auxquelles aboutissent les fentes perpendiculaires qui les tranchent du haut en has: ces cavernes et ces fentes contiennent des matières qui s'enflamment par la seule effervescence, ou qui sont allumées par les étincelles électriques de la chaleur intérieure du glube. Dès que le feu commence à se faire sentir, l'air attiré par la raréfaction en augmente la force et produit bientôt un grand incendie, dont l'effet est de produire à son tour les mouveuiens et les orages intestins, les tonnerres souterrains, et toutes les impulsions, les bruits el les secousses qui précèdent et accompagnent l'éruption des volcans. On doit donc cesser d'être étonné que les volcans soient tous situés dans les hautes gnes, puisque ce sont les seuls i Voits de la terre où les cavités intérieures se soient maintenues, les seuls où ces cavités communiquent de has en haut par des fentes qui ne sont pas encore comblées, et enfin les seuls où l'espace vide étoil assez vaste pour contenir la très grande quantité de matières qui servent d'aliment au feu des volcans permanens et encore subsistans. Au reste, ils s'éteindront comme les autres dans la suite des siècles; leurs éruptions cesseront: oserai-je même dire que les hommes pourraient y contribuer? En coûteroit-il autant pour couper la communication d'un volcan avec la mer voisine qu'il en a coûté pour construire les pyramides d'Égypte? Ces monumens inutiles d'une gloire fausse et vaine nous apprennent au moins qu'en employant les mêmes forces pour des monumens de sagesse, nous pourrions faire de très grandes choses, et peut-être maitriser la nature au point de faire cesser, ou du moins de diriger les ravages du feu, comme nous savons déjà, par notre art, diriger et rompre les efforts 'de l'eau.

Jusqu'au temps de l'action des volcans il n'existoit sur lê globe que trois sortes de matières: i° les vitrescibles produites par le feu primitif; 2° les calcaires formées par l'intermède de l'eau; 3° toutes les substances produites par le détriment des animaux et des végétaux: mais le feu des volcans a donné naissance à des matières d'une quatrième sorte, qui souvent participent dé la nature des trois autres. La première classe renferme non seulement les matières premières solides et vitrescibles dont la nature n'a point été altérée, et qui forment le fond du globe, ainsi que le noyau de toutes les montagnes primordiales, mais encore les sables, les schistes, les ardoises, les argiles, et toutes les matières vitrescibles décomposées et transportées par les eaux. La seconde classe contient toutes les matières calcaires, c'est-à-dire toutes les substances produites par les coquillages et autres animaux de la mer: elles s'étendent sur des provinces entières, et couvrent même d'assez vastes contrées; elles se trouvent aussi à des profondeurs assez considérables, et elles environnent les hases des montagnes les plus élevées jusqu'à une très grande hauteur. La troisième classe comprend toutes les substances qui doivent leur origine aux matières animales et végétales, et ces substances sont eu très grand nombre; leur quantité paroit immense, car elles recouvrent toute fa superficie de la terre. Enfin la quatrième classe est celle des matières soulevées et rejetées par les volcans, dont quelques-unes paraissent être un mélange des premières, et d'autres, pures de tout mélange, ont subi une seconde action du feu qui leur a donné un nouveau caractère. Nous rapportons à ces quatre classes toutes les substances minérales, parce qu'en les examinant on peut toujours reconnoitre à laquelle de ces classes elles appartiennent, et par conséquent prononcer sur leur origine; ce qui suffit pour nous indiquer à peu près le temps de

leur formation; car, comme nous venons de l'exposer, il paroit clairement que toutes les matières vitrescibles solides, et qui n'ont pas changé de nature ni de situation, ont été produites par le feu primitif, et que leur formation appartient au temps de notre seconde époque, tandis que la formation des matières calcaires, ainsi que celle des argiles, des charbons, etc., n'a eu lieu que dans des temps subséquens, et doit être rapportée à notre troisième époque. Et comme dans les matières rejetées par les volcans on trouve quelquefois des substances calcaires, et souvent des soufres et des bitumes, on ne peut guère douter que la formation de ces substances rejetées par les volcans ne soit encore postérieure a la formation de toutes ces matières, et n'appartienne à notre quatrième époque.

'Quoique la quantité des matières rejetées par les volcans soit très petite en comparaison de la quantité de matières calcaires, elles ne laissent pas d'occuper d'assez grands espaces sur la surface des terres situées aux environs de ces montagnes ardentes et de celles dont les feux sont éteints et assoupis. Par leurs éruptions réitérées elles ont comblé les vallées, couvert les plaines, et même produit d'autres montagnes. Ensuite, lorsque les éruptions ont cessé, la plupart des volcans ont continué de brûler, mais d'un feu paisible et qui ne produit aucune explosion violente, parce qu'étant éloignés des mers il n'y a plus de choc de l'eau contre le feu: les matières en effervescence et les substances combustibles anciennement enflammées continuent de brûler; et c'est ce qui fait aujourd'hui la chaleur de toutes, nos eaux thermales; elles passent sur les foyers de ce feu souterrain, et sortent très chaudes du sein de la terre. Il y a aussi quelques exemples de mines de charbon qui brûlent de temps immémorial, et qui se sont allumées par la foudre souterraine ou par le feu tranquille d'un volcan dont les éruptions ont cessé. Ces eaux thermales et ces mines allumées se trouvent souvent, comme ks volcans éteints, dans les terres éloignées de la mer.

La surface de la terre nous présente en mille endroits les vestiges et les preuves de l'existence de ces volcans éteints: dans la France seule nous connoissons les vieux volcans de l'Auvergne, du Velay, du Vivarais, de la Provence, et du Languedoc. En Italie, presque toute la terre est formée de débris de matières volcanisées; et il en est de même de plusieurs autres contrées. Mais pour réunir les objets sous un point de vue général, et concevoir nettement l'ordre des bouleversemens que les volcans ont produits à la surface du globe, il faut reprendre notre troisième époque à cette date où la mer étoit universelle et couvrait toute la surface du globe, à l'exception des lieux élevés sur lesquels s'étoit fait le premier mélange dus scories vitrées de la masse terrestre avec les eaux: c'est à cette même date que les végétaux ont pris naissance et qu'ils se sont multipliés sur les terres que la mer venoit d'abandonner. Les volcans n'existoient pas encore; car les matières qui servent d'aliment à leur feu, c'est-à-dire les bitumes, les charbons de terre, les pyrites, et même les acides, ne pouvoients être formés précédemment, puisque leur composition suppose l'intermède de l'eau et la destruction des végétaux.

Ainsi les premiers volcans ont existé dans les terres élevées du milieu des coutinens; et à mesure que les mers, en s'abaissant, se sont éloignées de leur pied, leurs feux se sont assoupis et ont cessé de produire ces éruptions violentes qui ne peuvent s'opérer que par le conflit d'une grande masse d'eau contre un grand volume de feu. Or il a fallu vingt mille ans pour i et abaissement successif des mers, et pour la formation de toutes nos collines calcaires; et comme les amas des matières combustibles et minérales qui servent d'aliment aux volcans n'ont pu se déposer que successivement, et qu'il a dû s'écouler beaucoup de temps avant qu'elles se soient mises en action, ce n'est guère que sur la fin de cette période, c'est-à-dire à cinquante mille ans de la formation du globe, que les volcans ont commencé à ravager la terre. Comme les environs de tous les lieux découverts étoient encore baignés des eaux, il y a eu des volcans presque partout, et il s'est fait de fréquentes et prodigieuses éruptions qui n'ont cessé qu'après la retraite des mers; mais cette retraite ne pouvant se faire que par l'affaissement des boursouflures du globe, il est souvent arrivé que l'eau venant à flots remplir la profondeur de ces terres affaissées, elle a mis en action les volcans sous-marins, qui, par leur explosion, ont soulevé une partie de ces terres nouvellement

affaissées, et les ont quelquefois poussées au dessus du niveau de la mer, où elles ont formé des iles nouvelles. comme nous l'avons vu dans la petite ile formée auprès de celle de Santorin: néanmoins ces effets sont rares, et l'action des volcans sous-marins n'est ni permanente ni assez puissante pour élever un grand espace de terre au dessus de la surface des mers. Les volcans terrestres, par la continuité de leurs éruptions, ont au contraire couvert de leurs déblais tous les terrains qui les environnement; ils ont. par le dépôt successif de leurs laves, formé de nouvelles rouelles; ces laves devenues fécondes avec le temps sont une preuve invincible que la surface primitive de la terre, d'abord en fusion, puis consolidée, a pu de même devenir féconde: enfin les volcans ont aussi produit ces mornes ou tertres qui se voient dans toutes les montagnes à volcan, et ils ont élevé ces remparts de basalte qui servent de cotes aux mers dont ils sont voisins. Ainsi après que l'eau, par des mouvement uniformes et constans, eut achevé la construction horizontale des couches de la terre, le feu des volcans, par des explosions subites, a bouleversé, tranché, et couvert plusieurs de ces couches; et l'on ne doit pas être étonné de voir sortir du sein des volcans des matières de toute espèce, des cendres, des pierres calcinées, des terres brûlées, ni de trouver ces matières mélangées des substances calcaires et vitrescibles dont ces mêmes couches sont composées.

Les tremblemens de terre ont dû se faire sentir long-temps avant l'éruption des volcans: des les premiers momens de l'affaissement des cavernes il s'est fait de violentes secousses qui ont produit des effets tout aussi violens et bien plus étendus que ceux des volcans. Pour s'en former l'idée, supposons qu'une caverne soutenant un terrain de cent lieues carrées, ce qui ne ferait qu'une des petites boursouflures du globe, se soit tout à coup écroulée: cet écroulement n'aura-t-il pas été nécessairement suivi d'une commotion qui se sera communiquée et fait sentir très loin par un tremblement plus ou moins violent? Quoique cent lieues carrées ne fassent que la deux cent soixante millième panie de la surface de la terre, la chute de cette masse n'a pu manquer d’ébranler toutes les terres adjacentes, et de faire peut-être écrouler en même temps les cavernes voisines: il ne s'est donc fait aucun affaissement un peu considérable qui n'ait été accompagné de violentes secousses de tremblement de terre, dont le mouvement s'est communauté par la force du ressort dont toute matière est douée, et qui a dû se propager quelquefois très loin par les routes que peuvent offrir les vides de la terre dans lesquels les vents souterrains, excités par ces commotions, auront peut-être allumé les feux des volcans; en sorte que d'une seule cause, c'est-à-dire de l'affaissement d'une caverne, il a pu résulter plusieurs effets, tous grands et la plupart terribles: d'abord l'abaissement de la mer, forcée de courir à grands flots pour remplir cette nouvelle profondeur, et laisser par conséquent, à découvert de nouveaux terrains; 2* l'ébranlement des terres voisines par la commotion de la chute des matières solides qui formoient les voûtes de la caverne, et cet ébranlement fuit pencher les montagnes, les fend vers le sommet, et en détache des masses qui roulent jusqu'à leur hase; 3° le même mouvement produit par la commotion, et propagé par les vents et les feux souterrains, soulève au loin la terre et les eaux, élève des terins et des mornes, forme des gouffres et des crevasses, change le cours des rivières, tarit les anciennes sources, en produit de nouvelles, et ravage en moins de temps que je ne puis le dire tout ce qui se trouve dans sa direction. Nous devons donc cesser d'être surpris de voir en tant de lieux l'uniformité de l'ouvrage horizontal des eaux détruite et tranchée par des fentes inclinées, des éboutemens irréguliers, et souvent cachés par des déblais informes accumulés sans ordre, non plus que de trouver de si grandes contrées toutes recouvertes de matières rejetées par les volcans; ce désordre, causé par les tremblemens de terre, ne fait néanmoins que masquer la nature aux yeux de ceux qui ne la voient qu'en petit, et qui, d'un effet accidentel et particulier, font une cause générale et constante. C'est l'eau seule qui, comme cause générale et subséquente à celle du feu primitif, a achevé de construire et de figurer la surface actuelle de la terre; et ce qui manque à l'uniformité de cette construction universelle n'est que l'effet particulier de la cause accidentelle des tremblemens de terre et de l'action des volcans.

Or, dans cette construction de la surface de la terre par le mouvement et le sédiment des eaux, il faut distinguer deux périodes de temps. La première a commencé après l'établissement de la mer universelle, c'est-à-dire après la dépuration parfaite de l'atmosphère par la chute des eaux et de toutes les matières volatiles que l'ardeur du globe y tenoit reléguées: cette période a duré autant qu'il étoit nécessaire pour multiplier les coquillages au point de remplir de leurs dépouilles toutes nos collines calcaires, autant qu'il étoit nécessaire pour multiplier les végétaux, et pour former de leurs débris toutes nos mines de charbon, enfin autant qu'il étoit nécessaire pour convertir les scories du verre primitif en argiles, et former les acides, les sels, les py rites, etc. Tous ces premiers et grands effets ont été produits ensemble dans les temps qui se sont écoulés depuis l'établissement des eaux jusqu'à leur abaissement. Ensuite a commencé la seconde période. Cette retraite des eaux ne s'est pas faite tout à coup, mais par une longue succession de temps, dans laquelle il faut encore saisir des points différeus. Les montagnes composées de pierres calcaires ont certainement été construites dans cette mer ancienne, dont les différens courans les ont tout aussi certainement figurées par angles correspondans. Or l'inspection attentive des côtes de nos vallées nous démontre que le travail particulier des courans a été postérieur à l'ouvrage général de la mer. Ce fait, qu'on n'a pas même soupçonné, est trop important pour ne le pas appuyer de tout ce qui peut le rendre sensible à tous les yeux.

Prenons pour exemple la plus haute montagne calcaire de la France, celle de Laugres, qui s'élève au dessus de toutes les terres de la Champagne, s'étend en Bourgogne jusqu'à Monthard, et même jusqu'à Tonnerre, et qui, dans la direction opposée, domine de même sur les terres de ta Lorraine et de la Franche-Comté '. Ce cordon continu de la montagne de laugres, qui, depuis les sources de la Seine jusqu'à celles de la Saone, a plus de quarante lieues en longueur, est entièrement calcaire, c'est-à-dire entièrement composé des productions de la mer; et c'est par cette raison que je l'ai choisi pour nous servir d'exemple. Le point le plus élevé de cette chaîne de montagnes est très voisin de la vile de Langres, et l'on voit que, d'un côté, cette même chaîne verse ses eaux dans l'Océan par la Meuse, la Marne, la Seine, etc., et que, de l'autre côté, elle les verse dans la Méditerranée par les rivières qui aboutissent à la Saône. Le 1. Voyez la carte ci-jointe, et de la Vingeanne. Si nous examinons ces terrains en détail, nous observerons que les sources de la Meuse sortent en partie des marécages du Bassigny, et d'autres petites vallées très étroites et très escarpées; que la Mance et la Vingeanne, qui toutes deux se jettent dans la Saône, sortent aussi des vallées très étroites de l'autre côté du sommet; que la vallée de la Marne, sous Langres, a environ cent toises de profondeur; que dans tous ces premiers vallons les coteaux sont voisins et escarpés; que dans les vallées inférieures, et à mesure que les courans se sont éloignés du sommet général et commun, ils se sont étendu ont par conséquent élargi les vallées, dont les côtes sont aussi moins escarpées, parce que le mouvement des eaux y étoit plus libre et moins rapide que dans les vallons étroits des terrains voisins du sommet.

L'on doit encore remarquer que la direction des courans a varié dans leur cours, et que la déclinaison des coteaux a changé par la même cause. Les courans dont la pente étoit vers le midi, et qui nous sont représentés par les vallons de la Tille, de la Venelle, de la Vingeanne, du Saulon, et de la Mance, ont agi plus fortement contre les coteaux tournés vers le sommet de Langres et à l'aspect du nord. Les courans, au contraire, dont la pente étoit vers le nord, et qui nous sont représentés par les vallons de l'Aujon, de la Suize, de la Marne, et du Rognon, ainsi que par ceux de la Meuse, ont plus fortement agi contre les coteaux qui sont tournés vers ce même sommet de Langres, et qui se trouvent à l'aspect du midi.

Il y avoit donc, lorsque les eaux ont laissé le sommet de Langres à découvert, une mer dont les mouvemens et les courans étoient dirigés vers le nord, et, de l'autre côté de ce sommet, une autre mer dont les mouvemens étoient dirigés vers le midi: ces deux mers battoient les deux flancs opposés de cette chaine de montagnes, comme Ion voit dans la mer actuelle les eaux battre les deux flancs opposés d'une longue ile ou d'un promontoire avancé. Il u'est donc pas étonnant que

tous les coteaux escarpés de ces vallons se trouvent également des deux côtés de ce sommet général des montagnes; ce n'est que l'effet nécessaire d'une cause très évidente.

Si l'on considère le terrain qui environne l'une des sources de la Marne près de Langres, on reconnoîtra qu'elle sort d'un demicercle coupé presque à plomb; et, en examinant les lits de pierre de cette espèce d'amphithéâtre, on se démontrera que ceux des deux côtés et ceux du fond de l'arc de cercle qu il présente étoient autrefois continus, et ne faisaient qu'une seule masse que les eaux ont détruite dans la partie qui forme aujourd'hui ce demi-cercle. Ou verra la même chose à l'origine des deux autres sources de la Marne; savoir, dans le vallon de Ralesme et dans celui de Saint-Maurice: tout ce terrain étoit continu avant l'abaissement de la mer; et cette espèce de promontoire à l'extrémité duquel la ville de Langres est située étoit, dans ce même temps,continu non seulement avec ces premiers terrains, mais avec ceux de Breuvone, de Peigney, de Noidan-le-Rocbeux, etc. Il est aisé de se convaincre par ses yeux que la continuité de ces terrains n'a été détruite que par le mouvement et l'action des eaux.

Dans cette chaîne de la montagne de Langres, ou trouve plusieurs collines isolées, les unes en forme de cône tronqué, comme celle de Montsaugeon, les autres en forme elliptique, comme celles de Monthard, ile Montréal; et d'autres tout aussi remarquables autour des sources de la Meuse, vers Clermont et Monligny-le-Roi, qui est situé sur un monticule adhérent au continent par une langue de terre très étroite. On voit encore une de ces collines isolées à Andilly, une autre auprès d'Heuilly-Coton, etc. Nous devons observer qu'en général ces collines calcaires isolées sont moins hautes que celles qui les environnent, et desquelles ces collines sont actuellement séparées, parce que le courant, remplissant toute la largeur du vallon, passoit par dessus ces collines isolées avec un mouvement direct, et les détrùisoit par le sommet, tandis qu'il ne faisoit que baigner le terrain des coteaux du vallon, et ne les attaquoit que par un mouvement oblique; en sorte que les montagnes qui bordent les vallons sont demeurées plus élevées que les collines isolées qui se trouvent entre deux. A Monthard, par exemple, la hauteur de la colline isolée au dessus de laquelle sont situés les murs de I ancien château n'est que de cent quarante pieds, tandis que les montagnes qui bordent le vallon des deux côtés, au nord et au midi, en ont plus de trois cent cinquante; et il eu est de même des autres collines calcaires que nous venons de citer: toutes celles qui sont isolées sont en même temps moins élevées que les autres, parce qu'étant au milieu du vallon et au fil d,' l'eau elles ont été minées sur leurs sommets par le courant, toujours plus violent et plus rapide dans le milieu que vers les bords de son cours.

Lorsqu'on regarde ces escarpemens, souvent élevés à pic à plusieurs toises de hauteur; lorsqu'on les voit composés du haut en bas de bancs de pierres calcaires très massives et fort dures, ou est émerveillé du temps prodigieux qu'il faut supposer pour que les eaux aient ouvert et creusé ces énormes tranchées. Mais deux circonstances ont concouru à l'accélération de ce grand ouvrage: l'une de ces circonstances est (pie, dans toutes les collines et les montagnes calcaires, les lits supérieurs sont les moins compactes et les plus tendres, en sorte que les eaux ont aisément entamé la superficie ^ du lorrain, et formé la première ravine qui a dirigé leur cours; la seconde circonstance est que, quoique ces bancs de matière calcaire se soient formés et même séchés et pétrifiés sous les eaux de la mer, il est néanmoins très certain qu'ils n'étoient d'abord que des sédimens superposés de matières molles, lesquelles n'ont acquis de la dureté que successivement par l'action de la gravité sur la masse totale, et par l'exercice de la force d'affinité de leurs parties constituantes. Nous sommes donc assurés que ces matières n'avoiem pas acquis toute la solidité et la dureté que nous leur voyons aujourd'hui, et que, dans ce temps de l'action des courans de la mer, elles devoient lui céder avec moins de résistance. Cette considération diminue l'énormité de la durée du temps de ce travail des eaux, et explique d'autant mieux la correspondance des angles saillans et rentrons des collines, qui ressemblent parfaitement à la correspondance des bords de nos rivières dans tous les terrains aisés à diviser.

C'est pour la construction même de ces terrains calcaires, et non pour leur division, qu'il est nécessaire d'admettre une très longue période de temps; en sorte que, dans les vingt mille ans, j'en prendrois au moins les trois premiers quarts pour la multiplication des coquillages, le transport de leurs dépouilles, et la composition des masses qui les renferment, et le dernier quart pour la division et pour la configuration de ces mêmes terrains calcaires: il a fallu vingt mille ans pour la retraite des eaux, qui d'abord étoienl élevées de deux mille toises au dessus du niveau de nos mers actuelles; et ce n'est que vers la fin de cette longue marche en retraite que nos vallons ont été creusés, nos plaines établies et nos collines découvertes: pendant tout ce temps le globe n'éloit peuplé que de poissons et d'animaux à coquilles; les sommets des montagnes et quelques terres élevées, que les eaux n'avoient pas surmontés, ou qu'elles avoient abandonnés les premiers, étoient aussi couverts de végétaux; car leurs détrimens en volume immense ont formé les veines de charbon, dans le même temps que les dépouilles des coquillages ont formé les lits de nos pierres calcaires. Il est donc démontré par l'inspection attentive de ces mon unions authentiques de la nature, savoir, les coquilles dans les marbres, les poissons dans les ardoises, et les végétaux dans les mines de charbon, (pie tous ces êtres organisés ont existé long temps avant les animaux terrestres; d'autant qu'on ne trouve aucun indice, aucun vestige de l'existence de ceux-ci dans toutes les couches anciennes qui se sont formées par le sédiment des eaux de la mer. On n'a trouvé les os, les dents, les défenses des animaux terrestres que dans les couches superficielles, ou bien dans ces vallées et dans ces plaines dont nous avons parlé, qui ont été comblées de déblais entraînés des lieux supérieurs par les eaux courantes; il y a seulement quelques exemples d'ossemens trouvés dans les cavités sous des rochers, près des bords de la mer, et dans des terrains has: mais ces rochers sous lesquels gisoient ces ossemens d'animaux terrestres sont eux-mêmes de nouvelle formation, ainsi que toutes les carrières calcaires en pays has, qui ne sont formées que des détrimens des anciennes couches de pierres, toutes situées au dessus de ces nouvelles carrières; et c'est par cette raison que je les ai désignées par le nom de carrières parasites, parce qu'elles se forment en effet aux dépens des premières.

Notre globe, pendant trente-cinq mille ans, n'a donc été qu'une masse de chaleur et de feu, dont aucun être sensible ne pouvoit approcher; ensuite, pendant quinze ou vingt mille ans, sa surface n'étoit qu'une mer universelle: il a fallu cette longue succession de siècles pour le refroidissement de la terre et pour la retraite des eaux, et ce n'est qu'à la iin de cette seconde période que la surface de nos continens a été figurée.

Mais ces derniers effets de l'action des courans de la mer ont été précédés de quelques autres effets encore plus généraux, lesquels ont influé sur quelques traits de la face entière de la terre. Nous avons dit que les eaux, venant en plus grande quantité du pôle austral, avoient aiguisé toutes les pointes des continens; mais après la chute complète des eaux, lorsque la mer universelle eut pris son équilibre, le mouvement du midi au nord cessa, et la mer n'eut plus à obéir qu'à la puissance constante de la lune, qui, se combinant avec celle du soleil, produisit les marées et le mouvement constant d'orient en occident. Les eaux, dans leur premier avènement, avoient d'abord été dirigées des pôles vers l'équateur, parce que les parties polaires, plus refroidies que le reste du globe, les avoient reçues les premières; ensuite elles ont gagné successivement les régions de l'équateur; et lorsque ces régions ont été couvertes comme toutes les autres par les eaux, le mouvement d'orient en occident s'est dès lors établi pour jamais; car non seulement il s'est maintenu pendant cette longue période de là retraite des mers, niais il se maintient encore aujourd'hui. Or ce mouvement général de la hier d'odent en occident à produit sur la surface de la masse terrestre un effet tout aussi général; c'est d'avoir escarpé toutes les rdles occidentales des continens terrestres, ét d'avoir eh mérite temps laissé tous les terrains en pente douce du coté de l'orient.

A mesure que les mers s'àhaissoient et découvroient les pointes les plus élevées dès continens, ces sommets, comme autant de soupiraux qu'on viendrait de déboucher, commencèrent a laisser

exhaler les nouveaux feux produits dans l'irtiérieur de la terré par l'effervescence des matières qui servent d aliment aux volcans. Le domaine dè la terre, sur la lin de celle seconde pér iode de vingt mille ans, étoit partagé entre le fèu et l'eau; également déchirée et dévorée par la fureur de ces deux éléniehs, il n'y avoit nullè part ni sûreté ni repos: mais Iicureusèihent ces anciennes scènes, les plus épouvantables dè la nature, n'ont point eu de spectateurs, et ce n'est qu'après cette Seconde période entièrement révolue que l'on peut dater la naissance des animaux terrestres; lès eaux étoient alors retirées, puisque les deux grands continens étoient unis vers le nord, et également peuplés d élèphans; le nombre des volcans étoit aussi beaucoup diminue, parce que leurs éruptions ne pouvant s'opérer que par le conflit de l'eau et du feu. elles aroient cessé dès que la mer, en s abaissant, s'en étoit éloignée. Qu'on se représente encore l'aspect qu'offroit la terre immediat. mènt après cette seconde période, c'est à-dire à cinquante cinq ou soixante mille ans de sa formation: dans toutes les parties asses, des mares profondes, des cburans rapides, et des toufnolemens d'èati; des tremblemens de terre presque continuels, produits par l'affaissemertt des cavernes et les fréquentes explosions des volcans, tant sous mer que Sur terre; des orages généraux et particuliers; dès tourbillons de fumeè et des tempêtes excitées par lés violentes secousses de la terre et de la mer; des inondations, des débordemens, des détnges occasionés par ct'S mêmes commotions; des fleuves de verra fondu, de bitume, et de soufre, ravageant les montagnes èt venant dans la plaine empoisonner les eaux; Ife soleil même presque toujours offusqué non seulement par des nuages aqueux, mais par des masses épaisses de cendres èt dè pierres poussées par les Volcans; et nous remercierons le Créateur de n'avùir pas rendn l'homme témoin de ces scènes effrayantes et terribles, qui ont précédé et pour ainsi dire annoncé la naissance 3e la nature intelligente et sensible.

Cinquième Époque - Lorsque Les Eléphans Et Les Autres, Animaux Du Midi Ont Habité Les Terres Du Nord

Tout ce qui èxiste aujourd'hui dans la nature vivante a pu exister de même dès que la température de la terre s'est trouvée la même. Or les contrées septentrionales du globe ont joui pendant long-temps du même degré de chaleur dont jouissent aujourd'hui les terres méridionaiès; et dans le temps où ces contrées du nord jouissoient de cette température, les terres avancées vers le midi étoient encore brûlantes et sont demeurées désertes pendant un long espace de temps. Il semble même que la mémoire s'en soit conservée par la tradition; car les anciens étoient persuadés que les terres de la zone torride étoient inhabitées: elles étoient en effet encore inhabitables long-lemps après la population des terres du nord; car en supposant trente-cinq mille ans pour lè temps nécessaire au refroidissement de la terre sous les pôles sèûlemènt ait point d'en pouvoir toucher la surlace sans se briller, et vingt ou vingt-cinq mille ans de plus, tant sous la retraité des iners que pour l'attiéissement nécessaire à l'existence des êtres aussi sensibles què le sont les animaux terrestres, on sentira bien qu'il fatit compter quelques milliers d'années de pins pour le refroidissement du globe à l'équateur, tant à cause de lapins grande épaisseur de la terre q"ûe de l'accession de la chaleur solaire, qui est considérable sous l'équateur et presque nulle sous le pôle.

Et quand même ces deux causes réunies He seraient pas suffisantes pour produire «ne si grande différence de temps entre ces deux populations, l'on doit considérer que l'équateur a reçu les eaux de l'atmosphère bien plus tard que les poles, et que par conséquent cette cause secondaire du refroidissement agissant plus promptement et plus puissamment que les deux premières causes,1a chaleur des terres du nord se sera considérablement attiédie par la chute des eanx, tandis que la chaleur des terres méridionales Se maintenoit et ne pouvoit diminuer que par sa propre déperdition. Et quand même on m'objecterait que la chute des eaux, soit sur l'équateur, soit sur les pôles, n'étant que la suite du refroidissement à un çhain degré de chacune de ces deux parties du globe, elle n'a eu lieu dans l'une et dans l'autre que quand la température de la terre et celle des eaux tomhantes ont été respectivement les mêmes, et que par conséquent cette chute d'eau n'a pas autant contribué que je le dis à accélérer le refroidissement sous le pôle plus que sous

l'équateur, on sera forcé de convenir que les vapeurs, et par conséquent les eaux tombant sur l'équateur, avoient plus de chaleur à cause de l'action du soleil, et que, par cette raison, elles ont refroidi plus lentement les terres de la zone torride, en sorte que j'admettrais au ntoins neuf à dix mille ans entre le temps de la naissance des éléphans dans les contrées septentrionales et le temps où ils se sont retirés jusqu'aux contrées les plus méridionales: car le froid ne venoit et ne vient encore que d'en haut-, les pluies continuelles qui tomboient sur les parties polaires du globe en accéléraient incessamment le refroidissement, tandis qu'aucune .cause extérieure ne contribuoit à celui des parties de l'équateur. Or, cette cause qui nous parait si sensible par les neiges de nos hivers et les grêles de notre été, ce froid,qui des hautes régions de l'air, nous arrive par intervalles, tomboit à-plomb et sans interruption sur les terres septentrionales, et les a refroidies bien plus promptement que n'ont pu se refraidir les terres de l'équateur sur lesquelles ces ministres du froid, l'eau, là neige, et la grêle, ne pouvoient agir ni tomber. D'ailleurs nous devons faire entrer ici une considération très importante sur les limites qui bornent la durée de la nature vivante: nous en avons établi le premier terme possible à,trente-cinq mille ans de la formation du globe terrestre, et 1* dernier terme à quatre-vingt-treize mille ans à dater de ce jour; ce qui tait cent trente deux. mille ans pour la durée absolue de cette belle nature Voilà les limites les plus éloignées et là plus grande étendue de durée que nous ayons données, d'après nos hypothèses, à la vie de la nature sensible: cette vie aura pu commencer à trente-cinq Ou trente-six mille ans, parce qu'alors le globe étoit assez refroidi à ses parties polaires pour qu'on pût le toucher Sans se brûler, et elle pourra ne flnir que dans quatre-vingt-treize mille ans, lorsque le globe Sera plus froid (jue la glace. Mais, entre ces deux limites si éloignées, il faut en admettre d'autres plus rapprochées. Les eaux et toutes les matières qui sont tombées de l'atmosphère n'ont cessé d'être dans un état d'ébullition qu'au moment où on pouvoit les toucher sans se brûler: ce n'est donc que long-temps aprcs cette période de trente-six mille ans que les êtres doués d'une sensibilité pareille à celle que nous leur connoissons ont pu naître et subsister; car si la terre, l'air, et l'eau, oré noient tout à coup ce degré de chaleur qui ne nous permettrait de pouvoir les toucher sans en être vivement offensés, y aurait-il un seul des êtres actuels capable de résister à cette chaleur mortelle, puisqu'elle excéderait de beaucoup la chaleur vitale de leur corps? Il a pu exister alors des végétaux, des coquillages, et des poissons d'une nature moins sensible à la chaleur, dont les espaces ont été anéanties par le refroidissement dans les âges subséquens, et ce sont ceux dont nous trouvons les dépouilles et les détrimens dans les mines de charbon, dans les ardoises, dans les schistes, et dans les couches d'argile, aussi bien que dans les bancs de marbre et des autres matières calcaires; mais toutes les espèces plus sensibles, et particulièrement les animaux terrestres, n'ont pu naître et se multiplier que dans les temps postérieurs et plus voisins du nôtre.

Et dans quelle contrée du nord les premiers animaux terrestres auront-ils pris naissance? n'est-il pas probable que c'est dans les terres les plus élevées, puisqu'elles ont été refroidies avant les autres? et n'est-il pas également probable que les éléphans et les autres animaux actuellement habitant les terres du midi sont nés les premiers de tous, et qu'ils ont occupé ces terres du nord pendant quelques milliers d'années, et longtemps avant la naissance des rennes qui habitent aujourd'hui ces mêmes terres du nord?

Dans ce temps, qui n'est guère éloigné du notre que de quinze mille ans, les éléphans, les rhinocéros, les hippopotames, et probablement touies les espèces qui ne peuvent se multiplier actuellement que sous la zone torride, vivoient donc et se multiplioient dans les terres du nord, dont la chaleur étoit au même degré, et p;tr conséquent tout aussi convenable à leur nature; ils y étoient en grand nombre; ils y oui séjourné long-temps; la quantité d'ivoire et de leurs autres dépouilles que l'on a découvertes et que l'on découvre tous les jours dans ces contrées septentrionales nous démontre évidemment qu'elles ont été leur patrie, leur pays natal, et certainement la première terre qu'ils aient occupée: mais, de plus, ils ont existé en même temps dans les comrées septentrionales de l'Europe, de l'Asie, et de l'Amérique; ce qui nous fait connoître que les deux continens étoient alors contigus, et qu'ils n'ont été séparés que dans des temps

suhséquens. J'ai dit que nous avions au Cabinet du Roi des défenses d'éléphant trouvées en Russie et en Sibérie, et d'autres qui ont été trouvées au Canada, près de la rivière d'Ohio. Les grosses dents molaires de l'hippopotame et de l'énorme animal dont l'espèce est perdue nous sont arrivées du Canada, et d'autres toutes semblables sont venues de Tartarie et de Sibérie. On ne peut donc pas douter que ces animaux, qui n'habitent aujourd'hui que les terres du midi de notre contuient, n'existassent aussi dans les terres septentrionales de l'autre, et dans le même temps, car la terre étoit également chaude ou refroidie au même degré dans tous deux. Et ce n'est pas seulement dans les terres du nord qu'on a trouvé ces dépouilles d'animaux du midi, mais elles se trouvent encore dans tous les pays tempérés, en France, en Allemagne, en Italie, en Angleterre, etc. Nous avons sur cela des monumens authentiques; c'est-à-dire des défenses d'éléphans et d'autres ossemens de i es animaux trouvés dans plusieurs provinces de l'Europe.

Dans les temps précédens, ces mêmes terres septentrionales étoient recouvertes par les eaux de la mer, lesquelles, par leur mouvement, y ont produit les mêmes effets que partout ailleurs; elles en ont figuré les collines, elles les ont composées de couches horizontales, elles ont déposé les argiles et les matières calcaires en forme de sédiment; car on trouve dans ces terres du nord, comme dans nos contrées, les coquillages et les débris des autres productions marines enfouis à d'assez grandes profondeurs dans l'intérieur de la terre, tandis que ce n'est pour ainsi dire qu'à sa superficie, c'est-à-dire à quelques pieds de profondeur, que l'on trouve les squelettes d'éléphans, de rhinocéros, et les autres dépouilles des animaux terrestres.

Il paroit même que ces premiers animaux terrestres étoient, comme les premiers animaux marins, plus grands qu'ils ne le sont aujourd'hui. Nous avons parlé de ces énormes dents carrées à pointes mousses qui ont appartenu à un animal plus grand que l'elephan, et dont l'espèce ne subsiste plus: nous avons indiqué ces coquillages en volutes qui ont jusqu'à huit pieds de diamètre sur un pied d'épaisseur; et nous avons vu de même des défenses, des dents, des omoplates, des fémurs d'éléphans d'une taille supérieure à celle des éléphans actuellement existans. Nous avons reconnu, par la comparaison immédiate des dents mâcbelières des hippopotames d'aujourd'hui avec les grosses dents qui nous sont venues de la Sibérie et du Canada, que les anciens hippopotames auxquels ces grosses dents ont autrefois appartenu étoient au moins quatre fois plus volumineux que ne le sont les hippopotames actuellement existans. Ces grands ossemens et ces énormes dents sont des témoins subsistons de la grande force de la nature dans ces premiers âges. Mais, pour ne pas perdre de vue notre objet principal, suivons nos éléphans dans leur marche progressive du nord au midi.

Nous ne pouvons douter qu'après avoir occupé les parties septentrionales de la Russie et de la Sibérie jusqu'au 60" degré ', où l'on a trouvé leurs dépouilles en grande quantité, ils n'aient ensuite gagné les terres moins septentrionales, puisqu'on trouve encore de ces mêmes dépouilles en Moscovie, en Pologne, en Allemagne, en Angleterre, en France, en Italie; en sorte qu'à mesure que les terres du nord se refroidissoient, ces animaux cheleboient des terres plus chaudes; et il est clair que tous les climats, depuis le nord jusqu'à l'équateur, ont successivement joui du degré de chaleur convenable à leur nature. Ainsi, quoique de mémoire d'homme l'espèce de l'éléphant ne paroisse avoir occupé (lue U s climats actuellement les plus chauds dans notre comment, c'est-à-dire les terres qui s'étendent à peu près à ao degrés des deux rôles de l'équateur, et qu'ils y paraissent confinés depuis plusieurs siècles, les monumens de leurs dépouilles trouvées dans toutes les parties tempérées de ce même comment démontrent qu'ils ont aussi habité pendant autant de siècles les différais climats de ce même continent; d'abord du 60e au 5oe degré, puis du 5oe au 40% ensuite du 400 au 3o% et du 3oe au 2o°, enfin du ao" à l'équaleur1, et au delà à la même distance. On pourrait même présumer qu'en faisant des recherches en Laponie, dans les terres de l'Europe et de l'Asie qui sont au delà du 60e degré, on pourrait y trouver de même des défenses et des ossemens d'éléphans, ainsi que des autres animaux du midi, à moins qu'on ne veuille supposer (ce qui n'est pas sans vraisemblance) que, la surface de la terre étant encore plus élevée en Sibérie que dans toutes les

provinces qui l avoisiuent du coté du nord, ces mêmes terres de la Sibérie ont été les premières abandonnées par les eaux, et par conséquent les premières où les animaux terrestres aient pu s'établir. Quoiqu'il en soit, il est certain que les éléphans ont vécu, produit, multiplié pendant plusieurs siècles dans cette même Sibérie et dans le nord de la Russie; qu'ensuite ils ont gagné les terres du 5oe au 40e degré, et qu'ils y ont subsisté plus long-temps que dans leur terre natale, et encore plus long-temps dans les contrées du 40e au 3oe degré, etc., parce que le refroidissement successif du globe a toujours été plus lent, à mesure que les climats se sont trouvés plus voisins de l'équateur, tant par la plus forte épaisseur du globe que par la plus grande chaleur du soleil.

Nous avons fixé, d'après nos hypothèses, le premier instant possible du commencement de la nature vivan, à trente-cinq ou trente-six mille ans, à dater de la formalion du globe, parce que ce n'est qu'à cet instant qu'on aurait pu commencer à le toucher sans se brûler: en donnant vingt-cinq mille ans de plus pour achever l'ouvrage immense de la construction de nos montagnes calcaires, pour leur figuration par angles saillans et rentrans, pour l'abaissement des mers, pour les ravages des volcans et pour le dessèchement de la surface de la terre, nous ne compterons qu'environ quinze mille ans depuis le temps où la terre, après avoir essuyé, éprouvé tant de bouleversemens et de changemens, s'est enfin trouvée dans un état plus calme et assez fixe pour que les causes de destruction ne fussent pas plus puissantes et plus générales que celles de la production. Donnant doue quinze mille aus d'ancienneté à la nature vivante, telle qu'elle nous est parvenue, c'est-à-dire quinze mille ans d'ancienneté aux espèces d'animaux terrestres nées dans les terres du nord et actuellement existantes dans celles du midi, nous pourrons supposer qu'il y a peut-être cinq mille ans que les éléphans sont confinés dans la zone torride, et qu'ils ont séjourné tout autant de temps dans les climats qui forment aujourd'hui les zones tempérées, et peut-être autant dans les climats du nord, où ils ont pris naissance.

Mais cette marche régulière qu'ont suivie les plus grands, les premiers animaux de notre continent, paraît avoir souffert des obstacles dans l'autre. Il est très certain qu'on a trouvé, et il est très probable qu'on trouvera encore, des défenses et des ossemens d'éléphans en Canada, dans le pays des Illinois, au .Mexique, et dans quelques autres endroits de l'Amérique septentrionale; mais nous n'avons aucune observation, aucun monument, qui nous indiquent le même fait pour les terres de l'Amérique méridionale. D'ailleurs l'espèce même de l'éléphant qui s'est conservée dans l'ancien continent ne subsiste plus dans l'autre: non seulement cette espèce ni aucune autre de toutes celles des animaux terrestres qui occupent actuellement les terres méridionales de notre continent ne se sont trouvées dans les terres méridionales du Nouveau Monde, mais même il parait qu'ils n'ont existé que dans les contrées septentrionales de ce nouveau continent; et cela dans le même temps qu'ils existoient dans celles de notre continent. Ce fait ne démontre-t-il pas que l'ancien et le nouveau continent n'étoient pas alors séparés vers le nord, et que leur séparation ne s'est faite que postérieurement au temps de l'existence des éléphans dans l'Amérique septentrionale, où leur espèce s'est probablement éteinte par le refroidissement, et à peu près dans le temps de cette séparation des continens, parce que ces animaux n'auront pu gagner les régions de l'équateur dans ce nouveau continent comme ils l'ont fait dans l'ancien, tant eu Asie qu'en Afrique? En effet, si l'on considère la surface de ce nouveau continent, on voit que les parties méridionales voisines de l'isthme de Panama sout occupées par de très hautes montagnes: les éléphans n'ont pu franchir Ces barrières invincibles pour eux, à cause du trop grand froid qui se bit sentir sur ces bailleurs; ils n'auront donc pas été au delà des terres de l'isthme, et n'auront subsisté dans l'Amérique septentrionale qu'autant Cpl'aura duré dans celle terre le degré de chaleur nécessaire à leur multiplication. Il in est de même de tous les autres animaux des parties méridionales de notre continent; aucun ne s est trouvé dans les parties méridionales de l'autre. J'ai démontré cette vérité par un si grand nombre d'exemples qu'ou ne peut la révoquer en doute.

Les animaux, au contraire, qui peuplent actuellement nos régions tempérées et froides se trouvent également dans les parties septeutrionales des deux continens; ils y sont nés postérieurement aux

premiers et s y sont conservés, parce que leur nature n exige pas une aussi grande chaleur. Les rennes et les autres animaux qt*: ne peuvent subsister que dans les climats les plus froids sont venus les derniers; et qui sait si, par succession de temps, lorsque la terre sera refroidie, il ne paroitra p-.s de nouvelles especes dont le tempérament différera de celui du venue autant que la nature du renne diffère à cet égard de celle de I eléphant? Quoi qu'il en soit, il est certain qu'aucun des animaux propres cl particuliers aux lerivs méridionales de noire continent ne s'est trouvé dans les terres méridionales de l'autre, et que même, dans le nombre des animaux communs à notre continent et à celui de l'Amerique septentrionale, dont les especes se sont conservées dans tous les deux, à peine en peut-on citer une qui soit arrivée à l'Amérique méridionale. Cette partie du monde n'a donc pas été peuplée comme toutes les autres ni dans le même temps; elle est demeurée pour ainsi dire isolée et séparée du reste de la terre par les mers et par ses hautes montagnes. Les premiers ammaux terrestres nés dans les terres du nord n'ont donc pu s'établir, par communication, dans ce continent méridional de l'Amérique, ni subsister dans sou continent septentrional qu'autant qu'il a conservé le degré de chaleur nécessaire à leur propagation; et cette terre de l'Amérique méridionale, réduite à ses propres forces, n'a enfanté que des animaux plus ioibles et beaucoup plus petits que ceux qui sont-venus du nord pour peupler nos contrées du midi.

Je dis que les animaux qui peuplent aujourd'hui les terres du midi de notre continent y sont venus du nord, et je crois pou* voir l'aflirmer avec tout fondement: car, d'une part, les mouumens que nous venons d'exposer le démontrent; il, d'autre côté, nous ne connoissons aucune espcce grande et principale, actuellement subsistante dans ces terres du midi, qui n'ait existé précédemment dans les terres du nord, puisqu'on y trouve des défenses et des ossemetis d éléphans, des squelettes de rbinocéros, des dents d'hippopotames, et des tèles monstrueuses de bœufs, qui ont frappé par leur grandeur, et qu'il est plus que probable qu'on y a trouvé de même des débris de plusieurs autres especes moins remarquables, en sorte que si l'on veut distinguer dans les terres méridionales de notre contineut les animaux qui y sont arrivés du nord, de ceux que celte même terre a pu produira par -es propres forces, on reconnoitra que tout ce qu il v a de colossal et de grand dans la nature a été formé dans les terres du nord; et que si celles de léqualeur ont produit quelques animaux, ce sont des especes interieures bieu plus petites que les première.

Mais ce qui doit faire douter de cette production, c'est que ces espèces, que nous supposons ici produites par les propres forces de- terres méridionales de notre continent, auraient dû ressembler aux animaux des terres méridionales de l'autre continent, lesquels u oui de même élé produits que par la propre force de celle terre isolée: cest néanmoins tout le contraire, car aucun des anima de l'Amérique méridionale ne ressemble assez aux ammaux des terres du midi de noire continent pour qu'on puisse les regarder comme de la même espece; ils sont, pour la plupart, d'une forme si différente, que ce u'est qu'apres un long examen qu'on peut les soupçonner d'être les représentant oe quelques uns de ceux de nobe continent. Quelle différence de l'éléphant au tapir, qui cependant est de tous le seul qu'on puisse lui comparer, mais qui s en éloigne déjà beaucoup pur la ligure, et prodigiei'semeut par ta gtaudeurl or ce tapir, cet é1* pliant du Nouveau-Monde, n'a ni trompe ni défenses, el n'est guère plus grand qu'un âne. Aucun animal de l'Amérique meridionale ne ressemble au rbinocéros, aucun a l'hippopotame, aucun à la girafe: et quelle dilféreuce encore entre le lama el le chameau, quoiqu'elle soit moins grande qu entre le tapir el t dépbant!

Létablissement Je la nature vivante, sur tout de celle des animaux terrestres, s'est donc fait dans l'Amérique meridionale bien Estér purement à son «'jour déjà fixé dans terres du nord; et peut èlielu différence du temps est-elle de plus de quatre ou cinq mille ans. Nous avons exposé une partie des faits et des raisons qui doivent faire penser que le Nouveau-Monde, surtout dans ses parties méridionales, est une terre plus récemment peuplée que celle de notre continent; que la nature, l>ieu loin d'y être dégénérée par vétusté, y est au contraire née tard, et n'y a jamais existé avec les mêmes forces, la nièute puissance active que dans les contrées septentrionales; car on ne peut douter, après ce qui vient d'être dit, que les grandes et premières formations des êtres animés

ne se soient laites dans les terres élevées du nord, d'uù-ellcs ont successivement passé dans les contrées du midi sous la ntèuie forme, et sans avoir rien perdu que sur les dimensions de leur grandeur. iNos éléphans et nos hippopotames, qui nous paruis-enl si gros, ont eu des ancêtres plus grands dans les temps qu'ils iiahiloicnl les terres septentrionales où ils ont laissé leurs dépouilles: les cetacés d aujourd'hui sont aussi moins gros qu'ils ne l'étnient anciennement: mais c'est peut-être par une autre raison.

Les haleines, les gibhars, motard, cachalots, uaruals, et autres gramts retaecs, appartiennent aux mers septentrionales, taudis que l'on ne trouve dans les mers tempérées et méridionales que les lamantins, lesdugons, les marsouins, qui tous sont inférieurs aux premiers en grandeur. Il semble donc, au premier coup d'œil, que la nature ait opéré d'une manière contraire et par une succession imerse, puisque tous les plus grands animaux terrestres se trouvent actuellement dans les contrées du midi, taudis que tous lcs plus grands animaux marins n'habitent que les régions de notre pôle. Kt pourquoi ces grandes et presque monstrueuses espcces paruissent-elles confinées dans ces mers froides? Pourquoi n'ont-ellcs pas gagné successivement, comme les éléphans, les régions les plus chaudes:. En un mut, pourquoi ne se trouvent-elles ni dans les mers tempérées ni dans celles du midi? car, à l'exception de quelques cachait ts qui viennent assez souvent autour des Açores, et quelquefois échouer sur nos côtes, et dont l'espèce parait la plus vagabonde de ces grands cétacés, toutes les autres sont demeurées el ont encore leur séjour constant dans les mers boréales des deux rontinens. On a bien remarque, depuis qu'on a commencé la pèche ou plutôt la chasse de ces grands animaux, qu'ils se sont retirés des endroits où l'homme alloit les inquiéter. On a de plus observé que ces premieres haleines, c’est-à-dire celles que l'on pèchoit il y a cent cinquante et deux cents ans, étoient beaucoup plus grosses que celles d'aujourd'hui; elles avoient jusqu'à cent pieds de longueur, tandis que les plus grandes que l'on prend actuellement n'en ont que soixante. Ou pourroit même expliquer d'une manière assez satisfaisants) les raisons de cette différence de grandeur; car les haleines, ainsi que tous les autres cétacés, el même la plupart des poissons, vivent, sans comp&raisun, bien plus longtemps qu'aucun des animaux terrestres; et des lors leur entier accroissement demande aussi un temps beaucoup plus long, t 11* quand on a commencé la pèche des haleines, il y B cent cinquante uu deux cents ans, ou a trouvé les plus Agées et celles qui avoient pris leur entier accroissement; on les a poursuivies, chassées de préférence; enfin on les a detruites, el il ne reste aujourd'hui dans les mets fréquentées par nos pêcheurs que Celles qui n'ont pas encore atteint toutes leurs dimensions: car, comme nous l'avons dit ailleurs, une haleme peut bien vivra nulle ans, puisqu'une carpe en vil plus de deux cents.

La permanence du séjour de ces grands animaux dans les mers boreales semble lournir une nouvelle preuve de la continuite des continens icra les régions de notre nord, et nous indiquer que cet état de continuité à subsisté long temps; car si ces animaux marins, que nous supposerons pour un moment nés eu même temps (pie les éléphans, eussent trouvé la ronle ouverte, ifs auroient gagné les mers du midi, pour peu que lè refroidissement des eaux leur eut été contraire; et cela seroit arrivé s'ils eussent pris naissance dans le temps que là mer étoit encore chaude. On doit donc présumer què leur existence est postérieure à celle des éléphans et des autres animaux qui ne peuvent subsister que dans les climats du midi. Cependant il se pourroit aussi que la différence de température fût, pour ainsi dire, indifférente ou beaucoup moins sensible aux animaux aquatiques qu'aux animaux terrestres. Le froid et le chaud sur la surface de la terre et de la mer suivent à la vérité l'ordre des climats, et la chaleur de l'intérieur dti globe est la même dans le sein de la mer et dans celui de la terre à la même profondeur: mai» les vai iations de leuiperaiure, qui sont si grandes à la surface de la terre, sont beaucoup moindres, et presque nulles, à quelques toises de profondeur sous les eaux. Les injures de l'air ne s'y font pas sentir, et ces grands cétacés ne les éprouvent pas, ou du moins peuvent s'en garantir: d'ailleurs, par la nature même de leur organisation, ils paroissent être plutôt munis contre le froid que contre la grande chaleur; car, quoique leur sang soit à peu près aussi chaud que celui des animaux quadrupèdes, l'énorme quantité de lard et d'huile qui recouvre leur corps, en les privant du sentiment vif qu'ont les autres

animaux, les défend en même temps de toutes les impressions extérieures: et il est à présumer qu'ils restent où ils sont parce qu'ils n'ont pas même le sentiment qui pourroit les conduire vers une température plus douce, ni l'idée de se trouver mieux ailleurs; car il faut de l'instinct pour se mettre à son aise, il en faut pour se déterminer à changer de demeure, et il y a des animaux, et même des hommes, si bruts, qu'ils 1inferent de languir dans leur ingrate terre natale, à la peine qu'il faudrait prendre pour se giter plus commodément ailleurs '. Il est donc très probable que ces cachalots que nous voyons de temps en temps arriver des mers septentrionales sur nos côtes ne se décident pas à faire ce voyage pour jouir d'une température plus douce, mais qu'ils y sont déterminés par les colonnes de harengs, de maquereaux, et d'autres petits poissons, qu'ils suivent et avalent par milliers.

Je puis en citer nu exemple frappant: les Maillés, petite nation sauvage de la Guiane, à peu de distance de l'embouchure de la rivière Ouassa, n'ont pas d'autre domicile que les arbres, au dessus desquels ils se tiennent toute l'année, parce que leur terrain est toujours plus ou moins couvert d'eau; ils ne descendent de ces arbres que pour aller en canots chercher leur subsistance Voilà un singulier exemple du stupide attachement à la terre natale; car il ne tiendroit qu'à ces sauvages d'aller comme If s autres habiter sur la terre, en s'éloignam de quelques lieues des savanes noyées où ils ont pris naissance et où ils veulent mourir. Ce Tait, cité par quelques voyageurs, m'a été confirmé par plusieurs témoins, qui ont vu récemment celte petite nation, composée de trois on quatre cents sauvages: ils se tiennent en efTet sur les arbres au dessus de l'eau, ils y demeurent toute l'année t leur terrain est une grande nappe d'eau pendant les huit ou neuf mois de pluie; et, pendant les quatre mois d'été, la terre n'est qu'une boue fangeuse, sur laquelle il se forme une prtite croûte de cinq ou six pouces d'épaisseur, composée d'herbes plutot que de terre, et sous lesquelles on trouve une grande épaisseur d'eau croupissante et fort infecte. (Add. Bu//.)

Toutes ces considérations nous font présumer que les régions de notre nord, soit de la mer, soit de la terre, ont non seulement été les premières fécondées, mais que c'est encore dans ces mêmes régions que la nature vivante s'est élevée à ses plus grandes dimensions. Et comment expliquer cette supériorité de force et cette supériorité de formation donnée à cette région du nord exclusivement à toutes les autres parties de la terre? car nous voyons par l'exemple de l'Amérique méridionale, dans les terres de laquelle il ne se trouve que de petits animaux, et dans les mers le seul lamantin, qui est aussi petit en comparaison de la haleine que le tapir l'est en comparaison de l'éléphant; nous voyons, dis-je, par cet exemple frappant, que la nature n'a jamais produit dans les terres du midi des animaux comparables en grandeur aux animaux du nord; et nous voyons de même, par un second exemple tiré des monumens, que, dans les terres méridionales de noire continent, les plus grands animaux sont ceux qui sont venus du nord, et que, s'il s'en est produit dans ces terres de noire midi, ce ne sont que des espèces très inférieures aux premières en grandeur et en force. On doit même croire qu'il ne s'en est produit aucune dans les terres méridionales de l'ancien continent, quoiqu'il s'en soit formé dans celles du nouveau; et voici les motifs de cette présomption:

Toute production, toute génération, et même tout accroissement, tout développement, supposent le concours et la réunion d'une grande quantité de molécules organiques vivantes; ces molécules, qui animent tons les corps organisés, sont successivement employées à la nutrition et à la génération de tous les êtres. Si tout à coup ta plus grande partie de ces êtres étoil supprimée, on verroit paraitre des espèces nouvelles, parce que ces molécules organiques, qui sont indestructibles et toujours actives, se réunirnient pour composer d'autres corps organisés; mais étant entièrement absorbée* par les moules intérieurs des êtres existans, il ne peut se former d'espèces nouvelles, du moins dans les premières classes de la nature, telles que celles des grands animaux. Or ces grands animaux sont arrivés du nord sur 1rs terres du midi; ils s'y sont nourris, reproduits, multipliés, et ont par conséquent absorbé les molécules vivantes, en sorte qu'ils n'en ont point laissé de super et nous savons qu'ils descendent en hiver à quelque» degrés au dessous; mais ils ne viennent jamais eu

nombre dans les mers tempérées ou chaudes, et flues qui miraient pn former des espères nouvelles; tandis qu'au contraire dans les terres de l'Amérique méridionale, où les grands animaux du nord n'ont pn pénétrer, les molécules organiques vivantes ne se trouvant absorbées par aucun moule animal déjà subsistant, elles se seront réunies pour former des espèces qui ne ressemblent point aux autres, et qui toutes sont inférieures, tant par la force que par la grandeur, à celles des animaux venus du nord.

Ces deux formations, quoique d'un temps différent, se sont faites de la même manière et par les mêmes moyens; et si les premières sont supérieures à tous égards aux dernières, c'est que la fécondité de la terre, c'est-à-dire la quantité de la matière organique vivante, étoit moins abondante dans ces climats méridionaux que dans celui du nord. Ou peut en donner la raison, sans la chercher ailleurs que dans notre hypothèse; car toutes les parties aqueuses, huileuses, et ductiles, qui devoient entrer dans la composition des êtres organNés, sont tombées avec les eaux sur les parties septentrionales du globe bien plus tôt et en bien plus grande quantité que sur les parties méridionales. C'est dans ces matières aqueuses et ductiles que les molécules organiques vivantes ont commencé à exercer leur pu ssance pour modeler et développer les corps organisés; et comme les molécules organiques ne sont produites que par la chaleur sur les matières ductiles, elles étoienl aussi plus abondantes dans les terres du nord qu'elles n'ont pu l'être dans les terres du midi, où ces mêmes matières étoient en moindre quantité: il n'est pas étonnant que les premières, les plus fortes, elles plus grandes productions de la nature vivante se soient faites dans ces mêmes terres du nord, tandis que dans celles de l'équateur, et particulièrement dans celles de l'Amérique méridionale, où la quantité de ces mêmes matieres ductiles étoil bien moindre, il ne s'est forme que des espèces inférieures plus petites et plus foibles que celles des terres du nord.

Mais revenons à l'objet principal de notre époque. Dans ce même temps où les éléphans habitoient nos terres septentrionales, les arbres et les plantes qui couvrent actuellement nos contrées méridionales existoient aussi dans ces mêmes terres du nord. Les mounmeus semblent le démontrer; car toutes les impressions bien avérées des plantes qu'on a trouvées dans nos ardoises et nos charbons présentent la figure de plantes qui n'existent actuellement que dans les grandes Indes ou dans les autres parties du midi. On pourra m'objecter, malgré la certitude du fait par l'évidence de ces preuves, que les arbres et les plantes n'ont pu voyager comme les animaux. ni par conséquent se transporter du nord au midi. A cela je réponds. i° que ce transport ne s'est pas fait tout à coup, mais successivement: les espèces de végétaux se sont semées de proche en proche dans les terres dont la température leur devenoit convenable; et ensuite ces mêmes espèces, après avoir gagné jusqu'aux contrées de l'equateur, auront péri dans celles du nord, dont elles ne pouvoient plus supporter le froid, a° Ce transport ou plutôt ces accrues successives de bois ne sont pas même nécessaires pour rendre raison de l'existence de ces végétaux dans les pays méridionaux; car en général la même température, c'est-à-dire le même degré de ehaleur. produit partout les mêmes plantes sans qu'elles y aient été transportees. La population des terres méridionales par les végétaux est donc encore plus simple que par Us animaux.

Il reste celle de l'homme: a-t-elle été contemporaine à celle des animaux? Des motifs majeurs et des raisons tres-solides se joignent ici pour prouver qu'elle s'est faite postérieurement à toutes nos époques, et que l'homme est en effet le grand et dernier œuvre de la création. On ne manquera pas de nous dire que l'analogie semble démontrer que l'espèce humaine a suivi la même marche et qu'elle date du même temps que les autres espèces; qu'elle s'est même plus universellement répandue, et que, si l'époque de sa création est postérieure à celle des animaux, rien ne prouve que l'homme n'ait pas au moins subi les mêmes lois de la nature, les mêmes altérations, les mêmes changemens. Nous conviendrons que l'espèce humaine ne differe pas essentiellement des autres espèces par ses facultés corporelles, et qu'à cet égard son sort eût été le même à peu près que celui des autres espèces: mais pouvons-nous douter que nous ne différions prodigieusement des animaux par le rayon divin qu'il a plu au souverain Être de nous départir? Ne voyons - nous pas que

dans l'homme la matière est conduite par l'esprit? Il a donc pu modifier les effets de la nature; il a trouvé le moyen de résister aux intempéries des climats; il a créé de la chaleur, lorsque le froid l'a détruite: la découverte et les usages de l'élément du feu, dus à sa seule intelligence, l'ont rendu plus fort et plus robuste qu'aucun des anunafix, el 1'onl mis en état de braver les tristes effets du refroidissement. D'autres arts, c'«st-ji-d«e d'autres traits de sou intelligence, lui oui fourni des vétemens, des armes, el bientôt il s'est trouvé 1e maitre du domame de la terre: ces mêmes arts lui ont donné les moyens d'en parcourir .toute la surface et de s'habituer partout, parce qu'avec plus ou moins de précautions tous les climats lui sont devenus pour ainsi dire égaux. Il n'est doue pas étonnant une, quoiqu'il n'existe aucun des auimaux du midi de notre continent dans l'anlre, l'iiomme seul, c'est-à-dire son espèce, se trouve également dans cette terre isolée de l'Amérique méridionale qui parait n'avoir eu aucune part aux premieres formations des animaux, et aussi dans toutes les parties froides ou chaudes de la surface de la terre: car quelque part et quelque loin que l'on ait pénétré depuis la perfection de l'art de la navigatiou, l'iiomme a trouvé partout des hommes; les terres les plus disgraciées, les iles les plus isolées, les plus éloignées des continens, se sont presque toutes trouvées peuplées; et l'on ne peut pas dire que ces hommes, tels que ceux des iles Matianes, on ceux d'Otaliiti, et des autres petites iles situées dans le nulieu des mers à de si granites distances de toutes ternis habitées, ne soient néanmoins des hommes de noire espèce, puisqu'ils peuvent lx oduire avec nous, et que les petites différences qu'on remarque dans leur nature ne sont que de légères yariéiés causées j,ar l'inllueuce du climat et de la nourriture.

Néanmoins, si I on considère que l'homme, qui peut se munir aisément contre le froid, ne peut an contraire se défendre par aucun moyeu contre 1a chaleur trop grande, que même il souffre beaucoup dans les climats que les anuuaux du midi cherchent de préfèrence, on aura une raison de plus pour croire que la création de l'homme a été postérieure à celle de ces grands animaux. Le souverain Etre n'a pas répandu le souffle de vie dans le même instant sur toute la surface de la terre; il a commencé pur féconder les mers, et ensuite les terres les plus élevées; et il a voulu donner tout le temps nécessaire à la terre pour se consolider, se refroidir, se découvrir, se sécher, et arriver enfm à l'état de repos et de tranquillité où l'homme pouvoit être le témoin intelligent, la(luiirateur paisible du grand spectacle de la nature et des merveilles de la création. Ainsi nous sommes persuadés, indépendamment de l'autorité des livres sacrés, que l'homme a été créé le dernier, et qu'il u'est venu prendre le sceptre de la terre que quand elle s'est trouvée digne de son empire. 11 paroit' néanmoins que son premier séjour a d'aliord été, comme celui, des animaux terrestres, dans les hautes terres de l'Asie; que c'est dans ces mêmes terres où sont nés les arts de premiere nécessité, et bientot aprcs U s sciences, éi;alemenl nécessaires à l'exercice de la puissance de l'homme, et sans lesquelles il u'auruit pu former de societé, ni compter sa vie, ni commander aux animaux, ni se servir autrement des végétaux que pour les brouter. Mais nous nous réservons d exposer dans notre dernière époque les principaux faits qui ont rapport à l'histoire des premiers hommes.

Sixieme Epoque - Lorsque S'est Faite La Séparation Des Continens

Le temps de la séparation des continens est certainement postérieur au temps où les éléphans habitoient les terres du nord, puisqu'alors leur espèce éloit également subsistante en Amérique, en Europe, et en Asie. Cela nous est démontré par les monumens, qui sont les dépouilles de ces animaux trouvées dans les parties septentrionales du nouveau continent, comme dons celles de l'ancien. Mais comment est-il arrivé que cette séparation des continens paroisse s'être faite en deux endroits par deux bandes de mer qui s'étendent depuis les contrées septentrionales, toujours en s'élargissant, jusqu'aux contrées les plus méridionales? Pourquoi ces handes de mer ne se trouvent-elles pas, au contraire, presque parallèles à l'équateur, puisque le 'mouvement général des mers se fait d'orient en occident? N'est-ce pas une nouvelle preuve que les eaux sont primitivement venues des pôles, et qu'elles n'ont gagné les parties de l'équateur que successivement? Tant qu'a duré ta chute des eaux, et jusqu'à l'entière épuration de l'atmosphère, leur mouvement général a été dirigé

des poles à l'équateur; el comme elles venoienl en plus grande quantité du pole austral, elles ont formé e vastes mers dans cet hémisphère, lesquelles vont en se rétrécissant de plus en plus dans l'hémisphère boréal, jusque sous le cercle polaire; et c'est parce mouvement dirigé du sud au nord que les eaux ont aiguisé toutes les pointes des continens: Biais aptes leur entier établissement sur la surface de la terre, qu'elles surmontaient partout de deux milles toises, leur mouvement des pôles à l'equateur ne se sera-i-il pas combiné, avant de cesser. avce le mouvement d'orient en occident? et, lorsqu'il a cessé loul-à-fait, les eaux eutrainées par le seul mouvement d'orient en occident n'ont-elles pas escarpé tous les revers occidentaux des continens terrestres, quand elles se sont successnemeut ahaissées? et enfm n'est-ce pas après leur retraite que tous les continens ont paru, et que leurs contours ont pris leur dernière forme? Nous observerons d'abord que l'étendue des terres dans, l'hémisphère boréal, en le prenant du cercle polaire à l'équateur, est si grande en comparaison de l'étendue des terres prises de même dans l'hémisphère austral, qu'on pourroit regarder le premier comme l'hémisphère terrestre, et le second comme l'hémisphère maritime. D'ailleurs il y a si peu de distance entre tes deux continens vers les régions de notre pôle, qu'on ne peut guère douter qu'ils ne lussent continus dans les temps qui ont succédé à U retraite des eaux. Si l'Europe est aujourd'hui séparée du Groenland, c'est probablement parce qu'il s'est fait un affaissement considérable entre les terres du Groenland et celles de Norwège et de la pointe de l'Écosse, dont les Orcades, l'ile de Schetland, celles de Feroé, de l'Islande, et de Hola, ne nous montrent plus que les sommets des terrains submergés; et si le continent de l'Asie n'est plus contigu à celui de l'Amérique vers le nord, c'est sans doute en conséquence d'un effet tout semblable. Ce premier affaissement que les volcans de l'Islande paraissent nous indiquer a non seulement cté postérieur aux affaissement des contrées de l'équateur et à la retraite drs mers, mais postérieur encore de quelques siecles à la naissance des grands animaux terrestres dans les contrées septentrionales; et l'on ne peut douter que la séparation des continens vers le nord ne soit d'un temps assez moderne en comparaison de la division de ces mêmes couti* nens vers les parties de t'équaleur.

Nous présumons encore que non seulement le Groenland a été joint à la INorwcgecl à l'Écosse, mais aussi que leGanada pouvoil l'être à l'Kspagne par les bancs de Terre-Neuve, les Adores el les autres ileg et hauts-fonds qui se trouvent dans cet itt*' tervalle de mer; ils semblent nous prcsenter aujourd'hui les sommets les plus élevés de ces terres affaissées sous les eaux. La submersion en est peut-être encore plut moderne que celle du continent de 1 Islande, puisque la tradition parait s'en être conservée: l'histoire de l'iie Atlantide, rapportée par Diodore et Platon, ne peut expliquér qu'à une très grande terre qui s'éteudoit fort an loin à l'occident de l'Espagne; cette terre Atlantide étoit très peuplée, gouvernée par des rois puissans qui commandoient à plusieurs milliers de combattans, et cela nous indique assez positivement le voisinage de l'Amérique avec ces terres Atlantiques situées entre ces deux continens. Nous avouerons néanmoins que la seule chose qui soit ici démontrée par le fait, c'est que les deux continens étoient réunis dans le temps de l'existence des éléphans dans les contrées septentrionales de l'un et de l'autre, et il y a, selon moi, beaucoup plus de probabilité pour cette continuité de l'Amérique avec l'Asie qu'avec l'Europe. Voici les faits et les observations sur lesquels je fonde cette opinion:

Quoiqu'il soit probable que les terres du Groenland tiennent à celles de l'Amérique, l'on n'en est pas assuré; car cetle terre du Groenland eu est séparée d'abord par le détroit de Davis, qui ne laisse pas d'èlre fort large, et ensuite par la baie de Baffin, qui l'est encore plus; et cette baie s'étend jusqu'au 78e degré, en sorte que ce n'est qu'au delà de ce terme que le Groenland et l'Amérique peuvent être contigus.

Le Spitzberg paroit ette une continuité des terres de la côte orientale du Groenland, et il y a un assez grand intervalle de mer entre cette côte du Groenland et celle de la Laponie: ainsi l'on ne peut guère imaginer que les éléphans de Sibérie ou de Russie aient pu passer au Groenland. Il en est de même de leur passage par la bande de terre que l'on peut supposer entre laNorwège,

l'Écosse, l'Islande, et le Groenland: car cet intervalle nous présente des mers d'une largeur assez considérable; et d'ailleurs ces terres, ainsi que celles du Groenland, sont plus septentrionales que celles où l'on trouve les ossemens d'éléphans, tant au Canada qu'en Sibérie: il n'est donc pas vraisemblable que ce soit par ce cbemin, actuellement détruit de fond en comble, que ces animaux aient communiqué d'un continent à l'autre.

Quoique la distance de l'Espagne au Canada soit beaucoup plus grande que celle de l'Écosse au Groenland, cette route me paroilroit la plus naturelle de toutes, si nous etions forcés d'admettre le passage des éléphans d'Europe en Amérique: car ce grand intervalle de mer entre l'Espagne et les terres voisines du Canada est prodigieusement raccourci par les bancs et les îles dont il est semé; et ce qui pourroit donner quelque probabilité de plus à cette présomption, c'est la tradition de la submersion de l'Allant ide.

L'on voit que de ces trois cbemins, les deux premiers paroissent impraticables, et le dernier si long, qu'il y a peu de vraisemblance que les éléphans aient pu passer d'Europe en Amérique. En même temps il y a des raisons très fortes qui me portent à croire que cetle communication des éléphans d'un continent à l'autre a dù se faire par les contrées septentrionales de l'Asie, voisines de l'Amérique. Nous avons observé qu'en général toutes les côtes, toutes les pentes des terres, sont plus rapides vers les mers à l'occidenl, lesquelles, par cette raison, sont ordinairement plus profondes que les mers à l'orient. Nous avons vu qu'an contraire tous les continens s'étendent en longues pentes douées vers ces mers de l'orient. On peut donc présumer avec fondement que les mers orientales au delà et au dessus de Kamtsrhalka n'ont que peu de profondeur; et l'on a déjà reconnu qu'elles sont semées d'une très grande quantité d'iles, dont quelques-unes forment des terrains d'une vaste étendue; c'est un archipel qui s'étend depuis Kamtschatka jusqu'à moitié de la distance de l'Asie à l'Amérique, sous le 60e degré, et qui semble y toucber sous le cercle polaire par les îles d'Anadir et par la pointe du continent de l'Asie.

D'ailleurs les voyageurs qui onl également fréquenté les côtes occidentales du nord de l'Amérique et les terres orientales depuis Kamtsehatka jusqu'au nord de cette partie de l'Asie conviennent que les naturels de ces deux contrées d'Amérique et d'Asie se ressemblent si fort, qu'on ne peut guère duuter qu'ils ne soient issus les uns des au tres: non seulement ils se ressemblent par la taille, par la forme des traits, la couleur des cbeveux, et la conformation du corps et des membres, mais encore par les mœurs et même par le langage. Il y a doue une très grande probabilité que c'est de ces terres de l'Asie que l'Amérique a reçu ses premiers habitaus de toute espèce, à moins qu'on ne voulût prétendre que les éléphans et tous les autres animaux, ainsi que les végétaux, ont été créés en grand nombre dans tous les climats où la température pouvoit leur convenir; supposition hardia et plus que gratuite, puisqu'il suffit de deux individus on même d'un seul, c'est-à-dire d'un ou deux moules une fois donnés, et doués de la faculté de se reproduire, pour qu'en un certain nombre de siècles la terre •e «oit peuplée de tous les êlres organisés dont la reproduction suppose ou uou le concours des sexes.

En réflechissant sur la tradition de la submersion de l'Atlantide, il m'a paru que les anciens Égyptiens, qui nous l'ont transmise, avoient des communications de commerce par le Nil et la Mediterranée jusqu'en Espagne et en Mauritanie, et que c'est par cette communication qu'ils auront été informés de ce fait, qui, quelque grand et quelque mémorable qu'il soit, ne serait pas parvenu à leur conuoissance s'ils n'éloient pas sortis de leur pays, fort éloigné du lieu de l'événement. Il semblerait donc que la Méditerranée et même le détroit qui la joint à l'Océan existoient avant la submersion de l'Atlantide: néanmoins l'ouverture du détroit pourrait bien être de la même date. Les causes qui ont produit l'affaissement subit de cette vaste terre ont dû s'étendre aux enviions; la même commoiion qui l'a détruite a pu faire écrouler la petite portion de montagnes qui fermoit autrefois le détroit; les tremblemens de terre qui, même de nos jours, se font encore sentir si violemment aux environs de Lisbonne, nous indiquent assez qu'ils ne sont que les derniers effets

d'une ancienne et plus poissante cause, à laquelle on peut attribuer l'affaissement de cette portion de montagnes.

Mais qu'étoit la Méditerranée avant la rupture de cette harrière du côté de l'Océan, et de celle qui fermoit le Bosphore à son autre extrémité vers la mer Noire?

Pour répondre à cette question d'une manière satisfaisante, il faut réunir sous un même coup d'iril l'Asie, l'Europe, et l'Afrique . ne les regarder que comme un seul continent, et se représenter la forme en relief de la surface de tout ce continent, avec le cours de ses fleuves: il est certain que ceux qui tombent dans le lac Aral et dans la mer Caspienne ne fournissent qu'autant d'eau que ces lacs en perdent par 1 évaporaûou; il est encore certain que la mer Noire reçoit, en proportion de son étendue, beaucoup plus d'eau par les fleuves que n'en reçoit la Méditerranée: aussi la mer Noire se décharge t-elle par le Bosphore de ce qu'(lie a de trop, tandis qu'au contraire la Méditerranée, qui ne reçoit qu'une petite quantité d'eau par les fleuves, en tire de l'Océan et de la mer Noire. Ainsi, malgré cette communication avec l'Océan, la mer Méditerranée et ces autres mers intérieures ne doivent être regardées que comme des lacs dont l'étendue a varié, et qui ne sont pas aujourd'hui tels qu'ils étoient autrefois. I.a mer Caspienne devoit être beaucoup plus grande et la Méditerranee plus petite avant l'ouverture des détroits du Bosphore et de Gibraltar; le lac Aral et la Caspienne né faisoient qu'un seul grand lac, qui étoit le réceptacle commun du Wolga, du Jaïk, du Sirderoias, de l'Oxus, et de toutes les autres eaux qui ne pouvoient arriver à l'Océan: ces fleuves ont amené successivement les limons et les sables qui séparent aujourd'hui la Caspienne de l'Aral; le volume d'eau a diminué dans ces fleuves à mesure que les montagnes dont ils entrainent les terres ont diminué de hauteur; il est donc très probable que ce grand lac, qui est au centre de l'Asie, étoit anciennement encore plus grand, et qu'il communiquoit avec la mer Noire avant la rupture du Bosphore; car dans cette supposition, qoi me parait bien fondée', la mer Noire, qui reçoit aujourd'hui plus d'eau qu'elle ne pourrait en perdre par l'évaporation, étant alors jointe ave« la Caspienne, qui n'en reçoit qu'autant qu'elle en perd, la surface de ces deux mer» réunies étoit assez étendue pour que toutes les eaux ame nées par les fleuves fussent enlevées par l'évaporation.

D'ailleurs le Don et le Wolga sont si voisins l'un de l'autre au nord de ces deux mers, qu'on ne peut guère douter qu'elles ne fussent réunies dans le temps où le Bosphore encore fermé ne donnoit à leurs eaux aucune issue vers la Méditerranée: ainsi celles de la mer Noire et de ses dépendances étoient alors répandues sur toutes les terres hasses qui avoisinent le Don, le Don

En parcourant, dit M Pallas, les immenses déserts qui s'étendent entre le Wolga . te Jink, la mer Caspienne, el le Don, j'ai remarqué que ces steppes, ou déserts sablonneux, sont de toutes paris environnés d'une côte élevée, qui embrasse une grande partie du lit du Jaik, du Wolga, et du Don, et que ces rivières, très profondes avant que d'avoir pénétré dans cette enceinte, sont remplies d'ib-s et de has fonds dès qu'elles commencent à tomber dans les steppes, où ta grande rivière de Kuntan va se perdre elle-même dans tes sables- De ces observations réunies, je conclus que la mer Caspienne a couvert autrefois tous ces deserts; qu'elle n'a eu anciennement d'autres bords que ces mêmes côtes élevées qui les environnent de toutes parts, et qu'elle a communiqué, au moyen du Don, avec la mer Noire, supposé même que cette mer, ainsi que celle d'Azoff, n'en ail pas fait partie.

M. Pallas est sans contredit l'un de nos plus sa vans naturalistes; et c'est avec la plus grande satisfaction que je le vois ici entièrement de mon avis sur l'ancienne étendue de ia mer Caspienne, et sur la probabilité bien fondée qu'elle communiquoit autrefois avec la mer Noire. (Add. Buff.)

jec, etc., et celles de la mer Caspienne couvraient les |erres voisines du Wojga, ce qui formait un lac plus long que large qui réuaissoit ces deux mers. Si l'on compare l'étendue actuelle du lac Aral, de Ia mer Caspienne, et de la mer Noire, avec l'étendue que nous leur supposons dans le lemps de

leur continuité, c'est-à-dire avant l'ouverture du Bosphore, on sera convaincu, que, la surface de ces eaux étant alors plus que douitle de ce qu'elle est aujourd'hui, l'évaporation seule auffisoit pour en maintenir l'équilibre sans débordement.

Ce bassui, qui étoit alors peut-être aussi grand que l'est aujourd'hui celui de la Méditerranée, recevoit et conlenoit les eaux de tous les Deuves de l'intérieur du continent de l'Asie, lesquelles, parla position des montagnes, ne pouvoient s'écouler d'aucun coté pour se rendre dans l'Océan: ce grand bassin étoit le réceptacle commun des eaux du Danube, du Don, du Wolga, du Jaïk, du Sirderoias, et de plusieurs autres rivières très considérables qui arrivent à ces fleuves, ou qui tombent immédiatement dans ces mers intérieures. Ce bassin, situé au centre du continent, rerevoit les eaux des terres de l'Europe dont les pentes sont dirigées vers le cours du Danube, c'est-à-dire de la plus grande partie de l'Allemagne, de la Moldavie, de l'Ukraine, et de la Turquie d'Europe; il recevoit de même les eaux d'une grande partie des terres de l'Asie au nord, par le Don, le ltonjec, le Wo^ga, le Jaik, etc., et au midi par le Sirderoias et l'Oxus. ce qui présente nue très vaste étendue de terre dont toutes les eaux se versoienl dans ce réceptacle commun; tandis que le bassin de la Méditerranée ne recevoit alors que celles du Nil, du Rhône, du l'o, et de quelques antres rivières: de sorte qu'en comparant l'étendue des terres qui fournissent les eaux à ces derniers fleuves, on rceonnoilra évidemment que cette étendue est de moillé plus petite. Nous sommes donc bien fondés à présumer qu'avant la rupture du Bosphore et celle du détroit de Gibraltar, la mer Noire réunie avec la mer Caspienne et l'Aral formoil un bassin d'une étendue double de ce qu'il en reste; et qu'au contraire la Méditerranée étoit dans le même temps de moilié plus petite qu'elle ne l'est aujourd'hui.

Tant que les barrières du Bosphore et de .Gibraltar ont subsisté, la Méditerranée n'étoit donc qu'un lac d'assez médiocre étendue, dont l'évaporation suffisoit à la recette des eaux du Nil, du Rhône, et des autres rivières qui luj appartiennent; mais en supposait, comme les traditions semblent l'indiquer, que le Bosphore se soit ouvert le premier, la Méditerranée aura dès lors considérablement augmenté, et en même proportion que le bassin supérieur de la mer Noire et de la Caspienne aura diminué. Ce grand effet n'a rien que de trèsnaturel: car les eaux de la mer Noire, supérieures à celles de la Méditerranée, agissant continuellement par leur poids et par leur mouvement contre les terres qui formulent le Bosphore, elles les auront minées par la base, elles en auront attaqué les endroits les plus foibles; ou peut-être aurontelles été amenées par quelque affaissement causé par un tremblement de terre, et, s'étant une fuis ouvert cette issue, elles auront inondé toules les lernes inférieures, et causé le plus ancien déluge de notre coutineut: car il est nécessaire que cetle rupture du Bosphore ait produit tout à coup une grande inondation permanente qui a noyé, dès ce premier lemps, toutes les plus basses terres de la Grèce e1 des provinces adjacentes; et cette inondation s'est en même temps étendue sur les terres qui environnaient ancieunement le bassin de la Méditerranée, laquelle s'est dès lors élevée de plusieurs pieds, et aura couvert pour jamais les basses terres de son voisinage, encore plus du coté de l'Afrique que de celui (U l'Europe: car les rotes de la Mauritanie et de la Barbarie sont très basses en comparaison de celles de l'Espagne, de la France, et de l'Italie, tout le long de cette m»r. Ainsi le continent a lwrdu en Afrique et en Europe autant de terre qu'il en gagnoit, pour ainsi dire, en Asie, par la retraite des eaux entre la mer Noire, la Caspienne et l'Aral.

Ensuite il y a eu un sernnd déluge lorsque la porte du détroit de Gibraltar s'est ouverte; les eaux de l'Océan ont dû produire dans la Méditerranée une seconde augmentation, et oui acbevé d'inonder les terres qui n'étoient pas submergées. Ce n'est peut-être que dans ce second temps que sest formé le golfe Adriatique, ainsi (pie la séparation de la Sicile et des autres îles. Quoi qu'il en soit, ce n'est qu'après ces deux grands événemens que l'équilibre de ces deux mers intérieures a pu s'établir, et qu'elles ont pris leurs dimensions à peu près telles que nous les voyons aujourd'hui.

Au reste, l'époque de la séparation des deux grands coulineus, et même celle de la rupture dé ces Iwrrières de l'Océan et de la mer Noire, paroi.- seul être bien plus anciennes que la date des déluges dont les hommes ont conservé la mémoire: celui de Dencalion n'est que d'environ quinze cents ans avant l'ère chrétienne, et celui d'Ogygès de dix-huit cents ans; Ions deux n'ont été que des inondations particulières, dont la première ravagea la Tbessalie, et la seconde les terres de l'A l tique; tous deux n'ont été produits que par une cause particulière et passagère comme leurs effets; quelques secousses d'uu tremblement de terre ont pu soulever les eitux des mers voisines et les faire refluer sur les terres, qui auront été inondées pendant un petit temps sans être submergees à demeure. Le déluge de l'Arménie et de l'F.gvple, dont la tradition s'est conservée cbez les Kgypliens et les Hébreux, quoique plus ancien d'environ cinq siècles que celui d'Ogygès, est encore bien récent en comparaison des événemeus dont nous venons de parler, puisque l'on ne compte qu'environ quatre mille cent années depuis ce premier déluge, et qu'il est très certain que le temps où les étephans habitoienl les terres du nord étoit bien antérieur à cette date moderne: car nous sommes assurés p;ir les livres les plus anciens que l'ivoire se lirait des pays méridionaux; par conséquent nous ne pouvons douter qu'il n'y ait plus de trois mille ans que les éléphans habitent les terres où ils se trouvent aujourd'hui. On doit donc regarder ces trois déluges, quelque mémorables qu'ils soient, comme des inondations passagères (pli n'ont point changé ta surface de la terre, tandis que la séparation des deux contiueus du côté de IT.tirolie n'a pu se faire qu'en submergeant à jamais les terres qui les rcuuissoient. Il en est de même de la plus grande partie des terrains actuellement couverts par les eaux de la Méditerranée; ils ont éte submergés pour toujours des les temps où les portes se sont ouvertes aux deux extrémités de cette mer intérieure pour recevoir les eaux de la mer Noire et celles de l'Océan.

Ces événemens, quoique postérieurs à l'établissement des animaux terrestres dans les contrées du nord, ont peut-être précédé leur arrivée dans les terres du midi; car nous avons démontré, dans l'époque précédente, qu'il s'est écoulé bien des siecles avant que leséléphans de Sibérie aient pu venir en Afrique, ou dans les parties méridionales de l'Inde. Nous avons compté dix mille ans pour cette espèce de migration, qui ne s'est faile qu'à mesure du refroidissement successif et fort lent des différons climats depuis le cercle polaire à l'équateur. Ainsi la séparation des coutinens, la submersion des terres qui les réunissoiont, celle des terrains adjacens à l'ancien lac de la Méditerranée, et enfui la séparation de la mer Noire, de la Caspienne, et de l'Aral, quoique toutef postérieurs à l'établissement de ces animaux dans les contrées du uord, pourraient bien être antérieures à la population des terres du midi, dont la chaleur trop grande alors ne permetloit pas aux êtres sensibles de s'y hallituer, ni même d'en approcher. Le soleil étoit encore l'etuiemi de ta nature dans ces régions brûlantes de leur propre chaleur, et il n'en est devenu le ftère.que quand cette chaleur intérieure de la terre s'est assez attiédie pour ne pas offenser la sensibilité des êtres qui nous ressemblent. Il n'y a peutêtre pas cinq mille ans que les terres de la zone torride sont habitées, tandis qu'on en doit compter au moins quinze mille depuis l'établissement des animaux terrestres dans les contrées du nord.

Les hautes montagnes, quoique situées dans les climats les plus chauds, se sont re froidics peut-être aussi proniplement que celles des pays tempérés, parce qu'étant plus élevées que ces dernières, elles forment des pointes plus éloignées de la oiasse du globe; l'on doit donc considérer qu'indépendaramenl du refroidissement général et successif de la terre depiws les pôles à l'équateur, il y a eu des relroidissemens particuliers plus Ou moins prompts dans tout*» les montagnes et dans les terres élevées des différentes | arties du glube, et que, dans le temps de sa trop grande chaleur, les seuls lieux qui fussent convenables à la natiu'e vivante ont été les sommets des montagnes et les autres terres élevées, telles (pie celles de la Sibérie et de la haute Tartarie.

Lorsque toutes les eaux ont été établies sur le globe, leur mouvement d'orient en occident a escarpé les revers occidentaux de tous les coutinens pendant tout le temps qu'a duré l'abaissement des mers: ensuite ce même mouvement d'orient en occident a dirigé les eaux contre les pentes

douces des terrrs orientales, et l'Océan s'est emparé de leurs anciennes côtes; et, de plus, il parait avoir tranché toutes les pointes des conlinens terrestres, et avoir formé les détroits de Magellan à la poime de l'Amérique, de Ceylan à la pointe de l'Inde, de Forbisber à celle du Groenland, etc.

C'est à la date d'environ dix mille ans, à compter de ce jour, en arrière, que je placerois la séparation de l'Europe et de l'Amérique; et c'est à peu près dans ce même temps que l'Angleterre a été sépaiée de la •France, l'Irlande de l'Angleterre, la Sicile «le l'Italie, la Sardaigne de la Corse, et toutes deux du continent de l'Afrique: c'est peut-être aussi dans ce même temps que les Antilles, Saint-Domingue, et Cuba, onl été séparés du continent de l'Amérique. Tuutes ces divisions particulières sont contemporaines ou de peu postérieures à la grande séparation des deux continent; la plupart même ne paroissent être que les suites nécessaires de cette grande division, laquelle ayant ouvert une large route aux eaux de i'Océan leur aura permis de refluer sur toutes les terres basses, d'en attaquer par leur mouvement les parties les moins solides, de les miner peu à peu, et de les trancber enfin jusqu'à les séparer des continens voisins.

On peut attribuer la division entre l'Europe et l'Amérique à l'affaissement des terres qui formoienl autrefois l'Atlantide; et la séparation entre l'Asie et l'Amérique (si elle existe réellement) supposerait un pareil affaissement dans les mers septentrionales de l'orient: mats la tradition ne nous a conservé que la mémoire de la submersion de la Taprobane, terre située dans le voisinage de la zone torride, et par conséquent trop éloignée pour avoir influé sur cette séparation des continens vers le nord. L'inspection •du globe nous indique, à la vérité, qu'il y * eu des botileversemens plus grands et plus fréquens dans l'Océan indien que dans aucune autre partie du monde 1, et que non seulement il s'est fait de grands changemens dans ces contrées par l'affaissement des cavernes, les lremblemens de terre, et l'action des volcans, mais encore par l'effet continuel du mouvement général des mers, qui, constamment dirigées d'orient en occident, ont gagné une grande étendue de terrain sur les côtes anciennes de l'Asie, et ont formé les petites mers intérieures du Kamtschatka, de la Corée, de la Chine, etc. Il Ïiaroit même qu'elles ont aussi noyé toutes es terres basses qui étoient à l'orient de ce continent; car si l'on tire une ligne depuis l'extrémité septentrionale de l'Asie, en passant par la pointe du Kamtschatka, jusqu'à la Nouvelle-Guinée, c'est-à-dire depuis le cercle polaire jusqu'à l'équateur, on verra que les îles Marianes et celles des Callanos, qui se trouvent dans la direction de cette ligne sur une longueur de plus de deux cent cinquante lieues, sont les restes ou plutot les anciennes cotes de ces vastes terres envabies par la mer: ensuite si l'on considère les terres, depuis celles du Japon à Formose, de Kormose aux Philippines, des Philippines à la Nouvelle-Guinée, on sera porté à (*roire que le continent de l'Asie étoil autrefois contigu avec celui de la Nouvelle-Hollande, lequel s'aigtlise et aboutit en pointe vers le midi, comme tous les autres grands continens.

Ces bouleversemens si multipliés et si évidens dans les mers méridionales, l'envahissement tout aussi évident des anciennes terres orientales par les eaux de ce même Océan, nous indiquent assez les prodigieux changemens qui sont arrivés dans cette vaste partie du monde, surtout dans les contrées voisines de Téquateur: cependant ni l'une ni l'autre de ces grandes causes n'a pu produire la séparation de l'Asie et de l'Amérique vers le nord; il semblerait au contraire que si ces continens eussent été séparés au lieu d'être continus, les affaissemetts vers le midi, et l'irruption des eaux dans les terres de l'orient, auraient dû attirer celles du nord, et par conséquent découvrir la terre de cette région entre l'Asie et l'Amérique. Cette considération confirme les raisons que j'ai données ci-devant pour la continuité réelle des deux continens vers le nord en Asie.

Après la séparation de l'Europe et de l'Amérique, après la rupture des détroits, les eaux ont cessé d'envabir de grands espaces; et dans la suite la terre a plus gagné sur la mer qu'elle n'a perdu: car, indépendamment des terrains de l'intérieur de l'Asie nouvellement abandonnés par les eaux, tels que ceux qui environnent la Caspienne et l'Aral, indépendamment de toutes les cotes en pente douce que cette dernière retraite des eaux laissoit à découvert, les grands fleuves ont presque tous

formé des îles et de nouvelles contrées près de leurs embouchures. On sait que le Delta de l'Égypte, dont l'étendue ne laisse pas d'être considé rable, n'est qu'un atterrissement produit par les dépôts du Nil. Il en est de même de la grande île à l'entrée du fleuve Amour, dans la mer orientale de la Tartarie chinoise. En Amérique, la partie méridionale de la Louisiane, près du fleuve Mississipi, et la partie orientale située à l'embouchure de la rivière des Amazones, sont des terres nouvellement formées par le dépôt de ces grands fleuves. Mais nous ne pouvons choisir un exemple plus grand d'une contrée récente que celui des vastes terres de la Cuiane; leur aspect nous rappellera l'idée de la nature brute, et nous présentera le tableau nuancé de la formation successive d'une terre nouvelle.

Dans une étendue de plus de cenj vingt lieues, depuis l'embouchure de la rivière de Cayenne jusqu'à celle des Amazones, la mer, de niveau avec la terre, n'a d'autre fond que de la vase, et d'anlres cotes qu'une couronne de bois aquatiques, de man'gles ou palétuviers, dont les racines, les tiges, et les branches courbées, trempent également dans l'eau salée, et ne présentent que des halliers aqueux qu'on ne peut pénétrer qu'eu canot el la hache à la main. Ce fond de vase s'étend en pente douce à plusieurs lieues sous les eaux de la mer. Du coté de la terre, au delà de cette large lisière de palétuviers, dont les branches, plus inclinées vers l'eau qu'élevées vers le ciel, forment un fort qui sert de repaire aux animaux immondes, s'étendent encore des savanes noyées, plantées de palmiers lataniers, et jonchées de leurs débris: ces lalaniers sont de grands arbres, dont, à la vérité, le pied est encore dans l'eau, mais dont la téte et les branches élevées et garnies de fruits invitent les oiseaux à s'y percher. Au delà des palétuviers et des lataniers l'on ne trouve encore que des bois mous, des comons, des pineaux, qui ne croissent pas dans l'eau, mais dans les terrains bourbeux auxquels aboutissent les savanes noyées; ensuite commencent des forêts d'une autre essence: les terres s'élèvent en pente douce, et marquent pour ainsi dire leur élévation par la solidité et la dureté des bois qu'elles produisent. Enfin, après quelques lieues de chemin en ligne directe depuis la mer, on trouve des collines dont les coteaux, quoique rapides, et même les sommets, sont également garnis d'une grande épaisseur de bonne terre, plantée partout d'arbres de tout âge si pressés, si serrés les uns contre les autres, que leurs cimes entrelacées laissent à peine passer la lumière du soleil, et sous leur ombre épaisse entretiennent une humidité si froide que le voyageur est obligé d'allumer du fes pour y passer la nuit; tandis qu'à quelque distance de ces sombres forêts, dans les lieui défrichés, ta chaleur excessive pendant!e jour est encore trop grande pendant la nuit. Cette vaste time dis côles et de l'intérieur de la Guiane n'est donc qu'une forêt tout aussi vaste, dans laquelle des sauvages, en petit nombre, ont fait quelques clairieres et de petits ahat is pour pouvoir s'y domicilier sans perdre la jouissance de la chaleur de la terre et de la lumière du jour.

La grande épaisseur de terre végétale qui se trouve jusque sur le sommet des collines démontre la formation récente de toute la contrée; elle l'est en effet au point qu'au dessus de l'une de ces collines, nommée la Gabrielte, ou voit un petit lac peuplé de crocodiles caïmans que la mer y a laissés à cinq ou six lieues de distance et à six ou sept cents pieds de hauteur au dessus de son niveau. Nulle part on ne trouve de la pierre calcaire, car on transporte de France la chaux nécessaire pour bâtir à Cayenne: ce qu'on appelle pierre à ravets n'est point une pierre, mais une lave de volcan, trouée comme les scories des forges; cette lave se présente en blocs épars ou en monceaux irréguliers dans quelques montagnes où l'on voit les bouches des anciens volcans qui sont actuellement éteints, parce que la mer s'est retirée et éloignée du pied de ces montagnes. Tout concourt donc à prouver qu'il n'y a pas long-temps que les eaux ont abandonné ces col1ines, et encore moins de temps qu'elles ont laissé paroitre les plaines et les terres hasses: car celles-ci ont été presque entièrement formées par le dépot des eaux courantes. Les fleuves, les rivières, les ruisseaux, sont si voisins les uns des autres, et en même temps si larges, si gonflés, si rapides dans la saison des pluies, qu'ils entrainent incessamment des limons immenses, lesquels se déposent sur toutes les terres hasses et sur le fond de la mer en sédimens vaseux. Ainsi cette terre nouvelle s'accroitra de siècle en siècle tant qu'elle ne sera pas peuplée; car on doit compter pour rien le

petit nombre d'hommes qu'on y rencon* tre: ils sont encore, tant au moral qu'au physique, dans l'état de pure nature; ni vôtemens, ni religion, ni société, qu'entre quelques familles dispersées à de grandes distances, peut-être au nombre de trois ou quatre cents cachets, dans une terre dont l'étendue est quatre fois plus grande que celle de la France.

Ces hommes, ainsi que la terre qu'ils habitent, paraissent être les plus nouveaux de l'univers: ils y sont arrivés des pays plus éleves et dans des temps postérieurs à l'établissement de l'espèce humaine dans les hautes contrées du Mexique, du Pérou, et du Chili; car, en supposant les premiers hommes en Asie, ils auront passe par la même route que les éléphans, et se seront, en arrivant, répandus dans les terres de l'Amérique septentrionale et du Mexique; ils auront ensuite aisément franchi les hautes Verres au delà de l'isthme, et se seront établis dans «elles du Pérou, et enfm ils auront pénétré jusque dans les contrées les plus reculées" de FAoiérique méridionale. Mais n'est-il pas* singulier que ce soit dans quelques-unes de ces dernières contrées qu'existent encore de nos jours les géans de l'espèce humaine, tandis qu'on n'y voit que des pyginées dans le genre des animaux? car on ne peut douter qu'on n'ait rencontré dans l'Amérique méridionale des hommes eu grand nombre, fous plus grands, plus1 carrés, plus épais, et plus forts que ne le sont tous les autres hommes de la terre. Les races de géans, autrefois si communes en Asie, n'y subsistent plus. Pourquoi se trouvent-elles en Ameri* que aujourd'hui? ne pouvons-nous pas croire qne quelques géans, ainsi que les éléphans, ont passé de l'Asie en Amérique, où, s'étant trouvés pour ainsi dire seuls, leur race s'est conservée dans ce continent désert, tandis qu'elle a été entièrement détruite par le nombre des autres hommes dans les contrées peuplées? Une circonstance me paroil avoir concouru au maintien de cette ancienne race de géans dans le continent du NouveauMonde; ce sont les hautes montagnes qui le partagent dans toute sa longueur et sons fous les climats. Or on sait qu'eu général les liallitalis des montagnes sont plus gra ids et plus forts que ceux des valtées ou des plaines. Supposant donc quelques couples de géans passés en Amérique, où ils auront trouvé la liberté, la tranquillité, la paix, ou d'autres avantages que peut-être ils n'avoienl pas cbez eux, n auront-ils pas choisi dans les terres de leur nouveau domaine celles qui' leur couvenoieut le mieux, tant pour la chaleur que pour la salubrité de l'air et des eaux? Ils auront fixé leur domicile à une hauteur médiocre dans les montagnes; ils se seront arrêtés sous le climat le plus favorable à leur multiplication; et comme ils avoieut peu d'occasions de se mésallier, puisque toutes les terres voisines étoieut désertes, ou du moins tout aussi nouvellement peuplées par un petit nombre d'hommes bien inférieurs eu force, leur race gigantesque s'est propagée sans obstacle et presque sans mélange: elle a duré et subsisté jusqu'à ce jour, tandis qu'il y a nombre de siècles qu'elle a été détruite dans les lieux de son origine en Asie, par la très grande et plus ancienne population de cette partie du monde.

Mais autant les hommes se sont multipliés dans les terres (pli sont actuellement chaudes et (eoipérces, autant leur nombre a diminué dans cetles qui sont devenues trop froidès. Le nord du Groenland, dri la Laponie, du Spitzberg, de la Nouvelle-Zemble, de, I» terre des Samoïedr?, aussi bien qu'une partie dé celles qui «voisinent la mer Glaciale jtisim'à' l'extrémité de l'Asie au nord de Kaoirschatka, sont actuellement!désertes, ou plutôt dépeuplées depuis un temps' assez moderue.'On voit même par les cartes' russes, que depuis les embouchures des fleuves Olenek, Lena, et Jana, sons les 73 et 75e degrés, la roule, tout le long des cotes de cette mer Glaciale jusqu'à la terre des TschuLschis, étoit autrefois toit fréquentée, et qu'actuellement elle est impraticable, ou tout au moins si difficile, qu'elle est abandoimée. Ces mêmes cartes nous montrent que des trois vaisseaux partis en 104!! de l'embouchure commune des fleuves de K.Olliua et Olohion, sous le 73e degre, un seul a doublé le cap de la terre des Tschuts(his sous le 75p degré, et seul est arrivé, di-ent les mêmes cartes, aux Mes d'Anadir, voisines de l'Amérique sous le cercle polaire. Mais autant je suis persuadé de la vérité de ces premiers faits, autant je doule de celle du dernier; car cette même carte qui présente par une suite de points la roule de ce vaisseau russe autour de la terre des Tschutschis porte en même temps en toutes let" tres qu'on ne commit pas l'étendue de cette terre: or, quand même on aurait, en 1648, parcouru cette mer et fait le tour de

cette pouite de l'Asie, il est sûr que depuis ce temps les Russes, quoique lres-intéressés à cette navigation pour arriver à Kamtschatka, et de là au Japon et à la Chine, l'ont entièrement abandonnée; mais peut-être aussi se sont-ils réservé pour eux seuls la connoisfiauoe de cette route autour de cette terre des Tschutschis, qui forme l'extrémité la plus septentrionale et la plus avancée du contineut de l'Asie.

Quoi qu'il en soit, toutes les régions septentrionales au delà du 76e degré, depuis le nord de la Norvège jusqu'à l'extrémité de l'Asie, sont actuellement dénuées d'ba-. bitans, à l'exception de quelques malbeureux que les Danois et les Russes ont établis pour la pècbe, et qui seuls entretiennent un reste de population et de commerce dans ce climat glacé. Les terres du nord, autrefois assez chaudes pour faire multiplier les éléplians et les hippopotames, s'éiant déjà refroidies au point de ne pouvoir nourir que des ours blancs et des rennes, seront, dans quelques milliers d'années, entièrement dénuées el désertes par les seuls effets du refroidissement. Il y a même de très fortes raisons qui me portent à croire que la région de noire pole qui n'a pas été reconnue ne le sera jamais: car ce refroidissement glacial me paroit s'être emparé du pôle jusqu'à la distance de sept ou nuit degrés, et il est plus probable que toute cette plage polaire, autrefois terre ou mer, n'est aujouril'liui que glace; el si cette présomption est fondée, le circuit et 1 étendue de ces glaces, loin de diminuer, ne pourra qu'augmenter avec le refroidissement de la terre.

Or, si nous considérons ce qui se passe sur les hautes montagnes, même dans nos climats, nous y trouverons une nouvelle preuve démonstrative de la réalité de ce refroidissement, et nous eu tirerons en même temps une comparaison qui me paroit frappante. On trouve au dessus des Alpes, dans une longueur de plus de soixante lieues sur vingt et même trente de largeur en certains endroits, depuis Ira montagnes de la Savoie el du canton de Berne jusqu'a celles du Tyrol, une étendue immense et presque continue de vallées, de plaines, et d ènunuences de glaces ', la plupart sans mélange d'aucune autre matière, el presque toutes permanentes, el qui ne fondent jamais en entier. Ces grandes plages de glace, loin de diminuer dans leur circuit, augmentent et S'étendent de plus en plus; elles gagnent de l'espace sur les terres voisines et plus hasses: ce fait est démontré par les cimes des grands arbres, et même par une pointe de clocher, qui sont enveloppés dans ces masses de glaces, et qui ne paroissent que dans certains étés très chauds, pendant lesquels ces glaces diminuent de quelques pieds de hauteur; mais la masse intérieure, qui, dans certains endroits, est épaisse de cent toise*, ne s'est pas fondue de mémoire d'homme. Il est donc évident que ces forêts et ce clocher enfouis dans ces glitces épais* ses et permanentes ctoient ci-devant situés dans des terres découvertes, habitées, et par conséquent moies refroidies qu elles ne le soin aujourd'hui; il est de même très certain que cette augmentation successive de glace ne peut l ire attribuée à l'augmentation de la quantité de vapeurs aqueuses, puisque tous les sommets des montagnes qui surmontent ces glacières ne se sont point clevés, et se sont au contraire abaisses avec le temps et par la chute d'une infmité die rOehers et de masses en débris qui ont roulé soit au fond des glacières, soit dans les variées inférieures. Des lors, l'agrandissement de ces contrées de glace est déjà, et sera dans la suite la preuve la plus palpable du refroidissement successif de la terre, duquel il est plus aisé de saisir les degrés dans ces pointes avancées du globe que partout ailleurs: si l'on continue donc d'observer les progrès de ces glacières permanentes des Alpes, on saura, dans quelques siecles, combien il faut d'années pour que le froid glacial s'empare d'une terre actuellement. habitée, el de là on pourra conclure si j'ai eompté trop ou trop peu de temps pour le refroidissement du globe.

Maintenant, si nous transportons cette idée sur la région du pôle, nous nous persuaderons aisément que non seulement elle est entierement glacée, mais même que le circuit el l'étendue de ces glaces augmente de siccle en siècle, el continuera d augmenter avec le refroidissement du globe. Les terres du Spitzberg, quoique à ro degrés du pôle, sont presque entièrement glacées, même en été; et par les nouvelles tentatives que l'on a faites pour approcher du pôle de plus près, il paroit qu'on

n'a trouvé que des glaces, que je regarde comme les appendices de la grande glacière qui couvrecette région tout entiere depuis lè pole jusqu'à 7 ou 8 degrés de distance. Les glaces immenses reconnues par le capitaine Phipps à 8o el 8i degrés, et qui part oui l'ont empêché d'avancer plus loin, semblent prouver la vérité de ce fail important; car l'on ne doit pas présumer qu'il y ait sous le pole des sources et des fleuves d'eau douce qui puissent produire et amener ces glaces, puisqu'en toutes saisons ces fleuves seroient glacés. Il paroit donc que les glaces qui ont empêché ce navigateur intrépide de pénétrer au delà du 8ae degré, sur une longueur de plus de 24 degrés en longitude; il paroit, dis-je, que ces glaces continues formeut une partie de la circonférence de l'immense glacière de notre poie, produite par le refroidissement successif du globe; et si l'on veut supputer la surface de cette zone glacée depuis le pole jusqu'au 8a* degré de latitude, on verra qu'elle est de plus de cent trente mille lieues carrées, et que par conséquent voilà déjà la deux centième partie du globe envahie par le refroidissement el anéantie pour la nature vivante; el comme le froid esl plus grand dans les régions du pôle aus irai, l'on doit présumer que l'envabissement des glaces y est aussi plus grand, puisqu'on en rencontre dans quelques-nues de ces plages australes des le 47e degré. Mais pour ne considérer ici que notre hémisphère boréal, dont nous présumons que la glace a déjà envabi la centieme partie, c'est-à-dire toute la surface de la portion de sphère qui s'étend depuis le pole jusqu'à 8 degréa ou deux cents lieues de distance, l'on sent bien que s'il éloit possible de déterminer le temps où ces glaces ont commencé de s'établir sur le point du (tôle, et ensuite le temps de la progression successive de leur envabissement jusqu'à deux cents lieues, on pourroit en déduire celui de leur progression à venir, et conuoitre d'avance quelle sera la durée de la nature vivante dans tous les climats jusqu'à celui de l'équateur. Par exemple, si nous supposons qu'il y ait mille ans que la glace permanente a commencé de s'établir sous le point même du pôle, et que, dans la succession de ce millier d'années, les glaces se soient étendues autour de ce point jusqu'à deux cents lieues, ce qui fait la centième partie de la surlare de l'hémisphère depuis le pôle à l'équateur, on peut présumer qu'il s'écoulera encore quatrevingt-dix-neuf mille ans avant qu'elles puissent l'envabir dans toute sou étendue, en supposant uniforme la progression du froid glacial, comme l'est celle du refroidissement du globe; et ceci s'accorde assez avec la durée de quatre-vingt-treize mille ans que nous avons donnée à la nature vivante, à dater de ce jour, et que nous avons déduite de la seule loi du refroidissement. Quoi qu'il en soit, il est certain que les glaces se présentent de tous- côtés, à 8 degrés du pôle, comme des harrières et des obstacles insurmontables, car le capitaine Phipps a parcouru plus de la quinzieme partie de cette circ onférence vers le nord-est; et avant lui, Baffin et Smith en avoient reconnu tout autant vers le nord-ouest, et partout ils n'ont trouvé que glace. Je suis donc persuadé que si quelques autres navigateurs aussi courageux entreprennent de reconnoitre le reste de cette circonférence, ils la trouveront de même burnée partout par des glaces qu'ils ne pourront pénétrer ni franchir, et que par conséquent celle région du pole est entièrement et à jamais perdue pour nous. La brume continuelle qui couvre ces climats et qui n'est que de la neige glacée dans l'air, IArrêtant ainsi que toutes les autres vapeurs contre les parois de ces côtes de glace, elle y forme de nouvelles couches et d'autre glaces, qui augmentent incessamment et s'étendront toujours de plus en plus, à mesure que le globe se refroidira davantage.

Au reste, la surface de l'hémisphère boréal présentant beaucoup plus de terre que celle de l'hémisphère austral, cette différence suffit, indépendamment des autres causes ci-devant indiquées, pour que ce dernier hémisphère soit plus froid que le premier: aussi trouve-i-on des glaces dès le 47 ou 5o" degré dans les mers australes, au lieu qu'on n'en rencontre qu'à 20 degrés plus loin dans l'hémisphère boréal. On voit d'ailleurs que, sous notre cercle polaire, il y a moitié plus de terre que d'eau, taudis que tout est mer sous le cercle antarctique: l'on voit qu'entre notre cercle polaire et le tropique du Cancer il y a plus de deux tiers de terre sur un tiers de mer, au lieu qu'emre le cercle polaire antarctique et le tropique du Capricorne il y a peutêtre quinze fois plus de mer que de terre. Cet hémisphère austral a doue été de tout temps, comme il l'est encore aujourd'hui, beaucoup plus aqueux et plus froid que le nôtre; et il n'y a pas d'apparence que passé? le 5oe degré l'on y trouve jamais des terres heureuses et tempérées. Il est donc presque certain que

les glaces ont envabi une plus grande étendue sous le pôle antarctique, et que leur circonférence s'étend peut-être beaucoup plus loin que celle des glaces du pôle antique. Ces immenses glacières des deux pôles, produites par le refroidissement, iront comme les glacieres des Alpes toujours en augmentant. La postérité ne tardera pas à le savoir, et nous nous croyons fondés à le présumer d'après notre théorie, et d'apres les faits que nous venons d'exposer, auxquels nous devons ajouter relui des glaces permanentes qui se sont formées depuis quelques siecles contre la côte orientale du Groenland; on peut encore y joindre l'augmentation des glaces près de la NouvelleZemble, dans le détroit de Waigats, dont le passage est devenu plus difficile et presque unpraticable; et enfin I impossibilité où l'on est de parcourir la mer Glaciale au nord de l'Asie; car, malgré ce qu'en ont dit les Russes, il est très douteux que les cotes de cette mer les plus avancées vers le nord aient été reconnues, et qu ils aient fait le tour de la pointe septentrionale de l'Asie '.

Nous voilà, comme je me le suis proposé, descendus du sommet de l'échelle du temps jusqu'à des siecles assez voisins du nôtre; nous avons passé du chaos à la lumière, de l'incandescence du globe à son premier refroidissement, et cette période de temps a été de vingt-cinq mille ans. Le second degré de refroidissement a permis la clinle des eaux, et a produit la dépuration de l'atmosphère, depuis vingt-rin(l à trente-citnl mille ans. Dans la troisième époque s'est fait l'établissement de la mer universelle, la production des premiers coquillages et des premiers végétaux, la construction de la surface de la terre par lits horizontaux, ouvrage de quinze ou vingt antres milliers d'années. Sur la fin de ln troisieme époque et au commencement de la quatrième s'est faite la retraite des eaux; les courans de la mer ont creusé nos vallons, et les feux souterrains ont commencé de ravager la terre par leurs explosions. Tous ces derniers mouvemens ont duré dix mille ans de plus; et en somme totale ces grands événemens, ces opérations, et ces constructions supposent au moins une succession de soixante mille années, après quoi la nature, dans son premier moment de repos, a donné ses productions les plus nobles; la cinquième époque nous présente la naissante des animaux terrestres. Il est vrai (pie ce repos n'étoit pas absolu; la tej-re n'étoit pas encore tout-àfait tranquille, puisque ce n'est qu'après la naissance des premiers animaux terrestres que s'est faite la séparation des coutinens, et que sont arrivés les grands changemens que je viens d'exposer dans cette sixième époque.

Au reste, j'ai fait ce que j ai pu pour proportionner dans chacune de ces périodes in durée du temps à la grandeur des ouvrages; j'ai tâché, d'aprcs mes hypothèses, de tracer le tableau successif des grandes révolutions de la nature, sans néanmoins avoir prétendu la saisir à son origine, et encore moins lavoir embrassée dans toute sou étendue; et meshvpoihèsesfussent-elles contestées, et mon tableau ne fût-il qu'une esquisse très imparfaite de celui de la nature, je suis convaincu (pie tous ceux qui de bonne foi voudront examiner cette esquisse et la comparer avec le modèle, trouveront assez de ressemblance lwiur pouvoir au moins satisfajre leurs yeux et lixer leurs idées sur les plus grands objets de la philosophie naturelle.

Additions De Buffon

La plus ancienne tradition qui reste de ces affaissemens dans les terres du midi est celle de la Taprohane, dont on croit que les Maldives et les Laquedives ont fait autrefois partie. Ces iles, ainsi que les écueils et les bancs qui régnent depuis Madagascar jusqu'à la pointe de l'Inde, semblent indiquer les sommets des terres qui réunissoient l'Afrique avec l'Asie; car ces iles ont presque toutes, du rôté du nord, des terres tt des bancs qui se prolongent très loin sous les eaux.

Il paroit aussi que les iles de Madagascar et de Ceylan étoient autrefois unies aux enntitiens qui les avoMuent. Ces séparations et ces grands bouleversemens dans les mers du midi ont la plupart été produits par l'affaissement des cavernes, par les treiublemens de terre, et par l'explosion des feux souterrains; mais il y a eu aussi beaucoup de terres envahies par le mouvement lent et successif de la mer d'orient en occident. Les endroits du momie où cet effet est le plus sensible sont les régions

du Japon, de la Chine, et de toutes les parties orientales de l'Asie. Ces mers situées à l'occident de la Chine et du Japon ne sont pour ainsi dire qu'accidentelles et peut-être encore plus récentes que notre Méditerranée.

Les iles de la Sonde, les Moluques, et les Philippines, ne présentent que des terres bouleversées, et sont encore pleines de volcans; il y en a beaucoup aussi dans les iles du Japon, et l'on prétend que c'est l'endroit de l'univers le plus sujet aux trembleniens de terre; on y trouve quantité de fontaines d'eau chaude. La plupart des autrOS iles de l'Océan indien ne nous offrent aussi que des pics ou des sommets de montagnes isolées qui vomissent le feu. L'Ile-de-France et l'ile de iiourbon paraissent deux de ci s sommets presque entierement couverts de matières rejetées par les volcans: ces deux iles étoient inhabitées lorsqu'on en a fait la decouverte.

Les cotes de la Guiane française sont si hasses, que ce sont plutôt des grèves toutes couvertes de vase en pente très douce, qui commence dans les terres et s'étend sur le fond de la mer à une très grande distance. Les gros navires ne peuvent approcher de la rivière de Cayennesans toucher, et les vaisseaux de guerre sont obligés de rester à deux ou trois lieues en mer. Ces vases en pente douce s'étendent, tout le long des rivages, depuis Cayenne jusqu'à la rivière des Amazones: l'on ne trouve dans cette grande étendue que de la va»e et point dcsable, et tous les bords de la mer sont rouverts de palétuviers: mais à sept ou huit lieues au dessus de Cayenne, du coté du nord-ouest, jusqu'au fleuve Marony, on trouve quelques anses dont le fond est de sable et de radiers qui forment des brisans; la vase cependant les recouvre pour la plupart, aussi bien que les ciuiclies de sable, el cette vase a d'autant plus d'épaisseur qu'elle s'eloigne davantage du bord de la mer: les petits rochers n'eiupéchenl pas que ce terrain ne sritl en peule très douce à plusieurs lieues d'étendue dan» les 1er les. Celle partie de la (iuianeq.ii est au nord-ouest de Cayenne est une contrée plus élevée que celles qui sonl au sud-est: on en a une preuve démonstralive; car tout le long des bords de la mer ou trouve de grandes savanes noyées qui bordent la cote, et dont la plupart sont desséchées dans la partie du nord-ouest, tandis qu'elles sont toutes couvertes des eaux de la mer dans la partie sud-est. Outre ces terrains noyés actuellement par la mer, il y en a d'autres plus éloignés, et qui de même étoient noyés autrefois. Ou trouve aussi en quelques endroits des savane* d'eau douce; mais cellesci ne produisent point de palétuviers, et seulement beaucoup de palmiers lataniers. On ne trouve pas une seule pierre sur toutes ces côtes hasses: la marée ne laisse pas d'y monter de sept ou huit pieds de hauteur, quoique les courans lui soient opposés; car ils sont tous dirigés vers les iles Antilles. La marée est forl sensible lorsque les eaux des fleuves sont hasses, el on s'en aperçoit alors jusqu'à quarante el même cinquante lieues dans ces fleuves; mais en hiver, c'est-à-dire dans la saison des pluies, lorsque les fleuves sont gonflés, la marée y est à peine sensible à unc ou deux lieues, tant le courant de ces fleuves est rapide, et il devient de la plus grande impétuosité à l'heure du reflux.

Les grosses tortues de mer viennent déposer leurs tpufs sur le fond de ces anses de sable, et on ne les voit jamais fréquenter les terrains vaseux; en sorte (pie, depuis Cayenne jusqu'à la rivière des Amazones, il n'y a point de tortues, et on va les pécher depuis la rivière Courait jusqu'au fleuve Marriny. ïl semble que la vase gagne tous les jours du terrain sur les sables, el qu avec le temps celle côte nord-ouest de Cayenne en sera recouverte comme la côte sud-est; car les tortues, qui ne veulent que du sable pour y déposer leurs tenfs. s'éloignent peu à peu de la riviere Courou, el depuis quelques années on est obligé de les aller chercher plus loin (lu côté du fleuve Marony, dont les i.ables ne sont pas encore couverts.

Au delà des savanes, dont les unes sont sèches et les autres noyées, s'étend un cordon de collines, qui sont toutes couvertes d'une grande épaisseur de terre plantée partout de vieilles forêts: communément ces collines ont 35o ou 400 pieds d'élévation; mais en «'éloignant davantage, on en trouve de plus élevées, el peut-être de plus du double, en s'avançanl dans les terres jusqu'à dix ou douze lieues. La plupart de ces montagnes sont évidemment d'anciens volcans éteints. Il y eu a

pourtant une, appelée la Gahnrlle, au sommet de 1aquelle on trouve une grande mare ou petit lac, qui nourrit des caïmans en assez grand nombre, dont apparemment l'espèce s'y est conservée depuis le temps où la mer couvrait cette colline.

Au delà de cette montagne Gabrielle, on. ne trouve que de petits vallons, des terres, des mornes, et des matières volcauisées qui ne sont point eu grandes masses, mais qui sont brisées par petits blocs. La pierre la plus commune, et dont les eaux ont entrainé des blocs jusqu'à Cayenne, est celle que l'on appelle la pierre à raveti, qui, comme nous l'avons dit, n'est point une pierre, mais une lave de volcan: on l'a pommée pierre à ravels, parce qu'elle est troi ée, el que les insectes appelés ravets se logent dans les trous de cette lave.

On ne peut pas douter qu'il n'y ait eu des individus géans dans tous les climats de la terre, puisque de nos jours on eu voit encore naitre en tout pays, et que récemment on en a vu un qui ctoil uè sur les coulins de la Lapoule, du lôté de la Kinlunde. Mais ou n'est pas également sûr qu'il y ait eu des races constantes et moins encore des peuples entiers de géans: cependant le témoignage de plusieurs auteurs anciens, et ceux de l'Ecriture-Saillie, qui esl encore plus ancienne, me paroissenl indiquer assez clairement qu'il y a eu des races de géans en Asie; el nous rrovous devoir présenter ièi les passages les plus positifs à ce sujet. Il est dit, Numlires, cliap. X.11I, verset 3 i: " Nous avons vu les géans de (a race « d'Hauak, aux yeux desquels nous ne der « vions paraitre pas plus grands que des eir *« g.des. » Kl par une autre version il est lit: « Nous avons vu des monstres de la « race d'Kuac, auprès desquels nous n'él ions w pas plus . grands que des sauterelles. » Quoique ceci ail l'ait' d'une exagération, assez ordinaire dans le style orientai, cela prouve néanmoins que ces géans étoient très grands.

Dans le second livre des Rois, chapitre XXI, verset ao, il est parlé d'un homme très grand ■ de la race d'Arapha, qui avoit « six doigts aux pieds et aux mains; » et l'on voit par le verset 18 que cette race d'Arapha éloit de genere gignntum. ' On trouve encore dans le Denlércnome plusieurs passages qui prouvent l'existence des géans et leur destruction. « Un peuple * nombreux, est-il dit, et d'une grande « hauteur, comme ceux d'Énacim, que le « Seigneur a détruits (chap. II, verset ai). » Et il est dit, versets 19 et ao: « Le pays « d'Ammon est réputé pour un pays de « géans, dans lequel ont autrefois habité les « géans que les Ammonites appellent Zom« zommim.

Dans Josué, chapitre XI, verset aa, il est dit: « Les seuls géans de la race d'Éna« cim qui soient restés parmi les enfans « d'Israël étoient dans les villes de Gaza, ■ de Geth et d'Azot; tous les autres géans « de cette race ont été détruits.

Philon, saint Cyrille, et plusieurs autres auteurs, semblent croire que le mot de géans n'indique que des hommes superbes et impies, et non pas des hommes d'une grandeur e corps extraordinaire; mais ce sentiment ne peut pas se soutenir, puisque souvent 11 est question de la hauteur et de la force de corps de ces mêmes hommes.

Dans le prophète Amos, il est dit que le peuple des Amoirbcens étoit si haut, qu'on les a comparés aux cèdres, sans donnerd'autres mesures à leur grande hauteur.

Og, roi de Bazan, avoil la hauteur de neuf coudées, et Goliath, de dix coudées el un palme. Le lit d'Og avoit neuf coudées de longueur, c'est-à-dire treize pieds et demi, et de largeur quatre coudées, qui font six pieds.

Le corselet de Goliath pesoit a08 livres 4 onces, et le 1er de sa lance pesoit ni livres.

Ces témoignages me paraissent suffisant pour qu'on puisse croire avec quelque fondement qu'il a autrefois existé dans le continent de l'Asie non seulement des individus, mais des races degéars, qui

ont été détruits, et dont les derniers lobsistoient encore du temps de David. Et quelquefois la nature, qui ne perd jamais ses droits, semble remonter a ce même point de force de production et de développement; car, dans Sresque tous les climats de la terre, il paroit e temps en temps des hommes d'une grandeur extraordinaire, c'est-à-dire de sept pieds et demi, huit, et même neuf pieds: car, indépendamment des géans bien avérés, et dont nous avons dejà fait mention, nous pourrions citer un nombre infini d'autres exemples, rapportés par les auteurs anciens et modernes, des géans de dix, douze, quinze, dix-huit pieds de hauteur, el même «ncore au delà; mais je suis bien persuadé qu'il faut beaucoup rahattre de ces dernières mesures: on a souvent pris des os d'éléphant pour des os humains; et d ailleurs la nature, telle qu'elle nous est connue, ne nous offre dans aucune espèce des disproportions aussi grandes, excepté peut-être dans l'espèce de l'hippopotame, dont les dents trouvées dans le sein de la terre sont au moins quatre fois plus grosses que les dents des hippopotames actuels.

Les os du prétendu roi Theutobochus, trouvés en Dauphiné, ont fait le sujet d'une dispute entre Habicot, chirurgien de Paris, et Riolan, docteur en médecine, célèbre anatomiste. Habicot a écrit, dans un petit ouvrage qui a pour titre Gigantostéologie, que ces os étoient dans un sépulcre de brique à 18 pieds en terre, entouré de sablon: il ne donne ni la description exacte, ni les dimensions, ni le nombre de ces os; il prétend que ces os étoient vraiment des os humains, d'autant, dit-il, qu'aucun animal n'en possède de tels. Il ajoute que ce sont des maçons qui, travaillant chez le seigneur de Langou, gentilhomme du Dauphiné, trouvèrent, le 11 janvier 1613, ce tombeau, proche les masures du château de Chaumont; que ce tombeau étoit de brique; qu'il avoit 3o pieds de longueur, 1a de largeur, et 8 de profondeur, en comptant 'le chapiteau, au milieu duquel éloit une pierre grise sur laquelle étoil gravé Tlwnto* titchui re.r; que ce tombeau ayant été ouvert, on vil un squelette humain de 25 pieds 1/a de longueur, 10 de largeur à l'endroit de* épaules . el 5 pieds d'épaisseur: qu'ar vaut de loucher ces os, on mesura la tète, qui avoit 5 pieds de longueur et 10 en rondeur, (le dois observer qu» la proportion de la longueur de la tète humaine avec celle du corps n'est pas d'un cinquième, mais d'un septième et demi; en sorte que cette tête de 5 pieds supposerait un corps humam 'de 37 pieds 1/a de hauteur.) Knlin il dit que la mâchoire inférieur'"a voit 6 pieds de lour, les orbites des yeux 7 pouces de lour, chaque clavicule 4 pieds de long, et que la plupart de ces ossemens se mirent en poudre après avoir été frappés de l'air.

Le docteur Riolan publia, la même année 16i3, un écrit, sous le nom de Gigantomachie, dans lequel il dit que le chirurgien Habicot a donné, dans sa Gigantostéologie, des mesures fausses de la grandeur du corps et des os du prélendu géant Tbcutobochus; que lui Riolan a mesuré l'os de la cuisse, celui de la jambe, avec l'astragale joint au calcanéum, et qu'il ne leur a trouvé que 6 1/2 pieds, y compris l'os pubis, ce qui ne ferait que i3 pieds au lieu de 2S pour la hauteur du géant.

Il donne ensuite les raisons qui lui font douter que ces os soient des os humains; el il conclut eu disant que ces os présentés par Habicot ne sont pas des os humains, mais des os d'éléphant.

Un an ou deux après la publication de la Gigantostéologie d'Habicot, et de la Gigantomachie de Riolan, il parut une brochure sous le titre de l'Imposture découverte des os humains supposés, et faussement attribués au roi Theutoboekus, dans laquelle on ne trouve autre chose sinon (pie ces os ne sont pas des os humains, mais des os fossiles engendrés par la vertu de la terre; et encore un antre livret, sans nom d'auteur, dans lequel il est dit qu'à la vérité il }' a parmi ces os des os humains, mais il y en avoit d'autres qui n'étoienl pas humains.

Ensuite, en 1618, Riolan publia un écrit, sous le nom de Gigantuiogie, où il prétend non seulement que les os en question ne sont pas des os humains, mais encore que .les hommes en général n'ont jamais été plus grands qu'ils ne le sont aujourd'hui.

Habicot répondit à Riolan dans la même année 1618; et il dit qu'il a offert au roi Louis XIII sa Gigantostéologie, et qu'en 16i3, sur la fm de juillet, on exposa aux yeux du public les os énoncés dans cet ouvrage, et que ce sont vraiment des os humains: il cite un grand nombre d'exemples, tirés des auteurs anciens et modernes, pour prouver qu'il y a eu des hommes d'une grandeur excessive. Il persiste à dire que les os calcanéum, tibia, et fémur, du géant Theutobochus, étant joints tes uns avec les autres, portoient plus de 11 pieds de hauteur.

Il donne ensuite les lettres qui lui ont été écrites dans le temps de la découverte de ces os, et qui semblent confirmer la réalité du fait du tombeau et des os du géant Xheutobochus. Il paroit parla lettre du seigneur de Langou, datée de Saint-Alarcellin eu Dauphiné, el par nue autre du sieur Mazurier, chirurgien à Reaurepaire, qu'on avoit trouve des monnoies d'argent avec les os. La première lettre est conçue dans les termes suivaus:

Comme sa majesté désire d'avoir le reste des os du roi Thenlobochus, avec la monnoie d'argent qui s'y est trouvée, je puis vous dire d'avance que vos parties adverses sont très mal fondées, et que s'ils savoient leur métier, ils ne douteraient pas que ces os ne soient véritablement des os humains. Les docteurs en médecine de Montpellier se sont transportés ici, et auraient bien voulu* avoir ces os pour de l'argent. M. le maréchal de Lesdiguières les a fait porler à Grenoble pour les voir, et les médecins et chirurgiens de Grenoble les ont reconnus pour des os humains; de sorte qu'il n'y a que les ignorans qui puissent nier cette vérité, etc.

Au reste, dans cette dispute, Riolan et Habicot, l'un médecin et l'autre chirurgien, se sont dit plus d'injures qu'ils n'ont écrit de faits et de raisons: ni l'un ni l'autre n'ont eu assez de sens pour décrire exactement les os dont il est question; mais tous deux, emportés par l'esprit de corps et de parti, ont ecrit d'une manière à ôter toute confiance. Il est donc très difficile de prononcer affirmativement sur l'espece de ces os: mais s'ils ont été eu effet trouvés dans un tombeau de brique, avec un couvercle de pierre, sur lequel étoit l'inscription Tlieutobochus rex; s'il s'est trouvé des montioies dans ce tombeau, s il ne ronteuoit qu'un seul cadaM ede 14 ou 25 pieds de longueur, si la lettre du seigneur de Langon contient vérité, on ne pourrait guère douter du fait essentiel, c'est-à-dire de l'existence d'un géant de 24 pieds de hauteur, à moins de supposer un concours fort extraordinaire de circonstances mensongères; mais aussi le fait n'est pas prouvé d'une manière assez positive, pour qu'on ne doive pas en douter beaucoup. Il est vrai que plusieurs auteurs, d'ailleurs dignes de foi, ont parlé de géans aussi grands et encore plus grands. Pline rapporte que, par un tremblement de terre en Crete, une montagne s'étant entrouverte, on y trouva un corps de 16 coudées, que les uns ont dit être le corps d'Olus, et d'autres celui d'Orion? Les 16 coudées donnent 24 pieds de longueur, c'est-à-dire la même que celle du roi Tlieutobochus.

On trouve dans mt mémoire de M. Le Cat, académicien de Rouen, une énumération de plusieurs géans d'une grandeur excessive; savoir, deuv géans dont les squelettes furent trouvés par les Athéniens près de leur ville, l'un de 36 et l'autre de 34 pieds de hauteur; un autre de 3u pieds, trouvé en Sicile, près de l'alerme, en i548; un autre de 33 pieds, trouvé de même en Sicile en i55o; encore un autre trouvé de même en Sicile prcs de Mazarino, qui avoit 3o pieds de hauteur.

Malgré tous ces témoignages, je crois qu'un aura bien de la peine à se persuader qu'il ait jamais existé des hommes de 3o ou 3(1 pieds de hauteur; ce seroit déjà bien trop (pie de ne pas se refuser à croire qu'il y en a eu de 24: cependant les témoignages se multiplient, deviennent pins positifs, et vont pour ainsi dire par nuances d'accroissement à mesure que l'on descend. M. Le Cat rapporte que l'on trouva en 170D pres des bords de la rivière Morderi, au pii'd de la montagne de Crussol, le squelette d'un géant de 22 pieds 1/2 Je hauieur, et que les dominicains de Valence ont une partie de sa jambe avec l'articulation du genou.

Materas, médecin célèbre, atteste qu'il a vu à Lucerne le squelette d'un homme de 19 pieds au moins de hauteur.

Le géant Ferragus, tué par Roland, neveu de Charleuiagne, avoit 18 pieds de hauteur.

Dans les cavernes sépulcrales de l'ile de Ténériffe, on a trouvé le squelette d'un guanche qui avoit i5 pieds de hauteur, et "dont la tôle avoit 80 dents. Ces trois faits sont rapportés, comme les précédens, dans le Mémoire de M. te Cat sur les géans. 11 cite encore un squelette, trouvé dans un fossé près du couvent des Dominicains de Rouen, dont le crâne lenoit in boisseau de blé, et dont l'os de la jambe avoit environ 4 pieds de longueur; ce qui donne pour la hauteur du corps entier 17 à rS pieds. Sur la tombe de ce géant étoit une inscription gravée, où on lisoit: Cï-git noble et puissant seigneurie chevalier Ricon de Valmont et ses os.

On trouve dans le Journal littéraire de l'abbé Nazai i que, dans la haute Calabre, au mois de juin 1665, on déterra dans les jardins du seigneur de Tiviolo un squelette de 18 pieds romains de longueur; que là tête avoit 2 pieds 1/2; que chaque dent molaire pesoit environ une once et un tiers, et les autres dents trois quarts d'once, et que ce squelette étoit couché sur une masse de bitume.

Hector Boetins, dans son Histoire dè CÉcosse, livre VII, rapporte que l'on conserve encore quelques os d'un homme, nommé par contre-vérité le Petit-Jean, qu'on croit

avoir eu 14 pieds de hauteur, c'est-à-dire i3 pieds 2 pouces 6 lignes de France.

On trouve dans le Journal des Savons, année 1*192, une lettre du 1'. Gentil, prêtre de l'Oratoire, professeur de philosophie à Angers, où il dit qu'ayant eu avis de la découverte qui s'étoil faite d un cadavre gigantesque dans le bourg de Lassé, à neuf lieues de cette ville, il fut lui-même sur les lieux pour s'informer du fait. Il appril que le curé du lieu ayant fait creuser dans son jardin, on avoit trouvé un sépulcre qui renfermoit un corps de 17 pieds 2 pouces de long, qui n'avoit plus de peau. Ce cadavre avoit d'autres corps entre ses bras et ses jambes, qui pouvoient être ses enfans. On trouva dans le même lieu quatorze ou quinze autres sépulcres, les uns de it1 pieds, les autres de 12, et d'autres même de 14 pieds, qui renfermoient des corps de même longueur. Le sépulcre de ce géant resta exposé à l'air pendant plus d'un an; mais comme cela attirait trop de visites au curé, il l'a fait recouvrir de terre, et planter trois arbres sur la place. Ces sépulcres sont d'une pierre semblable à la craie.

Thomas Molincux a vu, aux écoles de médecine de Leyde, un os frontal humain prodigieux: sa hauteur prise depuis sa jonction aux os du nez, jusqu'à la suture sagittale, étoit de 9 1/12 pouces, sa largeur de 12 1/10 pouces, son épaisseur d'un demipouce; c'est-à-dire que chacune de ces dimensions étoit double de la dimension correspondante à l'os frontal, tel qu'il est dans les hommes detaille ordinaire; en sorte que l'homme à qui cet os gigantesque a appartenu étoit probablement une fois plus grand que les bonlmes ordinaires, c'est-à-dire qu'il avoit 11 pieds de haut. Cet os étoit très certainement un os frontal humain; et il ne paroit pas qu'il eut acquis ce volume par un vice morbitique, car son épaisseur étoit proportionnée à ses autres dimensions, re qui n'a pas lieu dans les os viciés.

Dans le cabinet de M. Witreu à Amsterdam, M. Klein dit avoir vu un os frontal d'après lequel il lui parut que l'homme auquel il avoit appartenu avoit i3 pieds 4 pouces de hauteur, c'est-à-dire environ 12 pieds 1/2 de France.

D'après tous les faits que je viens d'exposer, et ceux que j'ai discutés ci-devant au sujet des Patagons, je laisse à mes lecteurs le même emharras où je suis, pour pouvoir prononcer sur

l'existence réelle de ces géans de 24 pieds; je ne puis me persuader q:i'en aucun temps et par aucun moyen, aucune circonstance, le corps humain ait pu s'élever à des dimensions àussi démesurées; mais je crois en même temps qu'on ne peul guère doitt'T qu'il n'v ait eu des géaus de tu, I*, et peut-être de i5 pieds de hauteur, et qu'il est presque certain que, dans les premiers âges de la nature vivante, il i existé non seulement des individus gigantesques en grand nombre, mais meme quelques races constantes et successives de geans, dont celle des Patagons est la seule qui se soit conservée.

Voir ce que M. Grouner et quelques autres bons observateurs et témoins oculaires rapportent à ce sujet.

Dans les' plus hautes régions des Alpes, les eaux provenant annuellement de la tonte des neiges se gèlent dans tous les aspects et à tous les pomts de ces montagnes, depuis leur hase jusqu'à leur sommet, surtout dans les vallons et sur le penchant de celles qui sont groupées; en sorte que les eaux ont dans ces vallees formé des montagnes qui ont des roi lies pour noyau, et d autres montagnes qui sont entierement de glace, lesquelles ont six, sept à huit lieues d'étendue en longueur, sur une lieue de largeur, et souvent nulle a doute cents luises d,- hauteur: elles rejoignent les autres montagnes par leur sommet. (!es énormes amas de glace gagnent de l'étendue en se prolongeant dans les vallées; en sorte qu'il est démontré que toutes les glacières s'accroissent successivement, quoique, dans les années chaudes et pluvieuses, non seulement leur progression soit arrêtée, mais même leur masse immense diminuée.

La hauteur de la congélation fixée à 2440 toises sous l'équaleur, pour les hautes montagnes isolées, n'est point une régie pour les groupes de montagnes gelées depuis leur hase jusqu'à leur sommet; elles ne dégèlent jamais. Dans les Alpes, la hauteur du degré de congélation pour les montagnes isolées est fixée à i500 toises d'élévation, et toute la partie au dessous de cette hauteur se dégele entièrement; tandis que celles qui sont entassées gèlent à une moindre hauteur, et ne degèlent jamais dans aucun point de leur élévation depuis leur hase, tant le degré de froid est augmenté par la masse de matières congelées réunies dans un même espace.

Toutes les montagnes glaciales de la Suisse, réunies, occupent une étendue de 66 lieues du levant au couchant, mesurée en ligne droite, depuis les bornes occidentales du canton de Vallis. ver2 la Savoie, jusqu'aux bornes orientales du canton de Rend lier, vers le Tvrol; ce qui forme une chaîne interrompue, dont plusieurs bras s'étendent du midi au nord sur une longueur d'environ 36 lieues. Le grand Oothard, le Kourk, et le Grimscl, sont les montagnes les plus élevées de celle partie: elles occupent le centre de ces cliaines qui divisent la Suisse en deux parties; elles sont toujours couvertes de neige et de glace, ce qui leur a fait donner le nom générique de glacières.

L'on divise les glacières en montagnes glacées, vallons de glace, champs de glace ou mers glaciales, et en gletchers ou amas de glaçons.

Les montagnes glacées sont ces grosses masses de rochers qui s'élèvent jusqu'aux nues, et qui sont toujours couvertes de neige et de glace.

Les vallons de glace sont des enfoncemens qui sont beaucoup plus élevés enlre les montagnes que les vallons inférieurs; ils sont toujours remplis de neige qui s'y accumule et forme des monceaux de glace qui ont plusieurs lieues d'étendue, et qui rejoignent les hautes montagnes.

Les champs de glace, ou mers glaciales, sont des terrains eu pente douce, qui sont dans le circuit des montagnes; ils ne peuvent être appelés vallons, parce qu'ils n'ont pas assez de profondeur: ils sont couverts d'une neige épaisse. Ces champs reçoivent l'eau de la fonte des.neiges qui descendent

des montagnes et qui regèlent: la surface de ces glaces fond et gele alternativement, et tous ces endroits sont rouverts de couches épaisses de neige et de glace.

Les ç/etchers sont des amas de glaçons formés par les glaces et les neiges qui sont précipitces des montagnes: ces neiges se regelent et s'entassent en différentes manières; ce qui fait qu'on divise les gletchers en monts, en revêtemens et en murs de glace.

Les monts de glace s'élèvent entre les sommets des hautes montagnes; ils ont euxmêmes la forme de montagnes; mais il n'entre point de rochers dans leur structure: ils sont composés entièrement de pure glace, qui a quelquefois plusieurs lieues en longueur, une lieue de largeur, et une demi lieue d'épaisseur.

Les revêtemens de glaçons sont formés dans les vallées supérieures et sur les cotés des montagnes, qui sont recouvertes comme de draperies de glaces taillées en pointes, elles versent leurs eaux superflues dans les vallées intérieures.

Les murs de glace sont des revêtemens escarpes qui terminent les vallées de glace qui uni unc forme aplatie, et (lui paroisseul de loin routme des mers agitees, dont les (luis ont été saisis et glacés dans le moment de leur agitation. Os murs ne sont point hérissés de pointes deglaces; souvent ils toi ment des colonnes, des pyramides, et des louis énormes par leur hauteur et leur grosseur, taillées à plusieurs faces, quelquefois hexagones, et de couleur bleue ou vert céladon.

Il se forme aussi sur les côtés et au pied des montagnes des amas de neige qui sont ensuite arrosés par l'eau des neiges fondues et recouvertes de nouvelles neiges. L'on voit aussi des glaçons qui s'accumulent eu tas, qui ne tiennent ni aux vallons ni aux monts deglace; leur position est ou horizontale ou inclinée: tous ces amas détachés se nomment lits ou couches Je glace.

La chaleur intérieure de la terre mine plusieurs de ces montagnes deglace par dessous, et y entretient des courans d eau qui fondent 1eurs surfaces ultérieures; alors les masses s'affaissent insensiblement par leur propre poids, et leur hauteur est réparée par les eaux, les neiges et les glaces qui viennent successivement les recouvrir: ces atïaisseinens occasionenl souvent des craque* mens horribles; les crevasses qui s'ouvrent dans l'épaisseur des glaces forment des précipices aussi fâcheux qu'ils sont multipliés. Ces animes sont d'autant pins perfides et funestes, qu'ils sont ordinairement recouverts de neige? les voyageurs, les curieux, et les chasseurs qui courMl les daims, les chamois, les bouquetins, ou qui font la recherche des mines de cristal, sont souvent engloutis dans les gouffres, et rejetés sur la surface par les Ilots qui s'élevent du fond de ces abimes.

Les pluies douces fondent promptemenl les nciges: mais toute» les eaux qui eu proviennent ne se précipitent pas dans les abimes inférieurs par les crevasses; une grande partie se regèle, et, tomhant sur la surface des glaces, en augmente le volume.

Les vents chauds du midi, qui régnent ordinairement dans le mois de mai, sont les agens les plus puissaus qui detruisent les neiges et les glace-; alors leur foule annoncée par le bruissement des lacs glacés, et par le fracas épouvantable du choc des pierres et des glaces qui se précipitent confusément du haut des montagnes, porte de tou

tes parts dans les vallées inférieures les eaux des loriens, qui tombent du haut des rochers de plus de 1200 pieds de hauteur.

Le soleil n'a que peu de prise sur les neiges el sur les glace-» pour en opérer la foule. L'expérience a prouvé que ces glaces formées pendant un laps de temps très long, sous des faideaux énormes,

dans ui; degré de froid si multiplié et d'eau si pure; que ces glaces, dis-je, éloient d'une matière si dense et si purgée d'air, que de petits glaçons exposés au soleil le plus ardent dans la plaine pendant un jour entier s'y fondoient à peine.

Quoique la masse de ces glacières fonde en partie Ions les ans dans les trois mois de l'été; que les pluies, les vents, et la chaleur, plus actifs dans certaines années, détruisent les progrès (pie les glaces ont laits pendant plusieurs autres années, cependant il est prouvé que ces glacières prennent an aceruisstment constant, et quelles s'éfendent; les annales du pavs le prouvent: des actes authentiques le démunirent, la tradition est invariable sur ce sujet. Indépendamment de ces autorités et de.-observations journalières, celte progression des glacières est prouvé par tle&Joiets de mélèzes qui ont été absorbées par les glaces, et dont ta cime de quelques-uns de ces arbres surpasse encore la surface des glacières; ce sont des témoins irréprochables qui al test eut!e progrès des glacières, ainsi que le haut des cU1chers d'un village qui a élé englouti sous les neiges, et que l'on aperçoit lorsqu'il se fait des fonles extraordinaires. Cette progression des glacières ne peut avoir d'autre cause que l'augmentation de l'intensité du froid, qui s'aceroit dans les montagnes glacées en raison des masses de glaces, et il est prouvé que, dans les glacieres de Suisse, le froid est aujourd'hui plus vif, mais moins long (pie dans l'Istande, dont les glacières, ainsi que celles de INorvvège, ont beaucoup de rapport avec celles de la Suisse.

Le massif des montagnes glacées de la Suisse est composé comme celui de toutes les hautes montagnes: le noyau est une roche vitreuse qui s'étend jusqu'à leur sommet; la partie au dessous, à commencer du point où elles ont été couvertes des eaux de la mer, est composée en revêtement de pierre calcaire, amsi que tout le massif des montagnes d'un ordre inférieur qui sont groupées sur la hase des montagnes primitives de ces glacieres; enfin ces masses calcaires ont pour hase des schistes produits par le dépôt du limon des eaux.

Les masses vitreuses sont des rocs -vifs, des granites, des quartz; leurs fentes sont remplies de métaux, de demi-métaux, de substances minérales, et de cristaux.

Les masses calcinantes sont des pierres à chaux, des marines de toutes les especes en couleurs et variétés, des craies, des gypses, des spaibs, et des albâtres, etc.

Les masses Schisteuses sont des ardoises de différentes qualités et couleurs, qui contiennent des plantes et des poissons, et qui sont souvent posées à des hauteurs assez considérables: leur lit n'est pas toujours horizontal; il est souvent incliné, même sinueux, et perpendiculaire en quelques endroits.

L'on ne petit révoquer en doute l'ancien séjour des eaux de la mer sur les montagnes qui forment aujourd'hui ces glacieres; l'immense quantité de coquilles qu'on y trouve l'atteste, ainsi que les ardoises et lrs antres pierres de ce genre. Les coquilles y sont distribuées par familles, ou bien elles sont mêlées les unes avec les attires, et l'on y en trouve à de très grandes hauteurs.

Il y a lieu de penser (pie ces montagnes n'ont pas formé des glacieres continues dans la hauie antiquité, pas même depuis que les eaux de la mer les ont abandonnées, quoiqu'il paroisse par leur très grand éloignemcnt des mers, qui est de près de cent lieues, et par leur excessive hauteur, qu'elles ont été les premieres qui sont sorties des eaux sur le continent de l'Europe. Elles ont eu anciennement leurs volcans; il paroit que le dernier qui s'est éteint étoit celui de la montagne de Myssenbérg, dans le canton deSchwitz; ces deux principaux sommets, qui sont très hauts et isolés, sont terminés coniquement, comme toutes les boucbes de volcan; et l'on voit encore le cratère de l'un de ces cônes qui est creusé à une grande profondeur.

M. Nourrit, qui eitf le courage de faire un grand nombre de courses dans les glacières de Savoie, dit « qu'on ne peut douter de l'accroissement de toutes les glacières des Alpes; que la quantité de neige qui y est tombée pendant les hivers l'a emporté sur la quantité fondue pendant les étés; que non seulement la même cause subsiste, mais que ces amas de glace déjà formés doivent l'augmenter toujours plus, puisqu'il en résulte et plus de neige et une moindre fonte Ainsi il n'y a pas de doute que les glacières n'aillent en augmentant, et même dans une progression croissante. » Cet observateur infatigable a fait un grand nombre de courses dans les glacières; et eu partant de celle du Glatchérs ou glacières des Bossons, il dit « qu'il paroit s'augmenter tous les jours; que le sol qu'il occupe présentement étoit, il y a quelques années, un champ cultivé, et que les glaces augmentent encore Ions les jours. Il rapporte que l'accroissement des glaces paroit démontré non seulement dans cet endroit, mais dans plusieurs autres; que l'on a encore le souvenir d'une communication qu'il y a voit autrefois de Chamouuis à la Val-d'Aost, et (pie les glaces Tout absolument fermée; que les glaces en génécal doivent s'être accrues en s'éteudant d'abord de sommité en sommité, et ensuite de vallée en vallée, et (pie c'est ainsi (pie s'est faite la communication des glaces du Mont-HIanc avec celles des antres montagnes et glacières du Vallais et de la Suisse. Il paroit, dit-il ailleurs, que tous ces pays de montagnes n'étoieul pas anciennement aussi remplis de neiges et de glaces qu'ils le sont aujourd'hui.., L'on ne date que depuis quelques siècles les désastres arrivés par l'accroissement des neiges et des glaces, par leur accumulation dans plusieurs vallées, par la chute des montagnes elles-mêmes et des rochers; ce sont ces accidens presque continuels, et cette augmentation annuelle des glaces, qui peuvent seuls rendre raison de ce que l'on sait de l'histoire de ce pays touchant le peuple qui l'habitoit anciennement. »

M. Engel, qui regarde comme impossible le passage au nord-otie.* par les baies d'Hudsou et de Bai'fm, paroit au contraire persuadé qu'on trouvera un passage plus court et plus sur par le noid-est; et il ajoute aux raisons assez foibles qu'il en donne, un passage de M. Gmeiin, qui, parlant des tentatives faites par les Russes pour trouver ce passage au nord-est, dit que « la mautère ., dont on a procédé à ces découvertes fera « en son temps le sujet du plus grand éton« nement de tout le monde, lorsqu'on en «aura la relation autbentique; ce qui dé« pend uniquement, ajonte-t-il, de la haute volonté de l'impératrice. » « Quel sera donc, dit M. Engel, ce sujet d'étonnement, si ce n'est d'apprendre que le passage regardé jusqu'à présent comme impossible est trèspraticable? Voilà le seul fait, ajoute-t-il, qui puisse surprendre ceux qu'on a tâché d'effrayer par des relations publiées à dessein de rebuter les navigateurs, etc.

Je remarque d'abord qu'il faudroil être bien assuré des choses avant de faire à la nation russe cette imputation. En second lien, elle me paroit mal fondée, et les paroles de M. Gmelin pourroient bien signifier tout le (-ontrdiredel'interprétation que leur donne M. Engel, c'est-à-dire qu'on sera fort étonné lorsque l'on saura qu'il n'existe point de passage praticable au nord-est; et ce qui me confirme dans cette opinion, indépendamment des raisons générales que j'en ai données, c'est que les Russes eux-mêmes n'ont nouvellement tenté des découvertes qu'en remontant de Kamtschatka, et point du tout en descendant de la pointe de l'Asie. Les capitaines Bebring et Tsehirikow ont, en 174 1, reconnu des parties de côtes de l' Amérique jusqu'au 59e degré; et ni l'un ni l'autre ne sont venus par la mer du Nord le long des côtes de l'Asie: cela prouve assez que le passage n'est pas aussi praticable que le suppose M. Engel; ou, pour mieux dire, cela prouve que les Russes savent qu'il n'est pas praticable, sans quoi ils eussent préféré d'envoyer leurs navigateurs par cette route, plutôt que de les faire partir de Kamlschatka pour faire la découverte de l'Amérique occidentale.

M. Muller, envoyé avec M. Gmelin lur l'impératrice en Sibérie, est d'un avis bien different de M. Engel: après avoir comparé toutes les relations, M. Muller conclut par dire qu'il n'y a qu'une très petite séparation entre l'Asie et l'Amérique, et que ce détroit offre une ou plusieurs iles qui servent de route ou de stations communes aux habitans des deux contineus. Je crois cette opinion bien fondée, et M. Muller rassemble un grand nombre de faits pour l'appuyer. Dans lesdemeuies souterraines des unhitans de l'ile Karaga, ou voit des poutres fuites de grands arbres de sapin, que

cette ile ne produit point, non plus que les terres de Kamtschatka dont elle est très voisine: les habitans disent que ce bois leur vient par un vent d'est qui l'amène sur leurs côtes. Celles de Kamtschalka reçoivent, du même côté, des glaces que la mer orientale y pousse en hiver deux à trois jours de suite: on^ voit en certains temps des volsd'oiseaux, qui, après un séjour de quelques mois., retournent à l'est, d'où ils étoient arrivés. Le continent opposé à celui de l'Asie vers le nord descend donc jusqu'à la latitude' de Kamlschatka: ce continent doit être celui de l'Amérique occidentale. M. Muller, après avoir donné le précis de cinq ou six voyages tentés par la mer du Nord pour doubler la pointe sepientrionale de l'Asie, finit par dire que tout annonce l'impossibilité de celle navigation et il le prouvé par les raisons suivantes: Cette navigation devroit se faire dans un été; or l'intervalle depuis Archangel à l'Oby, et de ce fleuve ad Jéniséik, demande une belle saison tout entiere. Le passage du Waigats a couté des peines infinies aux Anglois et aux Hollandois . au sortir de ce détroit glacial, on rencontre des iles qui ferment le chemin; ensuite le continent qui forme un cap entre les fleuves Piasida et Ckatanga, s'avançant au delà du 76e degré de latitude, est de même bordé d'une chaîne d'iles qui laissent difficilement un passage à la navigation. Si l'on veut s'éloigner des côtes et gagner la haute mer vers le pôle, les montagnes de glaces presque immobiles qu'on trouve au Groenland et au Spitzberg n'aunourent-elles pas une continuité de glaces jusqu'au pôle? Si l'on veut longer les côtes, cette navigation est moins aisée au elle ne l'étoit il y a cent ans; l'eau de l'Ocean y a diminué insensiblement: on voit encore loin des bords que haigne la mer Glaciale les bois qu'elle a jetés sur des terres qui jadis lui servoient de rivage; ces bords y sont si peu profonds, qu'on ne pourront y employer que des hateaux très plats, qui, trop foiblcs pour résister aux glaces, sauroient fournir une longue navigation, ni se charger des provisions qu'elle exige. Quoique les Russes aient des ressources et des moyens que n'ont pas la plupart des autres nations européennes pour fréquenter ces mers froides, on voit (pie les voyages tentés sur la mer Glaciale n'ont pas encore ouvert une route de l'Europe et de l'Asie à l'Amérique; el ce n'est qu'en parlant de Kamlschatka, ou d'un autre point de l'Asie la plus orientale, qu'on a decouvert quelques côles de l'Amérique occidentale.

Le capitaine Bebring l artit du port d'Awatscha en Kamtschatka le 4 juin 1741. Après avoir couru au sud-est et remonlé au nord est, il aperçut, le 18 du mois suivant, le continent de l'Amérique à 58 degrés 28' de latitude; deux jours après, il mouilla près d'une ile enfoncée dans une haie; de là, voyant deux caps, il appela l'un à l'orient Saint-Élie, et l'autre au couchant Saint-Hermogène; ensuite il dépêcha Chitrou, l'un de ses officiers, pour reconnoilre et visiter le golfe où il venoit d'entrer. On le trouva coupé ou parsemé d'iles: une entre autres offrit des cahanes désertes; elles étoient de planches bien unies et même échaucrées. On conjectura que cette ile pou voit avoir été habitée par quelques peuples du continent de l'Amérique. M. Sieller. envoyé pour faire des observations sur res terres nouvellement découvertes, trouva une cave où lon avoit mis une provision de saumon fumé, et laissé des cordes, des meubles, et des ustensiles: (Vus loin, il vit fuir des Américains à son aspect. Bientôt on aperçut du fen sur une colline assez éloignée: les sauvages sans doute s'y étoient retirés; un rocher escarpé y couvroit leur retraite.

D'après l'exposé de ces faits, il est aisé de juger que ce ne sera jamais qu'en partant de Kamtschatka que les Russes pourront faire le commerce de ta Chine et du Japon, et qu'il leur est aussi difficile, pour ne pas dire impossible, qu'aux autres nations de l'Europe de passer par les mers du nordest, donl la plus grande partie est entierement glicée: je ne crains donc pas de répéter que le seul passige possible est par le nord-ouest, au fond de la haie d'Hudsun, et que c'est l'endroit auquel les navigateurs doivent s'attacher pour trouver ce passage si désiré et si évidemment utile.

Comme j'avois déjà livré à l'unpression toutes les feuilles préeédenles de ce volume, j'ai reçu de la part de M. le comte de SchouvalolT, ce grand homme d'état que toute l'Europe estime el respecte; j'ai reçu, dis-je, en date du 29 octobre 1777, un excellent Mémoire composé nar M. de Domascheneff, le président de la société impéraie de Pélersburg, et auquel l'impératrice a confié, à juste titre, le département de tout ce qui a rapport aux sciences et aux arts. Cet illustre s;iv;mt

m'a en même temps envoyé une copie faite à la main de la carte du pilote Otcheredin, dans laquelle sont représentées les routes fit Tes découvertes qu'il a faites, en 1770 et 177Î, entre Kamtschatka et le continent de l'Amérique. M. de Domascheneff observe dans son Mémoire que cette carte du pilote Otcheredin est la plus exacte de toutes, et que celle qui a été donnée en 1773 par l'Académie de Pétersbourg doit être réformée en plusieurs points, et notamment sur la position des iles et le prétendu archipel qu'on y a représenté entre les iles Aleutes ou Aléoules et celtes d'A nadir, autrement appelées iles d'Andrien. La carte du pilote Otcheredin semble démontrer eu effet (pie ces deux groupes des iles Aleutes et des iles Andrien sont séparés par une mer libre de plus de cent lieues d'étendue. M. de Domascheneff assure que la grande carte générale de l'empire de Russie, qu'on vient de publier cette année 1777, représente exactement les côtes de toute l'extrémité septentrionale de l'Asie habiter par les Tsehtits* dis. Il dit que cette carte a été dressée d'après les rutuioïssauces les plus récentes acquises par la dernière expédition du major Pawluxki contre ce penple. - («tte côte, dit M de Doiuascheuefl, termine la grande chaîne de montagnes, laquelle .sépare toute la Sibérie de l'Asie méridionale, et finit en se partageant entre la chaîne qui parcourt Kamtschatka et celles qui remplissent toutes les terres entre les lieuves qui coulent à l'est du Lena. Les iles reconnues entre les côtes de Kamtschatka et celles de l'Amérique sont montagneuses, ainsi que les côtes de Kamtschatka et celles du continent de l'Amérique: il y a donc une continuation bien marquée entre les chaînes de montagnes et ces deux contiueus, dont les interruptions, jadis peut-être moins considérables, peuvent avoir été élargies par le dépérissement de la roche, par les courans continuels qui entrent de la mer Glaciale vers la grande mer du Sud, el par les catastrophes du globe.

Mais cette chaîne sous-marine qui joint les terres de Kamtschatka avec celles de l'Amérique est plus méridionale de 7 ou H degrés que celle des iles Anadir ou Andrien, qui de temps immémorial ont servi de passage aux Tschutsrbis pour aller en Amérique.

M. de Domascheneff dit qu'il est certain que cette traversée de la pointe de l'Asie au continent de l'Amérique se fait à la rame, et que ces peuples y vont trafiquer des ferrailles russes avec les Américains; que les iles qui sont sur ce passage sont si fréquentes, qu'on peut coucher toutes les nuits à terre, et que le continent de l'Amérique où les Tschutschis commercent est montagneux et couvert de forêts peuplées de renards, de martres, et de zibelines, dont ils rapportent des fourrures de qualités et de couleurs toutes différentes de celles de Siïtène. Ces iles septentrionales situées entre les deux continens ne sont guere connues que des Tschutschis; elles forment une chaîne entre la pointe fa plus orientale de l'Asie el le continent de 1 Amérique, sous le 64e degré; et cette chaîne est séparée par une mer ouverte de la seconde chaîne plus méridionale dont nous venons de parler, située sôus le 56e degré entre Kamtschatka et l'Amérique; ce sont les iles de cette seconde chaîne que les Russes el les habitans de Kamtschatka fréquentent pour lâchasse des loutres marines et des les fourrures sont très précieuses. On avoit connaissance de ces iles, même des plus orientales dans cette dernière chaîne, avant l'année 1760: l'une de ces iles porte le nom du commandeur Behring, une autre assez voisine s'appelle Vile Medenoi; ensuite on trouve les qutitre iles Aleutes ou Aléoutes, les deux premières situées un peu au dessus et les dernières un peu a» dessous du 55* degré; ensuite on trouve environ au 56e degré les iles Atkhou et Aralaïgh, qui sont les premières de la chaîne des iles aux Renards, laquelle s'étend vers le nord-est jusqu'au 6i* degré de latitude: le nom de ces iles est venu du nombre prodigieux de renards qu'on y a trouvés. Les deux iles du commandeur Bebring et de Medenoi étoient inhabitées lorsqu'on en lit la découverte: mais on a trouvé dans les iles Aïenles, quoique plus avaurées vers l'orient, plus d'une soixantaine de familles dont la langue ne se rapporte ni à celle de Kamtschatka ni à aucune de celles de l'Asie orientale, et n'est qu'un dialecte de la langue que l'on parle dans les autres iles voisines de l'Amérique; ce qui semblerait indiquer qu'elles ont été peuplées par les Américains, et non par les As2atiques.

Les iles nommées par léquipage de Behring IV/* Saint-Julien, Saint-Théodore, Saint-Abraham, sont les mêmes (pie celles qu'on appelle aujourd'hui les fies Aïenles; et de même l'ile de Chommaghin, de SaintDolmat, indiquées par ce navigateur, font partie de celles qu'on appelle ncs aux Renards.

La grande distance, dit M. de DomaschenelT, et la mer ouverte et profonde qui se trouve entre les iles Aleutes et les iles aux Renards, jointes au gisement différent de ces dernières, peuvent faire présumer que ces iles ne forment pas une cliaine marine continue; mais que les premières, avec celles de Medenoi et de Bebring, font une cliaine marine qui vient de Kamtschatka, et que les iles aux Renards en représentent une autre issue de l'Amérique; que l'une et l'autre de ces chaînes vont généralement se perdre dans la profondeur de la grande mer, et sont des promontoires des deux continens. La suite des iles aux Renards, dont quelques-unes sont d'une grande étendue, est entremêlée d'éeueils et de brisans, et se continue sans interruption jusqu'au continent de l'Amérique; mais celles qui sont les plus voisines de ce continent sont trèspeu fréquentées par les harques des chasseurs russes, parce qu'elles sont fort peu pires, et qu'il serait dangereux d'v séjourner. Il y a plusieurs de ces iles voisines de la terre-ferme de l'Amérique, qui ne sont pas encore bien reconnues. Quelques navires ont cependant pénétré jusqu'à l'ile de Kadjak, ijui est tres-voisine du continent de l'Amérique; l'on en est assuré tant sur le rapport des insulaires que par d'autres raisons: une de ces raisons est qu'au lieu que toutes les iles plus occidentales ne produisent que di s arbrisseaux rabougris et rampans, que les vems de pleine merempèchetit de s'élever, l'ile de Kadjak, au contraire, et les petites iles voisines, produisent des bosquets d'aunes, qui Semblent indiquer qu'elles se trouvent moins à découvert, et qu'elles sont garanties au nord et à l'est par un continent voisin. De plus, on y a trouvé des loutres d'eau douce, qui ne se voient point aux autres iles, de même qu'une petite espèce de marmotte, qui paroit être la marmotte du Canada; enfin l'on y a remarqué des traces d'ours et de loups, et les habitans sont vêtus de peaux de rennes, qui leur viennent du continent de l'Amérique, dout ils Sont très voisins.

On voit, par la relation d'un voyage poussé jusqu'à l'ile de Kadjak, sous la conduite d'un certain Gcottuf, que les insulaires nomment Atnkthan le continent de l'Amérique; ils disent que cette grande terre est montagneuse et toute couverte de forêts; ils placent cette grande terre au nord de leur ile, et nomment l'embouchure d'un grand fleuve, Alaglischak, qui s'y trouve... D'autre part, l'on ne sauroit douter que Bebring, aussi bien que Tschirikow, n'ait effectivement touché à ce grand continent, puisqu'au cap Élie, où sa frégate mouilla, l'on vit- des bords de la mer le terrain s'élever en montagne continue et toute revêtue d'épaisses forêts: le terrain y étoil d'une nature toute différente de celui de Kamtschatka; nombre de plantes américaines y furent recueillies par Steller.

M. de Domascheneff observe de plus que toutes les iles aux Renards, ainsi que les iles Aleutes, et celle de Bebring, sont montagneuses; que leurs cotes sont, pour la plupart, hérissées de rochers, coupées par des précipices, et environnées d'éeueils jusqu'à une assez grande distance; que le terrain s'élève depuis les cotes jusqu'au milieu de ces iles en montagnes fort roides, qui forment de petites chaînes dans le sens de la longueur de chaque ile: au reste, il y a eu et il y a encore des volcans dans plusieurs de ces iles, et celles où ces volcans sont éteints ont des sources d'eau chaude. Ou ne trouve point de métaux dans ces iles à volcans, mais seulement des calcédoines et quelques autres pierres colorées, de peu de valeur. On n'a d'autre bois dans ces iles que les tiges ou branches d'arbres floitées par la mer, et qui n'y arrivent pas en grande quantité; il s'en trouve plus sur l'ile Bebring et sur les Aleutes: il paroit que ces bois flottés viennent, pour la plupart, des plages méridionales; car on y a observé le bois de campbre du Japon.

Les habitans de ces iles sont assez nombreux; mais, comme ils mènent une vie errante, se transportant d'une ile à l'autre, il n'est pas possible de fixer leur nombre. On a généralement observé que plus les iles sont grandes, plus elles sont voisines de l'Amérique, et plus elles sont peuplées. Il paroit aussi que tous les insulaires des iles aux Kenardssont d'une même nation, à laquelle les habitans des Aleutes et des iles d'Andrien peuvent aussi se rapporter, quoiqu'ils en

diffèrent par quelques coutumes. Tout ce peuple a une très grande ressemblance pour les mœurs, la façon de vivre et de se nourrir, avec les Esquimaux et les Groenlandois. Le nom de Kanaghist, dont ces insulaires s'appellent dans leur langue, peut-être corrompu par les marins, est encore très ressemblant à celui de Karallt, dont les Esquimaux et leurs frères les Groenlandois se nomment. On n'a trouvé aux habitans de toutes ces iles, entre l'Asie et l'Amérique, d'autres outils que des haches de pierre, des cailloux taillés en scalpel, et des omoplates d'animaux aiguisées pour couper l'herbe; ils ont aussi des dards, qu'ils lancent de la main à l'aide d'une palette, et desquels la pointe est armée d'un caillou pointu et artistement taillé: aujourd'hui ils ont beaucoup de ferrailles volées ou enlevées aux Russes. Ils font des canots et des espe ces de pirogues comme les Esquimaux: il y en a d'assez grandes pour contenir vingt personnes; la charpente en est de bois léger, recouvert partout de peaux de phoques et d'autres animaux marins.

Il paroit, par tous ces faits, que de temps immémorial les Tscbutschis qui habitent la pointe la plus orientale de l'Asie, entre le 55" et le 70' degré, ont eu commerce avec les Américains, et que ce commerce étoit d'autant plus facile pour ces peuples accoutumés à la rigueur du froid, que l'on peut faire le voyage, qui n'est peut-être pas de cent lieues, en se reposant tous les jours d'ile en l'ile, et dans de simples canots, conduits à la rame en été, et peut-être sur la glace en hiver. L'Amérique a do:ic pu être peuplée par l'Asie sous ce parallèle; et loul semble indiquer que, quoiqu'il y ait aujourd'hui des interruptions de mer cuire les terres de ces iles, elles ne faisoient aulnfoit qu'un même continent, par lequel l'Amérique étoit jointe à l'Asie: cela semble indiquer aussi qu'au delà de ces iles Anadir ou Andrien, c'est-à-dire entre le 70' et le 75e degré, les deux coulinens sont absolument réunis par un terrain où il ne se trouve plus de mer, mais qui est peut-être entièrement couvert de glace. La reconnoissaure de ces plages au delà du 70e degré est une entreprise digne de l'attention de la grande souveraine des Russies, et il faudrait la confier à un navigateur aussi courageux que M. Phipps. Je suis bien persuadé qu'on trouverait les deux coniinens réunis; et s'il en est autrement, et qu'il y ait une mer ouverte au delà des iles Andrien, il me paroit certain qu'on trouveroit les appendices de la grande glacière du pole à 81 ou 82 degrés, comme M. Phipps les a trouvés à la même hauteur entre le Spitzberg et le Groenland.

Septième Et Dernière Époque - Lorsque La Puissance De L'homme A Secondé Celle De La Nature

Les premiers hommes témoins des mouvements convulsifs de la terre, encore récents et très fréquents, n'ayant que les montagnes pour asiles contre les inondations, chassés souvent de ces mêmes asiles par le feu des volcans, tremblants sur une terre qui trembloit sous leurs pieds, nus d'esprit et de corps, exposés aux injures de tous les éléments, victimes de la fureur des animaux féroces, dont ils ne pouvoient éviter de devenir la proie; tous également pénétrés du sentiment commun d'une terreur funeste, tous également pressés par la nécessité, n'ontils pas très promptement cherché à se réunir, d'abord pour se défendre par le nombre, ensuite pour s'aider et travailler de concert à se faire un domicile et des armes? Ils ont commencé par aiguiser en forme de haches ces cailloux durs, ces jades, ces pierres de foudre, que l'on a crues tombées des nues et formées par le tonnerre, et qui néanmoins ne sont que les premiers monuments de l'art de l'homme dans l'état de pure nature: il aura bientôt tiré du feu de ces mêmes cailloux en les frappant les uns contre les autres; il aura saisi la flamme des volcans, ou profité du feu de leurs laves brûlantes pour le communiquer, pour se faire jour dans les forêts, les broussailles; car, avec le secours de ce puissant élément, il a nettoyé, assaini, purifié les terrains qu'il vouloit habiter; avec la hache de pierre, il a tranché, coupé les arbres, menuisé le bois, façonné ses armes et les instruments de première nécessité. Et après s'être munis de massues et d'autres armes pesantes et défensives, ces premiers hommes n'ont-ils pas trouvé le moyen d'en faire d'offensives plus légères, pour atteindre de loin? Un nerf, un tendon d'animal, des fils d'aloès, ou l'écorcc souple d'une plante ligneuse, leur ont servi de corde pour réunir les deux extrémités d'une branche élastique dont ils ont fait leur arc; ils ont aiguisé d'autres petits cailloux pour en armer la flèche. Bientôt ils auront eu des filets, des radeaux, des canots, et s'en sont tenus là tant qu'ils n'ont formé que de petites nations composées

de quelques familles, ou plutôt de parents issus d'une même famille, comme nous le voyons encore aujourd'hui chez les sauvages, qui veulent demeurer sauvages, et qui le peuvent, dans les lieux où l'espace libre ne leur manque pas plus que le gibier, le poisson et les fruits. Mais dans tous ceux où l'espace s'est trouvé confiné par les eaux, ou resserré par les hautes montagnes, ces petites nations, devenues trop nombreuses, ont été forcées de partager leur terrain entre elles; et c'est de ce moment que la terre est devenue le domaine de l'homme: il en a pris possession par ses travaux de culture, et l'attachement à la patrie a suivi de très près les premiers actes de sa propriété. L'intérêt particulier faisant partie de l'intérêt national, l'ordre, la police et les lois ont dû succéder, et la société prendre de la consistance et des forces.

Néanmoins ces hommes, profondément affectés des calamités de leur premier état, et ayant encore sous les yeux les ravages des inondations, les incendies des volcans, les gouffres ouverts par les secousses de la terre, ont conservé un souvenir durable et presque éternel de ces malheurs du monde: l'idée qu'il doit périr par un déluge universel, ou par un embrasement général; le respect pour certaines montagnes (') sur lesquelles ils s'étoient sauvés des inondations; l'horreur pour ces autres montagnes qui lançoient des feux plus terribles que ceux du tonnerre,; fondement de la fable des titans et de leurs assauts contre les dieux; l'opinion de l'existence réelle d'un être malfaisant, la crainte et la superstition qui en sont le premier produit; tous ces sentimens fondés sur la terreur se sont dès lors empares â jamais du cœur el de l'esprit de l'homme: à peine est-il encore aujourd'hui rassuré par l'expérience des temps, par le calme qui a succédé à ces sièr les d'orages, enfm par la counoissance des effets et des opérations de la nature; conuoissance qui na pu s'acquérir qu'après l'établissement de quelque grande société dans des terres paisibles.

Ce n'est point en Afrique, ni dans les terres de l'Asie les plus avancées vers le midi, que les grandes sociétés ont pu d'abord se former; ces contrées étoient encore brûlantes et désertes; ce n'est point en Amérique, qui n'est évidemment, à l'exception de ses chaînes de montagnes, qu'une terre nouvelle; ce n'est pas même en Europe, qui n'a reçu que fort tard les lumières de l'Orient, que se sont établis les premiers hommes civilisés, puisqu'avant la fondation de Rome les contrées les plus heureuses de cette partie du monde, telles que l'Italie, la France, et l'Allemagne, n'étoient encore peuplées que d'hommes plus qu'à demi sauvages. Lisez Tacite, sur les niceurs des Germains; c'est le tableau de celles des Hurons, ou plutôt des habitudes de l'espèce humaine entiere sortant de l'étal de nature. C'est donc dans les contrées septentrionales de l'Asie que s'est élevée la tige des connoissances de l'homme, et c'est sur ce tronc de l'arbre de la science que s'est élevé le tronc de sa puissance: plus il a su, plus il a pu; mais aussi moins iia fait, moins il a su. Tout cela suppose les hommes actifs dans un climat heureux, sous un ciel pur pour l'observer, sut une terre féconde pour la cultiver, dans une contrée privilégiée, à l'abri des inondations, éloignée des volcans, plus élevée et par conséquent plus anciennement tempérée que les autres. Or toutes ces conditions, toutes ces circonstances, se sont trouvées réunies dans le centre du continent de l'Asie, depuis le 40' deg.ré de latitude jusqu'au 55°. Les fleuves qui portent les eaux dans la mer du nord, dans l'Océan oriental, dans les mers du midi et dans la Caspienne, partent également de cette région élevée qui fait aujourd'hui partie de la Sibérie méridionale el de la Tartarie. C'est dans cette terre plus élevée, plus solide que les autres, puisqu'elle leur Mrt de centre, et qu'elle est éloignée de près de cinq cents lieues de tous les océans; c'est dans cette contrée privilégiée que s'est formé le premier peuple digne de porter ce nom, digne de tous nos respects, comme créateur des sciences, des arts, et de toutes les institutions utiles. Cette vérité nous est également démontrée par les monumens de l'histoire naturelle et par les progrès presque inconcevables de l'ancienne astronomie. Comment des hommes si nouveaux ont-ils pu trouver la période lunisolalre de six cents ans 1? Je me borne à ce seul fait, quoiqu'on puisse en citer beaucoup d'autres tout aussi merveilleux, et tout aussi constans. Ils savoient donc autant d'astronomie qu en savoit de nos jours Dominique Cassini, qui le premier a démontré la réalité et l'exactitude de cette période de six cents ans; rontioissance à laquelle ni les Chaldéens, ni les" Égyptiens, ni les Grecs, ne sont pas arrivés; counoissance qui suppose celle des mouvemens précis de la lune et de la terre, et qui exige une grande perfection

dans les instrumens nécessaires aux observations; connoissance qui ne peut s'acquérir qu'après avoir tout acquis, laquelle n'étant fondée que sur une longue suite de recherches, d'études, et de travaux astronomiques, suppose au moins deux ou trois mille ans de culture à l'esprit humain pour y parvenir.

Ce premier peuple a été très heureux, puisqu'il est devenu très savant; il a joui, pendant plusieurs siècles, de la paix, du repos, du loisir nécessaire à cette culture de l'esprit, de laquelle dépend le fruit de toutes les autres cultures. Pour se douter de la période de six cents ans, il falloit au moins douze cents ans d'observations; pour l'assurer comme fait certain, il en a fallu plus du double: voilà donc déjà trois mille ans d'études agronomiques; et nous n'en serons pas étonnés, puisqu'il a fallu ce même temps aux astronomes, en les comptant depuis les Chatdéen, jusqu'à nous, pour reconnoitre cette période; et ces premiers trois mille ans d'observations astronomiques n'onl-ils pas été nécessairement précèdes de quelques siècles où la science n'étoil pas née? six mille ans, à compter de ce jour, sont-ils sulfisans pour remonter à l'époque la plus noble de l'histoire de l'homme, et même pour le suivre dans les premiers progrès qu'il a faits dans les arts et dans les sciences?

Mais malheureusement elles ont été perdues, ces hautes et belles sciences; elles ne nous sont parvenues que par débris trop informel pour nous servir autrement qu'à reconnoitre leur existence passée. L'invention de la formule d'après laquelle les brames calculent les éclipses suppose autant de science que la construction de nos éphémérides, et cependant ces mêmes brames n'ont pas la moindre idée de la composition de l'univers; ils n'eu ont que de fausses sur le mouvement, la grandeur, et la position des planètes; ils calculent les éclipses sans en connoilre la théorie, guidés comme des machines par une gamme fondée sur des formules savantes qu'ils ne comprennent pas, et que probablement leurs ancêtres n'ont point mventées, puisqu'ils n'ont rien perfectionné, et qu'ils n'ont pas transmis le moindre rayon de la science à leurs descendans: ces formules ne sont entre leurs mains que des méthodes de pratique; mais elles supposent des connoissances profondes dont ils n'ont pas les élémens, dont ils n'ont pas même conservé les moindres vestiges, et qui par conséquent ne leur ont jamais appartenu. Ces méthodes ne peuveut donc venir que de cet ancien peuple savant qui avoit réduit en formules les motivemeus des astres, et qui, par une longue suite d'observations, étoit parvenu non seulement à la prédiction des éclipses, mais à la connoissance bien plus difficile de la période de six cents ans, et de tous les faits astronomiques que cette connoissance exige et suppose nécessairement.

Je crois être fondé à dire que les brames n'ont pas imaguié ces formules savantes, puisque toutes leurs idées physiques sont contraires à la théorie dont les formules dépendent, et que s'ils eussent compris cette théorie même dans le temps qu'ils en ont reçu les résultats, ils eussent conservé la science, et ne se trouveroient pas réduits aujourd'hui à la plus grande ignorance, et livrés aux préjugés les plus ridicules sur le systeme du monde: car ils croient que la terre est immobile, et appuyée sur la cime d'une montagne d'or; ils pensent que la lune est éclipsée par des dragons aériens, que les planetes sont plus petites que ta lune, etc. Il est donc évident qu'ils n'ont jamais eu les premiers élémens de la théorie astronomique, ni même la moindre conuoissance des principes que s ipposent les méthodes dont ils se servent. Mais je dois renvoyer ici à I excellent ouvrage que M. Railly vient de publier sur l'ancienne astronomie, dans lequel il discute à fond tout ce qui est relatif à l'origine et au progres de cetle science: on verra que ses idées s'accordent avec les important avec une sagacité de génie et une profondeur d'érudition qui méritent des éloges de tous ceux qui s intéressent au progrès des sciences.

Les Chinois, un peu plus éclairés que les brames, calculent assez grossièrement les éclipses, et les calculent toujours de même depuis deux ou trois mille ans: puisqu'ils ne perfectionnent rien, ils n'ont jamais rien inventé; la science n'est donc pas plus née à la Chine qu'aux Indes. Quoique aussi voisins que les Indiens du premier peuple savant, les Chinois ne paroissent en avoir rien tiré; ils

n'ont pas même ces formules astro* Domiques dont les brames ont consevé l'usage, et qui sont néanmoins les prex, iers et grands monumeus du savoir et du h nbeur de l'homme. 11 ne paroît pas non pl is que les Chaldéens, les Perses, les cgyptii ns, et les Grecs, aient rien reçu de ce pi entier peuple éclairé; car, dans ces contn es du Levant, la nouvelle astronomie n'est dt qu'à l'opiniâtre assiduité des observateurs chaldéens, et ensuite aux travaux des Gr, es 1, qu'on ne doit dater que du temps Je la fondation de l'école d'Alexandrie. Néanmoins cette science étoit encore bien imparfaite après deux mille ans de nouvelle culture, et même jusqu'à nos derniers siècles. Il me paroit donc certain que ce premier peuple, qui avoit inventé et cultivé si beureusement et si long-temps l'astronomie, n'en a laissé que des débris et quelques résultats qu'on pouvoit retenir de mémoire, comme celui de la période de six cents ans, que l'historien Josèpbe nous a transmise sans la comprendre.

La perte des sciences, cette première plaie faite à l'humanité par la hacbe de la barbarie, fut sans doule l'effet d'une malbeureuse révolution qui aura réduit peut être en peu d'années l'ouvrage et les travaux de plusieurs siecles; car nous ne pouvons douter que ce premier peuple, aussi puissant d'abord que savant, ne se soit long temps maintenu dans sa splendeur, puisqu'il a fait de si grands progres dans les sciences, et par conséquent dans tous les arts qu'exige ieur étude. Mais il y a toute apparence que quand les terres situées au nord de cette beureuse contrée ont été trop refroidies, les hommes qui h s habitoieut, encore ignorons, faroucbes, et barbares, auront reflué vers cette même contrée ricbe, abondante, et cultivée par les arts; il est même assez étonnant qu'ils s'en soient emparés, et qu'ils y aient détruit non reniement les germes, mais même la mémoire de toute science; en sorte que trente siècles d'ignorance ont peul-èlre suivi les trente siècles de lumières qni les avoient précédés. De Ions ces beaux et premiers fruits de l'esprit humain il n'est resté que le marc; la métaphysique religieuse, ne pouvant être comprise, n'avoit pas besoin d étude. et ne devoit ni s'altérer ni se perdre que faute de mémoire, laquelle ne manque jamais quand elle est frappée du merveilleux. Aussi celle métaphysique s'est-elle répandue do ce premier centre des sciences à toutes les parties du monde; les idoles de Calicut se son' 'rouvces les mêmes que celles de Kéléginst oi. Les pèlerinages vers le grand Lama, établis à plus de deux mille lieues de distante; l'idée de la métempsycose portée o tour plus loin, adoptée comme article de foi pf r les Indiens, les Éthiopiens, les Atlante; ces mêmes idées défigurées, reçues par I:s Chinois, les Perses, les Grecs, et parv nues jusqu'à nous, tout semble nous déni mtrer que la première souche et la tige commune des counoissances humaines appartient à cette terre de la haute Asie', el que les rameaux stériles ou dégénérés des nobles branches de cette ancienne souche se sont étendus dans toutes les parties de la terre chez les peuples civilisés.

Et que pouvons-nous dire de ces siècles de harharie qui se sont écoulés en pure perte pour nous? ils sont ensevelis pour jamais dans une nuit profonde; l'homme d'alors, replongé dans les ténèbres de l'ignorance, a pour ainsi dire cessé d être homme: car la grossièreté, suivie de l'oubli des devoirs, commence par relâcher les liens de la société, la harharie achève de les rompre; les lois méprisées ou proscrites, les mœurs dégénérées en habitudes farouches; l'amour de l'humanité, quoique gravé en caractères sacrés, effacé dans les cœurs; l'homme enfin sans éducation, sans morale, réduit à mener une vie solitaire et sauvage, n'offre, au lieu de sa haute nature, que celle d'un être dégradé au dessous de l'animal.

Néanmoins, après la perte des sciences, les arts utiles auxquels elles avoient donné naissance se sont conservés: la culture de la terre devenue plus nécessaire à mesure que les hommes se trouvoient plus nombreux, plus serrés; loutes les pratiques qu'exige cette même culture, tous les arts (pte supposent la construction des édifices, la fabrication des idoles et des armes, la texture des étoffes, etc., ont survécu à la science; ils se sont répandus de proche en proche, perfectionnés de loin en loin; ils ont suivi le cours des grandes populations: l'ancien empire de la Chine s'est élevé le premier, el presque en même temps celui des Atlantes en Afrique; ceux du continent de l'Asie, celui de l'Égypte, d'Ethiopie, se sont successivement établis, et enfin celui de Rome, auquel noire

Europe doit son existence civile. Ce n'est donc que depuis environ trente siecles que la pnis-aure de l'homme s'est réunie à celle de la nature et s'est étendue sur la plus grande partie de la terre: les trésors de sa fécondité jusqu'alors étoient enfouis, l'homme les a mis au grand jour; ses autres richesses, encore plus profondément enterrées, n'ont pu se dérober à ses recherches, et sont devenues le prix de ses travaux. Partout, lorsqu'il s'est conduit avec sagesse, il a suivi les lois de la nature, profité de ses exemples, employé ses moyens, et choisi dans son immensité tous les objets qui pouvoient lui servir ou lui plaire. Par son intelligence les animaux ont été apprivoisés, subjugués, domptés, réduits à loi obéir à jamais; par ses travaux les marais ont été desséchés, les fleuves contenus, leurs cataractes effacées, les forêts éclaircies. les landes cultivées; par sa réflexion les temps ont été comptés, les espaces mesurés, les ntouvemens célestes reconnus, combinés, représentés, le ciel et la terre comparés, l'univers agrandi, et le Créateur dignement adoré; par son art émané de la science les mers om été traversées, les montagnes franchies, les peuples rapprochés, un nouveau monde découvert, mille autres terres isolées sont devenues son domaine; enfin la face eutière de la terre porte aujourd'hui l'empreinte de la puissance de l'homme. laquelle, quoique subordonnée à celle de la nature, souvent a fait plus qu'elle, ou du moins l'a si merveilleusement secondée, que c'est à l'aide de nos mains qu'elle s'est développée dans toute son étendue, et qu'elle est arrivée par degrés au point de perfection et de magnificence où nous la voyons aujourd'hui.

Comparez en effet la nature brute à la nature cultivée2; comparez les petites nations sauvages de l'Amérique avec nos grands peuples civilisés; comparez même celles de l'Afrique, qui ne le sont qu'à demi; voyez en même temps l'état des terres que ces nations habitent, vous jugerez aisément du peu de valeur de ces hommes par le peu d'impression que leurs mains ont faite sur leur sol. Soit stupidité, soit paresse, ces hommes à demi bruts, ces nations non policées, grandes ou petites, ne font que peser sur le gtobe sans soulager la terre, l'affamer sans la féconder, détruire sans édifier, tout user sans rien renouveler. Néanmoins la condition la plus méprisable de l'espèce humaine n'est pas celle du sauvage, mais celle de ces nations au quart policées qui de tout temps ont été les vrais fléaux de la nature humaine, et que les peuples civilisés ont encore peine à contenir aujourd'hui: ils ont, comme nous l'avons dit, ravagé la première terre beureuse, ils en ont arraché les germes du bonbeur et détruit les truils de la science. Kl de combien d'autres invasions cette première irruption des barbares n'a-t-elle pas été suivie! C'est de ces mêmes contrées du nord, où se Irouvoient autrefois tous les biens de l'espèce humaine, qu'ensuite sont venus tous ses maux. Combien n'a-t-on pas vu de ces débordemens d'animaux à face humaine, toujours venant du nord, ravager les terres du midi! Jetez les yeux sur les annales de tous les peuples, vous y compterez vingt siècles de désolation pour quelques années de paix et de repos.

Il a fallu six cents siècles à la nature pour construire ses grands ouvrages, pour attiédir la terre, pour en façonner la surface, et arriver à un état tranquille: combien n'en faudra-t-il pas pour que les hommes arrivent au même point et cessent de s'inquiéter, de s'agiter, et de s'entre-détruire? Quand reconuoitront-ils que la jouissance paisible des terres de leur partie suffit à leur bonbeur? Quand seront-ils assez sages pour rabattre de leurs prétentions, pour renoncer à des dominations imaginaires, à des possessions éloignées, souvent ruineuses, ou du moins plus à charge qu'utiles? L'empire de l'Espagne, aussi étendu que celui de la France en Europe, et dix fois plus grand en Amérique, est-il dix fois plus puissant? l'est-il même autant que si cette lière et grande nation se fût bornée à tirer de son beureuse terre tous les biens qu'elle pouvoit fournir? Les Auglois, ce peuple si sensé, si profondément pensant, n'ont-ils pas fait une grande faute en étendant trop loin les linutes de leurs colonies? Les anciens me paroissent avoir eu des idées plus saines de ces établissemens; ils ne projetoient des émigrations que quand leur population les surrhargeoit, et que leurs terres et leur commerce ne suffisoient plus à leurs besoins. Les invasions des barbares, qu'on regarde avec horreur, n'oul-elles pas eu des causes encore plus pressantes lorsqu'ils se sont trouvés trop serrés dans des terres ingrates, froides, et dénuées, et en même temps voisines d'autres terres

cultivées, fécondes, et couvertes de tous les biens qui leur manquoienl? Mais aussi que de sang ont coulé ces funestes conquêtes! que de malbeurs, que de pertes les ont accompagnées et suivies!

Ne nous arrêtons pas plus long-temps sur le triste spectacle de ces révolutions de mort et de dévastation, toutes produites par l'ignorance; espérons que l'équilibre, quoique imparfait, qui se trouve actuellement entre les puissances des peuples civilisés se maintiendra, et pourra même devenir plus stable à mesure que les hommes sentiront mieux leurs véritables intérêts, qu'ils reconnoitront le prix de la paix et du bonheur tranquille, qu'ils en feront le seul objet de leur ambition, que les princes dédaigneront la fausse gloire des conquérons, et mépriseront la petite vanité de ceux qui, pour jouer un rôle, les excitent à de grands mouvemens.

Supposons donc le monde en paix, et voyons de plus près combien la puissance de l'homme pourrait influer sur celle de la nature. Rien ne paraît plus difficile, pour ne pas dire impossible, que de s'opposer au refroidissement successif de la terre, «\. de réchauffer la température d'un climat; cependant l'homme le peut faire et l'a fait. Paris et Québec sont à peu près sous la même lalitude et à la même élévation sur le globe: Paris serait donc aussi froid que Québec si la France et toutes les contrées qui l'avoisinent étoient aussi dépourvues d'hommes, aussi couvertes de bois, aussi baignées par les eaux, que le sont les terres voisines du Canada. Assainir, défricber, et peupler un pays, c'est lui rendre de la chaleur pour plusieurs milliers d'années; et ceci prévient la seule objection raisonnable que l'on puisse faire contre mon opinion, ou, pour mieux dire, contre le fait réel du refroidissement de la terre.

Selon votre système, me dira-t-on, toute la terre doit être plus froide aujourd'hui qu'elle ne l'étoit il y a deux mille ans; or la tradition semble nous prouver le contraire. Les Gaules et la Germanie nourrissoienl des élans, des loups-cerviers, des ours, et d'autrès animaux qui se sont retirés depuis dans les pays septentrionaux: cette progression est bien différente de celle que vous leur supposez du nord au midi. D'ailleurs l'histoire nous apprend que tous les ans la riMère de Seine étoit ordinairement glacée pendant une partie de l'hiver: ces fait? ne paroissent-ils pas être directement opposés au prétendu refroidissement successif du globe? Ils le seraient, je l'avoue, si la France et l'Allemagne d'aujourd'hui étoient semblables à la Gaule et la Germanie; si l'on n'eût pas ahattu les forêts, desséché les marais, contenu les torrens, dirigé les fleuves, et défriché toutes les terres trop couvertes et surchargées des débris mêmes de leurs productions. Mais ne doit-on pas considérer que la déperdition de la chaleur du globe se fait d'une manière insensible; qu'il a fallu soixante-seize mille ans pour l'attiédir au point de la température actuelle, et que, dans soixante-seize autres nulle ans, il ne sera pas encore assez refroidi pour que la chaleur particulière de la nature vivante y soit anéantie? Ne faut-il pas comparer ensuite à ce refroidissement si lent le froid prompt et subit qui nous arrive des régions de l'air, se rappeler qu'il n'y a néanmoins qu'un trente-deuxième de différence entre le plus grand chaud de nos étés et le plus grand freid de nos hivers, et l'on sentira déjà que les causes extérieures influent beaucoup plus que la cause intérieure sur la température de chaque climat, et que, dans tous ceux où le froid de la région supérieure de l'air est attiré par l'humidité ou poussé par les vents qui le rahattent vers la surface de la terre, les effets de ces causes particulières l'emportent de beaucoup sur le produit de la cause générale? Nous pouvons en donner un exemple qui ne laissera aucun doute sur ce sujet, et qui prévient en même temps toute objection de cette espèce.

Dans l'immense étendue des terres de la Guiane, qui ne sont que des forêts épaisses où le soleil peut à peine pénétrer, où les eaux répandues occupent de grands espaces, où les fleuves, très voisins les uns des autres, ne sont ni continus ni dirigés, où il pleut continuellement pendant huit mois de l'année, l'on a commencé seulemeut depuis un siècle à défricher autour de Cayenne un très petit canton de ces vastes forêts; et déjà la différence de température, dans cette petite étendue de terrain défriché, est si sensible, qu'on y éprouve trop de chaleur, même pendant la nuit, tandis que, dans toutes les autres terres couvertes de bois, 'il fait assez froid la nuit pour qu'on soit forcé

d'allumer du feu. Il en est de même de la quantité èt de la continuité des pluies: elles cessent plus tôt et commencent plus tard à Cayenne que dans l'intérieur des terres; elles sont aussi moins abondantes et moins continues. Il y a quatre mois de sécheresse absolue à Cayenne, au lieu que, dans l'intérieur du pays, la saison sèche ne dure que trois mois, et encore y pleut-il tons les jours par un orage assez violent qu'on appelle le grain de midi, parce que c'est vers le milieu du jour que cet orage se forme: de plus, il ne tonne presque jamais à Cayenne, tandis que les tonnerres sont violens et très fréquens dans l'intérieur du pays, où les nuages sont noirs, épais, et très has. Ces faits, qui sont certains, ne démontrent-ils pas qu'on feroit cesser ces pluies continuelles de huit mois, et qu'on augmenteroit prodigieusement la chaleur dans toute cette contrée, si l'on détruisoit les forêts qui la couvrent, si l'on y resserroit les eaux en dirigeant les fleuves, et si la culture de la terre, qui suppose le mouvement et le grand nombre des animaux et des hommes, chassoit l'humidité froide et superflue que le nombre infiniment trop grand des végétaux attire, entretient, et répand?

Comme tout mouvement, toute action, produit de la chaleur, et que tous les êtres doués du mouvement progressif sont eux-mêmes autant de petits foyers de chaleur, c:est de la proportion du nombre des hommes et des animaux à celui des végétaux que dépend (toutes choses égales d'ailleurs) la température locale de chaque terre en particulier; les premiers répandent de la chaleur, les seconds ne produisent que de l'humidité. L'usage habituel que l'homme fait du feu ajoute beaucoup à cette température artificielle dans tous les lieux où il habite en nombre. A Paris, dans les grands froids, les thermomètres au faubourg SaintHonoré marquent 2 ou 3 degrés de froid de plus qu'au faubourg Saint-Marceau, parce que le vent du nord se tempère eu passant sur les cheminées de cette grande ville. Une seule forêt de plus ou de moins dans un pays suffit pour en changer la température: tant que les arbres sont sur pied, ils attirent le froid, ils diminuent par leui ombrage la chaleur du soleil; ils produisent des vapeurs humides qui forment des nuages et retombent en pluie d'autant plus froide qu'elle descend de plus haut: et si ces forêts sont abandonnées à la seule nature, ces mêmes arbres, tombés de vétusté, pourrissent froidement sur la terre, tandis qu'entre les mains de l'homme ils servent d'aliment à l'élément du feu, et deviennent les causes secondaires de toute chaleur particulière. Dans les pays de prairie, avant la récolte des herbes, on a toujours des rosées abondantes, et Irès-souvent de petites pluies qui cessent dès que ces herbes sont levées. Ces petites pluies deviendraient donc plus abondantes, et ne cesseroient pas, si nos prairies, comme les savanes de l'Amérique, étoient toujours couvertes d'une même quantité d'herbes, qui, loin de diminuer, ne peut qu'augmenter par l'engrais de toutes celles qui se dessèchent et pourrissent sur la terre.

Je donnerais aisément plusieurs autres exemples qui tous concourent à démontrer que l'homme peut modifier les influences du climat qu'il habite, et en fixer, pour ainsi dire, la température au point qui lui convient. Et ce qu'il y a de singulier, c'est qu'il lui serait plus difficile de refroidir la terre que de la réchauffer: maitre de l'élément du feu, qu'il peut augmenter et propager à sou gré, il ne l'est pas de l'élément du froid, qu'il ne peut saisir ni communiquer. Le principe du froid n'est pas même une substance réelle, mais une simple privation, ou plutôt une diminution de chaleur, diminution qui doit élre très grande dans les hautes régions de l'air, et qui l'est assez à une lieue de distance de la terre pour y convertir en grêle et en neige les vapeurs aqueuses; car les émanations de la chaleur propre du globe suivent la même loi que toutes les autres quantités ou qualités physiques qui partent d'un centre commun; et leur intensité décroissant en raison inverse du carré de la distance, il parait certain qu'il fait quatre fois plus froid à deux lieues qu'à une lieue de hauteur dans notre atmosphère, en prenant chaque point de la surface de la terre pour centre. D'autre part, la chaleur intérieure du globe est constante, dans toutes les saisons, à 10 degrés au dessus de la congélation; ainsi tout froid plus grand, ou plutot toute chaleur moindre de to degrés, ne peut arriver sur la terre que par la chute des matières refroidies dans la région supérieure de l'air, où les effets de cette chaleur propre du globe diminuent d'autant plus qu'on s'élève plus haut. Or la puissance de l'homme ne s'étend pas si loin; il ne peut faire descendre le froid comme il fait

monter le chaud; il n'a d'autre moyen pour se garantir de la trop grande ardeur du soleil que de créer de l'ombre; mais il est bien pins aisé d'ahattre des forêts à la Guiane pour en réchauffer la terre humide que d'en planter en Arabie pour en rafraichir les sables arides; cependant une seule forêt dans le milieu de ces déserts brûlans suffiroit pour les tempérer, pour y ramener les eaux du ciel, pour rendre à la terre tous les principes de sa fécondité, et par conséquent pour y faire jouir l'homme de toutes les douceurs d'un climat tempéré.

C'est de la différence de température que dépend la plus ou moins grande énergie de la nature; l'accroissement, le développement, et la production même de tous les êtres organises, ne sont que des effets particuliers de cette cause générale: ainsi 1 homme en la modifiant peut en même temps détruire ce qui lui nuit, et faire éclore tout ce qui lui convient. Heureuses les contrées où tous les élemens de la température se trouvent halancés, et assez avantageusement combinés pour n'opérer que de bons effets! Mais en est-il aucune qui, dès son origine, ait eu ce privilège? aucune où la puissance de l'homme n'ait pas secondé celle de la nature, soit en attirant ou détournant les eaux, soit en détruisant les herbes inutiles et les végétaux nuisibles ou superflus, soit en se conciliant les animaux utiles et les multipliant? Sur trois cents espèces d'animaux quadrupèdes et quinze cents espèces d'oiseaux qui peuplent la surface de la terre, l'homme en a choisi dix-neuf ou vingt '; et ces vingt espèces figurent seules plus grandement dans la nature, et font plus de bieu sur la terre, que toutes les autres espèces réunies. Elles figurent olus grandement, parce qu'elles sont dirigces par l'homme, et qu'il les a prodigieusement multipliées: elles opèrent de concert avec lui tout le bien qu'on peut attendre d'une sage administration de forces et de puissance pour la culture de la terre, pour le transport et le commerce de ses productions, pour l'augmentation des subsistances; en un mot, pour tous les besoins, et même pour les plaisirs d'un seul maitre qui puisse payer leurs services par ses soins.

Et dans ce petit nombre d'espèces d'animaux dont l'homme a fait choix, celles de la poule et du cochon, qui sont les plus fécondes, sont aussi les plus généralement répandues, comme si l'aptilude à la plus grande multiplication étoit accompagnée de cette vigueur de tempérament qui brave tous les inconvéniens. On a trouve la poule et le cochon dans 1rs parties les moins fréquentées de la terre, à établi, et dans les autres iles de tout temps inconnues et les plus éloignées des continens: il semble que ces espèces aient suivi celle de l'homme dans toutes ses migrations. Dans le continent isolé de l'Amérique méridionale, où nul de nos animaux n'a pu pénétrer, on a trouvé le pérari et la poule sauvage, qui, quoique plus petits et un peu difiérrns du cochon et de la poule de noire continent, doivent néanmoins être regardés comme espèces trèsvoisines, qu'on pourroit de même réduire en domesticité: mais l'homme sauvage n'ayant point d'idée de la société n'a pas même cherché celle des animaux. Dans tontes les terres de l'Amérique méridionale, les sauvages n'ont point d'animaux domestiques; ils détruisent indifféremment les bonnes espèces comme les mauvaises; ils ne font choix d'aucune pour les élever et les multiplier, tandis qu'une seule espèce féconde, comme celle du liocco l, qu'ils ont sous la main, leur fournirait sans peine, et seulement avec un peu de soin, plus de subsistances qu'ils ne peuvent s'en procurer par leurs chasses pénibles.

Aussi le premier trait de l'homme qui commence à se civiliser est l'empire qu'il sait prendre sur les animaux; et ce premier trait de son intelligence devient ensuite le plus grand caractère de sa puissance sur la nature: car ce n'est qu'après se les être soumis qu'il a, par leur secours, changé la face de la terre, converti les déserts en guérets et les bruyères en épis. En multipliant les espèces utiles d'auimaux, l'homme augmente sur la terre la quantité de mouvement et de vie; il ennoblit en même temps la suite entière des êtres, et s'ennoblit luimême, en transformant le végétal en animal, et tous deux en sa propre substance, qui se répand ensuite par une nombreuse multiplication: partout il produit l'abondance, toujours suivie de la grande population; des millions d'hommes existent daus le même espace qu'occupoient autrefois deux ou trois cents sauvages, des milliers d'animaux où il y avoil à peine quelques individus; par lui et pour lui les germes précieux

sont les seuls développés, les productions de la classe la plus noble les seules cultivées; sur l'arbre immense de la fécondité les branches à fruit seules subsistantes et toutes perfectionnées.

Le grain dont l'homme fait son pain n'est point un don de la nature, mais le grand, l'utile fruit de ses recherches et de son intelligence dans le premier des arts; nulle part sur la terre on n'a trouvé de blé sauvage, et c'est évidemment une herbe pref1ctionnée par ses soins: il a donc fallu reconnoitre et choisir entre mille et mille autres cette herbe précieuse; il a fallu la semer, la rerueillir nombre de fois pour s'apercevoir de sa multiplication, toujours proportionnée à la culture et à l'engrais des terres. Et cette propriété, pour ainsi dire unique, qu'a le froment de résister, dans son premier âge, au froid de nos hivers, quoique soumis, comme toutes les plantes annuelles, à périr après avoir donné sa graine; et la qualité merveilleuse de cette graine, qui convient à tous les hommes, à tous les animaux, à presque tous les climats, qui d'ailleurs se conserve long-temps sans attération, sans perdre la puissance de se reproduire; tout nous démonire que c'est la plus heureuse découverte que l'homme ail jamais faite, et que, quelque ancienne qu'on veuille la supposer, elle a néanmoins été précédée de l'art de l'agriculture, fondé sur la science et perfectionné par l'observation.

Si l'on veut des exemples plus modernes et même récens de la puissance de l'homme sur la nature des végétaux, il n'y a qu'à comparer nos légumes, nos fleurs, et nos fruits, avec les mêmes espèces telles qu'elles étoient il y a cent cinquante ans: cette comparaison peut se faire immédiatement et très précisement en parcourant des yeux la grande collection de dessins coloriés, commencée dès le temps de Gaston d'Orléans, et qui se continue encore aujourd hui au Jardin du Roi: on y verra peut - être avec surprise que les plus belles fleurs de ce temps, renoncules, œillets, tulipes, oreilles-d'ours, etc., seroient rejetées aujourd'hui, je ne dis pas par nos fleuristes, mais par les jardiniers de village. Ces Heurs, quoique déjà cultivées alors, n'étoient pas encore bien loin de leur état de nature: un simple rang de pétales, de longs pistils, et des couleurs dures ou fausses, sans velouté, sans variété, sans nuances, tous caractères agrestes de la nature sauvage. Dans les plantes potagères, une seule espèce de chicorée et deux sortes de laitues, toutes deux assez mauvaises; tandis qu'aujourd'hui nous pouvons compter plus de cinquante laitues et connus, que les arts destructeurs enfantés par la guerre? Il semble que de tout temps l'homme ait fait moins de réflexions sur le bien que de recherches pour le mal: toute sociéte est mêlée de l'un et de l'autre; et comme de tous les sentimens qui affectent la multitude, la crainte est le plus puissant, les grands talens dans l'art de faire du mal ont été les premiers qui aient frappé l'esprit cle l'homme; ensuite ceux qui font amusé put occupé son cœur; et ce n'est qu'après un trop long usage de ces deux moyens de faux honneur et de plaisir stérile qu'enfin il a reconnu que sa vraie gloire est la science, et là paix sou vrai bonheur.

Additions De Buffon

La période de six cents ans dont Josèphe dit que se servoient les anciens patriarches avant le déluge est une des plus belles et des plus exactes que l'on ait jamais inventées, ïl est de fait que, prenant le mois lunaire de 29 jours 12 heures 44 minutes 3 secondes, ou trouve que 219 mille 146 jours 1/2 font 7 mille 421 mois lunaires; et ce même nombre de 219 mille 146 jours 1/2 donne 600 années solaires, chacune de 365 jours 5 heures 5i minutes 36 secondes, d'où résulte le mois lunaire à une seconde près, tel que les astronomes modernes l'ont déterminé, et l'année solaire plus juste qu'Hipparque et Ptoléuiée ne l'ont donnée plus de deux mille ans après le déluge. Josèphe a cité, comme ses garans, Manéthon, Bérose, et plusieurs autres anciens auteurs dont les écrits sont perdus il y a long-temps... Quel que soit le fondement sur lequel Josèphe a parlé de cetfe 'période, U faut qu'il y ait eu réellement et de temps immémorial une telle période ou grande année, qu'on avoit oubliée depuis plusieurs siècles, puisque les astronomes qui sont venus après cet historien s'en seroient servis préférablement à d'autres hypothèses moins exactes pour la détermination de

l'année solaire et du mois lunaire, s'ils l'avoient connue, ou s'en seroient fait honneur, s'ils l'avoient imaginée.

Il est constant, dit le savant astronome Dominique Cassini, que dès le premier âge du monde, les hommes avoient déjà fait de grands progrès dans la science du mouvement des astres: on pourrait même avancer qu'ils en avoient beaucoup plus de connoissances que l'on n'en a eu long-temps depuis le déluge, s'il est bien vrai que l'année dont les anciens patriarches se servoient fût de la grandeur de celles qui composent la grande période de six cents ans dont il est fait mention dans les antiquités des Juifs, écrites par Josèphe. Nous ne trouvons dans les monumens qui nous restent de toutes les autres nations aucun vestige de cette période de six cents ans, qui est une des plus belles que l'on ait encore inventées.

M. Cassini s'en rapporte, comme on voit, à Josèphe, et Josèphe avoit pour garans les historiographes égyptiens, habyloniens, phéniciens, et grecs; Manéthon, Bérose, Mochus, Hestiéus, Jérome l'Égyptien, Hésiode, Hécatée, etc., dont les écrits pouvoient subsister et subsistoient vraisemblablement de son temps.

Or, cela posé, et quoi qu'on puisse opposer au témoignage de ces auteurs, M. de Mairan dit, avec raison, que l'incompétence des juges ou des témoins ne saurait avoir lieu ici. Le fait dépose par lui-même son authenticité: il suffit qu'une semblable période ait été nommée, il suffit qu'elle ait existé, pour qu'on soit en droit d'en conclure qu'il aura donc aussi existé des siècles d'observations et en grand nombre, qui l'ont précédée; que l'oubli dont elle fut suivie est aussi bien ancien, car on doit regarder comme temps d'oubli tout celui où l'on a ignoré la justesse de cette période, et où l'on a dédaigné d'en approfondir les élémens et de s'en servir pour rectifier la théorie des mouvemens célestes, et où l'on s'est avisé d'y en substituer de moins exactes. Donc, si Hipparque, Méton, Pythagore, Thalès, et tous les anciens astronomes de la Grèce, ont ignoré la période de six cents ans, on est fondé à dire qu'elle étoit oubliée non seulement chez les Grecs, mais aussi en Égypte, dans la Phénicie, et dans la Chaldpe, où les Grecs avoient tous été puiser leur grand savoir en astronomie.

Les astronomes et les philosophes grecs avoient puisé en Égypte et aux Indes la plus grande partie de leurs connoissances. Les Grecs étoient donc des gens très nouveaux en astronomie en comparaison des Indiens, des Chinois, et des Atlantes habitant de l'Afrique occidentale; Uranus et Atlas chez ces derniers peuples, Fo-hi à la Chine, Mercure en Égypte, Zoroastre eu Perse, etc.

Les Atlantes, chez qui régnoit Atlas, pa roissent être les plus anciens peuples de l'A. frique, et beaucoup plus anciens que les Égyptiens. La théogonie des Allantes, rapportée par Diodore de Sicile, s'est probablement introduite en Égypte, en Éthiopie, èt en Phénicie, dans le temps de cette grande irruption dont il est parlé dans le Timée dé Platon, d'un peuplé mnombrable qui sortit de l'île Atlantide et se jeta sur une grande partie de l'Europe, de l'Asie, et de l'Afrique.

Dans l'occident de l'Asie, dans l'Europe, dans l'Afrique, tout est fondé sur les connojssances des Atlantes, tandis que les peuples orientaux, chaldéens, indiens, et chinois, n'ont été instruits que plus tard, et ont toujours formé des peuples qui n'ont pas eu de relation avec les Atlantes, dont 1 irruption est plus ancienne que la première date d'aucun de ces derniers peuples.

Atlas, fils d'Uranus et frère de Saturne, vivoit, selon Manéthon et Dicéarque, 3 mille 900 ans environ avant l'ère chrétienne.

Quoique Diogène-Laèrce, Hérodote, Diodore de Sicile, Pomponins Mêla, etc., donnent à l'âge d'Uranus, les uns 48 mille 860 ans, les autres 23 mille ans, etc., cela n'empêcbe pas qu'en réduisant

ces années à la vraie mesure du temps dont on se servoit dans différens siècles cbez ces peuples, ces mesures ne reviennent au même, c'està-dire à 3 mille 890 ans avant l'ère chrétienne.

Le temps du déluge, selon les Septante, a été 2 mille 256 ans après la création.

L'astronomie a été cultivée en Égypte plus de trois mille ans avant l'ère chrétienne; on peut le démontrer par ce que rapporte Ptolémée sur le lever heliaque de Sirins: ce lever de Sirins étoit très important cbez les Égyptiens, parce qu'il annonçoil le débordement du Nil.

Les Chaldéens paroissent plus nouveaux dans la carrière astronomique que les Égyptiens.

Les Égyptiens connoissoientle mouvement du soleil plus de 3 mille ans avant JésusChrist, et les Chaldéens plus de 2 mille 473 ans.

Il y avoit cbez les Phrygiens un temple dédié à Hercule qui paroit avoir été fondé

2 mille 800 ans avant l'ère chrétienne, et l'on sait qu'Hercule a été dans l'antiquité l'emblème du soleil.

On peut aussi dater les connoissances astronomiques cbez les anciens Perses plus de 3 mille 200 ans avant Jésus-Christ. L'astronomie cbez les Indiens est tout aussi ancienne; ils admettent quatre âges, et c'est au commencement du quatrième qu'est liée leur première époque astronomique: cet âge duroit en 1762 depuis 4 mille 863 ans, ce qui remonte à l'année 3102 avant Jésus-Christ. Ce dernier âge des Indiens est réellement composé d'années solaires: mais les trois autres, dont le premier est de 1 million 728 mille années, le second de 1 million 296 mille, et le troisième de 864 mille années, sont évidemment composés d'années ou plutôt de révolutions de temps beaucoup plus courtes que les années solaires.

Il est aussi démontré par les époques astronomiques que les Chinois avoieut cultivé l'astronomie plus de 3 mille ans avant Jésus Christ, et dès le temps de Fo-hi.

Il y a donc une espèce de niveau entre ces peuples égyptiens, chaldéens ou perses, indiens, chinois, et tartares. Us ne s'élèvent pas plus les uns que les autres dans l'antiquite, et cette époque remarquable de trois mille ans d'ancienneté pour l'astronomie est à peu près la même partout.

Ceux qui résident depuis long-temps dans la Pensylvanie et dans les colonies voisines ont observé, dit M. Hugues Williamson, que leur climat a considérablement changé depuis quarante ou cinquante ans, et que les hivers ne sont point aussi froids

La température de l'air dans la Pensylvanie est différente de celle des contrées de l'Europe situées sous le même parallèle. Pour juger de la chaleur d'un pays, il fatit non seulement avoir égard à sa latitude, mais encore à sa situation et aux vents qui ont coutume d'y régner, puisque ceux-ci ne sauraient changer sans que le climat change aussi. La face d'un pays peut être entièrement métamorphosée par la culture; et l'on se convaincra, en examinant la cause des vents, que leur cours peut pareillement prendre de nouvelles directions.

Depuis l'établissement de nos colonies, continue M. AVilliamson, nous sommes parvenus non seulement à donner plus de chaleur au terrain des cantons habités, mais encore à changer en partie la direction des vents. Les marins, qui sont les plus intéressés à cette affaire, nous ont dit qu'il leur falloit autrefois quatre ou cinq semaines pour aborder sur nos côtes, tandis qu'aujourd'hui ils y abordent avec la moitié moins de temps. On convient encore que le froid est moins rude, la neige

moins abondante et moins continue qu'elle ne l'a jamais été, depuis que nous sommes établis dans cette province.

Il y a plusieurs autres causes qui peuvent augmenter et diminuer la chaleur de l'air; mais on ne saurait m'alléguer cependant un seul exemple du changement de climat, qu'on ne puisse attribuer au défricbement du pays où il a lieu. On m'objectera celui qui est arrivé depuis dix-sept cents ans dans l'Italie et dans quelques contrées de l'Orient, comme une exception à cette règle générale. On nous dit que l'Italie étoit mieux cultivée du temps d'Auguste qu'elle ne l'est aujourd'hui, et que cependant le climat y est beaucoup plus tempéré ... Il cil vrai que l'hiver étoit plus rude en Italie il y a dix-sept cents ans qu'il ne l'est aujourd'hui .... mais on peut en attribuer la lause aux vastes forcis dont l'Allemagne, qui est au nord Je Itooie, étoit couverte dans ces temps là Il s'élevoit de ces déserts incultes des vents du nord perçans, qui se répandoient comme un torrent dans l'Italie, et y causoient un froid excessif... et l'air étoit autrefois si froid dans ces régions incultes, qu'il devoit détruire la balance dans l'atmosphère de l'Italie, ce qui n'est plus de nos jours.

On peut donc raisonnablement conclure que dans quelques années d'ici, et lorsque nos desrendans auront défriché ta partie intérieure de ce pays, ils ne seront presque plus sujets à ta gelée ni à la neige, et que leurs hivers seront extrêmement tempérés.

Ces vues de SI. Williamson sont très justes, et je ne doute pas que notre postérité ne les voie confirmées par l'expérience.

1779
David Hume
Dialogues Concerning Natural Religion (Problems with Proofs of Deity)
Book Published After Hume’s Death

Pamphilus To Hermippus.
It has been remarked, my Hermippus, that though the ancient philosophers conveyed most of their instruction in the form of dialogue, this method of composition has been little practised in later ages, and has seldom succeeded in the hands of those who have attempted it. Accurate and regular argument, indeed, such as is now expected of philosophical enquirers, naturally throws a man into the methodical and didactic manner; where he can immediately, without preparation, explain the point at which he aims; and thence proceed, without interruption, to deduce the proofs on which it is established. To deliver a SYSTEM in conversation, scarcely appears natural; and while the dialogue-writer desires, by departing from the direct style of composition, to give a freer air to his performance, and avoid the appearance of Author and Reader, he is apt to run into a worse inconvenience, and convey the image of Pedagogue and Pupil. Or, if he carries on the dispute in the natural spirit of good company, by throwing in a variety of topics, and preserving a proper balance among the speakers, he often loses so much time in preparations and transitions, that the reader will scarcely think himself compensated, by all the graces of dialogue, for the order, brevity, and precision, which are sacrificed to them.

There are some subjects, however, to which dialogue-writing is peculiarly adapted, and where it is still preferable to the direct and simple method of composition.

Any point of doctrine, which is so obvious that it scarcely admits of dispute, but at the same time so important that it cannot be too often inculcated, seems to require some such method of handling it; where the novelty of the manner may compensate the triteness of the subject; where

the vivacity of conversation may enforce the precept; and where the variety of lights, presented by various personages and characters, may appear neither tedious nor redundant.

Any question of philosophy, on the other hand, which is so obscure and uncertain, that human reason can reach no fixed determination with regard to it; if it should be treated at all, seems to lead us naturally into the style of dialogue and conversation. Reasonable men may be allowed to differ, where no one can reasonably be positive. Opposite sentiments, even without any decision, afford an agreeable amusement; and if the subject be curious and interesting, the book carries us, in a manner, into company; and unites the two greatest and purest pleasures of human life, study and society.

Happily, these circumstances are all to be found in the subject of NATURAL RELIGION. What truth so obvious, so certain, as the being of a God, which the most ignorant ages have acknowledged, for which the most refined geniuses have ambitiously striven to produce new proofs and arguments? What truth so important as this, which is the ground of all our hopes, the surest foundation of morality, the firmest support of society, and the only principle which ought never to be a moment absent from our thoughts and meditations? But, in treating of this obvious and important truth, what obscure questions occur concerning the nature of that Divine Being, his attributes, his decrees, his plan of providence? These have been always subjected to the disputations of men; concerning these human reason has not reached any certain determination. But these are topics so interesting, that we cannot restrain our restless enquiry with regard to them; though nothing but doubt, uncertainty, and contradiction, have as yet been the result of our most accurate researches.

This I had lately occasion to observe, while I passed, as usual, part of the summer season with Cleanthes, and was present at those conversations of his with Philo and Demea, of which I gave you lately some imperfect account. Your curiosity, you then told me, was so excited, that I must, of necessity, enter into a more exact detail of their reasonings, and display those various systems which they advanced with regard to so delicate a subject as that of natural religion. The remarkable contrast in their characters still further raised your expectations; while you opposed the accurate philosophical turn of Cleanthes to the careless scepticism of Philo, or compared either of their dispositions with the rigid inflexible orthodoxy of Demea. My youth rendered me a mere auditor of their disputes; and that curiosity, natural to the early season of life, has so deeply imprinted in my memory the whole chain and connexion of their arguments, that, I hope, I shall not omit or confound any considerable part of them in the recital.

Part I

After I joined the company, whom I found sitting in Cleanthes's library, Demea paid Cleanthes some compliments on the great care which he took of my education, and on his unwearied perseverance and constancy in all his friendships. The father of Pamphilus, said he, was your intimate friend: The son is your pupil; and may indeed be regarded as your adopted son, were we to judge by the pains which you bestow in conveying to him every useful branch of literature and science. You are no more wanting, I am persuaded, in prudence, than in industry. I shall, therefore, communicate to you a maxim, which I have observed with regard to my own children, that I may learn how far it agrees with your practice. The method I follow in their education is founded on the saying of an ancient, "That students of philosophy ought first to learn logics, then ethics, next physics, last of all the nature of the gods." 1 This science of natural theology, according to him, being the most profound and abstruse of any, required the maturest judgment in its students; and none but a mind enriched with all the other sciences, can safely be intrusted with it.

Are you so late, says Philo, in teaching your children the principles of religion? Is there no danger of their neglecting, or rejecting altogether those opinions of which they have heard so little during the whole course of their education? It is only as a science, replied Demea, subjected to human

reasoning and disputation, that I postpone the study of Natural Theology. To season their minds with early piety, is my chief care; and by continual precept and instruction, and I hope too by example, I imprint deeply on their tender minds an habitual reverence for all the principles of religion. While they pass through every other science, I still remark the uncertainty of each part; the eternal disputations of men; the obscurity of all philosophy; and the strange, ridiculous conclusions, which some of the greatest geniuses have derived from the principles of mere human reason. Having thus tamed their mind to a proper submission and self- diffidence, I have no longer any scruple of opening to them the greatest mysteries of religion; nor apprehend any danger from that assuming arrogance of philosophy, which may lead them to reject the most established doctrines and opinions.

Your precaution, says Philo, of seasoning your children's minds early with piety, is certainly very reasonable; and no more than is requisite in this profane and irreligious age. But what I chiefly admire in your plan of education, is your method of drawing advantage from the very principles of philosophy and learning, which, by inspiring pride and self-sufficiency, have commonly, in all ages, been found so destructive to the principles of religion. The vulgar, indeed, we may remark, who are unacquainted with science and profound enquiry, observing the endless disputes of the learned, have commonly a thorough contempt for philosophy; and rivet themselves the faster, by that means, in the great points of theology which have been taught them. Those who enter a little into study and enquiry, finding many appearances of evidence in doctrines the newest and most extraordinary, think nothing too difficult for human reason; and, presumptuously breaking through all fences, profane the inmost sanctuaries of the temple. But Cleanthes will, I hope, agree with me, that, after we have abandoned ignorance, the surest remedy, there is still one expedient left to prevent this profane liberty. Let Demea's principles be improved and cultivated: let us become thoroughly sensible of the weakness, blindness, and narrow limits of human reason: let us duly consider its uncertainty and endless contrarieties, even in subjects of common life and practice: let the errors and deceits of our very senses be set before us; the insuperable difficulties which attend first principles in all systems; the contradictions which adhere to the very ideas of matter, cause and effect, extension, space, time, motion; and in a word, quantity of all kinds, the object of the only science that can fairly pretend to any certainty or evidence. When these topics are displayed in their full light, as they are by some philosophers and almost all divines; who can retain such confidence in this frail faculty of reason as to pay any regard to its determinations in points so sublime, so abstruse, so remote from common life and experience? When the coherence of the parts of a stone, or even that composition of parts which renders it extended; when these familiar objects, I say, are so inexplicable, and contain circumstances so repugnant and contradictory; with what assurance can we decide concerning the origin of worlds, or trace their history from eternity to eternity?

While Philo pronounced these words, I could observe a smile in the countenance both of Demea and Cleanthes. That of Demea seemed to imply an unreserved satisfaction in the doctrines delivered: but, in Cleanthes's features, I could distinguish an air of finesse; as if he perceived some raillery or artificial malice in the reasonings of Philo.

You propose then, Philo, said Cleanthes, to erect religious faith on philosophical scepticism; and you think, that if certainty or evidence be expelled from every other subject of enquiry, it will all retire to these theological doctrines, and there acquire a superior force and authority. Whether your scepticism be as absolute and sincere as you pretend, we shall learn by and by, when the company breaks up: we shall then see, whether you go out at the door or the window; and whether you really doubt if your body has gravity, or can be injured by its fall; according to popular opinion, derived from our fallacious senses, and more fallacious experience. And this consideration, Demea, may, I think, fairly serve to abate our ill-will to this humourous sect of the sceptics. If they be thoroughly in earnest, they will not long trouble the world with their doubts, cavils, and disputes: if

they be only in jest, they are, perhaps, bad railers; but can never be very dangerous, either to the state, to philosophy, or to religion.

In reality, Philo, continued he, it seems certain, that though a man, in a flush of humour, after intense reflection on the many contradictions and imperfections of human reason, may entirely renounce all belief and opinion, it is impossible for him to persevere in this total scepticism, or make it appear in his conduct for a few hours. External objects press in upon him; passions solicit him; his philosophical melancholy dissipates; and even the utmost violence upon his own temper will not be able, during any time, to preserve the poor appearance of scepticism. And for what reason impose on himself such a violence? This is a point in which it will be impossible for him ever to satisfy himself, consistently with his sceptical principles. So that, upon the whole, nothing could be more ridiculous than the principles of the ancient Pyrrhonians; if in reality they endeavoured, as is pretended, to extend, throughout, the same scepticism which they had learned from the declamations of their schools, and which they ought to have confined to them.

In this view, there appears a great resemblance between the sects of the Stoics and Pyrrhonians, though perpetual antagonists; and both of them seem founded on this erroneous maxim, That what a man can perform sometimes, and in some dispositions, he can perform always, and in every disposition. When the mind, by Stoical reflections, is elevated into a sublime enthusiasm of virtue, and strongly smit with any species of honour or public good, the utmost bodily pain and sufferings will not prevail over such a high sense of duty; and it is possible, perhaps, by its means, even to smile and exult in the midst of tortures. If this sometimes may be the case in fact and reality, much more may a philosopher, in his school, or even in his closet, work himself up to such an enthusiasm, and support in imagination the acutest pain or most calamitous event which he can possibly conceive. But how shall he support this enthusiasm itself? The bent of his mind relaxes, and cannot be recalled at pleasure; avocations lead him astray; misfortunes attack him unawares; and the philosopher sinks by degrees into the plebeian.

I allow of your comparison between the Stoics and Sceptics, replied Philo. But you may observe, at the same time, that though the mind cannot, in Stoicism, support the highest flights of philosophy, yet, even when it sinks lower, it still retains somewhat of its former disposition; and the effects of the Stoic's reasoning will appear in his conduct in common life, and through the whole tenor of his actions. The ancient schools, particularly that of Zeno, produced examples of virtue and constancy which seem astonishing to present times.

Vain Wisdom all and false Philosophy.
Yet with a pleasing sorcery could charm
Pain, for a while, or anguish; and excite
Fallacious Hope, or arm the obdurate breast
With stubborn Patience, as with triple steel.

In like manner, if a man has accustomed himself to sceptical considerations on the uncertainty and narrow limits of reason, he will not entirely forget them when he turns his reflection on other subjects; but in all his philosophical principles and reasoning, I dare not say in his common conduct, he will be found different from those, who either never formed any opinions in the case, or have entertained sentiments more favourable to human reason.

To whatever length any one may push his speculative principles of scepticism, he must act, I own, and live, and converse, like other men; and for this conduct he is not obliged to give any other reason, than the absolute necessity he lies under of so doing. If he ever carries his speculations further than this necessity constrains him, and philosophizes either on natural or moral subjects, he is allured by a certain pleasure and satisfaction which he finds in employing himself after that

manner. He considers besides, that every one, even in common life, is constrained to have more or less of this philosophy; that from our earliest infancy we make continual advances in forming more general principles of conduct and reasoning; that the larger experience we acquire, and the stronger reason we are endued with, we always render our principles the more general and comprehensive; and that what we call philosophy is nothing but a more regular and methodical operation of the same kind. To philosophize on such subjects, is nothing essentially different from reasoning on common life; and we may only expect greater stability, if not greater truth, from our philosophy, on account of its exacter and more scrupulous method of proceeding.

But when we look beyond human affairs and the properties of the surrounding bodies: when we carry our speculations into the two eternities, before and after the present state of things; into the creation and formation of the universe; the existence and properties of spirits; the powers and operations of one universal Spirit existing without beginning and without end; omnipotent, omniscient, immutable, infinite, and incomprehensible: we must be far removed from the smallest tendency to scepticism not to be apprehensive, that we have here got quite beyond the reach of our faculties. So long as we confine our speculations to trade, or morals, or politics, or criticism, we make appeals, every moment, to common sense and experience, which strengthen our philosophical conclusions, and remove, at least in part, the suspicion which we so justly entertain with regard to every reasoning that is very subtile and refined. But, in theological reasonings, we have not this advantage; while, at the same time, we are employed upon objects, which, we must be sensible, are too large for our grasp, and of all others, require most to be familiarized to our apprehension. We are like foreigners in a strange country, to whom every thing must seem suspicious, and who are in danger every moment of transgressing against the laws and customs of the people with whom they live and converse. We know not how far we ought to trust our vulgar methods of reasoning in such a subject; since, even in common life, and in that province which is peculiarly appropriated to them, we cannot account for them, and are entirely guided by a kind of instinct or necessity in employing them.

All sceptics pretend, that, if reason be considered in an abstract view, it furnishes invincible arguments against itself; and that we could never retain any conviction or assurance, on any subject, were not the sceptical reasonings so refined and subtile, that they are not able to counterpoise the more solid and more natural arguments derived from the senses and experience. But it is evident, whenever our arguments lose this advantage, and run wide of common life, that the most refined scepticism comes to be upon a footing with them, and is able to oppose and counterbalance them. The one has no more weight than the other. The mind must remain in suspense between them; and it is that very suspense or balance, which is the triumph of scepticism.

But I observe, says Cleanthes, with regard to you, Philo, and all speculative sceptics, that your doctrine and practice are as much at variance in the most abstruse points of theory as in the conduct of common life. Wherever evidence discovers itself, you adhere to it, notwithstanding your pretended scepticism; and I can observe, too, some of your sect to be as decisive as those who make greater professions of certainty and assurance. In reality, would not a man be ridiculous, who pretended to reject Newton's explication of the wonderful phenomenon of the rainbow, because that explication gives a minute anatomy of the rays of light; a subject, forsooth, too refined for human comprehension? And what would you say to one, who, having nothing particular to object to the arguments of Copernicus and Galileo for the motion of the earth, should withhold his assent, on that general principle, that these subjects were too magnificent and remote to be explained by the narrow and fallacious reason of mankind?

There is indeed a kind of brutish and ignorant scepticism, as you well observed, which gives the vulgar a general prejudice against what they do not easily understand, and makes them reject

every principle which requires elaborate reasoning to prove and establish it. This species of scepticism is fatal to knowledge, not to religion; since we find, that those who make greatest profession of it, give often their assent, not only to the great truths of Theism and natural theology, but even to the most absurd tenets which a traditional superstition has recommended to them. They firmly believe in witches, though they will not believe nor attend to the most simple proposition of Euclid. But the refined and philosophical sceptics fall into an inconsistence of an opposite nature. They push their researches into the most abstruse corners of science; and their assent attends them in every step, proportioned to the evidence which they meet with. They are even obliged to acknowledge, that the most abstruse and remote objects are those which are best explained by philosophy. Light is in reality anatomized. The true system of the heavenly bodies is discovered and ascertained. But the nourishment of bodies by food is still an inexplicable mystery. The cohesion of the parts of matter is still incomprehensible. These sceptics, therefore, are obliged, in every question, to consider each particular evidence apart, and proportion their assent to the precise degree of evidence which occurs. This is their practice in all natural, mathematical, moral, and political science. And why not the same, I ask, in the theological and religious? Why must conclusions of this nature be alone rejected on the general presumption of the insufficiency of human reason, without any particular discussion of the evidence? Is not such an unequal conduct a plain proof of prejudice and passion?

Our senses, you say, are fallacious; our understanding erroneous; our ideas, even of the most familiar objects, extension, duration, motion, full of absurdities and contradictions. You defy me to solve the difficulties, or reconcile the repugnancies which you discover in them. I have not capacity for so great an undertaking: I have not leisure for it: I perceive it to be superfluous. Your own conduct, in every circumstance, refutes your principles, and shews the firmest reliance on all the received maxims of science, morals, prudence, and behaviour.

I shall never assent to so harsh an opinion as that of a celebrated writer, 2 who says, that the Sceptics are not a sect of philosophers: they are only a sect of liars. I may, however, affirm (I hope without offence), that they are a sect of jesters or railers. But for my part, whenever I find myself disposed to mirth and amusement, I shall certainly choose my entertainment of a less perplexing and abstruse nature. A comedy, a novel, or at most a history, seems a more natural recreation than such metaphysical subtilties and abstractions.

In vain would the sceptic make a distinction between science and common life, or between one science and another. The arguments employed in all, if just, are of a similar nature, and contain the same force and evidence. Or if there be any difference among them, the advantage lies entirely on the side of theology and natural religion. Many principles of mechanics are founded on very abstruse reasoning; yet no man who has any pretensions to science, even no speculative sceptic, pretends to entertain the least doubt with regard to them. The Copernican system contains the most surprising paradox, and the most contrary to our natural conceptions, to appearances, and to our very senses: yet even monks and inquisitors are now constrained to withdraw their opposition to it. And shall Philo, a man of so liberal a genius and extensive knowledge, entertain any general undistinguished scruples with regard to the religious hypothesis, which is founded on the simplest and most obvious arguments, and, unless it meets with artificial obstacles, has such easy access and admission into the mind of man?

And here we may observe, continued he, turning himself towards Demea, a pretty curious circumstance in the history of the sciences. After the union of philosophy with the popular religion, upon the first establishment of Christianity, nothing was more usual, among all religious teachers, than declamations against reason, against the senses, against every principle derived merely from human research and enquiry. All the topics of the ancient Academics were adopted by the fathers; and thence propagated for several ages in every school and pulpit throughout Christendom. The

Reformers embraced the same principles of reasoning, or rather declamation; and all panegyrics on the excellency of faith, were sure to be interlarded with some severe strokes of satire against natural reason. A celebrated prelate too, 3 of the Romish communion, a man of the most extensive learning, who wrote a demonstration of Christianity, has also composed a treatise, which contains all the cavils of the boldest and most determined Pyrrhonism. Locke seems to have been the first Christian who ventured openly to assert, that faith was nothing but a species of reason; that religion was only a branch of philosophy; and that a chain of arguments, similar to that which established any truth in morals, politics, or physics, was always employed in discovering all the principles of theology, natural and revealed. The ill use which Bayle and other libertines made of the philosophical scepticism of the fathers and first reformers, still further propagated the judicious sentiment of Mr. Locke: and it is now in a manner avowed, by all pretenders to reasoning and philosophy, that Atheist and Sceptic are almost synonymous. And as it is certain that no man is in earnest when he professes the latter principle, I would fain hope that there are as few who seriously maintain the former.

Don't you remember, said Philo, the excellent saying of Lord Bacon on this head? That a little philosophy, replied Cleanthes, makes a man an Atheist: a great deal converts him to religion. That is a very judicious remark too, said Philo. But what I have in my eye is another passage, where, having mentioned David's fool, who said in his heart there is no God, this great philosopher observes, that the Atheists nowadays have a double share of folly; for they are not contented to say in their hearts there is no God, but they also utter that impiety with their lips, and are thereby guilty of multiplied indiscretion and imprudence. Such people, though they were ever so much in earnest, cannot, methinks, be very formidable.

But though you should rank me in this class of fools, I cannot forbear communicating a remark that occurs to me, from the history of the religious and irreligious scepticism with which you have entertained us. It appears to me, that there are strong symptoms of priestcraft in the whole progress of this affair. During ignorant ages, such as those which followed the dissolution of the ancient schools, the priests perceived, that Atheism, Deism, or heresy of any kind, could only proceed from the presumptuous questioning of received opinions, and from a belief that human reason was equal to every thing. Education had then a mighty influence over the minds of men, and was almost equal in force to those suggestions of the senses and common understanding, by which the most determined sceptic must allow himself to be governed. But at present, when the influence of education is much diminished, and men, from a more open commerce of the world, have learned to compare the popular principles of different nations and ages, our sagacious divines have changed their whole system of philosophy, and talk the language of Stoics, Platonists, and Peripatetics, not that of Pyrrhonians and Academics. If we distrust human reason, we have now no other principle to lead us into religion. Thus, sceptics in one age, dogmatists in another; whichever system best suits the purpose of these reverend gentlemen, in giving them an ascendant over mankind, they are sure to make it their favourite principle, and established tenet.

It is very natural, said Cleanthes, for men to embrace those principles, by which they find they can best defend their doctrines; nor need we have any recourse to priestcraft to account for so reasonable an expedient. And, surely nothing can afford a stronger presumption, that any set of principles are true, and ought to be embraced, than to observe that they tend to the confirmation of true religion, and serve to confound the cavils of Atheists, Libertines, and Freethinkers of all denominations.

Part II.

I must own, Cleanthes, said Demea, that nothing can more surprize me, than the light in which you have all along put this argument. By the whole tenor of your discourse, one would imagine that you were maintaining the Being of a God, against the cavils of Atheists and Infidels; and were

necessitated to become a champion for that fundamental principle of all religion. But this, I hope, is not by any means a question among us. No man, no man at least of common sense, I am persuaded, ever entertained a serious doubt with regard to a truth so certain and self-evident. The question is not concerning the BEING, but the NATURE of GOD. This, I affirm, from the infirmities of human understanding, to be altogether incomprehensible and unknown to us. The essence of that supreme Mind, his attributes, the manner of his existence, the very nature of his duration; these, and every particular which regards so divine a Being, are mysterious to men. Finite, weak, and blind creatures, we ought to humble ourselves in his august presence; and, conscious of our frailties, adore in silence his infinite perfections, which eye hath not seen, ear hath not heard, neither hath it entered into the heart of man to conceive. They are covered in a deep cloud from human curiosity. It is profaneness to attempt penetrating through these sacred obscurities. And, next to the impiety of denying his existence, is the temerity of prying into his nature and essence, decrees and attributes.

But lest you should think that my piety has here got the better of my philosophy, I shall support my opinion, if it needs any support, by a very great authority. I might cite all the divines, almost, from the foundation of Christianity, who have ever treated of this or any other theological subject: but I shall confine myself, at present, to one equally celebrated for piety and philosophy. It is Father Malebranche, who, I remember, thus expresses himself. 4 "One ought not so much," says he, "to call God a spirit, in order to express positively what he is, as in order to signify that he is not matter. He is a Being infinitely perfect: of this we cannot doubt. But in the same manner as we ought not to imagine, even supposing him corporeal, that he is clothed with a human body, as the Anthropomorphites asserted, under colour that that figure was the most perfect of any; so, neither ought we to imagine that the spirit of God has human ideas, or bears any resemblance to our spirit, under colour that we know nothing more perfect than a human mind. We ought rather to believe, that as he comprehends the perfections of matter without being material . . . he comprehends also the perfections of created spirits without being spirit, in the manner we conceive spirit: that his true name is, He that is; or, in other words, Being without restriction, All Being, the Being infinite and universal."

After so great an authority, Demea, replied Philo, as that which you have produced, and a thousand more which you might produce, it would appear ridiculous in me to add my sentiment, or express my approbation of your doctrine. But surely, where reasonable men treat these subjects, the question can never be concerning the Being, but only the Nature, of the Deity. The former truth, as you well observe, is unquestionable and self-evident. Nothing exists without a cause; and the original cause of this universe (whatever it be) we call God; and piously ascribe to him every species of perfection. Whoever scruples this fundamental truth, deserves every punishment which can be inflicted among philosophers, to wit, the greatest ridicule, contempt, and disapprobation. But as all perfection is entirely relative, we ought never to imagine that we comprehend the attributes of this divine Being, or to suppose that his perfections have any analogy or likeness to the perfections of a human creature. Wisdom, Thought, Design, Knowledge; these we justly ascribe to him; because these words are honourable among men, and we have no other language or other conceptions by which we can express our adoration of him. But let us beware, lest we think that our ideas anywise correspond to his perfections, or that his attributes have any resemblance to these qualities among men. He is infinitely superior to our limited view and comprehension; and is more the object of worship in the temple, than of disputation in the schools.

In reality, Cleanthes, continued he, there is no need of having recourse to that affected scepticism so displeasing to you, in order to come at this determination. Our ideas reach no further than our experience. We have no experience of divine attributes and operations. I need not conclude my syllogism. You can draw the inference yourself. And it is a pleasure to me (and I hope to you too)

that just reasoning and sound piety here concur in the same conclusion, and both of them establish the adorably mysterious and incomprehensible nature of the Supreme Being.

Not to lose any time in circumlocutions, said Cleanthes, addressing himself to Demea, much less in replying to the pious declamations of Philo; I shall briefly explain how I conceive this matter. Look round the world: contemplate the whole and every part of it: you will find it to be nothing but one great machine, subdivided into an infinite number of lesser machines, which again admit of subdivisions to a degree beyond what human senses and faculties can trace and explain. All these various machines, and even their most minute parts, are adjusted to each other with an accuracy which ravishes into admiration all men who have ever contemplated them. The curious adapting of means to ends, throughout all nature, resembles exactly, though it much exceeds, the productions of human contrivance; of human designs, thought, wisdom, and intelligence. Since, therefore, the effects resemble each other, we are led to infer, by all the rules of analogy, that the causes also resemble; and that the Author of Nature is somewhat similar to the mind of man, though possessed of much larger faculties, proportioned to the grandeur of the work which he has executed. By this argument a posteriori, and by this argument alone, do we prove at once the existence of a Deity, and his similarity to human mind and intelligence.

I shall be so free, Cleanthes, said Demea, as to tell you, that from the beginning, I could not approve of your conclusion concerning the similarity of the Deity to men; still less can I approve of the mediums by which you endeavour to establish it. What! No demonstration of the Being of God! No abstract arguments! No proofs a priori! Are these, which have hitherto been so much insisted on by philosophers, all fallacy, all sophism? Can we reach no further in this subject than experience and probability? I will not say that this is betraying the cause of a Deity: but surely, by this affected candour, you give advantages to Atheists, which they never could obtain by the mere dint of argument and reasoning.

What I chiefly scruple in this subject, said Philo, is not so much that all religious arguments are by Cleanthes reduced to experience, as that they appear not to be even the most certain and irrefragable of that inferior kind. That a stone will fall, that fire will burn, that the earth has solidity, we have observed a thousand and a thousand times; and when any new instance of this nature is presented, we draw without hesitation the accustomed inference. The exact similarity of the cases gives us a perfect assurance of a similar event; and a stronger evidence is never desired nor sought after. But wherever you depart, in the least, from the similarity of the cases, you diminish proportionably the evidence; and may at last bring it to a very weak analogy, which is confessedly liable to error and uncertainty. After having experienced the circulation of the blood in human creatures, we make no doubt that it takes place in Titius and Maevius. But from its circulation in frogs and fishes, it is only a presumption, though a strong one, from analogy, that it takes place in men and other animals. The analogical reasoning is much weaker, when we infer the circulation of the sap in vegetables from our experience that the blood circulates in animals; and those, who hastily followed that imperfect analogy, are found, by more accurate experiments, to have been mistaken.

If we see a house, Cleanthes, we conclude, with the greatest certainty, that it had an architect or builder; because this is precisely that species of effect which we have experienced to proceed from that species of cause. But surely you will not affirm, that the universe bears such a resemblance to a house that we can with the same certainty infer a similar cause, or that the analogy is here entire and perfect. The dissimilitude is so striking, that the utmost you can here pretend to is a guess, a conjecture, a presumption concerning a similar cause; and how that pretension will be received in the world, I leave you to consider.

It would surely be very ill received, replied Cleanthes; and I should be deservedly blamed and detested, did I allow, that the proofs of a Deity amounted to no more than a guess or conjecture. But is the whole adjustment of means to ends in a house and in the universe so slight a resemblance? The economy of final causes? The order, proportion, and arrangement of every part? Steps of a stair are plainly contrived, that human legs may use them in mounting; and this inference is certain and infallible. Human legs are also contrived for walking and mounting; and this inference, I allow, is not altogether so certain, because of the dissimilarity which you remark; but does it, therefore, deserve the name only of presumption or conjecture?

Good God! cried Demea, interrupting him, where are we? Zealous defenders of religion allow, that the proofs of a Deity fall short of perfect evidence! And you, Philo, on whose assistance I depended in proving the adorable mysteriousness of the Divine Nature, do you assent to all these extravagant opinions of Cleanthes? For what other name can I give them? or, why spare my censure, when such principles are advanced, supported by such an authority, before so young a man as Pamphilus?

You seem not to apprehend, replied Philo, that I argue with Cleanthes in his own way; and, by shewing him the dangerous consequences of his tenets, hope at last to reduce him to our opinion. But what sticks most with you, I observe, is the representation which Cleanthes has made of the argument a posteriori; and finding that that argument is likely to escape your hold and vanish into air, you think it so disguised, that you can scarcely believe it to be set in its true light. Now, however much I may dissent, in other respects, from the dangerous principles of Cleanthes, I must allow that he has fairly represented that argument; and I shall endeavour so to state the matter to you, that you will entertain no further scruples with regard to it.

Were a man to abstract from every thing which he knows or has seen, he would be altogether incapable, merely from his own ideas, to determine what kind of scene the universe must be, or to give the preference to one state or situation of things above another. For as nothing which he clearly conceives could be esteemed impossible or implying a contradiction, every chimera of his fancy would be upon an equal footing; nor could he assign any just reason why he adheres to one idea or system, and rejects the others which are equally possible.

Again; after he opens his eyes, and contemplates the world as it really is, it would be impossible for him at first to assign the cause of any one event, much less of the whole of things, or of the universe. He might set his fancy a rambling; and she might bring him in an infinite variety of reports and representations. These would all be possible; but being all equally possible, he would never of himself give a satisfactory account for his preferring one of them to the rest. Experience alone can point out to him the true cause of any phenomenon.

Now, according to this method of reasoning, Demea, it follows, (and is, indeed, tacitly allowed by Cleanthes himself,) that order, arrangement, or the adjustment of final causes, is not of itself any proof of design; but only so far as it has been experienced to proceed from that principle. For ought we can know a priori, matter may contain the source or spring of order originally within itself as well as mind does; and there is no more difficulty in conceiving, that the several elements, from an internal unknown cause, may fall into the most exquisite arrangement, than to conceive that their ideas, in the great universal mind, from a like internal unknown cause, fall into that arrangement. The equal possibility of both these suppositions is allowed. But, by experience, we find, (according to Cleanthes,) that there is a difference between them. Throw several pieces of steel together, without shape or form; they will never arrange themselves so as to compose a watch. Stone, and mortar, and wood, without an architect, never erect a house. But the ideas in a human mind, we see, by an unknown, inexplicable economy, arrange themselves so as to form the plan of a watch or house. Experience, therefore, proves, that there is an original principle of order in mind, not in matter. From similar effects we infer similar causes. The adjustment of means to

ends is alike in the universe, as in a machine of human contrivance. The causes, therefore, must be resembling.

I was from the beginning scandalized, I must own, with this resemblance, which is asserted, between the Deity and human creatures; and must conceive it to imply such a degradation of the Supreme Being as no sound Theist could endure. With your assistance, therefore, Demea, I shall endeavour to defend what you justly call the adorable mysteriousness of the Divine Nature, and shall refute this reasoning of Cleanthes, provided he allows that I have made a fair representation of it.

When Cleanthes had assented, Philo, after a short pause, proceeded in the following manner.

That all inferences, Cleanthes, concerning fact, are founded on experience; and that all experimental reasonings are founded on the supposition that similar causes prove similar effects, and similar effects similar causes; I shall not at present much dispute with you. But observe, I entreat you, with what extreme caution all just reasoners proceed in the transferring of experiments to similar cases. Unless the cases be exactly similar, they repose no perfect confidence in applying their past observation to any particular phenomenon. Every alteration of circumstances occasions a doubt concerning the event; and it requires new experiments to prove certainly, that the new circumstances are of no moment or importance. A change in bulk, situation, arrangement, age, disposition of the air, or surrounding bodies; any of these particulars may be attended with the most unexpected consequences: and unless the objects be quite familiar to us, it is the highest temerity to expect with assurance, after any of these changes, an event similar to that which before fell under our observation. The slow and deliberate steps of philosophers here, if any where, are distinguished from the precipitate march of the vulgar, who, hurried on by the smallest similitude, are incapable of all discernment or consideration.

But can you think, Cleanthes, that your usual phlegm and philosophy have been preserved in so wide a step as you have taken, when you compared to the universe houses, ships, furniture, machines, and, from their similarity in some circumstances, inferred a similarity in their causes? Thought, design, intelligence, such as we discover in men and other animals, is no more than one of the springs and principles of the universe, as well as heat or cold, attraction or repulsion, and a hundred others, which fall under daily observation. It is an active cause, by which some particular parts of nature, we find, produce alterations on other parts. But can a conclusion, with any propriety, be transferred from parts to the whole? Does not the great disproportion bar all comparison and inference? From observing the growth of a hair, can we learn any thing concerning the generation of a man? Would the manner of a leaf's blowing, even though perfectly known, afford us any instruction concerning the vegetation of a tree?

But, allowing that we were to take the operations of one part of nature upon another, for the foundation of our judgment concerning the origin of the whole, (which never can be admitted,) yet why select so minute, so weak, so bounded a principle, as the reason and design of animals is found to be upon this planet? What peculiar privilege has this little agitation of the brain which we call thought, that we must thus make it the model of the whole universe? Our partiality in our own favour does indeed present it on all occasions; but sound philosophy ought carefully to guard against so natural an illusion.

So far from admitting, continued Philo, that the operations of a part can afford us any just conclusion concerning the origin of the whole, I will not allow any one part to form a rule for another part, if the latter be very remote from the former. Is there any reasonable ground to conclude, that the inhabitants of other planets possess thought, intelligence, reason, or any thing similar to these faculties in men? When nature has so extremely diversified her manner of operation

in this small globe, can we imagine that she incessantly copies herself throughout so immense a universe? And if thought, as we may well suppose, be confined merely to this narrow corner, and has even there so limited a sphere of action, with what propriety can we assign it for the original cause of all things? The narrow views of a peasant, who makes his domestic economy the rule for the government of kingdoms, is in comparison a pardonable sophism.

But were we ever so much assured, that a thought and reason, resembling the human, were to be found throughout the whole universe, and were its activity elsewhere vastly greater and more commanding than it appears in this globe; yet I cannot see, why the operations of a world constituted, arranged, adjusted, can with any propriety be extended to a world which is in its embryo state, and is advancing towards that constitution and arrangement. By observation, we know somewhat of the economy, action, and nourishment of a finished animal; but we must transfer with great caution that observation to the growth of a foetus in the womb, and still more in the formation of an animalcule in the loins of its male parent. Nature, we find, even from our limited experience, possesses an infinite number of springs and principles, which incessantly discover themselves on every change of her position and situation. And what new and unknown principles would actuate her in so new and unknown a situation as that of the formation of a universe, we cannot, without the utmost temerity, pretend to determine.

A very small part of this great system, during a very short time, is very imperfectly discovered to us; and do we then pronounce decisively concerning the origin of the whole?

Admirable conclusion! Stone, wood, brick, iron, brass, have not, at this time, in this minute globe of earth, an order or arrangement without human art and contrivance; therefore the universe could not originally attain its order and arrangement, without something similar to human art. But is a part of nature a rule for another part very wide of the former? Is it a rule for the whole? Is a very small part a rule for the universe? Is nature in one situation, a certain rule for nature in another situation vastly different from the former?

And can you blame me, Cleanthes, if I here imitate the prudent reserve of Simonides, who, according to the noted story, being asked by Hiero, What God was? desired a day to think of it, and then two days more; and after that manner continually prolonged the term, without ever bringing in his definition or description? Could you even blame me, if I answered at first, that I did not know, and was sensible that this subject lay vastly beyond the reach of my faculties? You might cry out sceptic and rallier, as much as you pleased: but having found, in so many other subjects much more familiar, the imperfections and even contradictions of human reason, I never should expect any success from its feeble conjectures, in a subject so sublime, and so remote from the sphere of our observation. When two species of objects have always been observed to be conjoined together, I can infer, by custom, the existence of one wherever I see the existence of the other; and this I call an argument from experience. But how this argument can have place, where the objects, as in the present case, are single, individual, without parallel, or specific resemblance, may be difficult to explain. And will any man tell me with a serious countenance, that an orderly universe must arise from some thought and art like the human, because we have experience of it? To ascertain this reasoning, it were requisite that we had experience of the origin of worlds; and it is not sufficient, surely, that we have seen ships and cities arise from human art and contrivance.

Philo was proceeding in this vehement manner, somewhat between jest and earnest, as it appeared to me, when he observed some signs of impatience in Cleanthes, and then immediately stopped short. What I had to suggest, said Cleanthes, is only that you would not abuse terms, or make use of popular expressions to subvert philosophical reasonings. You know, that the vulgar often distinguish reason from experience, even where the question relates only to matter of fact and existence; though it is found, where that reason is properly analyzed, that it is nothing but a species of

experience. To prove by experience the origin of the universe from mind, is not more contrary to common speech, than to prove the motion of the earth from the same principle. And a caviller might raise all the same objections to the Copernican system, which you have urged against my reasonings. Have you other earths, might he say, which you have seen to move? Have . . . . . .

Yes! cried Philo, interrupting him, we have other earths. Is not the moon another earth, which we see to turn round its centre? Is not Venus another earth, where we observe the same phenomenon? Are not the revolutions of the sun also a confirmation, from analogy, of the same theory? All the planets, are they not earths, which revolve about the sun? Are not the satellites moons, which move round Jupiter and Saturn, and along with these primary planets round the sun? These analogies and resemblances, with others which I have not mentioned, are the sole proofs of the Copernican system; and to you it belongs to consider, whether you have any analogies of the same kind to support your theory.

In reality, Cleanthes, continued he, the modern system of astronomy is now so much received by all enquirers, and has become so essential a part even of our earliest education, that we are not commonly very scrupulous in examining the reasons upon which it is founded. It is now become a matter of mere curiosity to study the first writers on that subject, who had the full force of prejudice to encounter, and were obliged to turn their arguments on every side in order to render them popular and convincing. But if we peruse Galileo's famous Dialogues concerning the system of the world, we shall find, that that great genius, one of the sublimest that ever existed, first bent all his endeavours to prove, that there was no foundation for the distinction commonly made between elementary and celestial substances. The schools, proceeding from the illusions of sense, had carried this distinction very far; and had established the latter substances to be ingenerable, incorruptible, unalterable, impassible; and had assigned all the opposite qualities to the former. But Galileo, beginning with the moon, proved its similarity in every particular to the earth; its convex figure, its natural darkness when not illuminated, its density, its distinction into solid and liquid, the variations of its phases, the mutual illuminations of the earth and moon, their mutual eclipses, the inequalities of the lunar surface, etc. After many instances of this kind, with regard to all the planets, men plainly saw that these bodies became proper objects of experience; and that the similarity of their nature enabled us to extend the same arguments and phenomena from one to the other.

In this cautious proceeding of the astronomers, you may read your own condemnation, Cleanthes; or rather may see, that the subject in which you are engaged exceeds all human reason and enquiry. Can you pretend to shew any such similarity between the fabric of a house, and the generation of a universe? Have you ever seen nature in any such situation as resembles the first arrangement of the elements? Have worlds ever been formed under your eye; and have you had leisure to observe the whole progress of the phenomenon, from the first appearance of order to its final consummation? If you have, then cite your experience, and deliver your theory.

Part III.

How he most absurd argument, replied Cleanthes, in the hands of a man of ingenuity and invention, may acquire an air of probability! Are you not aware, Philo, that it became necessary for Copernicus and his first disciples to prove the similarity of the terrestrial and celestial matter; because several philosophers, blinded by old systems, and supported by some sensible appearances, had denied that similarity? but that it is by no means necessary, that Theists should prove the similarity of the works of Nature to those of Art; because this similarity is self-evident and undeniable? The same matter, a like form; what more is requisite to shew an analogy between their causes, and to ascertain the origin of all things from a divine purpose and intention? Your objections, I must freely tell you, are no better than the abstruse cavils of those philosophers who

denied motion; and ought to be refuted in the same manner, by illustrations, examples, and instances, rather than by serious argument and philosophy.

Suppose, therefore, that an articulate voice were heard in the clouds, much louder and more melodious than any which human art could ever reach: suppose, that this voice were extended in the same instant over all nations, and spoke to each nation in its own language and dialect: suppose, that the words delivered not only contain a just sense and meaning, but convey some instruction altogether worthy of a benevolent Being, superior to mankind: could you possibly hesitate a moment concerning the cause of this voice? and must you not instantly ascribe it to some design or purpose? Yet I cannot see but all the same objections (if they merit that appellation) which lie against the system of Theism, may also be produced against this inference.

Might you not say, that all conclusions concerning fact were founded on experience: that when we hear an articulate voice in the dark, and thence infer a man, it is only the resemblance of the effects which leads us to conclude that there is a like resemblance in the cause: but that this extraordinary voice, by its loudness, extent, and flexibility to all languages, bears so little analogy to any human voice, that we have no reason to suppose any analogy in their causes: and consequently, that a rational, wise, coherent speech proceeded, you know not whence, from some accidental whistling of the winds, not from any divine reason or intelligence? You see clearly your own objections in these cavils, and I hope too you see clearly, that they cannot possibly have more force in the one case than in the other.

But to bring the case still nearer the present one of the universe, I shall make two suppositions, which imply not any absurdity or impossibility. Suppose that there is a natural, universal, invariable language, common to every individual of human race; and that books are natural productions, which perpetuate themselves in the same manner with animals and vegetables, by descent and propagation. Several expressions of our passions contain a universal language: all brute animals have a natural speech, which, however limited, is very intelligible to their own species. And as there are infinitely fewer parts and less contrivance in the finest composition of eloquence, than in the coarsest organized body, the propagation of an Iliad or Aeneid is an easier supposition than that of any plant or animal.

Suppose, therefore, that you enter into your library, thus peopled by natural volumes, containing the most refined reason and most exquisite beauty; could you possibly open one of them, and doubt, that its original cause bore the strongest analogy to mind and intelligence? When it reasons and discourses; when it expostulates, argues, and enforces its views and topics; when it applies sometimes to the pure intellect, sometimes to the affections; when it collects, disposes, and adorns every consideration suited to the subject; could you persist in asserting, that all this, at the bottom, had really no meaning; and that the first formation of this volume in the loins of its original parent proceeded not from thought and design? Your obstinacy, I know, reaches not that degree of firmness: even your sceptical play and wantonness would be abashed at so glaring an absurdity.

But if there be any difference, Philo, between this supposed case and the real one of the universe, it is all to the advantage of the latter. The anatomy of an animal affords many stronger instances of design than the perusal of Livy or Tacitus; and any objection which you start in the former case, by carrying me back to so unusual and extraordinary a scene as the first formation of worlds, the same objection has place on the supposition of our vegetating library. Choose, then, your party, Philo, without ambiguity or evasion; assert either that a rational volume is no proof of a rational cause, or admit of a similar cause to all the works of nature.

Let me here observe too, continued Cleanthes, that this religious argument, instead of being weakened by that scepticism so much affected by you, rather acquires force from it, and becomes more firm and undisputed. To exclude all argument or reasoning of every kind, is either affectation or madness. The declared profession of every reasonable sceptic is only to reject abstruse, remote, and refined arguments; to adhere to common sense and the plain instincts of nature; and to assent, wherever any reasons strike him with so full a force that he cannot, without the greatest violence, prevent it. Now the arguments for Natural Religion are plainly of this kind; and nothing but the most perverse, obstinate metaphysics can reject them. Consider, anatomize the eye; survey its structure and contrivance; and tell me, from your own feeling, if the idea of a contriver does not immediately flow in upon you with a force like that of sensation. The most obvious conclusion, surely, is in favour of design; and it requires time, reflection, and study, to summon up those frivolous, though abstruse objections, which can support Infidelity. Who can behold the male and female of each species, the correspondence of their parts and instincts, their passions, and whole course of life before and after generation, but must be sensible, that the propagation of the species is intended by Nature? Millions and millions of such instances present themselves through every part of the universe; and no language can convey a more intelligible irresistible meaning, than the curious adjustment of final causes. To what degree, therefore, of blind dogmatism must one have attained, to reject such natural and such convincing arguments?

Some beauties in writing we may meet with, which seem contrary to rules, and which gain the affections, and animate the imagination, in opposition to all the precepts of criticism, and to the authority of the established masters of art. And if the argument for Theism be, as you pretend, contradictory to the principles of logic; its universal, its irresistible influence proves clearly, that there may be arguments of a like irregular nature. Whatever cavils may be urged, an orderly world, as well as a coherent, articulate speech, will still be received as an incontestable proof of design and intention.

It sometimes happens, I own, that the religious arguments have not their due influence on an ignorant savage and barbarian; not because they are obscure and difficult, but because he never asks himself any question with regard to them. Whence arises the curious structure of an animal? From the copulation of its parents. And these whence? From their parents? A few removes set the objects at such a distance, that to him they are lost in darkness and confusion; nor is he actuated by any curiosity to trace them further. But this is neither dogmatism nor scepticism, but stupidity: a state of mind very different from your sifting, inquisitive disposition, my ingenious friend. You can trace causes from effects: you can compare the most distant and remote objects: and your greatest errors proceed not from barrenness of thought and invention, but from too luxuriant a fertility, which suppresses your natural good sense, by a profusion of unnecessary scruples and objections.

Here I could observe, Hermippus, that Philo was a little embarrassed and confounded: but while he hesitated in delivering an answer, luckily for him, Demea broke in upon the discourse, and saved his countenance.

Your instance, Cleanthes, said he, drawn from books and language, being familiar, has, I confess, so much more force on that account: but is there not some danger too in this very circumstance; and may it not render us presumptuous, by making us imagine we comprehend the Deity, and have some adequate idea of his nature and attributes? When I read a volume, I enter into the mind and intention of the author: I become him, in a manner, for the instant; and have an immediate feeling and conception of those ideas which revolved in his imagination while employed in that composition. But so near an approach we never surely can make to the Deity. His ways are not our ways. His attributes are perfect, but incomprehensible. And this volume of nature contains a great and inexplicable riddle, more than any intelligible discourse or reasoning.

The ancient Platonists, you know, were the most religious and devout of all the Pagan philosophers; yet many of them, particularly Plotinus, expressly declare, that intellect or understanding is not to be ascribed to the Deity; and that our most perfect worship of him consists, not in acts of veneration, reverence, gratitude, or love; but in a certain mysterious self-annihilation, or total extinction of all our faculties. These ideas are, perhaps, too far stretched; but still it must be acknowledged, that, by representing the Deity as so intelligible and comprehensible, and so similar to a human mind, we are guilty of the grossest and most narrow partiality, and make ourselves the model of the whole universe.

All the sentiments of the human mind, gratitude, resentment, love, friendship, approbation, blame, pity, emulation, envy, have a plain reference to the state and situation of man, and are calculated for preserving the existence and promoting the activity of such a being in such circumstances. It seems, therefore, unreasonable to transfer such sentiments to a supreme existence, or to suppose him actuated by them; and the phenomena besides of the universe will not support us in such a theory. All our ideas derived from the senses are confusedly false and illusive; and cannot therefore be supposed to have place in a supreme intelligence: and as the ideas of internal sentiment, added to those of the external senses, compose the whole furniture of human understanding, we may conclude, that none of the materials of thought are in any respect similar in the human and in the divine intelligence. Now, as to the manner of thinking; how can we make any comparison between them, or suppose them anywise resembling? Our thought is fluctuating, uncertain, fleeting, successive, and compounded; and were we to remove these circumstances, we absolutely annihilate its essence, and it would in such a case be an abuse of terms to apply to it the name of thought or reason. At least if it appear more pious and respectful (as it really is) still to retain these terms, when we mention the Supreme Being, we ought to acknowledge, that their meaning, in that case, is totally incomprehensible; and that the infirmities of our nature do not permit us to reach any ideas which in the least correspond to the ineffable sublimity of the Divine attributes.

Part IV.

It seems strange to me, said Cleanthes, that you, Demea, who are so sincere in the cause of religion, should still maintain the mysterious, incomprehensible nature of the Deity, and should insist so strenuously that he has no manner of likeness or resemblance to human creatures. The Deity, I can readily allow, possesses many powers and attributes of which we can have no comprehension: but if our ideas, so far as they go, be not just, and adequate, and correspondent to his real nature, I know not what there is in this subject worth insisting on. Is the name, without any meaning, of such mighty importance? Or how do you mystics, who maintain the absolute incomprehensibility of the Deity, differ from Sceptics or Atheists, who assert, that the first cause of all is unknown and unintelligible? Their temerity must be very great, if, after rejecting the production by a mind, I mean a mind resembling the human, (for I know of no other,) they pretend to assign, with certainty, any other specific intelligible cause: and their conscience must be very scrupulous indeed, if they refuse to call the universal unknown cause a God or Deity; and to bestow on him as many sublime eulogies and unmeaning epithets as you shall please to require of them.

Who could imagine, replied Demea, that Cleanthes, the calm philosophical Cleanthes, would attempt to refute his antagonists by affixing a nickname to them; and, like the common bigots and inquisitors of the age, have recourse to invective and declamation, instead of reasoning? Or does he not perceive, that these topics are easily retorted, and that Anthropomorphite is an appellation as invidious, and implies as dangerous consequences, as the epithet of Mystic, with which he has honoured us? In reality, Cleanthes, consider what it is you assert when you represent the Deity as similar to a human mind and understanding. What is the soul of man? A composition of various faculties, passions, sentiments, ideas; united, indeed, into one self or person, but still distinct from

each other. When it reasons, the ideas, which are the parts of its discourse, arrange themselves in a certain form or order; which is not preserved entire for a moment, but immediately gives place to another arrangement. New opinions, new passions, new affections, new feelings arise, which continually diversify the mental scene, and produce in it the greatest variety and most rapid succession imaginable. How is this compatible with that perfect immutability and simplicity which all true Theists ascribe to the Deity? By the same act, say they, he sees past, present, and future: his love and hatred, his mercy and justice, are one individual operation: he is entire in every point of space; and compleat in every instant of duration. No succession, no change, no acquisition, no diminution. What he is implies not in it any shadow of distinction or diversity. And what he is this moment he ever has been, and ever will be, without any new judgment, sentiment, or operation. He stands fixed in one simple, perfect state: nor can you ever say, with any propriety, that this act of his is different from that other; or that this judgment or idea has been lately formed, and will give place, by succession, to any different judgment or idea.

I can readily allow, said Cleanthes, that those who maintain the perfect simplicity of the Supreme Being, to the extent in which you have explained it, are compleat Mystics, and chargeable with all the consequences which I have drawn from their opinion. They are, in a word, Atheists, without knowing it. For though it be allowed, that the Deity possesses attributes of which we have no comprehension, yet ought we never to ascribe to him any attributes which are absolutely incompatible with that intelligent nature essential to him. A mind, whose acts and sentiments and ideas are not distinct and successive; one, that is wholly simple, and totally immutable, is a mind which has no thought, no reason, no will, no sentiment, no love, no hatred; or, in a word, is no mind at all. It is an abuse of terms to give it that appellation; and we may as well speak of limited extension without figure, or of number without composition.

Pray consider, said Philo, whom you are at present inveighing against. You are honouring with the appellation of Atheist all the sound, orthodox divines, almost, who have treated of this subject; and you will at last be, yourself, found, according to your reckoning, the only sound Theist in the world. But if idolaters be Atheists, as, I think, may justly be asserted, and Christian Theologians the same, what becomes of the argument, so much celebrated, derived from the universal consent of mankind?

But because I know you are not much swayed by names and authorities, I shall endeavour to shew you, a little more distinctly, the inconveniences of that Anthropomorphism, which you have embraced; and shall prove, that there is no ground to suppose a plan of the world to be formed in the Divine mind, consisting of distinct ideas, differently arranged, in the same manner as an architect forms in his head the plan of a house which he intends to execute.

It is not easy, I own, to see what is gained by this supposition, whether we judge of the matter by Reason or by Experience. We are still obliged to mount higher, in order to find the cause of this cause, which you had assigned as satisfactory and conclusive.

If Reason (I mean abstract reason, derived from enquiries a priori) be not alike mute with regard to all questions concerning cause and effect, this sentence at least it will venture to pronounce, That a mental world, or universe of ideas, requires a cause as much, as does a material world, or universe of objects; and, if similar in its arrangement, must require a similar cause. For what is there in this subject, which should occasion a different conclusion or inference? In an abstract view, they are entirely alike; and no difficulty attends the one supposition, which is not common to both of them.

Again, when we will needs force Experience to pronounce some sentence, even on these subjects which lie beyond her sphere, neither can she perceive any material difference in this particular,

between these two kinds of worlds; but finds them to be governed by similar principles, and to depend upon an equal variety of causes in their operations. We have specimens in miniature of both of them. Our own mind resembles the one; a vegetable or animal body the other. Let experience, therefore, judge from these samples. Nothing seems more delicate, with regard to its causes, than thought; and as these causes never operate in two persons after the same manner, so we never find two persons who think exactly alike. Nor indeed does the same person think exactly alike at any two different periods of time. A difference of age, of the disposition of his body, of weather, of food, of company, of books, of passions; any of these particulars, or others more minute, are sufficient to alter the curious machinery of thought, and communicate to it very different movements and operations. As far as we can judge, vegetables and animal bodies are not more delicate in their motions, nor depend upon a greater variety or more curious adjustment of springs and principles.

How, therefore, shall we satisfy ourselves concerning the cause of that Being whom you suppose the Author of Nature, or, according to your system of Anthropomorphism, the ideal world, into which you trace the material? Have we not the same reason to trace that ideal world into another ideal world, or new intelligent principle? But if we stop, and go no further; why go so far? why not stop at the material world? How can we satisfy ourselves without going on in infinitum? And, after all, what satisfaction is there in that infinite progression? Let us remember the story of the Indian philosopher and his elephant. It was never more applicable than to the present subject. If the material world rests upon a similar ideal world, this ideal world must rest upon some other; and so on, without end. It were better, therefore, never to look beyond the present material world. By supposing it to contain the principle of its order within itself, we really assert it to be God; and the sooner we arrive at that Divine Being, so much the better. When you go one step beyond the mundane system, you only excite an inquisitive humour which it is impossible ever to satisfy.

To say, that the different ideas which compose the reason of the Supreme Being, fall into order of themselves, and by their own nature, is really to talk without any precise meaning. If it has a meaning, I would fain know, why it is not as good sense to say, that the parts of the material world fall into order of themselves and by their own nature. Can the one opinion be intelligible, while the other is not so?

We have, indeed, experience of ideas which fall into order of themselves, and without any known cause. But, I am sure, we have a much larger experience of matter which does the same; as, in all instances of generation and vegetation, where the accurate analysis of the cause exceeds all human comprehension. We have also experience of particular systems of thought and of matter which have no order; of the first in madness, of the second in corruption. Why, then, should we think, that order is more essential to one than the other? And if it requires a cause in both, what do we gain by your system, in tracing the universe of objects into a similar universe of ideas? The first step which we make leads us on for ever. It were, therefore, wise in us to limit all our enquiries to the present world, without looking further. No satisfaction can ever be attained by these speculations, which so far exceed the narrow bounds of human understanding.

It was usual with the Peripatetics, you know, Cleanthes, when the cause of any phenomenon was demanded, to have recourse to their faculties or occult qualities; and to say, for instance, that bread, nourished by its nutritive faculty, and senna purged by its purgative. But it has been discovered, that this subterfuge was nothing but the disguise of ignorance; and that these philosophers, though less ingenuous, really said the same thing with the sceptics or the vulgar, who fairly confessed that they knew not the cause of these phenomena. In like manner, when it is asked, what cause produces order in the ideas of the Supreme Being; can any other reason be assigned by you, Anthropomorphites, than that it is a rational faculty, and that such is the nature of the Deity? But why a similar answer will not be equally satisfactory in accounting for the order of

the world, without having recourse to any such intelligent creator as you insist on, may be difficult to determine. It is only to say, that such is the nature of material objects, and that they are all originally possessed of a faculty of order and proportion. These are only more learned and elaborate ways of confessing our ignorance; nor has the one hypothesis any real advantage above the other, except in its greater conformity to vulgar prejudices.

You have displayed this argument with great emphasis, replied Cleanthes. You seem not sensible how easy it is to answer it. Even in common life, if I assign a cause for any event, is it any objection, Philo, that I cannot assign the cause of that cause, and answer every new question which may incessantly be started? And what philosophers could possibly submit to so rigid a rule? philosophers, who confess ultimate causes to be totally unknown; and are sensible, that the most refined principles into which they trace the phenomena, are still to them as inexplicable as these phenomena themselves are to the vulgar. The order and arrangement of nature, the curious adjustment of final causes, the plain use and intention of every part and organ; all these bespeak in the clearest language an intelligent cause or author. The heavens and the earth join in the same testimony: the whole chorus of Nature raises one hymn to the praises of its Creator. You alone, or almost alone, disturb this general harmony. You start abstruse doubts, cavils, and objections: you ask me, what is the cause of this cause? I know not; I care not; that concerns not me. I have found a Deity; and here I stop my enquiry. Let those go further, who are wiser or more enterprising.

I pretend to be neither, replied Philo: and for that very reason, I should never perhaps have attempted to go so far; especially when I am sensible, that I must at last be contented to sit down with the same answer, which, without further trouble, might have satisfied me from the beginning. If I am still to remain in utter ignorance of causes, and can absolutely give an explication of nothing, I shall never esteem it any advantage to shove off for a moment a difficulty, which, you acknowledge, must immediately, in its full force, recur upon me. Naturalists indeed very justly explain particular effects by more general causes, though these general causes themselves should remain in the end totally inexplicable; but they never surely thought it satisfactory to explain a particular effect by a particular cause, which was no more to be accounted for than the effect itself. An ideal system, arranged of itself, without a precedent design, is not a whit more explicable than a material one, which attains its order in a like manner; nor is there any more difficulty in the latter supposition than in the former.

Part V.

But to shew you still more inconveniences, continued Philo, in your Anthropomorphism, please to take a new survey of your principles. Like effects prove like causes. This is the experimental argument; and this, you say too, is the sole theological argument. Now, it is certain, that the liker the effects are which are seen, and the liker the causes which are inferred, the stronger is the argument. Every departure on either side diminishes the probability, and renders the experiment less conclusive. You cannot doubt of the principle; neither ought you to reject its consequences.

All the new discoveries in astronomy, which prove the immense grandeur and magnificence of the works of Nature, are so many additional arguments for a Deity, according to the true system of Theism; but, according to your hypothesis of experimental Theism, they become so many objections, by removing the effect still further from all resemblance to the effects of human art and contrivance. For, if Lucretius, 5 even following the old system of the world, could exclaim,

> Quis regere immensi summam, quis habere profundi
> Indu manu validas potis est moderanter habenas?
> Quis pariter coelos omnes convertere? et omnes
> Ignibus aetheriis terras suffire feraces?
> Omnibus inque locis esse omni tempore praesto?

[Who can rule the sum, who hold in his hand with controlling force the strong reins, of the immeasurable deep? Who can at once make all the different heavens roll and warm with ethereal fires all the fruitful earths, or be present in all places at all times? (Munro's translation)]

If Tully 6 esteemed this reasoning so natural, as to put it into the mouth of his Epicurean: "Quibus enim oculis animi intueri potuit vester Plato fabricam illam tanti operis, qua construi a Deo atque aedificari mundum facit? quae molitio? quae ferramenta? qui vectes? quae machinae? qui minstri tanti muneris fuerunt? quemadmodum autem obedire et parere voluntati architecti aer, ignis, aqua, terra potuerunt?" If this argument, I say, had any force in former ages, how much greater must it have at present, when the bounds of Nature are so infinitely enlarged, and such a magnificent scene is opened to us? It is still more unreasonable to form our idea of so unlimited a cause from our experience of the narrow productions of human design and invention.

The discoveries by microscopes, as they open a new universe in miniature, are still objections, according to you, arguments, according to me. The further we push our researches of this kind, we are still led to infer the universal cause of all to be vastly different from mankind, or from any object of human experience and observation.

And what say you to the discoveries in anatomy, chemistry, botany? . . . . . These surely are no objections, replied Cleanthes; they only discover new instances of art and contrivance. It is still the image of mind reflected on us from innumerable objects. Add, a mind like the human, said Philo. I know of no other, replied Cleanthes. And the liker the better, insisted Philo. To be sure, said Cleanthes.

Now, Cleanthes, said Philo, with an air of alacrity and triumph, mark the consequences. First, By this method of reasoning, you renounce all claim to infinity in any of the attributes of the Deity. For, as the cause ought only to be proportioned to the effect, and the effect, so far as it falls under our cognizance, is not infinite; what pretensions have we, upon your suppositions, to ascribe that attribute to the Divine Being? You will still insist, that, by removing him so much from all similarity to human creatures, we give in to the most arbitrary hypothesis, and at the same time weaken all proofs of his existence.

Secondly, You have no reason, on your theory, for ascribing perfection to the Deity, even in his finite capacity, or for supposing him free from every error, mistake, or incoherence, in his undertakings. There are many inexplicable difficulties in the works of Nature, which, if we allow a perfect author to be proved a priori, are easily solved, and become only seeming difficulties, from the narrow capacity of man, who cannot trace infinite relations. But according to your method of reasoning, these difficulties become all real; and perhaps will be insisted on, as new instances of likeness to human art and contrivance. At least, you must acknowledge, that it is impossible for us to tell, from our limited views, whether this system contains any great faults, or deserves any considerable praise, if compared to other possible, and even real systems. Could a peasant, if the Aeneid were read to him, pronounce that poem to be absolutely faultless, or even assign to it its proper rank among the productions of human wit, he, who had never seen any other production?

But were this world ever so perfect a production, it must still remain uncertain, whether all the excellences of the work can justly be ascribed to the workman. If we survey a ship, what an exalted idea must we form of the ingenuity of the carpenter who framed so complicated, useful, and beautiful a machine? And what surprize must we feel, when we find him a stupid mechanic, who imitated others, and copied an art, which, through a long succession of ages, after multiplied trials, mistakes, corrections, deliberations, and controversies, had been gradually improving? Many worlds might have been botched and bungled, throughout an eternity, ere this system was struck out;

much labour lost, many fruitless trials made; and a slow, but continued improvement carried on during infinite ages in the art of world-making. In such subjects, who can determine, where the truth; nay, who can conjecture where the probability lies, amidst a great number of hypotheses which may be proposed, and a still greater which may be imagined?

And what shadow of an argument, continued Philo, can you produce, from your hypothesis, to prove the unity of the Deity? A great number of men join in building a house or ship, in rearing a city, in framing a commonwealth; why may not several deities combine in contriving and framing a world? This is only so much greater similarity to human affairs. By sharing the work among several, we may so much further limit the attributes of each, and get rid of that extensive power and knowledge, which must be supposed in one deity, and which, according to you, can only serve to weaken the proof of his existence. And if such foolish, such vicious creatures as man, can yet often unite in framing and executing one plan, how much more those deities or demons, whom we may suppose several degrees more perfect!

To multiply causes without necessity, is indeed contrary to true philosophy: but this principle applies not to the present case. Were one deity antecedently proved by your theory, who were possessed of every attribute requisite to the production of the universe; it would be needless, I own, (though not absurd,) to suppose any other deity existent. But while it is still a question, Whether all these attributes are united in one subject, or dispersed among several independent beings, by what phenomena in nature can we pretend to decide the controversy? Where we see a body raised in a scale, we are sure that there is in the opposite scale, however concealed from sight, some counterpoising weight equal to it; but it is still allowed to doubt, whether that weight be an aggregate of several distinct bodies, or one uniform united mass. And if the weight requisite very much exceeds any thing which we have ever seen conjoined in any single body, the former supposition becomes still more probable and natural. An intelligent being of such vast power and capacity as is necessary to produce the universe, or, to speak in the language of ancient philosophy, so prodigious an animal exceeds all analogy, and even comprehension.

But further, Cleanthes: men are mortal, and renew their species by generation; and this is common to all living creatures. The two great sexes of male and female, says Milton, animate the world. Why must this circumstance, so universal, so essential, be excluded from those numerous and limited deities? Behold, then, the theogony of ancient times brought back upon us.

And why not become a perfect Anthropomorphite? Why not assert the deity or deities to be corporeal, and to have eyes, a nose, mouth, ears, etc.? Epicurus maintained, that no man had ever seen reason but in a human figure; therefore the gods must have a human figure. And this argument, which is deservedly so much ridiculed by Cicero, becomes, according to you, solid and philosophical.

In a word, Cleanthes, a man who follows your hypothesis is able perhaps to assert, or conjecture, that the universe, sometime, arose from something like design: but beyond that position he cannot ascertain one single circumstance; and is left afterwards to fix every point of his theology by the utmost license of fancy and hypothesis. This world, for aught he knows, is very faulty and imperfect, compared to a superior standard; and was only the first rude essay of some infant deity, who afterwards abandoned it, ashamed of his lame performance: it is the work only of some dependent, inferior deity; and is the object of derision to his superiors: it is the production of old age and dotage in some superannuated deity; and ever since his death, has run on at adventures, from the first impulse and active force which it received from him. You justly give signs of horror, Demea, at these strange suppositions; but these, and a thousand more of the same kind, are Cleanthes's suppositions, not mine. From the moment the attributes of the Deity are supposed

finite, all these have place. And I cannot, for my part, think that so wild and unsettled a system of theology is, in any respect, preferable to none at all.

These suppositions I absolutely disown, cried Cleanthes: they strike me, however, with no horror, especially when proposed in that rambling way in which they drop from you. On the contrary, they give me pleasure, when I see, that, by the utmost indulgence of your imagination, you never get rid of the hypothesis of design in the universe, but are obliged at every turn to have recourse to it. To this concession I adhere steadily; and this I regard as a sufficient foundation for religion.

Part VI.

It must be a slight fabric, indeed, said Demea, which can be erected on so tottering a foundation. While we are uncertain whether there is one deity or many; whether the deity or deities, to whom we owe our existence, be perfect or imperfect, subordinate or supreme, dead or alive, what trust or confidence can we repose in them? What devotion or worship address to them? What veneration or obedience pay them? To all the purposes of life the theory of religion becomes altogether useless: and even with regard to speculative consequences, its uncertainty, according to you, must render it totally precarious and unsatisfactory.

To render it still more unsatisfactory, said Philo, there occurs to me another hypothesis, which must acquire an air of probability from the method of reasoning so much insisted on by Cleanthes. That like effects arise from like causes: this principle he supposes the foundation of all religion. But there is another principle of the same kind, no less certain, and derived from the same source of experience; that where several known circumstances are observed to be similar, the unknown will also be found similar. Thus, if we see the limbs of a human body, we conclude that it is also attended with a human head, though hid from us. Thus, if we see, through a chink in a wall, a small part of the sun, we conclude, that, were the wall removed, we should see the whole body. In short, this method of reasoning is so obvious and familiar, that no scruple can ever be made with regard to its solidity.

Now, if we survey the universe, so far as it falls under our knowledge, it bears a great resemblance to an animal or organized body, and seems actuated with a like principle of life and motion. A continual circulation of matter in it produces no disorder: a continual waste in every part is incessantly repaired: the closest sympathy is perceived throughout the entire system: and each part or member, in performing its proper offices, operates both to its own preservation and to that of the whole. The world, therefore, I infer, is an animal; and the Deity is the SOUL of the world, actuating it, and actuated by it.

You have too much learning, Cleanthes, to be at all surprized at this opinion, which, you know, was maintained by almost all the Theists of antiquity, and chiefly prevails in their discourses and reasonings. For though, sometimes, the ancient philosophers reason from final causes, as if they thought the world the workmanship of God; yet it appears rather their favourite notion to consider it as his body, whose organization renders it subservient to him. And it must be confessed, that, as the universe resembles more a human body than it does the works of human art and contrivance, if our limited analogy could ever, with any propriety, be extended to the whole of nature, the inference seems juster in favour of the ancient than the modern theory.

There are many other advantages, too, in the former theory, which recommended it to the ancient theologians. Nothing more repugnant to all their notions, because nothing more repugnant to common experience, than mind without body; a mere spiritual substance, which fell not under their senses nor comprehension, and of which they had not observed one single instance throughout all nature. Mind and body they knew, because they felt both: an order, arrangement, organization, or internal machinery, in both, they likewise knew, after the same manner: and it could not but

seem reasonable to transfer this experience to the universe; and to suppose the divine mind and body to be also coeval, and to have, both of them, order and arrangement naturally inherent in them, and inseparable from them.

Here, therefore, is a new species of Anthropomorphism, Cleanthes, on which you may deliberate; and a theory which seems not liable to any considerable difficulties. You are too much superior, surely, to systematical prejudices, to find any more difficulty in supposing an animal body to be, originally, of itself, or from unknown causes, possessed of order and organization, than in supposing a similar order to belong to mind. But the vulgar prejudice, that body and mind ought always to accompany each other, ought not, one should think, to be entirely neglected; since it is founded on vulgar experience, the only guide which you profess to follow in all these theological enquiries. And if you assert, that our limited experience is an unequal standard, by which to judge of the unlimited extent of nature; you entirely abandon your own hypothesis, and must thenceforward adopt our Mysticism, as you call it, and admit of the absolute incomprehensibility of the Divine Nature.

This theory, I own, replied Cleanthes, has never before occurred to me, though a pretty natural one; and I cannot readily, upon so short an examination and reflection, deliver any opinion with regard to it. You are very scrupulous, indeed, said Philo: were I to examine any system of yours, I should not have acted with half that caution and reserve, in starting objections and difficulties to it. However, if any thing occur to you, you will oblige us by proposing it.

Why then, replied Cleanthes, it seems to me, that, though the world does, in many circumstances, resemble an animal body; yet is the analogy also defective in many circumstances the most material: no organs of sense; no seat of thought or reason; no one precise origin of motion and action. In short, it seems to bear a stronger resemblance to a vegetable than to an animal, and your inference would be so far inconclusive in favour of the soul of the world.

But, in the next place, your theory seems to imply the eternity of the world; and that is a principle, which, I think, can be refuted by the strongest reasons and probabilities. I shall suggest an argument to this purpose, which, I believe, has not been insisted on by any writer. Those, who reason from the late origin of arts and sciences, though their inference wants not force, may perhaps be refuted by considerations derived from the nature of human society, which is in continual revolution, between ignorance and knowledge, liberty and slavery, riches and poverty; so that it is impossible for us, from our limited experience, to foretell with assurance what events may or may not be expected. Ancient learning and history seem to have been in great danger of entirely perishing after the inundation of the barbarous nations; and had these convulsions continued a little longer, or been a little more violent, we should not probably have now known what passed in the world a few centuries before us. Nay, were it not for the superstition of the Popes, who preserved a little jargon of Latin, in order to support the appearance of an ancient and universal church, that tongue must have been utterly lost; in which case, the Western world, being totally barbarous, would not have been in a fit disposition for receiving the Greek language and learning, which was conveyed to them after the sacking of Constantinople. When learning and books had been extinguished, even the mechanical arts would have fallen considerably to decay; and it is easily imagined, that fable or tradition might ascribe to them a much later origin than the true one. This vulgar argument, therefore, against the eternity of the world, seems a little precarious.

But here appears to be the foundation of a better argument. Lucullus was the first that brought cherry-trees from Asia to Europe; though that tree thrives so well in many European climates, that it grows in the woods without any culture. Is it possible, that throughout a whole eternity, no European had ever passed into Asia, and thought of transplanting so delicious a fruit into his own country? Or if the tree was once transplanted and propagated, how could it ever afterwards perish?

Empires may rise and fall, liberty and slavery succeed alternately, ignorance and knowledge give place to each other; but the cherry-tree will still remain in the woods of Greece, Spain, and Italy, and will never be affected by the revolutions of human society.

It is not two thousand years since vines were transplanted into France, though there is no climate in the world more favourable to them. It is not three centuries since horses, cows, sheep, swine, dogs, corn, were known in America. Is it possible, that during the revolutions of a whole eternity, there never arose a Columbus, who might open the communication between Europe and that continent? We may as well imagine, that all men would wear stockings for ten thousand years, and never have the sense to think of garters to tie them. All these seem convincing proofs of the youth, or rather infancy of the world; as being founded on the operation of principles more constant and steady than those by which human society is governed and directed. Nothing less than a total convulsion of the elements will ever destroy all the European animals and vegetables which are now to be found in the Western world.

And what argument have you against such convulsions? replied Philo. Strong and almost incontestable proofs may be traced over the whole earth, that every part of this globe has continued for many ages entirely covered with water. And though order were supposed inseparable from matter, and inherent in it; yet may matter be susceptible of many and great revolutions, through the endless periods of eternal duration. The incessant changes, to which every part of it is subject, seem to intimate some such general transformations; though, at the same time, it is observable, that all the changes and corruptions of which we have ever had experience, are but passages from one state of order to another; nor can matter ever rest in total deformity and confusion. What we see in the parts, we may infer in the whole; at least, that is the method of reasoning on which you rest your whole theory. And were I obliged to defend any particular system of this nature, which I never willingly should do, I esteem none more plausible than that which ascribes an eternal inherent principle of order to the world, though attended with great and continual revolutions and alterations. This at once solves all difficulties; and if the solution, by being so general, is not entirely compleat and satisfactory, it is at least a theory that we must sooner or later have recourse to, whatever system we embrace. How could things have been as they are, were there not an original inherent principle of order somewhere, in thought or in matter? And it is very indifferent to which of these we give the preference. Chance has no place, on any hypothesis, sceptical or religious. Every thing is surely governed by steady, inviolable laws. And were the inmost essence of things laid open to us, we should then discover a scene, of which, at present, we can have no idea. Instead of admiring the order of natural beings, we should clearly see that it was absolutely impossible for them, in the smallest article, ever to admit of any other disposition.

Were any one inclined to revive the ancient Pagan Theology, which maintained, as we learn from Hesiod, that this globe was governed by thirty thousand deities, who arose from the unknown powers of nature: you would naturally object, Cleanthes, that nothing is gained by this hypothesis; and that it is as easy to suppose all men animals, beings more numerous, but less perfect, to have sprung immediately from a like origin. Push the same inference a step further, and you will find a numerous society of deities as explicable as one universal deity, who possesses within himself the powers and perfections of the whole society. All these systems, then, of Scepticism, Polytheism, and Theism, you must allow, on your principles, to be on a like footing, and that no one of them has any advantage over the others. You may thence learn the fallacy of your principles.

Part VII.

But here, continued Philo, in examining the ancient system of the soul of the world, there strikes me, all on a sudden, a new idea, which, if just, must go near to subvert all your reasoning, and destroy even your first inferences, on which you repose such confidence. If the universe bears a

greater likeness to animal bodies and to vegetables, than to the works of human art, it is more probable that its cause resembles the cause of the former than that of the latter, and its origin ought rather to be ascribed to generation or vegetation, than to reason or design. Your conclusion, even according to your own principles, is therefore lame and defective.

Pray open up this argument a little further, said Demea, for I do not rightly apprehend it in that concise manner in which you have expressed it.

Our friend Cleanthes, replied Philo, as you have heard, asserts, that since no question of fact can be proved otherwise than by experience, the existence of a Deity admits not of proof from any other medium. The world, says he, resembles the works of human contrivance; therefore its cause must also resemble that of the other. Here we may remark, that the operation of one very small part of nature, to wit man, upon another very small part, to wit that inanimate matter lying within his reach, is the rule by which Cleanthes judges of the origin of the whole; and he measures objects, so widely disproportioned, by the same individual standard. But to waive all objections drawn from this topic, I affirm, that there are other parts of the universe (besides the machines of human invention) which bear still a greater resemblance to the fabric of the world, and which, therefore, afford a better conjecture concerning the universal origin of this system. These parts are animals and vegetables. The world plainly resembles more an animal or a vegetable, than it does a watch or a knitting-loom. Its cause, therefore, it is more probable, resembles the cause of the former. The cause of the former is generation or vegetation. The cause, therefore, of the world, we may infer to be something similar or analogous to generation or vegetation.

But how is it conceivable, said Demea, that the world can arise from any thing similar to vegetation or generation?

Very easily, replied Philo. In like manner as a tree sheds its seeds into the neighbouring fields, and produces other trees; so the great vegetable, the world, or this planetary system, produces within itself certain seeds, which, being scattered into the surrounding chaos, vegetate into new worlds. A comet, for instance, is the seed of a world; and after it has been fully ripened, by passing from sun to sun, and star to star, it is at last tossed into the unformed elements which every where surround this universe, and immediately sprouts up into a new system.

Or if, for the sake of variety (for I see no other advantage), we should suppose this world to be an animal; a comet is the egg of this animal: and in like manner as an ostrich lays its egg in the sand, which, without any further care, hatches the egg, and produces a new animal; so . . . I understand you, says Demea: but what wild, arbitrary suppositions are these! What data have you for such extraordinary conclusions? And is the slight, imaginary resemblance of the world to a vegetable or an animal sufficient to establish the same inference with regard to both? Objects, which are in general so widely different, ought they to be a standard for each other?

Right, cries Philo: this is the topic on which I have all along insisted. I have still asserted, that we have no data to establish any system of cosmogony. Our experience, so imperfect in itself, and so limited both in extent and duration, can afford us no probable conjecture concerning the whole of things. But if we must needs fix on some hypothesis; by what rule, pray, ought we to determine our choice? Is there any other rule than the greater similarity of the objects compared? And does not a plant or an animal, which springs from vegetation or generation, bear a stronger resemblance to the world, than does any artificial machine, which arises from reason and design?

But what is this vegetation and generation of which you talk? said Demea. Can you explain their operations, and anatomize that fine internal structure on which they depend?

As much, at least, replied Philo, as Cleanthes can explain the operations of reason, or anatomize that internal structure on which it depends. But without any such elaborate disquisitions, when I see an animal, I infer, that it sprang from generation; and that with as great certainty as you conclude a house to have been reared by design. These words, generation, reason, mark only certain powers and energies in nature, whose effects are known, but whose essence is incomprehensible; and one of these principles, more than the other, has no privilege for being made a standard to the whole of nature.

In reality, Demea, it may reasonably be expected, that the larger the views are which we take of things, the better will they conduct us in our conclusions concerning such extraordinary and such magnificent subjects. In this little corner of the world alone, there are four principles, reason, instinct, generation, vegetation, which are similar to each other, and are the causes of similar effects. What a number of other principles may we naturally suppose in the immense extent and variety of the universe, could we travel from planet to planet, and from system to system, in order to examine each part of this mighty fabric? Any one of these four principles above mentioned, (and a hundred others which lie open to our conjecture,) may afford us a theory by which to judge of the origin of the world; and it is a palpable and egregious partiality to confine our view entirely to that principle by which our own minds operate. Were this principle more intelligible on that account, such a partiality might be somewhat excusable: but reason, in its internal fabric and structure, is really as little known to us as instinct or vegetation; and, perhaps, even that vague, undeterminate word, Nature, to which the vulgar refer every thing, is not at the bottom more inexplicable. The effects of these principles are all known to us from experience; but the principles themselves, and their manner of operation, are totally unknown; nor is it less intelligible, or less conformable to experience, to say, that the world arose by vegetation, from a seed shed by another world, than to say that it arose from a divine reason or contrivance, according to the sense in which Cleanthes understands it.

But methinks, said Demea, if the world had a vegetative quality, and could sow the seeds of new worlds into the infinite chaos, this power would be still an additional argument for design in its author. For whence could arise so wonderful a faculty but from design? Or how can order spring from any thing which perceives not that order which it bestows?

You need only look around you, replied Philo, to satisfy yourself with regard to this question. A tree bestows order and organization on that tree which springs from it, without knowing the order; an animal in the same manner on its offspring; a bird on its nest; and instances of this kind are even more frequent in the world than those of order, which arise from reason and contrivance. To say, that all this order in animals and vegetables proceeds ultimately from design, is begging the question; nor can that great point be ascertained otherwise than by proving, a priori, both that order is, from its nature, inseparably attached to thought; and that it can never of itself, or from original unknown principles, belong to matter.

But further, Demea; this objection which you urge can never be made use of by Cleanthes, without renouncing a defence which he has already made against one of my objections. When I enquired concerning the cause of that supreme reason and intelligence into which he resolves every thing; he told me, that the impossibility of satisfying such enquiries could never be admitted as an objection in any species of philosophy. We must stop somewhere, says he; nor is it ever within the reach of human capacity to explain ultimate causes, or shew the last connexions of any objects. It is sufficient, if any steps, so far as we go, are supported by experience and observation. Now, that vegetation and generation, as well as reason, are experienced to be principles of order in nature, is undeniable. If I rest my system of cosmogony on the former, preferably to the latter, it is at my choice. The matter seems entirely arbitrary. And when Cleanthes asks me what is the cause of my great vegetative or generative faculty, I am equally entitled to ask him the cause of his great

reasoning principle. These questions we have agreed to forbear on both sides; and it is chiefly his interest on the present occasion to stick to this agreement. Judging by our limited and imperfect experience, generation has some privileges above reason: for we see every day the latter arise from the former, never the former from the latter.

Compare, I beseech you, the consequences on both sides. The world, say I, resembles an animal; therefore it is an animal, therefore it arose from generation. The steps, I confess, are wide; yet there is some small appearance of analogy in each step. The world, says Cleanthes, resembles a machine; therefore it is a machine, therefore it arose from design. The steps are here equally wide, and the analogy less striking. And if he pretends to carry on my hypothesis a step further, and to infer design or reason from the great principle of generation, on which I insist; I may, with better authority, use the same freedom to push further his hypothesis, and infer a divine generation or theogony from his principle of reason. I have at least some faint shadow of experience, which is the utmost that can ever be attained in the present subject. Reason, in innumerable instances, is observed to arise from the principle of generation, and never to arise from any other principle.

Hesiod, and all the ancient mythologists, were so struck with this analogy, that they universally explained the origin of nature from an animal birth, and copulation. Plato too, so far as he is intelligible, seems to have adopted some such notion in his Timaeus.

The Brahmins assert, that the world arose from an infinite spider, who spun this whole complicated mass from his bowels, and annihilates afterwards the whole or any part of it, by absorbing it again, and resolving it into his own essence. Here is a species of cosmogony, which appears to us ridiculous; because a spider is a little contemptible animal, whose operations we are never likely to take for a model of the whole universe. But still here is a new species of analogy, even in our globe. And were there a planet wholly inhabited by spiders, (which is very possible,) this inference would there appear as natural and irrefragable as that which in our planet ascribes the origin of all things to design and intelligence, as explained by Cleanthes. Why an orderly system may not be spun from the belly as well as from the brain, it will be difficult for him to give a satisfactory reason.

I must confess, Philo, replied Cleanthes, that of all men living, the task which you have undertaken, of raising doubts and objections, suits you best, and seems, in a manner, natural and unavoidable to you. So great is your fertility of invention, that I am not ashamed to acknowledge myself unable, on a sudden, to solve regularly such out-of-the-way difficulties as you incessantly start upon me: though I clearly see, in general, their fallacy and error. And I question not, but you are yourself, at present, in the same case, and have not the solution so ready as the objection: while you must be sensible, that common sense and reason are entirely against you; and that such whimsies as you have delivered, may puzzle, but never can convince us.

Part VIII.

What you ascribe to the fertility of my invention, replied Philo, is entirely owing to the nature of the subject. In subjects adapted to the narrow compass of human reason, there is commonly but one determination, which carries probability or conviction with it; and to a man of sound judgment, all other suppositions, but that one, appear entirely absurd and chimerical. But in such questions as the present, a hundred contradictory views may preserve a kind of imperfect analogy; and invention has here full scope to exert itself. Without any great effort of thought, I believe that I could, in an instant, propose other systems of cosmogony, which would have some faint appearance of truth, though it is a thousand, a million to one, if either yours or any one of mine be the true system.

For instance, what if I should revive the old Epicurean hypothesis? This is commonly, and I believe justly esteemed the most absurd system that has yet been proposed; yet I know not whether, with a few alterations, it might not be brought to bear a faint appearance of probability. Instead of supposing matter infinite, as Epicurus did, let us suppose it finite. A finite number of particles is only susceptible of finite transpositions: and it must happen, in an eternal duration, that every possible order or position must be tried an infinite number of times. This world, therefore, with all its events, even the most minute, has before been produced and destroyed, and will again be produced and destroyed, without any bounds and limitations. No one, who has a conception of the powers of infinite, in comparison of finite, will ever scruple this determination.

But this supposes, said Demea, that matter can acquire motion, without any voluntary agent or first mover.

And where is the difficulty, replied Philo, of that supposition? Every event, before experience, is equally difficult and incomprehensible; and every event, after experience, is equally easy and intelligible. Motion, in many instances, from gravity, from elasticity, from electricity, begins in matter, without any known voluntary agent: and to suppose always, in these cases, an unknown voluntary agent, is mere hypothesis; and hypothesis attended with no advantages. The beginning of motion in matter itself is as conceivable a priori as its communication from mind and intelligence.

Besides, why may not motion have been propagated by impulse through all eternity, and the same stock of it, or nearly the same, be still upheld in the universe? As much is lost by the composition of motion, as much is gained by its resolution. And whatever the causes are, the fact is certain, that matter is, and always has been, in continual agitation, as far as human experience or tradition reaches. There is not probably, at present, in the whole universe, one particle of matter at absolute rest.

And this very consideration too, continued Philo, which we have stumbled on in the course of the argument, suggests a new hypothesis of cosmogony, that is not absolutely absurd and improbable. Is there a system, an order, an economy of things, by which matter can preserve that perpetual agitation which seems essential to it, and yet maintain a constancy in the forms which it produces? There certainly is such an economy; for this is actually the case with the present world. The continual motion of matter, therefore, in less than infinite transpositions, must produce this economy or order; and by its very nature, that order, when once established, supports itself, for many ages, if not to eternity. But wherever matter is so poised, arranged, and adjusted, as to continue in perpetual motion, and yet preserve a constancy in the forms, its situation must, of necessity, have all the same appearance of art and contrivance which we observe at present. All the parts of each form must have a relation to each other, and to the whole; and the whole itself must have a relation to the other parts of the universe; to the element in which the form subsists; to the materials with which it repairs its waste and decay; and to every other form which is hostile or friendly. A defect in any of these particulars destroys the form; and the matter of which it is composed is again set loose, and is thrown into irregular motions and fermentations, till it unite itself to some other regular form. If no such form be prepared to receive it, and if there be a great quantity of this corrupted matter in the universe, the universe itself is entirely disordered; whether it be the feeble embryo of a world in its first beginnings that is thus destroyed, or the rotten carcase of one languishing in old age and infirmity. In either case, a chaos ensues; till finite, though innumerable revolutions produce at last some forms, whose parts and organs are so adjusted as to support the forms amidst a continued succession of matter.

Suppose (for we shall endeavour to vary the expression), that matter were thrown into any position, by a blind, unguided force; it is evident that this first position must, in all probability, be the most confused and most disorderly imaginable, without any resemblance to those works of

human contrivance, which, along with a symmetry of parts, discover an adjustment of means to ends, and a tendency to self- preservation. If the actuating force cease after this operation, matter must remain for ever in disorder, and continue an immense chaos, without any proportion or activity. But suppose that the actuating force, whatever it be, still continues in matter, this first position will immediately give place to a second, which will likewise in all probability be as disorderly as the first, and so on through many successions of changes and revolutions. No particular order or position ever continues a moment unaltered. The original force, still remaining in activity, gives a perpetual restlessness to matter. Every possible situation is produced, and instantly destroyed. If a glimpse or dawn of order appears for a moment, it is instantly hurried away, and confounded, by that never-ceasing force which actuates every part of matter.

Thus the universe goes on for many ages in a continued succession of chaos and disorder. But is it not possible that it may settle at last, so as not to lose its motion and active force (for that we have supposed inherent in it), yet so as to preserve an uniformity of appearance, amidst the continual motion and fluctuation of its parts? This we find to be the case with the universe at present. Every individual is perpetually changing, and every part of every individual; and yet the whole remains, in appearance, the same. May we not hope for such a position, or rather be assured of it, from the eternal revolutions of unguided matter; and may not this account for all the appearing wisdom and contrivance which is in the universe? Let us contemplate the subject a little, and we shall find, that this adjustment, if attained by matter of a seeming stability in the forms, with a real and perpetual revolution or motion of parts, affords a plausible, if not a true solution of the difficulty.

It is in vain, therefore, to insist upon the uses of the parts in animals or vegetables, and their curious adjustment to each other. I would fain know, how an animal could subsist, unless its parts were so adjusted? Do we not find, that it immediately perishes whenever this adjustment ceases, and that its matter corrupting tries some new form? It happens indeed, that the parts of the world are so well adjusted, that some regular form immediately lays claim to this corrupted matter: and if it were not so, could the world subsist? Must it not dissolve as well as the animal, and pass through new positions and situations, till in great, but finite succession, it falls at last into the present or some such order?

It is well, replied Cleanthes, you told us, that this hypothesis was suggested on a sudden, in the course of the argument. Had you had leisure to examine it, you would soon have perceived the insuperable objections to which it is exposed. No form, you say, can subsist, unless it possess those powers and organs requisite for its subsistence: some new order or economy must be tried, and so on, without intermission; till at last some order, which can support and maintain itself, is fallen upon. But according to this hypothesis, whence arise the many conveniences and advantages which men and all animals possess? Two eyes, two ears, are not absolutely necessary for the subsistence of the species. Human race might have been propagated and preserved, without horses, dogs, cows, sheep, and those innumerable fruits and products which serve to our satisfaction and enjoyment. If no camels had been created for the use of man in the sandy deserts of Africa and Arabia, would the world have been dissolved? If no loadstone had been framed to give that wonderful and useful direction to the needle, would human society and the human kind have been immediately extinguished? Though the maxims of Nature be in general very frugal, yet instances of this kind are far from being rare; and any one of them is a sufficient proof of design, and of a benevolent design, which gave rise to the order and arrangement of the universe.

At least, you may safely infer, said Philo, that the foregoing hypothesis is so far incompleat and imperfect, which I shall not scruple to allow. But can we ever reasonably expect greater success in any attempts of this nature? Or can we ever hope to erect a system of cosmogony, that will be liable to no exceptions, and will contain no circumstance repugnant to our limited and imperfect

experience of the analogy of Nature? Your theory itself cannot surely pretend to any such advantage, even though you have run into Anthropomorphism, the better to preserve a conformity to common experience. Let us once more put it to trial. In all instances which we have ever seen, ideas are copied from real objects, and are ectypal, not archetypal, to express myself in learned terms: you reverse this order, and give thought the precedence. In all instances which we have ever seen, thought has no influence upon matter, except where that matter is so conjoined with it as to have an equal reciprocal influence upon it. No animal can move immediately any thing but the members of its own body; and indeed, the equality of action and reaction seems to be an universal law of nature: but your theory implies a contradiction to this experience. These instances, with many more, which it were easy to collect, (particularly the supposition of a mind or system of thought that is eternal, or, in other words, an animal ingenerable and immortal); these instances, I say, may teach all of us sobriety in condemning each other, and let us see, that as no system of this kind ought ever to be received from a slight analogy, so neither ought any to be rejected on account of a small incongruity. For that is an inconvenience from which we can justly pronounce no one to be exempted.

All religious systems, it is confessed, are subject to great and insuperable difficulties. Each disputant triumphs in his turn; while he carries on an offensive war, and exposes the absurdities, barbarities, and pernicious tenets of his antagonist. But all of them, on the whole, prepare a compleat triumph for the Sceptic; who tells them, that no system ought ever to be embraced with regard to such subjects: for this plain reason, that no absurdity ought ever to be assented to with regard to any subject. A total suspense of judgment is here our only reasonable resource. And if every attack, as is commonly observed, and no defence, among Theologians, is successful; how compleat must be his victory, who remains always, with all mankind, on the offensive, and has himself no fixed station or abiding city, which he is ever, on any occasion, obliged to defend?

Part IX.

But if so many difficulties attend the argument a posteriori, said Demea, had we not better adhere to that simple and sublime argument a priori, which, by offering to us infallible demonstration, cuts off at once all doubt and difficulty? By this argument, too, we may prove the INFINITY of the Divine attributes, which, I am afraid, can never be ascertained with certainty from any other topic. For how can an effect, which either is finite, or, for aught we know, may be so; how can such an effect, I say, prove an infinite cause? The unity too of the Divine Nature, it is very difficult, if not absolutely impossible, to deduce merely from contemplating the works of nature; nor will the uniformity alone of the plan, even were it allowed, give us any assurance of that attribute. Whereas the argument a priori . . . . .

You seem to reason, Demea, interposed Cleanthes, as if those advantages and conveniences in the abstract argument were full proofs of its solidity. But it is first proper, in my opinion, to determine what argument of this nature you choose to insist on; and we shall afterwards, from itself, better than from its useful consequences, endeavour to determine what value we ought to put upon it.

The argument, replied Demea, which I would insist on, is the common one. Whatever exists must have a cause or reason of its existence; it being absolutely impossible for any thing to produce itself, or be the cause of its own existence. In mounting up, therefore, from effects to causes, we must either go on in tracing an infinite succession, without any ultimate cause at all; or must at last have recourse to some ultimate cause, that is necessarily existent: now, that the first supposition is absurd, may be thus proved. In the infinite chain or succession of causes and effects, each single effect is determined to exist by the power and efficacy of that cause which immediately preceded; but the whole eternal chain or succession, taken together, is not determined or caused by any thing; and yet it is evident that it requires a cause or reason, as much as any particular object which begins to exist in time. The question is still reasonable, why this

particular succession of causes existed from eternity, and not any other succession, or no succession at all. If there be no necessarily existent being, any supposition which can be formed is equally possible; nor is there any more absurdity in Nothing's having existed from eternity, than there is in that succession of causes which constitutes the universe. What was it, then, which determined Something to exist rather than Nothing, and bestowed being on a particular possibility, exclusive of the rest? External causes, there are supposed to be none. Chance is a word without a meaning. Was it Nothing? But that can never produce any thing. We must, therefore, have recourse to a necessarily existent Being, who carries the REASON of his existence in himself, and who cannot be supposed not to exist, without an express contradiction. There is, consequently, such a Being; that is, there is a Deity.

I shall not leave it to Philo, said Cleanthes, though I know that the starting objections is his chief delight, to point out the weakness of this metaphysical reasoning. It seems to me so obviously ill-grounded, and at the same time of so little consequence to the cause of true piety and religion, that I shall myself venture to shew the fallacy of it.

I shall begin with observing, that there is an evident absurdity in pretending to demonstrate a matter of fact, or to prove it by any arguments a priori. Nothing is demonstrable, unless the contrary implies a contradiction. Nothing, that is distinctly conceivable, implies a contradiction. Whatever we conceive as existent, we can also conceive as non-existent. There is no being, therefore, whose non- existence implies a contradiction. Consequently there is no being, whose existence is demonstrable. I propose this argument as entirely decisive, and am willing to rest the whole controversy upon it.

It is pretended that the Deity is a necessarily existent being; and this necessity of his existence is attempted to be explained by asserting, that if we knew his whole essence or nature, we should perceive it to be as impossible for him not to exist, as for twice two not to be four. But it is evident that this can never happen, while our faculties remain the same as at present. It will still be possible for us, at any time, to conceive the non-existence of what we formerly conceived to exist; nor can the mind ever lie under a necessity of supposing any object to remain always in being; in the same manner as we lie under a necessity of always conceiving twice two to be four. The words, therefore, necessary existence, have no meaning; or, which is the same thing, none that is consistent.

But further, why may not the material universe be the necessarily existent being, according to this pretended explication of necessity? We dare not affirm that we know all the qualities of matter; and for aught we can determine, it may contain some qualities, which, were they known, would make its non- existence appear as great a contradiction as that twice two is five. I find only one argument employed to prove, that the material world is not the necessarily existent Being: and this argument is derived from the contingency both of the matter and the form of the world. "Any particle of matter," it is said, 7 "may be conceived to be annihilated; and any form may be conceived to be altered. Such an annihilation or alteration, therefore, is not impossible." But it seems a great partiality not to perceive, that the same argument extends equally to the Deity, so far as we have any conception of him; and that the mind can at least imagine him to be non-existent, or his attributes to be altered. It must be some unknown, inconceivable qualities, which can make his non-existence appear impossible, or his attributes unalterable: and no reason can be assigned, why these qualities may not belong to matter. As they are altogether unknown and inconceivable, they can never be proved incompatible with it.

Add to this, that in tracing an eternal succession of objects, it seems absurd to enquire for a general cause or first author. How can any thing, that exists from eternity, have a cause, since that relation implies a priority in time, and a beginning of existence?

In such a chain, too, or succession of objects, each part is caused by that which preceded it, and causes that which succeeds it. Where then is the difficulty? But the WHOLE, you say, wants a cause. I answer, that the uniting of these parts into a whole, like the uniting of several distinct countries into one kingdom, or several distinct members into one body, is performed merely by an arbitrary act of the mind, and has no influence on the nature of things. Did I shew you the particular causes of each individual in a collection of twenty particles of matter, I should think it very unreasonable, should you afterwards ask me, what was the cause of the whole twenty. This is sufficiently explained in explaining the cause of the parts.

Though the reasonings which you have urged, Cleanthes, may well excuse me, said Philo, from starting any further difficulties, yet I cannot forbear insisting still upon another topic. It is observed by arithmeticians, that the products of 9, compose always either 9, or some lesser product of 9, if you add together all the characters of which any of the former products is composed. Thus, of 18, 27, 36, which are products of 9, you make 9 by adding 1 to 8, 2 to 7, 3 to 6. Thus, 369 is a product also of 9; and if you add 3, 6, and 9, you make 18, a lesser product of 9. 8 To a superficial observer, so wonderful a regularity may be admired as the effect either of chance or design: but a skilful algebraist immediately concludes it to be the work of necessity, and demonstrates, that it must forever result from the nature of these numbers. Is it not probable, I ask, that the whole economy of the universe is conducted by a like necessity, though no human algebra can furnish a key which solves the difficulty? And instead of admiring the order of natural beings, may it not happen, that, could we penetrate into the intimate nature of bodies, we should clearly see why it was absolutely impossible they could ever admit of any other disposition? So dangerous is it to introduce this idea of necessity into the present question! and so naturally does it afford an inference directly opposite to the religious hypothesis!

But dropping all these abstractions, continued Philo, and confining ourselves to more familiar topics, I shall venture to add an observation, that the argument a priori has seldom been found very convincing, except to people of a metaphysical head, who have accustomed themselves to abstract reasoning, and who, finding from mathematics, that the understanding frequently leads to truth through obscurity, and, contrary to first appearances, have transferred the same habit of thinking to subjects where it ought not to have place. Other people, even of good sense and the best inclined to religion, feel always some deficiency in such arguments, though they are not perhaps able to explain distinctly where it lies; a certain proof that men ever did, and ever will derive their religion from other sources than from this species of reasoning.

Part X.

It is my opinion, I own, replied Demea, that each man feels, in a manner, the truth of religion within his own breast, and, from a consciousness of his imbecility and misery, rather than from any reasoning, is led to seek protection from that Being, on whom he and all nature is dependent. So anxious or so tedious are even the best scenes of life, that futurity is still the object of all our hopes and fears. We incessantly look forward, and endeavour, by prayers, adoration, and sacrifice, to appease those unknown powers, whom we find, by experience, so able to afflict and oppress us. Wretched creatures that we are! what resource for us amidst the innumerable ills of life, did not religion suggest some methods of atonement, and appease those terrors with which we are incessantly agitated and tormented?

I am indeed persuaded, said Philo, that the best, and indeed the only method of bringing every one to a due sense of religion, is by just representations of the misery and wickedness of men. And for that purpose a talent of eloquence and strong imagery is more requisite than that of reasoning and argument. For is it necessary to prove what every one feels within himself? It is only necessary to make us feel it, if possible, more intimately and sensibly.

The people, indeed, replied Demea, are sufficiently convinced of this great and melancholy truth. The miseries of life; the unhappiness of man; the general corruptions of our nature; the unsatisfactory enjoyment of pleasures, riches, honours; these phrases have become almost proverbial in all languages. And who can doubt of what all men declare from their own immediate feeling and experience?

In this point, said Philo, the learned are perfectly agreed with the vulgar; and in all letters, sacred and profane, the topic of human misery has been insisted on with the most pathetic eloquence that sorrow and melancholy could inspire. The poets, who speak from sentiment, without a system, and whose testimony has therefore the more authority, abound in images of this nature. From Homer down to Dr. Young, the whole inspired tribe have ever been sensible, that no other representation of things would suit the feeling and observation of each individual.

As to authorities, replied Demea, you need not seek them. Look round this library of Cleanthes. I shall venture to affirm, that, except authors of particular sciences, such as chemistry or botany, who have no occasion to treat of human life, there is scarce one of those innumerable writers, from whom the sense of human misery has not, in some passage or other, extorted a complaint and confession of it. At least, the chance is entirely on that side; and no one author has ever, so far as I can recollect, been so extravagant as to deny it.

There you must excuse me, said Philo: Leibnitz has denied it; and is perhaps the first 9 who ventured upon so bold and paradoxical an opinion; at least, the first who made it essential to his philosophical system.

And by being the first, replied Demea, might he not have been sensible of his error? For is this a subject in which philosophers can propose to make discoveries especially in so late an age? And can any man hope by a simple denial (for the subject scarcely admits of reasoning), to bear down the united testimony of mankind, founded on sense and consciousness?

And why should man, added he, pretend to an exemption from the lot of all other animals? The whole earth, believe me, Philo, is cursed and polluted. A perpetual war is kindled amongst all living creatures. Necessity, hunger, want, stimulate the strong and courageous: fear, anxiety, terror, agitate the weak and infirm. The first entrance into life gives anguish to the new-born infant and to its wretched parent: weakness, impotence, distress, attend each stage of that life: and it is at last finished in agony and horror.

Observe too, says Philo, the curious artifices of Nature, in order to embitter the life of every living being. The stronger prey upon the weaker, and keep them in perpetual terror and anxiety. The weaker too, in their turn, often prey upon the stronger, and vex and molest them without relaxation. Consider that innumerable race of insects, which either are bred on the body of each animal, or, flying about, infix their stings in him. These insects have others still less than themselves, which torment them. And thus on each hand, before and behind, above and below, every animal is surrounded with enemies, which incessantly seek his misery and distruction.

Man alone, said Demea, seems to be, in part, an exception to this rule. For by combination in society, he can easily master lions, tigers, and bears, whose greater strength and agility naturally enable them to prey upon him.

On the contrary, it is here chiefly, cried Philo, that the uniform and equal maxims of Nature are most apparent. Man, it is true, can, by combination, surmount all his real enemies, and become master of the whole animal creation: but does he not immediately raise up to himself imaginary

enemies, the demons of his fancy, who haunt him with superstitious terrors, and blast every enjoyment of life? His pleasure, as he imagines, becomes, in their eyes, a crime: his food and repose give them umbrage and offence: his very sleep and dreams furnish new materials to anxious fear: and even death, his refuge from every other ill, presents only the dread of endless and innumerable woes. Nor does the wolf molest more the timid flock, than superstition does the anxious breast of wretched mortals.

Besides, consider, Demea: this very society, by which we surmount those wild beasts, our natural enemies; what new enemies does it not raise to us? What woe and misery does it not occasion? Man is the greatest enemy of man. Oppression, injustice, contempt, contumely, violence, sedition, war, calumny, treachery, fraud; by these they mutually torment each other; and they would soon dissolve that society which they had formed, were it not for the dread of still greater ills, which must attend their separation.

But though these external insults, said Demea, from animals, from men, from all the elements, which assault us, form a frightful catalogue of woes, they are nothing in comparison of those which arise within ourselves, from the distempered condition of our mind and body. How many lie under the lingering torment of diseases? Hear the pathetic enumeration of the great poet.

Intestine stone and ulcer, colic-pangs,

Demoniac frenzy, moping melancholy,

And moon-struck madness, pining atrohy,

Marasmus, and wide-wasting pestilence.

Dire was the tossing, deep the groans: DESPAIR

Tended the sick, busiest from couch to couch.

And over them triumphant DEATH his dart

Shook: but delay'd to strike, though oft invok'd

With vows, as their chief good and final hope.

The disorders of the mind, continued Demea, though more secret, are not perhaps less dismal and vexatious. Remorse, shame, anguish, rage, disappointment, anxiety, fear, dejection, despair; who has ever passed through life without cruel inroads from these tormentors? How many have scarcely ever felt any better sensations? Labour and poverty, so abhorred by every one, are the certain lot of the far greater number; and those few privileged persons, who enjoy ease and opulence, never reach contentment or true felicity. All the goods of life united would not make a very happy man; but all the ills united would make a wretch indeed; and any one of them almost (and who can be free from every one?) nay often the absence of one good (and who can possess all?) is sufficient to render life ineligible.

Were a stranger to drop on a sudden into this world, I would shew him, as a specimen of its ills, an hospital full of diseases, a prison crowded with malefactors and debtors, a field of battle strewed with carcases, a fleet foundering in the ocean, a nation languishing under tyranny, famine, or pestilence. To turn the gay side of life to him and give him a notion of its pleasures; whither should

I conduct him? to a ball, to an opera, to court? He might justly think, that I was only shewing him a diversity of distress and sorrow.

There is no evading such striking instances, said Philo, but by apologies, which still further aggravate the charge. Why have all men, I ask, in all ages, complained incessantly of the miseries of life? . . . . They have no just reason, says one: these complaints proceed only from their discontented, repining, anxious disposition . . . . And can there possibly, I reply, be a more certain foundation of misery, than such a wretched temper?

But if they were really as unhappy as they pretend, says my antagonist, why do they remain in life? . . . .

Not satisfied with life, afraid of death.

This is the secret chain, say I, that holds us. We are terrified, not bribed to the continuance of our existence.

It is only a false delicacy, he may insist, which a few refined spirits indulge, and which has spread these complaints among the whole race of mankind. . . . And what is this delicacy, I ask, which you blame? Is it any thing but a greater sensibility to all the pleasures and pains of life? and if the man of a delicate, refined temper, by being so much more alive than the rest of the world, is only so much more unhappy, what judgment must we form in general of human life?

Let men remain at rest, says our adversary, and they will be easy. They are willing artificers of their own misery. . . . No! reply I: an anxious languor follows their repose; disappointment, vexation, trouble, their activity and ambition.

I can observe something like what you mention in some others, replied Cleanthes: but I confess I feel little or nothing of it in myself, and hope that it is not so common as you represent it.

If you feel not human misery yourself, cried Demea, I congratulate you on so happy a singularity. Others, seemingly the most prosperous, have not been ashamed to vent their complaints in the most melancholy strains. Let us attend to the great, the fortunate emperor, Charles V., when, tired with human grandeur, he resigned all his extensive dominions into the hands of his son. In the last harangue which he made on that memorable occasion, he publicly avowed, that the greatest prosperities which he had ever enjoyed, had been mixed with so many adversities, that he might truly say he had never enjoyed any satisfaction or contentment. But did the retired life, in which he sought for shelter, afford him any greater happiness? If we may credit his son's account, his repentance commenced the very day of his resignation.

Cicero's fortune, from small beginnings, rose to the greatest lustre and renown; yet what pathetic complaints of the ills of life do his familiar letters, as well as philosophical discourses, contain? And suitably to his own experience, he introduces Cato, the great, the fortunate Cato, protesting in his old age, that had he a new life in his offer, he would reject the present.

Ask yourself, ask any of your acquaintance, whether they would live over again the last ten or twenty years of their lives. No! but the next twenty, they say, will be better:

And from the dregs of life, hope to receive
What the first sprightly running could not give0.

Thus at last they find (such is the greatness of human misery, it reconciles even contradictions), that they complain at once of the shortness of life, and of its vanity and sorrow.

And is it possible, Cleanthes, said Philo, that after all these reflections, and infinitely more, which might be suggested, you can still persevere in your Anthropomorphism, and assert the moral attributes of the Deity, his justice, benevolence, mercy, and rectitude, to be of the same nature with these virtues in human creatures? His power we allow is infinite: whatever he wills is executed: but neither man nor any other animal is happy: therefore he does not will their happiness. His wisdom is infinite: he is never mistaken in choosing the means to any end: but the course of Nature tends not to human or animal felicity: therefore it is not established for that purpose. Through the whole compass of human knowledge, there are no inferences more certain and infallible than these. In what respect, then, do his benevolence and mercy resemble the benevolence and mercy of men?

Epicurus's old questions are yet unanswered.

Is he willing to prevent evil, but not able? then is he impotent. Is he able, but not willing? then is he malevolent. Is he both able and willing? whence then is evil?

You ascribe, Cleanthes (and I believe justly), a purpose and intention to Nature. But what, I beseech you, is the object of that curious artifice and machinery, which she has displayed in all animals? The preservation alone of individuals, and propagation of the species. It seems enough for her purpose, if such a rank be barely upheld in the universe, without any care or concern for the happiness of the members that compose it. No resource for this purpose: no machinery, in order merely to give pleasure or ease: no fund of pure joy and contentment: no indulgence, without some want or necessity accompanying it. At least, the few phenomena of this nature are overbalanced by opposite phenomena of still greater importance.

Our sense of music, harmony, and indeed beauty of all kinds, gives satisfaction, without being absolutely necessary to the preservation and propagation of the species. But what racking pains, on the other hand, arise from gouts, gravels, megrims, toothaches, rheumatisms, where the injury to the animal machinery is either small or incurable? Mirth, laughter, play, frolic, seems gratuitous satisfactions, which have no further tendency: spleen, melancholy, discontent, superstition, are pains of the same nature. How then does the Divine benevolence display itself, in the sense of you Anthropomorphites? None but we Mystics, as you were pleased to call us, can account for this strange mixture of phenomena, by deriving it from attributes, infinitely perfect, but incomprehensible.

And have you at last, said Cleanthes, smiling, betrayed your intentions, Philo? Your long agreement with Demea did indeed a little surprize me; but I find you were all the while erecting a concealed battery against me. And I must confess, that you have now fallen upon a subject worthy of your noble spirit of opposition and controversy. If you can make out the present point, and prove mankind to be unhappy or corrupted, there is an end at once of all religion. For to what purpose establish the natural attributes of the Deity, while the moral are still doubtful and uncertain?

You take umbrage very easily, replied Demea, at opinions the most innocent, and the most generally received, even amongst the religious and devout themselves: and nothing can be more surprising than to find a topic like this, concerning the wickedness and misery of man, charged with no less than Atheism and profaneness. Have not all pious divines and preachers, who have indulged their rhetoric on so fertile a subject; have they not easily, I say, given a solution of any difficulties which may attend it? This world is but a point in comparison of the universe; this life but a moment in comparison of eternity. The present evil phenomena, therefore, are rectified in other regions,

and in some future period of existence. And the eyes of men, being then opened to larger views of things, see the whole connexion of general laws; and trace with adoration, the benevolence and rectitude of the Deity, through all the mazes and intricacies of his providence.

No! replied Cleanthes, No! These arbitrary suppositions can never be admitted, contrary to matter of fact, visible and uncontroverted. Whence can any cause be known but from its known effects? Whence can any hypothesis be proved but from the apparent phenomena? To establish one hypothesis upon another, is building entirely in the air; and the utmost we ever attain, by these conjectures and fictions, is to ascertain the bare possibility of our opinion; but never can we, upon such terms, establish its reality.

The only method of supporting Divine benevolence, and it is what I willingly embrace, is to deny absolutely the misery and wickedness of man. Your representations are exaggerated; your melancholy views mostly fictitious; your inferences contrary to fact and experience. Health is more common than sickness; pleasure than pain; happiness than misery. And for one vexation which we meet with, we attain, upon computation, a hundred enjoyments.

Admitting your position, replied Philo, which yet is extremely doubtful, you must at the same time allow, that if pain be less frequent than pleasure, it is infinitely more violent and durable. One hour of it is often able to outweigh a day, a week, a month of our common insipid enjoyments; and how many days, weeks, and months, are passed by several in the most acute torments? Pleasure, scarcely in one instance, is ever able to reach ecstasy and rapture; and in no one instance can it continue for any time at its highest pitch and altitude. The spirits evaporate, the nerves relax, the fabric is disordered, and the enjoyment quickly degenerates into fatigue and uneasiness. But pain often, good God, how often! rises to torture and agony; and the longer it continues, it becomes still more genuine agony and torture. Patience is exhausted, courage languishes, melancholy seizes us, and nothing terminates our misery but the removal of its cause, or another event, which is the sole cure of all evil, but which, from our natural folly, we regard with still greater horror and consternation.

But not to insist upon these topics, continued Philo, though most obvious, certain, and important; I must use the freedom to admonish you, Cleanthes, that you have put the controversy upon a most dangerous issue, and are unawares introducing a total scepticism into the most essential articles of natural and revealed theology. What! no method of fixing a just foundation for religion, unless we allow the happiness of human life, and maintain a continued existence even in this world, with all our present pains, infirmities, vexations, and follies, to be eligible and desirable! But this is contrary to every one's feeling and experience: it is contrary to an authority so established as nothing can subvert. No decisive proofs can ever be produced against this authority; nor is it possible for you to compute, estimate, and compare, all the pains and all the pleasures in the lives of all men and of all animals: and thus, by your resting the whole system of religion on a point, which, from its very nature, must for ever be uncertain, you tacitly confess, that that system is equally uncertain.

But allowing you what never will be believed, at least what you never possibly can prove, that animal, or at least human happiness, in this life, exceeds its misery, you have yet done nothing: for this is not, by any means, what we expect from infinite power, infinite wisdom, and infinite goodness. Why is there any misery at all in the world? Not by chance surely. From some cause then. Is it from the intention of the Deity? But he is perfectly benevolent. Is it contrary to his intention? But he is almighty. Nothing can shake the solidity of this reasoning, so short, so clear, so decisive; except we assert, that these subjects exceed all human capacity, and that our common measures of truth and falsehood are not applicable to them; a topic which I have all along insisted on, but which you have, from the beginning, rejected with scorn and indignation.

But I will be contented to retire still from this intrenchment, for I deny that you can ever force me in it. I will allow, that pain or misery in man is compatible with infinite power and goodness in the Deity, even in your sense of these attributes: what are you advanced by all these concessions? A mere possible compatibility is not sufficient. You must prove these pure, unmixed, and uncontrollable attributes from the present mixed and confused phenomena, and from these alone. A hopeful undertaking! Were the phenomena ever so pure and unmixed, yet being finite, they would be insufficient for that purpose. How much more, where they are also so jarring and discordant!

Here, Cleanthes, I find myself at ease in my argument. Here I triumph. Formerly, when we argued concerning the natural attributes of intelligence and design, I needed all my sceptical and metaphysical subtilty to elude your grasp. In many views of the universe and of its parts, particularly the latter, the beauty and fitness of final causes strike us with such irresistible force, that all objections appear (what I believe they really are) mere cavils and sophisms; nor can we then imagine how it was ever possible for us to repose any weight on them. But there is no view of human life, or of the condition of mankind, from which, without the greatest violence, we can infer the moral attributes, or learn that infinite benevolence, conjoined with infinite power and infinite wisdom, which we must discover by the eyes of faith alone. It is your turn now to tug the laboring oar, and to support your philosophical subtilties against the dictates of plain reason and experience.

Part XI.

I scruple not to allow, said Cleanthes, that I have been apt to suspect the frequent repetition of the word infinite, which we meet with in all theological writers, to savour more of panegyric than of philosophy; and that any purposes of reasoning, and even of religion, would be better served, were we to rest contented with more accurate and more moderate expressions. The terms, admirable, excellent, superlatively great, wise, and holy; these sufficiently fill the imaginations of men; and any thing beyond, besides that it leads into absurdities, has no influence on the affections or sentiments. Thus, in the present subject, if we abandon all human analogy, as seems your intention, Demea, I am afraid we abandon all religion, and retain no conception of the great object of our adoration. If we preserve human analogy, we must for ever find it impossible to reconcile any mixture of evil in the universe with infinite attributes; much less can we ever prove the latter from the former. But supposing the Author of Nature to be finitely perfect, though far exceeding mankind, a satisfactory account may then be given of natural and moral evil, and every untoward phenomenon be explained and adjusted. A less evil may then be chosen, in order to avoid a greater; inconveniences be submitted to, in order to reach a desirable end; and in a word, benevolence, regulated by wisdom, and limited by necessity, may produce just such a world as the present. You, Philo, who are so prompt at starting views, and reflections, and analogies, I would gladly hear, at length, without interruption, your opinion of this new theory; and if it deserve our attention, we may afterwards, at more leisure, reduce it into form.

My sentiments, replied Philo, are not worth being made a mystery of; and therefore, without any ceremony, I shall deliver what occurs to me with regard to the present subject. It must, I think, be allowed, that if a very limited intelligence, whom we shall suppose utterly unacquainted with the universe, were assured, that it were the production of a very good, wise, and powerful Being, however finite, he would, from his conjectures, form beforehand a different notion of it from what we find it to be by experience; nor would he ever imagine, merely from these attributes of the cause, of which he is informed, that the effect could be so full of vice and misery and disorder, as it appears in this life. Supposing now, that this person were brought into the world, still assured that it was the workmanship of such a sublime and benevolent Being; he might, perhaps, be surprized at the disappointment; but would never retract his former belief, if founded on any very

solid argument; since such a limited intelligence must be sensible of his own blindness and ignorance, and must allow, that there may be many solutions of those phenomena, which will for ever escape his comprehension. But supposing, which is the real case with regard to man, that this creature is not antecedently convinced of a supreme intelligence, benevolent and powerful, but is left to gather such a belief from the appearances of things; this entirely alters the case, nor will he ever find any reason for such a conclusion. He may be fully convinced of the narrow limits of his understanding; but this will not help him in forming an inference concerning the goodness of superior powers, since he must form that inference from what he knows, not from what he is ignorant of. The more you exaggerate his weakness and ignorance, the more diffident you render him, and give him the greater suspicion that such subjects are beyond the reach of his faculties. You are obliged, therefore, to reason with him merely from the known phenomena, and to drop every arbitrary supposition or conjecture.

Did I shew you a house or palace, where there was not one apartment convenient or agreeable; where the windows, doors, fires, passages, stairs, and the whole economy of the building, were the source of noise, confusion, fatigue, darkness, and the extremes of heat and cold; you would certainly blame the contrivance, without any further examination. The architect would in vain display his subtilty, and prove to you, that if this door or that window were altered, greater ills would ensue. What he says may be strictly true: the alteration of one particular, while the other parts of the building remain, may only augment the inconveniences. But still you would assert in general, that, if the architect had had skill and good intentions, he might have formed such a plan of the whole, and might have adjusted the parts in such a manner, as would have remedied all or most of these inconveniences. His ignorance, or even your own ignorance of such a plan, will never convince you of the impossibility of it. If you find any inconveniences and deformities in the building, you will always, without entering into any detail, condemn the architect.

In short, I repeat the question: Is the world, considered in general, and as it appears to us in this life, different from what a man, or such a limited being, would, beforehand, expect from a very powerful, wise, and benevolent Deity? It must be strange prejudice to assert the contrary. And from thence I conclude, that however consistent the world may be, allowing certain suppositions and conjectures, with the idea of such a Deity, it can never afford us an inference concerning his existence. The consistence is not absolutely denied, only the inference. Conjectures, especially where infinity is excluded from the Divine attributes, may perhaps be sufficient to prove a consistence, but can never be foundations for any inference.

There seems to be four circumstances, on which depend all, or the greatest part of the ills, that molest sensible creatures; and it is not impossible but all these circumstances may be necessary and unavoidable. We know so little beyond common life, or even of common life, that, with regard to the economy of a universe, there is no conjecture, however wild, which may not be just; nor any one, however plausible, which may not be erroneous. All that belongs to human understanding, in this deep ignorance and obscurity, is to be sceptical, or at least cautious, and not to admit of any hypothesis whatever, much less of any which is supported by no appearance of probability. Now, this I assert to be the case with regard to all the causes of evil, and the circumstances on which it depends. None of them appear to human reason in the least degree necessary or unavoidable; nor can we suppose them such, without the utmost license of imagination.

The first circumstance which introduces evil, is that contrivance or economy of the animal creation, by which pains, as well as pleasures, are employed to excite all creatures to action, and make them vigilant in the great work of self-preservation. Now pleasure alone, in its various degrees, seems to human understanding sufficient for this purpose. All animals might be constantly in a state of enjoyment: but when urged by any of the necessities of nature, such as thirst, hunger, weariness; instead of pain, they might feel a diminution of pleasure, by which they might be

prompted to seek that object which is necessary to their subsistence. Men pursue pleasure as eagerly as they avoid pain; at least they might have been so constituted. It seems, therefore, plainly possible to carry on the business of life without any pain. Why then is any animal ever rendered susceptible of such a sensation? If animals can be free from it an hour, they might enjoy a perpetual exemption from it; and it required as particular a contrivance of their organs to produce that feeling, as to endow them with sight, hearing, or any of the senses. Shall we conjecture, that such a contrivance was necessary, without any appearance of reason? and shall we build on that conjecture as on the most certain truth?

But a capacity of pain would not alone produce pain, were it not for the second circumstance, viz. the conducting of the world by general laws; and this seems nowise necessary to a very perfect Being. It is true, if every thing were conducted by particular volitions, the course of nature would be perpetually broken, and no man could employ his reason in the conduct of life. But might not other particular volitions remedy this inconvenience? In short, might not the Deity exterminate all ill, wherever it were to be found; and produce all good, without any preparation, or long progress of causes and effects?

Besides, we must consider, that, according to the present economy of the world, the course of nature, though supposed exactly regular, yet to us appears not so, and many events are uncertain, and many disappoint our expectations. Health and sickness, calm and tempest, with an infinite number of other accidents, whose causes are unknown and variable, have a great influence both on the fortunes of particular persons and on the prosperity of public societies; and indeed all human life, in a manner, depends on such accidents. A being, therefore, who knows the secret springs of the universe, might easily, by particular volitions, turn all these accidents to the good of mankind, and render the whole world happy, without discovering himself in any operation. A fleet, whose purposes were salutary to society, might always meet with a fair wind. Good princes enjoy sound health and long life. Persons born to power and authority, be framed with good tempers and virtuous dispositions. A few such events as these, regularly and wisely conducted, would change the face of the world; and yet would no more seem to disturb the course of nature, or confound human conduct, than the present economy of things, where the causes are secret, and variable, and compounded. Some small touches given to Caligula's brain in his infancy, might have converted him into a Trajan. One wave, a little higher than the rest, by burying Caesar and his fortune in the bottom of the ocean, might have restored liberty to a considerable part of mankind. There may, for aught we know, be good reasons why Providence interposes not in this manner; but they are unknown to us; and though the mere supposition, that such reasons exist, may be sufficient to save the conclusion concerning the Divine attributes, yet surely it can never be sufficient to establish that conclusion.

If every thing in the universe be conducted by general laws, and if animals be rendered susceptible of pain, it scarcely seems possible but some ill must arise in the various shocks of matter, and the various concurrence and opposition of general laws; but this ill would be very rare, were it not for the third circumstance, which I proposed to mention, viz. the great frugality with which all powers and faculties are distributed to every particular being. So well adjusted are the organs and capacities of all animals, and so well fitted to their preservation, that, as far as history or tradition reaches, there appears not to be any single species which has yet been extinguished in the universe. Every animal has the requisite endowments; but these endowments are bestowed with so scrupulous an economy, that any considerable diminution must entirely destroy the creature. Wherever one power is encreased, there is a proportional abatement in the others. Animals which excel in swiftness are commonly defective in force. Those which possess both are either imperfect in some of their senses, or are oppressed with the most craving wants. The human species, whose chief excellency is reason and sagacity, is of all others the most necessitous, and the most deficient in bodily advantages; without clothes, without arms, without food, without lodging, without any

convenience of life, except what they owe to their own skill and industry. In short, nature seems to have formed an exact calculation of the necessities of her creatures; and, like a rigid master, has afforded them little more powers or endowments than what are strictly sufficient to supply those necessities. An indulgent parent would have bestowed a large stock, in order to guard against accidents, and secure the happiness and welfare of the creature in the most unfortunate concurrence of circumstances. Every course of life would not have been so surrounded with precipices, that the least departure from the true path, by mistake or necessity, must involve us in misery and ruin. Some reserve, some fund, would have been provided to insure happiness; nor would the powers and the necessities have been adjusted with so rigid an economy. The Author of Nature is inconceivably powerful: his force is supposed great, if not altogether inexhaustible: nor is there any reason, as far as we can judge, to make him observe this strict frugality in his dealings with his creatures. It would have been better, were his power extremely limited, to have created fewer animals, and to have endowed these with more faculties for their happiness and preservation. A builder is never esteemed prudent, who undertakes a plan beyond what his stock will enable him to finish.

In order to cure most of the ills of human life, I require not that man should have the wings of the eagle, the swiftness of the stag, the force of the ox, the arms of the lion, the scales of the crocodile or rhinoceros; much less do I demand the sagacity of an angel or cherubim. I am contented to take an increase in one single power or faculty of his soul. Let him be endowed with a greater propensity to industry and labour; a more vigorous spring and activity of mind; a more constant bent to business and application. Let the whole species possess naturally an equal diligence with that which many individuals are able to attain by habit and reflection; and the most beneficial consequences, without any alloy of ill, is the immediate and necessary result of this endowment. Almost all the moral, as well as natural evils of human life, arise from idleness; and were our species, by the original constitution of their frame, exempt from this vice or infirmity, the perfect cultivation of land, the improvement of arts and manufactures, the exact execution of every office and duty, immediately follow; and men at once may fully reach that state of society, which is so imperfectly attained by the best regulated government. But as industry is a power, and the most valuable of any, Nature seems determined, suitably to her usual maxims, to bestow it on men with a very sparing hand; and rather to punish him severely for his deficiency in it, than to reward him for his attainments. She has so contrived his frame, that nothing but the most violent necessity can oblige him to labour; and she employs all his other wants to overcome, at least in part, the want of diligence, and to endow him with some share of a faculty of which she has thought fit naturally to bereave him. Here our demands may be allowed very humble, and therefore the more reasonable. If we required the endowments of superior penetration and judgment, of a more delicate taste of beauty, of a nicer sensibility to benevolence and friendship; we might be told, that we impiously pretend to break the order of Nature; that we want to exalt ourselves into a higher rank of being; that the presents which we require, not being suitable to our state and condition, would only be pernicious to us. But it is hard; I dare to repeat it, it is hard, that being placed in a world so full of wants and necessities, where almost every being and element is either our foe or refuses its assistance . . . we should also have our own temper to struggle with, and should be deprived of that faculty which can alone fence against these multiplied evils.

The fourth circumstance, whence arises the misery and ill of the universe, is the inaccurate workmanship of all the springs and principles of the great machine of nature. It must be acknowledged, that there are few parts of the universe, which seem not to serve some purpose, and whose removal would not produce a visible defect and disorder in the whole. The parts hang all together; nor can one be touched without affecting the rest, in a greater or less degree. But at the same time, it must be observed, that none of these parts or principles, however useful, are so accurately adjusted, as to keep precisely within those bounds in which their utility consists; but they are, all of them, apt, on every occasion, to run into the one extreme or the other. One would

imagine, that this grand production had not received the last hand of the maker; so little finished is every part, and so coarse are the strokes with which it is executed. Thus, the winds are requisite to convey the vapours along the surface of the globe, and to assist men in navigation: but how oft, rising up to tempests and hurricanes, do they become pernicious? Rains are necessary to nourish all the plants and animals of the earth: but how often are they defective? how often excessive? Heat is requisite to all life and vegetation; but is not always found in the due proportion. On the mixture and secretion of the humours and juices of the body depend the health and prosperity of the animal: but the parts perform not regularly their proper function. What more useful than all the passions of the mind, ambition, vanity, love, anger? But how oft do they break their bounds, and cause the greatest convulsions in society? There is nothing so advantageous in the universe, but what frequently becomes pernicious, by its excess or defect; nor has Nature guarded, with the requisite accuracy, against all disorder or confusion. The irregularity is never perhaps so great as to destroy any species; but is often sufficient to involve the individuals in ruin and misery.

On the concurrence, then, of these four circumstances, does all or the greatest part of natural evil depend. Were all living creatures incapable of pain, or were the world administered by particular volitions, evil never could have found access into the universe: and were animals endowed with a large stock of powers and faculties, beyond what strict necessity requires; or were the several springs and principles of the universe so accurately framed as to preserve always the just temperament and medium; there must have been very little ill in comparison of what we feel at present. What then shall we pronounce on this occasion? Shall we say that these circumstances are not necessary, and that they might easily have been altered in the contrivance of the universe? This decision seems too presumptuous for creatures so blind and ignorant. Let us be more modest in our conclusions. Let us allow, that, if the goodness of the Deity (I mean a goodness like the human) could be established on any tolerable reasons a priori, these phenomena, however untoward, would not be sufficient to subvert that principle; but might easily, in some unknown manner, be reconcilable to it. But let us still assert, that as this goodness is not antecedently established, but must be inferred from the phenomena, there can be no grounds for such an inference, while there are so many ills in the universe, and while these ills might so easily have been remedied, as far as human understanding can be allowed to judge on such a subject. I am Sceptic enough to allow, that the bad appearances, notwithstanding all my reasonings, may be compatible with such attributes as you suppose; but surely they can never prove these attributes. Such a conclusion cannot result from Scepticism, but must arise from the phenomena, and from our confidence in the reasonings which we deduce from these phenomena.

Look round this universe. What an immense profusion of beings, animated and organized, sensible and active! You admire this prodigious variety and fecundity. But inspect a little more narrowly these living existences, the only beings worth regarding. How hostile and destructive to each other! How insufficient all of them for their own happiness! How contemptible or odious to the spectator! The whole presents nothing but the idea of a blind Nature, impregnated by a great vivifying principle, and pouring forth from her lap, without discernment or parental care, her maimed and abortive children!

Here the Manichaean system occurs as a proper hypothesis to solve the difficulty: and no doubt, in some respects, it is very specious, and has more probability than the common hypothesis, by giving a plausible account of the strange mixture of good and ill which appears in life. But if we consider, on the other hand, the perfect uniformity and agreement of the parts of the universe, we shall not discover in it any marks of the combat of a malevolent with a benevolent being. There is indeed an opposition of pains and pleasures in the feelings of sensible creatures: but are not all the operations of Nature carried on by an opposition of principles, of hot and cold, moist and dry, light and heavy? The true conclusion is, that the original Source of all things is entirely indifferent to all

these principles; and has no more regard to good above ill, than to heat above cold, or to drought above moisture, or to light above heavy.

There may four hypotheses be framed concerning the first causes of the universe: that they are endowed with perfect goodness; that they have perfect malice; that they are opposite, and have both goodness and malice; that they have neither goodness nor malice. Mixed phenomena can never prove the two former unmixed principles; and the uniformity and steadiness of general laws seem to oppose the third. The fourth, therefore, seems by far the most probable.

What I have said concerning natural evil will apply to moral, with little or no variation; and we have no more reason to infer, that the rectitude of the Supreme Being resembles human rectitude, than that his benevolence resembles the human. Nay, it will be thought, that we have still greater cause to exclude from him moral sentiments, such as we feel them; since moral evil, in the opinion of many, is much more predominant above moral good than natural evil above natural good.

But even though this should not be allowed, and though the virtue which is in mankind should be acknowledged much superior to the vice, yet so long as there is any vice at all in the universe, it will very much puzzle you Anthropomorphites, how to account for it. You must assign a cause for it, without having recourse to the first cause. But as every effect must have a cause, and that cause another, you must either carry on the progression in infinitum, or rest on that original principle, who is the ultimate cause of all things . . . .

Hold! hold! cried Demea: whither does your imagination hurry you? I joined in alliance with you, in order to prove the incomprehensible nature of the Divine Being, and refute the principles of Cleanthes, who would measure every thing by human rule and standard. But I now find you running into all the topics of the greatest libertines and infidels, and betraying that holy cause which you seemingly espoused. Are you secretly, then, a more dangerous enemy than Cleanthes himself?

And are you so late in perceiving it? replied Cleanthes. Believe me, Demea, your friend Philo, from the beginning, has been amusing himself at both our expense; and it must be confessed, that the injudicious reasoning of our vulgar theology has given him but too just a handle of ridicule. The total infirmity of human reason, the absolute incomprehensibility of the Divine Nature, the great and universal misery, and still greater wickedness of men; these are strange topics, surely, to be so fondly cherished by orthodox divines and doctors. In ages of stupidity and ignorance, indeed, these principles may safely be espoused; and perhaps no views of things are more proper to promote superstition, than such as encourage the blind amazement, the diffidence, and melancholy of mankind. But at present . . . . . .

Blame not so much, interposed Philo, the ignorance of these reverend gentlemen. They know how to change their style with the times. Formerly it was a most popular theological topic to maintain, that human life was vanity and misery, and to exaggerate all the ills and pains which are incident to men. But of late years, divines, we find, begin to retract this position; and maintain, though still with some hesitation, that there are more goods than evils, more pleasures than pains, even in this life. When religion stood entirely upon temper and education, it was thought proper to encourage melancholy; as indeed mankind never have recourse to superior powers so readily as in that disposition. But as men have now learned to form principles, and to draw consequences, it is necessary to change the batteries, and to make use of such arguments as will endure at least some scrutiny and examination. This variation is the same (and from the same causes) with that which I formerly remarked with regard to Scepticism.

Thus Philo continued to the last his spirit of opposition, and his censure of established opinions. But I could observe that Demea did not at all relish the latter part of the discourse; and he took occasion soon after, on some pretence or other, to leave the company.

Part XII.

After Demea's departure, Cleanthes and Philo continued the conversation in the following manner. Our friend, I am afraid, said Cleanthes, will have little inclination to revive this topic of discourse, while you are in company; and to tell truth, Philo, I should rather wish to reason with either of you apart on a subject so sublime and interesting. Your spirit of controversy, joined to your abhorrence of vulgar superstition, carries you strange lengths, when engaged in an argument; and there is nothing so sacred and venerable, even in your own eyes, which you spare on that occasion.

I must confess, replied Philo, that I am less cautious on the subject of Natural Religion than on any other; both because I know that I can never, on that head, corrupt the principles of any man of common sense; and because no one, I am confident, in whose eyes I appear a man of common sense, will ever mistake my intentions. You, in particular, Cleanthes, with whom I live in unreserved intimacy; you are sensible, that notwithstanding the freedom of my conversation, and my love of singular arguments, no one has a deeper sense of religion impressed on his mind, or pays more profound adoration to the Divine Being, as he discovers himself to reason, in the inexplicable contrivance and artifice of nature. A purpose, an intention, a design, strikes every where the most careless, the most stupid thinker; and no man can be so hardened in absurd systems, as at all times to reject it. That Nature does nothing in vain, is a maxim established in all the schools, merely from the contemplation of the works of Nature, without any religious purpose; and, from a firm conviction of its truth, an anatomist, who had observed a new organ or canal, would never be satisfied till he had also discovered its use and intention. One great foundation of the Copernican system is the maxim, That Nature acts by the simplest methods, and chooses the most proper means to any end; and astronomers often, without thinking of it, lay this strong foundation of piety and religion. The same thing is observable in other parts of philosophy: and thus all the sciences almost lead us insensibly to acknowledge a first intelligent Author; and their authority is often so much the greater, as they do not directly profess that intention.

It is with pleasure I hear Galen reason concerning the structure of the human body. The anatomy of a man, says he, 10 discovers above six hundred different muscles; and whoever duly considers these, will find, that, in each of them, Nature must have adjusted at least ten different circumstances, in order to attain the end which she proposed; proper figure, just magnitude, right disposition of the several ends, upper and lower position of the whole, the due insertion of the several nerves, veins, and arteries: so that, in the muscles alone, above six thousand several views and intentions must have been formed and executed. The bones he calculates to be two hundred and eighty-four: the distinct purposes aimed at in the structure of each, above forty. What a prodigious display of artifice, even in these simple and homogeneous parts! But if we consider the skin, ligaments, vessels, glandules, humours, the several limbs and members of the body; how must our astonishment rise upon us, in proportion to the number and intricacy of the parts so artificially adjusted! The further we advance in these researches, we discover new scenes of art and wisdom: but descry still, at a distance, further scenes beyond our reach; in the fine internal structure of the parts, in the economy of the brain, in the fabric of the seminal vessels. All these artifices are repeated in every different species of animal, with wonderful variety, and with exact propriety, suited to the different intentions of Nature in framing each species. And if the infidelity of Galen, even when these natural sciences were still imperfect, could not withstand such striking appearances, to what pitch of pertinacious obstinacy must a philosopher in this age have attained, who can now doubt of a Supreme Intelligence!

Could I meet with one of this species (who, I thank God, are very rare), I would ask him: Supposing there were a God, who did not discover himself immediately to our senses, were it possible for him to give stronger proofs of his existence, than what appear on the whole face of Nature? What indeed could such a Divine Being do, but copy the present economy of things; render many of his artifices so plain, that no stupidity could mistake them; afford glimpses of still greater artifices, which demonstrate his prodigious superiority above our narrow apprehensions; and conceal altogether a great many from such imperfect creatures? Now, according to all rules of just reasoning, every fact must pass for undisputed, when it is supported by all the arguments which its nature admits of; even though these arguments be not in themselves, very numerous or forcible: how much more, in the present case, where no human imagination can compute their number, and no understanding estimate their cogency!

I shall further add, said Cleanthes, to what you have so well urged, that one great advantage of the principle of Theism, is, that it is the only system of cosmogony which can be rendered intelligible and compleat, and yet can throughout preserve a strong analogy to what we every day see and experience in the world. The comparison of the universe to a machine of human contrivance, is so obvious and natural, and is justified by so many instances of order and design in Nature, that it must immediately strike all unprejudiced apprehensions, and procure universal approbation. Whoever attempts to weaken this theory, cannot pretend to succeed by establishing in its place any other that is precise and determinate: it is sufficient for him if he start doubts and difficulties; and by remote and abstract views of things, reach that suspense of judgment, which is here the utmost boundary of his wishes. But, besides that this state of mind is in itself unsatisfactory, it can never be steadily maintained against such striking appearances as continually engage us into the religious hypothesis. A false, absurd system, human nature, from the force of prejudice, is capable of adhering to with obstinacy and perseverance: but no system at all, in opposition to theory supported by strong and obvious reason, by natural propensity, and by early education, I think it absolutely impossible to maintain or defend.

So little, replied Philo, do I esteem this suspense of judgment in the present case to be possible, that I am apt to suspect there enters somewhat of a dispute of words into this controversy, more than is usually imagined. That the works of Nature bear a great analogy to the productions of art, is evident; and according to all the rules of good reasoning, we ought to infer, if we argue at all concerning them, that their causes have a proportional analogy. But as there are also considerable differences, we have reason to suppose a proportional difference in the causes; and in particular, ought to attribute a much higher degree of power and energy to the supreme cause, than any we have ever observed in mankind. Here then the existence of a DEITY is plainly ascertained by reason: and if we make it a question, whether, on account of these analogies, we can properly call him a mind or intelligence, notwithstanding the vast difference which may reasonably be supposed between him and human minds; what is this but a mere verbal controversy? No man can deny the analogies between the effects: to restrain ourselves from enquiring concerning the causes is scarcely possible. From this enquiry, the legitimate conclusion is, that the causes have also an analogy: and if we are not contented with calling the first and supreme cause a GOD or DEITY, but desire to vary the expression; what can we call him but MIND or THOUGHT, to which he is justly supposed to bear a considerable resemblance?

All men of sound reason are disgusted with verbal disputes, which abound so much in philosophical and theological enquiries; and it is found, that the only remedy for this abuse, must arise from clear definitions, from the precision of those ideas which enter into any argument, and from the strict and uniform use of those terms which are employed. But there is a species of controversy, which, from the very nature of language and of human ideas, is involved in perpetual ambiguity, and can never, by any precaution or any definitions, be able to reach a reasonable certainty or precision. These are the controversies concerning the degrees of any quality or circumstance. Men

may argue to all eternity, whether Hannibal be a great, or a very great, or a superlatively great man, what degree of beauty Cleopatra possessed, what epithet of praise Livy or Thucydides is entitled to, without bringing the controversy to any determination. The disputants may here agree in their sense, and differ in the terms, or vice versa; yet never be able to define their terms, so as to enter into each other's meaning: because the degrees of these qualities are not, like quantity or number, susceptible of any exact mensuration, which may be the standard in the controversy. That the dispute concerning Theism is of this nature, and consequently is merely verbal, or perhaps, if possible, still more incurably ambiguous, will appear upon the slightest enquiry. I ask the Theist, if he does not allow, that there is a great and immeasurable, because incomprehensible difference between the human and the divine mind: the more pious he is, the more readily will he assent to the affirmative, and the more will he be disposed to magnify the difference: he will even assert, that the difference is of a nature which cannot be too much magnified. I next turn to the Atheist, who, I assert, is only nominally so, and can never possibly be in earnest; and I ask him, whether, from the coherence and apparent sympathy in all the parts of this world, there be not a certain degree of analogy among all the operations of Nature, in every situation and in every age; whether the rotting of a turnip, the generation of an animal, and the structure of human thought, be not energies that probably bear some remote analogy to each other: it is impossible he can deny it: he will readily acknowledge it. Having obtained this concession, I push him still further in his retreat; and I ask him, if it be not probable, that the principle which first arranged, and still maintains order in this universe, bears not also some remote inconceivable analogy to the other operations of nature, and, among the rest, to the economy of human mind and thought. However reluctant, he must give his assent. Where then, cry I to both these antagonists, is the subject of your dispute? The Theist allows, that the original intelligence is very different from human reason: the Atheist allows, that the original principle of order bears some remote analogy to it. Will you quarrel, gentlemen, about the degrees, and enter into a controversy, which admits not of any precise meaning, nor consequently of any determination? If you should be so obstinate, I should not be surprized to find you insensibly change sides; while the Theist, on the one hand, exaggerates the dissimilarity between the Supreme Being, and frail, imperfect, variable, fleeting, and mortal creatures; and the Atheist, on the other, magnifies the analogy among all the operations of Nature, in every period, every situation, and every position. Consider then, where the real point of controversy lies; and if you cannot lay aside your disputes, endeavour, at least, to cure yourselves of your animosity.

And here I must also acknowledge, Cleanthes, that as the works of Nature have a much greater analogy to the effects of our art and contrivance, than to those of our benevolence and justice, we have reason to infer, that the natural attributes of the Deity have a greater resemblance to those of men, than his moral have to human virtues. But what is the consequence? Nothing but this, that the moral qualities of man are more defective in their kind than his natural abilities. For, as the Supreme Being is allowed to be absolutely and entirely perfect, whatever differs most from him, departs the furthest from the supreme standard of rectitude and perfection. 11

These, Cleanthes, are my unfeigned sentiments on this subject; and these sentiments, you know, I have ever cherished and maintained. But in proportion to my veneration for true religion, is my abhorrence of vulgar superstitions; and I indulge a peculiar pleasure, I confess, in pushing such principles, sometimes into absurdity, sometimes into impiety. And you are sensible, that all bigots, notwithstanding their great aversion to the latter above the former, are commonly equally guilty of both.

My inclination, replied Cleanthes, lies, I own, a contrary way. Religion, however corrupted, is still better than no religion at all. The doctrine of a future state is so strong and necessary a security to morals, that we never ought to abandon or neglect it. For if finite and temporary rewards and

punishments have so great an effect, as we daily find; how much greater must be expected from such as are infinite and eternal?

How happens it then, said Philo, if vulgar superstition be so salutary to society, that all history abounds so much with accounts of its pernicious consequences on public affairs? Factions, civil wars, persecutions, subversions of government, oppression, slavery; these are the dismal consequences which always attend its prevalency over the minds of men. If the religious spirit be ever mentioned in any historical narration, we are sure to meet afterwards with a detail of the miseries which attend it. And no period of time can be happier or more prosperous, than those in which it is never regarded or heard of.

The reason of this observation, replied Cleanthes, is obvious. The proper office of religion is to regulate the heart of men, humanize their conduct, infuse the spirit of temperance, order, and obedience; and as its operation is silent, and only enforces the motives of morality and justice, it is in danger of being overlooked, and confounded with these other motives. When it distinguishes itself, and acts as a separate principle over men, it has departed from its proper sphere, and has become only a cover to faction and ambition.

And so will all religion, said Philo, except the philosophical and rational kind. Your reasonings are more easily eluded than my facts. The inference is not just, because finite and temporary rewards and punishments have so great influence, that therefore such as are infinite and eternal must have so much greater. Consider, I beseech you, the attachment which we have to present things, and the little concern which we discover for objects so remote and uncertain. When divines are declaiming against the common behaviour and conduct of the world, they always represent this principle as the strongest imaginable (which indeed it is); and describe almost all human kind as lying under the influence of it, and sunk into the deepest lethargy and unconcern about their religious interests. Yet these same divines, when they refute their speculative antagonists, suppose the motives of religion to be so powerful, that, without them, it were impossible for civil society to subsist; nor are they ashamed of so palpable a contradiction. It is certain, from experience, that the smallest grain of natural honesty and benevolence has more effect on men's conduct, than the most pompous views suggested by theological theories and systems. A man's natural inclination works incessantly upon him; it is for ever present to the mind, and mingles itself with every view and consideration: whereas religious motives, where they act at all, operate only by starts and bounds; and it is scarcely possible for them to become altogether habitual to the mind. The force of the greatest gravity, say the philosophers, is infinitely small, in comparison of that of the least impulse: yet it is certain, that the smallest gravity will, in the end, prevail above a great impulse; because no strokes or blows can be repeated with such constancy as attraction and gravitation.

Another advantage of inclination: it engages on its side all the wit and ingenuity of the mind; and when set in opposition to religious principles, seeks every method and art of eluding them: in which it is almost always successful. Who can explain the heart of man, or account for those strange salvos and excuses, with which people satisfy themselves, when they follow their inclinations in opposition to their religious duty? This is well understood in the world; and none but fools ever repose less trust in a man, because they hear, that from study and philosophy, he has entertained some speculative doubts with regard to theological subjects. And when we have to do with a man, who makes a great profession of religion and devotion, has this any other effect upon several, who pass for prudent, than to put them on their guard, lest they be cheated and deceived by him?

We must further consider, that philosophers, who cultivate reason and reflection, stand less in need of such motives to keep them under the restraint of morals; and that the vulgar, who alone may need them, are utterly incapable of so pure a religion as represents the Deity to be pleased with nothing but virtue in human behaviour. The recommendations to the Divinity are generally

supposed to be either frivolous observances, or rapturous ecstasies, or a bigoted credulity. We need not run back into antiquity, or wander into remote regions, to find instances of this degeneracy. Amongst ourselves, some have been guilty of that atrociousness, unknown to the Egyptian and Grecian superstitions, of declaiming in express terms, against morality; and representing it as a sure forfeiture of the Divine favour, if the least trust or reliance be laid upon it.

But even though superstition or enthusiasm should not put itself in direct opposition to morality; the very diverting of the attention, the raising up a new and frivolous species of merit, the preposterous distribution which it makes of praise and blame, must have the most pernicious consequences, and weaken extremely men's attachment to the natural motives of justice and humanity.

Such a principle of action likewise, not being any of the familiar motives of human conduct, acts only by intervals on the temper; and must be rouzed by continual efforts, in order to render the pious zealot satisfied with his own conduct, and make him fulfil his devotional task. Many religious exercises are entered into with seeming fervour, where the heart, at the time, feels cold and languid: a habit of dissimulation is by degrees contracted; and fraud and falsehood become the predominant principle. Hence the reason of that vulgar observation, that the highest zeal in religion and the deepest hypocrisy, so far from being inconsistent, are often or commonly united in the same individual character.

The bad effects of such habits, even in common life, are easily imagined; but where the interests of religion are concerned, no morality can be forcible enough to bind the enthusiastic zealot. The sacredness of the cause sanctifies every measure which can be made use of to promote it.

The steady attention alone to so important an interest as that of eternal salvation, is apt to extinguish the benevolent affections, and beget a narrow, contracted selfishness. And when such a temper is encouraged, it easily eludes all the general precepts of charity and benevolence.

Thus, the motives of vulgar superstition have no great influence on general conduct; nor is their operation favourable to morality, in the instances where they predominate.

Is there any maxim in politics more certain and infallible, than that both the number and authority of priests should be confined within very narrow limits; and that the civil magistrate ought, for ever, to keep his fasces and axes from such dangerous hands? But if the spirit of popular religion were so salutary to society, a contrary maxim ought to prevail. The greater number of priests, and their greater authority and riches, will always augment the religious spirit. And though the priests have the guidance of this spirit, why may we not expect a superior sanctity of life, and greater benevolence and moderation, from persons who are set apart for religion, who are continually inculcating it upon others, and who must themselves imbibe a greater share of it? Whence comes it then, that, in fact, the utmost a wise magistrate can propose with regard to popular religions, is, as far as possible, to make a saving game of it, and to prevent their pernicious consequences with regard to society? Every expedient which he tries for so humble a purpose is surrounded with inconveniences. If he admits only one religion among his subjects, he must sacrifice, to an uncertain prospect of tranquillity, every consideration of public liberty, science, reason, industry, and even his own independency. If he gives indulgence to several sects, which is the wiser maxim, he must preserve a very philosophical indifference to all of them, and carefully restrain the pretensions of the prevailing sect; otherwise he can expect nothing but endless disputes, quarrels, factions, persecutions, and civil commotions.

True religion, I allow, has no such pernicious consequences: but we must treat of religion, as it has commonly been found in the world; nor have I any thing to do with that speculative tenet of

Theism, which, as it is a species of philosophy, must partake of the beneficial influence of that principle, and at the same time must lie under a like inconvenience, of being always confined to very few persons.

Oaths are requisite in all courts of judicature; but it is a question whether their authority arises from any popular religion. It is the solemnity and importance of the occasion, the regard to reputation, and the reflecting on the general interests of society, which are the chief restraints upon mankind. Custom- house oaths and political oaths are but little regarded even by some who pretend to principles of honesty and religion; and a Quaker's asseveration is with us justly put upon the same footing with the oath of any other person. I know, that Polybius 12 ascribes the infamy of Greek faith to the prevalency of the Epicurean philosophy: but I know also, that Punic faith had as bad a reputation in ancient times as Irish evidence has in modern; though we cannot account for these vulgar observations by the same reason. Not to mention that Greek faith was infamous before the rise of the Epicurean philosophy; and Euripides, 13 in a passage which I shall point out to you, has glanced a remarkable stroke of satire against his nation, with regard to this circumstance.

Take care, Philo, replied Cleanthes, take care: push not matters too far: allow not your zeal against false religion to undermine your veneration for the true. Forfeit not this principle, the chief, the only great comfort in life; and our principal support amidst all the attacks of adverse fortune. The most agreeable reflection, which it is possible for human imagination to suggest, is that of genuine Theism, which represents us as the workmanship of a Being perfectly good, wise, and powerful; who created us for happiness; and who, having implanted in us immeasurable desires of good, will prolong our existence to all eternity, and will transfer us into an infinite variety of scenes, in order to satisfy those desires, and render our felicity compleat and durable. Next to such a Being himself (if the comparison be allowed), the happiest lot which we can imagine, is that of being under his guardianship and protection.

These appearances, said Philo, are most engaging and alluring; and with regard to the true philosopher, they are more than appearances. But it happens here, as in the former case, that, with regard to the greater part of mankind, the appearances are deceitful, and that the terrors of religion commonly prevail above its comforts.

It is allowed, that men never have recourse to devotion so readily as when dejected with grief or depressed with sickness. Is not this a proof, that the religious spirit is not so nearly allied to joy as to sorrow?

But men, when afflicted, find consolation in religion, replied Cleanthes. Sometimes, said Philo: but it is natural to imagine, that they will form a notion of those unknown beings, suitably to the present gloom and melancholy of their temper, when they betake themselves to the contemplation of them. Accordingly, we find the tremendous images to predominate in all religions; and we ourselves, after having employed the most exalted expression in our descriptions of the Deity, fall into the flattest contradiction in affirming that the damned are infinitely superior in number to the elect.

I shall venture to affirm, that there never was a popular religion, which represented the state of departed souls in such a light, as would render it eligible for human kind that there should be such a state. These fine models of religion are the mere product of philosophy. For as death lies between the eye and the prospect of futurity, that event is so shocking to Nature, that it must throw a gloom on all the regions which lie beyond it; and suggest to the generality of mankind the idea of Cerberus and Furies; devils, and torrents of fire and brimstone.

It is true, both fear and hope enter into religion; because both these passions, at different times, agitate the human mind, and each of them forms a species of divinity suitable to itself. But when a man is in a cheerful disposition, he is fit for business, or company, or entertainment of any kind; and he naturally applies himself to these, and thinks not of religion. When melancholy and dejected, he has nothing to do but brood upon the terrors of the invisible world, and to plunge himself still deeper in affliction. It may indeed happen, that after he has, in this manner, engraved the religious opinions deep into his thought and imagination, there may arrive a change of health or circumstances, which may restore his good-humour, and raising cheerful prospects of futurity, make him run into the other extreme of joy and triumph. But still it must be acknowledged, that, as terror is the primary principle of religion, it is the passion which always predominates in it, and admits but of short intervals of pleasure.

Not to mention, that these fits of excessive, enthusiastic joy, by exhausting the spirits, always prepare the way for equal fits of superstitious terror and dejection; nor is there any state of mind so happy as the calm and equable. But this state it is impossible to support, where a man thinks that he lies in such profound darkness and uncertainty, between an eternity of happiness and an eternity of misery. No wonder that such an opinion disjoints the ordinary frame of the mind, and throws it into the utmost confusion. And though that opinion is seldom so steady in its operation as to influence all the actions; yet it is apt to make a considerable breach in the temper, and to produce that gloom and melancholy so remarkable in all devout people.

It is contrary to common sense to entertain apprehensions or terrors upon account of any opinion whatsoever, or to imagine that we run any risk hereafter, by the freest use of our reason. Such a sentiment implies both an absurdity and an inconsistency. It is an absurdity to believe that the Deity has human passions, and one of the lowest of human passions, a restless appetite for applause. It is an inconsistency to believe, that, since the Deity has this human passion, he has not others also; and, in particular, a disregard to the opinions of creatures so much inferior.

To know God, says Seneca, is to worship him. All other worship is indeed absurd, superstitious, and even impious. It degrades him to the low condition of mankind, who are delighted with entreaty, solicitation, presents, and flattery. Yet is this impiety the smallest of which superstition is guilty. Commonly, it depresses the Deity far below the condition of mankind; and represents him as a capricious demon, who exercises his power without reason and without humanity! And were that Divine Being disposed to be offended at the vices and follies of silly mortals, who are his own workmanship, ill would it surely fare with the votaries of most popular superstitions. Nor would any of human race merit his favour, but a very few, the philosophical Theists, who entertain, or rather indeed endeavour to entertain, suitable notions of his Divine perfections: as the only persons entitled to his compassion and indulgence would be the philosophical Sceptics, a sect almost equally rare, who, from a natural diffidence of their own capacity, suspend, or endeavour to suspend, all judgment with regard to such sublime and such extraordinary subjects.

If the whole of Natural Theology, as some people seem to maintain, resolves itself into one simple, though somewhat ambiguous, at least undefined proposition, That the cause or causes of order in the universe probably bear some remote analogy to human intelligence: if this proposition be not capable of extension, variation, or more particular explication: if it affords no inference that affects human life, or can be the source of any action or forbearance: and if the analogy, imperfect as it is, can be carried no further than to the human intelligence, and cannot be transferred, with any appearance of probability, to the qualities of the mind; if this really be the case, what can the most inquisitive, contemplative, and religious man do more than give a plain, philosophical assent to the proposition, as often as it occurs, and believe that the arguments on which it is established exceed the objections which lie against it? Some astonishment, indeed, will naturally arise from the greatness of the object; some melancholy from its obscurity; some contempt of human reason, that

it can give no solution more satisfactory with regard to so extraordinary and magnificent a question. But believe me, Cleanthes, the most natural sentiment which a well-disposed mind will feel on this occasion, is a longing desire and expectation that Heaven would be pleased to dissipate, at least alleviate, this profound ignorance, by affording some particular revelation to mankind, and making discoveries of the nature, attributes, and operations of the Divine object of our faith. A person, seasoned with a just sense of the imperfections of natural reason, will fly to revealed truth with the greatest avidity: while the haughty Dogmatist, persuaded that he can erect a compleat system of Theology by the mere help of philosophy, disdains any further aid, and rejects this adventitious instructor. To be a philosophical Sceptic is, in a man of letters, the first and most essential step towards being a sound, believing Christian; a proposition which I would willingly recommend to the attention of Pamphilus: and I hope Cleanthes will forgive me for interposing so far in the education and instruction of his pupil.

Cleanthes and Philo pursued not this conversation much further: and as nothing ever made greater impression on me, than all the reasonings of that day, so I confess, that, upon a serious review of the whole, I cannot but think, that Philo's principles are more probable than Demea's; but that those of Cleanthes approach still nearer to the truth.

Footnotes
1 Chrysippus apud Plut. de repug. Stoicorum.
2 L'art de penser.
3 Mons. Huet.
4 Recherche de la Verite, liv. 3, cap. 9.
5 Lib. xi. 1094.
6 De Nat. Deor. lib. i.
7 Dr. Clarke.
8 Republique des Lettres, Aout 1685.
9 That sentiment had been maintained by Dr. King, and some few others, before Leibnitz, though by none of so great fame as that German philosopher.
10 De Formatione Foetus.
11 It seems evident that the dispute between the Sceptics and Dogmatists is entirely verbal, or at least regards only the degrees of doubt and assurance which we ought to indulge with regard to all reasoning; and such disputes are commonly, at the bottom, verbal, and admit not of any precise determination. No philosophical Dogmatist denies that there are difficulties both with regard to the senses and to all science, and that these difficulties are in a regular, logical method, absolutely insolvable. No Sceptic denies that we lie under an absolute necessity, notwithstanding these difficulties, of thinking, and believing, and reasoning, with regard to all kinds of subjects, and even of frequently assenting with confidence and security. The only difference, then, between these sects, if they merit that name, is, that the Sceptic, from habit, caprice, or inclination, insists most on the difficulties; the Dogmatist, for like reasons, on the necessity.
12 Lib. vi. cap. 54.
13 Iphigenia in Tauride.

1780
Redige par L'abbé Viet, Prior Of St Ouen, Auteur de “Des Premiers Temps Du Monde Prouvée Par L'accord De La Physique Avec La Genèse”
Réflexions Sur Les Époques De La Nature, Par De Buffon

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Réduire la création de l'Univers à un système purement mécanique, c'est l'entreprise d'un Physicien téméraire qui 'veut se singulariser; ou plutôt, c'est le désire d'un savant Philosophe, qui veut donner à la Nature le droit de partager avec Dieu la toute-puissance.

Pour parler d'un ouvrage si singulier & si incompréhensible, il faut consulter son cœur, & se défier de son esprit; il faut examiner de bonne foi, s'il y a un Être éternel; & se bien pénétrer de sa puissance; c'est un crime contre soi-même, & un attentat contre la société, de traverser sur un article aussi important.

Faire dépendre d'un arrangement physique tant de merveilles, si fort au dessus de l'homme, & de la Nature, toujours dépendante d'un premier Auteur, c'est souvent le comble de l'égarement de l'esprit, & presque toujours le fruit de la prévention & de l'amour-propre. Celui qui évite d'établir l'existence de Dieu, ne s'occupe point de sa toute-puissance; il écarte avec adresse tout ce qui pourroit la rappeler: il ne songe qu'à mettre toute la Nature en action; elle est entre ses mains la créatrice universelle, & sa fécondité ne l'altère jamais. Les loix physiques semblent être en mouvement de toute éternité; elles se sont établies sans le concours d'aucune puissance supérieure, & sa seule Nature est le Dieu de l'Univers.

Un Ecrivain qui avouerait l'existence de Dieu, qui, malgré cet aveu, attribue oit à un autre agent les effets de la toute-puissance, & ajouteroit à tout cela une profession de foi solonnelle, paroîtront sans doute à nos yeux un homme inconséquent, timide & craintif, un homme qui, par des raisonnemens entortillés, voudroit se réserver une porte, pour sortir de l'embarras de la censure qu'il craint) car il n'est pas douteux que la toute-puissance qu'il attribue à la Nature, dégrade l'Être qui ne seroit pas Dieu, sans cette prérogative essentielle. Il n'y a donc qu'un homme tout-à-fait enivré de system & de nouveautés, qui puisse avancer un paradoxe aussi outré.

L'Auteur de l'Histoire naturelle est sans doute bien éloigné d'un pareil reproche. Sa déclaration n'est pas équivoque. Il soumet, il ne dit pas ses écrits, mais ses pensées aux vérités révélées, qu'il regarde comme des axiomes immuables; & quand même, ajoute-il, le plan de son ouvrage ne s'accorderoit pas entièrement avec ces vérités qu'il reconnoît incontestables, il faudroit juger ses intentions, & se rappeler qu'il ne propose qu'un système purement hypothétique, & que, quelque vraisemblable qu'il puisse être, il laisse les vérités révélées dans leur entier, & ne peut mettre aucune entrave à la croyance reçue. Rien de si honnête & de si désintéressé que ce raisonnement; il est fait pour contenter tout le monde.

On doit également approuver le commentaire grammatical fait sur les premiers versets de la Genèse: on prétend qu'ils avoient besoin de cette explication qui développe leur véritable sens, & qui met l’homme à portée de sentir la progression successive des merveilles du Créateur, chaque nouvelle découverte est à ses yeux comme un nouveau miracle qui doit réveiller l'admiration de l'homme, & Ton respect pour l'Etre Suprême.

On convient qu'il n'est pas possible que les sciences, par elles-mêmes, aient affoibli dans l'homme la connaissance de l'Être $suprême ni celle de la Religion; mais il faut aussi convenir que l'orgueil & l'amour propre ont obscurci sa raison & égaré son esprit. Son goût pour les sciences est devenu un prétexte pour en abuser; les sophismes & les argumens insidieux ont rempli toutes ces idées; il a substitué aux vérités les plus évidentes les hypothèses les plus fausses & les plus ridicules; & bien loin que ce genre de Savans concoure à la perfection des sciences, il ne s'occupe au contraire qu'à inventer des subtilités pour mieux en abuser.

Mais à qui fera-t-on croire que les découvertes dans l'ordre physique n'aient pas produit un effet tout contraire?

En effet les œuvres de Dieu font-elles plus admirées, depuis qu'on fait que la terre & les autres planètes tournent autour du Soleil?

Est-on plus attaché à Dieu, depuis que Newton a expliqué la cause des couleurs de l'arc en ciel?

L'idée de la grandeur de Dieu a-t-elle augmenté, depuis qu'on croit savoir que le Soleil est à 30 ou 300 millions de lieues de distance de la terre?

Les calculs qui annoncent le passage de Vénus sous le disque du Soleil, & qui ont fait voyager tant de Savans, ont-ils ajouté quelque degré à l'idée qu'on avoit de Dieu? Ne font-ce pas ces sciences au contraire, qui, par l'abus qu'on en fait, ont contribué à affoiblir parmi les Savans le respect pour les vérités de la Religion? Et leur exemple n'est il pas devenu funeste même au simple peuple?

Quand on saura que la terre a été en fusion pendant 34.000 ans, qu'elle a ensuite été inondée durant 10000 autres années, que ces eaux renfermoient des molécules organiques de tous les espèces qui ont; produit tous les êtres vivans, sans que Dieu y ait eu aucune part; si, dis-je, on venoit à bien de persuader aux hommes ces espèces d'impiétés, qu'on donne pour des découvertes qui font honneur à la Divinité, loin de les en rapprocher,comme on l'annonce, ils deviendroient au contraire des hommes vains, des hommes plus injustes & plus indépendans; des homme qui s'accourcisseroient à oublier Dieu & à ne considérer que la Nature; des hommes qu'aucun frein ne pourroit arrêter, qui se livreroient à tous les excès, sans que rien pût les rappeller à leurs devoirs. Qu'on ne dise pas que la loi du Prince y suppléera; quand les oracles de la Divinité font muets, la loi des hommes est impuissante. Avouons-le à la honte, je ne dis pas des sciences, mais de la plupart des Savans qui nous inondent depuis trente ans. Qu'ont ils fait pour glorifier Dieu? Où plutôt, que n'ont-ils pas fait pour le méconnoître? Disons plutôt que ces découvertes, quelles soient, ont plutôt aveuglé l'esprit des hommes qu'elles ne l'ont éclairé. On sent bien que les Savans ne sauroient rien découvrir qui n'ait été fait par Dieu, que ces développement graduels, inventés pour favoriser leurs hypothèses, font au-dessus de la grandeur & de la puissance de l'Etre infini qui a créé tout ce qui existe par fa seule volonté. La gloire du Créateur n'est donc point du tout intéressée à ces détails d'actes multipliés, ni à ces développements dont on décore la Nature. Elle n'est que l'instrument que Dieu même a formé pour conserver l'ordre qu'il a universellement établi.

L'étoile invisible à nos yeux, que l'Astronome découvre, n'ajoute pas plus à la gloire de Dieu que la terre inconnue où le voyageur arrive; l'un & l'autre étoient faits au moment de la création; il falloit imaginer des moyens capables de rapprocher ces globes lumineux trop éloignés;. Il falloit construire des vaisseaux pour arriver aux terres séparées par les eaux. Il ne s'est fait aucun changement dans le Ciel, depuis que Dieu l'a créé au commencement des tems, & les révolutions des astres sont les mêmes depuis leur création. Les variations que le globe de la terre a éprouvées, sont une suite nécessaire de la circulation des eaux, de l'agitation des vents, de la conformation utile ses matières combustibles, & des travaux lue Dieu avoit réservés aux hommes.

Il faut pourtant avouer que l'hypothèse qui donne à la Nature tant de prérogatives, est séduisante autant qu'ingénieuse. L'Auteur qui connoit fa supériorité, prévient que l'ouvrage qu'il propos, n'est pas fait pour les hommes ordinaires, ni pour ceux qui font trop brillement attachés à la lettre des traditions sacrées, dont ils ne veulent pas s'écarter, soit par respect, soit par foiblesse. Son système longtems médité & réfléchi, n'et fait, selon lui, que pour des hommes instruits, & dont les lumières font à l'abri des préjugés.

C'est dommage que l'Histoire de la Nature, d'ailleurs si curieuse & si intéressante, soit en contraste avec celle de Moïse sur la création. Le récit des époques anéantit, ou tend à anéantir le texte de la

Genèse. Rien ne ressemble plus au défi honteux que firent à Moïse les Magiciens de Pharaon. L'événement fera le même, & les époques tomberont dans l'oubli &c.

Le Livre de Moïse, qu'on peut appeller le Livre de Dieu même, fera toujours révéré; en vain veut-on le rendre inutile, et peut-être ridicule; en vain veut-on donner aux hommes des renseignements plus clairs sur tout ce qui a été fait, & sur la manière dont tout a été formé; en vain, nous dit-on que le voile de l'erreur vient d'être levé, que la révélation est une chimère, que nous avons actuellement des guides infaillibles, que la Nature les a placés comme exprès, pour que l'homme les considère; & qu'enfin chaque révolution qu'elle a éprouvée, a laissé des traces ineffaçables, pour qu'il ne se trompât point sur son origine & son antiquité. Dès qu'on croit aux vérités révélées, dès qu'on regarde Moïse comme l'interprète de Dieu, tous les raisonnements qu'on lui oppose, font des erreurs.

Malgré cela, on prétend tirer, da premier chapitre de la Genèse, des inductions qui favorisent le système des époques.

La création du ciel & de la terre, & de toute cette matière informe que nous avons vue dans les premières paroles de Moïse, a précédé les six jours qui ne commencent qu'à la création de la lumière: Dieu a voulu faire & marquer l'ébauche nie son ouvrage avant que d'en montrer la perfection: & après avoir fait d'abord le fond du monde, il en a voulu faire l'ornement avec six différens progrès qu'il a voulu appeller six jours, & il faisoit ces six jours l'un après l'autre, comme il faisoit toutes choses, pour faire voir qu'il leur donne l'être, la forme, la perfexion, comme il lui plaît, autant qu'il lui plaît.

Ainsi il fait la lumière avant que de faire les grands luminaires où il voulut la ramasser, S'il a fait la distinction des jours avant que d'avoir créé les astres, dont il s'est servi pour les régler parfaitement, & le soir & le matin ont été distingués avant que leur distinction & la division parfaite du jour & de la nuit fût bien marquée: & les arbres & les arbustes & les herbes ont germé sur la terre par ordre de Dieu, avant qu'il eût fait le Soleil qui devoit être le père de toutes les plantes, & il a détaché exprès les effets d'ave*

On y trouve que Dieu n'a créé que les matières dont un autre agent s'est servi, pour former le ciel & la terre, se qu'ils sont. Nous convenons que le ciel le la terre que Dieu a créés au commencement des tems, peuvent être plus anciens que les développemens & les différentes productions qui en ont été la suite; mais nous ne convenons pas qu'il a fallu à Dieu des siècles multipliés, pour leur faire prendre les différentes formes que nous en voyons, & nous ne convenons pas leurs causes naturelles, pour montrer que naturellement tout ne tient que de lui & ne dépend que de sa feule volonté. Ainsi la création de l'Univers, comme Dieu l'a voulu faire, & comme il en a inspiré le récit à Moïse, nous donne les vraies idées de sa puissance, & il nous fait voir que, 'il a astreint la Nature à certaines loix, il ne s'y avaient lui-même qu'autant qu'il lui plaît, se réservant le pouvoir suprême de détacher les effets qu'il voudra, des causes qu'il leur a données dans 'ordre commun, & de produire ces ouvrages extraordinaires que nous appelions miracles, selon qu'il plaira à sa Sagesse éternelle de les dispenser. Que tous ces siècles aient été figurés par les six jours que Moïse fait employer à Dieu, pour compléter l'ouvrage de la création.

C'est une risée de dire, qu'excepté la création du ciel & de la terre, qu'on restreint à la création de la matière seulement, c'est, dis-je, une forte de blasphème de vouloir prouver que Dieu n'a rien créé depuis; que les expressions de son interprète confirment cette vérité, & qu'il semble même éviter de se servir du mot de créer, dans les actes qui ont suivi la création. Il fait la lumière, & la sépare des ténèbres; il fait le firmament, sans le créer; il fait le Soleil, la Lune & les Etoiles, sans les créer, parce que, continue l'Auteur des époques, il savoit que ces magnifiques productions devoient être l'ouvrage du tems, & qu'il laissoit par-là les hommes maîtres de donner à ce tems

toute l’étendue dont ils auroient besoin pour calcule les opérations confiées à la Nature; d'où il s'ensuit que Dieu, après avoir créé la matière du ciel & de la terre, s'est reposé & ne s'est plus mêlé du reste.

C'est alors que tous les agens de la Nature se sont rassemblé, pour être les manœuvres du grand ouvrage de l'Univers. Plus lente dans ses opérations que la Divinité dans ses œuvres, il lui a fallu des milliers de siècles pour le faire arriver à la perfection où il est; il a fallu mettre le feu au globe de la terre, pour corriger ses défectuosités & lui donner la forme qu'elle a; il a fallu entretenir ce feu pendant 34000 ans, (calcul fait & vérifié) afin que toutes les matières que Dieu y avoit mises, soufflent entièrement fondues, calcinées, vitrifiées; il a fallu encore que ces mêmes agens de la Nature fissent dans l'atmosphère des réservoirs pour y loger & retenir toutes les vapeurs qui devoient s'exhaler de tant de matières bouillantes; enfin, il a fallu que la Nature & ses agens réactant dans l'inaction pendant 35 ou 36 ans, terme consacré par les loix de la Physique, pour parvenir à l'attiédissement du globe embrasé depuis si long-tems.

La terre alors plus sèche & plus aride qu'elle n'étoit le jour de fa création, avoit besoin d'être humectée. La Nature reprit aussi-tôt Tes opérations suspendues. Toujours vigilants, elle réprisit le moment de rendre, à la terre refroidie, l'humidité qu'elle avoit perdue pendant son embrasement. Elle rompit tout-à-coup les digues qui retenoient depuis si long-tems les eaux dans l’atmosphère. Elles tombèrent pendant 10,000 ans, sans sceller un moment, & inondèrent, non seulement la surface du globe, mais couvrirent encore les montagnes les plus élevées.

Tel a été le déluge formé par les loix de la Nature. Il nous a été transmis sans Prophètes & sans Apôtres; elle a sans doute donné à l'Ecrivain qui nous le révèle, un chiffre que lui seul pouvoit deviner.

La Nature ne fait rien contre ces loix immuables; les vapeurs qui s'étoient élevées de la terre par un effet naturel, y sont descendues par un effet tout pareil. Leur réunion dans l'atmosphère aussi bizarre qu'incroyable, produisit un déluge encore plus ridicule & plus inconcevable; ce déluge n'étoit pas, comme celui de Moïse, un ligne de mort & de destruction; la Nature est la mère tendre de tous les êtres; elle ne veut ni punir ni détruire. Ces eaux, loin d'être menaçantes, portoient partout la bienfaisance. Elles renfermoient dans leur sein le germe de toutes les productions. Fécondées par la puissance de cette mère généreuse, tous les êtres possibles devoient sortir d'elles: unies à la chaleur que la terre avoit conservée, les molécules organiques se réunirent pour se développer dans elles; & bientôt les poissons de tout genre, les animaux aquatiques de toute espèce, parurent dans les eaux qui couvroient encore la terre.

Cette première production devoit servir de premier monument à l'Auteur des époques, pour prouver l'antiquité du monde & établir Son hypothèse.

Les poissons alors n’habitoient pas dans la profondeur des eaux, c'est toujours dans les montagnes qu'on trouve leurs dépouilles, leurs squelettes, leurs écailles.

C'est donc pendant que les eaux se s’etiroient, c'est-à-dire, au moment de leur naissance, que ces animaux se trouvent arrêtés dans les sinuosités & autres cavités des montagnes, pour y laisser les preuves que nous y trouvons de leur ancienne existence.

A peine les eaux furent-elles rassemblées dans les profondeurs que la Nature leur avoit destinées, que d'autres animaux parurent sur la terre encore. Brûlante y-fut-y tout dans son milieu. Mais la Matière sage & prévoyante, eut soin de les placer à l'endroit le moins épais du globe, où la chaleur étoit moins sensible. Ces animaux quadrupèdes nouvellement formés, nouvellement arrivés, étoient d'une grandeur énorme; la Nature alors sembloit prodiguer fon sperme trop abondant, ces animaux

se trouvèrent habiter fur les Pôles, où la chaleur plus douce leur étoit plus analogue. On dit qu'ils s'y multiplièrent prodigieusement; mais ce degré de chaleur du pôle qui leur étoit propre, ne dura qu'un tems. Cette partie du globe faite pour être froide, rentra dans sa défumation, & bientôt les hippopotames, les rhinocéros, les éléphans, tous habitans de ce malheureux coin de terre, périrent de froid & de misère; mais ce désastre étoit prévu par la Nature, & devoit servir à ses desseins. Aussi forment-ils le monument le plus intéressant & le plus digne de l'hypothèse.

En effet les squelettes & les offerans de ces animaux qu'on trouve aujourd'hui dans les contrées du Nord, font des monumens précieux qui servent de base au système des époques. Car point d'élémens, point d'hypothèse, point d*ossemens, point d'époques; point d'animaux surpris & morts de froid sous le pôle qu'ils habitoient depuis longtems, plus de système à proposer; Moïse n'aura pas de peine à conserver tous ses droits.

On ne demandera pas à l'Auteur des époques par quelle magie de la Nature ces animaux ont été faits & envoyés fi inconsidérément, pour habiter une terre où ils devoient périr sans ressource & sans exception. Cette conduite de la Nature, si douce & si bienfaisante, n'est pas un chef-d'oeuvre de prévoyance, estan contraire une espèce de barbarie.

On peut demander encore si la Nature avoit placé des hommes dans ce climat funeste. L'affirmative est délicate, & l'Auteur des époques n'a jamais voulu se faire cette question. Il ne s'est occupé que du développement de la matière, & aussi des animaux.

Ce n'est qu'à la septième époque que, sans aucun événement qui y prépare, sans aucune indication, on trouve des hommes sur la terre, pèle mêle avec les animaux les plus féroces, sans savoir comment, ni par où ils y sont arrivés: malgré cette obscurité d'origine, on s'en sert pour prouver qu'il existoit des hommes, un grand nombre de siècles avant celui que Dieu créa de sa propre main.

D'après des témoignages aussi obscurs, des monumens si peu certains & des faits si bien arrangés, on peut comparer tout l'ouvrage à un grand édifice, dont l'architecture est exquise & les fondations sciences, ou à un tableau qui n'a d'autres mérite que le coloris, ou enfin, au plaidoyer d'un Avocat célèbre qui enchante: qui étonne, en plaidant une mauvaise cause. On ne faudroit douter que l'Histoire de Création, dictée à Moïse par le Créateur même, ne fois un chef-d'œuvre d'essence, que la (implicite du récit ne le ide noble & sublime; tout v annonce Divinité, ou plutôt, c'est la Divinité annonce tout, qui agit par-tout. Le it suit à sa parole, & sa voix fait tout r de l'abîme.

Faire ou créer dans cette occasion a toujours signifié la même chose chez tous les gens sensés. Dieu a donc fait ou créé la lumière, le firmament, & tous les corps lumineux, compris tous le mot d'étoiles, par différens actes de la même puissance, par laquelle il avoit créé le ciel & la terre.

Il est vrai que la terre étoit informe au moment de sa création; il est vrai que les ténèbres la couvroient; il est vrai que l'esprit de Dieu étoit porté sur les eaux, mais il n'est pas moins vrai que tous ces imparfaits ne sauroient signifier qu'elle sois restée dans cet état autant de milliers d'années qu'il en falloit pour arranger le système des époques. L'imparfait du Verbe ne signifie pas plus un espace très long qu'une durée très courte. Il falloit avoir grand besoin d'une longue étendue de tems, pour donner aux imparfaits de la Genèse une signification si forcée. Oui, la terre étoit informe au moment de fa création, mais ce mot étoit, ne signifié qu'elle soit restée long-tems; Dieu a l'instant d'après lui donner la forme; nous lui voyons, & le texte nous t'entendre qu'il l'a exécuté très vite. Moïse, instruit par l'esprit de Dieu de >ut ce qui s'étoit passe, l'a tramais au peuple dont il étoit le chef, d'une manière simple & naïve: c'étoit l'unique moyen de le faire entendre, & d'inspirer en même tems un grand respect: pour Dieu; il a dû s'atteindre aux expressions du seul idîôme que ce Peuple connoissait; il n'avoit point d'intérêt à raccourcir le tems qui avoit été employé à la création: il s'est servi, pour rendre ce que l'esprit de Dieu. Lui avoit inspiré, des termes d'une

langue pauvre, quoique très énergique, & les six espaces distinguées par les six jours, ne sauroient signifier qu'un tems très-limité. Si le langage des époques étoit celui de la vérité, il ne seroit pas contradictoire à celui de Moïse inspiré par la vérité même.

Si M. de Buffon, avant d'interpréter si légèrement les premiers versets de la Genèse, s'étoit donné la peine de lire les élévations de M. Bossuet sur la création.

Le dessein de Dieu dans la création Se dans la description que le Saint-Esprit en a dit à Moïse, est de se faire connoître d'abord comme le Tout-puissant & très-libre Créateur de toutes choses, qui sans être astreint à autre loi qu'à celle de sa volonté, avoir tout fait sans besoin & sans contrainte par sa seule & pure bonté. C'est pourquoi, lui qui pouvoir, par un seul décret de sa volonté, « créer & arranger toutes choses, en a voulu néanmoins suspendre avec ordre l'efficace de son action, Se faire en six jours ce qu'il pouvoit faire en un instant.

Dieu dit que la lumière soit: & la lumière fut. Dieu n'a point de lèvres à remuer, Dieu né frappe point l'air avec une langue pour en tirer quelque son; Dieu n'a qu'à vouloir en lui même Se tout ce qu'il veut éternellement, s'accomplit comme il a voulu, et au tems qu'il a marqué. Il dit donc que la lumière soit, et elle fut; qu'il y ait un firmament, & il y en eut un; que les faux s'assemblent, & elles furent actionnables; qu'il s'allume deux grands luminaires, 6* ils s'allumèrent; qu'il forte des animaux, & il en finit, Six. Il a dit, six les choses ont été faites: il a corn k sur les six jours, il auroit peut-être donné une autre tournure à l'explication qu'il en donne. MM. Bossuet & Buffon sont deux savans qui ne différent dans leurs écrits que par le but qu'ils se propose. L'un ne fait que célébrer la Nature, à qui il consacre tout l'art de fon pinceau. L'autre ne s'occupe que des grandeurs de la toute-puissance de Dieu; en peignant les actes de la Divinité, il peint la Divinité même. Son style est plein d'énergie, de majesté & d'oraissons. Tout ce qu'il dit enchante & persuade, il semble qu'il soit inspiré lui-même, quand il développe le texte inspiré & dicté par l'Esprit de Dieu. Il aplanit tous les doutes qu'on jette sur cette matière, il rend raison de tout: il satisfait fur ce que la lumière a été faite avant les globes qui devoient la recevoir; il explique pourquoi Dieu a fait la distinction des jours avant que d'avoir créé les astres qui devoient les régler, &c. en un mot, que l'on compare l'Ouvrage de M. Bossuet sur la Création, avec celui de M. de Buffon; sur les Epoques de la Nature: ils subsistent l'un & l'autre. Qu'on les lise, qu'on les médite, qu'on les réfléchisse, & que l'intégrité les juge.

On conçoit difficilement, ou plutôt, on ne conçoit pas, pourquoi les Physiciens & les Astronomes refusent si opiniâtrement à Dieu le développement de la matière qu'il avoit créée. Les expériences des uns & les calculs des autres en sociétés moins des sciences curieuses & sublimes, quand Dieu seul en seroit l'objet? & encore une fois, n'est-il pas honteux de prodiguer à la Nature un encens qui n'est dû qu'à son Auteur.

Que ces développemens aient été plus lentes ou plus promptes, ces belles sciences n'y perdent rien; c'eût été des champs différens qu'ils eussent labourés différemment. Les développemens successifs qu'on vient d'imaginer, intéressent beaucoup moins les sciences que les Savans; si le plan n'est pas neuf, l'élégance est nouvelle respec: qu'on étale pour la tradition sacrée, ne paroit être qu'un mot qui se confond avec l'idée peu avantageuse qu'on donne à l'Auteur de cette même tradition dont on ne doit jamais s, écarter qu'autant quelle est directement opposée à la fasse raison.

Plus un homme est vain, pi us il imagine avoir la raison la plus saine de son côté;& d'après cette opinion, l'examen particulier peut devenir légitimement la règle de chacun: & si la Loi de Dieu, comme celle du Prince, se trouvent opposées à la saine raison de chaque particulier, il deviendra le maître de ne s'y pas conformer. Telle est la conséquence qu'on peut tirer des principes répandus dans les époques. Au reste la raison toujours subordonnée, n'est point poire pour résister ces espèces d'obscurités qu'elle croit trouver dans les vérités révélées. Celle des Physiciens & des

Agronomes, quoi qu'ils en disent, n'a pas plus de privilège que celle des autres; elle ne diffère, parmi nous, que comme le plus de richesses, qui ajoute toujours à l'ostentation & rarement au mérite.

Si l'Auteur des époques avoit employé son esprit à bâtir un système d'après ces vérités, s'il s'étoit occupé à les faire valoir, comme il s'est attaché à les affoiblir, il auroit plu aux gens de toutes les religions, de tous les ordres, & n'auroit révolté personne: il auroit également prouvé que la lumière des corps célestes, que les révolutions des planètes, que les phénomènes qui nous environnent, ne font que les effets & les fuites des Loix que Dieu a établies: que la physique & l'astronomie ne sont autre chose que l'étude 8c la connoissance de ces mêmes Lobe, & qu'on reconnoissant qu'elles sont l'ouvrage de Dieu, on n'en est pas moins grand Physicien & grand Astronome.

Reconnoître Dieu dans tout ce qui a été fait, c'est la science qu'il avoit réservée à l'homme; mais donner à ces ouvrages des causes hasardées & puisées dans la seule puissance de la Nature, c'est donner lieu à l'erreur. On a toujours cru que la Nature n'avoit & ne pouvoit avoir aucune force, aucune vertu qui ne dépendît immédiatement de Dieu. Il a confié une portion de sa propre puissance à toutes les causes secondes, elles agissent consciemment, sans pouvoir s'écarter des Loix qui leur ont été prescrites.

Le Soleil tourne autour de lui même; toutes les planètes circulent autour de la terre, que nous voyons de plus près; nous paroît avoir des révolutions particulières, des tremblemens, des éruptions, des volcans, des inondations, &c. tous ces événemens sont les effets des matières différentes, dont Dieu a formé le globe en le créant. Ces feux souterrains, ces secouffes violentes,peuvent faciliter la nutrition & aider à la coction des métaux & des minéraux. Elles excitent encore une sublimation qui peut être utile à toutes les autres productions de la terre, elles la débarrassent de ces sortes nuisibles qui sont autant d'obstacles à la réunion des agens prolifiques; semblable au corps humain foible & malade, qui reprend fa force & fa vigueur, après avoir souffert les peines 6c les désagrémens d'un médicament salutaire. Jamais l'Auteur des Epoques ne fera croire à personne qu'un feu de fusion, qui a duré 34.000 ans, ait pu laisser dans le globe les matières telles que nous les y voyons: on dit qu'il le démontre mathématiquement: je laisse aux Savans le soin d'en vérifier les preuves. Je n'ai nulle prétention personnelle, je n'ai nulle envie de répondre aux Epoques, & encore moins de les critiquer: je réclame seulement l'autorité de Moïse & la cause de l'Etre Suprême, que je trouve compromise dans tout l'ouvrage. Je fais que les grandes sciences ne sont pas toujours bien in scrupuleuses, & qu'elles s'arrogent souvent!é droit de confondre les vérités avec les incertitudes. Je vois dans les Epoques, qu'on multiplie les tems & les siècles à son gré, pour arranger l'Univers selon ses caprices.

Tout système qui dégrade la puissance d'un Dieu créateur de tout, est bien près d'en insinuer la non-existence; il est toujours le fruit de l'incrédulité; il porte avec lui l'empreinte du matérialisme, & ceux qui le publient, s'estiment assez peu pour croire que les facultés de leur esprit, leurs talens, leur aptitude aux sciences, dépendent uniquement de leur organisation; parce que la matière seule peut prendre toutes les formes possibles & les multiplier à l'infini.

Il est honteux que le matérialisme soit devenu l'idole de ceux qui font profession des sciences, qui ne sont faites que pour mieux annoncer la grandeur & la puissance de la Divinité.

Tous les Peuples, les Savons de toutes les Nations n'ont presque jamais fait d'autre usage de leurs sciences, quelques profondes, quelques sublimes qu'elles aient été.

Aujourd'hui, ceux qui les représentent, ne savent à qui attribuer tant de merveilles. Depuis qu'ils croient avoir fouillé dans les vieux titres de la Nature, ils sont tentés de lui donner la préférence sur le Créateur de la Nature même.

Les hasards des Spinosistes, long-tems combattus, toujours détruits, semblent reparoître sous des formes plus agréables & plus captieuses.

Pour ne pas répéter ce qu'ont dit les Athées, & pour éviter la réclamation générale, on fait de tems en tems un petit compliment à l'Etre Suprême; c'est tout ce qu'on peut accorder à Dieu dans la confection de l'Univers, on lui donne le seul mérite d'avoir créé une masse de matière informe, abandonnée aux soins & à la vigilance de la Nature; & l'on sais entendre qu'elle a su mettre le feu à cet masse de matière, pour mieux la pénétrer, & qu'il eu est sorti successivement tout l'Univers, tel qu'il est aujourd'hui. Cette nouvelle fable, dans quelques siècles, pourra prendre du crédit, fi les Philosophes de celui-ci se succèdent pour la vanter.

Les hommes les plus savans ne sont pas exempts des vices du siècle, & surtout de la légèreté de celui-ci. On la voit percer à travers leur philosophie; on la voit dans les ouvrages qui ont le plus de droit à la célébrité; on la voit dans le jugement qu'ils portent des Savans qui les ont précédés; & la frivolité fait aujourd'hui fut les sciences, sur les esprits, sur les mœurs, tout ce qu'on lui Voit faire fur les modes. Tous les Ecrits de Voltaire font timbrés de fa façon: Moïse & la Religion n'ont pas été exempts de la légèreté de ses censures: quoi qu'il en soit, son bel esprit s'est envolé, mais ses impiétés nous sont restées. Tel est le goût dominant du siècle, que le Gouvernement n'a peut-être pas allez prévu.

Le règne de Louis XIV a produit des Savans d'une toute autre trempe. Par exemple, on voit dans M. Bossuet, non un Evêque gonflé de préjugés, mais un Ecrivain éclairé, peine de sagesse & de bonne foi, qui parcourt l'histoire des tems les plus reculés, qui remonte aux époques les plus anciennes, présentant toujours des preuves qui tiennent à l'évidence, qui a recherché l'origine du monde dans tous les monumens possibles. La critique l'a respecté, & l'Europe l'a admiré. Si ce Savant, si ce génie vivoit aujourd'hui, on lui feroit voir qu'il n'a pas connu l'antiquité, & que ses recherches sont des inutilités. M. Bailly lui prouveroit qu'il vient de découvrir un Peuple qui devoir exister tres-florissant il y a plus de 20000 ans, que l'erreur de la création est évidente, & que si le monde n'avoit pas au, moins 77000 ans, les sciences, & singulièrement l'astronomie, n'auroient pu acquérir cette perfection dont les Philosophes Chinois nous ont laisse des monumens puisés chez des peuples bien plus anciens qu'eux.

Ces monumens sont, la science agronomique, presqu'aussi perfectionnée dans ces tems reculés qu'elle l'est aujourd'hui. Or cette perfection ne sauroit s'acquérir que par une infinité d'observations successives qui exigent des milliers d'années; & en considérant le degré de perfection où les premiers Indiens ont pousse l'astronomie, en calculant le tems qu'il. Faut pour acquérir ce degré de connoissance, qui dépend de telle ou de telle observation qu'on ne peut faire que tous les mille ans, & qu'il faut vérifier mille fois avant d'en avoir la preuve, il s'ensuit que les sciences, & surtout l'astronomie, que l'on trouve en vigueur chez les plus anciens Peuples, la devoient nécessairement à des Peuples plus anciens qu'eux.

Avec de pareils calculs, on se rend maître de tous les tems; en multipliant les siècles, on ne s'apperçoit pas qu'on se perd dans l'éternité.

Ah! Que le coeur de l'homme est vain, & que son imagination est folle!

Tous ceux qui s'attribuent quelque droit aux privilèges de la raison, sont les admirateurs outrés de tout ce qui tient à la nouvelle philosophie.

Nous avouons que les Epoques de la Nature, & les recherches "sur l'origine des sciences, confédérées comme des romans, sont dignes des plus grands éloges, te style en est charmant: c'est

un vernis précieux sur de beaux tableaux, dont la touche est nouvelle; ils séduisent les hommes avidesde nouveautés, & qui se livrent naturellement à l'enthousiasme.

Dans ce siècle où l'Esprit est commun (parce qu'on en fait) les sciences ne se perdront point comme celles de ces peuples qu'on vient de retrouver: nous multiplions les preuves & les monumens des nôtres: elles sont marquées à un coin qu'on reconnoître sans peine.

Au reste nous reconnoissons que l'astronomie est une science sublime & fort au dessus de nos forces: elle roule sur des objets qui ne doivent annoncer aux hommes que la magnificence de la Divinité: c'en est assez pour nous la faire respecter & admirer.

Mais si son antiquité est telle que M. Bailly le prétend, si elle a été substituée de siècle en siècle, les travaux des Astronomes doivent être moins pénibles. Les anciens Peuples dont il parle, possedoient cette science au même degré de perfection que nous; ils connoissoient donc le cours & les révolutions de tous les astres, les approches dangereuses des comètes, la formation des planètes, toutes les loix qui en maintiennent l'ordre, établi par Dieu seul: car si ils les eussent attribués à la Nature, on n'auroit pas manqué de s'en prévaloir. Quoi qu'il en soit, on doit admirer les sciences, de quelque part & de quelque main qu'elles nous viennent, en croire les conséquences, quand elles ne sont pas contraires aux intérêts & à la gloire de Dieu, & enfin, savoir gracieux qui veulent bien prendre soin de s'en occuper, d'en multiplier les procédés, pour les rendre utiles & les perpétuer.

Je suis trop l'admirateur de la façon d'écrire de M. Bailly, pour être soupçonné de vouloir le critiquer; mais je ne saurois m'empêcher de lui dire que toute science, tout système, qui n'est fondé que sur des probabilités, est toujours faux, toujours dangereux; car si on ne prouve l'existence de ces Peuples qu'on suppose avoir précédés Adam de tant de milliers de siècles, si on n'appuie ce système que sur des probabilités capables d'ébranler les esprits, & les faire douter de la vérité de la révélation sur le fait de la création, alors je dirai que, d'opposer des probabilités à un point de foi si vénérable, si confiant, c'est afficher l'incrédulité sur la tradition sacrée: c'est donner atteinte à la croyance reçue; c'est troubler l'ordre établi qui fait le lien des Peuples: c'est favoriser les prétentions impies répandues dans tant de libelles, que la nouvelle philosophie a si médiumment multipliés. Voilà tout l'objet de mes réflexions, il n'est pas incompatible avec l'amour des sciences; & la plus digne de l'homme sera toujours celle qui ne mettra pas en avant des probabilités ou des hypothèses diamétralement opposées aux vérités consacrées dans le texte de Moïse.

D'un autre côté, il est probable que l'astronomie n'a pas eu besoin de tant de siècles pour fixer certaines révolutions, ou pour faire telle ou telle découverte; par exemple, les Chinois réclament la période lunisolaire, comme ayant été inventée par un de leur compatriote. Cette même période, très-connue des Patriarches avant le déluge, est restée dans un oubli total, après cet événement, de sorte que Ptolémée & Hipparque ont retrouvé cette période sans le secours de leurs Anciens,plus de deux mille ans après le déluge. Il n'est donc plus que probable que ce n'est pas à la multitude des observations qu'on doit les découvertes astronomiques. M. de Buffon en a fait plus, en méditant & en calculant seul dans son cabinet, que n'avoit fait toute l'antiquité jusqu'à lui. D'après les contradictions de ce grand homme, il est plus que probable que les probabilités de M. Bailly sont des chimères, que ces sortes d'opinions sont abusives, tant en morale qu'en physique; il doit savoir que la se&e, si accréditée des Probabilistes, à été pour toujours anéantie par M. Pascal.

Disons donc, d'après les probabilités de ces Meilleurs, que quelqu'ancien que soit un Peuple savant, il doit tenir les sciences d'un plus ancien que lui; & quand l'histoire des tems ne leur en fournit point d'exemple, ils en imaginent, ils en supposent, & en rendent l'existence probable aux dépens de la vérité, au détriment de la Religion & à l'entier oubli de Dieu même.

Tout cela est moins difficile à croire que l'oubli total d'un grand Peuple très savant, qui a dû être très-industrieux & très-riche, & qui a dû rectifier, embellir & fertiliser le vaste terrain qu'il habitoit, terrain dont il ne reste aucun vestige, Peuple dont il ne reste aucune trace, & dont l'existence n'est sondée que sur le rêve de quelques Indiens qui se vantent de posséder des Livres qu'ils avouent n'avoir jamais pu lire, qui ne sauroient en deviner la langue, langue qu'on dit pourtant savante, quoiqu'on n'ait jamais pu la pénétrer, & qui suppose un Peuple savant qu'on connoît tout aussi peu.

Les recherches de M. Bailler sur ce savant Peuple seroient bien plus précieuses, s'il nous disoit qu'il a vu ces manuscrits antiques, qu'il les a déchiffrés, & qu'il y a reconnu le transcrit, cette langue si riche, inconnue jusqu'à lui, qu'elle annonce un Peuple glorifiant dont il ne reste aucun vestige. Avouons que ce sorte de supposition est une savante parce qui sait pitié & qui joue bien avec i'hypothèse.

Au reste, que des Peuples aient existé tin peu plutôt, un peu plus tard, que les fruits
Sciences soient plus ou moins anciennes, il n'en résulte rien pour notre bonheur. Les premiers Savans ont peut-être été plus heureux que nous. Les premiers actuellemen connoisssoient peut-être mieux que nous l'état du ciel & ses rapports avec la terre, ainsi que ses influences utiles ou nuisibles. On a négligé la partie peut-être la plus essentielle de la sublime science astronomique, pour ne s'occuper que de curieuses inutilités; il semble que les recherches qu'on sait, ne tendent qu'à donner aux loix physiques une préférence coupable sur l'Être infini qui a tout sait.

Il semble qu'on ne veuille pénétrer l'antiquité que pour démentir l'époque de' Moïse sur la création du ciel de la terre, tels qu'ils sont: création qui n'a jamais été contredite, ni par des négatives formelles, ni par des hypothèses spécieuses.

D'ailleurs quelque véritable que sois l,'Ecriture Sainte, il est possible que des révolutions que nous ignorons, aient fait disparoître des titres qui seroient remonter notre chronologie à des tems plus reculés; Adam alors seroit moins jeune, mais seroit-il pour cela' sorti des molécules organiques? & seroit-il moins l'ouvrage de Dieu?

Eh! Meilleurs les Savans, laissez-nous des préjugés qui sont sacrés pour nous, & qui peuvent nous rendre meilleurs & plus heureux! Ne croire à rien, c'est, sans contredit le plus grand des malheurs; nous aimons mieux nous croire les enfans d'Adam qui a Dieu pour père, que de confondre notre origine avec celle des plus vils animaux; il est dans la nature de connoître & d'aimer son père, la reconnoissance est muette, quand on ne connoît pas son bienfaiteur.

Toutes ces brillantes observations philosophiques ne tendent qu'à écarter nos obligations & à affaiblir notre soi; Se quand M. de Buffon avance cette assertion, que les sciences sont le bonheur des hommes, sans doute qu'il tache ce bonheur à la vanité des Savans, qui veulent être les dépositaires, & les despotes de l'esprit & des actions des hommes.

Il saut pourtant avouer qu'il n'est pas possible de mettre plus de finesse, plus d'agrémens, plus de délicatesse, que l'aimable Auteur des mondes en a mis dans son Roman agronomique, il semble qu'il ait été dit-té par un esprit enchanteur, ce qu'un habitant du ciel y ait présidé.

L'hypothèse de la somation de l'Univers est exquise; ce n'est pas une plaisanterie qui fait rire; mais c'est: une histoire fabuleuse, ornée de tableaux délicieux qui ont l'air & le ton de la vérité. C'est un conte qui, à la première leur, étonne & frappe celui qui le lit, & comme on croit voir des habitans dans la Lune en lisant Fontenelle, on est tenté de croire la sable de la Comète en lisant les Epoques.

Les Lettres sur l'origine des sciences sont calquées sur ces deux modèles: on ne sauroit mettre plus d'esprit, plus d'art, plus d'intérêt que l'Auteur en met dans ses recherches charmantes & ingénieuses; si le Peuple savan qu'il a découvert avoit existé, il est sûr qu'il auroit été le père des sciences, & surtout de l'Astronomie. Or, d'après son assertion, il a fallu un premier être qui sût la tige des sciences; cet être a dû être un Peuple; & ce Peuple dont il ne reste aucun vertige, est celui dont M. Bailly suppose l'existence.

Tant que de pareils systèmes, ou d'aussi jolies sables, resteront entre les mains d'hommes sensés & raisonnables, les privilèges de la Divinité resteront dans leur entier, & la raison ne cessera de s'y soumettre & de les respecter. Mais il y a tout lieu de craindre que l'imagination de ces petits Savans qui se propagent tous les jours, ne s'échauffe & n'abuse de ces jeux du génie, pour fonder avec plus d'audace les vérités reçues chez tous les Peuples, & consacrées dans les annales de toutes les Nations.

Plus on résséchit sur la prétendue existence de ces Peuples qu'on suppose si instruits, & qui ont vécu tant de milliers d'années avant le premier homme créé par Dieu, plus on est étonné qu'ils n'aient laissée aucun monument, aucune tradition sur l'origine du monde, & qu'on nous étale à si grand frais le mérite de leurs observations. On leur prodigue avec emphase l'intelligence de toutes les sciences, tandis qu'on essaye de faire la connoissance naturelle qu'ils avoient d'un Être Suprême. Us connoissient même à un certain degré de perfection la physique & l'astronomie: ces deux objets de science devoient exciter l'attention & la curiosité des premiers comme des derniers hommes, elles tiennent à des vérités utiles qui frappent les sens.

L'ordre qui règne, & les mouvemens que les premiers hommes ont apperçu dans les astres, ont dû les étonner, il étoit naturel de les observer soigneusement, dans l'espérance d'y découvrir quelqu'avantage après en avoir admiré la magnificence; ils faisoient moins de bruit que nous, & savoient peut-être davantage. Ils n'avoient pas les moyens que nous avons, ni la même facilité de se communiquer & de perpétuer leurs connoissances, mais les recherches de nos Savans savent y suppléer. Il est bien étonnant que dans toutes ces recherches, on n'y trouve pas un seul mot qui annonce la Divinité, que tous ces Peuples ont reconnu, que les Sauvages reconnoissent & respectoient. Il paroit bien singulier que la formation de l'Univers n'y soit pour rien, & que, sans dire qu'il est éternel, ces anciens Savans ne disent pas qu'il a eu un commencement.

Tous les emblèmes des Philosophes & les allégories du sable, ne sauroient s'interpréter en saveur d'aucune hypothèse. Et comme les hypothèses elles-mêmes sont des espèces de sables plus ou moins séduisantes, que ce sont des jeux de l'imagination, des écarts de l'esprit, fondés sur des calculs souvent incalculables, & sur des expériences toujours invérifiables, il s'ensuit que tous les raisonnemens ne sont que des sophismes .insidieux qui aveuglent les savans & les ignorans, les sorts & les foibles, & les entraînent tous dans le précipice de l'erreur.

Pendant que le Physicien cherche à s'assurer des effets, dans l'espérance d'en découvrir les causes, il s'écarte presque toujours des desseins de Dieu pour satisfaire sa curiosité. Tandis qu'il cherche la cause de differens phénomènes, il n'en apperçoit ni l'utilité ni la nécessité. Il ne veut pas sentir ni convenir que toutes les commotions qui arrivent dans le globe, sont utiles à toute espèce de productions. Elles sont l'effet des vents, qui ébranlent les arbres jusques dans leurs racines, pour y mieux faire pénétrer les sucs nourriciers: les matières rejettes par les éruptions & les volcans, sont comme les excrémens de la terre qu'elle vomit pour s'en débarrasser. Tous ces effets sont si vrais, si naturels, qu'il est étonnant que nos grands hommes veuillent s'en servir pour fabriquer des hypothèses.

Ce bel ordre qui règne dans la Nature, toutes les Singularités qui s'y rencontrent, les phénomènes effrayans qu'on croit voir dans le ciel, & qui enslamment l'atmosphère, ceux qui forcent des entrailles de la terre, sont des événemens purement physiques que Dieu a rendus tels. Le Physicien qui les contemple, ne sauroit s'empêcher de convenir qu'il a fallu un Être tout-puissànt, pour établir tant d'ordre au milieu de tant de confusion.

On demande, si la terre est réellement composée des mêmes matières que les planètes? Je sais que la manière, ainsi que la matière dont on les forme, sont opposées au texte de la Genèse, & qu'elles sont la base principale du système publié dans les Epoques; M. de Buffon ne paroit point douter de ce sait important: mais il ne dit pas, si les phénomènes, qui semblent appartenir à la terre, sont les mêmes que ceux qui arrivent dans la Lune; si les différentes espèces d'habitans & de productions qui sont dans l'une, ressemblent à celles qu'on doit supposer dans l'autre. Car si la terre, la Lune & les autres planètes sont composées des mêmes matières, si ce sont des fragmens du Soleil qui leur ont donné naissance, on a droit de supposer, que ce qui arrive dans l'un, doit arriver dans l'autre: la réponse est du ressort des Astronomes.

La connoissance du ciel est bien digne de leurs travaux pénibles; les calculs & les instrumens qu'ils ont imaginés, sont admirables; c'est à l'aide de ces moyens qu'ils sont venus à bout de découvrir des astres invisibles & inconnus, de distinguer leurs marches, leurs mouvemens, leurs révolutions: c'est par leurs observations qu'ils en ont mesuré les distances précises, qu'ils en ont connu les dimensions, la figure; c'est par leurs observations, & particulièrement par celles de M. de Buffon, qu'ils ont découvert des comètes redoutables, dont on doit craindre les approches, & des milliers de globes lumineux dont on ignore l'usage, sans compter ceux qu'on peut supposer & qui peuvent être bien plus nombreux; car tout ce qui est dans l'immensité, est incompréhensible. M. de Buffon lui-même, qui paroit si familier avec le ciel, n'y comprend pas plus que moi. Il a l'art d'éviter la difficulté; mais peut-il imaginer qu'on n'apperçoit pas ses transitions?

Le Philosophe le plus savant, comme le plus vain, a beau bâtir des systèmes, ils s'écrouleront bien vite. Il a beau s'imaginer, qu'il connoît l'architecture du ciel, qu'il sait le nom de toutes les pièces qui le composent, leurs rapports, leurs distances, leurs variations, leurs usages: il a beau observer cette multitude de merveilles qui le forcent à en soupçonner une infinité d'autres; tout l'avantage qu'il en peut tirer, c'est d'avouer que les systèmes les plus probables, enfantés par l'imagination, souvent nourris par la vanité, sont autant de prestiges qui tendent à méconnoître l'Auteur de ces merveilles, le seul Dieu qui les a pu faire, la seule puissance qui en établit la marche, dont la durée est inconnue & la fin impénétrable. Tous les calculs sont vains, les recherches sont inutiles. Les 03000 ans d'existence, que M. de Buffon accorde à la terre, subiront le sort de sa comète & de son système Dieu anéantira, quand il voudra, ce qu'il a sait, quand il l'a voulu.

Cependant si le Soleil, au lieu d'être immobile, si, au lieu d'avoir un mouvement de rotation, il en avoit un circulaire, & que les planètes eussent des mouvemens tellement combinés, que tout l'ordre qui règne dans cette grande machine, produisît des effets également utiles, quand on n'auroit pas apperçu le grand anneau de Saturne, ni tous les satellites des planètes, qu'en seroit-il arrivé? M. de Buffon n'auroit pas imaginé que ces accidens, autrefois lumineux, fusïènt sortis. Du corps de ces planètes, bouffies par la chaleur, dans le tems qu'elles étoient en fusion. Quel désavantage en seroit-il résulté? Quand les comètes supérieures, qu'on a eu tant de peine à découvrir, seroient ignorées, quel en seroit l'inconvénient? Il est vrai que nous n'aurions pas su tout ce que M. de Buffon nous dit sur la formation de l'Univers & de tous les êtres vivans; nous aurions continué de croire tout bonnement, que nous devions tous ces bienfaits à Dieu seul!, créateur de tout ce qui existe, nous aurions suivi l'impulsion de cette croyance qu'on trouve sou vent chez let honnêtes gens, rarement chez le vulgaire, & peut-être encore plus rarement chez les Savans.

Mais, encore une sois, souffrirons-nous de ne pas connoître une infinité d'étoiles ou de soleils qui peuvent exister dans l'immensité? Nous demandons à M. de Buffon, si tous ces corps célestes, si tous ces mondes, dont l'existence paroit indubitable, ont été créés, développés & arrangés par Dieu, ou non? Si la Nature sait dans ces régions tout ce qu'on lui sait faire ici? Alors le silence absolu de M. de Buffon suffira pour conclure, que Ton système est absolument le même que celui de la sable Se de la philosophie Payenne, habillé à la Françoise; il seroit bien plus vrai & bien plus honnête d'avouer & de reconnoître que Dieu a mis des bornes à notre raison, que l'homme, tel qu'il puisse être, ne pourra jamais franchir, & que les prétendus progrès dont nous nous vantons, sont autant de sections qui séduisent les autres, après nous avoir trompés.

On ne sàuroit disconvenir que notre globe ne renferme toutes les matières possibles; les commotions qu'il éprouve, sont proportionnées à la masse des matières combustibles, & cette commotion ne se termine, pour l'ordinaire, qu'en forçant la terre de s'ouvrir pour rejettera au loin les obstacles qui les retenoient trop serrées, trop renfermées, trop enchaînées. Les matières qui composent le tonnerre, produisent une explosion à-peu-près semblable, & notre poudre à canon en est l'image. Comment M. de Buffon peut-il avancer qu'il y a dans le centre de la terre un reste de son feu de fusion qui agit & qui produit ces effets, qui sont naturels, & non des phénomènes?; Ajoutons à ce que nous avons dit, que ces secoues & ces ébranlement paroissent être faits pour établir une circulation, & une communication utile pour faire parvenir jusqu'à la surface de la terre les avantages de la sublimation qui sait serciliser les productions des trois règnes, & qui leur donne des propriétés aussi utiles qu'incompréhensibles.

Or, si la terre avoit été en fusion pendant tant de milliers d'années, un seul aussi long & aussi violent n'auroit laissé dans son sein aucune matière utile ni combustible: elles se seroient toutes desséchées, calcinées, vitrisiées.

Il y a tout lieu de croire, comme le remarque l'Auteur des Epoques, que la sublimation que le feu opère sur les matières métalliques, ait pu renvoyer ver* la surface du globe des portions d'or & de pierres précieuses qui sont indestructibles, & dont les. Germes avoient été créés par Dieu, pour y multiplier selon les loix qu'il leur avoit imposées, & dont la Nature n'étoit que l'exécutrice.

D'ailleurs l'or qu'on veut nous faire entendre avoir été formé par la fusion totale du globe, auroit été acheté trop cher, c'est-à-dire, aux dépens de toutes les matières qui le constituent, aux dépens du globe même, qui auroit été calciné, & par conséquent stérile & inhabitable: en un mot il eût été tel qu'il sera, quand le seul descendra du ciel par l'ordre de Dieu, pour tout consumer; d'où il saut conclure que toutes les merveilles que Dieu seul a pu faire sortir du néant, doivent y rentrer, parce que Dieu ne seroit pas Dieu, si quelque chose pouvoit être éternel comme lui, ou subsister sans lui.

On a la témérité d'insinuer que tout ce qui a été écrit, tout ce qui a été cru jusqu'à présent, n'étoit sondé que sur des préjugés vulgaires, sur des sables que l'ignorance a transmises comme des vérités. L'orgueil qui se permet tout, prend le ton du respect. & du ménagement, pour affoiblir dans Moïse la qualité .de Prophète inspiré par l'esprit de Dieu. On le regarderont volontiers comme un ignorant qui n'avoit aucune idée des sciences, pas même de la physique & de Patronymie, sans lesquelles on ne peut avoir aucune notion de l'ouvrage de la somation du ciel & de la terre: il falloit que Moïse n'eût pas même entendu parler de ces savans Peuples, dont il étoit plus contemporain que M. Bailly qui les connoît, comme il connoît les Epoques, auxquelles il a voulu procurer des monumens: car tous les Savans veulent s'en mêler.

Suivant Moïse, l'époque du monde ne peur remonter qu'à sept à huit mille ans, tandis que MM. de Buffon & Bailly, en feuilletant, en déchirant, en débrouillant, les monumens les plus anciens, monumens ensevelis aux yeux du vulgaire, ils y ont trouvé des routes encore frayées, que la Nature y a tracées, & que les révolutions étonnantes qu'elle a éprouvées, ont respondées.

Tous ces Savans, tous ces subtils scrutateurs de la Nature ne sauroient pardonner à Moïse, d'avoir dit que ce grand ouvrage du monde, qui a coûté tant de milliers de siècles à la Nature, pour le rendre tel qu'il est (tandis qu'il n'est que ce qu'il a toujours été); ils ne veulent pas, dis je, convenir qu'un tel ouvrage ait pu être sait en si peu de tems, & que les six petits jours, que Moïse donne à la création, n'étoient qu'un jargon trivial pour fixer la crédulité des Peuples qu'il avoit intérêt d'entretenir.

Il est vrai que ce premier législateur, ce considoient de la Divinité, a décrit de la matière la plus simple la création & la formation de ce grand Univers: on voit bien que c'est la vérité qui parle: & encore une sois, les six espaces de tems qu il a désignés, n'ont besoin d'aucune interprétation: celle qu'on lit dans les Epoques, n'est qu'un racinement, une pure subtilité de grammaire, bien peu digne du grand homme qui la présente.

Mais quoique la terre ait été informe & stérile au premier moment, ce défaut de forme n'avoit pas besoin d'une élaboration de 34.000 ans, pour être réalisé. De tels calculs n'ont jamais pu entrer dans le projet de la Divinité.

Mais si ce sont des opérations purement physiques qui ont formé & perfectionné notre' terre, ainsi que toutes les planètes que nous connoissons, on est 'forcé de croire, que tous les corps célestes, visibles ou invisibles, ont été en fusion, & dérivent*de la même source que les nôtres, & que ce sont des causes physiques très-indépendantes de Dieu, qui les o#t produits. Quand on hasarde de soutenir, ou même de proposer de pareilles hypothèses ou d'aussi savantes puérilités, les complimens respectueux qu'on sait à la Divinité, sont bien équivoque?, & l'espèce de soumission qu'on affiche pour les vérités révélées, n'est qu'une dérision de plus. Nous sommes bien éloignés de vouloir affoiblir le mérite & les talens de l'Auteur des Epoques, à qui nous rendrons toujours le plus sincère hommage, quand les intérêts de Dieu & de la Religion ne seront pas compromis. On trouve dans ses récits des tableaux qui enchantent, des détails qui étonnent, & un style toujours séduisant & guidé par le génie. En un mot, son ouvrage est le résultat d'un esprit très actif, d'un travail assidu & d'une compilation immense: les contradictions sont adroitement couvertes, & les répétitions sont agréables.

Mais à travers ces effets du génie qu'on apperçoit dans l'Histoire Naturel Je, on voit que les Epoques qui en sont la conclusion, perdent à mesure qu'on les lit. On ne se seroit peut-être pas si-tôt apperçu des erreurs qu'elles contiennent, si la puissance de l'Être Suprême avoit été un peu plus ménagée, & si cette malheureuse hypothèse n'étoit pas appuyée sur un rêve aussi incroyable que ridicule, & dont les Savans comme le vulgaire Tentent l'invraisemblance.

Mais que l'Auteur de hypothèse! Me permette de lui demander, si c'est de bonne soi qu'il reconnoît la vérité du premier verset de la Genèse: ce verset. Il ne doit pas avoir plus de privilège que les autres, c'est le même esprit qui les a dit tous: M. de Buffon n'a d'autre certitude que Dieu a créé le ciel & la terre, que le texte de Moïse qu'il cite mot pour mot. Il est le seul qui ait annoncé cette vérité, parce que c'est à lui seul que Dieu l'a révélé.

Nier que Dieu ait créé le ciel & la terre, ou avancer qu'il a seulement créé la matière dont ils sont faits l'un & l'autre, c'est se donner le ton d'un interprète bien nouveau & bien audacieux. Vouloir encore que les autres aéles qui ont suivi la création du ciel & de la terre, n'appartiennent pas à la puissance de Dieu comme créateur, mais qu'ils ne sont que les produits de la Nature, parce qu'elle a été le principe des développemens & de l'arrangement des matières créées, c'est jouer le rôle d'un petit Dieu, que d'heureuses molécules organiques ont engendré dans le sein de la Nature, & destiné par elle à fixer des époques & à construire des monumens presque éternels, pour mieux la célébrer. Un pareil plan, s'il étoit sérieux, tendroit à renverser toutes les vérités reçues; mais d'après la

profession de foi de l'Auteur, on doit croire qu'il n'a pas eu ce dessein: la science des calculs éxhaust l'imagination, & quelque fois l'esprit s'oublie. . Dieu a pu vouloir créer d'abord les différentes maitres, dont il a sait le ciel & la terre: toutes les formes qu'il devoit leur donner, étoient arrangées dans sa volonté, & le tout a été développé par différens actes de son pouvoir, tels qu'ils nous ont été transmis par Moïse. Il est possible que tous les soleils, planètes, étoiles fixes, comètes, & .autres astres supérieurs que nous n'apercevons pas, aient été créés, formés & établis dans le même tems & par les mêmes actes de puissance. Cette manière de faire est bien le procédé de la Divinité. II. ne saut ni époques, ni monumens, ni calculs pour établir cette vérité: elle a été crue & respectée depuis qu'il y a des hommes. Dieu avoit voulu que les élémens fussent confondus; il a voulu les séparer; & d'un mot il l'a sait. Il avoit par sa volonté formé la terre de toutes les matières qui la composent.: tout nous le manifeste. Les deux souterrains que nous y reconnoissons, les effets des matières ignées qu'il y a mises: les pierres,: les rochers, & tous les corps solides qu?on y voit, sont, pour ainsi dire, les fondations, les pilastres, les archontans qui soutiennent lé grand édifice de notre globe. Le pouvoir du feu est bien exprimé dans les matières calcinées & vitrisiées qu'on trouve en différens endroits sur la terre. Tous ces effets sont autant de leçons pour l'homme, & à chique pas que l'on sait, on voit que Dieu a laissé des moyens de le mettre à portée de profiter de ses bienfaits.. Les germes de toutes les mines sans exception, & des matières les plus précieuses qu'on trouve dans les entrailles de là terre, y ont été placés par Dieu même, dans le tems de la création. Il y a établi une circulation d'eau, pour les charrier & les rassembler. Il y a mis un feu toujours agissant, pour leur donner la coction & la perfection nécessaires. Il a aiguisé par l'industrie & l'émulation dont il avoit gratifié l'homme. On voit donc, dans le récit de Moïse, un plan satisfaisant que la vérité trace.

Quand Dieu sépare les eaux d'avec la terre, il crée à l'instant des animaux propres pour habiter cet élément. La surface de la terre devenue libre, produit sur le champ des herbes, des plantes, des arbres & des fruits de toute espèce, pour servir de nourriture aux animaux, qu'il créa de même, avec cette variété étonnante qui n'appartient qu'à Dieu.

Et quand on veut supposer que les molécules organiques, qui devoient produire tous les êtres, étoient dans l'eau; & que la chaleur de la terre, combinée avec ces eaux déjà fécondées par la Nature, les a rapprochées, unies, développées, & qu'il en est sorti non-seulement les animaux aquatiques, mais encore les aériens & les terrestres qui ont subslsté & qui subsistent. Quand on considere que cette Nature, dont la puissance, à cet égard, est dans l'imagination, a donné à ces molécules organiques la vertu particulière & spécifique de ne pas confondre les espèces, d'en différencier les sexes pour pouvoir se reproduire, &c. De "telles prétentions ne sauroient appartenir à l'arrangement hasardeux de ces molécules répandues çà & là dans l'immensité des eaux, dont on voit avec peine l'Auteur des Epoques composer & animer tous les êtres vivans. Que M. de Buffon nous dise donc pourquoi la Nature ne s'accouple plus avec les eaux qu'elle avoit rendue! Par quelle catastrophe ont-elles perdu le pouvoir de tout former, de tout engendrer? Car depuis Moïse, on n'a pas vu une seule production de leur façon, pas un seul homme, pas un éléphant3 pas un hippopotame, pas même un moineau; d'où il s'ensuit que les molécules organiques de M. de B. sont tout aussi ridicules que les atomes crochus d'Epicure. Ce grand Ecrivain n'a rien dit dans son ouvrage sur la création de l'homme, il dit seulement qu'il a été sait le dernier. On ne voit rien qui la distingue de la formation de tous les animaux. Il parois être sorti des eaux comme tous les êtres vivans: la Nature qui savoit faire des éléphans, des hippopotames, savoit aussi former des hommes, c'est pourquoi M. de Buffon en fait paroit tout-à-coup une multitude sur le globe. Il les peint comme les plus vils habitans de la terre; ils n'ont que l'abri des montagnes pour asyle, dont ils sont chassés par le feu des volcans: toujours tremblans, aussi nuds d'esprit que de corps, exposés aux injures des élémens, victimes de la fureur des animaux féroces, dont ils deviennent souvent la proie; tous près lés par la nécessité, & tous également pénétrés du firmament de la terreur. Le Paradis terrestre n'étoit-il pas mieux imaginé! n'étoit-il pas plus digne du Créateur & de l'homme crée?

On aura beau demander à l'Auteur des Epoques, on aura beau le presser de dire, d'où il sait sortir ces hommes beaucoup moins industrieux que les animaux, errans sur la terre, sans y trouver d'asyle, vivans sans connoître leur subsistance: on aura beau le sommer de répondre à cette question, il n'y répondra jamais, mais il dira qu'il ne présente pas son hypothèse comme une démonstration ni comme une vérité révélée, & que rien n'oblige à la croire.

Mais faudra-t-il garder le silence sur l'athéisme qu'on tolère, & sur le déisme qu'on publie, parce que rien n'oblige à les croire? Faudra t-il accueillir le Système de la Nature, les impiétés du Dictionnaire philosophique, & tous les Livres de cette couleur, dont on a inondé la Capitale, parce que rien n'oblige à les croire? Tous ces complots de Savans, tous ces amas de sciences qu'on prodigue, ne sont ils pas répréhensibles? Avouer que rien n'oblige à croire des faussetés démontrées, des systèmes contraires à l'évidence, c'est se jouer de la raison, c'est la mépriser, c'est l'outrager: & cette même raison présentera toujours l'hypothèse sous le même point de vue, c'est-à-dire, cherchant à s'élever sur les débris de la création.

Tandis que les molécules organiques, formées par la Nature, couvées par la Nature, écloses par la Nature, sont célébrées par M. de Buffon, comme le principe de toutes les productions, Dieu reste indolent & comme anéanti: son nom, qui sait trembler les démons, n'intimide point nos Philosophes; & si on ne craignoit pas de trop blesser les foibles, on ne le prononceroit peut-être plus. " Le système des molécules est trop lié avec hypothèse! générale, pour être abandonné à la puissance d'un être invisible, qu'il saut croire, sans pouvoir le connoître, & dont les oeuvres ne sont point du tout à la portée de la raison: au lieu que, dans la narration des Epoques, si bien faite, si bien dite, si bien calculée, si bien mesurée, on voit évidemment que la seule puissance de la Nature a mis les poisons en possession des eaux, où ils ont été formés; les quadrupèdes sortir de la même source pour habiller la terre, & le pôle par préférence, & enfin des hommes timides répandus çà & là, sans savoir par où, ni comment ils y sont arrivés. On ne dit pas combien de milliers d'années ces hommes errans ont été exposés aux outrages de la terre agitée, & aux insultes des bêtes farouches & insatiables. On ne conçoit pas comment ils ont pu se conserver au milieu de tant de dangers, on conçoit encore moins comment ils se sont multipliés. La Nature qui renfermoit dans son sein le germe de tous les êtres, maîtresse de donner plus ou moins de vigueur & d'intelligence à qui elle voudrait, semble avoir été moins favorable aux hommes qu'aux animaux. Car ceux-ci, malgré les tremblemens, malgré les souterrains embrasés toujours ouverts sous leurs pieds, portèrent partout les marques de leur férocité, tandis que les hommes ne faisoient aucuns pas sans rencontrer des précipices.

Mais, malgré l'état de la terre qu'habitent ces malheureux hommes, terre toujours agitée par les terribles restes du feu de fusion qui agissait encore, la Nature plus seconde que prévoyante, se multiplioit par tout sans précaution; son sperme trop abondant la forçoit à la génération: & c'est sans doute ce qui sait dire à son panégyriste que les animaux étoient des géants, relativement à ceux qui nous restent de la même espèce.

Ce n'a été qu'après bien des siècles que ces mêmes hommes, en se rapprochant les uns des autres, ont cru sentir qu'ils avoient assez de force & d'adressé, pour se soustraire à la fureur des animaux, & même pour les dominer & les détruire. La terre, devenue plus tranquille, les rendoit moins timides: les volcans et les tremblemens devenus plus rares, ils sentirent dans leurs cœurs un mouvement de force & de courage, & cherchèrent les moyens de se rassembler.

Il est bien étonnant que l'immense quantité d'eau qui avoit submergé la terre, n'ait point appaisé l'action du feu qui résidoit dans ses entrailles, & que les mouvemens convulsivans, occasionnés par ces feux souterrains} aient subsisté si longtems & si universellement dans le globe. N'a-t-on pas droit de soupçonner que ces eaux prétendues sont plutôt des vapeurs de l'esprit humain que l'effet

d'une ébullition véritable? N'a-t-on pas lieu de croire que ce déluge précoce & chimérique étoit nécessaire au plan projette?

Quand l'Auteur des Epoques aura démontré, i°. que ces eaux ont existé, & qu'en second lieu,.elles renfermoient le germe de tous les animaux possibles % qu'elles n'avoient besoin que de s'unir à la terre brûlée ou brûlante, pour développer la fécondité, & que de ce mélange enfin de l'eau avec la terre, sont sorties toutes les espèces de poissons, de reptiles, d'oiseaux, de quadrupèdes, & l'homme» nous dirons encore, que si une telle généalogie n'est pas ridicule, la projection de la comète n'est qu'une gentillesse; mais telle sérieuse qu'on nous la donne, & qu'elle puisse être, les partisans de la Genèse ne s'en prévaudront pas.

Si le charmant Auteur des Epoques avoit voulu ne pas être l'antagoniste de Moïse, il auroit tiré un excellent parti de l'histoire qu'il auroit pu faire de la création. L'homme d'esprit a bien de l'avantage quand il est guidé par la vérité, & par un sentiment avoué de tous les tems, & peut-être de toutes les Nations. Mais enivré de l'esprit de la nouvelle philosophie, séduit par sa propre éloquence, il n'a pas senti que son sable seroit abandonnée comme une infinité d'autres auxquelles il a eu recours.

En vérité, il saut être bien enthousiaste pour employer tant d'érudition à peindre tant de chimères, pour annoncer que les rhinocéros, les éléphans, &c. ont été obligés d'habiter sous le tems après, ces animaux si superbes, 3c tant chéris par la Nature, soient tous péris de froid dans ce doux climat qu'elle leur avoit choisi: cette mère sans doute trop occupée de sa tendresse, avoit oublié que le pôle moins épais, devoit être glacé avant que l'équateur sût attiédi.

Ce malheur n'affligea pas la Nature, il devoit servir de monument principal aux Epoques, pour prouver l'antiquité de ses ouvrages & de sa puissance. En effet les squelettes de ces grands animaux qu'on découvre sans celle en Syberie 5 3 cinq ou six pieds de la surface de la terre, en sont des preuves plus qu'évidentes. Par conséquent, sans les ossemens d'éléphans gelés & conservés presque sur la surface de la terre, & encore sans les écailles dd poissons déposées plus anciennement & plus avant dans ce même terrain, il né reste plus de monumens valables; & sans ces monumens, plus d'hypothèse, plus d'époques. Or quel cas doit-on faire d'un édifice sondé sur des débris d'animaux aquatiques, & terminé par des os de quadrupèdes.

Les effets du véritable déluge consacrés dans les Livres Saints, & consistes par une tradition universelle, expliquent très clairement cet événement qui est très naturel, & qui n'a rien de singulier. Il est certain que tous les animaux, excepté ceux conservés dans l'arche, ont péri sous les eaux du déluge; il est probable que leurs cadavres ont suivi la pente naturelle des eaux dans le tems de leur retraite, & que les pôles beaucoup plus bas que les autres parties du globe, ont dû les recevoir. Il est donc plus raisonnable de croire que les squelettes d'éléphans qu'on trouve en Syberie, y ont été emmenés par la retraite des eaux du déluge, que d'imaginer qu'ils y ont péri par le refroidissement graduel dont ils ne se sont point apperçu. Nos hirondelles sont donc bien plus intelligentes. Il me semble que les hommes & les animaux d'aujourd'hui auroient plus d'esprit que ceux de ce tems-là; & que si un pareil refroidissement arrivoit en France, nous irions avec nos animaux chéris en Espagne pour nous y réchauffer. On objecte la séparation du continent qui

vient sort à propos pour servir hypothèse!. Avouons donc que depuis l'instant de la séparation des élémens, le pôle a toujours été froid, que les glaces l'environnement depuis ce moment, qu'elles sont faites pour renvoyer une fraîcheur dont tout le globe a besoin. D'où il saut conclure que jamais éléphans vivans n'ont habité ce terrain que le Soleil éclaire à peine; & que si on y trouve une multitude de squelettes & d'ossemens de ces animaux, ils n'ont pu y être entraînés que par les eaux du déluge.

Moïse, dans le récit de la création, n'a pensé qu'à imprimer de la reconnoissance & du respect pour le Créateur; il n'a pas eu dessein de donner des leçons de physique'& d'astronomie: i! savoit bien que Dieu avoit établi & dirigé la marche & le mouvement de tous les corps qu'il avoit créés.

Quand il dit que Dieu créa d'abord le ciel & la terre, ce mot ciel ne signifioit autre chose en ce moment, que cette voûte immense où nos regards se perdent, sous laquelle Dieu a créé tous ces corps lumineux visibles & invisibles, qui nous étonnent & nous ravisent. Le Soleil & les planètes qui paroissent nous avoisiner de plus près, semblent avoir été créés pour notre bonheur particulier: & on pourroit dire que la terre, qui étoit stérile & impuissante au moment de sa création, a celle de l'être, dès que la chaleur du Soleil a paru: on diroit qu'il a été sait pour la salubrité de la terre & pour développer les germes que Dieu venoit de mettre, Jamais Naturaliste ne contestera l'influence de cet astre bienfaisant, & ne devinera les matières qui le composent. Quand l'Ecrivain sacré nous dit encore que Dieu a créé le Soleil pour présider pendant le jour, cela ne doit-il pas signifier que sa chaleur étoit nécessaire pendant un certain tems, mais qu'elle eût été nuisible & funeste, si elle avoit été continuelle? Disons donc que la chaleur que tous reconnoisens venir du Soleil, est la seule qui soit véritablement utile aux habitans & aux productions de la terre; & que nous n'avons pas assez de conscience dans les Epoques, pour attribuer au reste du prétendu seul de fusion cette grande chaleur si peu sensible, qui diminue & diminuera au point que tout le globe sera glacé. On verra alors combien la chaleur du Soleil est impuissante.

Si Moïse avoit désigné les mouvemen & les phénomènes dépendans des révolutions de planètes; s'il avoit démontré par des calculs leur sorme, leur distance, &c. s'il avoit imaginé des instrumens faits pour rapprocher les objets qui S*échappent à la vue, enfin, s'il avoit détaillé les moyens qu'on emploie aujourd'hui, le nombre de MM. les Savans n'auroit pas sait une classe bien distinguer parmi les Nations: & la portion d'intelligence, donnée par Dieu aux Physiciens comme aux Astronomes, eût été vaine & sans actions, tout bon copiste y seroit parvenu.

Dieu a donc voulu laisser aux hommes les moyens d'exercer les talens qu'il leur avoit donnés; & c'est par une suite de sa sagesse & de sa prévoyance que ces mêmes hommes trouvent dans la Nature créée une variété d'objets capables d'occuper leur goût & leur génie. ' .

Mais l'homme, & sur tout l'homme qui se croit philosophe, en a toujours abusé, & en abuse plus que jamais. Il dit dans son cœur que son esprit n'est pas un don de la Divinité, & que sa science est le fruit de ses veilles & de ses travaux, abominâtes sacli sunt injludiis. Il veut nous faire entendre que le Soleil & tous les astres ont été faits sans Créateur, que le moment de leur existence est inconnu, & qu'un beau jour, sans que le Créateur s'en soit apperçu, l'un de ces corps lumineux tomba dans le Soleil. On ne dit pas ce qu'il est devenu, ni s'il a remonté dans son espace, ou s'il est resté en fusion avec les autres matieres qui bouillent sans cesse dans ce globe toujours embrasé.

On ajoute, avec un ton de conscience, que la chute de ce corps énorme dans l'astre, qui n'est qu'un feu liquide, en a sait jaillir des portions qui se sont anéanties dans l'immensité des airs à des dishleys inégales, toujours également soumises aux loix de l'attraction & à la force centrifugeuse: elles y sont restées comme immobiles, n'ayant d'autre mouvement que celui de rotation, pareil à celui qu'on attribue au Soleil leur père.

Telle est l'origine de toutes les planètes. Origine ancienne, puisqu'il a fallu 3693^ ans, tant pour achever la fusion du globe de la terre, que pour parvenir à un certain degré d'attiédissement encore beaucoup trop chaud pour pouvoir en approcher.

Quand aux phénomènes qui arriveront sur la terre pendant les 5)3000 ans qu'elle a encore à subsister, il se formera d'ici-là des Savans qui ne manqueront pas de les! recueillir & de les transmettre: il est même vraisemblable que la durée de cette époque, quelque longue qu'elle

paroisse, sera trouvée trop courte, & qu'on imaginera des moyens, par des calculs savans & invérifiables, de la prolonger tant qu'on voudra. Si la Nature a laissee des monumens tout exprès pour faire connoître aux hommes qu'elle avoit sait par degré tout ce qui existe, elle saura bien comment établir d'une autre espèce, qui serviront à prouver même l'éternité de (es ouvrages.

Cependant je doute qu'il naisse des observateurs qui égalent celui dont nous lisons l'ouvrage. Il saut bien des siècles, pour sormer un homme de sa trompe: il n'y a jamais eu qu'un Homère, & ses fixions ne sont pas mieux présentées, mieux dites, quel'est celle de la comète, que l'art du savàn Physicien & du grand Astronome a rendu presque vraisemblable.

La projection de la comète dans le Soleil, les éclabousïures de matières bouillantes dont on sait les planètes, leur su&>n, les boursouflures reliées à leur surface, qui ont formé s anneau de Saturne, les satellites de Jupiter, & peut-être bien d'autres accidens qu'on n'apperçoit pas, le refroidissement qui a suivi, les vapeurs excitées par le feu, qui ont formé toutes les eaux qui existent, l'inondation universelle qu'elles ont occasionnée, les germes des animaux de toute espèce que la Nature y a déposés, & qu'elle a secondés si prodigieusement, &c. tout ce plan: fabuleux n'est-il pas la parodie de celui de Moïse? Comment ose-t-on dire que ces ouvrages & ces effets extravagans & chimériques sont faits pour honorer l'Etre Suprême qu'on ne sait entrer pour riens dans ces arrangemens?

Que tous les Savans paroissent de quelque Nation & de quelque religion qu'ils soient; qu'ils mettent en comparaison la sable de la Comète, & l'invention des molécules organiques dont on sorme & dont on peuple l'Univers, avec le récit simple & naïs que sait Moïse dé la création, je ne leur demande que de .la bonne soi pour juger la question» L'un exprime avec la plus grande énergie la toute-puissance de Dieu, & l'autre la couvre d'un voile ridicule pour l'avilir.

Quand je vois Dieu faire sortir du néant, par sa volonté, par sa parole, tout l'Univers, mon âme persuadée semble s'élever jusqu'à lui, mon esprit ne cherche point à épiloguer une vérité qui le console, il voit par la magnificence de l'ouvrage, qu'il n'y a qu'un Dieu qui ait pu le faire.

Mais quand je lis attentivement les Epoques de la Nature, il me semble voir un homme monté sur des échassès pour se faire regarder; mes yeux & mon esprit se lassissent, Se mon cœur ne se sent pénétré de rien. La bouillie que les comètes sait jaillir pour sormer les planètes, est une chimère poétique élégamment rendue, qui excite d'abord la curiosité, & qu'on lit jusqu'au bout comme un roman, dans l'espérance d'y trouver un dénouement nouveau. Ici toute la pièce est l'exagération de la sable, Se le dénouement est il comble de l'absurdité & de l'humiliation pour l'homme, à qui on ne donne d'autre origine que des molécules concentrées dans les eaux secondées par la Nature: système déjà publié d'après le rêve de Téliamede; système qui sait paroître tout-à-coup des hommes sur la terre encore chaude & mouvante, environnés d'animaux féroces, dont ils sont la proie, & qui n'osent marcher sans craindre d'être engloutis. La manière dont.tout cela est présenté, est faite pour montrer de l'esprit & embellir hypothèse!. La sable de Deucalion & Pirrha sur l'origine de l'homme, mérite le même droit à Ta crédulité: il n'étoit pas nécessaire que Moïse est une description•des moyens propres adonner à la terre la sorme qui lui manquoit d'abord. Ces moyens trop au dessus de l'homme & de la Nature, résidoient dans la puissance & dans la volonté de Dieu. Il salloit dégager la terre des eaux qui l'environnoient; il l'a sait sur le champ; H salloit la rendre féconde, d'un seul mot il l'a sait: il falloir la rendre habitable, il l'a sait d'une seule parole.

La terre, l'air & les eaux n'étant plus confondus, par la séparation qu'en est Dieu par sa puissance, furent bientôt remplis des merveilles de la création de tous les animaux analogues à leur élément. Mais il falloit un Être plus parfait & supérieur à tous les autres, qui dominât sur eux, parce que tous avoient été faits pour son usage & son plaisir.

C'est l'homme qui fut le chef-d'œuvre & le dernier de ses ouvrages. Il le fit, dit le texte sacré, à son image & à sa ressemblance. C'est-à-dire, qu'il prit plaisir à lui donner une conformation majestueuse, une organisation plus précise, un cerveau sort & en même tems flexible, propre à recevoir & à conserver l'impression de son esprit, un cœur capable de sentir tous ses bienfaits une langue pour les publier. En un mot, il suffit de voir l'homme, pour croire qu'il y a quelque chose de divin dans lui, & que les molécules organiques, dans l'eau chaude ou dans la froide, sont des visions, & des chimères, quand il s'agit de la création.

Quand elle sut achevée, cette création si merveilleuse, que Dieu auroit pu faire en un moment, & à qui nous n'avons pas de compte à demander, la surface de le terre étoit remplie d'aspérités & d'inégalités: les eaux n'étoient dirigées que par leur sente naturelle, & concupiscoient en mille endroits; tout montroit à l'homme qu'il falloit redisiez par son travail l'espèce de désordre que Dieu avoit laissé sur la terre, & qu'en souillant dans son sein, il y trouveroit des sources de bonheur, de richesses & de satisfaction.

Si la loi du travail, imposé à l'homme coupable, étoit l'effet d'un châtiment mérité, Dieu ne lui avoit pas ôté l'intelligence primitive qu'il lui avoit donnée.

Le goût des sciences & des arts étoit comme inné dans lui. Celui qui tient au besoin, se développa le premier, & l'agriculture sut l'objet de son travail & de ses recherches.

II s'apperçut que toutes les productions de la terre encore brute, n'étoient que les symboles des produits de la terre cultivée. La Nature féconde & impuissante, paroissoit endormie, Dieu ne lui avoit encore rien dit. C'étoit à l'homme seul à qui il avoit parlé: il lui avoit dit de travailler, & qu'il béniroit son travail.

L'homme, instruit de la promesse de Dieu, ne sut pas long-tems à en reconnoître la vérité j il sentit que son travail serait la clefs de son bonheur, & qu'il rendrait la terre généreuse & bienfaisante.

Les arbres & les plantes se propageoient sans culture: leurs semences se répandoient d'elles-mêmes au hasard, & produissoient difficilement, tandis que les hommes qui se multiplioient tous les jours, sembloient demander à la terre de multiplier ses productions.

Devenus plus nombreux, les besoins devinrent plus sensibles & plus pressans; la nécessité ouvre l'intelligence, & l'enfan, qui crie la faim, arrache des entrailles paternelles les moyens de la soulager. Ils virent bientôt que la terre trop sèche & trop battue, étois presque stérile, & ne produisoit que des fruits maigres se languishans. Ils imaginèrent de l'ouvrir &T de la sillonner, pour y faire pénétrer la pluie du ciel, & les influences de l'air 8c du Soleil. Puis, animés par une espérance légitime, ils répandirent sur cette terre ainsi préparée, les différentes sciences qu'ils avoient eu soin de recueillir.

Ils virent bientôt avec étonnement, que leurs travaux n'étoient pas insructans, que les grains qu'ils avoient répandus, se multiplioient à l'infini, & animés par la reconnaissance, ils attribuent à la seule puissance de Dieu une fécondité si au desseins de celle de la Nature & de l'homme.

Ces premiers essais surent les premiers fondemens de l'agriculture, & le produit qui en résulta, de voir aux hommes que leur bonheur sur la terre dépendoit de leurs travaux, & que Dieu, en les condamnant à manger leur pain à la suit de leur visage, les avoit dédommagés par des avantages dignes de sa magnificence; & ils le regardoient comme le protecteur de leurs entreprises & l'objet de leurs respect &s.

Les familles bientôt se réunirent pour s'aider mutuellement, & concourir au bien commun, en se communiquant les idées qui se présentent à leur esprit, i!s parvinrent à trouver des moyens pour rendre leur vie plus agréable & plus heureuse.

Le génie se développe suivant les occasions & les circonstances: & tout ce qui tient à la conservation de son être, & au bonheur de la vie, l'homme en sait l'objet principal-de ses soins & de ses recherches.

'C'est par une suite de ce sentiment gravé dans son cœur, qu'il s'est apperçu que tout ce que Dieu avoit créé sur la terre, étoit sait pour son usage, & qu'après l'avoir fertilisé par sou travail, il lui restoit encore à dominer les animaux que Dieu avoit également créés pour lui. Pour y parvenir, ils imaginent des frondes, ils sont des arcs, ils arment des slècles, forment des matiers, fabriquent des dards pour détruire les plus féroces j ils tressent des filets avec des joncs & des écorces, pour en surprendre d'autres, & ils composent des jougs pour les apprivoiser.

Ils inventent aussi des instrumens pour pénétrer la terre; & les animaux, devenus dociles, partagent les travaux de l'homme, en lui prêtant leur force & leur vigueur»L'homme, après avoir creusé des cavernes dans les montagnes, après avoir entouré de branchages des places vagues, pour y former des asiles, devint plus actif & plus industrieux. Ce n'étoit point assez d'avoir trouvé sa subsistance dans les productions de la terre, il falloit encore imaginer des habitations qui le minéral abondes si tempérées des saisons, & hors des insultes des bêtes féroces. Il trouva bientôt lea moyens d'apprêter des bois & d'arranger des pierres. Cet art mise a été, après Réflexions d'agriculture, l'objet de son attention. Les dessins d'abord grossiers devinrent peu-à-peu plus réguliers, de légers qu'ils étoient d'abord, ils devinrent plus solides, l'art de bâtir se perfectionna par degrés, & le sens que Dieu avoit donné à l'homme, lui servit de maître pour apprendre les arts, & de guide pour les exercer» L'homme devenu maître des animaux, se les asservit. Il employa leurs forces pour faciliter ses travaux. Alors la culture de la terre changea de face, les rendirent la culture plus facile & les productions plus abondantes. Les grains. si nécessaires à sa subsistance, les plantes les plus utiles, les fruits de tout espèce, les fleurs les plus agréables parurent sortir du sein de la terre, & la Divinité se montrait par-tout la protectrice de l'homme & de ses travaux.

Les hommes de M. de Buffon, ces enfans des molécules, ces protégés de la Nature, ont-ils eu ces avantages? N'est-ce pas être insensé d'ôter à Dieu la puissance universelle pour l'attribuer à la Nature, qui n'est qu'une chimère en comparaison, qui est moins que n'est qu'un esclave vis-à-vis son maître. Vouloir. que sa puissance, unie au pouvoir de l'homme, soit la cause immédiate de toutes les productions, c'est dresser des autels à l'orgueil & à l'imposture, c'est ouvrir la porte à l'athéisme: en un mot, c'est exposer l'homme foible à dire comme l'impie, qu'il n'y a point de Dieu.

Ce mélange ridicule du pouvoir de l'homme & de la puissance de la Nature» est une conséquence du système des Epoques, c'est la Nature qui a sait tous les êtres vivans; l'homme doit lui être subordonné, & toujours agir de concert avec elle. Il est bien étonnant qu'il ne se soit pas encore trouvé un homme assez reconnaissant pour élever des autels, & établir un culte pour honorer les molécules à qui il doit son existence.

.Mais ouvrez les Epoques, vous y verrez que ce système la est uniquement célébré: on y annonce, & l'on croît y avois prouvé que tout ce qui existe, est l'ouvrage de la Nature.

Si les premiers hommes ont été les premiers admirateurs de ce grand spectacle de toutes ces magnificences qui s'offroient à leur vue, ils n'ont pas tardé à imaginer & à se persuader qu'il y avoit un Auteur invisible de toutes ces merveilles.

Il étoit possible qu'Adam leur eût transmis la connoissance particulière qu'il avoit eue de Dieu, & que cette connoissance précieuse se sût conservée parmi ses descendans, c'etoit un titre de plus pour affermir leur croyance.

Mais jamais. ils n'auroient imaginé que la Nature pût être le Dieu de l'Univers; cette découverte, comme tant d'autres du même calibre, étoit réservée au dix huitième siècle.

On ne se seroit jamais douté que de sciences vénérables & sublimes, dont les objets sont faits pour élever nos idées, asses rapprochant de la Divinité, se fussent accréditées aux dépens de la Divinité même.

La classe des Physiciens & des Astronomes paroit être réunie à la face des Philosophes, pour former un corps nombreux contre Dieu & contre ses oeuvres. Les uns font régner la Nature dans le ciel, & les autres la rendent maîtresse de la terre. Il semble que ce soit un complot médité parmi eux. Ce n'est pas assez d'ôter à Dieu sa puissance, ils veulent encore lui enlever son existence. En publiant des principes aussi dangereux, ils exposent, ils détruisent non seulement la foi, mais même les vertus sociales des Nations.

La bonne foi & l'honneur ne règnent déjà plus, les infidélités se multiplient, les passions toujours trop sortes dominent la raison toujours trop foible, & nous nous apercevons chaque jour que la cupidité devient la divinité générale. Si l'on cherche à ébranler le trône du Dieu vivant, du Dieu créateur de tout, le sceptre des Rois sur la terre sera-t-îl en sûreté?

Concluons que l'existence de Dieu est une vérité gravée dans les cœurs de tous les hommes, que cette croyance sait leur consolation, & que c'est un attentat de chercher à leur ravir ce bonheur. Recourir à la raison, c'est se servir d'un flambeau qui s'éteint au moindre vent, & que la seule Religion peut rallumer. La Religion donne aux vraies vertus des récompenses, & des châtimens aux crimes; c'est elle qui prescrit de rendre à Dieu ce qui lui est dû, & à César ce qui lui appartient. Il n'y a pas un seul principe dans les Epoques qui rappelle ces vérités qui doivent être la base de tous les Gouvernemens, ainsi que de toutes les Religions, & qui sont l'âme de celle qu'on professe en France.

Ajoutons, que toutes les Nations sont intéressées à soutenir que,h" on laisse établir un doute sur l'existence d'un Etre éternel, créateur & conservateur de tout ce qui existe* on ne sera pas long-tems sans voir régner les abominations dont l'homme, abandonné à soi-même, est capable. Or il est artificieusement insinué dans les Epoques, on s'y permet des ambiguïtés si étudiées, que Dieu n'y paroit que comme un. être imaginaire, ou indolent, & la révélation, comme une sable accréditée chez le vulgaire. Ce qu'on y dit de Dieu & de son interprète, est l'effet d'une politique craintive; & plus encore, de la répugnance naturelle qu'ont les hommes d'effacer de leurs cœurs l'existence de Dieu qui y est gravée. On sait semblant de croire, à dessein de mieux prouver la stupidité de ceux qui croient effectivement. Sans ces rafinemens, hypothèse! n'auroit pas été tant accueillie des Philosophes: ils l'estimeroient moins, si Dieu & la révélation n'y étoit pas dégradés & ridiculisés. On veut même ôter, par un silence coupable, à tous les anciens Peuples, la conviction qu'ils ont eue de; l'existence d'un Être Suprême, connoissance qu'ils ont exprimée avec tant de force & d'énergie par des emblèmes & des hyerogliffes, peut-être plus éloquens & plus expressifs que tout ce que les langues en ont pu dire. Il n’y a donc que les hommes inventés par M. de Buffon, que les peuples imagines par M. Bailly, qui n’aient pas eu d’idée de la Divinité; mais instruits peut-être qu’ils étoient enfans des molécules organiques, ils rougissoient sans doute d’une origine se humiliante. Comment ne rougit-on pas de proposer des absurdités si révoltantes? La liberté de l’hypothèse peut-elle être un prétexte assez raisonnable pour rendre équivoques des vérités reconnues de tous les tems & par tous les Peuples? Non sans doute, il faut donc conclure que le livre des Epoques est dangereux, en ce qu’il dénature le texte des Livres Sacres

FIN DU TEXTE SE MANQUE

1781
Immanuel Kant
Of the Ultimate Aim of the Natural Dialectic of Human Reason (Approval of Design Argument Only)
Critique Of Pure Reason

The highest formal unity, which is based on concepts of reason alone, is the systematical and intelligent unity of things, and it is the speculative interest of reason which makes it necessary to regard all order in the world as if it had originated in the design of a supreme wisdom. Such a principle opens to our reason in the field of experience quite new views, how to connect the things of the world according to teleological laws, and thus to arrive at their greatest systematical unity. The admission of a highest intelligence, as the only cause of the universe, though in the idea only, can therefore always benefit reason, and yet never injure it. For if, with regard to the figure of the earth (which is round, though somewhat flattened'), of mountains, and seas, &c., we admit at once nothing but wise intentions of their author, we are enabled to make in this wise a number of important discoveries. If we keep to this hypothesis as a purely regulative principle, even error cannot hurt us much; for the worst that could happen would be that, when we expected a teleological connection (nexus finalis), we only find a mechanical or physical (nexus effectivus), in which case we merely lose an additional unity, but we do not destroy the unity of reason in its empirical application. And even this failure could not affect the law itself, in its general and teleological character. For although an anatomist may be convicted of error, if referring any member of an animal body to a purpose of which it can clearly be shown that it does not belong to it, it is entirely impossible in any given case to prove that an arrangement of nature, be it what it may, has no purpose at all. Medical physiology, therefore, enlarges its very limited empirical knowledge of the purposes of the members of an organic body by a principle inspired by pure reason only, so far as to admit confidently, and with the approbation of all intelligent persons,'that everything in an animal has its purpose and advantage. Such a supposition, if used constitutively, goes far beyond where our present observation would justify us in going, which shows that it is nothing but a regulative principle of reason, leading us on to the highest systematical unity, by the idea of an intelligent causality in the supreme cause of the world, and by the supposition that this, as the highest intelligence, is the cause of everything, according to the wisest design.

earth is well known; but few only know that its flattening, which gives it the form of a spheroid, alone prevents the elevations of continents, or even of smaller volcanically raised mountains, from continuously and, within no very great space of time, considerably altering the axis of the earth. The protuberance of the earth at the equator forms however so considerable a mountain, that the impetus of every other mountain can never drive it perceptibly out of its position with reference to the axis of the earth. And yet people do not hesitate to explain this wise arrangement simply from the equilibrium of the once fluid mass.

But if we remove this restriction of the idea to a merely regulative use, reason is led away in many ways. It leaves the ground of experience, which ought always to show the vestiges of its progress, and ventures beyond it to what is inconceivable and unsearchable, becoming giddy from the very height of it, and from seeing itself on that high standpoint entirely cut off from its proper work in agreement with experience.

The first fault which arises from our using the idea of a supreme Being, not regulatively only, but (contrary to the nature of an idea) constitutively, is what I call the indolence of reason (ignava

ratiol.) We may so term every principle which causes us to look on our investigation of nature, wherever it may be, as absolutely complete, so that reason may rest as if her task were fully accomplished. Thus the task of reason is rendered very easy even by the psychological idea, if that idea is used as a constitutive principle for the explanation of the phenomena of our soul, and afterwards even for the extension of our knowledge beyond all possible experience (its state after death); but the natural use of reason, under the guidance of experience, is thus entirely ruined and destroyed. The dogmatical spiritualist finds no difficulty in explaining the unchanging unity of the person, amidst all the changes of condition, from the unity of the thinking substance, which he imagines he perceives directly in the I;—or the interest which we take in things that are to happen after death, from the consciousness of the immaterial nature of our thinking subject, and so on. He dispenses with all investigations of the origin of these internal phenomena from physical causes, passing by, as it were, by a decree of transcendent reason, the immanent sources of knowledge given by experience. This may be convenient to himself, but involves a sacrifice of all real insight. These detrimental consequences become still more palpable in the dogmatism involved in our idea of a supreme intelligence, and of the theological system of nature, erroneously based on it (physico-theology). For here all the aims which we observe in nature, many of which we only imagined ourselves, serve to make the investigation of causes extiemely easy, if, instead of looking for them in the general mechanical laws of matter, we appeal directly to the unsearchable counsel of the supreme wisdom, imagining the efforts of our reason as ended, when we have really dispensed with its employment, which nowhere finds its proper guidance, except where the order of nature and the succession of changes, according to their own general laws, supply it. This error may be avoided, if we do not merely consider certain parts of nature, such as the distribution of land, its structure, the constitution and direction of certain mountains, or even the organisation of plants and animals, from the standpoint of final aims, but look upon this systematical unity of nature as something general, in relation to the idea of a supreme intelligence. For, in this case, we look upon nature as founded on intelligent purposes, according to general laws, no particular arrangement of nature being exempt from them, but only exhibiting them more or less distinctly. We have then, in fact, a regulative principle of the systematical imity in a teleological connection, though we do not determine it beforehand, but only look forward to it expectantly, while following up the physico-mechanical connection according to general laws. In this way alone can the principle of systematical and intelligent unity enlarge the use of reason with reference to experience, without at any time being prejudicial to it.

1 This was a name given by the old dialecticians to a sophistical argument, which ran thus: If it is your fate that you should recover from this illness, you will recover, whether you send for a doctor or not. Cicero says that this argument was called ignava ratio, because, if we followed it, reason would have no use at all in life. It is for this reason that I apply the same name to this sophistical argument of pure reason.

The second error, arising from the misapprehension of the principle of systematical unity, is that of perverted reason (perversa ratio, va-repov Tt-porepov rationis). The idea of systematic unity was only intended as a regulative principle for discovering that unity, according to general laws, in the connection of things, believing that we have approached the completeness of its use by exactly so much as we have discovered of it empirically, though never able to reach it fully. Instead of this, the procedure is reversed; the reality of a principle of systematical unity is at once admitted and hypostasised, the concept of such a supreme intelligence, though being in itself entirely inscrutable, is determined anthropomorphically, and aims are afterwards imposed on nature violently and dictatorially, instead of looking for them by means of physical investigation. Thus teleology, which was meant to supplement the unity of nature according to general laws, contributes only to destroy it, and reason deprives itself of its own aim, namely, that of proving the existence of such an intelligent supreme cause from nature. For, if we may not presuppose a priori the most perfect design in nature as belonging to its very essence, what should direct us to look for

it, and to try to approach by degrees to the highest perfection of an author, that is, to an absolutely necessary and a priori intelligible perfection? The regulative principle requires us to admit absolutely, and as following from the very nature of things, systematical unity as an unity of nature, which has not only to be known empirically, but must be admitted a priori, though as yet in an indefinite form only. But if I begin with a supreme ordaining Being, as the ground of all things, the unity of nature is really surrendered as being quite foreign to the nature of things, purely contingent, and not to be known from its own general laws. Thus arises a vicious circle by our presupposing what, in reality, ought to have been proved. To mistake the regulative principle of the systematical unity of nature for a constitutive principle, and to presuppose hypostatically as cause, what is only in the idea made the foundation for the consistent use of reason, is simply to confound reason. The investigation of nature pursues its own course, guided by the chain of natural causes only, according to general laws. It knows the idea of an author, but not in order to derive from it that system of purposes which it tries to discover everywhere, but in order to recognise his existence from those purposes, which are sought in the essence of the things of nature, and, if possible, also in the essence of all things in general, and consequently as absolutely necessary. Whether this succeeds or not, the idea itself remains always true, as well as its use, if only it is restricted to the conditions of a merely regulative principle.

Complete unity of design constitutes perfection (absolutely considered). If we do not find such perfection in the nature of the things which form the object of experience, that is, of all our objectively valid knowledge; if we do not find it in the general and necessary laws of nature, how shall we thence infer the idea of a supreme and absolutely necessary perfection of an original being, as the origin of all causality \ The greatest systematical and, therefore, well-planned unity teaches us, and first enables us, to make the widest use of human reason, and that idea is, therefore, inseparably connected with the very nature of Oud reason. That idea becomes, in fact, to us a law, and hence it is very natural for us to assume a corresponding lawgiving reason (intellectus archetypus) from which, as the object of our reason, all systematical unity of nature should be derived.

When discussing the antinomy of pure reason, we remarked that all questions raised by pure reason must admit of an answer, and that the excuse derived from the natural limits of our knowledge, which in many questions concerning nature is as inevitable as it is just, cannot be admitted here, because questions are here placed before us through the very nature of our reason, referring entirely to its own natural constitution, and not to the nature of things. We have now an opportunity of confirming this assertion of ours, which at first sight may have appeared rash, with regard to the two questions in which pure reason takes the greatest interest, and of thus bringing to perfection our considerations on the Dialectic of pure reason.

If, then, we are asked the question (with reference to a transcendental theology)1, First, whether there is something different from the world, containing the ground of the order of the world and of its connection according to general laws? our answer is, Certainly there is. For the world is a sum of phenomena, and there must, therefore, be some transcendental ground of it, that is, a ground to be thought by the pure understanding only. If, secondly, we are asked whether that Being is a substance of the greatest reality, necessary, &c.? our answer is, that such a question has no meaning at all. For all the categories by which I can try to frame to myself a concept of such an object admit of none but an empirical use, and have no meaning at all, unless they are applied to objects of possible experience, that is, to the world of sense. Outside that field they are mere titles of concepts, which we may admit, but by which we can understand nothing. If, thirdly, the question is asked, whether we may not at least conceive this Being, which is different from the world, in analogy with the objects of experience? our answer is, Certainly, we may, but only as an object in the idea, and not in the reality, that is, in so far only as it remains a substratum, unknown to us, of the systematic unity, order, and design of the world, which reason is obliged to adopt as a

regulative principle in the investigation of nature. Nay, more, we need not be afraid to admit certain anthropomorphisms in that idea, which favour the regulative principle of our investigations. For it always remains an idea only, which is never referred directly to a Being, different from the world, but only to the regulative principle of the systematical unity of the world, and this by some schema of it, namely, that of a supreme intelligence, being the author of it, for the wisest purposes. It was not intended that by it we should try to form a conception of what that original cause of the unity of the world may be by itself; it was only meant to teach us how to use it, or rather its idea, with reference to the systematical use of reason, applied to the things of the world.

After what I have said before about the psychological idea, and its proper destination to serve as a regulative principle only for the use of reason, there is no necessity for my discussing separately and in full detail the transcendental illusion which leads us to represent hypostatieally that systematical unity of the manifold phenomena of the internal sense. The procedure would here be very similar to that which we are following in our criticism of the theological ideal.

But, surely, people will proceed to ask, we may, according to this, admit a wise and omnipotent Author of the world? Certainly, we answer, and not only we may, but we must. In that case, therefore, we surely extend our knowledge beyond the field of possible experience? By no means. For we have only presupposed a something of which we have no conception whatever as to what it is by itself (as a purely transcendental object). We have only, with reference to the systematical and well-designed order of the world, which we must presuppose, if we are to study nature at all, presented to ourselves that unknown Being in analogy with what is an empirical concept, namely, an intelligence; that is, we have, with reference to the purposes and the perfection which depend on it, attributed to it those very qualities on which, according to the conditions of our reason, such a systematical unity may depend. That idea, therefore, is entirely founded on the employment of our reason in the world, and if we were to attribute to it absolute and objective validity, we should be forgetting that it is only a Being in the idea which we think: and as we should then be taking our start from a cause, that cannot be determined by mundane considerations, we should no longer be able to employ that principle in accordance with the empirical use of reason.

But people will go on to ask, May we not then in this way use that concept, and the supposition of a Supreme Being in a rational consideration of the world \ No doubt we may, and it was for that very purpose that that idea of reason was established. And if it be asked whether we may look upon arrangements in nature which have all the appearance of design, as real designs, and trace them back to a divine will, though with the intervention of certain arrangements in the world, we answer again Yes, but only on condition that it be the same to you whether we say that the divine wisdom has arranged everything for the highest purposes, or whether we take the idea of the supreme wisdom as our rule in the investigation of nature, and as the principle of its systematical and well-planned unity according to general laws, even when we are not able to perceive that unity. In other words, it must be the same to you, even when you do perceive it, whether we say, God has wisely willed it so, or nature has wisely arranged it so. For it was that greatest systematical and well-planned unity, required by your reason as the regulative principle of all investigation of nature, which gave you the right to admit the idea of a supreme intelligence as the schema of that regulative principle. As much of design, therefore, as you discover in the world, so much of confirmation has the legitimacy of your idea received. But as that principle was only intended for finding the necessary and greatest possible unity in nature, we shall, no doubt, owe that unity, so far as we may find it, to our idea of a Supreme Being; but we cannot, without contradicting ourselves, ignore the general laws of nature for which that idea was adopted, or look upon the designs of nature as contingent and hyperphysical in their origin. For we were not justified in admitting a Being endowed with those qualities as above nature (hyperphysical), but only in using the idea of it in order to be able to look on all phenomena* as being systematically connected among themselves, in analogy with a causal determination.

For the same reason we are justified, not only in representing to ourselves the cause of the world in our idea according to a subtle kind of anthropomorphism (without which we can think nothing of it), as a Being endowed with understanding, the feelings of pleasure and displeasure, and accordingly with desire and will, but also in attributing to it infinite perfection, which therefore far transcends any perfection known to us from the empirical knowledge of the order of the world. For the regulative law of systematical unity requires that we should study nature as if there existed in it everywhere, with the greatest possible variety, an infinitely systematical and wellplanned unity. And although we can discover but little of that perfection of the world, it is nevertheless a law of our reason, always to look for it and to expect it; and it must be beneficial, and can never be hurtful, to carry on the investigation of nature according to this principle. But in admitting this fundamental idea of a supreme author, it is clear that I do not admit the existence and knowledge of such a Being, but its idea only, and that in reality I do not derive anything from that Being, but only from the idea of it, that is, from the nature of the things of the world, according to such an idea. It seems also, as if a certain, though undeveloped consciousness of the true use of this concept of reason had dictated the modest and reasonable language of philosophers of all times, when they use such expressions as the wisdom and providence of nature as synonymous with divine wisdom, nay, even prefer the former expression, when dealing with speculative reason only, as avoiding the pretension of a greater assertion than we are entitled to make, and at the same time restricting reason to its proper field, namely, nature.

1 Instead of der Erscheinungen, read die Erscheinungen.

Thus we find that pure reason, which at first seemed to promise nothing less than extension of our knowledge beyond all limits of experience, contains, if properly understood, nothing but regulative principles, which indeed postulate greater unity than the empirical use of the understanding can ever achieve, but which, by the very fact that they place the goal which has to be reached at so great a distance, carry the agreement of the understanding with itself by means of systematical unity to the highest possible degree; while, if they are misunderstood and mistaken for constitutive principles of transcendent knowledge, they produce, by a brilliant but deceptive illusion, some kind of persuasion and imaginary knowledge, but, at the same time, constant contradictions and disputes.

* * * *

Thus all human knowledge begins with intuitions, advances to concepts, and ends with ideas. Although with reference to every one of these three elements, it possesses a priori sources of knowledge, which at first sight seemed to despise the limits of all experience, a perfect criticism soon convinces us, that reason, in its speculative use, can never get with these elements beyond the field of possible experience, and that it is the true destination of that highest faculty of knowledge to use all methods and principles of reason with one object only, namely, to follow up nature into her deepest recesses, according to every principle of unity, the unity of design being the most important, but never to soar above its limits, outside of which there is for us nothing but empty space. No doubt, the critical examination of all propositions which seemed to be able to enlarge our knowledge beyond real experience, as given in the Transcendental Analytic, has fully convinced us that they could never lead to anything more than to a possible experience; and, if people were not suspicious even of the clearest abstract and general doctrines, and charming and specious prospects did not tempt us to throw off the restraint of those doctrines, we might indeed have dispensed with the laborious examination of all the dialectical witnesses which a transcendent reason brings into court in support of her pretensions. We knew beforehand with perfect certainty that all these pretensions, though perhaps honestly meant, were absolutely untenable, because they relate to a kind of knowledge to which man can never attain. But we know that there is no end

of talk, unless the true cause of the illusion, by which even the wisest are deceived, has been clearly exhibited. We also know that the analysis of all our transcendent knowledge into its elements (as a study of our own internal nature) has no little value in itself, and to a philosopher is really a matter of duty. We therefore thought that it was not only necessary to follow up the whole of this vain treatment of speculative reason to its first sources, but considered it advisable also, as the dialectical illusion does here not only deceive the judgment, but, owing to the interest which we take in the judgment, possesses and always will possess a certain natural and irresistible charm, to write down the records of this lawsuit in full detail, and to deposit them in the archives of human reason, to prevent for the future all errors of a similar kind. In its empirical use reason does not require such criticism, because its principles are constantly subject to the test of experience. Nor is such criticism required in mathematics, where the concepts of reason must at once be represented in concreto, in pure intuition, so that everything unfounded and arbitrary is at once discovered. But when neither empirical nor pure intuition keeps reason in a straight groove, that is, when it is used transcendently and according to mere concepts, the discipline to restrain its inclination to go beyond the narrow limits of possible experience, and to keep it from extravagance and error is so necessary, that the whole philosophy of pure reason is really concerned with that one negative discipline only. Single errors may be corrected by censure, and their causes removed by criticism. But when, as in pure reason, we are met by a whole system of illusions and fallacies, well connected among themselves and united by common principles, a separate negative code seems requisite, which, under the name of a discipline, should erect a system of caution and self-examination, founded on the nature of reason and of the objects of its use, before which no false sophistical illusion could stand, but should at once betray itself in spite of all excuses.

It should be well borne in mind, however, that in this second division of the transcendental critique, I mean to direct the discipline of pure reason not to its contents, but only to the method of its knowledge. The former task has been performed in the Elements of Transcendentalism. There is so much similarity in the practical use of reason, whatever be the subject to which it is applied, while its transcendental use is so essentially different from others, that, without the warning voice of a discipline, -especially devised for that purpose, it would be impossible to avoid errors arising necessarily from the improper application of methods, which are suitable to reason in other spheres, only not quite here.

1785
Thomas Reid, D.D.
Essays on the Intellectual Powers of Man (Response to David Hume)

Chapter V I - First Principles On Necessary Truths.

6. The last class of first principles I shall mention, we may call metaphysical.

I shall particularly consider three of these, because they have been called in question by Mr. Hume.

It is not more evident that two and two make four, than it is that figure cannot exist, unless there be something that is figured, nor motion without something that is moved. I not only perceive figure and motion, but I perceive them to be qualities. They have a necessary relation to something in which they exist as their subject. The difficulty which some philosophers have found in admitting this, is entirely owing to the theory of ideas. A subject of the sensible qualities which we perceive by our senses, is not an idea either of sensation or of consciousness; therefore say they, we have no such idea. Or, in the style of Mr. Hume, from what impression is the idea of substance derived? It is not a copy of any impression; therefore there is no such idea.

The distinction between sensible qualities, and the substance to which they belong, and between thought and the mind that thinks, is not the invention of philosophers; it is found in the structure of all languages, and therefore must be common to all men who speak with understanding. And I believe no man, however sceptical he may be in speculation, can talk on the common affairs of life for half an hour, without saying things that imply his belief of the reality of these distinctions.

Mr. Locke acknowledges, "That we cannot conceive how simple ideas of sensible qualities should subsist alone; and therefore we suppose them to exist in, and to be supported by, some common subject." In his Essay, indeed, some of his expressions seem to leave it dubious whether this belief, that sensible qualities must have a subject, be a true judgment or a vulgar prejudice. Out in his first letter to the Bishop of Worcester, he removes this doubt, and quotes many passages of his Essay, to shew that he neither denied nor doubted of the existence of substances, both thinking and material; and that he believed their existence on the same ground the Bishop did—to wit, " on the repugnancy to our conceptions, that modes and accidents should subsist by themselves." He offer* no proof of this repugnancy; nor, I think, can any proof of it be given, because it is a first principle.

It were to be wished that Mr. Locke, who inquired so accurately and so laudably into the origin, certainty, and extent of human knowledge, had turned his attention more particularly to the origin of these two opinions which he firmly believed; to wit, that sensible qualities must have a subject which we call body, and that thought must have a subject which we call mind. A due attention to these two opinions which govern the belief of all men, even of sceptics in the practice of life, would probably have led him to perceive, that sensation and consciousness are not the only sources of human knowledge; and that there are principles of belief in human nature, of which we can give no other account but that they necessarily result from the constitution of our faculties; and that, if it were in our power to throw off their influence upon our practice and conduct, we could neither speak nor act like reasonable men. cannot be ascribed to education, to systems of philosophy, or to priestcraft. One would think that a philosopher who takes it to be a general delusion or prejudice, would endeavour to shew from what causes in human nature such a general error may take its rise. But I forget that Mr. Hume might answer upon his own principles, that since things may happen without a cause— this error and delusion of men may be universal without any cause.

We cannot give a reason why we believe even our sensations to be real and not fallacious; why we believe what we are conscious of; why we trust any of our natural faculties. We say, it must be so, it cannot be otherwise. This expresses only a strong belief, which is indeed the voice of nature, and which therefore in vain we attempt to resist. But if, in spite of nature, we resolve to go deeper, and not to trust our faculties, without a reason to shew that they cannot be fallacious, I am afraid, that, seeking to become wise, and to be as gods, we shall become foolish, and, being unsatisfied with the lot of humanity, we shall throw off common sense.

The second metaphysical principle I mention is—That whatever exist, must have a cause produced it.

Philosophy is indebted to Mr. Hume in this respect among others, that, by calling in question many of the first principles of human knowledge, he hath put speculative men upon inquiring more carefully than was done before into the nature of the evidence upon which they rest. Truth can never suffer by a fair inquiry; It can bear to be seen naked and in the fullest light; and the strictest examination will always turn out in the issue to its advantage. I believe Mr. Hume was the first who ever called in question whether things that begin to exist must have a cause.

With regard to this point, we must hold one of these three things, either that it is an opinion for which we have no evidence, and which men have foolishly taken up without ground; or, secondly,

That it is capable of direct proof by argument; or, thirdly, That it is self-evident, and needs no proof, but ought to be received as an axiom, which cannot, by reasonable men, be called in question.

The first of these suppositions would put an end to all philosophy, to all religion, to all reasoning that would carry us beyond the objects of sense, and to all prudence in the conduct of life.

As to the second supposition, that this principle may be proved by direct reasoning, I am afraid we shall find the proof extremely difficult, if not altogether impossible.

I know only of three or four arguments that have been urged by philosophers, in the way of abstract reasoning, to prove that things which begin to exist must have a cause.

One is offered by Mr. Hobbes, another by Dr Samuel Clarke, another by Mr. Locke. Mr., in his "Treatise of Human. Nature," has examined them all;* and, in my opinion, has shewn that they take for granted the thing to be proved; a kind of false reasoning, which men are very apt to fall into when they attempt to prove what is self-evident.

It has been thought, that, although this principle does not admit of proof from abstract reasoning, it may be proved from experience, and may be justly drawn by induction, from instances that fall within our observation.

I conceive this method of proof will leave us in great uncertainty, for these three reasons:

lit, Because the proposition to be proved is not a contingent but a necessary proposition. It is not that things which begin to exist commonly have * cause, or even that they always in fact have a cause; but that they must have a cause, and cannot begin to exist without a cause.

Propositions of this kind, from their nature, are incapable of proof by induction. Experience informs us only of what is or has been, not of what must be; and the conclusion must be of the same nature with the premises. -|

For this reason, no mathematical proposition can be proved by induction. Though it should be found by experience in a thousand cases, that the area of a plane triangle is equal to the rectangle under the altitude and half the base, this would not prove that it must be so in all cases, and cannot be otherwise; which is what the mathematician

In like manner, though we had the most ample experimental proof that things which have begun to exist had a cause, this would not prove that they must have a cause, Experience may shew us what is the established course of nature, but can never shew what connections of things are in their nature necessary.

Sadly, General maxims, grounded on experience, have only a decree of probability proportioned to the extent of our experience, and ought always to be understood so as to leave room for exceptions, if future experience shall discover any such.

The law of gravitation has as full a proof from experience and induction as any principle can be supposed to have. Yet, if any philosopher should, by clear experiment,

•hew that there is a kind of matter in some bodies which does not gravitate, the law of gravitation ought to be limited by that exception.

Now it is evident that men have never considered the principle of the necessity of ' causes, as a truth of this kind which may admit of limitation or exception; and therefore it has not been received upon this kind of evidence.

3dly, I do not see that experience could satisfy us that every change in nature actually has a cause.

In the far greatest part of the changes in nature that fall within our observation, the causes are unknown; and, therefore, from experience, we cannot know whether they have causes or not.

Causation is not an object of sense. The only experience we can have of it, is in the consciousness we have of exerting some power in ordering our thoughts and actions. But this experience is surely too narrow a foundation for a general conclusion, that all things that have had or shall have a beginning, must have a cause.

For these reasons, this principle cannot be drawn from experience, any more than from abstract reasoning.

The third supposition is—That it is to be admitted as a first or self-evident principle. Two reasons may be urged for this.

1. The universal consent of mankind, not of philosophers only, but of the rude and unlearned vulgar.

Mr. Hume, as far as I know, was the first that ever expressed any doubt of this principle. And when we consider that he has rejected every principle of human knowledge, excepting that of consciousness, and has not even spared the axioms of mathematics, his authority is of small weight.

Indeed, with regard to first principles, there is no reason why the opinion of a philosopher should have more authority than that of another man of common sense, who has been accustomed to judge in such cases. The illiterate vulgar are competent judges; and the philosopher has no prerogative in matters of this kind; but he is more liable than they to be misled by a favourite system, especially if it is his own.

Setting aside the authority of Mr. Hume, what has philosophy been employed in since men first began to philosophise, but in the investigation of the causes of things? This it has always professed, when we trace it to its cradle. It never entered into any roan's thought, before the philosopher we have mentioned, to put the previous question, whether things have a cause or not? Had it been thought possible that they might not, it may be presumed that, in the variety of absurd and contradictory causes assigned, some one would have had recourse to this hypothesis.

They could conceive the world to arise from an egg, from a struggle between love and strife, between moisture and drought, between heat and cold; but they never supposed that it had no cause. We know not any atheistic sect that ever had recourse to this topic, though by it, they might have evaded every argument that could be brought against them, and answered all objections to their system.

But rather than adopt such an absurdity, they contrived some imaginary cause—such as chance, a concourse of atoms, or necessity—as the cause of the universe.

The accounts which philosophers have given of particular phenomena, as well as of the universe in general, proceed upon the same principle. That every phenomenon must have a cause, was always taken for granted, says Cicero. Though an Academic, he was dogmatical in this. And Plato, the

father of the Academy, was no less so. “It is impossible that anything should have its origin without a cause."—Tim.eus.

I believe Mr. Hume was the first who ever held the contrary. *This, indeed,” he avows, and assumes the honour of the discovery. "It is," says he, "a maxim in philosophy, that whatever begins to exist, must have a cause of existence. This is commonly taken for granted in all reasonings, without any proof given or demanded. It is supposed to be founded on intuition, and to be one of those maxims which, though they may be denied with the lips, it is impossible for men in their hearts really to doubt of. But, if we examine this maxim by the idea of knowledge above explained, we shall discover in it no mark of such intuitive certainty." The meaning of this seems to be, that it did not suit with his theory of intuitive certainty, and, therefore, he excludes it from that privilege.

The vulgar adhere to this maxim as firmly and universally as the philosophers. Their superstitions have the same origin as the systems of philosophers—to wit, a desire to know the causes of things. is the universal sense of men; but to say that anything can happen without a cause, shock* the common sense of a savage.

This universal belief of mankind is easily accounted for, if we allow that the necessity of a cause of every event is obvious to the rational powers of a man. But it is impossible to account for it otherwise.

2. A second reason why I conceive this to be a first principle, is, That mankind not only assent to it in speculation, but that the practice of life is grounded upon it in the most important matters, even in cases where experience leaves us doubtful; and it is impossible to act with common prudence if we set it aside.

In great families, there arc so many bad things done by a certain personage, called Nobody, that it is proverbial that there is a Nobody about every house who docs a great deal of mischief; and even where there is the exactest inspection and government, many events will happen of which no other author can be found; so that, if we trust merely to experience in this matter, Nobody will be found to be a very active person, and to have no inconsiderable share in the management of affairs. But whatever countenance this system may have from experience, it is too shocking to common sense to impose upon the most ignorant. A child knows that, when his top, or any of his playthings, are taken away, it must be done by somebody. Perhaps it would not be difficult to persuade him that it was done by some invisible being, but that it should be done by nobody he cannot believe.

Suppose a man's house to be broke open, his money and jewels taken away. Such things have happened times innumerable without any apparent cause; and were ho only to reason from experience in such a case, how must he behave 1 He must put in one scale the instances wherein a cause was found of such an event, and in the other scale the instances where no cause was found, and the preponderant scale must determine whether it be most probable that there was a cause of this event, or that there was none. Would any man of common understanding have recourse to such an expedient to direct his judgment?

Suppose a man to be found dead on the highway, his skull fractured, his body pierced with deadly wounds, his watch and money carried off. The coroner's jury sits upon the body; and the question is put, What was the cause of this man's death?— was it accident, or *felo de se,* or murder by persons unknown? Let us suppose an adept in Mr. Hume's philosophy to make one of the jury, and that he insists upon the previous question, whether there was any cause of the event, and whether it happened without a cause.

Surely, upon Mr. Hume's principles, a great deal might be said upon this point; and, if the matter is to be determined by past experience, it is dubious on which side the weight of argument might stand. But we may venture to say, that, if Mr. Hume had been of such a jury, he would have laid aside his philosophical principles, and acted according to the dictates of common prudence.

Many passages might be produced, even in Mr. Hume's philosophical writings, in which he, unawares, betrays the same inward conviction of the necessity of causes which is common to other men. I shall mention only one, in the "Treatise of Human Nature," and is that part of it where he combats this very principle:—"As to those impressions," says he, "which arise from the senses, their ultimate cause is, in my opinion, perfectly inexplicable by human reason; and it will always be impossible to decide with certainty whether they arise immediately from the object, or are produced by the creative power of the mind, or are derived from the Author of our being."

Among these alternatives, he never thought of their not arising from any cause.

The arguments which Mr. Hume offers to prove that this is not a self-evident principle, are three. First, That all certainty arises from a comparison of ideas, and a discovery of their unalterable relations, none of which relations imply this proposition, That whatever has a beginning must have a cause of existence. This theory of certainty has been examined before.

The second argument is, That whatever we can conceive is possible. This has likewise been examined.

The third argument is, That what we call a cause, is only something antecedent to, and always conjoined with, the effect. This is also one of Mr. Hume's peculiar doctrines, which we may have occasion to consider afterwards. It is sufficient here to observe, that we may learn from it that night is the cause of day, and day the cause of night: for no two things have more constantly followed each other since the beginning of the world.

The metaphysical principle I mention, which is opposed by the same author, is, That design and intelligence in the cause may be inferred, from marks or signs of it in the effect.

Intelligence, design, and skill, are not objects of the external senses, nor can we be conscious of them in any person but ourselves. Even in ourselves, we cannot, with propriety, be said to be conscious of the natural or acquired talents we possess. We are conscious only of the operations of mind in which they are exerted. Indeed, a man comes to know his own mental abilities, just as he knows another man's, by the effects they produce, when there is occasion to put them to exercise.

A man's wisdom is known to us only by the signs of it in his conduct; his eloquence by the signs of it in his speech. In the same manner, we judge of his virtue, of his fortitude, and of all his talents and virtues.

Yet it is to be observed, that we judge of men's talents with as little doubt or hesitation as we judge of the immediate objects of sense.

One person, we are sure, is a perfect idiot; another, who feigns idiocy to screen himself from punishment, is found, upon trial, to have the understanding of a man, and to be accountable for his conduct. We perceive one man to be open, another cunning; one to be ignorant, another very knowing; one to be slow of understanding, another quick. Every man forms such judgments of those he converses with; and the common affairs of life depend upon such judgments. We can as little avoid them as we can avoid seeing what is before our eyes.

From this it appears, that it is no less a part of the human constitution, to judge of men's characters, and of their intellectual powers, from the signs of them in their actions and discourse, than to judge of corporeal objects by our senses; that such judgments are common to the whole human race that are endowed with understanding; and that they are absolutely necessary in the conduct of life.

Now, every judgment of this kind we form, is only a particular application of the general principle, that intelligence, wisdom, and other mental qualities in the cause, may be inferred from their marks or signs in the effect.

The actions and discourses of men are effects, of which the actors and speakers are the causes. The effects are perceived by our senses; but the causes are behind the scene. We only conclude their existence and their degrees from our observation of the effect.

From wise conduct, we infer wisdom in the cause; from brave actions, we infer courage; and so in other cases.

This inference is mode with perfect security by all men. We cannot avoid it; it is necessary in the ordinary conduct of life; it has therefore the strongest marks of being a first principle.

Perhaps some may think that this principle may be learned either by reasoning or by experience, and therefore that there is no ground to think it a first principle.

If it can be shewn to be got by reasoning, by all, or the greater part of those who are governed by it, I shall very readily acknowledge that it ought not to be esteemed a first principle. But I apprehend the contrary appears from very convincing arguments.

First, The principle is too universal to be the effect of reasoning. It is common to philosophers and to the vulgar; to the learned and to the most illiterate; to the civilized and to the savage. And of those who are governed by it, not one in ten thousand can give a reason for it.

Secondly, We find philosophers, ancient and modern, who can reason excellently in subjects that admit of reasoning, when they have occasion to defend this principle, not offering reasons for it, or any medium of proof, but appealing to the common sense of mankind; mentioning particular instances, to make the absurdity of the contrary opinion more apparent, and sometimes using the weapons of wit and ridicule, which are very proper weapons for refuting absurdities, but altogether improper in points that are to be determined by reasoning.

To confirm this observation, I shall quote two authors, an ancient and a modern, who have more expressly undertaken the defence of this principle than any others I remember to have met with, and whose good sense and ability to reason, where reasoning is proper, will not be doubted.

Can anything done by chance have all the marks of design Four dice may by chance turn up four aces; but do you think that four hundred dice, thrown by chance, will turn up four hundred aces? Colours thrown upon canvas without design may have some similitude to a human face; but do you think they might make as beautiful a picture as that of the Coan Venus? A hog turning up the ground with his nose may make something of the form of the letter A; but do you think that a hog might describe on the ground the Andromache of Ennius? Carneades imagined that, in the stone quarries at Chios, he found, in a stone that was split, a representation of the head of a little Pan, or sylvan deity. I believe he might find a figure not unlike; but surely not such a one as you would say had been formed by an excellent sculptor like Scopus. For so, verily, the case is, that chance never perfectly imitates design. (Cicero)

Now, in all this discourse, I see very good sense, and what is apt to convince every unprejudiced mind; but I see not in the whole a single step of reasoning. It is barely an appeal to every man's common sense.

Let us next see how the same point is handled by the excellent Archbishop Tillotbon. (1st Sermon, vol. i.)

For I appeal to any man of reason, whether anything can be more unreasonable than obstinately to impute an effect to chance which carries in the face of it all the arguments and characters of design? Was ever any considerable work, in which there Was required a great variety of parts, and an orderly and regular adjustment of these parts, done by chance? Will chance fit means to ends, and that in ten thousand instances, and not fail in any one? [G25] How often might a man, after he had jumbled a set of letters in a bag, fling them out upon the ground before they would fall into an exact poem, yea, or so much as make a good discourse in prose? And may not a little book be as easily made as this great volume of the world? How long might a man sprinkle colours upon canvass with a careless hand, before they would make the exact picture of a man? And is a man easier made by chance than his picture? How long might twenty thousand blind men, which should be sent out from the remote parts of England, wander up and down before they would all meet upon Salisbury plains, and fall into rank and file in the exact order of an army? And yet this is much more easy to be imagined than how the innumerable blind parts of matter should rendezvous themselves into a word. A man that sees Henry VII.'s chapel at Westminster might, with as good reason, maintain, (yea, and much better, considering the vast difference between that little structure and the huge fabric of the world,) that it was never contrived or built by any man, but that the stones did by chance grow into those curious figures into which we see seem to have been cut and graven; and that, upon a time, (ns tales usually begin,) the materials of that building—the stone, mortar, timber, iron, lead, and gloss—happily met together, and very fortunately ranged themselves into that delicate order in which we see them now, so close compacted that it must be a very great chance that parts them again. What would the world think of a man that should advance such an opinion as this, and write a book for it? If they would do him right, they ought to look upon him as mad. But yet he might maintain this opinion with a little more reason than any man can have to say that the world was made by chance, or that the first men grew out of the earth, as plants do now; for, can anything be more ridiculous and against all reason, than to ascribe the production of men to the first fruitfulness of the earth, without so much as one instance or experiment in any age or history to countenance so monstrous a supposition? The thing is at first sight so gross and palpable, that no discourse about it can make it more apparent. And yet these shameful beggars of principles, who give this precarious account of the original of things, assume to themselves to be the men of reason, the great wits of the- world, the only cautious and wary persons, who hate to be imposed upon, that must have convincing evidence for everything, and can admit nothing without a clear demonstration for it.

In this passage, the excellent author takes what I conceive to be the proper method of refuting an absurdity, by exposing it in different lights, in which every man of common understanding conceives it to be ridiculous. And, although there is much good sense, as well as wit, in the passage I have quoted, I cannot find one medium of proof in the whole.

I have met with one or two respectable authors who draw an argument from the doctrine of chances, to shew how improbable it is that a regular arrangement of parts should be the effect of chance, or that it should not be the effect of design.

I do not object to this reasoning; but I would observe that the doctrine of chances is a branch of mathematics little more than an hundred years old. But the conclusion drawn from it has been held by all men from the beginning of the world. It cannot, therefore, be thought that men have been led to this conclusion by that reasoning. Indeed, it may be doubted whether the first principle upon which all the mathematical reasoning about chances is grounded, is more self-evident than this conclusion drawn from it, or whether it is not a particular instance of that general conclusion.

We are next to consider whether we may not learn this truth from experience, That effects which have all the marks and tokens of design, must proceed from a designing cause.

I apprehend that we cannot learn this truth from experience for two reasons.

First, Because it is a necessary truth, not a contingent one. It agrees with the experience of mankind since the beginning of the world, that the area of a triangle is equal to half the rectangle under its base and perpendicular. It agrees no less with experience, that the sun rises in the east and sets in the west. So far as experience lies, these truths are upon au equal footing. But every man perceives this distinction between them—that the first is a necessary truth, and that it is impossible it should not be true; but the last is not necessary, but contingent, depending upon the will of Him who made the world. As we cannot learn from experience that twice three must necessarily make six, so neither can we learn from experience that certain effects must proofed from a designing and intelligent cause. Experience informs us only of what has been, but never of what must be.

Secondly, It may be observed, that experience can shew a connection between a sign and the thing signified by it, in those cases only where both the sign and thing signified are perceived and have always been perceived in conjunction. But, if there be any case where the sign only is perceived, experience can never shew its connection with the thing signified. Tims, for example, thought is a sign of a thinking principle or mind. But how do we know that thought cannot be without a mind? If any man should say that he knows this by experience, he deceives himself. It is impossible he can have any experience of this; because, though we have an immediate knowledge of the existence of thought in ourselves by consciousness, yet we have no immediate knowledge of a mind. The mind is not an immediate object cither of sense or of consciousness. We may, therefore, justly conclude, that 'the necessary connection between thought and a mind, or thinking being, is not learned from experience.

The same reasoning may be applied to the connection between a work excellently fitted for some purpose, and design in the author or cause of that work. One of these —to wit, the work—may be an immediate object of perception. But the design and purpose of the author cannot be an immediate object of perception; and, therefore, experience can never inform us of any connection between the one and the other, far less of a necessary connection.

Thus, I think, it appears, that the principle we have been considering—to wit, that from certain signs or indications in the effect, we may infer that there must have been intelligence, wisdom, or other intellectual or moral qualities in the cause, is a principle which we get, neither by reasoning nor by experience; and, therefore, if it be a true principle, it must be a first principle. There is in the human understanding a light, by which we see immediately the evidence of it, when there is occasion to apply it.

Of how great importance this principle is in common life, we have already observed. And I need hardly mention its importance in natural theology.

The clear marks and signatures of wisdom, power, and goodness, in the constitution and government of the world, is, of all arguments that have been advanced for the being and providence of the Deity, that which in all ages has made the strongest impression upon candid and thinking minds; an argument, which has this peculiar advantage, that it gathers strength as human knowledge advances, and is more convincing at present than it was some centuries ago.

King Alphonsus might say, that he could contrive a better planetary system than that which astronomers held in his day. That system was not the work of God, but the fiction of men.

But since the true system of the sun, moon, and planets, has been discovered, no man, however atheistically disposed, has pretended to shew how a better could be contrived.

When we attend to the marks of good contrivance which appear in the works of God, every discovery we make in the constitution of the material or intellectual system becomes a hymn of praise to the great Creator and Governor of the world. And a man who is possessed of the genuine spirit of philosophy will think it impiety, to contaminate the divine workmanship, by mixing it with those fictions of human fancy, called theories and hypotheses, which will always bear the signatures of human folly, no less than the other does of divine wisdom.

I know of no person who ever called in question the principle now under our consideration, when it is applied to the actions and discourses of men. For this would be to deny that we have any means of discerning a wise man from an idiot, or a man that is illiterate in the highest degree from a man of knowledge and learning, which no man has the effrontery to deny.

But, in all ages, those who have been unfriendly to the principles of religion, have made attempts to weaken the force of the argument for the existence and perfections of the Deity, which is founded on this principle. That argument has got the name of the argument from final causes; and as the meaning of this name is well understood, we shall use it.

The argument from final causes, when reduced to a syllogism, has these two premises:

First,
That design and intelligence in the cause, may, with certainty, be inferred from marks or signs of it in the effect.

This is the principle we have been considering, and we may call it the major proposition of the argument

The second, which we call the minor proposition, is,

That there are in fact the clearest marks of design and wisdom in the works of nature;

and the conclusion is,

That the works of nature are the effects of a wise and intelligent Cause.

One must either assent to the conclusion, or deny one or other of the premises.

Those among the ancients who denied a God or a Providence, seem to me to have yielded the major proposition, and to have denied the minor; conceiving that there are not in the constitution of things such marks of wise contrivance as are sufficient to put the conclusion beyond doubt. This,

I think, we may learn, from the reasoning of Cotta the academic, in the third book of Cicero, of the Nature of the Gods.

The gradual advancement made in the knowledge of nature, hath put this opinion quite out of countenance.

When the structure of the human body was much less known than it is now, the famous Galen saw such evident marks of wise contrivance in it, that, though he had been educated an Epicurean, he renounced that system, and wrote his book of the use of the parts of the human body, on purpose to convince others of what appeared so clear to himself, that'll was impossible that such admirable contrivance should be the effect of chance.

Those, therefore, of later times, who arc dissatisfied with this argument from final causes, have quitted the stronghold of the ancient atheists, which had become untenable, and have chosen rather to make a defence against the major proposition.

Des Cartes seems to have led the way in this, though he was no atheist, but, having invented some new arguments for the being of God, he was, perhaps, led to disparage those that had been used before, that he might bring more credit to his own. Or perhaps he was offended with the Peripatetic's, because they often mixed final causes with physical, in order to account for the phenomena of nature.

He maintained, therefore, that physical causes only should be assigned for phoenomena; that the philosopher has nothing to do with final causes; and that it is presumption in us to pretend to determine for what end any work of nature is framed. Some of those who were great admirers of Des Cartes, and followed him in many points, differed from him in this, particularly Dr Henry More and the pious Archbishop Fenelon: but others, after the example of Des Cartes, have shewn a contempt of all reasoning from final causes. Among these, I think, we may reckon Maupertuis (Pierre Louis Maupertuis, 1698-1759) and Buffon (George Louis LeClerc Comte de Buffon, 1707-1788)

But the most direct attack has been made upon this principle by Mr. Hume, who puts an argument in the mouth of on Epicurean, on which he seems to lay great stress.

The argument is, That the universe is a singular effect, and, therefore, we can draw no conclusion from it, whether it may have been made by wisdom or not.

If I understand the force of this argument, it amounts to this, That, if we had been accustomed to see worlds produced, some by wisdom and others without it, and had observed that such a world as this which we inhabit was always the effect of wisdom, we might then, from past experience, conclude that this world was made by wisdom; but, having no such experience, we have no means of forming any conclusion about it.

That this is the strength of the argument appears, because, if the marks of wisdom seen in one world be no evidence of wisdom, the like marks seen in ten thousand will give as little evidence, unless, in time past, we perceived wisdom itself conjoined with the tokens of it; and, from their perceived conjunction in time past, conclude that, although, in the present world, we see only one of the two, the other must accompany it.

Whence it appears that this reasoning of Mr. Hume is built on the supposition that our inferring design from the strongest marks of it, is entirely owing to our past experience of having always found these two things conjoined- But I hope I have made it evident that this is not the case. And,

indeed, it is evident that, according to this reasoning, we can have no evidence of mind or design in any of our fellowmen.

How do I know that any man of my acquaintance has understanding? I never saw his understanding. I see only certain effects, which my judgment leads me to conclude to the marks and tokens of it

But, says the sceptical philosopher, yon can conclude nothing from these tokens, unless past experience has informed you that such tokens are always joined with understanding. Alas! sir, it is impossible I can ever have this experience. The understanding of another man is no immediate object of sight, or of any other faculty which God hath given me; and unless I can conclude its existence from tokens that are visible, I have no evidence that there is understanding in any man.

It seems, then, that the man who maintains that there is no force in the argument from final causes, must, if he will be consistent, see no evidence of the existence of any intelligent being but himself.

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Chapter I. State Of The Argument.

IN crossing a heath, suppose I pitched my foot against a *stone*, and were asked how the stone came to be there; I might possibly answer, that, for any thing I knew to the contrary, it had lain there for ever: nor would it perhaps be very easy to show the absurdity of this answer. But suppose I had found a *watch* upon the ground, and it should be inquired how the watch happened to be in that place; I should hardly think of the answer which I had before given, that, for any thing I knew, the watch might have always been there. Yet why should not this answer serve for the watch as well as for the stone? why is it not as admissible in the second case, as in the first? For this reason, and for no other, viz. that, when we come to inspect the watch, we perceive (what we could not discover in the stone) that its several parts are framed and put together for a purpose, *e. g.* that they are so formed and adjusted as to produce motion, and that motion so regulated as to point out the hour of the day; that, if the different parts had been differently shaped from what they are, of a different size from what they are, or placed after any other manner, or in any other order, than that in which they are placed, either no motion at all would have been carried on in the machine, or none which would have answered the use that is now served by it. To reckon up a few of the plainest of these parts, and of their offices, all tending to one result:-- We see a cylindrical box containing a coiled elastic spring, which, by its endeavour to relax itself, turns round the box. We next observe a flexible chain (artificially wrought for the sake of flexure), communicating the action of the spring from the box to the fusee. We then find a series of wheels, the teeth of which catch in, and apply to, each other, conducting the motion from the fusee to the balance, and from the balance to the pointer; and at the same time, by the size and shape of those wheels, so regulating that motion, as to terminate in causing an index, by an equable and measured progression, to pass over a given space in a given time. We take notice that the wheels are made of brass in order to keep them from rust; the springs of steel, no other metal being so elastic; that over the face of the watch there is placed a glass, a material employed in no other part of the work, but in the room of which, if there had been any other than a transparent substance, the hour could not be seen without opening the case. This mechanism being observed (it requires indeed an examination of the instrument, and perhaps some previous knowledge of the subject, to perceive and understand it; but being once, as we have said, observed and understood), the inference, we think, is inevitable, that the watch must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use.

I. Nor would it, I apprehend, weaken the conclusion, that we had never seen a watch made; that we had never known an artistcapable of making one; that we were altogether incapable of executing such a piece of workmanship ourselves, or of understanding in what manner it was performed; all this being no more than what is true of some exquisite remains of ancient art, of some lost arts, and, to the generality of mankind, of the more curious productions of modern manufacture. Does one man in a million know how oval frames are turned? Ignorance of this kind exalts our opinion of the unseen and unknown artist's skill, if he be unseen and unknown, but raises no doubt in our minds of the existence and agency of such an artist, at some former time, and in some place or other. Nor can I perceive that it varies at all the inference, whether the question arise concerning a human agent, or concerning an agent of a different species, or an agent possessing, in some respects, a different nature.

II. Neither, secondly, would it invalidate our conclusion, that the watch sometimes went wrong, or that it seldom went exactly right. The purpose of the machinery, the design, and the designer, might be evident, and in the case supposed would be evident, in whatever way we accounted for the irregularityof the movement, or whether we could account for it or not. It is not necessary that

a machine be perfect, in order to show with what design it was made: still less necessary, where the only question is, whether it were made with any design at all.

III. Nor, thirdly, would it bring any uncertainty into the argument, if there were a few parts of the watch, concerning which we could not discover, or had not yet discovered, in what manner they conduced to the general effect; or even some parts, concerning which we could not ascertain, whether they conduced to that effect in any manner whatever. For, as to the first branch of the case; if by the loss, or disorder, or decay of the parts in question, the movement of the watch were found in fact to be stopped, or disturbed, or retarded, no doubt would remain in our minds as to the utility or intention of these parts, although we should be unable to investigate the manner according to which, or the connexion by which, the ultimate effect depended upon their action or assistance; and the more complex is the machine, the more likely is this obscurity to arise. Then, as to the second thing supposed, namely, that there were parts which might be spared, without prejudice to the movement of the watch, and that we had proved this by experiment,--these superfluous parts, even if we were completely assured that they were such, would not vacate the reasoning which we had instituted concerning other parts. The indication of contrivance remained, with respect to them, nearly as it was before.

IV. Nor, fourthly, would any man in his senses think the existence of the watch, with its various machinery, accounted for, by being told that it was one out of possible combinations of material forms; that whatever he had found in the place where he found the watch, must have contained some internal configuration or other; and that this configuration might be the structure now exhibited, viz. of the works of a watch, as well as a different structure.

V. Nor, fifthly, would it yield his inquiry more satisfaction to be answered, that there existed in things a principle of order, which had disposed the parts of the watch into their present form and situation. He never knew a watch made by the principle of order; nor can he even form to himself an idea of what is meant by a principle of order, distinct from the intelligence of the watch-maker.

VI. Sixthly, he would be surprised to hear that the mechanism of the watch was no proof of contrivance, only a motive to induce the mind to think so:

VII. And not less surprised to be informed, that the watch in his hand was nothing more than the result of the laws of *metallic*nature. It is a perversion of language to assign any law, as the efficient, operative cause of any thing. A law presupposes an agent; for it is only the mode, according to which an agent proceeds: it implies a power; for it is the order, according to which that power acts. Without this agent, without this power, which are both distinct from itself, the *law* does nothing; is nothing. The expression, "the law of metallic nature," may sound strange and harsh to a philosophic ear; but it seems quite as justifiable as some others which are more familiar to him, such as "the law of vegetable nature," "the law of animal nature," or indeed as "the law of nature" in general, when assigned as the cause of phænomena, in exclusion of agency and power; or when it is substituted into the place of these.

VIII. Neither, lastly, would our observer be driven out of his conclusion, or from his confidence in its truth, by being told that he knew nothing at all about the matter. He knows enough for his argument: he knows the utility of the end: he knows the subserviency and adaptation of the means to the end. These points being known, his ignorance of other points, his doubts concerning other points, affect not the certainty of his reasoning. The consciousness of knowing little, need not beget a distrust of that which he does know.

Chapter Ii. State Of The Argument Continued.

SUPPOSE, in the next place, that the person who found the watch, should, after some time, discover that, in addition to all the properties which he had hitherto observed in it, it possessed the unexpected property of producing, in the course of its movement, another watch like itself (the thing is conceivable); that it contained within it a mechanism, a system of parts, a mould for instance, or a complex adjustment of lathes, files, and other tools, evidently and separately calculated for this purpose; let us inquire, what effect ought such a discovery to have upon his former conclusion. I. The first effect would be to increase his admiration of the contrivance, and his conviction of the consummate skill of the contriver. Whether he regarded the object of the contrivance, the distinct apparatus, the intricate, yet in many parts intelligible mechanism, by which it was carried on, he would perceive, in this new observation, nothing but an additional reason for doing what he had already done,--for referring the construction of the watch to design, and to supreme art. If that construction *without* this property, or which is the same thing, before this property had been noticed, proved intention and art to have been employed about it; still more strong would the proof appear, when he came to the knowledge of this further property, the crown and perfection of all the rest.

II. He would reflect, that though the watch before him were, *in some sense*, the maker of the watch, which was fabricated in the course of its movements, yet it was in a very different sense from that, in which a carpenter, for instance, is the maker of a chair; the author of its contrivance, the cause of the relation of its parts to their use. With respect to these, the first watch was no cause at all to the second: in no such sense as this was it the author of the constitution and order, either of the parts which the new watch contained, or of the parts by the aid and instrumentality of which it was produced. We might possibly say, but with great latitude of expression, that a stream of water ground corn: but no latitude of expression would allow us to say, no stretch of conjecture could lead us to think, that the stream of water built the mill, though it were too ancient for us to know who the builder was. What the stream of water does in the affair, is neither more nor less than this; by the application of an unintelligent impulse to a mechanism previously arranged, arranged independently of it, and arranged by intelligence, an effect is produced, viz. the corn is ground. But the effect results from the arrangement. The force of the stream cannot be said to be the cause or author of the effect, still less of the arrangement. Understanding and plan in the formation of the mill were not the less necessary, for any share which the water has in grinding the corn: yet is this share the same, as that which the watch would have contributed to the production of the new watch, upon the supposition assumed in the last section. Therefore,

III. Though it be now no longer probable, that the individual watch, which our observer had found, was made immediately by the hand of an artificer, yet doth not this alteration in anywise affect the inference, that an artificer had been originally employed and concerned in the production. The argument from design remains as it was. Marks of design and contrivance are no more accounted for now, than they were before. In the same thing, we may ask for the cause of different properties. We may ask for the cause of the colour of a body, of its hardness, of its head; and these causes may be all different. We are now asking for the cause of that subserviency to a use, that relation to an end, which we have remarked in the watch before us. No answer is given to this question, by telling us that a preceding watch produced it. There cannot be design without a designer; contrivance without a contriver; order without choice; arrangement, without any thing capable of arranging; subserviency and relation to a purpose, without that which could intend a purpose; means suitable to an end, and executing their office, in accomplishing that end, without

the end ever having been contemplated, or the means accommodated to it. Arrangement, disposition of parts, subserviency of means to an end, relation of instruments to a use, imply the presence of intelligence and mind. No one, therefore, can rationally believe, that the insensible, inanimate watch, from which the watch before us issued, was the proper cause of the mechanism we so much admire in it;--could be truly said to have constructed the instrument, disposed its parts, assigned their office, determined their order, action, and mutual dependency, combined their several motions into one result, and that also a result connected with the utilities of other beings. All these properties, therefore, are as much unaccounted for, as they were before.

IV. Nor is any thing gained by running the difficulty farther back, *i. e.* by supposing the watch before us to have been produced from another watch, that from a former, and so on indefinitely. Our going back ever so far, brings us no nearer to the least degree of satisfaction upon the subject. Contrivance is still unaccounted for. We still want a contriver. A designing mind is neither supplied by this supposition, nor dispensed with. If the difficulty were diminished the further we went back, by going back indefinitely we might exhaust it. And this is the only case to which this sort of reasoning applies. Where there is a tendency, or, as we increase the number of terms, a continual approach towards a limit, *there*, by supposing the number of terms to be what is called infinite, we may conceive the limit to be attained: but where there is no such tendency, or approach, nothing is effected by lengthening the series. There is no difference as to the point in question (whatever there may be as to many points), between one series and another; between a series which is finite, and a series which is infinite. A chain, composed of an infinite number of links, can no more support itself, than a chain composed of a finite number of links. And of this we are assured (though we never *can* have tried the experiment), because, by increasing the number of links, from ten for instance to a hundred, from a hundred to a thousand, &c. we make not the smallest approach, we observe not the smallest tendency, towards self-support. There is no difference in this respect (yet there may be a great difference in several respects) between a chain of a greater or less length, between one chain and another, between one that is finite and one that is infinite. This very much resembles the case before us. The machine which we are inspecting, demonstrates, by its construction, contrivance and design. Contrivance must have had a contriver; design, a designer; whether the machine immediately proceeded from another machine or not. That circumstance alters not the case. That other machine may, in like manner, have proceeded from a former machine: nor does that alter the case; contrivance must have had a contriver. That former one from one preceding it: no alteration still; a contriver is still necessary. No tendency is perceived, no approach towards a diminution of this necessity. It is the same with any and every succession of these machines; a succession of ten, of a hundred, of a thousand; with one series, as with another; a series which is finite, as with a series which is infinite. In whatever other respects they may differ, in this they do not. In all equally, contrivance and design are unaccounted for.

The question is not simply, How came the first watch into existence? which question, it may be pretended, is done away by supposing the series of watches thus produced from one another to have been infinite, and consequently to have had no-such *first*, for which it was necessary to provide a cause. This, perhaps, would have been nearly the state of the question, if no thing had been before us but an unorganized, unmechanized substance, without mark or indication of contrivance. It might be difficult to show that such substance could not have existed from eternity, either in succession (if it were possible, which I think it is not, for unorganized bodies to spring from one another), or by individual perpetuity. But that is not the question now. To suppose it to be so, is to suppose that it made no difference whether we had found a watch or a stone. As it is, the metaphysics of that question have no place; for, in the watch which we are examining, are seen contrivance, design; an end, a purpose; means for the end, adaptation to the purpose. And the question which irresistibly presses upon our thoughts, is, whence this contrivance and design? The thing required is the intending mind, the adapting hand, the intelligence by which that hand was directed. This question, this demand, is not shaken off, by increasing a number or succession of

substances, destitute of these properties; nor the more, by increasing that number to infinity. If it be said, that, upon the supposition of one watch being produced from another in the course of that other's movements, and by means of the mechanism within it, we have a cause for the watch in my hand, viz. the watch from which it proceeded. I deny, that for the design, the contrivance, the suitableness of means to an end, the adaptation of instruments to a use (all which we discover in the watch), we have any cause whatever. It is in vain, therefore, to assign a series of such causes, or to allege that a series may be carried back to infinity; for I do not admit that we have yet any cause at all of the phænomena, still less any series of causes either finite or infinite. Here is contrivance, but no contriver; proofs of design, but no designer.

V. Our observer would further also reflect, that the maker of the watch before him, was, in truth and reality, the maker of every watch produced from it; there being no difference (except that the latter manifests a more exquisite skill) between the making of another watch with his own hands, by the mediation of files, lathes, chisels, &c. and the disposing, fixing, and inserting of these instruments, or of others equivalent to them, in the body of the watch already made in such a manner, as to form a new watch in the course of the movements which he had given to the old one. It is only working by one set of tools, instead of another.

The conclusion of which the *first* examination of the watch, of its works, construction, and movement, suggested, was, that it must have had, for the cause and author of that construction, an artificer, who understood its mechanism, and designed its use. This conclusion is invincible. A *second* examination presents us with a new discovery. The watch is found, in the course of its movement, to produce another watch, similar to itself; and not only so, but we perceive in it a system or organization, separately calculated for that purpose. What effect would this discovery have, or ought it to have, upon our former inference? What, as hath already been said, but to increase, beyond measure, our admiration of the skill, which had been employed in the formation of such a machine? Or shall it, instead of this, all at once turn us round to an opposite conclusion, viz. that no art or skill whatever has been concerned in the business, although all other evidences of art and skill remain as they were, and this last and supreme piece of art be now added to the rest? Can this be maintained without absurdity? Yet this is atheism.

Chapter Iii. Application Of The Argument.

THIS is atheism: for every indication of contrivance, every manifestation of design, which existed in the watch, exists in the works of nature; with the difference, on the side of nature, of being greater and more, and that in a degree which exceeds all computation. I mean that the contrivances of nature surpass the contrivances of art, in the complexity, subtility, and curiosity of the mechanism; and still more, if possible, do they go beyond them in number and variety; yet, in a multitude of cases, are not less evidently mechanical, not less evidently contrivances, not less evidently accommodated to their end, or suited to their office, than are the most perfect productions of human ingenuity.

I know no better method of introducing so large a subject, than that of comparing a single thing with a single thing; an eye, for example, with a telescope. As far as the examination of the instrument goes, there is precisely the same proof that the eye was made for vision, as there is that the telescope was made for assisting it. They are made upon the same principles; both being adjusted to the laws by which the transmission and refraction of rays of light are regulated. I speak not of the origin of the laws themselves; but such laws being fixed, the construction, in both cases, is adapted to them. For instance; these laws require, in order to produce the same effect, that the rays of light, in passing from water into the eye, should be refracted by a more convex surface, than when it passes out of air into the eye. Accordingly we find that the eye of a fish, in that part of it called the crystalline lens, is much rounder than the eye of terrestrial animals. What plainer

manifestation of design can there be than this difference? What could a mathematical-instrument-maker have done more, to show his knowledge of his principle, his application of that knowledge, his suiting of his means to his end; I will not say to display the compass or excellence of his skill and art, for in these all comparison is indecorous, but to testify counsel, choice, consideration, purpose?

To some it may appear a difference sufficient to destroy all similitude between the eye and the telescope, that the one is a perceiving organ, the other an unperceiving instrument. The fact is, that they are both instruments. And, as to the mechanism, at least as to mechanism being employed, and even as to the kind of it, this circumstance varies not the analogy at all. For observe, what the constitution of the eye is. It is necessary, in order to produce distinct vision, that an image or picture of the object be formed at the bottom of the eye.

Whence this necessity arises, or how the picture is connected with the sensation, or contributes to it, it may be difficult, nay we will confess, if you please, impossible for us to search out. But the present question is not concerned in the inquiry. It may be true, that, in this, and in other instances, we trace mechanical contrivance a certain way; and that then we come to something which is not mechanical, or which is inscrutable. But this affects not the certainty of our investigation, as far as we have gone. The difference between an animal and an automatic statue, consists in this,--that, in the animal, we trace the mechanism to a certain point, and then we are stopped; either the mechanism becoming too subtile for our discerment, or something else beside the known laws of mechanism taking place; whereas, in the automaton, for the comparatively few motions of which it is capable, we trace the mechanism throughout. But, up to the limit, the reasoning is as clear and certain in the one case, as in the other. In the example before us, it is a matter of certainty, because it is a matter which experience and observation demonstrate, that the formation of an image at the bottom of the eye is necessary to perfect vision. The image itself can be shown. Whatever affects the distinctness of the image, affects the distinctness of the vision. The formation then of such an image being necessary (no matter how) to the sense of sight, and to the exercise of that sense, the apparatus by which it is formed is constructed and put together, not only with infinitely more art, but upon the self-same principles of art, as in the telescope or the camera obscura. The perception arising from the image may be laid out of the question; for the production of the image, these are instruments of the same kind. The end is the same; the means are the same. The purpose in both is alike; the contrivance for accomplishing that purpose is in both alike. The lenses of the telescope, and the humours of the eye, bear a complete resemblance to one another, in their figure, their position, and in their power over the rays of light, viz. in bringing each pencil to a point at the right distance from the lens; namely, in the eye, at the exact place where the membrane is spread to receive it. How is it possible, under circumstances of such close affinity, and under the operation of equal evidence, to exclude contrivance from the one; yet to acknowledge the proof of contrivance having been employed, as the plainest and clearest of all propositions, in the other?

The resemblance between the two cases is still more accurate, and obtains in more points than we have yet represented, or than we are, on the first view of the subject, aware of. In dioptric telescopes, there is an imperfection of this nature. Pencils of light, in passing through glass lenses, are separated into different colours, thereby tinging the object, especially the edges of it, as if it were viewed through a prism. To correct this inconvenience, had been long a desideratum in the art. At last it came into the mind of a sagacious optician, to inquire how this matter was managed in the eye; in which, there was exactly the same difficulty to contend with, as in the telescope. His observation taught him, that, in the eye, the evil was cured by combining lenses composed of different substances, *i. e.* of substances which possessed different refracting powers. Our artist borrowed thence his hint; and produced a correction of the defect by imitating, in glasses made from different materials, the effects of the different humours through which the rays of light pass

before they reach the bottom of the eye. Could this be in the eye without purpose, which suggested to the optician the only effectual means of attaining that purpose?

But further; there are other points, not so much perhaps of strict resemblance between the two, as of superiority of the eye over the telescope; yet of a superiority which, being founded in the laws that regulate both, may furnish topics of fair and just comparison. Two things were wanted to the eye, which were not wanted (at least in the same degree), to the telescope; and these were, the adaptation of the organ, first, to different degrees of light; and, secondly, to the vast diversity of distance at which objects are viewed by the naked eye, viz. from a few inches to as many miles. These difficulties present not themselves to the maker of the telescope. He wants all the light he can get; and he never directs his instrument to objects near at hand. In the eye, both these cases were to be provided for; and for the purpose of providing for them, a subtile and appropriate mechanism is introduced:

I. In order to exclude excess of light, when it is excessive, and to render objects visible under obscurer degrees of it, when no more can be had, the hole or aperture in the eye, through which the light enters, is so formed, as to contract or dilate itself for the purpose of admitting a greater or less number of rays at the same time. The chamber of the eye is a camera obscura, which when the light is too small, can enlarge its opening; when too strong, can again contract it; and that without any other assistance than that of its own exquisite machinery. It is further also, in the human subject, to be observed, that this hole in the eye, which we call the pupil, under all its different dimensions, retains its exact circular shape. This is a structure extremely artificial. Let an artist only try to execute the same; he will find that his threads and strings must be disposed with great consideration and contrivance, to make a circle, which shall continually change its diameter, yet preserve its form. This is done in the eye by an application of fibres, *i. e.* of strings, similar, in their position and action, to what an artist would and must employ, if he had the same piece of workmanship to perform.

II. The second difficulty which has been stated, was the suiting of the same organ to the perception of objects that lie near at hand, within a few inches, we will suppose, of the eye, and of objects which are placed at a considerable distance from it, that, for example of as many furlongs (I speak in both cases of the distance at which distinct vision can be exercised). Now this, according to the principles of optics, that is, according to the laws by which the transmission of light is regulated (and these laws are fixed), could not be done without the organ itself undergoing an alteration, and receiving an adjustment, that might correspond with the exigency of the case, that is to say, with the different inclination to one another under which the rays of light reached it. Rays issuing from points placed at a small distance from the eye, and which consequently must enter the eye in a spreading or diverging order, cannot, by the same optical instrument in the same state, be brought to a point, *i. e.* be made to form an image, in the same place with rays proceeding from objects situated at a much greater distance, and which rays arrive at the eye in directions nearly (and physically speaking) parallel. It requires a rounder lens to do it. The point of concourse behind the lens must fall critically upon the retina, or the vision is confused; yet, other things remaining the same, this point, by the immutable properties of light, is carried further back when the rays proceed from a near object, than when they are sent from one that is remote. A person who was using an optical instrument, would manage this matter by changing, as the occasion required, his lens or his telescope; or by adjusting the distance of his glasses with his hand or his screw: but how is it to be managed in the eye? What the alteration was, or in what part of the eye it took place, or by what means it was effected (for if the known laws which govern the refraction of light be maintained, some alteration in the state of the organ there must be), had long formed a subject of inquiry and conjecture. The change, though sufficient for the purpose, is so minute as to elude ordinary observation. Some very late discoveries, deduced from a laborious and most accurate inspection of the structure and operation of the organ, seem at length to have ascertained the

mechanical alteration which the parts of the eye undergo. It is found, that by the action of certain muscles, called the straight muscles, and which action is the most advantageous that could be imagined for the purpose,--it is found, I say, that, whenever the eye is directed to a near object, three changes are produced in it at the same time, all severally contributing to the adjustment required. The cornea, or outermost coat of the eye, is rendered more round and prominent; the crystalline lens underneath is pushed forward; and the axis of vision, as the depth of the eye is called, is elongated. These changes in the eye vary its power over the rays of light in such a manner and degree as to produce exactly the effect which is wanted, viz. the formation of an image *upon the retina*, whether the rays come to the eye in a state of divergency, which is the case when the object is near to the eye, or come parallel to one another, which is the case when the object is placed at a distance. Can any thing be more decisive of contrivance than this is? The most secret laws of optics must have been known to the author of a structure endowed with such a capacity of change. It is as though an optician, when he had a nearer object to view, should *rectify*his instrument by putting in another glass, at the same time drawing out also his tube to a different length.

Observe a new-born child first lifting up its eyelids. What does the opening of the curtain discover? The anterior part of two pellucid globes, which, when they come to be examined, are found to be constructed upon strict optical principles; the self-same principles upon which we ourselves construct optical instruments. We find them perfect for the purpose of forming an image by refraction; composed of parts executing different offices: one part having fulfilled its office upon the pencil of light, delivering it

over to the action of another part; that to a third, and so onward: the progressive action depending for its success upon the nicest and minutest adjustment of the parts concerned; yet, these parts so in fact adjusted, as to produce, not by a simple action or effect, but by a combination of actions and effects, the result which is ultimately wanted. And forasmuch as this organ would have to operate under different circumstances, with strong degrees of light, and with weak degrees, upon near objects, and upon remote ones, and these differences demanded, according to the laws by which the transmission of light is regulated, a corresponding diversity of structure; that the aperture, for example, through which the light passes, should be larger or less; the lenses rounder or flatter, or that their distance from the tablet, upon which the picture is delineated, should be shortened or lengthened: this, I say, being the case and the difficulty, to which the eye was to be adapted, we find its several parts capable of being occasionally changed, and a most artificial apparatus provided to produce that change. This is far beyond the common regulator of a watch, which requires the touch of a foreign hand to set it: but it is not altogether unlike Harrison's contrivance

for making a watch regulate itself, by inserting within it a machinery, which, by the artful use of the different expansion of metals, preserves the equability of the motion under all the various temperatures of heat and cold in which the instrument may happen to be placed. The ingenuity of this last contrivance has been justly praised. Shall, therefore, a structure which differs from it, chiefly by surpassing it, be accounted no contrivance at all? or, if it be a contrivance, that it is without a contriver!

But this, though much, is not the whole; by different species of animals the faculty we are describing is possessed, in degrees suited to the different range of vision which their mode of life, and of procuring their food, requires. *Birds*, for instance, in general, procure their food by means of their beak; and, the distance between the eye and the point of the beak being small, it becomes necessary that they should have the power of seeing very near objects distinctly. On the other hand, from being often elevated much above the ground, living in air, and moving through it with

great velocity, they require, for their safety, as well as for assisting them in descrying their prey, a power of seeing at a great distance; a power of which, in birds of

rapine, surprising examples are given. The fact accordingly is, that two peculiarities are found in the eyes of birds, both tending to *facilitate* the change upon which the adjustment of the eye to different distances depends. The one is a bony, yet, in most species, a flexible rim or hoop, surrounding the broadest part of the eye; which, confining the action of the muscles to that part, increases the effect of their lateral pressure upon the orb, by which pressure its axis is elongated for the purpose of looking at very near objects. The other is an additional muscle, called the marsupium, to draw, on occasion, the crystalline lens *back*, and to fit the same eye for the viewing of very distant objects. By these means, the eyes of birds can pass from one extreme to another of their scale of adjustment, with more ease and readiness than the eyes of other animals.

The eyes of *fishes* also, compared with those of terrestrial animals, exhibit certain distinctions of structure, adapted to their state and element. We have already observed upon the figure of the crystalline compensating by its roundness the density of the medium through which their light passes. To which we have to add, that the eyes of fish, in their natural and indolent state, appear to be adjusted to near objects, in this respect differing from the human eye, as well as those of quadrupeds and birds. The ordinary shape of the fish's eye being in a much higher degree convex than that of land-animals, a corresponding difference attends its muscular conformation, viz. that it is throughout calculated for *flattening* the eye.

The *iris* also in the eyes of fish does not admit of contraction. This is a great difference, of which the probable reason is, that the diminished light in water is never too strong for the retina.

In the *eel*, which has to work its head through sand and gravel, the roughest and harshest substances, there is placed before the eye, and at some distance from it, a transparent, horny, convex case or covering, which, without obstructing the sight, defends the organ. To such an animal, could any thing be more wanted, or more useful?

Thus, in comparing the eyes of different kinds of animals, we see, in their resemblances and distinctions, one general plan laid down, and that plan varied with the varying exigences to which it is to be applied.

There is one property however common, I believe, to all eyes, at least to all which have been examined(*Note:* The eye of the seal or sea-calf, I understand, is an exception. Mem. Acad. Paris. 1701, p. 123.), namely, that the optic nerve enters the bottom of the eye, not in the centre or middle, but a little on one side: not in the point where the axis of the eye meets the retina, but between that point and the nose. The difference which this makes is, that no part of an object is unperceived by both eyes at the same time.

In considering vision as achieved by the means of an image formed at the bottom of the eye, we can never reflect without wonder upon the smallness, yet correctness, of the picture, the subtility of the touch, the fineness of the lines. A landscape of five or six square leagues is brought into a space of half an inch diameter; yet the multitude of objects which it contains, are all preserved; are all discriminated in their magnitudes, positions, figures, colours. The prospect from Hampstead-hill is compressed into the compass of a six-pence, yet circumstantially represented. A stage coach, travelling at its ordinary speed for half an hour, passes, in the eye, only over one-twelfth of an inch, yet is this change of place in the image distinctly perceived throughout its whole progress;

for it is only by means of that perception that the motion of the coach itself is made sensible to the eye. If any thing can abate our admiration of the smallness of the visual tablet compared with the

extent of vision, it is a reflection, which the view of nature leads us, every hour, to make, viz. that, in the hands of the Creator, great and little are nothing.

Sturmius held, that the examination of the eye was a cure for atheism. Beside that conformity to optical principles which its internal constitution displays, and which alone amounts to a manifestation of intelligence having been exerted in the structure; besides this, which forms, no doubt, the leading character of the organ, there is to be seen, in every thing belonging to it and about it, an extraordinary degree of care, an anxiety for its preservation, due, if we may so speak, to its value and its tenderness. It is lodged in a strong, deep, bony socket, composed by the junction of seven different bones(*Note:* Heister, sect. 89.), hollowed out at their edges. In some few species, as that of the coatimondi (*Note:* Mem. R. Ac. Paris, p. 117.), the orbit is not bony throughout; but whenever this is the case, the upper, which is the deficient part, is supplied by a cartilaginous ligament; a substitution which shows the same care. Within this socket it is imbedded in fat, of all animal substances the best adapted both to its repose and motion. It is sheltered by the eyebrows; an arch of hair, which, like a thatched penthouse, prevents the sweat and moisture of the forehead from running down into it.

But it is still better protected by its *lid*. Of the superficial parts of the animal frame, I know none which, in its office and structure, is more deserving of attention than the eyelid. It defends the eye; it wipes it; it closes it in sleep. Are there, in any work of art whatever, purposes more evident than those which this organ fulfils? or an apparatus for executing those purposes more intelligible, more appropriate, or more mechanical? If it be overlooked by the observer of nature, it can only be because it is obvious and familiar. This is a tendency to be guarded against. We pass by the plainest instances, whilst we are exploring those which are rare and curious; by which conduct of the understanding, we sometimes neglect the strongest observations, being taken up with others, which, though more recondite and scientific, are, as solid arguments, entitled to much less consideration.

In order to keep the eye moist and clean (which qualities are necessary to its brightness and its use), a wash is constantly supplied by a secretion for the purpose; and the superfluous brine is conveyed to the nose through a perforation in the bone as large as a goose-quill. When once the fluid has entered the nose, it spreads itself upon the inside of the nostril, and is evaporated by the current of warm air, which, in the course of respiration, is continually passing over it. Can any pipe or outlet, for carrying off the waste liquor from a dye-house or a distillery, be more mechanical than this is? It is easily perceived, that the eye must want moisture: but could the want of the eye generate the gland which produces the tear, or bore the hole by which it is discharged,--a hole through a bone?

It is observable, that this provision is not found in fish,--the element in which they live supplying a constant lotion to the eye.

It were, however, injustice to dismiss the eye as a piece of mechanism, without noticing that most exquisite of all contrivances, the *nictitating membrane,* which is found in the eyes of birds and of many quadrupeds. Its use is to sweep the eye, which it does in an instant, to spread over it the lachrymal humour; to defend it also from sudden injuries: yet not totally, when drawn upon the pupil, to shut out the light. The commodiousness with which it lies folded up in the upper corner of the eye, ready for use and action, and the quickness with which it executes its purpose, are properties known and obvious to every observer: but what is equally admirable, though not quite so obvious, is the combination of two kinds of substance, muscular and elastic, and of two different kinds of action, by which the motion of this membrane is performed. It is not, as in ordinary cases, by the action of two antagonist muscles, one pulling forward and the other backward, that a reciprocal change is effected; but it is thus: The membrane itself is an elastic substance, capable of

being drawn out by force like a piece of elastic gum, and by its own elasticity returning, when the force is removed, to its former position. Such being its nature, in order to fit it up for its office, it is connected by a tendon or thread with a muscle in the back part of the eye: this tendon or thread, though strong, is so fine, as not to obstruct the sight, even when it passes across it; and the muscle itself, being placed in the *back* part of the eye, derives from its situation the advantage, not only of being secure,

but of being out of the way; which it would hardly have been in any position that could be assigned to it in the anterior part of the orb, where its function lies. When the muscle behind the eye contracts, the membrane, by means of the communicating thread, is instantly drawn over the fore-part of it. When the muscular contraction (which is a positive, and, most probably, a voluntary effort) ceases to be exerted, the elasticity alone of the membrane brings it back again to its position(*Note:* Phil. Trans. 1796.). Does not this, if any thing can do it, bespeak an artist, master of his work, acquainted with his materials? "Of a thousand other things," say the French Academicians, "we perceive not the contrivance, because we understand them only by the effects, of which we know not the causes: but we here treat of a machine, all the parts whereof are visible; and which need only be looked upon, to discover the reasons of its motion and action(*Note:* Memoirs for a Natural History of Animals, by the Royal Academy of Sciences at Paris, done into English by Order of the Royal Society, 1701, page 249.)."

In the configuration of the muscle which, though placed behind the eye, draws the nictitating membrane over the eye, there is, what the authors, just now quoted, deservedly call a marvellous mechanism. I suppose this structure to be found in other animals; but, in the memoirs from which this account is taken, it is anatomically demonstrated only in the cassowary. The muscle is *passed through a loop formed by another muscle:* and is there inflected, as if it were round a pulley. This is a peculiarity; and observe the advantage of it. A single muscle with a straight tendon, which is the common muscular form, would have been sufficient, if it had had power to draw far enough. But the contraction, necessary to draw the membrane over the whole eye, required a longer muscle than could lie straight at the bottom of the eye. Therefore, in order to have a greater length in a less compass, the cord of the main muscle makes an angle. This, so far, answers the end; but, still further, it makes an angle, not round a fixed pivot, but round a loop formed by another muscle; which second muscle, whenever it contracts, of course twitches the first muscle at the point of inflection, and thereby assists the action designed by both.

One question may possibly have dwelt in the reader's mind during the perusal of these observations, namely, Why should not the Deity have given to the animal the faculty of vision *at once?* Why this circuitous perception; the ministry of so many means; an element provided for the purpose; reflected from opaque substances, refracted through transparent ones; and both according to precise laws; then, a complex organ, an intricate and artificial apparatus, in order, by the operation of this element, and in conformity with the restrictions of these laws, to produce an image upon a membrane communicating with the brain? Wherefore all this? Why make the difficulty in order to surmount it? If to perceive objects by some other mode than that of touch, or objects which lay out of the reach of that sense, were the thing proposed; could not a simple volition of the Creator have communicated the capacity? Why resort to contrivance, where power is omnipotent? Contrivance, by its very definition and nature, is the refuge of imperfection. To have recourse to expedients, implies difficulty, impediment, restraint, defect of power. This question belongs to the other senses, as well as to sight; to the general functions of animal life, as nutrition, secretion, respiration; to the œconomy of vegetables; and indeed to almost all the operations of nature. The question, therefore, is

of very wide extent; and amongst other answers which may be given to it; beside reasons of which probably we are ignorant, one answer is this: It is only by the display of contrivance, that the

existence, the agency, the wisdom of the Deity, *could* be testified to his rational creatures. This is the scale by which we ascend to all the knowledge of our Creator which we possess, so far as it depends upon the phænomena, or the works of nature. Take away this, and you take away from us every subject of observation, and ground of reasoning; I mean as our rational faculties are formed at present. Whatever is done, God could have done without the intervention of instruments or means: but it is in the construction of instruments, in the choice and adaptation of means, that a creative intelligence is seen. It is this which constitutes the order and beauty of the universe. God, therefore, has been pleased to prescribe limits to his own power, and to work his end within those limits. The general laws of matter have perhaps the nature of these limits; its inertia, its re-action; the laws which govern the communication of motion, the refraction and reflection of light, the constitution of fluids non-elastic and elastic, the transmission of sound through the latter; the laws of magnetism, of electricity; and probably others, yet undiscovered. These are general laws; and when a particular purpose is to be effected, it is not by making a new law, nor by the suspension of the old ones, nor by making them wind, and bend, and yield to the occasion (for nature with great steadiness adheres to and supports them); but it is, as we have seen in the eye, by the interposition of an apparatus, corresponding with these laws, and suited to the exigency which results from them, that the purpose is at length attained. As we have said, therefore, God prescribes limits to his power, that he may let in the exercise, and thereby exhibit demonstrations of his wisdom. For then, *i. e.* such laws and limitations being laid down, it is as though one Being should have fixed certain rules; and, if we may so speak, provided certain materials; and, afterwards, have committed to another Being, out of these materials, and in subordination to these rules, the task of drawing forth a creation: a supposition which evidently leaves room, and induces indeed a necessity for contrivance. Nay, there may be many such agents, and many ranks of these. We do not advance this as a doctrine either of philosophy or of religion; but we say that the subject may safely be represented

under this view, because the Deity, acting himself by general laws, will have the same consequences upon our reasoning, as if he had prescribed these laws to another. It has been said, that the problem of creation was, "attraction and matter being given, to make a world out of them:" and, as above explained, this statement perhaps does not convey a false idea.

We have made choice of the eye as an instance upon which to rest the argument of this chapter. Some single example was to be proposed: and the eye offered itself under the advantage of admitting of a strict comparison with optical instruments. The ear, it is probable, is no less artificially and mechanically adapted to its office, than the eye. But we know less about it: we do not so well understand the action, the use, or the mutual dependency of its internal parts. Its general form, however, both external and internal, is sufficient to show that it is an instrument adapted to the reception of *sound;* that is to say, already knowing that sound consists in pulses of the air, we perceive, in the structure of the ear, a suitableness to receive impressions from this species of action, and to propagate thee impressions to the brain. For of what does this structure consist? An external ear (the concha), calculated, like an ear-trumpet, to catch and collect the pulses of which we have spoken; in large quadrupeds, turning to the sound, and possessing a configuration, as well as motion, evidently fitted for the office: of a tube which leads into the head, lying at the root of this outward ear, the folds and sinuses thereof tending and conducting the air towards it: of a thin membrane, like the pelt of a drum, stretched across this passage upon a bony rim: of a chain of moveable, and infinitely curious, bones, forming a communication, and the only communication that can be observed, between the membrane last mentioned and the interior channels and recesses of the skull: of cavities, similar in shape and form to wind instruments of music, being spiral or portions of circles: of the eustachian tube, like the hole in a drum, to let the air pass freely into and out of the barrel of the ear, as the covering membrane vibrates, or as the temperature may be altered: the whole labyrinth hewn out of a rock: that is, wrought into the substance of the hardest bone of the body. This assemblage of connected parts

constitutes together an apparatus, plainly enough relative to the transmission of sound, or of the impulses received from sound, and only to be lamented in not being better understood.

The communication within, formed by the small bones of the ear, is, to look upon, more like what we are accustomed to call machinery, than any thing I am acquainted with in animal bodies. It seems evidently designed to continue towards the sensorium the tremulous motions which are excited in the membrane of the tympanum, or what is better known by the name of the "drum of the ear." The compages of bones consists of four, which are so disposed, and so hinge upon one another, as that if the membrane, the drum of the ear, vibrate, all the four are put in motion together; and, by the result of their action, work the base of that which is the last in the series, upon an aperture which it closes, and upon which it plays, and which aperture opens into the tortuous canals that lead to the brain. This last bone of the four is called the *stapes*. The office of the drum of the ear is to spread out an extended surface, capable of receiving the impressions of sound, and of being put by them into a state of vibration. The office of the stapes is to repeat these vibrations. It is a repeating frigate, stationed more within the line. From which account of its action may be understood, how the sensation of sound will be excited, by any thing which communicates a vibratory motion to the stapes, though not, as in all ordinary cases, through the intervention of the membrana tympani. This is done by solid bodies applied to the bones of the skull, as by a metal bar holden at one end between the teeth, and touching at the other end a tremulous body. It likewise appears to be done, in a considerable degree, by the air itself, even when this membrane, the drum of the ear, is greatly damaged. Either in the natural or preternatural state of the organ, the use of the chain of bones is to propagate the impulse in a direction towards the brain, and to propagate it with the advantage of a lever; which advantage consists in increasing the force and strength of the vibration, and at the same time diminishing the space through which it oscillates: both of which changes may augment or facilitate the still deeper action of the auditory nerves.

The benefit of the eustachian tube to the organ, may be made out upon known pneumatic principles. Behind the drum of the ear is a second cavity, or barrel, called the tympanum. The eustachian tube is a slender pipe, but sufficient for the passage of air,

leading from this cavity into the back part of the mouth. Now, it would not have done to have had a vacuum in this cavity; for, in that case, the pressure of the atmosphere from without would have burst the membrane which covered it. Nor would it have done to have filled the cavity with lymph or any other secretion; which would necessarily have obstructed, both the vibration of the membrane, and the play of the small bones. Nor, lastly, would it have done to have occupied the space with confined air, because the expansion of that air by heat, or its contraction by cold, would have distended or relaxed the covering membrane, in a degree inconsistent with the purpose which it was assigned to execute. The only remaining expedient, and that for which the eustachian tube serves, is to open to this cavity a communication with the external air. In one word; it exactly answers the purpose of the hole in a drum.

The membrana tympani itself likewise, deserves all the examination which can be made of it. It is not found in the ears of fish; which furnishes an additional proof of what indeed is indicated by every thing about it, that it is appropriated to the action of air, or of an elastic medium. It bears an obvious resemblance to the pelt or head of a drum, from which it takes its name. It resembles also a drum-head in this principal property, that its use depends upon its tension. *Tension*is the state essential to it. Now we know that, in a drum, the pelt is carried over a hoop, and braced as occasion requires, by the means of strings attached to its circumference. In the membrane of the ear, the same purpose is provided for, more simply, but not less mechanically, nor less successfully, by a different expedient, viz. by the end of a bone (the handle of the malleus) pressing upon its centre. It is only in very large animals that the texture of this membrane can be discerned. In the

Philosophical Transactions for the year 1800 (vol. i.), Mr. Everard Home has given some curious observations upon the ear, and the drum of the ear of an *elephant*. He discovered in it, what he calls a radiated muscle, that is, straight muscular fibres, passing along the membrane from the circumference to the centre; from the bony rim which surrounds it towards the handle of the malleus to which the central part is attached. This muscle he supposes to be designed to bring the membrane into unison with different sounds: but then he also discovered, that this muscle itself cannot act,

unless the membrane be drawn to a stretch, and kept in a due state of tightness, by what may be called a foreign force, viz. the action of the muscles of the malleus. Supposing his explanation of the use of the parts to be just, our author is well founded in the reflection which he makes upon it: "that this mode of adapting the ear to different sounds, is one of the most beautiful applications of muscles in the body; *the mechanism is so simple, and the variety of effects so great*."

In another volume of the Transactions above referred to, and of the same year, two most curious cases are related, of persons who retained the sense of hearing, not in a perfect, but in a very considerable degree, notwithstanding the almost total loss of the membrane we have been describing. In one of these cases, the use here assigned to that membrane, of modifying the impressions of sound by change of tension, was attempted to be supplied by straining the muscles of the outward ear. "The external ear," we are told, "had acquired a distinct motion upward and backward, which was observable whenever the patient listened to any thing which he did not distinctly hear: when he was addressed in a whisper, the ear was seen immediately to move; when the tone of voice was louder, it then remained altogether motionless.

It appears probable, from both these cases, that a collateral, if not principal, use of the membrane, is to cover and protect the barrel of the ear which lies behind it. Both the patients suffered from cold: one, "a great increase of deafness from catching cold;"the other, "very considerable pain from exposure to a stream of cold air." Bad effects therefore followed from this cavity being left open to the external air; yet, had the Author of nature shut it up by any other cover, than what was capable, by its texture, of receiving vibrations from sound, and, by its connexion with the interior parts, of transmitting those vibrations to the brain, the use of the organ, so far as we can judge, must have been entirely obstructed.

Chapter Iv.
Of The Succession Of Plants And Animals.

THE *generation* of the animal no more accounts for the contrivance of the eye or ear, than, upon the supposition stated in a preceding chapter, the production of a watch by the motion and mechanism of a former watch, would account for the skill and intention evidenced in the watch, so produced; than it would account for the disposition of the wheels, the catching of their teeth, the relation of the several parts of the works to one another, and to their common end, for the suitableness of their forms and places to their offices, for their connexion, their operation, and the useful result of that operation. I do insist most strenuously upon the correctness of this comparison; that it holds as to every mode of specific propagation; and that whatever was true of the watch, under the hypothesis above-mentioned, is true of plants and animals.

I. To begin with the fructification of plants. Can it be doubted but that the seed contains a particular organization? Whether a latent plantule with the means of temporary nutrition, or whatever else it be, it encloses an organization suited to the germination of a new plant. Has the plant which produced the seed any thing more to do with that organization, than the watch would have had to do with the structure of the watch which was produced in the course of its mechanical movement? I mean, Has it any thing at all to do with the *contrivance?* The maker and contriver of

one watch, when he inserted within it a mechanism suited to the production of another watch, was, in truth, the maker and contriver of that other watch. All the properties of the new watch were to be referred to his agency: the design manifested in it, to his intention: the art, to him as the artist: the collocation of each part to his placing: the action, effect, and use, to his counsel, intelligence, and workmanship. In producing it by the intervention of a former watch, he was only working by one set of tools instead of another. So it is with the plant, and the seed produced by it. Can any distinction be assigned between the two cases; between the producing watch, and the producing plant; both passive, unconscious substances; both by the organization which was given to them, producing their like, without understanding or design; both, that is, instruments?

II. From plants we may proceed to oviparous animals; from seeds to eggs. Now I say, that the bird has the same concern in the formation of the egg which she lays, as the plant has in that of the seed which it drops; and no other, nor greater. The internal constitution of the egg is as much a secret to the hen, as if the hen were inanimate.

Her will cannot alter it, or change a single feather of the chick. She can neither foresee nor determine of which sex her brood shall be, or how many of either: yet the thing produced shall be, from the first, very different in its make, according to the sex which it bears. So far, therefore, from adapting the means, she is not beforehand apprised of the effect. If there be concealed within that smooth shell a provision and a preparation for the production and nourishment of a new animal, they are not of her providing or preparing: if there be contrivance, it is none of hers. Although, therefore, there be the difference of life and perceptivity between the animal and the plant, it is a difference which enters not into the account. It is a foreign circumstance. It is a difference of properties not employed. The animal function and the vegetable function are alike destitute of any design which can operate upon the form of the thing produced. The plant has no design in producing the seed, no comprehension of the nature or use of what it produces: the bird with respect to its egg, is not above the plant with respect to its seed. Neither the one nor the other bears that sort of relation to what proceeds from them, which a joiner does to the chair which he makes. Now a cause, which bears *this* relation to the effect, is what we want, in order to account for the suitableness of means to an end, the fitness and fitting of one thing to another; and this cause the parent plant or animal does not supply.

It is further observable concerning the propagation of plants and animals, that the apparatus employed exhibits no resemblance to the thing produced; in this respect holding an analogy with instruments and tools of art. The filaments, antheræ, and stigmata of flowers, bear no more resemblance to the young plant, or even to the seed, which is formed by their intervention, than a chisel or a plane does to a table or chair. What then are the filaments, antheræ, and stigmata of plants, but instruments strictly so called?

III. We may advance from animals which bring forth eggs, to animals which bring forth their young alive; and of this latter class, from the lowest to the highest; from irrational to rational life, from brutes to the human species; without perceiving, as we proceed, any alteration whatever in the terms of the comparison. The rational animal does not produce its offspring with more certainty or success than the irrational animal: a man than a quadruped, a quadruped than a bird; nor (for we may follow the gradation through its whole scale) a bird than a plant; nor a plant than a watch, a piece of dead mechanism, would do, upon the supposition which has already so often been repeated. Rationality therefore has nothing to do in the business. If an account must be given of the contrivance which we observe; if it be demanded, whence arose either the contrivance by which the young animal is produced, or the contrivance manifested in the young animal itself, it is not from the reason of the parent that any such account can be drawn. He is the cause of his offspring, in the same sense as that in which a gardener is the cause of the tulip which grows upon his parterre, and in no other. We admire the flower; we examine the plant; we perceive the

conduciveness of many of its parts to their end and office: we observe a provision for its nourishment, growth, protection, and fecundity; but we never think of the gardener in all this. We attribute nothing of this to his agency; yet it may still be true, that without the gardener, we should not have had the tulip: just so it is with the succession of animals even of the highest order. For the contrivance discovered in the structure of the thing produced, we want a contriver. The parent is not that contriver. His consciousness decides that question. He is in total ignorance why that which is produced took its present form rather than any other. It is for him only to be astonished by the effect. We can no more look therefore to the intelligence of the parent animal for what we are in search of, a cause of relation, and of subserviency of parts to their use, which relation and subserviency we see in the procreated body, than we can refer the internal conformation of an acorn to the intelligence of the oak from which it dropped, or the structure of the watch to the intelligence of the watch which produced it; there being no difference, as far as argument is concerned, between an intelligence which is not exerted, and an intelligence which does not exist.

CHAPTER V.
APPLICATION OF THE ARGUMENT CONTINUED.

EVERY observation which was made in our first chapter, concerning the watch, may be repeated with strict propriety, concerning the eye; concerning animals; concerning plants; concerning, indeed, all the organized parts of the works of nature. As,

I. When we are inquiring simply after the *existence* of an intelligent Creator, imperfection, inaccuracy, liability to disorder, occasional irregularities, may subsist in a considerable degree, without inducing any doubt into the question: just as a watch may frequently go wrong, seldom perhaps exactly right, may be faulty in some parts, defective in some, without the smallest ground of suspicion from thence arising that it was not a watch; not made; or not made for the purpose ascribed to it. When faults are pointed out, and when a question is started concerning the skill of the artist, or dexterity with which the work is executed, then indeed, in order to defend these qualities from accusation, we must be able, either to expose some intractableness and imperfection in the materials, or point out some invincible difficulty in the execution, into which imperfection and difficulty the matter of complaint may be resolved; or if we cannot do this, we must adduce such specimens of consummate art and contrivance, proceeding from the same hand, as may convince the inquirer, of the existence, in the case before him, of impediments like those which we have mentioned, although, what from the nature of the case is very likely to happen, they be unknown and unperceived by him. This we must do in order to vindicate the artist's skill, or, at least, the perfection of it; as we must also judge of his intention, and of the provisions employed in fulfilling that intention, not from an instance in which they fail, but from the great plurality of instances in which they succeed. But, after all, these are different questions from the question of the artist's existence: or, which is the same, whether the thing before us be a work of art or not: and the questions ought always to be kept separate in the mind. So likewise it is in the works of nature. Irregularities and imperfections are of little or no weight in the consideration, when that consideration relates simply to the existence of a Creator. When the argument respects his attributes, they are of weight; but are then to be taken in conjunction (the attention is not to rest upon them, but they are to be taken in conjunction) with the unexceptionable evidences which we possess, of skill, power, and benevolence, displayed in other instances; which evidences may, in strength; number, and variety, be such, and may so overpower apparent blemishes, as to induce us, upon the most reasonable ground, to believe, that these last ought to be referred to some cause, though we be ignorant of it, other than defect of knowledge or of benevolence in the author.

II. There may be also parts of plants and animals, as there were supposed to be of the watch, of which, in some instances, the operation, in others, the use, is unknown. These form different

cases; for the operation may be unknown, yet the use be certain. Thus it is with the lungs of animals. It does not, I think, appear, that we are acquainted with the action of the air upon the blood, or in what manner that action is communicated by the lungs: yet we find that a very short suspension of their office destroys the life of the animal. In this case, therefore, we may be said to know the use, nay we experience the necessity, of the organ, though we be ignorant of its operation. Nearly the same thing may be observed of what is called the lymphatic system. We suffer grievous inconveniences from its disorder, without being informed of the office which it sustains in the œconomy of our bodies. There may possibly also be some few examples of the second class, in which not only the operation is unknown, but in which experiments may seem to prove that the part is not necessary; or may leave a doubt, how far it is even useful to the plant or animal in which it is found.

This is said to be the case with the spleen; which has been extracted from dogs, without any sensible injury to their vital functions. Instances of the former kind, namely, in which we cannot explain the operation, may be numerous; for they will be so in proportion to our ignorance. They will be more or fewer to different persons, and in different stages of science. Every improvement of knowledge diminishes their number. There is hardly, perhaps, a year passes, that does not, in the works of nature, bring some operation, or some mode of operation, to light, which was before undiscovered,--probably unsuspected. Instances of the second kind, namely, where the part appears to be totally useless, I believe to be extremely rare; compared with the number of those, of which the use is evident, they are beneath any assignable proportion; and, perhaps, have never been submitted to a trial and examination sufficiently accurate, long enough continued, or often enough repeated. No accounts which I have seen, are satisfactory. The mutilated animal may live and grow fat (as was the case of the dog deprived of its spleen), yet may be defective in some other of its functions; which, whether they can all, or in what degree of vigour and perfection, be performed, or how long preserved, without the extirpated organ, does not seem to be ascertained by experiment. But to this case, even were it fully made out, may be applied the consideration which we suggested concerning the watch, viz. that these superfluous parts do not negative the reasoning which we instituted concerning those parts which are useful, and of which we know the use: the indication of contrivance, with respect to them, remains as it was before.

III. One atheistic way of replying to our observations upon the works of nature, and to the proofs of a Deity which we think that we perceive in them, is to tell us, that all which we see must necessarily have had some form, and that it might as well be its present form as any other. Let us now apply this answer to the eye, as we did before to the watch. Something or other must have occupied that place in the animal's head: must have filled up, we will say, that socket: we will say also, that it must have been of that sort of substance which we call animal substance, as flesh, bone, membrane, cartilage, &c. But that it should have been an *eye*, knowing as we do what an eye comprehends,--viz. that it should have consisted, first, of a series of transparent lenses (very different, by-the-bye, even in their substance, from the opaque materials of which the rest of the body is, in general at least, composed; and with which the whole of its surface, this single portion of it excepted, is covered): secondly, of a black cloth or canvass (the only membrane of the body which is black) spread out behind these lenses, so as to receive the image formed by pencils of light transmitted through them; and placed at the precise geometrical distance at which, and at which alone, a distinct image could be formed, namely, at the concourse of the refracted rays: thirdly, of a large nerve communicating between this membrane and the brain; without which, the action of light upon the membrane, however modified by the organ, would be lost to the purposes of sensation:--that this fortunate conformation of parts should have been the lot, not of one individual out of many thousand individuals, like the great prize in a lottery, or like some singularity in nature, but the happy chance of a whole species; nor of one species out of many thousand species, with which we are acquainted, but of by far the greatest number of all that exist; and that under varieties, not casual or capricious, but bearing marks of being suited to their respective exigencies'

--that all this should have taken place, merely because something must have occupied those points in every animal's forehead;--or, that all this should be thought to be accounted for, by the short answer, "that whatever was there, must have had some form or other," is too absurd to be made more so by any augmentation. We are not contented with this answer; we find no satisfaction in it, by way of accounting for appearances of organization far short of those of the eye, such as we observe in fossil shells, petrified bones, or other substances which bear the vestiges of animal or vegetable recrements, but which, either in respect of utility, or of the situation in which they are discovered, may seem accidental enough. It is no way of accounting even for these things, to say that the stone, for instance, which is shown to us (supposing the question to be concerning a petrification), must have contained some internal conformation or other. Nor does it mend the answer to add, with respect to the singularity of the conformation, that, after the event, it is no longer to be computed what the chances were against it. This is always to be computed, when the question is, whether a useful or imitative conformation be the produce of chance, or not: I desire no greater certainty in reasoning, than that by which chance is excluded from the present disposition of the natural world. Universal experience is against it. What does chance ever do for us? In the human body, for instance, chance, *i. e.*the operation of causes without design, may produce a wen, a wart, a mole, a pimple, but never an eye. Amongst inanimate substances, a clod, a pebble, a liquid drop might be; but never was a watch, a telescope, an organized body of any kind, answering a valuable purpose by a complicated mechanism, the effect of chance. In no assignable instance hath such a thing existed without intention somewhere.

IV. There is another answer which has the same effect as the resolving of things into chance; which answer would persuade us to believe, that the eye, the animal to which it belongs, every other animal, every plant, indeed every organized body which we see, are only so many out of the possible varieties and combinations of being, which the lapse of infinite ages has brought into existence; that the present world is the relict of that variety: millions of other bodily forms and other species having perished, being by the defect of their constitution incapable of preservation, or of continuance by generation. Now there is no foundation whatever for this conjecture in any thing which we observe in the works of nature; no such experiments are going on at present: no such energy operates, as that which is here supposed, and which should be constantly pushing into existence new varieties of beings. Nor are there any appearances to support an opinion, that every possible combination of vegetable or animal structure has formerly been tried. Multitudes of conformations, both of vegetables and animals, may be conceived capable of existence and succession, which yet do not exist. Perhaps almost as many forms of plants might have been found in the fields, as figures of plants can be delineated upon paper. A countless variety of animals might have existed, which do not exist. Upon the supposition here stated, we should see unicorns and mermaids, sylphs and centaurs, the fancies of painters, and the fables of poets, realized by examples. Or, if it be alleged that these may transgress the limits of possible life and propagation, we might, at least, have nations of human beings without nails upon their fingers, with more or fewer fingers and toes than ten, some with one eye, others with one ear, with one nostril, or without the sense of smelling at all. All these, and a thousand other imaginable varieties, might live and propagate. We may modify any one species many different ways, all consistent with life, and with the actions necessary to preservation, although affording different degrees of conveniency and enjoyment to the animal. And if we carry these modifications through the different species which are known to subsist, their number would be incalculable. No reason can be given why, if these deperdits ever existed, they have now disappeared. Yet, if all possible existences have been tried, they must have formed part of the catalogue.

But, moreover, the division of organized substances into animals and vegetables, and the distribution and sub-distribution of each into genera and species, which distribution is not an arbitrary act of the mind, but founded in the order which prevails in external nature, appear to me

to contradict the supposition of the present world being the remains of an indefinite variety of existences; of a variety which rejects all plan. The hypothesis teaches, that every possible variety of being hath, at one time or other, found its way into existence (by what cause or in what manner is not said), and that those which were badly formed, perished; but how or why those which survived should be cast, as we see that plants and animals are cast, into regular classes, the hypothesis does not explain; or rather the hypothesis is inconsistent with this phænomenon.

The hypothesis, indeed, is hardly deserving of the consideration which we have given to it. What should we think of a man who, because we had never ourselves seen watches, telescopes, stocking-mills, steam-engines, &c. made, knew not how they were made, or could prove by testimony when they were made, or by whom,--would have us believe that these machines, instead of deriving their curious structures from the thought and design of their inventors and contrivers, in truth derive them from no other origin than this; viz, that a mass of metals and other materials having run when melted into all possible figures, and combined themselves in all possible forms, and shapes, and proportions, these things which we see, are what were left from the accident, as best worth preserving; and, as such, are become the remaining stock of a magazine, which, at one time or other, has by this means, contained every mechanism, useful, and useless, convenient and inconvenient, into which such like materials could be thrown? I cannot distinguish the hypothesis as applied to the works of nature, from this solution which no one would accept, as applied to a collection of machines.

V. To the marks of contrivance discoverable in animal bodies, and to the argument deduced from them, in proof of design, and of a designing Creator, this turn is sometimes attempted to be given, namely, that the parts were not intended for the use, but that the use arose out of the parts. This distinction is intelligible. A cabinet-maker rubs his mahogany with fish-skin; yet it would be too much to assert that the skin of the dog-fish was made rough and granulated on purpose for the polishing of wood, and the use of cabinet-makers. Therefore the distinction is intelligible. But I think that there is very little place for it in the works of nature. When roundly and generally affirmed of them, as it hath sometimes been, it amounts to such another stretch of assertion, as it would be to say, that all the implements of the cabinet-maker's work-shop, as well as his fish-skin, were substances accidentally configurated, which he had picked up, and converted to his use; that his adzes, saws, planes, and gimlets, were not made, as we suppose, to hew, cut, smooth, shape out, or bore wood with; but that, these things being made, no matter with what design, or whether with any, the cabinet-maker perceived that they were applicable to his purpose, and turned them to account.

But, again. So far as this solution is attempted to be applied to those parts of animals the action of which does not depend upon the will of the animal, it is fraught with still more evident absurdity. Is it possible to believe that the eye was formed without any regard to vision; that it was the animal itself which found out, that, though formed with no such intention, it would serve to see with: and that the use of the eye, as an organ of sight, resulted from this discovery, and the animal's application of it? The same question may be asked of the ear; the same of all the senses. None of the senses fundamentally depend upon the election of the animal; consequently, neither upon his sagacity, nor his experience. It is the impression which objects make upon them, that constitutes their use. Under that impression, he is passive. He may bring objects to the sense, or within its reach; he may select these objects: but over the impression itself he has no power, or very little; and that properly is the sense.

Secondly; there are many parts of animal bodies which seem to depend upon the will of the animal in a greater degree than the senses do, and yet with respect to which, this solution is equally unsatisfactory. If we apply the solution to the human body, for instance, it forms itself into questions, upon which no reasonable mind can doubt; such as, whether the teeth were made

expressly for the mastication of food, the feet for walking, the hands for holding? or whether, these things being as they are, being in fact in the animal's possession, his own ingenuity taught him that they were convertible to these purposes, though no such purposes were contemplated in their formation?

All that there is of the appearance of reason in this way of considering the subject is, that in some cases the organization seems to determine the habits of the animal, and its choice to a particular mode of life; which, in a certain sense, may be called "the use arising out of the part." Now to all the instances, in which there is any place for this suggestion, it may be replied, that the organization determines the animal to habits beneficial and salutary to itself; and that this effect would not be seen so regularly to follow, if the several organizations did not bear a concerted and contrived relation to the substance by which the animal was surrounded. They would, otherwise, be capacities without objects; powers without employment. The web-foot determines, you say, the duck to swim: but what would that avail, if there were no water to swim in? The strong, hooked bill, and sharp talons, of one species of bird, determine it to prey upon animals; the soft, straight bill, and weak claws, of another species, determine it to pick up seeds: but neither determination could take effect in providing for the sustenance of the birds, if animal bodies and vegetable seeds did not lie within their reach. The peculiar conformation of the bill, and tongue, and claws of the woodpecker, determines that bird to search for his food amongst the insects lodged behind the bark, or in the wood, of decayed trees: but what would this profit him, if there were no trees, no decayed trees, no insects lodged under their bark, or in their trunk? The proboscis with which the bee is furnished, determines him to seek for honey: but what would that signify, if flowers supplied none? Faculties thrown down upon animals at random, and without reference to the objects amidst which they are placed, would not produce to them the services and benefits which we see: and if there be that reference, then there is intention.

Lastly; the solution fails entirely when applied to plants. The parts of plants answer their uses, without any concurrence from the will or choice of the plant.

VI. Others have chosen to refer every thing to a *principle of order* in nature. A principle of order is the word: but what is meant by a principle of order, as different from an intelligent Creator, has not been explained either by definition or example: and, without such explanation, it should seem to be a mere substitution of words for reasons, names for causes. Order itself is only the adaptation of means to an end: a principle of order therefore can only signify the mind and intention which so adapts them. Or, were it capable of being explained in any other sense, is there any experience, any analogy, to sustain it? Was a watch ever produced by a principle of order? and why might not a watch be so produced, as well as an eye?

Furthermore, a principle of order, acting blindly, and without choice, is negatived, by the observation, that order is not universal; which it would be, if it issued from a constant and necessary principle: nor indiscriminate, which it would be, if it issued from an unintelligent principle. Where order is wanted, there we find it; where order is not wanted, *i. e.* where, if it prevailed, it would be useless, there we do not find it. In the structure of the eye (for we adhere to our example), in the figure and position of its several parts, the most exact order is maintained. In the forms of rocks and mountains, in the lines which bound the coasts of continents and islands, in the shape of bays and promontories, no order whatever is perceived, because it would have been superfluous. No useful purpose would have arisen from moulding rocks and mountains into regular solids, bounding the channel of the ocean by geometrical curves; or from the map of the world, resembling a table of diagrams in Euclid's Elements, or Simpson's Conic Sections.

VII. Lastly; the confidence which we place in our observations upon the works of nature, in the marks which we discover of contrivance, choice, and design; and in our reasoning upon the proofs

afforded us; ought not to be shaken, as it is sometimes attempted to be done, by bringing forward to our view our own ignorance, or rather the general imperfection of our knowledge of nature. Nor, in many cases, ought this consideration to affect us, even when it respects some parts of the subject immediately under our notice. True fortitude of understanding consists in not suffering what we know, to be disturbed by what we do not know. If we perceive a useful end, and means adapted to that end, we perceive enough for our conclusion. If these things be clear, no matter what is obscure. The argument is finished. For instance; if the utility of vision to the animal which enjoys it, and the adaptation of the *eye* to this office, be evident and certain (and I can mention nothing which is more so), ought it to prejudice the inference which we draw from these premises, that we cannot explain the use of the spleen? Nay, more: if there be parts of the eye, viz. the cornea, the crystalline, the retina, in their substance, figure, and position, manifestly suited to the formation of an image by the refraction of rays of light, at least, as manifestly as the glasses and tubes of a dioptric telescope are suited to that purpose; it concerns not the proof which these afford of design, and of a designer, that there may perhaps be other parts, certain muscles for instance, or nerves in the same eye, of the agency or effect of which we can give no account; any more than we should be inclined to doubt, or ought to doubt, about the construction of a telescope, viz. for what purpose it was constructed, or whether it were constructed at all, because there belonged to it certain screws and pins, the use or action of which we did not comprehend. I take it to be a general way of infusing doubts and scruples into the mind, to recall to its own ignorance, its own imbecility: to tell us that upon these subjects we know little; that little imperfectly; or rather, that we know nothing properly about the matter. These suggestions so fall in with our consciousness, as sometimes to produce a general distrust of our faculties and our conclusions. But this is an unfounded jealousy. The uncertainty of one thing does not necessarily affect the certainty of another thing. Our ignorance of many points need not suspend our assurance of a few. Before we yield, in any particular instance, to the scepticism which this sort of insinuation would induce, we ought accurately to ascertain, whether our ignorance or doubt concern those precise points upon which our conclusion rests. Other points are nothing. Our ignorance of other points may be of no consequence to these, though they be points, in various respects, of great importance. A just reasoner removes from his consideration, not only what he knows, but what he does not know, touching matters not strictly connected with his argument, *i. e.* not forming the very steps of his deduction: beyond these, his knowledge and his ignorance are alike relative.

CHAPTER VI.
THE ARGUMENT CUMULATIVE.

WERE there no example in the world, of contrivance, except that of the *eye*, it would be alone sufficient to support the conclusion which we draw from it, as to the necessity of an intelligent Creator. It could never be got rid of; because it could not be accounted for by any other supposition, which did not contradict all the principles we possess of knowledge; the principles, according to which, things do, as often as they can be brought to the test of experience, turn out to be true or false. Its coats and humours, constructed, as the lenses of a telescope are constructed, for the refraction of rays of light to a point, which forms the proper action of the organ; the provision in its muscular tendons for turning its pupil to the object, similar to that which is given to the telescope by screws, and upon which power of direction in the eye, the exercise of its office as an optical instrument depends; the further provision for its defence, for its constant lubricity and moisture, which we see in its socket and its lids, in its gland for the secretion of the matter of tears, its outlet or communication with the nose for carrying off the liquid after the eye is washed with it; these provisions compose altogether an apparatus, a system of parts, a preparation of means, so manifest in their design, so exquisite in their contrivance, so successful in their issue, so precious, and so infinitely beneficial in their use, as, in my opinion, to bear down all doubt that can be raised upon the subject. And what I wish, under the title of the present chapter,

to observe is, that if other parts of nature were inaccessible to our inquiries, or even if other parts of nature presented nothing to our examination but disorder and confusion, the validity of this example would remain the same. If there were but one watch in the world, it would not be less certain that it had a maker. If we had never in our lives seen any but one single kind of hydraulic machine, yet, if of that one kind we understood the mechanism and use, we should be as perfectly assured that it proceeded from the hand, and thought, and skill of a workman, as if we visited a museum of the arts, and saw collected there twenty different kinds of machines for drawing water, or a thousand different kinds for other purposes. Of this point, each machine is a proof, independently of all the rest. So it is with the evidences of a Divine agency. The proof is not a conclusion which lies at the end of a chain of reasoning, of which chain each instance of contrivance is only a link, and of which, if one link fail, the whole falls; but it is an argument separately supplied by every separate example. An error in stating an example, affects only that example. The argument is cumulative, in the fullest sense of that term. The eye proves it without the ear; the ear without the eye. The proof in each example is complete; for when the design of the part, and the conduciveness of its structure to that design is shown, the mind may set itself at rest; no future consideration can detract any thing from the force of the example.

CHAPTER VII.
OF THE MECHANICAL AND IMMECHANICAL PARTS AND TUNCTIONS OF ANIMALS AND VEGETABLES.

IT is not that *every* part of an animal or vegetable has not proceeded from a contriving mind; or that every part is not constructed with a view to its proper end and purpose, according to the laws belonging to, and governing the substance or the action made use of in that part; or that each part is not so constructed as to effectuate its purpose whilst it operates according to these laws; but it is because these laws themselves are not in all cases equally understood; or, what amounts to nearly the same thing, are not equally exemplified in more simple processes, and more simple machines; that we lay down the distinction, here proposed, between the mechanical parts and other parts of animals and vegetables.

For instance: the principle of muscular motion, viz. upon what cause the swelling of the belly of the muscle, and consequent contraction of its tendons, either by an act of the will, or by involuntary irritation, depends, is wholly unknown to us. The substance employed, whether it be fluid, gaseous, elastic, electrical, or none of these, or nothing resembling these, is also unknown to us: of course, the laws belonging to that substance, and which regulate its action, are unknown to us. We see nothing similar to this contraction in any machine which we can make, or any process which we can execute. So far (it is confessed) we are in ignorance, but no further. This power and principle, from whatever cause it proceeds, being assumed, the collocation of the fibres to receive the principle, the disposition of the muscles for the use and application of the power, is mechanical; and is as intelligible as the adjustment of the wires and strings by which a puppet is moved. We see, therefore, as far as respects the subject before us, what is not mechanical in the animal frame, and what is. The nervous influence (for we are often obliged to give names to things which we know little about)--I say the nervous influence, by which the belly, or middle, of the muscle is swelled, is not mechanical. The utility of the effect we perceive; the means, or the preparation of means, by which it is produced, we do not. But obscurity as to the origin of muscular motion brings no doubtfulness into our observations, upon the sequel of the process. Which observations relate, 1st, to the constitution of the muscle; in consequence of which constitution, the swelling of the belly or middle part is necessarily and mechanically followed by a contraction of the tendons: 2dly, to the number and variety of the muscles and the corresponding number and variety of useful powers which they supply to the animal; which is astonishingly great: 3dly, to the judicious (if we may be permitted to use that term, in speaking of the author, or of the works of nature), to the wise and well-contrived disposition of each muscle for its specific purpose; for

moving the joint this way; and that way, and the other way; for pulling and drawing the part, to which it is attached in a determinate and particular direction; which is a mechanical operation, exemplified in a multitude of instances. To mention only one: The tendon of the trochlear muscle of the eye, to the end that it may draw in the line required, is passed through a cartilaginous ring, at which it is reverted, exactly in the same manner as a rope in a ship is carried over a block or round a stay, in order to make it pull in the direction which is wanted. All this, as we have said, is mechanical; and is as accessible to inspection, as capable of being ascertained, as the mechanism of the automation in the Strand. Suppose the automaton to be put in motion by a magnet (which is probable), it will supply us with a comparison very apt for our present purpose. Of the magnetic effluvium, we know perhaps as little as we do of the nervous fluid. But, magnetic attraction being assumed (it signifies nothing from what cause it proceeds), we can trace, or there can be pointed out to us, with perfect clearness and certainty, the mechanism, viz. the steel bars, the wheels, the joints, the wires, by which the motion so much admired is communicated to the fingers of the image: and to make any obscurity, or difficulty, or controversy in the doctrine of magnetism, an objection to our knowledge or our certainty, concerning the contrivance, or the marks of contrivance, displayed in the automaton, would be exactly the same thing, as it is to make our ignorance (which we acknowledge) of the cause of nervous agency, or even of the substance and structure of the nerves themselves, a ground of question or suspicion as to the reasoning which we institute concerning the mechanical part of our frame. That an animal is a machine, is a proposition neither correctly true nor wholly false. The distinction which we have been discussing will serve to show how far the comparison, which this expression implies, holds; and wherein it fails. And whether the distinction be thought of importance or not, it is certainly of importance to remember, that there is neither truth nor justice in endeavouring to bring a cloud over our understandings, or a distrust into our reasonings upon this subject, by suggesting that we know nothing of voluntary motion, of irritability, of the principle of life, of sensation, of animal heat, upon all which the animal functions depend; for, our ignorance of these parts of the animal frame concerns not at all our knowledge of the mechanical parts of the same frame. I contend, therefore, that there is mechanism in animals; that this mechanism is as properly such, as it is in machines made by art; that this mechanism is intelligible and certain; that it is not the less so, because it often begins or terminates with something which is not mechanical; that whenever it is intelligible and certain, it demonstrates intention and contrivance, as well in the works of nature, as in those of art; and that it is the best demonstration which either can afford.

But whilst I contend for these propositions, I do not exclude myself from asserting, that there may be, and that there are, other cases, in which although we cannot exhibit mechanism, or prove indeed that mechanism is employed, we want not sufficient evidence to conduct us to the same conclusion.

There is what may be called the *chymical*part of our frame; of which by reason of the imperfection of our chymistry, we can attain to no distinct knowledge; I mean, not to a knowledge, either in degree or kind, similar to that which we possess of the mechanical part of our frame. It does not, therefore, afford the same species of argument as that which mechanism affords; and yet it may afford an argument in a high degree satisfactory. The *gastric juice*, or the liquor which digests the food in the stomachs of animals, is of this class. Of all menstrua, it is the most active, the most universal. In the human stomach, for instance, consider what a variety of strange substances, and how widely different from one another, it, in a few hours, reduces to a uniform pulp, milk, or mucilage. It seizes upon every thing, it dissolves the texture of almost every thing that comes in its way. The flesh of perhaps all animals; the seeds and fruits of the greatest number of plants; the roots, and stalks, and leaves of many, hard and tough as they are, yield to its powerful pervasion. The change wrought by it is different from any chymical solution which we can produce, or with which we are acquainted, in this respect as well as many others, that, in our chymistry, particular menstrua act only upon particular substances. Consider moreover that this fluid, stronger in its

operation than a caustic alkali or mineral acid, than red precipitate, or aqua-fortis itself, is nevertheless as mild, and bland, and inoffensive to the touch or taste, as saliva or gum-water, which it much resembles. Consider, I say, these several properties of the digestive organ, and of the juice with which it is supplied, or rather with which it is made to supply itself, and you will confess it to be entitled to a name, which it has sometimes received, that of "the chymical wonder of animal nature."

Still we are ignorant of the composition of this fluid, and of the mode of its action; by which is meant that we are not capable, as we are in the mechanical part of our frame, of collating it with the operations of art. And this I call the imperfection of our chymistry; for, should the time ever arrive, which is not perhaps to be despaired of, when we can compound ingredients, so as to form a solvent which will act in the manner in which the gastric juice acts, we may be able to ascertain the chymical principles upon which its efficacy depends, as well as from what part, and by what concoction, in the human body, these principles are generated and derived.

In the mean time, ought that, which is in truth the defect of our chymistry, to hinder us from acquiescing in the inference, which a production of nature, by its place, its properties, its action, its surprising efficacy, its invaluable use, authorizes us to draw in respect of a creative design?

Another most subtile and curious function of animal bodies is *secretion*. This function is semi-chymical and semi-mechanical; exceedingly important and diversified in its effects, but obscure in its process and in its apparatus. The importance of the secretory organs is but too well attested by the diseases, which an excessive, a deficient, or a vitiated secretion is almost sure of producing. A single secretion being wrong, is enough to make life miserable, or sometimes to destroy it. Nor is the variety less than the importance. From one and the same blood (I speak of the human body) about twenty different fluids are separated; in their sensible properties, in taste, smell, colour, and consistency, the most unlike one another that is possible: thick, thin, salt, bitter, sweet; and, if from our own we pass to other species of animals, we find amongst their secretions not only the most various, but the most opposite properties, the most nutritious aliment, the deadliest poison; the sweetest perfumes, the most fœtid odours. Of these the greater part, as the gastric juice, the saliva, the bile, the slippery mucilage which lubricates the joints, the tears which moistens the eye, the wax which defends the ear, are, after they are secreted, made use of in the animal œconomy; are evidently subservient, and are actually contributing to the utilities of the animal itself. Other fluids seem to be separated only to be rejected. That this also is necessary (though why it was originally necessary, we cannot tell) is shown by the consequence of the separation being long suspended; which consequence is disease and death. Akin to secretion, if not the same thing, is assimilation, by which one and the same blood is converted into bone, muscular flesh, nerves, membranes, tendons; things as different as the wood and iron, canvass and cordage, of which a ship with its furniture is composed. We have no operation of art wherewith exactly to compare all this, for no other reason perhaps than that all operations of art are exceeded by it. No chymical election, no chymical analysis or resolution of a substance into its constituent parts, no mechanical sifting or division, that we are acquainted with, in perfection or variety come up to animal secretion. Nevertheless, the apparatus and process are obscure; not to say absolutely concealed from our inquiries. In a few, and only a few instances, we can discern a little of the constitution of a gland. In the kidneys of large animals, we can trace the emulgent artery dividing itself into an infinite number of branches; their extremities everywhere communicating with little round bodies, in the substance of which bodies, the secret of the machinery seems to reside, for there the change is made. We can discern pipes laid from these round bodies towards the pelvis, which is a bason within the solid of the kidney. We can discern these pipes joining and collecting together into larger pipes; and, when so collected, ending in innumerable papillæ, through which the secreted fluid is continually oozing into its receptacle. This is all we know of the mechanism of a gland, even in the case in which it seems most capable of being investigated. Yet to pronounce

that we know nothing of animal secretion, or nothing satisfactorily, and with that concise remark to dismiss the article from our argument, would be to dispose of the subject very hastily and very irrationally. For the purpose which we want, that of evincing intention, we know a great deal. And what we know is this. We see the blood carried by a pipe, conduit, or duct, *to* the gland. We see an organized apparatus, be its construction or action what it will, which we call that gland. We see the blood, or part of the blood, after it has passed through and undergone the action of the gland, coming *from* it by an emulgent vein or artery, *i. e.* by another pipe or conduit. And we see also at the same time a new and specific fluid issuing from the same gland by its excretory duct, *i. e.* by a third pipe or conduit; which new fluid is in some cases discharged out of the body, in more cases retained within it, and there executing some important and intelligent office. Now supposing, or admitting, that we know nothing of the proper internal constitution of a gland, or of the mode of its acting upon the blood; then our situation is precisely like that of an unmechanical looker-on, who stands by a stocking-loom, a cornmill, a carding-machine, or a threshing-machine, at work, the fabric and mechanism of which, as well as all that passes within, is hidden from his sight by the outside case; or, if seen, would be too complicated for his uninformed, uninstructed understanding to comprehend. And what is that situation? This spectator, ignorant as he is, sees at one end a material enter the machine, as unground grain the mill, raw cotton the carding-machine, sheaves of unthreshed corn the threshing-machine; and, when he casts his eye to the other end of the apparatus, he sees the material issuing from it in a new state; and, what is more, in a state manifestly adapted to future uses; the grain in meal fit for the making of bread, the wool in rovings ready for spinning into threads, the sheaf in corn dressed for the mill. Is it necessary that this man, in order to be convinced that design, that intention, that contrivance has been employed about the machine, should be allowed to pull it to pieces; should be enabled to examine the parts separately; explore their action upon one another, or their operation, whether simultaneous or successive, upon the material which is presented to them? He may long to do this to gratify his curiosity; he may desire to do it to improve his theoretic knowledge; or he may have a more substantial reason for requesting it, if he happen, instead of a common visitor, to be a mill-wright by profession, or a person sometimes called in to repair such like machines when out of order; but, for the purpose of ascertaining the existence of counsel and design in the formation of the machine, he wants no such intromission or privity. What he sees, is sufficient. The effect upon the material, the change produced in it, the utility of that change for future applications, abundantly testify, be the concealed part of the machine or of its construction what it will, the hand and agency of a contriver.

If any confirmation were wanting to the evidence which the animal secretions afford of design, it may be derived, as has been already hinted, from their variety, and from their appropriation to their place and use. They all come from the same blood: they are all drawn off by glands: yet the produce is very different, and the difference exactly adapted to the work which is to be done, or the end to be answered. No account can be given of this, without resorting to appointment. Why, for instance, is the saliva, which is diffused over the seat of taste, insipid, whilst so many others of the secretions, the urine, the tears, and the sweat, are salt? Why does the gland within the ear separate a viscid substance, which defends that passage; the gland in the upper angle of the eye, a thin brine, which washes the ball? Why is the synovia of the joints mucilaginous; the bile bitter, stimulating, and soapy? Why does the juice, which flows into the stomach, contain powers, which make that bowel, the great laboratory, as it is by its situation the recipient, of the materials of future nutrition? These are all fair questions; and no answer can be given to them, but what calls in intelligence and intention.

My object in the present chapter has been to teach three things: first, that it is a mistake to suppose that, in reasoning from the appearances of nature, the imperfection of our knowledge proportionably affects the certainty of our conclusion; for in many cases it does not affect it at all: secondly, that the different parts of the animal frame may be classed and distributed, according to

the degree of exactness with which we can compare them with works of art: thirdly, that the *mechanical* parts of our frame, or, those in which this comparison is most complete, although constituting, probably, the coarsest portions of nature's workmanship, are the most proper to be alleged as proofs and specimens of design.

CHAPTER VIII.
OF MECHANICAL ARRANGEMENT IN THE HUMAN FRAME.

WE proceed, therefore, to propose certain examples taken out of this class; making choice of such as, amongst those which have come to our knowledge, appear to be the most striking, and the best understood; but obliged, perhaps, to postpone both these recommendations to a third: that of the example being capable of explanation without plates, or figures, or technical language.

OF THE BONES.

I.--I challenge any man to produce, in the joints and pivots of the most complicated or the most flexible machine that was ever contrived, a construction more artificial, or more evidently artificial, than that which is seen in the vertebræ of the *human neck*.--Two things were to be done. The head was to have the power of bending forward and backward, as in the act of nodding, stooping, looking upward or downward; and, at the same time, of turning itself round upon the body to a certain extent, the quadrant we will say, or rather, perhaps, a hundred-and-twenty degrees of a circle. For these two purposes, two distinct contrivances are employed: First, the head rests immediately upon the uppermost of the vertebræ, and is united to it by a *hinge*-joint; upon which joint the head plays freely forward and backward, as far either way as is necessary, or as the ligaments allow: which was the first thing required.--But then the rotatory motion is unprovided for: Therefore, secondly, to make the head capable of this, a further mechanism is introduced; not between the head and the uppermost bone of the neck, where the hinge is, but between that bone, and the bone next underneath it. It is a mechanism resembling a *tenon and mortice*. This second, or uppermost bone but one, has what anatomists call a process, viz. a projection, somewhat similar, in size and shape, to a tooth; which tooth, entering a corresponding hole or socket in the bone above it, forms a pivot or axle, upon which that upper bone, together with the head which it supports, turns freely in a circle; and as far in the circle as the attached muscles permit the head to turn. Thus are both motions perfect, without interfering with each other. When we nod the head, we use the hinge-joint, which lies between the head and the first bone of the neck. When we turn the head round, we use the tenon and mortice, which runs between the first bone of the neck and the second. We see the same contrivance, and the same principle, employed in the frame or mounting of a telescope. It is occasionally requisite, that the object-end of the instrument be moved up and down, as well as horizontally, or equatorially. For the vertical motion, there is a hinge, upon which the telescope plays; for the horizontal or equatorial motion, an axis upon which the telescope and the hinge turn round together. And this is exactly the mechanism which is applied to the motion of the head: nor will any one here doubt of the existence of counsel and design, except it be by that debility of mind, which can trust to its own reasonings in nothing.

We may add, that it was, on another account also, expedient, that the motion of the head backward and forward should be performed upon the upper surface of the first vertebra: for, if the first vetebra itself had bent forward, it would have brought the spinal marrow, at the very beginning of its course, upon the point of the tooth.

II. Another mechanical contrivance, not unlike the last in its object, but different and original in its means, is seen in what anatomists call the *fore-arm;* that is, in the arm between the elbow and the wrist. Here, for the perfect use of the limb, two motions are wanted; a motion at the elbow backward and forward, which is called a reciprocal motion; and a rotatory motion, by which the

palm of the hand, as occasion requires, may be turned upward. How is this managed? The forearm, it is well known, consists of two bones, lying along-side each other, but touching only towards the ends. One, and only one, of these bones, is joined to the cubit, or upper part of the arm, at the elbow; the other alone, to the hand at the wrist. The first, by means, at the elbow, of a hinge joint (which allows only of motion in the same plane), swings backward and forward, carrying along with it the other bone, and the whole forearm. In the mean time, as often as there is occasion to turn the palm upward, that other bone to which the hand is attached, rolls upon the first, by the help of a groove or hollow near each end of one bone, to which is fitted a corresponding prominence in the other. If both bones had been joined to the cubit, or upper arm, at the elbow, or both to the hand at the wrist, the thing could not have been done. The first was to be at liberty at one end, and the second at the other; by which means, the two actions may be performed together. The great bone which carries the fore-arm, may be swinging upon its hinge at the elbow, at the very time that the lesser bone, which carries the hand, may be turning round it in the grooves. The management also of these grooves, or rather of the tubercles and grooves, is very observable. The two bones are called the *radius* and the *ulna*. Above, *i. e.* towards the elbow, a tubercle of the radius plays into a socket of the ulna; whilst below, *i. e.* towards the wrist, the radius finds the socket, and the ulna the tubercle. A single bone in the fore-arm, with a ball and socket joint at the elbow, which admits of motion in all directions, might, in some degree, have answered the purpose of both moving the arm and turning the hand. But how much better it is accomplished by the present mechanism, any person may convince himself, who puts the ease and quickness, with which be can shake his hand at the wrist circularly (moving likewise, if he pleases, his arm at the elbow at the same time), in competition with the comparatively slow and laborious motion, with which his arm can be made to turn round at the shoulder, by the aid of a ball and socket joint.

III. The *spine*, or back-bone, is a chain of joints of very wonderful construction. Various, difficult, and almost inconsistent offices were to be executed by the same instrument. It was to be firm, yet flexible; (now I know no chain made by art, which is both these; for by firmness I mean, not only strength, but stability); *firm*, to support the erect position of the body; *flexible*, to allow of the bending of the trunk in all degrees of curvature. It was further also (which is another, and quite a distinct purpose from the rest) to become a pipe or conduit for the safe conveyance from the brain, of the most important fluid of the animal frame, that, namely, upon which all voluntary motion depends, the spinal marrow; a substance not only of the first necessity to action, if not to life, but of a nature so delicate and tender, so susceptible, and so impatient of injury, as that any unusual pressure upon it, or any considerable obstruction of its course, is followed by paralysis or death. Now the spine was not only to furnish the main trunk for the passage of the medullary substance from the brain, but to give out, in the course of its progress, small pipes therefrom, which being afterwards indefinitely subdivided, might, under the name of nerves, distribute this exquisite supply to every part of the body. The same spine was also to serve another use not less wanted than the preceding, viz. to afford a fulerum, stay, or basis (or, more properly speaking, a series of these), for the insertion of the muscles which are spread over the trunk of the body; in which trunk there are not, as in the limbs, cylindrical bones, to which they can be fastened: and, likewise, which is a similar use, to furnish a support for the ends of the ribs to rest upon.

Bespeak of a workman a piece of mechanism which shall comprise all these purposes, and let him set about to contrive it: let him try his skill upon it; let him feel the difficulty of accomplishing the task, before he be told how the same thing is effected in the animal frame. Nothing will enable him to judge so well of the wisdom which has been employed; nothing will dispose him to think of it so truly. First, for the firmness, yet flexibility, of the spine; it is composed of a great number of bones (in the human subject, of twenty-four) joined to one another, and compacted by broad bases. The breadth of the bases upon which the parts severally rest, and the closeness of the junction, give to the chain its firmness and stability; the number of parts, and consequent frequency of joints, its flexibility.

Which flexibility, we may also observe, varies in different parts of the chain; is least in the back, where strength, more than flexure, is wanted; greater in the loins, which it was necessary should be more supple than the back; and greatest of all in the neck, for the free motion of the head. Then, secondly, in order to afford a passage for the descent of the medullary substance, each of these bones is bored through in the middle in such a manner, as that, when put together, the hole in one bone falls into a line, and corresponds with the holes in the two bones contiguous to it. By which means, the perforated pieces, when joined, form an entire, close, uninterrupted channel; at least, whilst the spine is upright, and at rest. But, as a settled posture is inconsistent with its use, a great difficulty still remained, which was to prevent the vertebræ shifting upon one another, so as to break the line of the canal as often as the body moves or twists; or the joints gaping externally, whenever the body is bent forward, and the spine thereupon made to take the form of a bow. These dangers, which are mechanical, are mechanically provided against. The vertebræ, by means of their processes and projections, and of the articulations which some of these form with one another at their extremities, are so locked in and confined, as to maintain, in what are called the bodies or broad surfaces of the bones, the relative position nearly unaltered; and to throw the change and the pressure, produced by flexion, almost entirely upon the intervening cartilages, the springiness and yielding nature of whose substance admits of all the motion which is necessary to be performed upon them, without any chasm being produced by a separation of the parts. I say of all the motion which is necessary; for although we bend our backs to every degree almost of inclination, the motion of each vertebra is very small: such is the advantage we receive from the chain being composed of so many links, the spine of so many bones. Had it consisted of three or four bones only; in bending the body, the spinal marrow must have been bruised at every angle. The reader need not be told, that these intervening cartilages are gristles; and he may see them in perfection in a loin of veal. Their form also favours the same intention. They are thicker before than behind; so that, when we stoop forward, the compressible substance of the cartilage, yielding in its thicker and anterior part to the force which squeezes it, brings the surfaces of the adjoining vertebræ nearer to the being parallel with one another than they were before, instead of increasing the inclination of their planes, which must have occasioned a fissure or opening between them. Thirdly, for the medullary canal giving out in its course, and in a convenient order, a supply of nerves to different parts of the body, notches are made in the upper and lower edge of every vertebra; two on each edge; equidistant on each side from the middle line of the back. When the vertebræ are put together, these notches, exactly fitting, form small holes, through which the nerves, at each articulation, issue out in pairs, in order to send their branches to every part of the body, and with an equal bounty to both sides of the body. The fourth purpose assigned to the same instrument, is the insertion of the bases of the muscles, and the support of the ends of the ribs; and for this fourth purpose, especially the former part of it, a figure, specifically suited to the design, and unnecessary for the other purposes, is given to the constituent bones. Whilst they are plain, and round, and smooth, towards the front, where any roughness or projection might have wounded the adjacent viscera, they run out, behind, and on each side, into long processes, to which processes the muscles necessary to the motions of the trunk are fixed; and fixed with such art, that, whilst the vertebræ supply a basis for the muscles, the muscles help to keep these bones in their position, or by their tendons to tie them together.

That most important, however, and general property, viz. the strength of the compages, and the security against luxation, was to be still more specially consulted: for, where so many joints were concerned, and where, in every one, derangement would have been fatal, it became a subject of studious precaution. For this purpose, the vertebræ are articulated, that is, the moveable joints between them are formed by means of those projections of their substance, which we have mentioned under the name of processes; and these so lock in with, and overwrap one another, as to secure the body of the vertebra, not only from accidentally slipping, but even from being pushed out of its place by any violence short of that which would break the bone. I have often remarked

and admired this structure in the chine of a hare. In this, as in many instances, a plain observer of the animal œconomy may spare himself the disgust of being present at human dissections, and yet learn enough for his information and satisfaction, by even examining the bones of the animals which come upon his table. Let him take, for example, into his hands, a piece of the clean-picked bone of a hare's back; consisting, we will suppose, of three vertebræ. He will find the middle bone of the three so implicated, by means of its projections or processes, with the bone on each side of it, that no pressure which he can use, will force it out of its place between them. It will give way neither forward, nor backward, nor on either side. In whichever direction he pushes, he perceives, in the form, or junction, or overlapping of the bones, an impediment opposed to his attempt; a check and guard against dislocation. In one part of the spine, he will find a still further fortifying expedient, in the mode according to which the ribs are annexed to the spine. Each rib rests upon two vertebræ. That is the thing to be remarked, and any one may remark it in carving a neck of mutton. The manner of it is this: the end of the rib is divided by a middle ridge into two surfaces; which surfaces are joined to the bodies of two contiguous vertebræ, the ridge applying itself to the intervening cartilage. Now this is the very contrivance which is employed in the famous iron-bridge at my door at Bishop-Wearmouth; and for the same purpose of stability; viz. the cheeks of the bars, which pass between the arches, ride across the joints, by which the pieces composing each arch are united. Each cross-bar rests upon two of these pieces at their place of junction; and by that position resists, at least in one direction, any tendency in either piece to slip out of its place. Thus perfectly, by one means or the other, is the danger of slipping laterally, or of being drawn aside out of the *line* of the back, provided against: and, to withstand the bones being pulled asunder longitudinally, or in the direction of that line, a strong membrane runs from one end of the chain to the other, sufficient to resist any force which is ever likely to act in the direction of the back, or parallel to it, and consequently to secure the whole combination in their places. The general result is, that not only the motions of the human body necessary for the ordinary offices of life are performed with safety, but that it is an accident hardly ever heard of, that even the gesticulations of a harlequin distort his spine.

Upon the whole, and as a guide to those who may be inclined to carry the consideration of this subject further, there are three views under which the spine ought to be regarded, and in all which, it cannot fail to excite our admiration. These views relate to its articulations, its ligaments, and its perforation; and to the corresponding advantages which the body derives from it, for action, for strength, and for that, which is essential to every part, a secure communication with the brain.

The structure of the spine is not in general different in different animals. In the serpent tribe, however, it is considerably varied; but with a strict reference to the conveniency of the animal. For, whereas in quadrupeds the number of vertebræ is from thirty to forty, in the serpent it is nearly one hundred and fifty: whereas in men and quadrupeds the surfaces of the bones are flat, and these flat surfaces laid one against the other, and bound tight by sinews; in the serpent, the bones play one within another like a ball and socket(*Note:* Der. Phys. Theol. p. 396.), so that they have a free motion upon one another in every direction: that is to say, in men and quadrupeds, firmness is more consulted; in serpents, pliancy. Yet even pliancy is not obtained at the expense of safety. The back-bone of a serpent, for coherence and flexibility, is one of the most curious pieces of animal mechanism, with which we are acquainted. The chain of a watch (I mean the chain which passes between the spring-barrel and the fusee), which aims at the same properties, is but a bungling piece of workmanship in comparison with that of which we speak.

IV. The reciprocal enlargement and contraction of the *chest* to allow for the play of the lungs, depends upon a simple yet beautiful mechanical contrivance, referable to the structure of the bones which enclose it. The ribs articulated to the back-bone, or rather to its side projections, *obliquely:* that is, in their natural position they bend or slope from the place of articulation downwards. But the basis upon which they rest at this end being fixed, the consequence of the

obliquity, or the inclination downwards, is, that, when they come to move, whatever pulls the ribs upwards, necessarily, at the same time, draws them out; and that, whilst the ribs are brought to a right angle with the spine behind, the sternum, or part of the chest to which they are attached in front, is thrust forward. The simple action, therefore, of the elevating muscles does the business; whereas, if the ribs had been articulated with the bodies of the vertebræ at right angles, the cavity of the thorax could never have been further enlarged by a change of their position. If each rib had been a rigid bone, articulated at both ends to fixed bases, the whole chest had been immoveable. Keill has observed, that the breast-bone, in an easy inspiration, is thrust out one-tenth of an inch: and he calculates that this, added to what is gained to the space within the chest by the flattening or descent of the diaphragm, leaves room for forty-two cubic inches of air to enter at every drawing-in of the breath. When there is a necessity for a deeper and more laborious inspiration, the enlargement of the capacity of the chest may be so increased by effort, as that the lungs may be distended with seventy or a hundred such cubic inches(*Note:* Anat. p. 229.). The thorax, says Schelhammer, forms a kind of bellows, such as never have been, nor probably will be, made by any artificer.

V. The *patella*, or knee-pan, is a curious little bone; in its form and office, unlike any other bone of the body. It is circular; the size of a crown piece; pretty thick; a little convex on both sides, and covered with a smooth cartilage. It lies upon the front of the knee: and the powerful tendons, by which the leg is brought forward, pass through it (or rather it makes a part of their continuation) from their origin in the thigh to their insertion in the tibia. It protects both the tendon and the joint from any injury which either might suffer, by the rubbing of one against the other, or by the pressure of unequal surfaces. It also gives to the tendons a very considerable mechanical advantage, by altering the line of their direction, and by advancing it further out from the centre of motion; and this upon the principles of the resolution of force, upon which principles all machinery is founded. These are its uses. But what is most observable in it is, that it appears to be supplemental, as it were, to the frame; added, as it should almost seem, afterward; not quite necessary, but very convenient. It is separate from the other bones; that is, it is not connected with any other bones by the common mode of union. It is soft, or hardly formed, in infancy; and produced by an ossification, of the inception or progress of which no account can be given from the structure or exercise of the part.

VI. The *shoulder-blade* is, in some material respects, a very singular bone; appearing to be made so expressly for its own purpose, and so independently of every other reason. In such quadrupeds as have no collar-bones, which are by far the greater number, the shoulder-blade has no bony communication with the trunk, either by a joint, or process, or in any other way. It does not grow to, or out of, any other bone of the trunk. It does not apply to any other bone of the trunk: (I know not whether this be true of any second bone in the body, except perhaps the os hyoïdes): in strictness, it forms no part of the skeleton. It is bedded in the flesh; attached only to the muscles. It is no other than a foundation bone for the arm, laid in, separate, as it were, and distinct, from the general ossification. The lower limbs connect themselves at the hip with bones which form part of the skeleton: but this connexion, in the upper limbs, being wanting, a basis, whereupon the arm might be articulated, was to be supplied by a detached ossification for the purpose.

OF THE JOINTS.

I. THE above are a few examples of bones made remarkable by their configuration: but to almost all the bones belong *joints;* and in these, still more clearly than in the form or shape of the bones themselves, are seen both contrivance and contriving wisdom. Every joint is a curiosity, and is also strictly mechanical. There is the hinge-joint, and the mortice and tenon-joint; each as manifestly such, and as accurately defined, as any which can be produced out of a cabinet-maker's shop: and one or the other prevails, as either is adapted to the motion which is wanted: *e. g.* a mortice and

tenon, or ball and socket joint, is not required at the knee, the leg standing in need only of a motion backward and forward in the same plane, for which a hinge-joint is sufficient; a mortice and tenon, or ball and socket joint, is wanted at the hip, that not only the progressive step may be provided for, but the interval between the limbs may be enlarged or contracted at pleasure. Now observe what would have been the inconveniency, *i. e.* both the superfluity and the defect of articulation, if the case had been inverted: if the ball and socket joint had been at the knee, and the hinge-joint at the hip. The thighs must have been kept constantly together, and the legs have been loose and straddling. There would have been no use, that we know of, in being able to turn the calves of the legs before; and there would have been great confinement by restraining the motion of the thighs to one plane. The disadvantage would not have been less, if the joints at the hip and the knee had been both of the same sort; both balls and sockets, or both hinges: yet why, independently of utility, and of a Creator who consulted that utility, should the same bone (the thigh-bone) be rounded at one end, and channelled at the other?

The *hinge-joint* is not formed by a bolt passing through the two parts of the hinge, and thus keeping them in their places; but by a different expedient. A strong, tough, parchment-like membrane, rising from the receiving bones, and inserted all round the received bones a little below their heads, encloses the joint on every side. This membrane ties, confines, and holds the ends of the bones together; keeping the corresponding parts of the joint, *i. e.* the relative convexities and concavities, in close application to each other.

For the *ball and socket joint*, beside the membrane already described, there is in some important joints, as an additional security, a short, strong, yet flexible ligament, inserted by one end into the head of the ball, by the other into the bottom of the cup? which ligament keeps the two parts of the joint so firmly in their place, that none of the motions which the limb naturally performs, none of the jerks and twists to which it is ordinarily liable, nothing less indeed than the utmost and the most unnatural violence, can pull them asunder. It is hardly imaginable, how great a force is necessary, even to stretch, still more to break, this ligament; yet so flexible is it, as to oppose no impediment to the suppleness of the joint. By its situation also, it is inaccessible to injury from sharp edges. As it cannot be ruptured (such is its strength); so it cannot be cut, except by an accident which would sever the limb. If I had been permitted to frame a proof of contrivance, such as might satisfy the most distrustful inquirer, I know not whether I could have chosen an example of mechanism more unequivocal, or more free from objection, than this ligament. Nothing can be more mechanical; nothing, however subservient to the safety, less capable of being generated by the action of the joint. I would particularly solicit the reader's attention to this provision, as it is found in the head of the *thigh-bone;* to its strength, its structure, and its use. It is an instance upon which I lay my hand. One single fact, weighed by a mind in earnest, leaves oftentimes the deepest impression. For the purpose of addressing different understandings and different apprehensions,--for the purpose of sentiment, for the purpose of exciting admiration of the Creator's works, we diversify our views, we multiply examples; but for the purpose of strict argument, one clear instance is sufficient; and not only sufficient, but capable perhaps of generating a firmer assurance than what can arise from a divided attention.

The *ginglymus*, or hinge-joint, does not, it is manifest, admit of a ligament of the same kind with that of the ball and socket joint, but it is always fortified by the species of ligament of which it does admit. The strong, firm, investing membrane, above described, accompanies it in every part: and in particular joints, this membrane, which is properly a ligament, is considerably stronger on the sides than either before or behind, in order that the convexities may play true in their concavities, and not be subject to slip sideways, which is the chief danger; for the muscular tendons generally restrain the parts from going farther than they ought to go in the plane of their motion. In the *knee*, which is a joint of this form, and of great importance, there are superadded to the common provisions for the stability of the joint, two strong ligaments which cross each other;

and cross each other in such a manner, as to secure the joint from being displaced in any assignable direction. "I think," says Cheselden, "that the knee cannot be completely dislocated without breaking the *cross* ligaments(*Note:* Ches, Anat. ed. 7th, p. 45.)." We can hardly help comparing this with the binding up of a fracture, where the fillet is almost always strapped across, for the sake of giving firmness and strength to the bandage.

Another no less important joint, and that also of the ginglymus sort, is the *ankle;* yet though important (in order, perhaps, to preserve the symmetry and lightness of the limb), *small*, and, on that account, more liable to injury. Now this joint is strengthened, *i. e.* is defended from dislocation, by two remarkable processes or prolongations of the bones of the leg: which processes form the protuberances that we call the inner and outer ankle. It is part of each bone going down lower than the other part, and thereby overlapping the joint: so that, if the joint be in danger of slipping outward, it is curbed by the inner projection, *i. e.* that of the tibia; if inward, by the outer projection, *i. e.* that of the fibula. Between both, it is locked in its position. I know no account that can be given of this structure, except its utility. Why should the tibia terminate, at its lower extremity, with a double end, and the fibula the same,--but to barricade the joint on both sides by a continuation of part of the thickness of the bone over it? The joint at the *shoulder*compared with the joint at the *hip*, though both ball and socket joints, discovers a difference in their form and proportions, well suited to the different offices which the limbs have to execute. The cup or socket at the shoulder is much shallower and flatter than it is at the hip, and is also in part formed of cartilage set round the rim of the cup. The socket, into which the head of the thigh-bone is inserted, is deeper, and made of more solid materials. This agrees with the duties assigned to each part. The arm is an instrument of motion, principally, if not solely. Accordingly the shallowness of the socket at the shoulder, and the yieldingness of the cartilaginous substance with which its edge is set round, and which in fact composes a considerable part of its concavity, are excellently adapted for the allowance of a free motion and a wide range; both which, the arm wants. Whereas, the lower limb, forming a part of the column of the body; having to support the body, as well as to be the means of its locomotion; firmness was to be consulted, as well as action. With a capacity for motion, in all directions indeed, as at the shoulder, but not in any direction to the same extent as in the arm, was to be united stability, or resistance to dislocation. Hence the deeper excavation of the socket; and the presence of a less proportion of cartilage upon the edge.

The suppleness and pliability of the joints, we every moment experience; and the *firmness*of animal articulation, the property we have hitherto been considering, may be judged of, from this single observation, that, at any given moment of time, there are millions of animal joints in complete repair and use, for one that is dislocated; and this, notwithstanding the contortions and wrenches to which the limbs of animals are continually subject.

II. The *joints*, or rather the ends of the bones which form them, display also, in their configuration, another use. The nerves, blood-vessels, and tendons, which are necessary to the life, or for the motion, of the limbs, must, it is evident, in their way from the trunk of the body to the place of their destination, travel over the moveable joints; and it is no less evident, that, in this part of their course, they will have, from sudden motions and from attrition, or laceration. To guard fibres so tender against consequences so injurious, their path is in those parts protected with peculiar care; and that by a provision in the figure of the bones themselves. The nerves which supply the *fore-arm*, especially the inferior cubital nerves, are at the elbow conducted, by a kind of covered way, between the condyls, or rather under the inner extuberances of the bone, which composes the upper part of the arm(*Note:* Ches. Anat. p. 255, ed. 7.). At the *knee*, the extremity of the thigh-bone is divided by a sinus or cliff into two heads or protuberances: and these heads on the back part stand out beyond the cylinder of the bone. Through the hollow, which lies between the hind-parts of these two heads, that is to say, under the ham, between the ham-strings, and within the concave recess of the bone formed by the extuberances on each side; in a word, along a defile,

between rocks, pass the great vessels and nerves which go to the leg(*Note:* Ib. p. 35.). Who led these vessels by a road so defended and secured? In the joint at the *shoulder*, in the edge of the cup which receives the head of the bone, is a *notch*, which is joined or covered at the top with a ligament. Through this hole, thus guarded, the blood-vessels steal to their destination in the arm, instead of mounting over the edge of the concavity(*Note:* Ches. Anat. ed. 7. p. 30.).

III. In all joints, the ends of the bones, which work against each other, are tipped with *gristle*. In the ball and socket joint, the cup is lined, and the ball capped with it. The smooth surface, the elastic and unfriable nature of cartilage, render it of all substances the most proper for the place and purpose. I should, therefore, have pointed this out amongst the foremost of the provisions which have been made in the joints for the facilitating of their action, had it not been alleged, that cartilage in truth is only nascent or imperfect bone; and that the bone in these places is kept soft and imperfect, in consequence of a more complete and rigid ossification being prevented from taking place by the continual motion and rubbing of the surfaces. Which being so, what we represent as a designed advantage, is an unavoidable effect. I am far from being convinced that this is a true account of the fact; or that, if it were so, it answers the argument. To me, the surmounting of the ends of the bones with gristle, looks more like a plating with a different metal, than like the same metal kept in a different state by the action to which it is exposed. At all events, we have a great particular benefit, though arising from a general constitution: but this last not being quite what my argument requires, lest I should seem by applying the instance to overrate its value, I have thought it fair to state the question which attends it.

IV. In some joints, very particularly in the knees, there are loose cartilages or gristles between the bones, and within the joint, so that the ends of the bones, instead of working upon one another, work upon the intermediate cartilages. Cheselden has observed(*Note:* Cheseld. Anat. p. 13. ed. 7th.), that the contrivance of a loose ring is practised by mechanics, where the friction of the joints of any of their machines is great; as between the parts of crook-hinges of large gates, or under the head of the male screw of large vices. The cartilages of which we speak, have very much of the form of these rings. The comparison moreover shows the reason why we find them in the knees rather than in other joints. It is an expedient, we have seen, which a mechanic resorts to, only when some strong and heavy work is to be done. So here the thigh-bone has to achieve its motion at the knee, with the whole weight of the body pressing upon it, and often, as in rising from our seat, with the whole weight of the body to lift. It should seem also, from Cheselden's account, that the slipping and sliding of the loose cartilages, though it be probably a small and obscure change, humoured the motion of the end of the thigh-bone, under the particular configuration which was necessary to be given to it for the commodious action of the tendons; (and which configuration requires what he calls a variable socket, that is, a concavity, the lines of which assume a different curvature in different inclinations of the bones).

V. We have now done with the configuration: but there is also in the joints, and that common to them all, another exquisite provision, manifestly adapted to their use, and concerning which there can, I think, be no dispute, namely, the regular supply of a *mucilage*, more emollient and slippery than oil itself, which is constantly softening and lubricating the parts that rub upon each other, and thereby diminishing the effect of attrition in the highest possible degree. For the continual secretion of this important liniment, and for the feeding of the cavities of the joint with it, glands are fixed near each joint; the excretory ducts of which glands, dripping with their balsamic contents, hang loose like fringes within the cavity of the joints. A late improvement in what are called friction-wheels, which consist of a mechanism so ordered, as to be regularly dropping oil into a box, which encloses the axis, the nave, and certain balls upon which the nave revolves, may be said, in some sort, to represent the contrivance in the animal joint; with this superiority, however, on the part of the joint, viz. that here, the oil is not only dropped, but *made*.

In considering the joints, there is nothing, perhaps, which ought to move our gratitude more than the reflection, *how well they wear*. A limb shall swing upon its hinge, or play in its socket, many hundred times in an hour, for sixty years together, without diminution of its agility: which is a long time for any thing to last; for any thing so much worked and exercised as the joints are. This durability, I should attribute, in part, to the provision which is made for the preventing of wear and tear, first, by the polish of the cartilaginous surfaces; secondly, by the healing lubrication of the mucilage; and, in part, to that astonishing property of animal constitutions, assimilation, by which, in every portion of the body, let it consist of what it will, substance is restored, and waste repaired.

Moveable joints, I think, compose the curiosity of bones; but their union, even where no motion is intended or wanted, carries marks of mechanism and of mechanical wisdom. The teeth, especially the front teeth, are one bone fixed in another, like a peg driven into a board. The sutures of the skull are like the edges of two saws clapped together, in such a manner as that the teeth of one enter the intervals of the other. We have sometimes one bone lapping over another, and planed down at the edges; sometimes also the thin lamella of one bone received into a narrow furrow of another. In all which varieties, we seem to discover the same design, viz. firmness of juncture, without clumsiness in the seam.

CHAPTER IX.
OF THE MUSCLES.

MUSCLES, with their tendons, are the instruments by which animal motion is performed. It will be our business to point out instances in which, and properties with respect to which, the disposition of these muscles is as strictly mechanical, as that of the wires and strings of a puppet. I. We may observe, what I believe is universal, an exact relation between the joint and the muscles which move it. Whatever motion the joint, by its mechanical construction, is capable of performing, that motion, the annexed muscles, by their position, are capable of producing. For example; if there be, as at the knee and elbow, a hinge-joint, capable of motion only in the same plane, the leaders, as they are called, *i. e.* the muscular tendons, are placed in directions parallel to the bone, so as, by the contraction or relaxation of the muscles to which they belong, to produce that motion and no other. If these joints were capable of a freer motion, there are no muscles to produce it. Whereas at the shoulder and the hip, where the ball and socket joint allows by its construction of a rotatory or sweeping motion, tendons are placed in such a position, and pull in such a direction, as to produce the motion of which the joint admits. For instance, the sartorius or tailor's muscle, rising from the spine, running diagonally across the thigh, and taking hold of the inside of the main bone of the leg, a little below the knee, enables us, by its contraction, to throw one leg and thigh over the other; giving effect, at the same time, to the ball and socket joint at the hip, and the hinge-joint at the knee. There is, as we have seen, a specific mechanism in the bones, for the rotatory motions of the head and hands: there is, also, in the oblique direction of the muscles belonging to them, a specific provision for the putting of this mechanism of the bones into action. And mark the consent of uses. The oblique muscles would have been inefficient without that particular articulation: that particular articulation would have been lost, without the oblique muscles. It may be proper however to observe with respect to the *head*, although I think it does not vary the case, that its oblique motions and inclinations are often motions in a *diagonal*, produced by the joint action of muscles lying in straight directions. But whether the pull be single or combined, the articulation is always such, as to be capable of obeying the action of the muscles. The oblique muscles attached to the head, are likewise so disposed, as to be capable of steadying the globe, as well as of moving it. The head of a new-born infant is often obliged to be filleted up. After death, the head drops and rolls in every direction. So that it is by the equilibre of the muscles, by the aid of a considerable and equipollent muscular force in constant exertion, that the head maintains its erect posture. The muscles here supply what would otherwise be a great defect in the articulation:

for, the joint in the neck, although admirably adapted to the motion of the head, is insufficient for its support. It is not only by the means of a most curious structure of the bones that a man turns his head, but by virtue of an adjusted muscular power, that he even holds it up.

As another example of what we are illustrating, viz, conformity of use between the bones and the muscles, it has been observed of the different vertebræ, that their processes are exactly proportioned to the quantity of motion which the other bones allow of, and which the respective muscles are capable of producing.

II. A muscle acts only by contraction. Its force is exerted in no other way. When the exertion ceases, it relaxes itself, that is, it returns by relaxation to its former state; but without energy. This is the nature of the muscular fibre: and being so, it is evident that the reciprocal *energetic* motion of the limbs, by which we mean motion *with force*in opposite directions, can only be produced by the instrumentality of opposite or antagonist muscles; of flexors and extensors answering to each other. For instance, the biceps and brachiæus *internus* muscles placed in the front part of the upper arm, by their contraction, bend the elbow: and with such degree of force, as the case requires, or the strength admits of. The relaxation of these muscles, after the effort, would merely let the fore-arm drop down. For the *back stroke*, therefore, and that the arm may not only bend at the elbow, but also extend and straighten itself, with force, other muscles, the longus and brevis brachiæus *externus* and the anconæus, placed on the hinder part of the arms, by their contractile twitch fetch back the fore-arm into a straight line with the cubit, with no less force than that with which it was bent out of it. The same thing obtains in all the limbs, and in every moveable part of the body. A finger is not bent and straightened, without the *contraction* of two muscles taking place. It is evident therefore, that the animal functions require that particular disposition of the muscles which we describe by the name of antagonist muscles. And they are accordingly so disposed. Every muscle is provided with an adversary. They act, like two sawyers in a pit, by an opposite pull: and nothing surely can more strongly indicate design and attention to an end, than their being thus stationed, than this collocation. The nature of the muscular fibre being what it is, the purposes of the animal could be answered by no other. And not only the capacity for motion, but the aspect and symmetry of the body is preserved by the muscles being marshalled according to this order, *e. g.* the mouth is holden in the middle of the face, and its angles kept in a state of exact correspondency, by two muscles drawing against, and balancing each other. In a hemiplegia, when the muscle on one side is weakened, the muscle on the other side draws the mouth awry.

III. Another property of the muscles, which could only be the result of care, is, their being almost universally so disposed, as not to obstruct or interfere with one another's action. I know but one instance in which this impediment is perceived. We cannot easily swallow whilst we gape. This, I understand, is owing to the muscles employed in the act of deglutition being so implicated with the muscles of the lower jaw, that, whilst these last are contracted, the former cannot act with freedom. The obstruction is, in this instance, attended with little inconveniency; but it shows what the effect is where it does exist; and what loss of faculty there would be if it were more frequent. Now, when we reflect upon the number of muscles, not fewer than four hundred-and-forty-six in the human body, known and named(*Note:* Keill's Anatomy, p. 295, ed. 3.), how contiguous they lie to each other, in layers, as it were, over one another, crossing one another, sometimes embedded in one another, sometimes perforating one another: an arrangement, which leaves to each his liberty, and its full play, must necessarily require meditation and counsel.

IV. The following is oftentimes the case with the muscles. Their action is wanted, where their situation would be inconvenient. In which case, the body of the muscle is placed in some commodious position at a distance, and made to communicate with the point of action, by slender strings or wires. If the muscles which move the fingers, had been placed in the palm or back of the

hand, they would have swelled that part to an awkward and clumsy thickness. The beauty, the proportions of the part would have been destroyed. They are therefore disposed in the arm, and even up to the elbow; and act by long tendons, strapped down at the wrist, and passing under the ligaments to the fingers, and to the joints of the fingers, which they are severally to move. In like manner, the muscles which move the toes, and many of the joints of the foot, how gracefully are they disposed in the calf of the leg, instead of forming an unwieldy tumefaction in the foot itself! The observation may be repeated of the muscle which draws the nictitating membrane over the eye. Its office is in the front of the eye; but its body is lodged in the back part of the globe, where it lies safe, and where it incumbers nothing.

V. The great mechanical variety in the figure of the muscles may be thus stated. It appears to be a fixed law, that the contraction of a muscle shall be towards its centre. Therefore the subject for mechanism on each occasion is, so to modify the figure, and adjust the position of the muscle, as to produce the motion required, agreeably with this law. This can only be done by giving to different muscles, a diversity of configuration, suited to their several offices, and to their situation with respect to the work which they have to perform. On which account we find them under a multiplicity of forms and attitudes; sometimes with double, sometimes with treble, tendons, sometimes with none: sometimes one tendon to several muscles, at other times one muscle to several tendons. The shape of the organ is susceptible of an incalculable variety, whilst the original property of the muscle, the law and line of its contraction, remains the same, and is simple. Herein the muscular system may be said to bear a perfect resemblance to our works of art. An artist does not alter the native quality of his materials, or their laws of action. He takes these as he finds them. His skill and ingenuity are employed in turning them, such as they are, to his account, by giving to the parts of his machine a form and relation, in which these unalterable properties may operate to the production of the effects intended.

VI. The ejaculations can never too often be repeated;--How many things must go right for us to be an hour at ease! how many more for us to be vigorous and active! Yet vigour and activity are, in a vast plurality of instances, preserved in human bodies, notwithstanding that they depend upon so great a number of instruments of motion, and notwithstanding that the defect or disorder sometimes of a very small instrument, of a single pair, for instance, out of the four hundred-and-forty-six muscles which are employed, may be attended with grievous inconveniency.

There is piety and good sense in the following observation, taken out of the *Religious Philosopher:* "With much compassion," says this writer, "as well as astonishment at the goodness of our loving Creator, have I considered the sad state of a certain gentleman, who, as to the rest, was in pretty good health, but only wanted the use of these *two little muscles* that serve to lift up the eyelids, and so had almost lost the use of his sight, being forced, as long as this defect lasted, to shove up his eyelids every moment with his own hands!"--In general we may remark in how small a degree those, who enjoy the perfect use of their organs, know the comprehensiveness of the blessing, the variety of their obligation. They perceive a result, but they think little of the multitude of concurrences and rectitudes which go to form it.

Beside these observations, which belong to the muscular organ as such, we may notice some advantages of structure which are more conspicuous in muscles of a certain class or description than in others. Thus:

I. The variety, quickness, and precision, of which muscular motion is capable, are seen, I think, in no part so remarkably as in the *tongue*. It is worth any man's while to watch the agility of his tongue; the wonderful promptitude with which it executes changes of position, and the perfect exactness. Each syllable of articulated sound requires for its utterance a specific action of the tongue, and of the parts adjacent to it. The disposition and configuration of the mouth,

appertaining to every letter and word, is not only peculiar, but, if nicely and accurately attended to, perceptible to the sight; insomuch, that curious persons have availed themselves of this circumstance to teach the deaf to speak, and to understand what is said by others. In the same person, and after his habit of speaking is formed, one, and only one, position of the parts, will produce a given articulate sound correctly. How instantaneously are these positions assumed and dismissed; how numerous are the permutations, how various, yet how infallible! Arbitrary and antic variety is not the thing we admire; but variety obeying a rule, conducing to an effect, and commensurate with exigencies infinitely diversified. I believe also that the anatomy of the tongue corresponds with these observations upon its activity. The muscles of the tongue are so numerous, and so implicated with one another, that they cannot be traced by the nicest dissection; nevertheless (which is a great perfection of the organ), neither the number, nor the complexity, nor what might seem to be the entanglement of its fibres, in any wise impede its motion, or render the determination or success of its efforts uncertain.

I here entreat the reader's permission, to step a little out of my way to consider *the parts of the mouth,* in some of their other properties. It has been said, and that by an eminent physiologist, that, whenever nature attempts to work two or more purposes by one instrument, she does both or all imperfectly. Is this true of the tongue, regarded as an instrument of speech, and of taste; or regarded as an instrument of speech, of taste, and of deglutition? So much otherwise, that many persons, that is to say, nine hundred and ninety-nine persons out of a thousand, by the instrumentality of this one organ, talk, and taste, and swallow, very well. In fact, the constant warmth and moisture of the tongue, the thinness of the skin, the papillæ upon its surface, qualify this organ for its office of tasting, as much as its inextricable multiplicity of fibres do for the rapid movements which are necessary to speech. Animals which feed upon grass, have their tongues covered with a perforated skin, so as to admit the dissolved food to the papillæ underneath, which, in the mean time, remain defended from the rough action of the unbruised spiculæ.

There are brought together within the cavity of the mouth more distinct uses, and parts executing more distinct offices, than I think can be found lying so near to one another, or within the same compass, in any other portion of the body: viz. teeth of different shape, first for cutting, secondly for grinding; muscles, most artificially disposed for carrying on the compound motion of the lower jaw, half lateral and half vertical, by which the mill is worked: fountains of saliva, springing up in different parts of the cavity for the moistening of the food, whilst the mastication is going on: glands, to feed the fountains; a muscular constriction of a very peculiar kind in the back part of the cavity, for the guiding of the prepared aliment into its passage towards the stomach, and in many cases for carrying it along that passage; for, although we may imagine this to be done simply by the weight of the food itself, it in truth is not so, even in the upright posture of the human neck; and most evidently is not the case with quadrupeds, with a horse for instance, in which, when pasturing, the food is thrust upward by muscular strength, instead of descending of its own accord.

In the mean time, and within the same cavity, is going on another business, altogether different from what is here described,--that of respiration and speech. In addition therefore to all that has been mentioned, we have a passage opened, from this cavity to the lungs, for the admission of air, exclusively of every other substance; we have muscles, some in the larynx, and without number in the tongue, for the purpose of modulating that air in its passage, with a variety, a compass, and precision, of which no other musical instrument is capable. And, lastly, which in my opinion crowns the whole as a piece of machinery, we have a specific contrivance for dividing the pneumatic part from the mechanical, and for preventing one set of actions interfering with the other. Where various functions are united, the difficulty is to guard against the inconveniencies of a too great complexity. In no apparatus put together by art, and for the purposes of art, do I know such multifarious uses so aptly combined, as in the natural organization of the human mouth; or, where the structure, compared with the uses, is so simple. The mouth, with all these intentions to serve,

is a single cavity; is one machine; with its parts neither crowded nor confused, and each unembarrassed by the rest: each at least at liberty in a degree sufficient for the end to be attained. If we cannot eat and sing at the same moment, we can eat one moment, and sing the next: the respiration proceeding freely all the while.

There is one case however of this double office, and that of the *earliest* nesessity, which the mouth alone could not perform; and that is, carrying on together the two actions of sucking and breathing. Another route therefore is opened for the air, namely, through the nose, which lets the breath pass backward and forward, whilst the lips, in the act of sucking, are necessarily shut close upon the body from which the nutriment is drawn. This is a circumstance which always appeared to me worthy of notice. The nose would have been necessary, although it had not been the organ of smelling. The making it the seat of a sense, was superadding a new use to a part already wanted; was taking a wise advantage of an antecedent and a constitutional necessity.

But to return to that which is the proper subject of the present section,--the celerity and precision of muscular motion. These qualities may be particularly observed in the execution of many species of instrumental *music*, in which the changes produced by the hand of the musician are exceedingly rapid; are exactly measured, even when most minute; and display, on the part of the muscles, an obedience of action, alike wonderful for its quickness and its correctness.

Or let a person only observe his own hand whilst he is *writing*; the number of muscles, which are brought to bear upon the pen; how the joint and adjusted operation of several tendons is concerned in every stroke, yet that five hundred such strokes are drawn in a minute. Not a letter can be turned without more than one, or two, or three tendinous contractions, definite, both as to the choice of the tendon, and as to the space through which the contraction moves; yet how currently does the work proceed! and when we look at it, how faithful have the muscles been to their duty, how true to the order which endeavour or habit hath inculcated! For let it be remembered, that, whilst a man's handwriting is the same, an exactitude of order is preserved, whether he write well, or ill. These two instances, of music and writing, show not only the quickness and precision of muscular action, but the docility.

II. Regarding the particular configuration of muscles, *sphincter* or circular muscles appear to me admirable pieces of mechanism. It is the muscular power most happily applied; the same quality of the muscular substance, but under a new modification. The circular disposition of the fibres is strictly mechanical; but, though the most mechanical, is not the only thing in sphincters which deserves our notice. The regulated degree of contractile force with which they are endowed, sufficient for retention, yet vincible when requisite, together with their ordinary state of actual contraction, by means of which their dependence upon the will is not constant, but occasional, gives to them a constitution, of which the conveniency is inestimable. This their semi-voluntary character, is exactly such as suits with the wants and functions of the animal.

III. We may also, upon the subject of muscles, observe, that many of our most important actions are achieved by the combined help of different muscles. Frequently, a diagonal motion is produced, by the contraction of tendons pulling in the direction of the sides of the parallelogram. This is the case, as hath been already noticed, with some of the oblique nutations of the head. Sometimes the number of co-operating muscles is very great. Dr. Nieuentyt, in the Leipsic Transactions, reckons up a hundred muscles that are employed every time we breathe; yet we take in, or let out, our breath, without reflecting what a work is thereby performed: what an apparatus is laid in, of instruments for the service, and how many such contribute their assistance to the effect! Breathing with ease, is a blessing of every moment; yet, of all others, it is that which we possess with the least consciousness. A man in an asthma is the only man who knows how to estimate it.

IV. Mr. Home has observed(*Note:* Phil. Trans. part i. 1800. p. S.), that the most important and the most delicate actions are performed in the body by the smallest muscles: and he mentions, as his examples, the muscles which have been discovered in the iris of the eye, and the drum of the ear. The tenuity of these muscles is astonishing. They are microscopic hairs; must be magnified to be visible; yet are they real, effective muscles: and not only such, but the grandest and most precious of our faculties, sight, and hearing, depend upon their health and action.

V. The muscles act in the limbs with what is called a mechanical disadvantage. The muscle at the shoulder, by which the arm is raised, is fixed nearly in the same manner as the load is fixed upon a steelyard, within a few decimals, we will say, of an inch, from the centre upon which the steelyard turns. In this situation, we find that a very heavy draught is no more than sufficient to countervail the force of a small lead plummet, placed upon the long arm of the steelyard, at the distance of perhaps fifteen or twenty inches from the centre, and on the other side of it. And this is the disadvantage which is meant. And an absolute disadvantage, no doubt, it would be, if the object were, to spare the force of muscular contraction. But observe how conducive is this constitution to animal conveniency. Mechanism has always in view one or other of these two purposes; either to move a great weight slowly, and through a small space, or to move a light weight rapidly, through a considerable sweep. For the former of these purposes, a different species of lever, and a different collocation of the muscles, might be better than the present: but for the second, the present structure is the true one. Now so it happens, that the second, and not the first, is that which the occasions of animal life principally call for. In what concerns the human body, it is of much more consequence to any man to be able to carry his hand to his head with due expedition, than it would be to have the power of raising from the ground a heavier load (of two or three more hundred weight, we will suppose,) than he can lift at present. This last is a faculty, which on some extraordinary occasions, he may desire to possess; but the other is what he wants and uses every hour or minute. In like manner, a husbandman or a gardener will do more execution, by being able to carry his scythe, his rake, or his flail, with a sufficient dispatch through a sufficient space, than if, with greater strength, his motions were proportionably more confined and slow. It is the same with a mechanic in the use of his tools. It is the same also with other animals in the use of their limbs. In general, the vivacity of their motions would be ill exchanged for greater force under a clumsier structure.

We have offered our observations upon the structure of muscles in general; we have also noticed certain species of muscles: but there are also *single* muscles, which bear marks of mechanical contrivance, appropriate as well as particular. Out of many instances of this kind, we select the following.

I. Of muscular actions, even of those which are well understood, some of the most curious are incapable of popular explanation; at least, without the aid of plates and figures. This is in a great measure the case, with a very familiar, but, at the same time, a very complicated motion,--that of the *lower jaw;* and with the muscular structure by which it is produced. One of the muscles concerned may, however, be described in such a manner, as to be, I think, sufficiently comprehended for our present purpose. The problem is to pull the lower jaw *down*. The obvious method should seem to be, to placea straight muscle, viz. to fix a string from the chin to the breast, the contraction of which would open the mouth, and produce the motion required at once. But it is evident that the form and liberty of the neck forbid a muscle being laid in such a position; and that, consistently with the preservation of this form, the motion, which we want, must be effectuated, by some muscular mechanism, disposed further back in the jaw. The mechanism adopted is as follows. A certain muscle called the *diagastric*, rises on the side of the face, considerably *above* the insertion of the lower jaw, and comes down, being converted in its progress into a round tendon. Now it is manifest that the tendon, whilst it pursues a direction *descending*

towards the jaw, must, by its contraction, pull the jaw up, instead of down. What then was to be done? This, we find, is done. The descending tendon, when it is got low enough, is passed through a loop, or ring, or pulley, in the os hyoïdes, and then made to ascend; and, having thus changed its line of direction, is inserted into the inner part of the chin: by which device, viz. the turn at the loop, the action of the muscle (which in all muscles is contraction) that before would have pulled the jaw up, now as necessarily draws it down. "The mouth," says Heister, "is opened by means of this trochlea in a most wonderful and elegant manner."

II. What contrivance can be more mechanical than the following, viz. a slit in one tendon to let another tendon pass through it? This structure is found in the tendons which move the toes and fingers. The long tendon, as it is called, in the foot, which bends the first joint of the toe, passes *through* the short tendon which bends the second joint; which course allows to the sinew more liberty, and a more commodious action than it would otherwise have been capable of exerting(*Note:* Ches. Anat. p, 119.). There is nothing, I believe, in a silk or cotton mill, in the belts, or straps, or ropes, by which, motion is communicated from one part of the machine to another, that is more artificial, or more evidently so, than this *perforation*.

III. The next circumstance which I shall mention, under this head of muscular arrangement, is so decisive a mark of intention, that it always appeared to me to supersede, in some measure, the necessity of seeking for any other observation upon the subject: and that circumstance is, the tendons, which pass from the leg to the foot, being bound down by a ligament at the ancle. The foot is placed at a considerable angle with the leg. It is manifest, therefore, that flexible strings, passing along the interior of the angle, if left to themselves, would, when stretched, start from it. The obvious preventive is to tie them down. And this is done in fact. Across the instep, or rather just above it, the anatomist finds a strong ligament, *under* which the tendons pass to the foot. The effect of the ligament as a bandage, can be made evident to the senses: for if it be cut, the tendons start up. The simplicity, yet the clearness of this contrivance, its exact resemblance to established resources of art, place it amongst the most indubitable manifestations of design with which we are acquainted.

There is also a further use to be made of the present example, and that is, as it precisely contradicts the opinion, that the parts of animals may have been all formed by what is called *appetency*, i. e. endeavour, perpetuated, and imperceptibly working its effect, through an incalculable series of generations. We have here no endeavour, but the reverse of it; a constant renitency and reluctance. The endeavour is all the other way. The pressure of the ligament constrains the tendons; the tendons re-act upon the pressure of the ligament. It is impossible that the ligament should ever have been generated by the exercise of the tendon, or in the course of that exercise, forasmuch as the force of the tendon perpendicularly resists the fibre which confines it, and is constantly endeavouring, not to form, but to rupture and displace, the threads of which the ligament is composed.

Keill has reckoned up, in the human body, four hundred and forty-six muscles, dissectible and describable; and hath assigned a use to every one of the number. This cannot be all imagination.

Bishop Wilkins hath observed from Galen, that there are, at least, ten several qualifications to be attended to in each particular muscle; viz. its proper figure; its just magnitude; its fulcrum; its point of action, supposing the figure to be fixed; its collocation, with respect to its two ends, the upper and the lower; the place; the position of the whole muscle; the introduction into it of nerves, arteries, veins. How are things, including so many adjustments, to be made; or, when made, how are they to be put together, without intelligence?

I have sometimes wondered, why we are not struck with mechanism in animal bodies, as readily and as strongly as we are struck with it, at first sight, in a watch or a mill. One reason of the difference may be, that animal bodies are, in a great measure, made up of soft, flabby, substances, such as muscles and membranes; whereas we have been accustomed to trace mechanism in sharp lines, in the configuration of hard materials, in the moulding, chiseling, and filing into shapes, of such articles as metals or wood. There is something therefore of habit in the case; but it is sufficiently evident, that there can be no proper reason for any distinction of the sort. Mechanism may be displayed in the one kind of substance, as well as in the other.

Although the few instances we have selected, even as they stand in our description, are nothing short perhaps of logical proofs of design, yet it must not be forgotten, that, in every part of anatomy, description is a poor substitute for inspection. It is well said by an able anatomist(*Note:* Steno, in Blas. Anat. Animal. p. 2. c. 4.), and said in reference to the very part of the subject which we have been treating of;--"Imperfecta hæc musculorum descriptio, non minùs arida est legentibus, quàm inspectantibus fuerit jucunda eorundem præparatio. Elegantissima enim mechanicês artificia, creberrimè in illis obvia, verbis nonnisi obscurè exprimuntur: carnium autem ductu, tendinum colore, insertionum proportione, et trochlearium distributione, oculis exposita, omnem superant admirationem."

CHAPTER X.
OF THE VESSELS OF ANIMAL BODIES.

THE circulation of the *blood*, through the bodies of men and quadrupeds, and the apparatus by which it is carried on, compose a system, and testify a contrivance, perhaps the best understood of any part of the animal frame. The lymphatic system, or the nervous system, may be more subtile and intricate; nay, it is possible that in their structure they may be even more artificial than the sanguiferous; but we do not know so much about them.

The utility of the circulation of the blood, I assume as an acknowledged point. One grand purpose is plainly answered by it; the distributing to every part, every extremity, every nook and corner, of the body, the nourishment which is received into it by one aperture. What enters at the mouth, finds its way to the fingers' ends. A more difficult mechanical problem could hardly I think be proposed, than to discover a method of constantly repairing the waste, and of supplying an accession of substance to every part, of a complicated machine, at the same time.

This system presents itself under two views: first, the disposition of the blood-vessels, *i. e.* the laying of the pipes; and, secondly, the construction of the engine at the centre, viz. the heart, for driving the blood through them.

I. The disposition of the blood-vessels, as far as regards the supply of the body, is like that of the water-pipes in a city, viz. large and main trunks branching off by smaller pipes (and these again by still narrower tubes) in every direction, and towards every part in which the fluid, which they convey, can be wanted. So far the water-pipes, which serve a town, may represent the vessels which carry the blood from the heart. But there is another thing necessary to the blood, which is not wanted for the water; and that is, the carrying of it back again to its source. For this office, a reversed system of vessels is prepared, which, uniting at their extremities with the extremities of the first system, collects the divided and subdivided streamlets, first by capillary ramifications into larger branches, secondly, by these branches into trunks; and thus returns the blood (almost exactly inverting the order in which it went out) to the fountain whence its motion proceeded. All which is evident mechanism.

The body, therefore, contains two systems of blood-vessels, arteries and veins. Between the constitution of the systems there are also two differences, suited to the functions which the systems have to execute. The blood, in going out, passing always from wider into narrower tubes; and, in coming back, from narrower into wider; it is evident, that the impulse and pressure upon the sides of the blood-vessel, will be much greater in one case than the other. Accordingly, the arteries which carry out the blood, are formed of much tougher and stronger coats, than the veins which bring it back. That is one difference: the other is still more artificial, or, if I may so speak, indicates, still more clearly, the care and anxiety of the artificer. Forasmuch as in the arteries, by reason of the greater force with which the blood is urged along them, a wound or rupture would be more dangerous than in the veins, these vessels are defended from injury, not only by their texture, but by their situation; and by every advantage of situation which can be given to them. They are buried in sinuses, or they creep along-grooves, made for them in the bones; for instance, the under-edge of the ribs is sloped and furrowed solely for the passage of these vessels. Sometimes they proceed in channels, protected by stout parapets on each side; which last description is remarkable in the bones of the fingers, these being hollowed out, on the under-side, like a scoop, and with such a concavity, that the finger may be cut across to the bone, without hurting the artery which runs along it. At other times, the arteries pass in canals wrought in the substance, and in the very middle of the substance, of the bone; this takes place in the lower jaw; and is found where there would, otherwise, be danger of compression by sudden curvature. All this care is wonderful, yet not more than what the importance of the case required. To those, who venture their lives in a ship, it has been often said, that there is only an inch-board between them and death; but in the body itself, especially in the arterial system, there is, in many parts, only a membrane, a skin, a thread. For which reason, this system lies deep under the integuments; whereas the veins, in which the mischief that ensues from injuring the coats is much less, lie in general above the arteries; come nearer to the surface; are more exposed.

It may be further observed concerning the two systems taken together, that though the arterial, with its trunk and branches and small twigs, may be imagined to issue or proceed; in other words, to *grow* from the heart; like a plant from its root, or the fibres of a leaf from its foot-stalk (which however, were it so, would be only to resolve one mechanism into another), yet the venal, the returning system, can never be formed in this manner. The arteries might go on shooting out from their extremities, *i. e.* lengthening and subdividing indefinitely; but an inverted system, continually uniting its streams, instead of dividing, and thus carrying back what the other system carried out, could not be referred to the same process.

II. The next thing to be considered is the engine which works this machinery, viz. the *heart*. For our purpose it is unnecessary to ascertain the principle upon which the heart acts. Whether it be irritation excited by the contact of the blood, by the influx of the nervous fluid, or whatever else be the cause of its motion, it is something which is capable of producing, in a living muscular fibre, reciprocal contraction and relaxation. This is the power we have to work with: and the inquiry is, how this power is applied in the instance before us. There is provided, in the central part of the body, a hollow muscle, invested with spiral fibres, running in both directions, the layers intersecting one another; in some animals, however, appearing to be semicircular rather than spiral. By the contraction of these fibres, the sides of the muscular cavities are necessarily squeezed together, so as to force out from them any fluid which they may at that time contain; by the relaxation of the same fibres, the cavities are in their turn dilated, and, of course, prepared to admit every fluid which may be poured into them. Into these cavities are inserted the great trunks, both of the arteries which carry out the blood, and of the veins which bring it back. This is a general account of the apparatus; and the simplest idea of its action is, that, by each contraction, a portion of blood is forced by a syringe into the arteries: and, at each dilatation, an equal portion is received from the veins. This, produces at each pulse, a motion, and change in the mass of blood, to the amount of what the cavity contains, which in a full-grown human heart I understand is

about an ounce, or two tablespoons full. How quickly these changes succeed one another, and by this succession how sufficient they are to support a stream or circulation throughout the system, may be understood by the following computation, abridged from Keill's Anatomy, p. 117, ed. 3: "Each ventricle will at least contain one ounce of blood. The heart contracts four thousand times in one hour; from which it follows, that there pass through the heart, every hour, four thousand ounces, or three-hundred-and-fifty pounds of blood. Now the whole mass of blood is said to be about" twenty-five pounds; so that a quantity of blood, equal to the whole mass of blood, passes through the heart fourt eentimes in one hour; which is about once every four minutes. Consider what an affair this is, when we come to very large animals. The aörta of a whale is larger in the bore than the main pipe of the water-works at London-Bridge: and the water roaring in its passage through that pipe is inferior, in impetus and velocity, to the blood gushing from the whale's heart. Hear Dr. Hunter's account of the dissection of a whale:--"The aörta measured a foot diameter. Ten or fifteen gallons of blood are thrown out of the heart at a stroke with an immense velocity, through a tube of a foot diameter. The whole idea fills the mind with wonder(*Note:* Dr. Hunter's Account of the Dissection of a Whale. (Phil. Trans.))."

The account which we have here stated, of the injection of blood into the arteries by the contraction, and of the corresponding reception of it from the veins by the dilatation, of the cavities of the heart, and of the circulation being thereby maintained through the blood-vessels of the body, is true, but imperfect. The heart performs this office, but it is in conjunction with another of equal curiosity and importance. It was necessary that the blood should be successively brought into contact, or contiguity, or proximity, with the *air*. I do not know that the chymical reason, upon which this necessity is founded, has been yet sufficiently explored. It seems to be made appear, that the atmosphere which we breathe is a mixture of two kinds of air; one pure and vital, the other, for the purposes of life, effete, foul, and noxious; that when we have drawn-in our breath, the blood in the lungs imbibes from the air, thus brought into contiguity with it, a portion of its pure ingredient, and at the same time, gives out the effete or corrupt air which it contained, and which is carried away, along with the halitus, every time we expire. At least; by comparing the air which is breathed from the lungs, with the air which enters the lungs, it is found to have lost some of its pure part, and to have brought away with it an addition of its impure part. Whether these experiments satisfy the question, as to the need which the blood stands in of being visited by continual accesses of air, is not for us to inquire into; nor material to our argument: it is sufficient to know, that, in the constitution of most animals, such a necessity exists, and that the air, by some means or other, *must* be introduced into a near communication with the blood. The lungs of animals are constructed for this purpose. They consist of blood-vessels and air-vessels, lying close to each other; and whenever there is a branch of the trachea or windpipe, there is a branch accompanying it of the vein and artery, and the air-vessel is always in the middle between the blood-vessels(*Note:* Keill's Anatomy, p. 121.). The internal surface of these vessels, upon which the application of the air to the blood depends, would, if collected, and expanded, be, in a man, equal to a superficies of fifteen feet square. Now, in order to give the blood in its course the benefit of this organization (and this is the part of the subject with which we are chiefly concerned), the following operation takes place. As soon as the blood is received by the heart from the veins of the body, and *before* that it is sent out again into its arteries, it is carried, by the force of the contraction of the heart, and by means of a separate and supplementary artery, to the lungs, and made to enter the vessels of the lungs; from which, after it has undergone the action, whatever it be, of that viscus, it is brought back by a large vein once more to the heart, in order, when thus concocted and prepared, to be thence distributed anew into the system. This assigns to the heart a double office. The pulmonary circulation is a system within a system; and one action of the heart is the origin of both.

For this complicated function, four cavities become necessary; and four are accordingly provided: two, called ventricles, which *send out* the blood, viz. one into the lungs, in the first instance; the

other into the mass, after it has returned from the lungs: two others also, called auricles, which *receive* the blood from the veins; viz. one, as it comes immediately from the body; the other, as the same blood comes a second time after its circulation through the lungs. So that there are two receiving cavities, and two forcing cavities. The structure of the heart has reference to the lungs; for without the lungs, one of each would have been sufficient. The translation of the blood in the heart itself is after this manner. The receiving cavities respectively communicate with the forcing cavities, and, by their contraction, unload the received blood into them. The forcing cavities, when it is their turn to contract, compel the same blood into the mouths of the arteries.

The account here given will not convey to a reader, ignorant of anatomy, any thing like an accurate notion of the form, action, or use of the parts, (nor can any short and popular account do this); but it is abundantly sufficient to testify contrivance; and although imperfect, being true as far as it goes, may be relied upon for the only purpose for which we offer it, the purpose of this conclusion.

"The wisdom of the Creator," saith Hamburgher, "is in nothing seen more gloriously than in the heart." And how well doth it execute its office! An anatomist, who understood the structure of the heart, might say beforehand that it would play; but he would expect, I think, from the complexity of its mechanism, and the delicacy of many of its parts, that it should always be liable to derangement, or that it would soon work itself out. Yet shall this wonderful machine go, night and day, for eighty years together, at the rate of a hundred thousand strokes every twenty-four hours, having, at every stroke, a great resistance to overcome; and shall continue this action for this length of time, without disorder and without weariness!

But further; from the account which has been given of the mechanism of the heart, it is evident that it must require the interposition of *valves;* that the success indeed of its action must depend upon these; for when any one of its cavities contracts, the necessary tendency of the force will be to drive the enclosed blood, not only into the mouth of the artery where it ought to go, but also back again into the mouth of the vein from which it flowed. In like manner, when by the relaxation of the fibres the same cavity is dilated, the blood would not only run into it from the vein, which was the course intended, but back from the artery, through which it ought to be moving forward. The way of preventing a reflux of the fluid, in both these cases, is to fix valves, which, like flood-gates, may open a way to the stream in one direction, and shut up the passage against it in another. The heart, constituted as it is, can no more work without valves, than a pump can. When the piston descends in a pump, if it were not for the stoppage by the valve beneath, the motion would only thrust down the water which it had before drawn up. A similar consequence would frustrate the action of the heart. Valves, therefore, properly disposed, *i. e.* properly with respect to the course of the blood which it is necessary to promote, are essential to the contrivance. *And valves so disposed, are accordingly provided.* A valve is placed in the communication between each auricle and its ventricle, lest when the ventricle contracts, part of the blood should get back again into the auricle, intead of the whole entering, as it ought to do, the mouth of the artery. A valve is also fixed at the mouth of each of the great arteries which take the blood from the heart; leaving the passage free, so long as the blood holds its proper course forward; closing it, whenever the blood, in consequence of the relaxation of the ventricle, would attempt to flow back. There is some variety in the construction of these valves, though all the valves of the body act nearly upon the same principle, and are destined to the same use. In general they consist of a thin membrane, lying close to the side of the vessel, and consequently allowing an open passage whilst the stream runs one way, but thrust out from the side by the fluid getting behind it, and opposing the passage of the blood, when it would flow the other way. Where more than one membrane is employed, the different membranes only compose one valve. Their joint action fulfils the office of a valve: for instance; over the entrance of the right auricle of the heart into the right ventricle, three of these skins or membranes are fixed, of a triangular figure, the bases of the triangles fastened to the flesh; the sides and summits loose; but, though loose, connected by threads of a determinate

length, with certain small fleshy prominences adjoining. The effect of this construction is, that, when the ventricle contracts, the blood endeavouring to escape in all directions, and amongst other directions, pressing upwards, gets *between* these membranes and the sides of the passage; and thereby forces them up into such a position, as that, together, they constitute, when raised, a hollow cone (the strings, before spoken of, hindering them from proceeding or separating further; which cone, entirely occupying the passage, prevents the return of the blood into the auricle. A shorter account of the matter may be this: So long as the blood proceeds in its proper course, the membranes which compose the valve, are pressed close to the side of the vessel, and occasion no impediment to the circulation: when the blood would regurgitate, they are raised from the side of the vessel, and, meeting in the middle of its cavity, shut up the channel. Can any one doubt of contrivance here; or is it possible to shut our eyes against the proof of it?

This valve, also, is not more curious in its structure, than it is important in its office. Upon the play of the valve, even upon the proportioned length of the strings or fibres which check the ascent of the membranes, depends, as it should seem, nothing less than the life itself of the animal. We may here likewise repeat, what we before observed concerning some of the ligaments of the body, that they could not be formed by any action of the parts themselves. There are cases in which, although good uses appear to arise from the shape or configuration of a part, yet that shape or configuration itself may seem to be produced by the action of the part, or by the action or pressure of adjoining parts. Thus the bend, and the internal smooth concavity of the ribs, may be attributed to the equal pressure of the soft bowels; the particular shape of some bones and joints, to the traction of the annexed muscles, or to the position of contiguous muscles. But valves could not be so formed. Action and pressure are all against them. The blood, in its proper course, has no tendency to produce such things; and, in its improper or reflected current, has a tendency to prevent their production. Whilst we see, therefore, the use and necessity of this machinery, we can look to no other account of its origin or formation than the intending mind of a Creator. Nor can we without admiration reflect, that such thin membranes, such weak and tender instruments, as these valves are, should be able to hold out for seventy or eighty years.

Here also we cannot consider but with gratitude, how happy it is that our vital motions are *involuntary*. We should have enough to do, if we had to keep our hearts beating, and our stomachs at work. Did these things depend, we will not say upon our effort, but upon our bidding, our care, or our attention, they would leave us leisure for nothing else. We must have been continually upon the watch, and continually in fear; nor would this constitution have allowed of sleep.

It might perhaps be expected, that an organ so precious, of such central and primary importance as the heart is, should be defended by *a case*. The fact is, that a membranous purse or bag, made of strong, tough materials, is provided for it; holding the heart within its cavity; sitting loosely ande asily about it; guarding its substance, without confining its motion; and containing likewise a spoonful or two of water, just sufficient to keep the surface of the heart in a state of suppleness and moisture. How should such a loose covering be generated by the action of the heart? Does not the enclosing of it in a sack, answering no other purpose but that enclosure, show the care that has been taken of its preservation?

One use of the circulation of the blood probably (amongst other uses) is to distribute nourishment to the different parts of the body. How minute and multiplied the ramifications of the blood-vessels, for that purpose, are; and how thickly spread, over at least the superficies of the body, is proved by the single observation, that we cannot prick the point of a pin into the flesh, without drawing blood, *i. e.* without finding a blood-vessel. Nor, internally, is their diffusion less universal. Blood-vessels run along the surface of membranes, pervade the substance of muscles, penetrate the bones. Even into every tooth, we trace, through a small hole in the root, an artery to feed the

bone, as well as a vein to bring back the spare blood from it; both which, with the addition of an accompanying nerve, form a thread only a little thicker than a horse-hair.

Wherefore, when the nourishment taken in at the mouth, has once reached, and mixed itself with, the blood, every part of the body is in the way of being supplied with it. And this introduces another grand topic, namely, the manner in which the aliment gets into the *blood;* which is a subject distinct from the preceding, and brings us to the consideration of another entire system of vessels.

II. For this necessary part of the animal œconomy, an apparatus is provided, in a great measure capable of being, what anatomists call, demonstrated, that is, shown in the dead body;--and a line or course of conveyance, which we can pursue by our examinations.

First, the food descends by a wide passage into the intestines, undergoing two great preparations on its way, one, in the mouth by mastication and moisture,--(can it be doubted with what design the teeth were placed in the road to the stomach, or that there was choice in fixing them in this situation?) the other, by digestion in the stomach itself. Of this last surprising dissolution I say nothing; because it is chymistry, and I am endeavouring to display mechanism. The figure and position of the stomach (I speak all along with a reference to the human organ) are calculated for detaining the food long enough for the action of its digestive juice. It has the shape of the pouch of a bagpipe; lies across the body; and the pylorus, or passage by which the food leaves it, is somewhat higher in the body than the cardia, or orifice by which it enters; so that it is by the contraction of the muscular coat of the stomach, that the contents, after having undergone the application of the gastric menstruum, are gradually pressed out. In dogs and cats, this action of the coats of the stomach has been displayed to the eye. It is a slow and gentle undulation, propagated from one orifice of the stomach to the other. For the same reason that I omitted, for the present, offering any observation upon the digestive fluid, I shall say nothing concerning the bile or the pancreatic juice, further than to observe upon the mechanism, viz. that from the glands in which these secretions are elaborated, pipes are laid into the first of the intestines, through which pipes the product of each gland flows into that bowel, and is there mixed with the aliment, as soon almost as it passes the stomach; adding also as a remark how grievously this same bile offends the stomach itself, yet cherishes the vessel that lies next to it.

Secondly, We have now the aliment in the intestines, converted into pulp; and, though lately consisting of ten different viands, reduced to nearly an uniform substance, and to a state fitted for yielding its essence, which is called chyle, but which is milk, or more nearly resembling milk than any other liquor with which it can be compared. For the straining off this fluid from the digested aliment in the course of its long progress through the body, myriads of capillary tubes, *i. e.* pipes as small as hairs, open their orifices into the cavity of every part of the intestines. These tubes, which are so fine and slender as not to be visible unless when distended with chyle, soon unite into larger branches. The pipes, formed by this union, terminate in glands, from which other pipes of a still larger diameter arising, carry the chyle from all parts, into a common reservoir or *receptacle*. This receptacle is a bag of size enough to hold about two table-spoons full; and from this vessel a duct or main pipe proceeds, climbing up the back part of the chest, and afterwards creeping along the gullet till it reach the neck. Here it meets the river: here it discharges itself into a large vein, which soon conveys the chyle, now flowing along with the old blood, to the heart. This whole route can be exhibited to the eye; nothing is left to be supplied by imagination or conjecture. Now, beside the subserviency of this structure, collectively considered, to a manifest and necessary purpose, we may remark two or three separate particulars in it, which show, not only the contrivance, but the perfection of it. We may remark, first, the length of the intestines, which, in the human subject, is six times that of the body. Simply for a passage, these voluminous bowels, this prolixity of gut, seems in no wise necessary; but, in order to allow time and space for the

successive extraction of the chyle from the digested aliment, namely, that the chyle, which escapes the lacteals of one part of the guts, may be taken up by those of some other part, the length of the canal is of evident use and conduciveness. Secondly, we must also remark their peristaltic motion; which is made up of contractions, following one another like waves upon the surface of a fluid, and not unlike what we observe in the body of an earth-worm crawling along the ground; and which is effected by the joint action of longitudinal and of spiral, or rather perhaps of a great number of separate semicircular fibres. This curious action pushes forward the grosser part of the aliment, at the same time that the more subtile parts, which we call chyle, are, by a series of gentle compressions, squeezed into the narrow orifices of the lacteal veins. Thirdly, it was necessary that these tubes, which we denominate lacteals, or their mouths at least, should be made as narrow as possible, in order to deny admission into the blood to any particle, which is of size enough to make a lodgement afterwards in the small arteries, and thereby to obstruct the circulation: And it was also necessary that this extreme tenuity should be compensated by multitude; for, a large quantity of chyle (in ordinary constitutions, not less, it has been computed, than two or three quarts in a day) is, by some means or other, to be passed through them. Accordingly, we find the number of the lacteals exceeding all powers of computation; and their pipes so fine and slender, as not to be visible, unless filled, to the naked eye; and their orifices, which open into the intestines, so small, as not to be discernible even by the best microscope. Fourthly, the main pipe which carries the chyle from the reservoir to the blood, viz. the thoracic duct, being fixed in an almost upright position, and wanting that advantage of propulsion which the arteries possess, is furnished with a succession of valves to check the ascendmg fluid, when once it has passed them, from falling back. These valves look upward, so as to leave the ascent free, but to prevent the return of the chyle, if, for want of sufficient force to push it on, its weight should at any time cause it to descend. Fifthly, the chyle enters the blood in an odd place, but perhaps the most commodious place possible. viz. at a large vein in the neck, so situated with respect to the circulation, as speedily to bring the mixture to the heart. And this seems to be a circumstance of great moment; for had the chyle entered the blood at an artery, or at a distant vein, the fluid, composed of the old and the new materials, must have performed a considerable part of the circulation, before it received that churning in the lungs, which is, probably, necessary for the intimate and perfect union of the old blood with the recent chyle. Who could have dreamt of a communication between the cavity of the intestines and the left great vein of the *neck?* Who could have suspected that this communication should be the medium through which all nourishment is derived to the body? or this the place, where, by a side-inlet, the important junction is formed between the blood and the material which feeds it?

We postponed the consideration of *digestion*, lest it should interrupt us in tracing the course of the food to the blood; but, in treating of the alimentary system, so principal a part of the process cannot be omitted.

Of the gastric juice, the immediate agent by which that change which food undergoes in our stomachs is effected, we shall take our account from the numerous, careful, and varied experiments of the Abbé Spallanzani.

1. It is not a simple diluent, but a real solvent. A quarter of an ounce of beef had scarcely touched the stomach of a crow, when the solution began.

2. It has not the nature of saliva; it has not the nature of bile; but is distinct from both. By experiments out of the body it appears, that neither of these secretions acts upon alimentary substances, in the same manner as the gastric juice acts.

3. Digestion is not *putrefaction:* for, the digesting fluid resists putrefaction most pertinaciously; nay, not only checks its further progress, but restores putrid substances.

4. It is not a *fermentative* process: for, the solution begins at the surface, and proceeds towards the centre, contrary to the order in which fermentation acts and spreads.

5. It is not the *digestion of heat:* for, the cold maw of a cod or sturgeon will dissolve the shells of crabs or lobsters, harder than the sides of the stomach which contains them.

In a word, animal digestion carries about it the marks of being a power and a process completely *sui generis;* distinct from every other; at least from every chymical process with which we are acquainted. And the most wonderful thing about it is its appropriation; its subserviency to the particular œconomy of each animal. The gastric juice of an owl, falcon, or kite, will not touch grain; no, not even to finish the macerated and half-digested pulse which is left in the crops of the sparrows that the bird devours. In poultry, the trituration of the gizzard, and the gastric juice, conspire in the work of digestion. The gastric juice will not dissolve the grain whilst it is whole. Entire grains of barley, inclosed in tubes or spherules, are not affected by it. But if the same grain be by any means broken or ground, the gastric juice immediately lays hold of it. Here then is wanted, and here we find, a combination of mechanism and chymistry. For the preparatory grinding, the gizzard lends its mill. And, as all mill-work should be strong, its structure is so, beyond that of any other muscle belonging to the animal. The internal coat also, or lining of the gizzard, is, for the same purpose, hard and cartilaginous. But, forasmuch as this is not the sort of animal substance suited for the reception of glands, or for secretion, the gastric juice, in this family, is not supplied as in membranous stomachs, by the stomach itself, but by the gullet, in which the feeding glands are placed, and from which it trickles down into the stomach.

In sheep, the gastric fluid has no effect in digesting plants, *unless they have been previously masticated*. It only produces a slight maceration; nearly such as common water would produce, in a degree of heat somewhat exceeding the medium temperature of the atmosphere. But provided that the plant has been reduced to pieces by chewing, the gastric juice then proceeds with it, first by softening its substance; next by destroying its natural consistency, and, lastly, by dissolving it so completely, as not even to spare the toughest and most stringy parts, such as the nerves of the leaves.

So far our accurate and indefatigable Abbé.--Dr. Stevens, of Edinburgh, in 1777, found, by experiments tried with perforated balls, that the gastric juice of the sheep and the ox speedily dissolved vegetables, but made no impression upon beef, mutton, and other animal bodies. Dr. Hunter discovered a property of this fluid, of a most curious kind; viz. that, in the stomachs of animals which feed upon flesh, irresistibly as this fluid acts upon animal substances, it is only upon the *dead* substance, that it operates at all. The *living* fibre suffers no injury from lying in contact with it. Worms and insects are found alive in the stomachs of such animals. The coats of the human stomach, in a healthy state, are insensible to its presence: yet, in cases of sudden death (wherein the gastric juice, not having been weakened by disease, retains its activity), it has been known to eat a hole through the bowel which contains it(*Note:* Phil. Trans, vol. lxii. p. 447.). How nice is this discrimination of action, yet how necessary!

But to return to our hydraulics.

III. The gall-bladder is a very remarkable contrivance. It is the reservoir of a canal. It does not form the channel itself, *i. e.* the direct communication between the liver and the intestine, which is by another passage, viz. the ductus hepaticus, continued under the name of the ductus communis; but it lies adjacent to this channel, joining it by a duct of its own, the ductus cysticus; by which structure it is enabled, as occasions may require, to add its contents to, and increase, the flow of bile into the duodenum. And the position of the gall-bladder is such as to apply this structure to the

best advantage. In its natural situation, it touches the exterior surface of the stomach, and consequently is compressed by the distension of that vessel: the effect of which compression is, to force out from the bag, and send into the duodenum, an extraordinary quantity of bile, to meet the extraordinary demand which the repletion of the stomach by food is about to occasion(*Note:* Keill's Anat. p. 64.). Cheselden describes(*Note:* Anat. p. 164.) the gall-bladder as seated against the duodenum, and thereby liable to have its fluid pressed out, by the passage of the aliment through that cavity: which likewise will have the effect of causing it to be received into the intestine, at a right time, and in a due proportion.

There may be other purposes answered by this contrivance; and it is probable that there are. The contents of the gall-bladder are not exactly of the same kind as what passes from the liver through the direct passage(*Note:* Keill (from Malpighius), p. 63.). It is possible that the gall may be changed, and for some purposes meliorated, by keeping.

The entrance of the gall-duct into the duodenum, furnishes another observation. Whenever, either smaller tubes are inserted into larger tubes, or tubes into vessels and cavities, such receiving-tubes, vessels, or cavities, being subject to muscular constriction, we always find a contrivance to prevent *regurgitation*. In some cases, valves are used; in other cases, amongst which is that now before us, a different expedient is resorted to; which may be thus described: The gall-duct enters the duodenum obliquely: after it has pierced the first coat, it runs near two fingers' breadth *between* the coats, before it open into the cavity of the intestine(*Note:* Keill's Anat. p. 62.). The same contrivance is used in another part, where there is exactly the same occasion for it, viz. in the insertion of the ureters in the bladder. These enter the bladder near its neck, running obliquely for the space of an inch between its coats.(*Note:* Ches. Anat. p. 260.) It is, in both cases, sufficiently evident, that this structure has a necessary mechanical tendency to resist regurgitation; for, whatever force acts in such a direction as to urge the fluid back into the orifices of the tubes, must, at the same time, stretch the coats of the vessels, and thereby compress that part of the tube, which is included between them.

IV. Amongst the *vessels* of the human body, the pipe which conveys the saliva from the place where it is made, to the place where it is wanted, deserves to be reckoned amongst the most intelligible pieces of mechanism with which we are acquainted. The saliva, we all know, is used in the mouth: but much of it is produced on the outside of the cheek, by the parotid gland, which lies between the ear and the angle of the lower jaw. In order to carry the secreted juice to its destination, there is laid from the gland on the outside, a pipe, about the thickness of a wheat straw, and about three fingers' breadth in length; which after riding over the masseter muscle, bores for itself a hole through the very middle of the cheek; enters by that hole, which is a complete perforation of the buccinator muscle, into the mouth; and there discharges its fluid very copiously.

V. Another exquisite structure, differing indeed from the four preceding instances in that it does not relate to the conveyance of fluids, but still belonging, like these, to the class of pipes or conduits of the body, is seen in the *larynx*. We all know that there go down the throat two pipes, one leading to the stomach, the other to the lungs; the one being the passage for the food, the other for the breath and voice: we know also that both these passages open into the bottom of the mouth; the gullet, necessarily, for the conveyance of food; and the wind-pipe, for speech and the modulation of sound, not much less so: therefore the difficulty was, the passages being so contiguous, to prevent the food, especially the liquids which we swallow into the stomach, from entering the wind-pipe, *i. e.* the road to the lungs; the consequence of which error, when it does happen, is perceived by the convulsive throes that are instantly produced. This business, which is very nice, is managed in this manner. The gullet (the passage for food) opens into the mouth like the cone or upper part of a funnel, the capacity of which forms indeed the bottom of the mouth. Into the side of this funnel, at the part which lies the lowest, enters the wind-pipe, by a chink or

slit, with a lid or flap, like a little tongue accurately fitted to the orifice. The solids or liquids which we swallow, pass over this lid or flap, as they descend by the funnel into the gullet. Both the weight of the food, and the action of the muscles concerned in swallowing, contribute to keep the lid close down upon the aperture, whilst any thing is passing; whereas, by means of its natural cartilaginous spring, it raises itself a little, as soon as the food is passed, thereby allowing a free inlet and outlet for the respiration of air by the lungs. Such is its structure: And we may here remark the almost complete success of the expedient, viz. how seldom it fails of its purpose, compared with the number of instances in which it fulfils it. Reflect how frequently we swallow, how constantly we breathe. In a city-feast, for example, what deglutition, what anhelation! yet does this little cartilage, the epiglottis, so effectually interpose its office, so securely guard the entrance of the wind-pipe, that whilst morsel after morsel, draught after draught, are coursing one another over it, an accident of a crumb or a drop slipping into this passage (which nevertheless must be opened for the breath every second of time), excites in the whole company, not only alarm by its danger, but surprise by its novelty. Not two guests are choked in a century.

There is no room for pretending that the action of the parts may have gradually formed the epiglottis: I do not mean in the same individual, but in a succession of generations. Not only the action of the parts has no such tendency, but the animal could not live, nor consequently the parts act, either without it, or with it in a half-formed state. The species was not to wait for the gradual formation or expansion of a part which was, from the first, necessary to the life of the individual.

Not only is the larynx curious, but the whole wind-pipe possesses a structure adapted to its peculiar office. It is made up (as any one may perceive by putting his fingers to his throat) of stout cartilaginous ringlets, placed at small and equal distances from one another. Now this is not the case with any other of the numerous conduits of the body. The use of these cartilages is to keep the passage for the air *constantly* open; which they do mechanically. A pipe with soft membranous coats, liable to collapse and close when empty, would not have answered here; although this be the general vascular structure, and a structure which serves very well for those tubes which are kept in a state of perpetual distention by the fluid they enclose, or which afford a passage to solid and protruding substances.

Nevertheless (which is another particularity well worthy of notice), these rings are not complete, that is, are not cartilaginous and stiff all round; but their hinder part, which is contiguous to the gullet, is membranous and soft, easily yielding to the distentions of that organ occasioned by the descent of solid food. The same rings are also bevelled off at the upper and lower edges, the better to close upon one another, when the trachea is compressed or shortened. The constitution of the trachea may sug gest likewise another reflection. The membrane which lines its inside, is, perhaps, the most sensible, irritable membrane of the body. It rejects the touch of a crumb of bread, or a drop of water, with a spasm which convulses the whole frame; yet, left to itself, and its proper office, the intromission of air alone, nothing can be so quiet. It does not even make itself felt; a man does not know that he has a trachea. This capacity of perceiving with such acuteness, this impatience of offence, yet perfect rest and ease when let alone, are properties, one would have thought, not likely to reside in the same subject. It is to the junction, however, of these almost inconsistent qualities, in this, as well as in some other delicate parts of the body, that we owe our safety and our comfort;--our safety to their sensibility, our comfort to their repose.

The larynx, or rather the whole wind-pipe taken together (for the larynx is only the upper part of the wind-pipe), besides its other uses, is also a musical instrument, that is to say, it is *mechanism* expressly adapted to the modulation of sound; for it has been found upon trial that, by relaxing or tightening the tendinous bands at the extremity of the wind-pipe, and blowing in at the other end, all the cries and notes might be produced of which the living animal was capable. It can be sounded, just as a pipe or flute is sounded.

Birds, says Bonnet, have, at the lower end of the wind-pipe, a conformation like the reed of a hautboy, for the modulation of their notes. A tuneful bird is a ventriloquist. The seat of the song is in the breast.

The use of the lungs *in* the system has been said to be obscure: one use however is plain, though, in some sense, external to the system, and that is, the formation, in conjunction with the larynx, of voice and speech. They are, to animal utterance, what the bellows are to the organ.

For the sake of method, we have considered animal bodies under three divisions; their bones, their muscles, and their vessels: and we have stated our observations upon these parts separately. But this is to diminish the strength of the argument. The wisdom of the Creator is seen, not in their separate but their collective action; in their mutual subserviency and dependence; in their contributing *together* to one effect, and one use. It has been said, that a man cannot lift his hand to his head, without finding enough to convince him of the existence of a God. And it is well said; for he has only to reflect, familiar as this action is, and simple as it seems to be, how many things are requisite for the performing of it: how many things which we understand, to say nothing of many more, probably, which we do not; viz. first, a long, hard, strong cylinder, in order to give to the arm its firmness and tension; but which, being rigid, and, in its substance, inflexible, can only turn upon joints: secondly, therefore, joints for this purpose, one at the shoulder to raise the arm, another at the elbow to bend it: these joints continually fed with a soft mucilage to make the parts slip easily upon one another, and holden together by strong braces, to keep them in their position: then, thirdly, strings and wires, *i. e.*muscles and tendons, artificially inserted for the purpose of drawing the bones in the directions in which the joints allow them to move. Hitherto we seem to understand the mechanism pretty well; and, understanding this, we possess enough for our conclusion: Nevertheless, we have hitherto only a machine standing still; a dead organization,--an apparatus. To put the system in a state of activity; to set it at work; a further provision is necessary, viz. a communication with the brain by means of nerves. We know the existence of this communication, because we can see the communicating threads, and can trace them to the brain; its necessity we also know, because if the thread be cut, if the communication be intercepted, the muscle becomes paralytic: but beyond this, we know little; the organization being too minute and subtile for our inspection.

To what has been enumerated, as officiating in the single act of a man's raising his hand to his head, must be added likewise, all that is necessary, and all that contributes to the growth, nourishment, and sustentation of the limb, the repair of its waste, the preservation of its health: such as the circulation of the blood through every part of it; its lymphatics, exhalants, absorbents; its excretions and integuments. All these share in the result; join in the effect: and how all these, or any of them, come together without a designing, disposing intelligence, it is impossible to conceive.

CHAPTER XI.

OF THE ANIMAL STRUCTURE REGARDED AS A MASS. CONTEMPLATING *an animal body* in its collective capacity, we cannot forget to notice, what a number of instruments are brought together, and often within how small a compass. It is a cluster of contrivances. In a canary bird, for instance, and in the single ounce of matter which composes his body (but which seems to be all employed), we have instruments for eating, for digesting, for nourishment, for breathing, for generation, for running, for flying, for seeing, for hearing, for smelling; each appropriate,--each entirely different from all the rest.

The human, or indeed the animal frame, considered as a mass or assemblage, exhibits in its composition three properties, which have long struck my mind as indubitable evidences not only of design, but of a great deal of attention and accuracy in prosecuting the design.

1. The first is, the exact correspondency of the two sides of the same animal; the right hand answering to the left, leg to leg, eye to eye, one side of the countenance to the other; and with a precision, to imitate which in any tolerable degree forms one of the difficulties of statuary, and requires, on the part of the artist, a constant attention to this property of his work, distinct from every other.

It is the most difficult thing that can be to get a wig made even; yet how seldom is the *face* awry! And what care is taken that it should not be so, the anatomy of its bones demonstrates. The upper part of the face is composed of thirteen bones, six on each side, answering each to each, and the thirteenth, without a fellow, in the middle; the lower part of the face is in like manner composed of six bones, three on each side respectively corresponding, and the lower jaw in the centre. In building an arch, could more be done in order to make the curve *true*, i. e. the parts equi-distant from the middle, alike in figure and position?

The exact resemblance of the *eyes*, considering how compounded this organ is in its structure, how various and how delicate are the shades of colour with which its iris is tinged, how differently, as to effect upon appearance, the eye may be mounted in its socket, and how differently in different heads eyes actually are set, is a property of animal bodies much to be admired. Of ten thousand eyes, I do not know that it would be possible to match one, except with its own fellow; or to distribute them into suitable pairs by any other selection than that which obtains.

This regularity of the animal struct re is rendered more remarkable by the three following considerations.--First, the limbs, *separately*taken, have not this correlation of parts, but the contrary of it. A knife drawn down the chine, cuts the human body into two parts, externally equal and alike; you cannot draw a straight line which will divide a hand, a foot, the leg, the thigh, the cheek, the eye, the ear, into two parts equal and alike. Those parts which are placed upon the middle or partition line of the body, or which traverse that line, as the nose, the tongue, the lips, may be so divided, or, more properly speaking, are double organs; but other parts cannot. This shows that the correspondency which we have been describing, does not arise by any necessity in the nature of the subject: for, if necessary, it would be universal; whereas it is observed only in the system or assemblage: it is not true of the separate parts; that is to say, it is found where it conduces to beauty or utility; it is not found, where it would subsist at the expense of both. The two wings of a bird always correspond: the two sides of a feather frequently do not. In centipedes, millepedes, and that whole tribe of insects, no two legs on the same side are alike: yet there is the most exact parity between the legs opposite to one another.

2. The next circumstance to be remarked, is, that, whilst the cavities of the body are so configurated, as *externally* to exhibit the most exact correspondency of the opposite sides, the contents of these cavities have no such correspondency. A line drawn down the middle of the breast, divides the thorax into two sides exactly similar; yet these two sides enclose very different contents. The heart lies on the left side; a lobe of the lungs on the right; balancing each other, neither in size nor shape. The same thing holds of the abdomen. The liver lies on the right side, without any similar viscus opposed to it on the left. The spleen indeed is situated over against the liver; but agreeing with the liver neither in bulk nor form. There is no equipollency between these. The stomach is a vessel, both irregular in its shape, and oblique in its position. The foldings and doublings of the intestines do not present a parity of sides. Yet that symmetry which depends upon the correlation of the sides, is externally preserved throughout the whole trunk; and is the more remarkable in the lower parts of it, as the integuments are soft; and the shape, consequently, is

not, as the thorax is by its ribs, reduced by natural stays. It is evident, therefore, that the external proportion does not arise from any equality in the shape or pressure of the internal contents. What is it indeed but a correction of inequalities? an adjustment, by mutual compensation of anomalous forms into a regular congeries? the effect, in a word, of artful, and, if we might be permitted so to speak, of studied collocation?

3. Similar also to this, is the third observation; that an internal inequality in the feeding vessels is so managed, as to produce no inequality in parts which were intended to correspond. The right arm answers accurately to the left, both in size and shape; but the arterial branches, which supply the two arms, do not go off from their trunk, in a pair, in the same manner, at the same place, or at the same angle. Under which want of similitude, it is very difficult to conceive how the same quantity of blood should be pushed through each artery: yet the result is right; the two limbs, which are nourished by them, perceive no difference of supply, no effects of excess or deficiency.

Concerning the difference of manner, in which the subclavian and carotid arteries, upon the different sides of the body, separate themselves from the aörta, Cheselden seems to have thought, that the advantage which the left gain by going off at an angle much more acute than the right, is made up to the right by their going off together in one branch(*Note:* Ches. Anat. p. 184. ed. 7.). It is very possible that this may be the compensating contrivance: and if it be so, how curious, how hydrostatical!

II. Another perfection of the animal mass is the *package*. I know nothing which is so surprising. Examine the contents of the trunk of any large animal. Take notice how soft, how tender, how intricate they are; how constantly in action, how necessary to life! Reflect upon the danger of any injury to their substance, any derangement of their position, any obstruction to their office. Observe the heart pumping at the centre, at the rate of eighty strokes in a minute: one set of pipes carrying the stream away from it, another set, bringing, in its course, the fluid back to it again; the lungs performing their elaborate office, viz. distending and contracting their many thousand vesicles, by a reciprocation which cannot cease for a minute; the stomach exercising its powerful chymistry; the bowels silently propelling the changed aliment; collecting from it, as it proceeds, and transmitting to the blood an incessant supply of prepared and assimilated nourishment; that blood pursuing its course; the liver, the kidneys, the pancreas, the parotid, with many other known and distinguishable glands, drawing off from it, all the while, their proper secretions. These several operations, together with others more subtile but less capable of being investigated, are going on within us, at one and the same time. Think of this; and then observe how the body itself, the case which holds this machinery, is rolled, and jolted, and tossed about, the mechanism remaining unhurt, and with very little molestation even of its nicest motions. Observe a rope-dancer, a tumbler, or a monkey; the sudden inversions and contortions which the internal parts sustain by the postures into which their bodies are thrown; or rather observe the shocks, which these parts, even in ordinary subjects, sometimes receive from falls and bruises, or by abrupt jerks and twists, without sensible, or with soon-recovered damage. Observe this, and then reflect how firmly every part must be secured, how carefully surrounded, how well tied down and packed together.

This property of animal bodies has never, I think, been considered under a distinct head, or so fully as it deserves. I may be allowed therefore, in order to verify my observation concerning it, to set forth a short anatomical detail, though it oblige me to use more technical language than I should wish to introduce into a work of this kind.

I. The *heart* (such care is taken of the centre of life) is placed between two soft lobes of the lungs; is *tied* to the mediastinum and to the pericardium; which pericardium is not only itself an exceedingly strong membrane, but *adheres* firmly to the duplicature of the mediastinum, and, by

its point, to the middle tendon of the diaphragm. The heart is also *sustained* in its place by the great blood-vessels which issue from it(*Note:* Keill's Anat. p. 107. ed. 3.).

2. The *lungs* are *tied* to the sternum by the mediastinum, before; to the vertebræ by the pleura, behind. It seems indeed to be the very use of the mediastinum (which is a membrane that goes straight through the middle of the thorax, from the breast to the back) to keep the contents of the thorax in their places; in particular to hinder one lobe of the lungs from incommoding another, or the parts of the lungs from pressing upon each other when we lie on one side(*Note:* Keill's Anat. p. 119, ed. 3.).

3. The *liver* is fastened in the body by two ligaments; the first, which is large and strong, comes from the covering of the diaphragm, and penetrates the substance of the liver; the second is the umbilical vein, which, after birth, degenerates into a ligament. The first, which is the principal, fixes the liver in its situation, whilst the body holds an erect posture; the second prevents it from pressing upon the diaphragm when we lie down: and both together *sling* or suspend the liver when we lie upon our backs, so that it may not compress or obstruct the ascending vena cava(*Note:* Ches. Anat. p. 162.), to which belongs the important office of returning the blood from the body to the heart.

4. The *bladder* is tied to the navel by the urachus, transformed into a ligament: thus, what was a passage for urine to the fœtus, becomes, after birth, a support or stay to the bladder. The peritonæum also keeps the viscera from confounding themselves with, or pressing irregularly upon, the bladder: for the kidneys and bladder are contained in a distinct duplicature of that membrane, being thereby partitioned off from the other contents of the abdomen.

5. The *kidneys* are lodged in a bed of fat.

6. The *pancreas*, or sweetbread, is strongly tied to the peritonæum, which is the great wrapping sheet, that encloses all the bowels contained in the lower belly(*Note:* Keill's Anat. p. 57.).

7. The *spleen* also is confined to its place by an adhesion to the peritonæum and diaphragm, and by a connexion with the omentum(*Note:* Ches. Anat. p. 167.). It is possible, in my opinion, that the spleen may be merely a *stuffing*, a soft cushion to fill up a vacancy or hollow, which, unless occupied, would leave the package loose and unsteady: for, supposing that it answers no other purpose than this, it must be vascular, and admit of a circulation through it, in order to be kept alive, or be a part of a living body.

8. The *omentum*, epiplöon, or cawl, is an apron tucked up, or doubling upon itself, at its lowest part. The upper edge is tied to the bottom of the stomach, to the spleen, as hath already been observed, and to part of the duodenum. The reflected edge also, after forming the doubling, comes up behind the front flap, and is tied to the colon and adjoining viscera(*Note:* Ches. Anat. p. 167.).

9. The septa of the brain probably prevent one part of that organ from pressing with too great a weight upon another part. The processes of the dura mater divide the cavity of the skull, like so many inner partition walls, and thereby confine each hemisphere and lobe of the brain to the chamber which is assigned to it, without its being liable to rest upon, or intermix with, the neighbouring parts. The great art and caution of packing, is to prevent one thing hurting another. This, in the head, the chest, and the abdomen, of an animal body, is, amongst other methods, provided for by membranous partitions and wrappings, which keep the parts separate.

The above may serve as a short account of the manner, in which the principal viscera are sustained in their places. But of the provisions for this purpose, by far, in my opinion, the most curious, and

where also such a provision was most wanted, is in the *guts*. It is pretty evident, that a long narrow tube (in man, about five times the length of the body) laid from side to side in folds upon one another, winding in oblique and circuitous directions, composed also of a soft and yielding substance, must, without some extraordinary precaution for its safety, be continually displaced by the various, sudden, and abrupt motions of the body which contains it. I should expect that, if not bruised or wounded by every fall, or leap, or twist, it would be entangled, or be involved with itself; or, at the least, slipped and shaken out of the order in which it is disposed, and which order is necessary to be preserved for the carrying on of the important functions which it has to execute in the animal œconomy. Let us see, therefore, how a danger so serious, and yet so natural to the length, narrowness, and tubular form of the part, is provided against. The expedient is admirable: and it is this. The intestinal canal, throughout its whole process, is knit to the edge of a broad fat membrane called the mesentery. It forms the margin of this mesentery, being stitched and fastened to it like the edging of a ruffle: being four times as long as the mesentery itself, it is what a sempstress would call, "puckered or gathered on" to it. This is the nature of the connexion of the gut with the mesentery; and being thus joined to, or rather made a part of the mesentery, it is folded and wrapped up together with it. Now the mesentery, having a considerable dimension in breadth, being in its substance, withal, both thick and suety, is capable of a close and safe folding, in comparison of what the intestinal tube would admit of, if it had remained loose. The mesentery likewise not only keeps the intestinal canal in its proper place and position under all the turns and windings of its course, but sustains the numberless small vessels, the arteries, the veins, the lympheducts, and, above all, the lacteals, which lead from or to almost every point of its coats and cavity. This membrane, which appears to be the great support and security of the alimentary apparatus, is itself strongly tied to the first three vertebræ of the loins(*Note:* Keill's Anat. p. 45.).

III. A third general property of animal forms is *beauty*. I do not mean relative beauty, or that of one individual above another of the same species, or of one species compared with another species; but I mean, generally, the provision which is made in the body of almost every animal, to adapt its appearance to the perception of the animals with which it converses. In our own species, for example, only consider what the parts and materials are, of which the fairest body is composed; and no further observation will be necessary to show, how well these things are wrapped up, so as to form a mass, which shall be capable of symmetry in its proportion, and of beauty in its aspect: how the bones are covered, the bowels concealed, the roughnesses of the muscle smoothed and softened; and how over the whole is drawn an integument, which converts the disgusting materials of a dissecting-room into an object of attraction to the sight, or one upon which it rests, at least, with ease and satisfaction. Much of this effect is to be attributed to the intervention of the cellular or adipose membrane, which lies immediately under the skin; is a kind of lining to it; is moist, soft, slippery, and compressible; every-where filling up the interstices of the muscles, and forming thereby their roundness and flowing line, as well as the evenness and polish of the whole surface.

All which seems to be a strong indication of design, and of a design studiously directed to this purpose. And it being once allowed, that such a purpose existed with respect to *any* of the productions of nature, we may refer, with a considerable degree of probability, other particulars to the same intention; such as the teints of flowers, the plumage of birds, the furs of beasts, the bright scales of fishes, the painted wings of butterflies and beetles, the rich colours and spotted lustre of many tribes of insects.

There are parts also of animals ornamental, and the properties by which they are so, not subservient, that we know of, to any other purpose. The *irides* of most animals are very beautiful, without conducing at all, by their beauty, to the perfection of vision; and nature could in no part have employed her pencil to so much advantage, because no part presents itself so conspicuously to the observer, or communicates so great an effect to the whole aspect.

In plants, especially in the flowers of plants, the principle of beauty holds a still more considerable place in their composition; is still more confessed than in animals. Why, for one instance out of a thousand, does the corolla of the tulip, when advanced to its size and maturity, change its colour? The purposes, so far as we can see, of vegetable nutrition, might have been carried on as well by its continuing green. Or, if this could not be, consistently with the progress of vegetable life, why break into such a variety of colours? This is no proper effect of age, or of declension in the ascent of the sap; for that, like the autumnal teints, would have produced one colour on one leaf, with marks of fading and withering. It seems a lame account to call it, as it has been called, a disease of the plant. Is it not more probable, that this property, which is independent, as it should seem, of the wants and utilities of the plant, was calculated for beauty, intended for display?

A ground, I know, of objection, has been taken against the whole topic of argument, namely, that there is no such thing as beauty at all; in other words, that whatever is useful and familiar, comes of course to be thought beautiful; and that things appear to be so, only by their alliance with these qualities. Our idea of beauty is capable of being in so great a degree modified by habit, by fashion, by the experience of advantage or pleasure, and by associations arising out of that experience, that a question has been made, whether it be not altogether generated by these causes, or would have any proper existence without them. It seems, however, a carrying of the conclusion too far, to deny the existence of the principle, viz. a native capacity of perceiving beauty, on account of an influence, or of varieties proceeding from that influence, to which it is subject, seeing that principles the most acknowledged, are liable to be affected in the same manner. I should rather argue thus. The question respects objects of sight. Now every other sense hath its distinction of agreeable and disagreeable. Some tastes offend the palate, others gratify it. In brutes and insects, this distinction is stronger and more regular than in man. Every horse, ox, sheep, swine, when at liberty to choose, and when in a natural state, that is, when not vitiated by habits forced upon it, eats and rejects the same plants. Many insects which feed upon particular plants, will rather die than change their appropriate leaf. All this looks like a determination in the sense itself to particular tastes. In like manner, smells affect the nose with sensations pleasurable or disgusting. Some sounds, or compositions of sound, delight the ear; others torture it. Habit can do much in all these cases (and it is well for us that it can; for it is this power which reconciles us to many necessities): but has the distinction, in the mean time, of agreeable and disagreeable, no foundation in the sense itself? What is true of the other senses, is most probably true of the eye (the analogy is irresistible), viz. that there belongs to it an original constitution, fitted to receive pleasure from some impressions, and pain from others. I do not however know, that the argument which alleges beauty as a final cause, rests upon this concession. We possess a sense of beauty, however we come by it. It in fact exists. Things are not indifferent to this sense; all objects do not suit it; many, which we see, are agreeable to it; many others disagreeable. It is certainly not the effect of habit upon the particular object, because the most agreeable objects are often the most rare; many, which are very common, continue to be offensive. If they be made supportable by habit, it is all which habit can do; they never become agreeable. If this sense, therefore, be acquired, it is a result; the produce of numerous and complicated actions of external objects upon the senses, and of the mind upon its sensations. With this *result*, there must be a certain congruity to enable any particular object to please: and that congruity, we contend, is consulted in the *aspect* which is given to animal and vegetable bodies.

IV. The skin and covering of animals is that upon which their appearance chiefly depends, and it is that part which, perhaps, in all animals is most decorated, and most free from impurities. But were beauty, or agreeableness of aspect, entirely out of the question, there is another purpose answered by this integument, and by the collocation of the parts of the body beneath it, which is of still greater importance; and that purpose is *concealment*. Were it possible to view through the skin the mechanism of our bodies, the sight would frighten us out of our wits. "Durst we make a single movement,"asks a lively French writer, "or stir a step from the place we were in, if we *saw* our

blood circulating, the tendons pulling, the lungs blowing, the humours filtrating, and all the incomprehensible assemblage of fibres, tubes, pumps, valves, currents, pivots, which sustain an existence at once so frail, and so presumptuous?"

V. Of animal bodies, considered as masses, there is another property, more curious than it is generally thought to be; which is the faculty of *standing:* and it is more remarkable in two-legged animals than in quadrupeds, and, most of all, as being the tallest, and resting upon the smallest base, in man. There is more, I think, in the matter than we are aware of. The statue of a man, placed loosely upon its pedestal, would not be secure of standing half an hour. You are obliged to fix its feet to the block by bolts and solder; or the first shake, the first gust of wind, is sure to throw it down. Yet this statue shall express all the mechanical proportions of a living model. It is not therefore the mere figure, or merely placing the centre of gravity within the base, that is sufficient. Either the law of gravitation is suspended in favour of living substances, or something more is done for them, in order to enable them to uphold their posture. There is no reason whatever to doubt, but that their parts descend by gravitation in the same manner as those of dead matter. The gift therefore appears to me to consist in a faculty of perpetually shifting the centre of gravity, by a set of obscure, indeed, but of quick-balancing actions, so as to keep the line of direction, which is a line drawn from that centre to the ground, within its prescribed limits. Of these actions it may be observed, first, that they in part constitute what we call strength. The dead body drops down. The mere adjustment therefore of weight and pressure, which may be the same the moment after death as the moment before, does not support the column. In cases also of extreme weakness, the patient cannot stand upright. Secondly, that these actions are only in a small degree voluntary. A man is seldom conscious of his voluntary powers in keeping himself upon his legs. A child learning to walk is the greatest posture-master in the world: but art, if it may be so called, sinks into habit: and he is soon able to poise himself in a great variety of attitudes, without being sensible either of caution or effort. But still there must be an aptitude of parts, upon which habit can thus attach; a previous capacity of motions which the animal is thus taught to exercise: and the facility, with which this exercise is acquired, forms one object of our admiration. What parts are principally employed, or in what manner each contributes its office, is, as hath already been confessed, difficult to explain. Perhaps the obscure motion of the bones of the feet may have their share in this effect. They are put in action by every slip or vacillation of the body, and seem to assist in restoring its balance. Certain it is, that this circumstance in the structure of the foot, viz. its being composed of many small bones, applied to, and articulating with one another, by diversely shaped surfaces, instead of being made of one piece, like the last of a shoe, is very remarkable. I suppose also that it would be difficult to stand firmly upon stilts or wooden legs, though their base exactly imitated the figure and dimensions of the sole of the foot. The alternation of the joints, the knee-joint bending backward, the hip-joint forward; the flexibility, in every direction, of the spine, especially in the loins and neck, appear to be of great moment in preserving the equilibrium of the body. With respect to this last circumstance, it is observable, that the vertebræ are so confined by ligaments as to allow no more slipping upon their bases, than what is just sufficient to break the shock which any violent motion may occasion to the body. A certain degree also of tension of the sinews appears to be essential to an erect posture; for it is by the loss of this, that the dead or paralytic body drops down. The whole is a wonderful result of combined powers, and of very complicated operations. Indeed, that *standing* is not so simple a business as we imagine it to be, is evident from the strange gesticulations of a drunken man, who has lost the government of the centre of gravity.

We have said that this property is the most worthy of observation in the *human*body: but a *bird*, resting upon its perch, or hopping upon a spray, affords no mean specimen of the same faculty. A chicken runs off as soon as it is hatched from the egg; yet a chicken, considered geometrically, and with relation to its centre of gravity, its line of direction, and its equilibrium, is a very irregular

solid. Is this gift, therefore, or instruction? May it not be said to be with great attention, that nature hath balanced the body upon its pivots?

I observe also in the same *bird* a piece of useful mechanism of this kind. In the trussing of a fowl, upon bending the legs and thighs up towards the body, the cook finds that the claws close of their own accord. Now let it be remembered, that this is the position of the limbs, in which the bird rests upon its perch. And in this position it sleeps in safety; for the claws do their office in keeping hold of the support, not by any exertion of voluntary power, which sleep might suspend, but by the traction of the tendons in consequence of the attitude which the legs and thighs take by the bird sitting down, and to which the mere weight of the body gives the force that is necessary.

VI. Regarding the human body as a mass; regarding the general conformations which obtain in it; regarding also particular parts in respect to those conformations; we shall be led to observe what I call "interrupted analogies." The following are examples of what I mean by these terms; and I do not know, how such critical deviations can, by any possible hypothesis, be accounted for without design.

I. All the bones of the body are covered with a *periosteum*, except the teeth; where it ceases, and an enamel of ivory, which saws and files will hardly touch, comes into its place. No one can doubt of the use and propriety of this difference; of the "analogy"being thus "interrupted;" of the rule, which belongs to the conformation of the bones, stopping where it does stop: for, had so exquisitely sensible a membrane as the periosteum, invested the teeth, as it invests every other bone of the body, *their* action, necessary exposure, and irritation, would have subjected the animal to continual pain. General as it is, it was not the sort of integument which suited the teeth; what they stood in need of, was a strong, hard, insensible, defensive coat: and exactly such a covering is given to them, in the ivory enamel which adheres to their surface.

2. The scarf-skin, which clothes all the rest of the body, gives way, at the extremities of the toes and fingers, to *nails*. A man has only to look at his hand, to observe with what nicety and precision, that covering which extends over every other part, is here superseded by a different substance, and a different texture. Now, if either the rule had been necessary, or the deviation from it accidental, this effect would not be seen. When I speak of the rule being necessary, I mean the formation of the skin upon the surface being produced by a set of causes constituted without design, and acting, as all ignorant causes must act, by a general operation. Were this the case, no account could be given of the operation being suspended at the fingers' ends, or on the back part of the fingers, and not on the fore part. On the other hand; if the deviation were accidental, an error, an anomalism; were it any thing else than settled by intention; we should meet with nails upon other parts of the body. They would be scattered over the surface, like warts or pimples.

3. All the great cavities of the body are enclosed by membranes, except the *skull*. Why should not the brain be content with the same covering as that which serves for the other principal organs of the body? The heart, the lungs, the liver, the stomach, the bowels, have all soft integuments, and nothing else. The muscular coats are all soft and membranous. I can see a reason for this distinction in the final cause, but in no other. The importance of the brain to life (which experience proves to be immediate), and the extreme tenderness of its substance, make a solid case more necessary for it, than for any other part: and such a case the hardness of the skull supplies. When the smallest portion of this natural casquet is lost, how carefully, yet how imperfectly is it replaced by a plate of metal! If an anatomist should say, that this bony protection is not confined to the brain, but is extended along the course of the spine, I answer, that he adds strength to the argument. If he remark, that the chest also is fortified by bones, I reply that I should have alleged this instance myself, if the ribs had not appeared subservient to the purpose of motion, as well as of defence. What distinguishes the skull from every other cavity is, that the bony covering

completely surrounds its contents, and is calculated, not for motion, but solely for defence. Those hollows, likewise, and inequalities, which we observe in the inside of the skull, and which exactly fit the folds of the brain, answer the important design of keeping the substance of the brain steady, and of guarding it against concussions.

CHAPTER XII.

COMPARATIVE ANATOMY.

WHENEVER we find a general plan pursued, yet with such variations in it as are, in each case, required by the particular exigency of the subject to which it is applied, we possess, in such plan and such adaptation, the strongest evidence that can be afforded of intelligence and design; an evidence which the most completely excludes every other hypothesis. If the general plan proceeded from any fixed necessity in the nature of things, how could it accommodate itself to the various wants and uses which it had to serve under different circumstances, and on different occasions? *Arkwright's* mill was invented for the spinning of cotton. We see it employed for the spinning of wool, flax, and hemp, with such modifications of the original principle, such variety in the same plan, as the texture of those different materials rendered necessary. Of the machine's being put together with design, if it were possible to doubt, whilst we saw it only under one mode, and in one form; when we came to observe it in its different applications, with such changes of structure, such additions and supplements, as the special and particular use in each case demanded, we could not refuse any longer our assent to the proposition, "that intelligence, properly and strictly so called (including under that name, foresight, consideration, reference to utility), had been employed, as well in the primitive plan, as in the several changes and accommodations which it is made to undergo."

Very much of this reasoning is applicable to what has been called *Comparative Anatomy*. In their general œconomy, in the outlines of the plan, in the construction as well as offices of their principal parts, there exists between all large terrestrial animals a close resemblance. In all, life is sustained, and the body nourished by nearly the same apparatus. The heart, the lungs, the stomach, the liver, the kidneys, are much alike in all. The same fluid (for no distinction of blood has been observed) circulates through their vessels, and nearly in the same order. The same cause, therefore, whatever that cause was, has been concerned in the origin, has governed the production of these different animal forms.

When we pass on to smaller animals, or to the inhabitants of a different element, the resemblance becomes more distant and more obscure; but still the plan accompanies us.

And, what we can never enough commend, and which it is our business at present to exemplify, the plan is attended, through all its varieties and deflections, by subserviences to special occasions and utilities.

I. The *covering* of different animals (though whether I am correct in classing this under their anatomy, I do not know) is the first thing which presents itself to our observation: and is, in truth, both for its variety, and its suitableness to their several natures, as much to be admired as any part of their structure. We have bristles, hair, wool, furs, feathers, quills, prickles, scales; yet in this diversity both of material and form, we cannot change one animal's coat for another, without evidently changing it for the worse: taking care however to remark, that these coverings are, in many cases, armour as well as clothing: intended for protection as well as warmth.

The *human* animal is the only one which is naked, and the only one which can clothe itself. This is one of the properties which renders him an animal of all climates, and of all seasons. He can adapt the warmth or lightness of his covering to the temperature of his habitation. Had he been born with a fleece upon his back, although he might have been comforted by its warmth in high latitudes, it would have oppressed him by its weight and heat, as the species spread towards the equator.

What art, however, does for men, nature has, in many instances, done for those animals which are incapable of art. Their clothing, of its own accord, changes with their necessities. This is particularly the case with that large tribe of quadrupeds which are covered with *furs*. Every dealer in hare-skins and rabbit-skins, knows how much the fur is thickened by the approach of winter. It seems to be a part of the same constitution and the same design, that wool, in hot countries, degenerates, as it is called, but in truth (most happily for the animal's ease) passes into hair; whilst, on the contrary, that hair, in the dogs of the polar regions, is turned into wool, or something very like it. To which may be referred, what naturalists have remarked, that bears, wolves, foxes, hares, which do not take the water, have the fur much thicker on the back than the belly: whereas in the beaver it is the thickest upon the belly; as are the feathers in water-fowl. We know the final cause of all this; and we know no other.

The *covering of birds* cannot escape the most vulgar observation. Its lightness, its smoothness, its warmth;--the disposition of the feathers all inclined backward, the down about their stem, the overlapping of their tips, their different configuration in different parts, not to mention the variety of their colours, constitute a vestment for the body, so beautiful, and so appropriate to the life which the animal is to lead, as that, I think, we should have had no conception of any thing equally perfect, if we had never seen it, or can now imagine any thing more so. Let us suppose (what is possible only in supposition) a person who had never seen a bird, to be presented with a plucked pheasant, and bid to set his wits to work, how to contrive for it a covering which shall unite the qualities of warmth, levity, and least resistance to the air, and the highest degree of each: giving it also as much of beauty and ornament as he could afford. He is the person to behold the work of the Deity, in this part of his creation, with the sentiments which are due to it.

The commendation, which the general aspect of the feathered world seldom fails of exciting, will be increased by further examination. It is one of those cases in which the philosopher has more to admire, than the common observer. Every *feather* is a mechanical wonder. If we look at the quill, we find properties not easily brought together,--strength and lightness. I know few things more remarkable than the strength and lightness of the very pen with which I am writing. If we cast our eye to the upper part of the stem, we see a material, made for the purpose, used in no other class of animals, and in no other part of birds; tough, light, pliant, elastic. The pith, also, which feeds the feathers, is amongst animal substances, *sui generis;* neither bone, flesh, membrane, nor tendon(*Note:* The quill-part of a feather is composed of circular and longitudinal fibres. In making a pen, you must scrape off the coat of circular fibres, or the quill will split in a ragged, jagged manner, making what boys call *cat's teeth*.).

But the artificial part of a feather is the *beard*, or, as it is sometimes, I believe, called, the vane. By the beards are meant, what are fastened on each side of the stem, and what constitute the breadth of the feather; what we usually strip off from one side or both, when we make a pen. The separate pieces or laminæ, of which the beard is composed, are called threads, sometimes filaments, or rays. Now the first thing which an attentive observer will remark is, how much stronger the beard of the feather shows itself to be, when pressed in a direction perpendicular to its plane, than when rubbed, either up or down, in the line of the stem, and he will soon discover the structure which occasions this difference, viz. that the laminæ whereof these beards are composed, are flat, and placed with their flat sides towards each other; by which means, whilst they *easily* bend for the approaching of each other, as any one may perceive by drawing his finger ever so lightly upwards, they are much harder to bend out of their plane, which is the direction in which they have to encounter the impulse and pressure of the air, and in which their strength is wanted, and put to the trial.

This is one particularity in the structure of a feather; a second is still more extraordinary. Whoever examines a feather, cannot help taking notice, that the threads or laminæ of which we have been speaking, in their natural state *unite;* that their union is something more than the mere apposition of loose surfaces; that they are not parted asunder without some degree of force; that nevertheless there is no glutinous cohesion between them; that, therefore, by some mechanical means or other, they catch or clasp among themselves, thereby giving to the beard or vane its closeness and compactness of texture. Nor is this all: when two laminæ, which have been separated by accident or force, are brought together again, they immediately *reclasp:* the connexion, whatever it was, is perfectly recovered, and the beard of the feather becomes as smooth and firm as if nothing had happened to it. Draw your finger down the feather, which is against the grain, and you break, probably, the junction of some of the contiguous threads; draw your finger up the feather, and you restore all things to their former state. This is no common contrivance: and now for the mechanism by which it is effected. The threads or laminæ above mentioned are *interlaced*with one another: and the interlacing is performed by means of a vast number of fibres, or teeth, which the laminæ shoot forth *on each side*, and which hook and grapple together. A friend of mine counted fifty of these fibres in one twentieth of an inch. These fibres are crooked; but curved after a different manner: for those, which proceed from the thread on the side towards the extremity of the feather, are longer, more flexible, and bent downward; whereas those which proceed from the side towards the beginning, or quill-end of the feather, are shorter, firmer, and turn upwards. The process then which takes place, is as follows: when two laminæ are pressed together, so that these long fibres are forced far enough over the short ones, *their*crooked parts fall into the cavity made by the crooked parts of the others; just as the latch that is fastened to a door, enters into the cavity of the catch fixed to the doorpost, and there hooking itself, *fastens* the door; for it is properly in this manner, that one thread of a feather is fastened to the other.

This admirable structure of the feather, which it is easy to see with the microscope, succeeds perfectly for the use to which nature has designed it; which use was, not only that the laminæ might be united, but that when one thread or lamina has been separated from another by some external violence, it might be reclasped with sufficient facility and expedition(*Note:* The above account is taken from Memoirs for a Natural History of Animals, by the Royal Academy of Paris, published in 1701, p. 219.).

In the *ostrich*, this apparatus of crotchets and fibres, of hooks and teeth, is wanting: and we see the consequence of the want. The filaments hang loose and separate from one another, forming only a kind of down; which constitution of the feathers, however it may fit them for the flowing honours of a lady's head-dress, may be reckoned an imperfection in the bird, inasmuch as wings, composed of these feathers, although they may greatly assist it in running, do not serve for flight.

But under the present division of our subject, our business with feathers is, as they are the *covering* of the bird. And herein a singular circumstance occurs. In the small order of birds which winter with us, from a snipe downwards, let the external colour of the feathers be what it will, their Creator has universally given them a bed of *black* down next their bodies. Black, we know, is the warmest colour: and the purpose here is, to *keep-in* the heat, arising from the heart and circulation of the blood. It is further likewise remarkable, that this is not found in larger birds; for which there is also a reason:--small birds are much more exposed to the cold than large ones; forasmuch as they present, in proportion to their bulk, a much larger surface to the air. If a turkey were divided into a number of wrens (supposing the shape of the turkey and the wren to be similar), the surface of all the wrens would exceed the surface of the turkey, in the proportion of the length, breadth (or, of any homologous line), of a turkey to that of a wren; which would be, perhaps, a proportion of ten to one. It was necessary therefore that small birds should be more warmly clad than large ones: and this seems to be the expedient, by which that exigency is provided for.

II. In comparing different animals, I know no part of their structure which exhibits greater variety, or, in that variety, a nicer accommodation to their respective conveniency, than that which is seen in the different formations of their *mouths*. Whether the purpose be the reception of aliment merely, or the catching of prey, the picking up of seeds, the cropping of herbage, the extraction of juices, the suction of liquids, the breaking and grinding of food, the taste of that food, together with the respiration of air, and, in conjunction with it, the utterance of sound; these various offices are assigned to this one part, and, in different species, provided for, as they are wanted, by its different constitution. In the human species, forasmuch as there are hands to convey the food to the mouth, the mouth is flat, and by reason of its flatness, fitted only for *reception:* whereas the projecting jaws, the wide rictus, the pointed teeth of the dog and his affinities, enable them to apply their mouths to *snatch and seize* the objects of their pursuit. The full lips, the rough tongue, the corrugated cartilaginous palate, the broad cutting teeth of the ox, the deer, the horse, and the sheep, qualify this tribe for *browsing* upon their pasture; either gathering large mouthfuls at once, where the grass is long, which is the case with the ox in particular; or biting close, where it is short, which the horse and the sheep are able to do, in a degree that one could hardly expect. The retired under-jaw of a swine *works in the ground*, after the protruding snout, like a prong or plough-share, has made its way to the roots upon which it feeds. A conformation so happy, was not the gift of chance.

In *birds*, this organ assumes a new character; new both in substance and in form; but in both, wonderfully adapted to the wants and uses of a distinct mode of existence. We have no longer the fleshy lips, the teeth of enamelled bone: but we have, in the place of these two parts, and to perform the office of both, a hard substance (of the same nature with that which composes the nails, claws, and hoofs of quadrupeds) cut out into proper shapes, and mechanically suited to the actions which are wanted. The sharp edge and tempered point of the *sparrow's* bill picks almost every kind of seed from its concealment in the plant; and not only so, but hulls the grain, breaks and shatters the coats of the seed, in order to get at the kernel. The hooked beak of the hawk-tribe separates the flesh from the bones of the animals which it feeds upon, almost with the cleanness and precision of a dissector's knife. The butcherbird transfixes its prey upon the spike of a thorn, whilst it picks its bones. In some birds of this class, we have the *cross*-bill, *i. e.*both the upper and lower bill hooked, and their tips crossing. The *spoon*-bill enables the goose to graze, to collect its food from the bottom of pools, or to seek it amidst the soft or liquid substances with which it is mixed. The *long* tapering bill of the snipe and woodcock, penetrates still deeper into moist earth, which is the bed in which the food of that species is lodged. This is exactly the instrument which the animal wanted. It did not want strength in its bill, which was inconsistent with the slender form of the animal's neck, as well as unnecessary for the kind of aliment upon which it subsists: but it wanted length to reach its object. But the species of bill which belongs to birds that live by *suction*, deserves to be described in its relation to that office. They are what naturalists call serrated or dentated bills; the inside of them, towards the edge, being thickly set with parallel or concentric rows of short, strong, sharp-pointed prickles. These, though they should be called teeth, are not for the purpose of mastication, like the teeth of quadrupeds: nor yet, as in fish, for the seizing and retaining of their prey; but for a quite different use. They form a filter. The *duck* by means of them discusses the mud; examining with great accuracy the puddle, the brake, every mixture which is likely to contain her food. The operation is thus carried on:--The liquid or semi-liquid substances, in which the animal has plunged her bill, she draws; by the action of her lungs, through the narrow interstices which lie between these teeth: catching, as the stream passes across her beak, whatever it may happen to bring along with it, that proves agreeable to her choice, and easily dismissing all the rest. Now, suppose the purpose to have been, out of a mass of confused and heterogeneous substances, to separate for the use of the animal, or rather to enable the animal to separate for its own, those few particles which suited its taste and digestion; what more artificial, or more commodious, instrument of selection, could have been given to it, than this natural filter? It has been observed, also (what must enable the bird to choose and distinguish with

greater acuteness, as well, probably, as what greatly increases its luxury), that the bills of this species are furnished with large nerves,--that they are covered with a skin,--and that the nerves run down to the very extremity. In the curlew, woodcock, and snipe, there are *three pairs*of nerves, equal almost to the optic nerve in thickness, which pass first along the roof of the mouth, and then along the upper chap down to the point of the bill, long as the bill is.

But to return to the train of our observations.--The similitude between the bills of birds and the mouths of quadrupeds, is exactly such, as, for the sake of the argument, might be wished for. It is near enough to show the continuation of the same plan: it is remote enough to exclude the supposition of the difference being produced by action or use. A more prominent contour, or a wider gape, might be resolved into the effect of continued efforts, on the part of the species, to thrust out the mouth, or open it to the stretch. But by what course of action, or exercise, or endeavour, shall we get rid of the lips, the gums, the teeth; and acquire in the place of them, pincers of horn? By what habit shall we so completely change, not only the shape of the part, but the substance of which it is composed? The truth is, if we had seen no other than the mouths of quadrupeds, we should have thought no other could have been formed: little could we have supposed, that all the purposes of a mouth, furnished with lips, and armed with teeth, could be answered by an instrument which had none of these; could be supplied, and that with many additional advantages, by the hardness, and sharpness, and figure of the bills of birds. Every thing about the animal *mouth* is mechanical. The teeth of fish have their points turned backward, like the teeth of a wool or cotton card. The teeth of lobsters work one against another, like the sides of a pair of shears. In many insects, the mouth is converted into a pump or sucker, fitted at the end sometimes with a whimble, sometimes with a forceps; by which double provision, viz. of the tube and the penetrating form of the point, the insect first bores through the integuments of its prey, and then extracts the juices. And, what is most extraordinary of all, one sort of mouth, as the occasion requires, shall be changed into another sort. The caterpillar could not live without teeth; in several species, the butterfly formed from it, could not use them. The old teeth therefore are cast off with the exuviæ of the grub; a new and totally different apparatus assumes their place in the fly. Amid these novelties of form, we sometimes forget that it is, all the while, the animal's *mouth*; that, whether it be lips, or teeth, or bill, or beak, or shears, or pump, it is the same part diversified: and it is also remarkable, that, under all the varieties of configuration with which we are acquainted, and which are very great, the organs of taste and smelling are situated near each other.

III. To the mouth adjoins the gullet: in this part also, comparative anatomy discovers a difference of structure, adapted to the different necessities of the animal. In brutes, because the posture of their neck conduces little to the passage of the aliment, the fibres of the gullet, which act in this business, run in two close spiral lines, crossing each other: in men, these fibres run only a little obliquely from the upper end of the œsophagus to the stomach, into which, by a gentle contraction, they easily transmit the descending morsels; that is to say, for the more laborious deglutition of animals, which thrust their food *up*instead of *down*, and also through a longer passage, a proportionably more powerful apparatus of muscles is provided; more powerful, not merely by the strength of the fibres, which might be attributed to the greater exercise of their force, but in their collocation, which is a determinate circumstance, and must have been original.

IV. The gullet leads to the *intestines:* here, likewise, as before, comparing quadrupeds with man, under a general similitude we meet with appropriate differences. The *valvulæ conniventes*, or, as they are by some called, the semilunar valves, found in the human intestine, are wanting in that of brutes. These are wrinkles or plates of the innermost coat of the guts, the effect of which is to retard the progress of the food through the alimentary canal. It is easy to understand how much more necessary such a provision may be to the body of an animal of an erect posture, and in which, consequently, the weight of the food is added to the action of the intestine, than in that of a

quadruped, in which the course of the food, from its entrance to its exit, is nearly horizontal: but it is impossible to assign any cause, except the final cause, for this distinction actually taking place. So far as depends upon the action of the part, this structure was more to be expected in a quadruped than in a man. In truth, it must in both have been formed, not by action, but in direct opposition to action and to pressure: but the opposition which would arise from pressure, is greater in the upright trunk than in any other. That theory therefore is pointedly contradicted by the example before us. The structure is found where its generation, according to the method by which the theorist would have it generated, is the most difficult; but *(observe)*it is found where its effect is most useful.

The different length of the intestines in carnivorous and herbivorous animals, has been noticed on a former occasion. The shortest, I believe, is that of some birds of prey, in which the intestinal canal is little more than a straight passage from the mouth to the vent. The longest is in the deer-kind. The intestines of a Canadian stag, four feet high, measured ninety-six feet(*Note:* Mem. Acad. Paris. 1701; p. 170.). The intestine of a sheep, unravelled, measured thirty times the length of the body. The intestine of a wild cat is only three times the length of the body. Universally, where the substance upon which the animal feeds is of slow concoction, or yields its chyle with more difficulty, there the passage is circuitous and dilatory, that time and space may be allowed for the change and the absorption which are necessary. Where the food is soon dissolved, or already half assimilated, an unnecessary or, perhaps, hurtful detention is avoided, by giving to it a shorter and a readier route.

V. In comparing the *bones* of different animals, we are struck, in the bones of birds, with a *propriety*, which could only proceed from the wisdom of an intelligent and designing Creator. In the bones of an animal which is to fly, the two qualities required are strength and lightness. Wherein, therefore, do the bones of birds (I speak of the cylindrical bones) differ, in these respects, from the bones of quadrupeds? In three properties: first, their cavities are much larger in proportion to the weight of the bone, than in those of quadrupeds; secondly, these cavities are empty; thirdly, the shell is of a firmer texture, than is the substance of other bones. It is easy to observe these particulars, even in picking the wing or leg of a chicken. Now, the weight being the same, the diameter, it is evident, will be greater in a hollow bone than in a solid one, and with the diameter, as every mathematician can prove, is increased, *cæteris paribus*, the strength of the cylinder, or its resistance to breaking. In a word, a bone of the *same weight* would not have been so strong in any other form; and to have made it heavier, would have incommoded the animal's flight. Yet this form could not be acquired by use, or the bone become hollow and tubelar by exercise. What appetency could excavate a bone?

VI. The *lungs* also of birds, as compared with the lungs of quadrupeds, contain in them a provision, distinguishingly calculated for this same purpose of levitation; namely, a communication (not found in other kinds of animals) between the air-vessels of the lungs and the cavities of the body: so that by the intromission of air from one to the other (at the will, as it should seem, of the animal), its body can be occasionally puffed out, and its tendency to descend in the air, or its specific gravity made less. The bodies of birds are blown up from their lungs (which no other animal bodies are), and thus rendered buoyant.

VII. All birds are *oviparous*. This likewise carries on the work of gestation with as little increase as possible of the weight of the body. A gravid uterus would have been a troublesome burthen to a bird in its flight. The advantage, in this respect, of an oviparous procreation is, that, whilst the whole brood are hatched together, the eggs are excluded singly, and at considerable intervals. Ten, fifteen, or twenty young birds may be produced in one cletch or covey, yet the parent bird have never been incumbered by the load of more than one full-grown egg at one time.

VIII. A principal topic of comparison between animals, is in their *instruments of motion*. These come before us under three divisions; feet, wings, and fins. I desire any man to say, which of the three is best fitted for its use; or whether the same consummate art be not conspicuous in them all. The constitution of the elements, in which the motion is to be performed, is very different. The animal action must necessarily follow that constitution. The Creator therefore, if we might so speak, had to prepare for different situations, for different difficulties: yet the purpose is accomplished not less successfully in one case than in the other. And, as between *wings* and the corresponding limbs of quadrupeds, it is accomplished without deserting the general idea. The idea is modified, not deserted. Strip a wing of its feathers, and it bears no obscure resemblance to the fore-leg of a quadruped. The articulations at the shoulder and the cubitus are much alike; and, what is a closer circumstance, in both cases the upper part of the limb consists of a single bone, the lower part of two.

But, fitted up with its furniture of feathers and quills, it becomes a wonderful instrument, more artificial than its first appearance indicates, though that be very striking: at least, the use, which the bird makes of its wings in flying, is more complicated, and more curious, than is generally known. One thing is certain, that if the flapping of the wings in flight were no more than the reciprocal motion of the same surface in opposite directions, either upwards and downwards, or estimated in any oblique line, the bird would lose as much by one motion, as she gained by another. The skylark could never ascend by such an action as this: for, though the stroke upon the air by the under-side of her wing would carry her up, the stroke from the upper-side, when she raised her wing again, would bring her down. In order, therefore, to account for the advantage which the bird derives from her wing, it is necessary to suppose, that the surface of the wing, measured upon the same plane, is contracted, whilst the wing is drawn up; and let out to its full expansion, when it descends upon the air for the purpose of moving the body by the re-action of that element. Now, the form and structure of the wing, its external convexity, the disposition, and particularly the overlapping, of its larger feathers, the action of the muscles, and joints of the pinions, are all adapted to this alternate adjustment of its shape and dimensions. Such a twist, for instance, or semirotatory motion, is given to the great feathers of the wing, that they strike the air with their flat side, but rise from the stroke slantwise. The turning of the oar in rowing, whilst the rower advances his hand for a new stroke, is a similar operation to that of the feather, and takes its name from the resemblance. I believe that this faculty is not found in the great feathers of the tail. This is the place also for observing, that the pinions are so set upon the body as to bring down the wings, not vertically, but in a direction obliquely tending towards the tail; which motion, by virtue of the common resolution of forces, does two things at the same time; supports the body in the air, and carries it forward. The *steerage* of a bird in its flight is effected partly by the wings, but in a principal degree, by the tail. And herein we meet with a circumstance not a little remarkable. Birds with long legs have short tails; and, in their flight, place their legs close to their bodies, at the same time stretching them out backwards, as far as they can. In this position, the legs extend beyond the rump, and become the rudder; supplying that steerage which the tail could not.

From the *wings* of birds, the transition is easy to the *fins* of fish. They are both, to their respective tribes, the instruments of their motion; but, in the work which they have to do, there is a considerable difference, founded in this circumstance. Fish, unlike birds, have very nearly the same specific gravity with the element in which they move. In the case of fish, therefore, there is little or no weight to bear up; what is wanted, is only an impulse sufficient to carry the body through a resisting medium, or to maintain the posture, or to support or restore the balance of the body, which is always the most unsteady where there is no weight to sink it. For these offices, the fins are as large as necessary, though much smaller than wings, their action mechanical, their position, and the muscles by which they are moved, in the highest degree convenient. The following short account of some experiments upon fish, made for the purpose of ascertaining the use of their fins, will be the best confirmation of what we assert. In most fish, beside the great fin the tail, we find

two pairs of fins upon the sides, two single fins upon the back, and one upon the belly, or rather between the belly and the tail. The *balancing* use of these organs is proved in this manner. Of the large-headed fish, if you cut off the pectoral fins, *i. e.* the pair which lies close behind the gills, the head falls prone to the bottom: if the right pectoral fin only be cut off, the fish leans to that side; if the ventral fin on the same side be cut away, then it loses its equilibrium entirely; if the dorsal and ventral fins be cut off, the fish reels to the right and left. When the fish dies, that is, when the fins cease to play, the belly turns upwards. The use of the same parts for *motion* is seen in the following observation upon them when put in action. The pectoral, and more particularly the ventral fins, serve to *raise and depress* the fish: when the fish desires to have a *retrograde*motion, a stroke forward with the pectoral fin effectually produces it: if the fish desire to *turn* either way, a single blow with the tail the opposite way, sends it round at once: if the tail strike both ways, the motion produced by the double lash is *progressive*, and enables the fish to dart forwards with an astonishing velocity(*Note:* Goldsmith, Hist. of An. Nat. vol. vi. p. 154.). The result is, not only, in some cases, the most rapid, but, in all cases, the most gentle, pliant, easy, animal motion, with which we are acquainted. However, when the tail is cut off, the fish loses all motion, and gives itself up to where the water impels it. The rest of the fins, therefore, so far as respects motion, seem to be merely subsidiary to this. In their mechanical use, the anal fin, may be rekoned the keel; the ventral fins, out-riggers; the pectoral muscles, the oars: and if there be any similitude between these parts of a boat and a fish, observe, that it is not the resemblance of imitation, but the likeness which arises from applying similar mechanical means to the same purpose.

We have seen that the *tail* in the fish is the great instrument of motion. Now, in cetaceous or warm-blooded fish, which are obliged to rise every two or three minutes to the surface to take breath, the tail, unlike what it is in other fish, is horizontal; its stroke, consequently, perpendicular to the horizon, which is the right direction for sending the fish to the top, or carrying it down to the bottom. Regarding animals in their instruments of motion, we have only followed the comparison through the first great division of animals into beasts, birds, and fish. If it were our intention to pursue the consideration further, I should take-in that generic distinction amongst birds, the *web-foot* of water-fowl. It is an instance which may be pointed out to a child. The utility of the web to water-fowl, the inutility to land-fowl, are so obvious, that it seems impossible to notice the difference without acknowledging the design. I am at a loss to know, how those, who deny the agency of an intelligent Creator, dispose of this example. There is nothing in the action of swimming, as carried on by a bird upon the surface of the water, that should generate a membrane between the toes. As to that membrane, it is an exercise of constant resistance. The only supposition I can think of is, that all birds have been originally water-fowl, and web-footed; that sparrows, hawks, linnets, &c. which frequent the land, have in process of time, and in the course of many generations, had this part worn away by treading upon hard ground. To such evasive assumptions must atheism always have recourse! and, after all, it confesses that the structure of the feet of birds, in their original form, was critically adapted to their original destination! The web-feet of amphibious quadrupeds, seals, otters, &c. fall under the same observation.

IX. The *five senses* are common to most large animals: nor have we much difference to remark in their constitution; or much, however, which is referable to mechanism.

The superior sagacity of animals which hunt their prey, and which, consequently, depend for their livelihood upon their *nose*, is well known, in its use; but not at all known in the organization which produces it.

The external *ears* of beasts of prey, of lions, tigers, wolves, have their trumpet-part, or concavity, standing forwards, to seize the sounds which are before them, viz. the sounds of the animals which they pursue or watch. The ears of animals of flight are turned backward, to give notice of the approach of their enemy from behind, whence he may steal upon them unseen. This is a critical

distinction; and is mechanical: but it may be suggested, and, I think, not without probability, that it is the effect of continual habit.

The *eyes* of animals which follow their prey by night, as cats, owls, &c. possess a faculty not given to those of other species, namely, of closing the pupil *entirely*. The final cause of which seems to be this.--It was necessary for such animals to be able to descry objects with very small degrees of light. This capacity depended upon the superior sensibility of the retina; that is, upon its being affected by the most feeble impulses. But that tenderness of structure, which rendered the membrane thus exquisitely sensible, rendered it also liable to be offended by the access of stronger degrees of light. The contractile range therefore of the pupil is increased in these animals, so as to enable them to close the aperture entirely: which includes the power of diminishing it in every degree; whereby at all times such portions, and only such portions of light are admitted as may be received without injury to the sense.

There appears to be also in the figure, and in some properties of the pupil of the eye, an appropriate relation to the wants of different animals. In horses, oxen, goats, sheep, the pupil of the eye is elliptical; the transverse axis being horizontal; by which structure, although the eye be placed on the side of the head, the anterior elongation of the pupil catches the forward rays, or those which come from objects immediately in front of the animal's face.

CHAPTER XIII.

PECULIAR ORGANIZATIONS. I BELIEVE that all the instances which I shall collect under this title, might, consistently enough with technical language, have been placed under the head of *Comparative Anatomy*. But there appears to me an impropriety in the use which that term hath obtained; it being, in some sort, absurd to call that a case of comparative anatomy, in which there is nothing to "compare;" in which a conformation is found in one animal, which hath nothing properly answering to it in another. Of this kind are the examples which I have to propose in the present chapter: and the reader will see that, though some of them be the strongest, perhaps, he will meet with under any division of our subject, they must necessarily be of an unconnected and miscellaneous nature. To dispose them, however, into some sort of order, we will notice, first, particularities of structure which belong to quadrupeds, birds, and fish, as such, or to many of the kinds included in these classes of animals; and then, such particularities as are confined to one or two species.

I. Along each side of the neck of large *quadrupeds*, runs a stiff, robust cartilage, which butchers call the pax-wax. No person can carve the upper end of a crop of beef without driving his knife against it. It is a tough, strong, tendinous substance, braced from the head to the middle of the back: its office is to assist in supporting the weight of the head. It is a mechanical provision, of which this is the undisputed use; and it is sufficient, and not more than sufficient, for the purpose which it has to execute. The head of an ox or a horse is a heavy weight, acting at the end of a long lever (consequently with a great purchase), and in a direction nearly perpendicular to the joints of the supporting neck. From such a force, so advantageously applied, the bones of the neck would be in constant danger of dislocation, if they were not fortified by this strong tape. No such organ is found in the human subject, because, from the erect position of the head (the pressure of it acting nearly in the direction of the spine) the junction of the vertebræ appears to be sufficiently secure without it. This cautionary expedient, therefore, is limited to quadrupeds: the care of the Creator is seen where it is wanted.

II. The oil with which *birds* prune their feathers, and the organ which supplies it, is a specific provision for the winged creation. On each side of the rump of birds is observed a small nipple, yielding upon pressure a butter-like substance, which the bird extracts by pinching the pap with its bill. With this oil, or ointment, thus procured, the bird dresses its coat; and repeats the action as

often as its own sensations teach it that it is in any part wanted, or as the excretion may be sufficient for the expense. The gland, the pap, the nature and quality of the excreted substance, the manner of obtaining it from its lodgement in the body, the application of it when obtained, form, collectively, an evidence of intention which it is not easy to withstand. Nothing similar to it is found in unfeathered animals. What blind *conatus* of nature should produce it in birds; should not produce it in beasts?

III. The air-bladder also of a *fish* affords a plain and direct instance, not only of contrivance, but strictly of that species of contrivance which we denominate mechanical. It is a philosophical apparatus in the body of an animal. The principle of the contrivance is clear; the application of the principle is also clear. The use of the organ to sustain, and, at will, also to elevate, the body of the fish in the water, is proved by observing, what has been tried, that, when the bladder is burst, the fish grovels at the bottom; and also, that flounders, soles, skates, which are without the air-bladder, seldom rise in the water, and that with effort. The manner in which the purpose is attained, and the suitableness of the means to the end, are not difficult to be apprehended. The rising and sinking of a fish in water, so far as it is independent of the stroke of the fins and tail, can only be regulated by the specific gravity of the body. When the bladder, contained in the body of the fish, is contracted, which the fish probably possesses a muscular power of doing, the bulk of the fish is contracted along with it; whereby, since the absolute weight remains the same, the specific gravity, which is the sinking force, is increased, and the fish descends: on the contrary, when, in consequence of the relaxation of the muscles, the clasticity of the inclosed and now compressed air, restores the dimensions of the bladder, the tendency downwards becomes proportionably less than it was before, or is turned into a contrary tendency. These are known properties of bodies immersed in a fluid. The enamelled figures, or little glass bubbles, in a jar of water, are made to rise and fall by the same artifice. A diving machine might be made to ascend and descend, upon the like principle; namely, by introducing into the inside of it an air-vessel, which, by its contraction, would diminish, and by its distension enlarge, the bulk of the machine itself, and thus render it specifically heavier, or specifically lighter, than the water which surrounds it. Suppose this to be done, and the artist to solicit a patent for his invention. The inspectors of the model, whatever they might think of the use or value of the contrivance, could, by no possibility, entertain a question in their minds, whether it were a contrivance or not. No reason has ever been assigned,--no reason can be assigned, why the conclusion is not as certain in the fish, as it is in the machine; why the argument is not as firm in one case as the other.

It would be very worthy of inquiry, if it were possible to discover, by what method an animal, which lives constantly in water, is able to supply a repository of air. The expedient, whatever it be, forms part, and perhaps the most curious part, of the provision. Nothing similar to the air-bladder is found in land-animals; and a life in the water has no natural tendency to produce a bag of air. Nothing can be further from an acquired organization than this is.

These examples mark the attention of the Creator to the three great kingdoms of his animal creation, and to their constitution as such.--The example which stands next in point of generality, belonging to a large tribe of animals, or rather to various species of that tribe, is the poisonous tooth of serpents.

I. The *fang of a viper* is a clear and curious example of mechanical contrivance. It is a perforated tooth, loose at the root: in its quiet state, lying down flat upon the jaw, but furnished with a muscle, which, with a jerk, and by the pluck, as it were, of a string, suddenly erects it. Under the tooth, close to its root, and communicating with the perforation, lies a small bag containing the venom. When the fang is raised, the closing of the jaw presses its root against the bag underneath; and the force of this compression sends out the fluid with a considerable impetus through the tube in the middle of the tooth. What more unequivocal, or effectual apparatus could be devised for the

double purpose of at once inflicting the wound, and injecting the poison? Yet, though lodged in the mouth, it is so constituted, as, in its inoffensive and quiescent state, not to interfere with the animal's ordinary office of receiving its food. It has been observed also, that none of the harmless serpents, the black snake, the blind worm, &c. have these fangs, but teeth of an equal size; not moveable, as this is, but fixed into the jaw.

II. In being the property of several different species, the preceding example is resembled by that which I shall next mention, which is the *bag of the opossum*. This is a mechanical contrivance, most properly so called. The simplicity of the expedient renders the contrivance more obvious than many others, and by no means less certain. A false skin under the belly of the animal, forms a pouch, into which the young litter are received at their birth; where they have an easy and constant access to the teats; in which they are transported by the dam from place to place; where they are at liberty to run in and out; and where they find a refuge from surprise and danger. It is their cradle, their asylum, and the machine for their conveyance. Can the use of this structure be doubted of? Nor is it a mere doubling of the skin; but it is a new organ, furnished with bones and muscles of its own. Two bones are placed before the os pubis, and joined to that bone as their base. These support, and give a fixture to, the muscles, which serve to open the bag. To these muscles there are antagonists, which serve in the same manner to shut it: and this office they perform so exactly, that, in the living animal, the opening can scarcely be discerned, except when the sides are forcibly drawn asunder(*Note:* Goldsmith, Nat. Hist. vol. iv. p. 244.). Is there any action in this part of the animal, any process arising from that action, by which these members could be formed? any account to be given of the formation, except design?

III. As a particularity, yet appertaining to more species than one; and also as strictly mechanical; we may notice a circumstance in the structure of the *claws* of certain birds. The middle claw of the heron and cormorant is toothed and notched like a saw. These birds are great fishers, and these notches assist them in holding their slippery prey. The use is evident; but the structure such, as cannot at all be accounted for by the effort of the animal, or the exercise of the part. Some other fishing birds have these notches in their *bills;* and for the same purpose. The gannet, or Soland goose, has the side of its bill irregularly jagged, that it may hold its prey the faster. Nor can the structure in this, more than in the former case, arise from the manner of employing the part. The smooth surfaces, and soft flesh of fish, were less likely to notch the bills of birds, than the hard bodies upon which many other species feed.

We now come to particularities strictly so called, as being limited to a single species of animal. Of these, I shall take one from a quadruped, and one from a bird.

I. The *stomach of the camel* is well known to retain large quantities of water, and to retain it unchanged for a considerable length of time. This property qualifies it for living in the desert. Let us see, therefore, what is the internal organization, upon which a faculty so rare, and so beneficial, depends. A number of distinct sacs or bags (in a dromedary thirty of these have been counted) are observed to lie between the membranes of the second stomach, and to open into the stomach near the top by small square apertures. Through these orifices, after the stomach is full, the annexed bags are filled from it: and the water so deposited is, in the first place, not liable to pass into the intestines; in the second place, is kept separate from the solid aliment; and, in the third place, is out of the reach of the digestive action of the stomach, or of mixture with the gastric juice. It appears probable, or rather certain, that the animal, by the conformation of its muscles, possesses the power of squeezing back this water from the adjacent bags into the stomach, whenever thirst excites it to put this power in action.

II. The *tongue of the woodpecker* is one of those singularities, which nature presents us with, when a singular purpose is to be answered. It is a particular instrument for a particular use: and what,

except design, ever produces such? The woodpecker lives chiefly upon insects, lodged in the bodies of decayed or decaying trees. For the purpose of boring into the wood, it is furnished with a bill, straight, hard, angular, and sharp. When, by means of this piercer, it has reached the cells of the insects, then comes the office of its tongue; which tongue is, first, of such a length that the bird can dart it out three or four inches from the bill,--in this respect differing greatly from every other species of bird; in the second place, it is tipped with a stiff, sharp, bony thorn; and, in the third place (which appears to me the most remarkable property of all), this tip is dentated on both sides, like the beard of an arrow or the barb of a hook. The description of the part declares its uses. The bird, having exposed the retreats of the insects by the assistance of its bill, with a motion inconceivably quick, launches out at them this long tongue; transfixes them upon the barbed needle at the end of it; and thus draws its prey within its mouth. If this be not mechanism, what is? Should it be said, that, by continual endeavours to shoot out the tongue to the stretch, the woodpecker's species may by degrees have lengthened the organ itself, beyond that of other birds, what account can be given of its form, of its tip? how, in particular, did it get its barb, its dentation? These barbs, in my opinion, wherever they occur, are decisive proofs of mechanical contrivance.

III. I shall add one more example, for the sake of its novelty. It is always an agreeable discovery, when, having remarked in an animal an extraordinary structure, we come at length to find out an unexpected use for it. The following narrative furnishes an instance of this kind. The babyrouessa, or Indian hog, a species of wild boar, found in the East Indies, has two *bent* teeth, more than half a yard long, growing upwards, and (which is the singularity) from the upper jaw. These instruments are not wanted for offence: that service being provided for by two tusks issuing from the upper-jaw, and resembling those of the common boar; nor does the animal use them for defence. They might seem therefore to be both a superfluity and in incumbrance. But observe the events--the animal sleeps standing; and, in order to support its head, hooks its upper tusks upon the branches of trees.

CHAPTER XIV.
PROSPECTIVE CONTRIVANCES.

I CAN hardly imagine to myself a more distinguishing mark, and, consequently, a more certain proof of design, than *preparation*, i. e. the providing of things beforehand, which are not to be used until a considerable time afterwards; for this implies a contemplation of the future, which belongs only to intelligence.

Of these *prospective* contrivances, the bodies of animals furnish various examples.

I. The human teeth afford an instance, not only of prospective contrivance, but of the completion of the contrivance being designedly suspended. They are formed within the gums, and there they stop: the fact being, that their further advance to maturity would not only be useless to the new-born animal, but extremely in its way; as it is evident that the act of *sucking*, by which it is for some time to be nourished, will be performed with more ease both to the nurse and to the infant, whilst the inside of the mouth and edges of the gums are smooth and soft than if set with hard pointed bones. By the time they are wanted the teeth are ready. They have been lodged within the gums for some months past but detained as it were, in their sockets so long as their further protrusion would interfere with the office to which the mouth is destined. Nature, namely, that intelligence which was employed in creation, looked beyond the first year of the infant's life; yet, whilst, she was providing for functions which were after that term to become necessary, was careful not to incommode those which preceded them. What renders it more probable that this is the effect of design, is, that the teeth are imperfect, whilst all other parts of the mouth are perfect. The lips are perfect, the tongue is perfect; the cheeks, the jaws, the palate, the pharynx,

the larynx, are all perfect: the teeth alone are not so. This is the fact with respect to the human mouth: the fact also is, that the parts above enumerated, are called into use from the beginning; whereas the teeth would be only so many obstacles and annoyances, if they were there. When a contrary order is necessary, a contrary order prevails. In the worm of the beetle, as hatched from the egg, the teeth are the first things which arrive at perfection. The insect begins to gnaw as soon as it escapes from the shell, though its other parts be only gradually advancing to their maturity.

What has been observed of the teeth, is true of the *horns* of animals; and for the same reason. The horn of a calf or a lamb does not bud, or at least does not sprout to any considerable length, until the animal be capable of browsing upon its pasture: because such a substance upon the forehead of the young animal, would very much incommode the teat of the dam in the office of giving suck.

But in the case of the *teeth*,--of the human teeth at least, the prospective contrivance looks still further. A succession of crops is provided, and provided from the beginning; a second tier being originally formed beneath the first, which do not come into use till several years afterwards. And this double or suppletory provision meets a difficulty in the mechanism of the mouth, which would have appeared almost unsurmountable. The expansion of the jaw (the consequence of the proportionable growth of the animal, and of its skull), necessarily separates the teeth of the first set, however compactly disposed, to a distance from one another, which would be very inconvenient. In due time, therefore, *i. e.* when the jaw has attained a great part of its dimensions, a new set of teeth springs up (loosening and pushing out the old ones before them), more exactly fitted to the space which they are to occupy, and rising also in such close ranks, as to allow for any extension of line which the subsequent enlargement of the head may occasion.

II. It is not very easy to conceive a more evidently prospective contrivance, than that which, in all viviparous animals, is found in the *milk* of the female parent. At the moment the young animal enters the world, there is its maintenance ready for it. The particulars to be remarked in this œconomy, are neither few nor slight. We have, first, the nutritious quality of the fluid, unlike, in this respect, every other excretion of the body; and in which nature hitherto remains unimitated, neither cookery nor chymistry having been able to make milk out of grass: we have, secondly, the organ for its reception and retention: we have, thirdly, the excretory duct, annexed to that organ: and we have, lastly, the determination of the milk to the breast, at the particular juncture when it is about to be wanted. We have all these properties in the subject before us: and they are all indications of design. The last circumstance is the strongest of any. If I had been to guess beforehand, I should have conjectured, that, at the time when there was an extraordinary demand for nourishment in one part of the system, there would be the least likelihood of a redundancy to supply another part. The advanced pregnancy of the female has no intelligible tendency to fill the breasts with milk. The lacteal system is a constant wonder: and it adds to other causes of our admiration, that the number of the teats or paps in each species is found to bear a proportion to the number of the young. In the sow, the bitch, the rabbit, the cat, the rat, which have numerous litters, the paps are numerous, and are disposed along the whole length of the belly; in the cow and mare, they are few. The most simple account of this, is to refer it to a designing Creator. But, in the argument before us, we are entitled to consider not only animal bodies when framed, but the circumstances under which they are framed: and in this view of the subject, the constitution of many of their parts is most strictly prospective.

III. The eye is of no use, at the time when it is formed. It is an optical instrument made in a dungeon; constructed for the refraction of light to a focus, and perfect for its purpose, before a ray of light has had access to it; geometrically adapted to the properties and action of an element, with which it has no communication. It is about indeed to enter into that communication: and this is precisely the thing which evidences intention. It is *providing* for the *future* in the closest sense which can be given to these terms: for, it is providing for a future change; not for the then-

subsisting condition of the animal; not for any gradual progress or advance in that same condition; but for a new state, the consequence of a great and sudden alteration, which the animal is to undergo at its birth. Is it to be believed that the eye was formed, or, which is the same thing, that the series of causes was fixed by which the eye is formed, without a view to this change; without a prospect of that condition, in which its fabric, of no use at present, is about to be of the greatest; without a consideration of the qualities of that element, hitherto entirely excluded, but with which it was hereafter to hold so intimate a relation? A young man makes a pair of spectacles for himself against he grows old; for which spectacles he has no want or use whatever at the time he makes them. Could this be done without knowing and considering the defect of vision to which advanced age is subject? Would not the precise suitableness of the instrument to its purpose, of the remedy to the defect, of the convex lens to the flattened eye, establish the certainty of the conclusion, that the case, afterwards to arise, had been considered beforehand, speculated upon, provided for? all which are exclusively the acts of a reasoning mind. The eye formed in one state, for use only in another state, and in a different state, affords a proof no less clear of destination to a future purpose; and a proof proportionably stronger, as the machinery is more complicated, and the adaptation more exact.

IV. What has been said of the eye, holds equally true of the lungs. Composed of airvessels, where there is no air; elaborately constructed for the alternate admission and expulsion of an elastic fluid, where no such fluid exists; this great organ, with the whole apparatus belonging to it, lies collapsed in the fœtal thorax, yet in order, and in readiness for action, the first moment that the occasion requires its service. This is having a machine locked up in store for future use; which incontestably proves, that the case was expected to occur, in which this use might be experienced: but expectation is the proper act of intelligence. Considering the state in which an animal exists before its birth, I should look for nothing less in its body than a system of lungs. It is like finding a pair of bellows in the bottom of the sea; of no sort of use in the situation in which they are found; formed for an action which was impossible to be exerted; holding no relation or fitness to the element which surrounds them, but both to another element in another place.

As part and parcel of the same plan, ought to be mentioned, in speaking of the lungs, the provisionary contrivances of the *foramen ovale* and *ductus arteriosus*. In the fœtus, pipes are laid for the passage of the blood through the lungs; but, until the lungs be inflated by the inspiration of air, that passage is impervious, or in a great degree obstructed. What then is to be done? What would an artist, what would a master, do upon the occasion? He would endeavour, most probably, to provide a *temporary* passage, which might carry on the communication required, until the other was open. Now this is the thing which is actually done in the heart:--Instead of the circuitous route through the lungs, which the blood afterwards takes, before it get from one auricle of the heart to the other; a portion of the blood passes immediately from the right auricle to the left, through a hole, placed in the partition, which separates these cavities. This hole, anatomists call the *foramen ovale*. There is likewise another cross cut, answering the same purpose, by what is called the *ductus arteriosus*, lying between the pulmonary artery and the ærta. But both expedients are so strictly temporary, that, after birth, the one passage is closed, and the tube which forms the other shrivelled up into a ligament. If this be not contrivance, what is?

But, forasmuch as the action of the air upon the blood in the lungs, appears to be necessary to the perfect concoction of that fluid, *i. e.* to the life and health of the animal (otherwise the shortest route might still be the best), how comes it to pass that the *fœtus* lives and grows, and thrives, without it? The answer is that the blood of the fœtus is the mother's; that it has undergone that action in her habit; that one pair of lungs serves for both. When the animals are separated, a new necessity arises; and to meet this necessity as soon as it occurs, an organization is prepared. It is ready for its purpose; it only waits for the atmosphere; it begins to play, the moment the air is admitted to it.

CHAPTER XV.
RELATIONS.

WHEN several different parts contribute to one effect; or, which is the same thing, when an effect is produced by the joint action of different instruments; the fitness of such parts or instruments to one another, for the purpose of producing, by their united action the effect, is what I call *relation:* and whereever this is observed in the works of nature or of man, it appears to me to carry along with it decisive evidence of understanding, intention, art. In examining, for instance, the several parts of a *watch*, the spring, the barrel, the chain, the fusee, the balance, the wheels of various sizes, forms, and positions, what is it which would take an observer's attention, as most plainly evincing a construction, directed by thought, deliberation, and contrivance? It is the suitableness of these parts to one another; first, in the succession and order in which they act; and, secondly, with a view to the effect finally produced. Thus, referring the spring to the wheels, our observer sees in it, that which originates and upholds *their* motion; in the chain, that which transmits the motion to the fusee; in the fusee, that which communicates it to the wheels; in the conical figure of the fusee, if he refer to the spring, he sees that which corrects the inequality of its force. Referring the wheels to one another, he notices, first, their teeth, which would have been without use or meaning, if there had been only one wheel, or if the wheels had had no connexion between themselves, or common bearing upon some joint effect; secondly, the correspondency of their position, so that the teeth of one wheel catch into the teeth of another; thirdly, the proportion observed in the number of teeth of each wheel, which determines the rate of going. Referring the balance to the rest of the works, he saw, when he came to understand its action, that which rendered their motions equable. Lastly, in looking upon the index and face of the watch, he saw the use and conclusion of the mechanism, viz. marking the succession of minutes and hours; but all depending upon the motions within, all upon the system of intermediate actions between the spring and the pointer. What thus struck his attention in the several parts of the watch, he might probably designate by one general name of "relation:" and observing with respect to all cases whatever, in which the origin and formation of a thing could be ascertained by evidence, that these relations were found in things produced by art and design, and in no other things, he would rightly deem of them as characteristic of such productions.--To apply the reasoning here described to the works of nature.

The animal œconomy is full; is made up of these *relations:*

I. There are, first, what, in one form or other, belong to all animals, the parts and powers which successively act upon their *food*. Compare this action with the process of a manufactory. In men and quadrupeds, the aliment is, first, broken and bruised by mechanical instruments of mastication, viz. sharp spikes or hard knobs, pressing against or rubbing upon one another: thus ground and comminuted, it is carried by a pipe into the stomach, where it waits to undergo a great chymical action, which we call digestion: when digested, it is delivered through an orifice, which opens and shuts as there is occasion, into the first intestine: there, after being mixed with certain proper ingredients, poured through a hole in the side of the vessel, it is further dissolved: in this state, the milk, chyle, or part which is wanted, and which is suited for animal nourishment, is strained off by the mouths of very small tubes, opening into the cavity of the intestines: thus freed from its grosser parts, the percolated fluid is carried by a long, winding, but traceable course, into the main stream of the old circulation; which conveys it, in its progress, to every part of the body. Now I say again, compare this with the process of a manufactory; with the making of cider, for example; with the bruising of the apples in the mill, the squeezing of them when so bruised in the press the fermentation in the vat, the bestowing of the liquor thus fermented in the hogsheads, the drawing off into bottles, the pouring out for use into the glass. Let any one show me any difference between these two cases, as to the point of contrivance. That which is at present under our

consideration, the "relation"of the parts successively employed, is not more clear in the last case, than in the first. The aptness of the jaws and teeth to prepare the food for the stomach, is, at least, as manifest, as that of the cider-mill to crush the apples for the press. The concoction of the food in the stomach is as necessary for its future use, as the fermentation of the stum in the vat is to the perfection of the liquor. The disposal of the aliment afterwards; the action and change which it undergoes; the route which it is made to take, in order that, and until that, it arrive at its destination, is more complex indeed and intricate, but, in the midst of complication and intricacy, as evident and certain, as is the apparatus of cocks, pipes, tunnels, for transferring the cider from one vessel to another; of barrels and bottles for preserving it till fit for use, or of cups and glasses for bringing it, when wanted, to the lip of the consumer. The character of the machinery is in both cases this, that one part answers to another part, and every part to the final result.

This parallel between the alimentary operation and some of the processes of art, might be carried further into detail. Spallanzani has remarked(*Note:* Dis. I. sect. liv.) a circumstantial resemblance between the stomachs of gallinaceous fowls and the structure of *corn-mills*. Whilst the two sides of the gizzard perform the office of the mill-stones, the craw or crop supplies the place of the *hopper*.

When our fowls are abundantly supplied with meat, they soon fill their craw: but it does not immediately pass thence into the gizzard; it always enters in very small quantities, in proportion to the progress of trituration; in like manner as, in a mill, a receiver is fixed above the two large stones which serve for grinding the corn; which receiver, although the corn be put into it by bushels, allows the grain to dribble only in small quantities, into the central hole in the upper millstone.

But we have not done with the alimentary history. There subsists a general *relation*between the external organs of an animal by which it procures its food, and the internal powers by which it digests it. Birds of prey, by their talons and beaks, are qualified to seize and devour many species, both of other birds, and of quadrupeds. The constitution of the stomach agrees exactly with the form of the members. The gastric juice of a bird of prey, of an owl, a falcon, or a kite, acts upon the animal fibre alone; it will not act upon seeds or grasses at all. On the other hand, the conformation of the mouth of the sheep or the ox is suited for browsing upon herbage. Nothing about these animals is fitted for the pursuit of living prey. Accordingly it has been found by experiments, tried not many years ago, with perforated balls, that the gastric juice of ruminating animals, such as the sheep, and the ox, speedily dissolves vegetables, but makes no impression upon animal bodies. This accordancy is still more particular. The gastric juice even of granivorous birds, will not act upon the grain, whilst whole and entire. In performing the experiment of digestion with the gastric juice in vessels, the grain must be crushed and bruised, before it be submitted to the menstruum, that is to say, must undergo by art without the body, the preparatory action which the gizzard exerts upon it within the body; or no digestion will take place. So strict, in this case, is the relation between the offices assigned to the digestive organ, between the mechanical operation, and the chymical process.

II. The relation of the kidneys to the bladder, and of the ureters to both, *i. e.* of the secreting organ to the vessel receiving the secreted liquor, and the pipe laid from one to the other for the purpose of conveying it from one to the other, is as manifest as it is amongst the different vessels employed in a distillery, or in the communications between them. The animal structure, in this case, being simple, and the parts easily separated, it forms an instance of correlation which may be presented by dissection to every eye, or which indeed, without dissection, is capable of being apprehended by every understanding. This correlation of instruments to one another fixes intention somewhere.

Especially when every other solution is negatived by the conformation. If the bladder had been merely an expansion of the ureter, produced by retention of the fluid, there ought to have been a bladder for each ureter. One receptacle, fed by two pipes, issuing from different sides of the body, yet from both conveying the same fluid, is not to be accounted for by any such supposition as this.

III. Relation of parts to one another accompanies us throughout the whole animal œconomy. Can any relation be more simple, yet more convincing, than this, that the eyes are so placed as to look in the direction in which the legs move and the hands work? It might have happened very differently, if it had been left to chance. There were, at least, three quarters of the compass out of four to have erred in. Any considerable alteration in the position of the eye, or the figure of the joints, would have disturbed the line, and destroyed the alliance between the sense and the limbs.

IV. But relation perhaps is never so striking as when it subsists, not between different parts of the same thing, but between different things. The relation between a lock and a key is more obvious, than it is between different parts of the lock. A bow was designed for an arrow, and an arrow for a bow: and the design is more evident for their being separate implements.

Nor do the works of the Deity want this clearest species of relation. The *sexes* are manifestly made for each other. They form the grand relation of animated nature; universal, organic, mechanical; subsisting like the clearest relations of art, in different individuals; unequivocal, inexplicable without design.

So much so, that, were every other proof of contrivance in nature dubious or obscure, this alone would be sufficient. The example is complete. Nothing is wanting to the argument. I see no way whatever of getting over it.

V. The teats of animals which give suck, bear a relation to the mouth of the suckling progeny; particularly to the lips and tongue. Here also, as before, is a correspondency of parts; which parts subsist in different individuals.

THESE are *general* relations, or the relations of parts which are found, either in all animals, or in large classes and descriptions of animals. *Particular* relations, or the relations which subsist between the particular configuration of one or more parts of certain species of animals, and the particular configuration of one or more other parts of the same animal (which is the sort of relation, that is, perhaps, most striking), are such as the following:

I. In the *swan;* the web-foot, the spoonbill, the long neck, the thick down, the graminivorous stomach, bear all a relation to one another, inasmuch as they all concur in one design, that of supplying the occasions of an aquatic fowl, floating upon the surface of shallow pools of water, and seeking its food at the bottom. Begin with any one of these particularities of structure, and observe how the rest follow it. The web-foot qualifies the bird for swimming; the spoon-bill enables it to graze. But how is an animal, floating upon the surface of pools of water, to graze at the bottom, except by the mediation of a long neck? A long neck accordingly is given to it. Again, a warm-blooded animal, which was to pass its life upon water, required a defence against the coldness of that element. Such a defence is furnished to the swan, in the muff in which its body is wrapped. But all this outward apparatus would have been in vain, if the intestinal system had not been suited to the digestion of vegetable substances. I say suited to the digestion of vegetable substances: for it is well known, that there are two intestinal systems found in birds, one with a membranous stomach and a gastric juice, capable of dissolving animal substances alone; the other with a crop and gizzard, calculated for the moistening, bruising, and afterwards digesting, of vegetable aliment.

Or set off with any other distinctive part in the body of the swan; for instance, with the long neck. The long neck, without the web-foot, would have been an incumbrance to the bird; yet there is no necessary connexion between a long neck and a web-foot. In fact they do not usually go together. How happens it, therefore, that they meet, only when a particular design demands the aid of both?

III. This mutual relation, arising from a subserviency to a common purpose, is very observable also in the parts of a *mole*. The strong short legs of that animal, the palmated feet armed with sharp nails, the pig-like nose, the teeth, the velvet coat, the small external ear, the sagacious smell, the sunk, protected eye, all conduce to the utilities or to the safety of its underground life. It is a special purpose, specially consulted throughout. The form of the feet fixes the character of the animal. They are so many shovels; they determine its action to that of rooting in the ground; and every thing about its body agrees with this destination. The cylindrical figure of the mole, as well as the compactness of its form, arising from the terseness of its limbs, proportionally lessens its labour; because, according to its bulk, it thereby requires the least possible quantity of earth to be removed for its progress. It has nearly the same structure of the face and jaws as a swine, and the same office for them. The nose is sharp, slender, tendinous, strong; with a pair of nerves, going down to the end of it. The plush covering, which, by the smoothness, closeness, and polish of the short piles that compose it, rejects the adhesion of almost every species of earth, defends the animal from cold and wet, and from the impediment which it would experience by the mould sticking to its body. From soils of all kinds the little pioneer comes forth bright and clean. Inhabiting dirt, it is, of all animals, the neatest.

But what I have always most admired in the mole is its *eyes*. This animal occasionally visiting the surface, and wanting, for its safety and direction, to be informed when it does so, or when it approaches it, a perception of light was necessary. I do not know that the clearness of sight depends at all upon the size of the organ. What is gained by the largeness or prominence of the globe of the eye, is width in the field of vision. Such a capacity would be of no use to an animal which was to seek its food in the dark. The mole did not want to look about it; nor would a large advanced eye have been easily defended from the annoyance to which the life of the animal must constantly expose it. How indeed was the mole, working its way under ground, to guard its eyes at all? In order to meet this difficulty, the eyes are made scarcely larger than the head of a corking pin; and these minute globules are sunk so deeply in the skull, and lie so sheltered within the velvet of its covering, as that any contraction of what may be called the eye-brows, not only closes up the apertures which lead to the eyes, but presents a cushion, as it were, to any sharp or protuding substance which might push against them. This aperture, even in its ordinary state, is like a pin-hole in a piece of velvet, scarcely pervious to loose particles of earth.

Observe then, in this structure, that which we call relation. There is no natural connexion between a small sunk eye and a shovel palmated foot. Palmated feet might have been joined with goggle eyes; or small eyes might have been joined with feet of any other form. What was it therefore which brought them together in the mole? That which brought together the barrel, the chain, and the fusee, in a watch; design; and design, in both cases, inferred, from the relation which the parts bear to one another in the prosecution of a common purpose. As hath already been observed, there are different ways of stating the relation, according as we set out from a different part. In the instance before us, we may either consider the shape of the feet, as qualifying the animal for that mode of life and inhabitation, to which the structure of its eyes confines it; or we may consider the structure of the eye, as the only one which would have suited with the action to which the feet are adapted. The relation is manifest, whichever of the parts related we place first in the order of our consideration. In a word; the feet of the mole are made for digging; the neck, nose, eyes, ears, and skin, are peculiarly adapted to an underground life; and this is what I call relation.

CHAPTER XVI.
COMPENSATION.

COMPENSATION is a species of relation. It is relation when the *defects* of one part, or of one organ, are supplied by the structure of another part or of another organ. Thus,

I. The short unbending neck of the *elephant*, is compensated by the length and flexibility of his *proboscis*. He could not have reached the ground without it; or, if it be supposed that he might have fed upon the fruit, leaves, or branches of trees, how was he to drink? Should it be asked, Why is the elephant's neck so short? it may be answered, that the weight of a head so heavy could not have been supported at the end of a longer lever. To a form, therefore, in some respects necessary, but in some respects also inadequate to the occasion of the animal, a supplement is added, which exactly makes up the deficiency under which he laboured.

If it be suggested that this proboscis may have been produced, in a long course of generations, by the constant endeavour of the elephant to thrust out his nose (which is the general hypothesis by which it has lately been attempted to account for the forms of animated nature), I would ask, How was the animal to subsist in the mean time; during the process; *until* this prolongation of snout were completed? What was to become of the individual, whilst the species was perfecting?

Our business at present is, simply to point out the relation which this organ bears to the peculiar figure of the animal to which it belongs. And herein all things correspond. The necessity of the elephant's proboscis arises from the shortness of his neck; the shortness of the neck is rendered necessary by the weight of the head. Were we to enter into an examination of the structure and anatomy of the proboscis itself, we should see in it one of the most curious of all examples of animal mechanism. The disposition of the ringlets and fibres, for the purpose, first, of forming a long cartilaginous pipe; secondly, of contracting and lengthening that pipe; thirdly, of turning it in every direction at the will of the animal; with the superaddition at the end, of a fleshy production, of about the length and thickness of a finger, and performing the office of a finger, so as to pick up a straw from the ground; these properties of the same organ, taken together, exhibit a specimen, not only of design (which is attested by the advantage), but of consummate art, and, as I may say, of elaborate preparation, in accomplishing that design.

II. The hook in the wing of a *bat* is strictly a mechanical, and, also, a *compensating*contrivance. At the angle of its wing there is a bent claw, exactly in the form of a hook, by which the bat attaches itself to the sides of rocks, caves, and buildings, laying hold of crevices, joinings, chinks, and roughnesses. It hooks itself by this claw; remains suspended by this hold; takes its flight from this position: which operations compensate for the decrepitude of its legs and feet. Without her hook, the bat would be the most helpless of all animals. She can neither run upon her feet, nor raise herself from the ground. These inabilities are made up to her by the contrivance in her wing: and in placing a claw on that part, the Creator has deviated from the analogy observed in winged animals.--A singular defect required a singular substitute.

III. The *crane*-kind are to live and seek their food amongst the waters; yet, having no web-feet, are incapable of swimming. To make up for this deficiency, they are furnished with long legs for wading, or long bills for groping; or usually with both. This is *compensation*. But I think the true reflection upon the present instance is, how every part of nature is tenanted by appropriate inhabitants. Not only is the surface of deep waters peopled by numerous tribes of birds that swim, but marshes and shallow pools are furnished with hardly less numerous tribes of birds that wade.

IV. The common *parrot* has, in the structure of its beak, both an inconveniency, and a *compensation* for it. When I speak of an inconveniency, I have a view to a dilemma which

frequently occurs in the works of nature, viz. that the peculiarity of structure by which an organ is made to answer one purpose, necessarily unfits it for some other purpose. This is the case before us. The upper bill of the parrot is so much hooked, and so much overlaps the lower, that if, as in other birds, the lower chap alone had motion, the bird could scarcely gape wide enough to receive its food: yet this hook and overlapping of the bill could not be spared, for it forms the very instrument by which the bird climbs: to say nothing of the use which it makes of it in breaking nuts and the hard substances upon which it feeds. How, therefore, has nature provided for the opening of this occluded mouth? By making the upper chap moveable, as well as the lower. In most birds, the upper chap is connected, and makes but one piece, with the skull; but in the parrot, the upper chap is joined to the bone of the head by a strong membrane placed on each side of it, which lifts and depresses it at pleasure(*Note:* Goldsmith's Natural History, vol. v. p. 274.).

V. The *spider's web* is a *compensating* contrivance. The spider lives upon flies, without wings to pursue them; a case one would have thought, of great difficulty, yet provided for, and provided for by a resource which no stratagem, no effort of the animal, could have produced, had not both its external and internal structure been specifically adapted to the operation.

VI. In many species of insects, the eye is fixed; and consequently without the power of turning the pupil to the object. This great defect is, however, perfectly *compensated*; and by a mechanism which we should not suspect. The eye is a multiplying glass, with a lens looking in every direction and catching every object. By which means, although the orb of the eye be stationary, the field of vision is as ample as that of other animals, and is commanded on every side. When this lattice-work was first observed, the multiplicity and minuteness of the surfaces must have added to the surprise of the discovery. Adams tells us, that fourteen hundred of these reticulations have been counted in the two eyes of a drone-bee.

In other cases the *compensation* is effected by the number and position of the eyes themselves. The spider has eight eyes, mounted upon different parts of the head; two in front, two in the top of the head, two on each side. These eyes are without motion; but, by their situation, suited to comprehend every view which the wants or safety of the animal render it necessary for it to take.

VII. The Memoirs for the Natural History of Animals, published by the French Academy, A. D. 1687, furnish us with some curious particulars in the eye of a chameleon. Instead of two eyelids, it is covered by an eyelid with a hole in it. This singular structure appears to be *compensatory*, and to answer to some other singularities in the shape of the animal. The neck of the chameleon is inflexible. To make up for this, the eye is so prominent, as that more than half of the ball stands out of the head; by means of which extraordinary projection, the pupil of the eye can be carried by the muscles in every direction, and is capable of being pointed towards every object. But then, so unusual an exposure of the globe of the eye requires, for its lubricity and defence, a more than ordinary protection of eyelid, as well as a more than ordinary supply of moisture; yet the motion of an eyelid, formed according to the common construction, would be impeded, as it should seem, by the convexity of the organ. The aperture in the lid meets this difficulty. It enables the animal to keep the principal part of the surface of the eye under cover, and to preserve it in a due state of humidity without shutting out the light; or without performing every moment a nictitation, which, it is probable, would be more laborious to this animal than to others.

VIII. In another animal, and in another part of the animal œconomy, the same Memoirs describe a most remarkable *substitution*. The reader will remember what we have already observed concerning the *intestinal*canal; that its length, so many times exceeding that of the body, promotes the extraction of the chyle from the aliment, by giving room for the lacteal vessels to act upon it through a greater space. This long intestine, wherever it occurs, is, in other animals, disposed in the abdomen from side to side in returning folds. But, in the animal now under our notice, the

matter is managed otherwise. The same intention is mechanically effectuated; but by a mechanism of a different kind. The animal of which I speak, is an amphibious quadruped, which our authors call the alopecias, or sea-fox. The intestine is straight from one end to the other: but in this straight, and consequently short intestine, is a winding, corkscrew, spiral passage, through which the food, not without several circumvolutions, and in fact by a long route, is conducted to its exit. Here the shortness of the gut is *compensated* by the obliquity of the perforation. IX. But the works of the Deity are known by expedients. Where we should look for absolute destitution; where we can reckon up nothing but wants; some contrivance always comes in, to supply the privation. A *snail*, without wings, feet, or thread, climbs up the stalks of plants, by the sole aid of a viscid humour discharged from her skin. She adheres to the stems, leaves, and fruits of plants, by means of a sticking-plaister. A *muscle*, which might seem, by its helplessness, to lie at the mercy of every wave that went over it, has the singular power of spinning strong, tendinous threads, by which she moors her shell to rocks and timbers. A *cockle*, on the contrary, by means of its stiff tongue, works for itself a shelter in the sand. The provisions of nature extend to cases the most desperate. A *lobster* has in its constitution a difficulty so great, that one could hardly conjecture beforehand how nature would dispose of it. In most animals, the skin grows with their growth. If, instead of a soft skin, there be a shell, still it admits of a gradual enlargement. If the shell, as in the tortoise, consist of several pieces, the accession of substance is made at the sutures. Bivalve shells grow bigger by receiving an accretion at their edge; it is the same with spiral shells at their mouth. The simplicity of their form admits of this. But the lobster's shell being applied to the limbs of the body, as well as to the body itself, allows not of either of the modes of growth which are observed to take place in other shells. Its hardness resists expansion; and its complexity renders it incapable of increasing its size by addition of substance to its edge. How then was the growth of the lobster to be provided for? Was room to be made for it in the old shell, or was it to be successively fitted with new ones? If a change of shell became necessary, how was the lobster to extricate himself from his present confinement? how was he to uncase his buckler, or draw his legs out of his boots? The process, which fishermen have observed to take place, is as follows: At certain seasons, the shell of the lobster grows soft; the animal swells its body; the seams open, and the claws burst at the joints. When the shell has thus become loose upon the body, the animal makes a second effort, and by a tremulous, spasmodic motion, casts it off. In this state, the liberated but defenceless fish retires into holes in the rock. The released body now suddenly pushes its growth. In about eight-and-forty hours, a fresh concretion of humour upon the surface, *i. e.* a new shell, is formed, adapted in every part to the increased dimensions of the animal. This wonderful mutation is repeated every year.

If there be imputed defects without compensation, I should suspect that they were defects only in appearance. Thus, the body of the *sloth* has often been reproached for the slowness of its motions, which has been attributed to an imperfection in the formation of its limbs. But it ought to be observed, that it is this slowness which alone suspends the voracity of the animal. He fasts during his migration from one tree to another: and this fast may be necessary for the relief of his over-charged vessels, as well as to allow time for the concoction of the mass of coarse and hard food which he has taken into his stomach. The tardiness of his pace seems to have reference to the capacity of his organs, and to his propensities with respect to food; *i. e.* is calculated to counteract the effects of repletion.

Or there may be cases, in which a defect is artificial, and compensated by the very cause which produces it. Thus the *sheep*, in the domesticated state in which we see it, is destitute of the ordinary means of defence or escape; is incapable either of resistance or flight. But this is not so with the wild animal. The natural sheep is swift and active: and, if it lose these qualities when it comes under the subjection of man, the loss is compensated by his protection. Perhaps there is no species of quadruped whatever, which suffers so little as this does, from the depredation of animals of prey.

For the sake of making our meaning better understood, we have considered this business of compensation under certain *particularities*of constitution, in which it appears to be most conspicuous. This view of the subject necessarily limits the instances to single species of animals. But there are compensations, perhaps, not less certain, which extend over large classes, and to large portions of living nature.

I. In quadrupeds, the deficiency of teeth is usually *compensated* by the faculty of rumination. The sheep, deer, and ox tribe, are without fore-teeth in the upper jaw. These ruminate. The horse and ass are furnished with teeth in the upper jaw, and do not ruminate. In the former class, the grass and hay descend into the stomach, nearly in the state in which they are cropped from the pasture, or gathered from the bundle. In the stomach, they are softened by the gastric juice, which in these animals is unusually copious. Thus softened and rendered tender, they are returned a second time to the action of the mouth, where the grinding teeth complete at their leisure the trituration which is necessary, but which was before left imperfect. I say, the trituration which is necessary; for it appears from experiments, that the gastric fluid of sheep, for example, has no effect in digesting plants, unless they have been previously masticated; that it only produces a slight maceration, nearly as common water would do in a like degree of heat; but that when once vegetables are reduced to pieces by mastication, the fluid then exerts upon them its specific operation. Its first effect is to soften them, and to destroy their natural consistency; it then goes on to dissolve them; not sparing even the toughest parts, such as the nerves of the leaves(*Note:* Spall. Dis. iii. sect. cxl.).

I think it very probable, that the gratification also of the animal is renewed and prolonged by this faculty. Sheep, deer, and oxen, appear to be in a state of enjoyment whilst they are chewing the cud. It is then, perhaps, that they best relish their food.

II. In birds, the *compensation* is still more striking. They have no teeth at all. What have they then to make up for this severe want? I speak of granivorous and herbivorous birds; such as common fowls, turkeys, ducks, geese, pi eons, &c.; for, it is concerning these alone that the question need be asked. All these are furnished with a peculiar and most powerful muscle, called the *gizzard;*the inner coat of which is fitted up with rough plaits, which, by a strong friction against one another, break and grind the hard aliment as effectually, and by the same mechanical action, as a coffee-mill would do. It has been proved by the most correct experiments, that the gastric juice of these birds will not operate upon the *entire* grain; not even when softened by water or macerated in the crop. Therefore without a grinding machine within its body, without the trituration of the gizzard, a chicken would have starved upon a heap of corn. Yet why should a bill and a gizzard go together? Why should a gizzard never be found where there are teeth?

Nor does the gizzard belong to birds as such. A gizzard is not found in birds of prey. *Their* food requires not to be ground down in a mill. The compensatory contrivance goes no further than the necessity. In both classes of birds, however, the digestive organ within the body bears a strict and mechanical relation to the external instruments for procuring food. The soft membranous stomach accompanies a hooked, notched beak; short, muscular legs; strong, sharp, crooked talons: the cartilaginous stomach attends that conformation of bill and toes, which restrains the bird to the picking of seeds, or the cropping of plants.

III. But to proceed with our *compensations*.--A very numerous and comprehensive tribe of terrestrial animals are entirely without feet; yet locomotive; and in a very considerable degree swift in their motion. How is the *want of feet* compensated? It is done by the disposition of the muscles and fibres of the trunk. In consequence of the just collocation, and by means of the joint action of longitudinal and annular fibres, that is to say, of strings and rings, the body and train of

reptiles are capable of being reciprocally shortened and lengthened, drawn up and stretched out. The result of this action is a progressive, and, in some cases, a rapid movement of the whole body, in any direction to which the will of the animal determines it. The meanest creature is a collection of wonders. The play of the rings in an *earthworm*, as it crawls; the undulatory motion propagated along the body; the beards or prickles with which the annuli are armed, and which the animal can either shut up close to its body, or let out to lay hold of the roughness of the surface upon which it creeps; and the power arising from all these, of changing its place and position, affords, when compared with the provisions for motion in other animals, proofs of new and appropriate mechanism. Suppose that we had never seen an animal move upon the ground without feet, and that the problem was; muscular action, *i. e.* reciprocal contraction and relaxation being given, to describe how such an animal might be constructed, capable of voluntarily changing place. Something, perhaps, like the organization of reptiles, might have been hit upon by the ingenuity of an artist; or might have been exhibited in an automaton, by the combination of springs, spiral wires, and ringlets: but to the solution of the problem would not be denied, surely, the praise of invention and of successful thought: least of all could it ever be questioned, whether intelligence had been employed about it, or not.

CHAPTER XVII.

THE RELATION OF ANIMATED BODIES TO INANIMATE NATURE. WE have already considered *relation*, and under different views; but it was the relation of parts to parts, of the parts of an animal to other parts of the same animal, or of another individual of the same species.

But the bodies of animals hold, in their constitution and properties, a close and important relation to natures altogether external to their own; to inanimate substances, and to the specific qualities of these, e. g. *they hold a strict relation to the* ELEMENTS*by which they are surrounded*.

I. Can it be doubted, whether the *wings of birds* bear a relation to air, and the *fins of fish* to water? They are instruments of motion, severally suited to the properties of the medium in which the motion is to be performed: which properties are different. Was not this difference contemplated, when the instruments were differently constituted?

II. The structure of the animal *ear* depends for its use not simply upon being surrounded by a fluid, but upon the specific nature of that fluid. Every fluid would not serve: its particles must repel one another; it must form an elastic medium: for it is by the successive pulses of *such* a medium, that the undulations excited by the surrounding body are carried to the organ; that a communication is formed between the object and the sense; which must be done, before the internal machinery of the ear, subtile as it is, can act at all.

III. The *organs* of voice, and respiration, are, no less than the ear, indebted, for the success of their operation, to the peculiar qualities of the fluid, in which the animal is immersed. They, therefore, as well as the ear, are constituted upon the supposition of such a fluid, *i. e.* of a fluid with such particular properties, being always present. Change the properties of the fluid, and the organ cannot act; change the organ, and the properties of the fluid would be lost. The structure therefore of our organs, and the properties of our atmosphere, are made for one another. Nor does it alter the relation, whether you allege the organ to be made for the element (which seems the most natural way of considering it), or the element as prepared for the organ. IV. But there is another fluid with which we have to do; with properties of its own; with laws of acting, and of being acted upon, totally different from those of air and water: and that is *light*. To this new, this singular element; to qualities perfectly peculiar, perfectly distinct and remote from the qualities of any other substance with which we are acquainted, an organ is adapted, an instrument is correctly adjusted, not less peculiar amongst the parts of the body, not less singular in its form, and in the substance of which it is composed, not less remote from the materials, the model, and the analogy

of any other part of the animal frame, than the element to which it relates, is specific amidst the substances with which we converse. If this does not prove appropriation, I desire to know what would prove it.

Yet the element of light and the organ of vision, however related in their office and use, have no connexion whatever in their original. The action of rays of light upon the surfaces of animals, has no tendency to breed eyes in their heads. The sun might shine for ever upon living bodies without the smallest approach towards producing the sense of sight. On the other hand also, the animal eye does *not* generate or emit light. V. Throughout the universe there is a wonderful *proportioning* of one thing to another. The size of animals, of the human animal especially, when considered with respect to other animals, or to the plants which grow around him, is such, as a regard to his conveniency would have pointed out. A giant or a pygmy could not have milked goats, reaped corn, or mowed grass; we may add, could not have rode a horse, trained a vine, shorn a sheep, with the same bodily ease as we do, if at all. A pygmy would have been lost amongst rushes, or carried off by birds of prey.

It may be mentioned likewise, that the model and the materials of the human body being what they are, a much greater bulk would have broken down by its own weight. The persons of men who much exceed the ordinary stature, betray this tendency.

VI. Again (and which includes a vast variety of particulars, and those of the greatest importance); how close is the *suitableness*of the earth and sea to their several inhabitants; and of these inhabitants, to the places of their appointed residence!

Take the *earth* as it is; and consider the correspondency of the powers of its inhabitants with the properties and condition of the soil which they tread. Take the inhabitants as they are; and consider the substances which the earth yields for their use. They can scratch its surface; and its surface supplies all which they want. This is the length of their faculties: and such is the constitution of the globe, and their own, that this is sufficient for all their occasions.

When we pass from the earth to the *sea*, from land to water, we pass through a great change: but an adequate change accompanies us, of animal forms and functions, of animal capacities and wants; so that *correspondency*remains. The earth in its nature is very different from the sea, and the sea from the earth: but one accords with its inhabitants, as exactly as the other.

VII. The last relation of this kind which I shall mention, is that of *sleep* to *night:* and it appears to me to be a relation which was expressly intended. Two points are manifest; first, that the animal frame requires sleep; secondly, that night brings with it a silence, and a cessation of activity, which allows of sleep being taken without interruption, and without loss. Animal existence is made up of action and slumber; nature has provided a season for each. An animal, which stood not in need of rest, would always live in day-light. An animal, which, though made for action, and delighting in action, must have its strength repaired by sleep, meets, by its constitution, the returns of day and night. In the human species, for instance, were the bustle, the labour, the motion of life upheld by the constant presence of light, sleep could not be enjoyed without being disturbed by noise, and without expense of that time which the eagerness of private interest would not contentedly resign. It is happy therefore for this part of the creation, I mean that it is conformable to the frame and wants of their constitution, that nature, by the very disposition of her elements, has commanded, as it were, and imposed upon them, at moderate intervals, a general intermission of their toils, their occupations, and pursuits.

But it is not for man, either solely or principally, that night is made. Inferior, but less perverted natures, taste its solace, and expect its return, with greater exactness and advantage than he does.

I have often observed, and never observed but to admire, the satisfaction, no less than the regularity, with which the greatest part of the irrational world yield to this soft necessity, this grateful vicissitude; how comfortably the birds of the air, for example, address themselves to the repose of the evening; with what alertness they resume the activity of the day!

Nor does it disturb our argument to confess, that certain species of animals are in motion during the night, and at rest in the day. With respect even to them, it is still true, that there is a change of condition in the animal, and an external change corresponding with it. There is still the relation, though inverted. The fact is, that the repose of other animals sets these at liberty, and invites them to their food or their sport.

If the relation of *sleep* to *night*, and, in some instances, its converse, be real, we cannot reflect without amazement upon the extent to which it carries us. Day and night are things close to us; the change applies immediately to our sensations; of all the phænomena of nature, it is the most obvious and the most familiar to our experience: but, in its cause, it belongs to the great motions which are passing in the heavens. Whilst the earth glides round her axle, she ministers to the alternate necessities of the animals dwelling upon her surface, at the same time that she obeys the influence of those attractions which regulate the order of many thousand worlds. The relation therefore of sleep to night, is the relation of the inhabitants of the earth to the rotation of their globe; probably it is more; it is a relation to the system, of which that globe is a part; and, still further, to the congregation of systems, of which theirs is only one. If this account be true, it connects the meanest individual with the universe itself; a chicken roosting upon its perch, with the spheres revolving in the firmament.

VIII. But if any one object to our representation, that the succession of day and night, or the rotation of the earth upon which it depends, is not resolvable into central attraction, we will refer him to that which certainly is,--to the change of the seasons. Now the constitution of animals susceptible of torpor, bears a relation to winter, similar to that which sleep bears to night. Against not only the cold, but the want of food, which the approach of winter induces, the Preserver of the world has provided in many animals by migration, in many others by torpor. As one example out of a thousand; the bat, if it did not sleep through the winter, must have starved, as the moths and flying insects upon which it feeds disappear. But the transition from summer to winter carries us into the very midst of physical astronomy, that is to say, into the midst of those laws which govern the solar system at least, and probably all the heavenly bodies.

CHAPTER XVIII.
INSTINCTS.

THE order may not be very obvious, by which I place *instincts* next to relations. But I consider them as a species of relation. They contribute, along with the animal organization, to a joint effect, in which view they are related to that organization. In many cases, they refer from one animal to another animal; and, when this is the case, become strictly relations in a second point of view.

An INSTINCT is a propensity, prior to experience, and independent of instruction. We contend, that it is by *instinct* that the sexes of animals seek each other; that animals cherish their offspring; that the young quadruped is directed to the teat of its dam; that birds build their nests, and brood with so much patience upon their eggs; that insects which do not sit upon their eggs, deposit them in those particular situations, in which the young, when hatched, find their appropriate food; that it is instinct which carries the salmon, and some other fish, out of the sea into rivers, for the purpose of shedding their spawn in fresh water.

We may select out of *this* catalogue the incubation of eggs. I entertain no doubt, but that a couple of sparrows hatched in an oven, and kept separate from the rest of their species, would proceed as other sparrows do, in every office which related to the production and preservation of their brood. Assuming this fact, the thing is inexplicable upon any other hypothesis than that of an instinct, impressed upon the constitution of the animal. For, first, what should induce the female bird to prepare a nest before she lays her eggs? It is in vain to suppose her to be possessed of the faculty of reasoning: for, no reasoning will reach the case. The fulness or distention which she might feel in a particular part of her body, from the growth and solidity of the egg within her, could not possibly inform her, that she was about to produce something, which, when produced, was to be preserved and taken care of. Prior to experience, there was nothing to lead to this inference, or to this suspicion. The analogy was *all* against it: for, in every other instance, what issued from the body, was cast out and rejected.

But, secondly, let us suppose the egg to be produced into day; how should birds know that their eggs contain their young? There is nothing, either in the aspect or in the internal composition of an egg, which could lead even the most daring imagination to conjecture, that it was hereafter to turn out from under its shell, a living, perfect bird. The form of the egg bears not the rudiments of a resemblance to that of the bird. Inspecting its contents, we find still less reason, if possible, to look for the result which actually takes place. If we should go so far, as, from the appearance of order and distinction in the disposition of the liquid substances which we noticed in the egg, to guess that it might be designed for the abode and nutriment of an animal (which would be a very bold hypothesis), we should expect a tadpole dabbling in the slime, much rather than a dry, winged, feathered creature; a compound of parts and properties impossible to be used in a state of confinement in the egg, and bearing no conceivable relation, either in quality or material, to any thing observed in it. From the white of an egg, would any one look for the feather of a gold-finch? or expect from a simple uniform mucilage, the most complicated of all machines, the most diversified of all collections of substances? Nor would the process of incubation, for some time at least, lead us to suspect the event. Who that saw red streaks, shooting in the fine membrane which divides the white from the yolk, would suppose that these were about to become bones and limbs? Who, that espied two discoloured points first making their appearance in the cicatrix, would have had the courage to predict, that these points were to grow into the heart and head of a bird? It is difficult to strip the mind of its experience. It is difficult to resuscitate surprise, when familiarity has once laid the sentiment asleep. But could we forget all that we know, and which *our* sparrows never knew, about oviparous generation; could we divest ourselves of every information, but what we derived from reasoning upon the appearances or quality discovered in the objects presented to us, I am convinced that Harlequin coming out of an egg upon the stage, is not more astonishing to a child, than the hatching of a chicken both would be, and ought to be, to a philosopher. But admit the sparrow by some means to know, that within that egg was concealed the principle of a future bird: from what chymist was she to learn, that *warmth* was necessary to bring it to maturity, or that the degree of warmth, imparted by the temperature of her own body, was the degree required?

To suppose, therefore, that the female bird acts in this process from a sagacity and reason of her own, is to suppose her to arrive at conclusions which there are no premises to justify. If our sparrow, sitting upon her eggs, expect young sparrows to come out of them, she forms, I will venture to say, a wild and extravagant expectation, in opposition to present appearances, and to probability. She must have penetrated into the order of nature, further than any faculties of ours will carry us: and it hath been well observed, that this deep sagacity, if it be sagacity, subsists in conjunction with great stupidity, even in relation to the same subject. "A chymical operation," says Addison, "could not be followed with greater art or diligence, than is seen in hatching a chicken: yet is the process carried on without the least glimmering of thought or common sense. The hen will mistake a piece of"

"" chalk for an egg; is insensible of the increase or diminution of their number; does not distinguish between her own and those of another species; is frightened when her supposititious breed of ducklings take the water.

But it will be said, that what reason could not do for the bird, observation, or instruction, or tradition might. Now if it be true, that a couple of sparrows, brought up from the first in a state of separation from all other birds, would build their nest, and brood upon their eggs, then there is an end of this solution. What can be the traditionary knowledge of a chicken hatched in an oven?

Of young birds taken in their nests, a few species breed, when kept in cages; and they which do so, build their nests nearly in the same manner as in the wild state, and sit upon their eggs. This is sufficient to prove an instinct, without having recourse to experiments upon birds, hatched by artificial heat, and deprived, from their birth, of all communication with their species: for we can hardly bring ourselves to believe, that the parent bird informed her unfledged pupil of the history of her gestation, her timely preparation of a nest, her exclusion of the eggs, her long incubation, and of the joyful eruption at last of her expected offspring; all which the bird in the cage must have learnt in her infancy, if we resolve her conduct into *institution*.

Unless we will rather suppose, that she remembers her own escape from the egg; had attentively observed the conformation of the nest in which she was nurtured; and had treasured up her remarks for future imitation: which is not only extremely improbable (for who, that sees a brood of callow birds in their nest, can believe that they are taking a plan of their habitation?), but leaves unaccounted for, one principal part of the difficulty, "the preparation of the nest before the laying of the egg." This she could not gain from observation in her infancy.

It is remarkable also, that the hen sits upon eggs which she has laid without any communication with the male; and which are therefore necessarily unfruitful. That secret she is not let into. Yet, if incubation had been a subject of instruction or of tradition, it should seem that this distinction would have formed part of the lesson: whereas the instinct of nature is calculated for a state of nature: the exception here alluded to, taking place, chiefly, if not solely, amongst domesticated fowls, in which nature is forced out of her course. There is another case of oviparous œconomy, which is still less likely to be the effect of education, than it is even in birds, namely, that of *moths* and *butterflies*, which deposit their eggs in the precise substance, that of a cabbage for example, from which, not the butterfly herself, but the caterpillar which is to issue from her egg, draws its appropriate food. The butterfly cannot taste the cabbage. Cabbage is no food for her: yet in the cabbage, not by chance, but studiously and electively, she lays her eggs. There are, amongst many other kinds, the willow-caterpillar and the cabbage-caterpillar: but we never find upon a willow, the caterpillar which eats the cabbage; nor the converse. This choice, as appears to me, cannot in the butterfly proceed from instruction. She had no teacher in her caterpillar state. She never knew her parent. I do not see, therefore, how knowledge, acquired by experience, if it ever were such, could be transmitted from one generation to another. There is no opportunity either for instruction or imitation. The parent race is gone, before the new brood is hatched. And if it be original reasoning in the butterfly, it is profound reasoning indeed. She must remember her caterpillar state, its tastes and habits: of which memory she shows no signs whatever. She must conclude from analogy (for here her recollection cannot serve her), that the little round body, which drops from her abdomen, will at a future period produce a living creature, not like herself, but like the caterpillar which she remembers herself once to have been. Under the influence of these reflections, she goes about to make provision for an order of things, which she concludes will, some time or other, take place. And it is to be observed, that not a few out of many, but that all butterflies argue thus; all draw this conclusion; all act upon it.

But suppose the address, and the selection, and the plan, which we perceive in the preparations which many irrational animals make for their young, to be traced to some probable origin; still there is left to be accounted for, that which is the source and foundation of these phænomena,

that which sets the whole at work, the , the parental affection which I contend to be inexplicable upon any other hypothesis than that of instinct.

For we shall hardly, I imagine, in brutes, refer their conduct towards their offspring to a sense of duty, or of decency, a care of reputation, a compliance with public manners, with public laws, or with rules of life built upon a long experience of their utility. And all attempts to account for the parental affection from association, I think, fail. With what is it associated? Most immediately with the throes of parturition, that is, with pain and terror and disease. The more remote, but not less strong association, that which depends upon analogy, is all against it. Every thing else, which proceeds from the body, is cast away, and rejected. In birds, is it the egg which the hen loves? or is it the expectation which she cherishes of a future progeny, that keeps her upon her nest? What cause has she to expect delight from her progeny? Can any rational answer be given to the question, why, prior to experience, the brooding hen should look for pleasure from her chickens? It does not, I think, appear, that the cuckoo ever knows her young: yet, in her way, she is as careful in making provision for them, as any other bird. She does not leave her egg in every hole.

The salmon suffers no surmountable obstacle to oppose her progress up the stream of fresh rivers. And what does she do there? She sheds a spawn, which she immediately quits, in order to return to the sea: and this issue of her body, she never afterwards recognizes in any shape whatever. Where shall we find a motive for her efforts and her perseverance? Shall we seek it in argumentation, or in instinct? The violet crab of Jamaica performs a fatiguing march of some months' continuance, from the mountains to the seaside. When she reaches the coast, she casts her spawn into the open sea; and sets out upon her return home.

Moths and butterflies, as hath already been observed, seek out for their eggs those precise situations and substances in which the offspring caterpillar will find its appropriate food. That dear caterpillar, the parent butterfly must never see. There are no experiments to prove that she would retain any knowledge of it, if she did. How shall we account for her conduct? I do not mean for her art and judgement in selecting and securing a maintenance for her young, but for the impulse upon which she acts. What should induce her to exert any art, or judgment, or choice, about the matter? The undisclosed grub, the animal, which she is destined not to know, can hardly be the object of a particular affection, if we deny the influence of instinct. There is nothing, therefore, left to her, but that of which her nature seems incapable, an abstract anxiety for the general preservation of the species; a kind of patriotism; a solicitude lest the butterfly race should cease from the creation.

Lastly; the principle of association will not explain the discontinuance of the affection when the young animal is grown up. Association, operating in its usual way, would rather produce a contrary effect. The object would become more necessary, by habits of society: whereas birds and beasts, after a certain time, banish their offspring; disown their acquaintance; seem to have even no knowledge of the objects which so lately engrossed the attention of their minds, and occupied the industry and labour of their bodies. This change, in different animals, takes place at different distances of time from the birth: but the time always corresponds with the ability of the young animal to maintain itself; never anticipates it. In the sparrow tribe, when it is perceived that the young brood can fly, and shift for themselves, then the parents forsake them for ever; and, though they continue to live together, pay them no more attention than they do to other birds in the same flock(*Note:* Goldsmith's Natural History, vol. iv. p. 244.). I believe the same thing is true of all gregarious quadrupeds.

In this part of the case, the variety of resources, expedients, and materials, which animals of the same species are said to have recourse to, under different circumstances, and when differently supplied, makes nothing against the doctrine of insects. The thing which we want to account for, is the propensity. The propensity being there, it is probable enough that it may put the animal upon different actions, according to different exigencies. And this adaptation of resources may look like the effect of art and consideration, rather than of instinct: but still the propensity is instinctive. For instance, suppose what is related of the woodpecker to be true, that in Europe she deposits her eggs in cavities, which she scoops out in the trunks of soft or decayed trees, and in which cavities the eggs lie concealed from the eye, and in some sort safe from the hand, of man: but that, in the forests of Guinea and the Brazils, which man seldom frequents, the same bird hangs her nest to the twigs of tall trees; thereby placing them out of the reach of *monkeys* and *snakes*, i. e. that in each situation she prepares against the danger which she has most occasion to apprehend: suppose, I say, this to be true, and to be alleged, on the part of the bird that builds these nests, as evidence of a reasoning and distinguishing precaution; still the question returns, whence the propensity to build at all?

Nor does parental affection accompany generation by any universal law of animal organization, if such a thing were intelligible. Some animals cherish their progeny with the most ardent fondness, and the most assiduous attention; others entirely neglect them: and this distinction always meets the constitution of the young animal, with respect to its wants and capacities. In many, the parental care extends to the young animal; in others, as in all oviparous fish, it is confined to the egg, and even, as to that, to the disposal of it in its proper element. Also, as there is generation without parental affection, so is there parental instinct, or what exactly resembles it, without generation. In the bee tribe, the grub is nurtured neither by the father nor the mother, but by the neutral bee. Probably the case is the same with ants.

I am not ignorant of the theory which resolves instinct into sensation; which asserts, that what appears to have a view and relation to the future, is the result only of the present disposition of the animal's body, and of pleasure or pain experienced *at the time*. Thus the incubation of eggs is accounted for by the pleasure which the bird is supposed to receive from the pressure of the smooth convex surface of the shells against the abdomen, or by the relief which the mild temperature of the egg may afford to the heat of the lower part of the body, which is observed at this time to be increased beyond its usual state. This present gratification is the only motive with the hen for sitting upon her nest; the hatching of the chickens is, with respect to her, an accidental consequence. The affection of viviparous animals for their young is, in like manner, solved by the relief, and perhaps the pleasure, which they perceive from giving suck. The young animal's seeking, in so many instances, the teat of its dam, is explained from its sense of smell, which is attracted by the odour of milk. The salmon's urging its way up the stream of fresh-water rivers, is attributed to some gratification or refreshment, which, in this particular state of the fish's body, she receives from the change of element. Now of this theory it may be said,

First, that of the cases which require solution, there are few to which it can be applied with tolerable probability; that there are none to which it can be applied without strong objections, furnished by the circumstances of the case. The attention of the cow to its calf, and of the ewe to its lamb, appear to be prior to their sucking. The attraction of the calf or lamb to the teat of the dam is not explained by simply referring it to the sense of smell. What made the scent of milk so agreeable to the lamb, that it should follow it up with its nose, or seek with its mouth the place from which it proceeded? No observation, no experience, no argument could teach the new-dropped animal, that the substance, from which the scent issued, was the material of its food. It had never tasted milk before its birth. None of the animals, which are not designed for that

nourishment, ever offer to suck, or to seek out any such food. What is the conclusion, but that the sugescent parts of animals are fitted for their use, and the knowledge of that use put into them?

We assert, secondly, that, even as to the cases in which the hypothesis has the fairest claim to consideration, it does not at all lessen the force of the argument for intention and design. The doctrine of instincts is that of appetencies, *superadded* to the constitution of an animal, for the effectuating of a purpose beneficial to the species. The above-stated solution would derive these appetencies from organization; but then this organization is not less specifically, not less precisely, and, therefore, not less evidently adapted to the same ends, than the appetencies themselves would be upon the old hypothesis. In this way of considering the subject, sensation supplies the place of foresight: but this is the effect of contrivance on the part of the Creator. Let it be allowed, for example, that the hen is induced to brood upon her eggs by the enjoyment or relief, which in the heated state of her abdomen, she experiences from the pressure of round smooth surfaces, or from the application of a temperate warmth. How comes this extraordinary heat or itching, or call it what you will, which you suppose to be the cause of the bird's inclination, to be felt, just at the time when the inclination itself is wanted; when it tallies so exactly with the internal constitution of the egg, and with the help which that constitution requires in order to bring it to maturity? In my opinion, this solution, if it be accepted as to the fact, ought to increase, rather than otherwise, our admiration of the contrivance. A gardener lighting up his stoves, just when he wants to force his fruit, and when his trees require the heat, gives not a more certain evidence of design. So again; when a male and female sparrow come together, they do not meet to confer upon the expediency of perpetuating their species. As an abstract proposition, they care not the value of a barley-corn, whether the species be perpetuated, or not: they follow their sensations; and all those consequences ensue, which the wisest counsels could have dictated, which the most solicitous care of futurity, which the most anxious concern for the sparrow-world, could have produced. But how do these consequences ensue? The sensations, and the constitution upon which they depend, are as manifestly directed to the purpose which we see fulfilled by them; and the train of intermediate effects, as manifestly laid and planned with a view to that purpose: that is to say, design is as completely evinced by the phænomena, as it would be, even if we suppose the operations to begin, or to be carried on, from what some will allow to be alone properly called instincts, that is, from desires directed to a future end, and having no accomplishment or gratification distinct from the attainment of that end.

In a word; I should say to the patrons of this opinion, Be it so: be it, that those actions of animals which we refer to instinct, are not gone about with any view to their consequences, but that they are attended in the animal with a present gratification, and are pursued for the sake of that gratification alone: what does all this prove, but that the *prospection*, which must be somewhere, is not in the animal, but in the Creator!

In treating of the parental affection in brutes, our business lies rather with the origin of the principle, than with the effects and expressions of it. Writers recount these with pleasure and admiration. The conduct of many kinds of animals towards their young, has escaped no observer, no historian of nature. "How will they caress them," says Derham, "with their affectionate notes; lull and quiet them with their tender parental voice; put food into their mouths; cherish and keep them warm; teach them to pick, and eat, and gather food for themselves; and, in a word, perform the part of so many nurses, deputed by the Sovereign Lord and Preserver of the world, to help such young and shiftless creatures!" Neither ought it, under this head, to be forgotten, how much the instinct *costs* the animal which feels it; how much a bird for example, gives up, by sitting upon her nest; how repugnant it is to her organization, her habits, and her pleasures. An animal, formed for liberty, submits to confinement, in the very season when every thing invites her abroad: what is more; an animal delighting in motion, made for motion, all whose motions are so easy and so free, hardly a moment, at other times, at rest, is, for many hours of many days together, fixed to her

nest, as close as if her limbs were tied down by pins and wires. For my part I never see a bird in that situation, but I recognize an invisible hand, detaining the contented prisoner from her fields and groves, for the purpose, as the event proves, the most worthy of the sacrifice, the most important, the most beneficial.

But the loss of liberty is not the whole of what the procreant bird suffers. Harvey tells us, that he has often found the female wasted to skin and bone by sitting upon her eggs.

One observation more, and I will dismiss the subject. The *pairing* of birds, and the *non-pairing* of beasts, forms a distinction between the two classes, which shows, that the conjugal instinct is modified with a reference to utility founded in the condition of the offspring. In quadrupeds, the young animal draws its nutriment from the body of the dam. The male parent neither does, nor can contribute any part to its sustentation. In the winged race, the young bird is supplied by an importation of food, to procure and bring home which, in a sufficient quantity for the demand of a numerous brood, requires the industry of both parents. In this difference, we see a reason for the vagrant instinct of the quadruped, and for the faithful love of the feathered mate.

CHAPTER XIX.
OF INSECTS.

WE are not writing a system of natural history; therefore we have not attended to the classes, into which the subjects of that science are distributed. What we had to observe concerning different species of animals, fell easily, for the most part, within the divisions, which the course of our argument led us to adopt. There remain, however, some remarks upon the *insect* tribe, which could not properly be introduced under any of these heads; and which therefore we have collected into a chapter by themselves.

The structure, and the use of the parts, of insects, are less understood than that of quadrupeds and birds, not only by reason of their minuteness, or the minuteness of their parts (for that minuteness we can, in some measure, follow with glasses), but also by reason of the remoteness of their manners and modes of life from those of larger animals. For instance: Insects, under all their varieties of form, are endowed with *antennæ*, which is the name given to those long feelers that rise from each side of the head; but to what common use or want of the insect kind, a provision so universal is subservient, has not yet been ascertained: and it has not been ascertained, because it admits not of a clear, or very probable, comparison, with any organs which we possess ourselves, or with the organs of animals which resemble ourselves in their functions and faculties, or with which we are better acquainted than we are with insects. We want a ground of analogy. This difficulty stands in our way as to some particulars in the insect constitution, which we might wish to be acquainted with. Nevertheless, there are many contrivances in the bodies of insects, neither dubious in their use, nor obscure in their structure, and most properly mechanical. These form parts of *our* argument.

I. The *elytra*, or scaly wings of the genus of scarabæus or beetle, furnish an example of this kind. The true wing of the animal is a light, transparent membrane, finer than the finest gauze, and not unlike it. It is also, when expanded, in proportion to the size of the animal, very large. In order to protect this delicate structure, and, perhaps, also to preserve it in a due state of suppleness and humidity, a strong, hard case is given to it, in the shape of the horny wing which we call the elytron. When the animal is at rest, the gauze wings lie folded up under this impenetrable shield. When the beetle prepares for flying, he raises the integument, and spreads out his thin membrane to the air. And it cannot be observed without admiration, what a tissue of cordage, *i. e.* of muscular tendons, must run in various and complicated, but determinate directions, along this fine surface, in order to enable the animal, either to gather it up into a certain precise form, whenever

it desires to place its wings under the shelter which nature hath given to them; or to expand again their folds, when wanted for action.

In some insects, the elytra cover the whole body; in others, half; in others, only a small part of it; but in all, they completely hide and cover the true wings. Also,

Many or most of the beetle species lodge in holes in the earth, environed by hard, rough substances, and have frequently to squeeze their way through narrow passages; in which situation, wings so tender, and so large could scarcely have escaped injury, without both a firm covering to defend them, and the capacity of collecting themselves up under its protection.

II. Another contrivance, equally mechanical, and equally clear, is the *awl*, or borer, fixed at the tails of various species of flies; and with which they pierce, in some cases, plants; in others, wood; in others, the skin and flesh of animals; in others, the coat of the chrysalis of insects of a different species from their own; and in others, even lime, mortar, and stone. I need not add, that having pierced the substance, they deposit their eggs in the hole. The descriptions which naturalists give of this organ, are such as the following: It is a sharp-pointed instrument, which, in its inactive state, lies concealed in the extremity of the abdomen, and which the animal draws out at pleasure, for the purpose of making a puncture in the leaves, stem, or bark, of the particular plant, which is suited to the nourishment of its young. In a sheath, which divides and opens whenever the organ is used, there is enclosed a compact, solid, dentated stem, along which runs a *gutter* or *groove*, by which groove, after the penetration is effected, the egg, assisted, in some cases, by a peristaltic motion, passes to its destined lodgement. In the œstrum or gad-fly, the wimble *draws out* like the pieces of a spy-glass; the last piece is armed with three hooks, and is able to bore through the hide of an ox. Can any thing more be necessary to display the mechanism, than to relate the fact?

III. The *stings* of insects, though for a different purpose, are, in their structure, not unlike the piercer. The sharpness to which the point in all of them is wrought; the temper and firmness of the substance of which it is composed; the strength of the muscles by which it is darted out, compared with the smallness and weakness of the insect, and with the soft and friable texture of the rest of the body; are properties of the sting to be noticed, and not a little to be admired. The sting of a *bee* will pierce through a goatskin glove. It penetrates the human flesh more readily than the finest point of a needle. The *action* of the sting affords an example of the union of chymistry and mechanism, such as, if it be not a proof of contrivance, nothing is. First, as to the chymistry: how highly concentrated must be the *venom*, which, in so small a quantity, can produce such powerful effects! And in the bee we may observe, that this venom is made from *honcy*, the only food of the insect, but the last material from which I should have expected that an exalted poison could, by any process or digestion whatsoever have been prepared. In the next place, with respect to the mechanism, the sting is not a simple, but a compound instrument. The visible sting, though drawn to a point exquisitely sharp, is in strictness only a sheath; for, near to the extremity, may be perceived by the microscope two minute orifices, from which orifices, in the act of stinging, and, as it should seem, after the point of the main sting has buried itself in the flesh, are launched out two subtile rays, which may be called the true or proper stings, as being those, through which the poison is infused into the puncture already made by the exterior sting. I have said, that chymistry and mechanism are here *united:* by which observation I meant, that all this machinery would have been useless, *telum imbelle*, if a supply of poison, intense in quality, in proportion to the smallness of the drop, had not been furnished to it by the chymical elaboration which was carried on in the insect's body; and that, on the other hand, the poison, the result of this process, could not have attained its effect, or reached its enemy, if, when it was collected at the extremity of the abdomen, it had not found there a machinery, fitted to conduct it to the external situations in which it was to operate, *viz.* an awl to bore a hole, and a syringe to inject the fluid. Yet these

attributes, though combined in their action, are independent in their origin. The venom does not breed the sting; nor does the sting concoct the venom.

IV. The *proboscis*, with which many insects are endowed, comes next in order to be considered. It is a tube attached to the head of the animal. In the bee, it is composed of two pieces, connected by a joint: for, if it were constantly extended, it would be too much exposed to accidental injuries; therefore, in its indolent state, it is doubled up by means of the joint, and in that position lies secure under a scaly penthouse. In many species of the butterfly, the proboscis, when not in use, is coiled up like a watch-spring. In the same bee, the proboscis serves the office of the mouth, the insect having no other: and how much better adapted it is, than a mouth would be, for the collecting of the proper nourishment of the animal, is sufficiently evident. The food of the bee is the nectar of flowers; a drop of syrup, lodged deep in the bottom of the corollæ, in the recesses of the petals, or down the neck of a monopetalous glove. Into these cells the bee thrusts its long narrow pump, through the cavity of which it sucks up this precious fluid, inaccessible to every other approach. It is observable also, that the plant is not the worse for what the bee does to it. The harmless plunderer rifles the sweets, but leaves the flower uninjured. The ringlets of which the proboscis of the bee is composed, the muscles by which it is extended and contracted, form so many microscopical wonders. The agility also, with which it is moved, can hardly fail to excite admiration. But it is enough for our purpose to observe, in general, the suitableness of the structure to the use, of the means to the end, and especially the wisdom by which nature has departed from its most general analogy (for, animals being furnished with mouths are such), when the purpose could be better answered by the deviation.

In some insects, the proboscis, or tongue, or trunk, is shut up in a sharp-pointed sheath: which sheath, being of a much firmer texture than the proboscis itself, as well as sharpened at the point, pierces the substance which contains the food, and then *opens within the wound*, to allow the enclosed tube, through which the juice is extracted, to perform its office. Can any mechanism be plainer than this is; or surpass this?

V. The *metamorphoses* of insects from grubs into moths and flies, is an astonishing process. A hairy caterpillar is transformed into a butterfly. Observe the change. We have four beautiful wings, where there were none before; a tubular proboscis, in the place of a mouth with jaws and teeth; six long legs, instead of fourteen feet. In another case, we see a white, smooth, soft worm, turned into a black, hard, crustaceous beetle, with gauze wings. These, as I said, are astonishing processes, and must require, as it should seem, a proportionably artificial apparatus. The hypothesis which appears to me most probable is, that, in the grub, there exist at the same time three animals, one within another, all nourished by the same digestion, and by a communicating circulation; but in different stages of maturity. The latest discoveries, made by naturalists, seem to favour this supposition. The insect already equipped with wings, is descried under the membranes both of the worm and nymph. In some species, the proboscis, the antennæ, the limbs, and wings of the fly, have been observed to be folded up within the body of the caterpillar; and with such nicety as to occupy a small space only under the two first wings. This being so, the outermost animal, which, besides its own proper character, serves as an integument to the other two, being the furthest advanced, dies, as we suppose, and drops off first. The second, the pupa or chrysalis, then offers itself to observation. This also, in its turn, dies; its dead and brittle husk falls to pieces, and makes way for the appearance of the fly or moth. Now, if this be the case, or indeed whatever explication be adopted, we have a prospective contrivance of the most curious kind: we have organizations *three deep;* yet a vascular system, which supplies nutrition, growth, and life, to all of them together.

VI. Almost all insects are oviparous. Nature keeps her butterflies, moths, and caterpillars, locked up during the winter in their egg-state; and we have to admire the various devices to which, if we

may so speak, the same nature hath resorted, for the *security* of the egg. Many insects enclose their eggs in a silken web; others cover them with a coat of hair, torn from their own bodies; some glue them together; and others, like the moth of the silk-worm, glue them to the leaves upon which they are deposited, that they may not be shaken off by the wind, or washed away by rain: some again make incisions into leaves, and hide an egg in each incision; whilst some envelope their eggs with a soft substance, which forms the first aliment of the young animal: and some again make a hole in the earth, and, having stored it with a quantity of proper food, deposit their eggs in it. In all which we are to observe, that the expedient depends, not so much upon the address of the animal, as upon the physical resources of his constitution.

The art also with which the young insect is *coiled up* in the egg, presents where it can be examined, a subject of great curiosity. The insect, furnished with all the members which it ought to have, is rolled up into a form which seems to contract it into the least possible space; by which contraction, notwithstanding the smallness of the egg, it has room enough in its apartment, and to spare. This folding of the limbs appears to me to indicate a special direction; for, if it were merely the effect of compression, the collocation of the parts would be more various than it is. In the same species, I believe, it is always the same.

These observations belong to the whole insect tribe, or to a great part of them. Other observations are limited to fewer species; but not, perhaps, less important or satisfactory.

I. The organization in the abdomen of the *silkworm*, or *spider*, whereby these insects form their *thread*, is as incontestably mechanical as a wire-drawer's mill. In the body of the silkworm are two bags, remarkable for their form, position, and use. They wind round the intestine; when drawn out, they are ten inches in length, though the animal itself be only two. Within these bags, is collected a glue; and communicating with the bags, are two paps or outlets, perforated, like a grater, by a number of small holes. The glue or gum, being passed through these minute apertures, forms hairs of almost imperceptible fineness; and these hairs, when joined, compose the silk which we wind off from the cone, in which the silkworm has wrapped itself up; in the spider, the web is formed from this thread. In both cases, the extremity of the thread, by means of its adhesive quality, is first attached by the animal to some external hold; and the end being now fastened to a point, the insect, by turning round its body, or by receding from that point, draws out the thread through the holes above described, by an operation, as hath been observed, exactly similar to the drawing of wire. The thread, like the wire, is formed by the hole through which it passes. In one respect there is a difference. The wire is the metal unaltered, except in figure. In the animal process, the nature of the substance is somewhat changed, as well as the form; for, as it exists within the insect, it is a soft, clammy gum, or glue. The thread acquires, it is probable, its firmness and tenacity from the action of the air upon its surface, in the moment of exposure; and a thread so fine is almost all surface. This property, however, of the paste, is part of the contrivance.

The mechanism itself consists of the bags, or reservoirs, into which the glue is collected, and of the external holes communicating with these bags: and the action of the machine is seen, in the forming of a thread, as wire is formed, by forcing the material already prepared through holes of proper dimensions. The secretion is an act too subtile for our discernment, except as we perceive it by the produce. But one thing answers to another; the secretory glands to the quality and consistence required in the secreted substance; the bag to its reception: the outlets and orifices are constructed, not merely for relieving the reservoirs of their burthen, but for manufacturing the contents into a form and texture, of great external use, or rather indeed of future necessity, to the life and functions of the insect.

II. BEES, under one character or other, have furnished every naturalist with a set of observations. I shall, in this place, confine myself to one; and that is the *relation* which obtains between the wax

and the honey. No person, who has inspected a bee-hive, can forbear remarking how commodiously the honey is bestowed in the comb; and, amongst other advantages, how effectually the fermentation of the honey is prevented by distributing it into small cells. The fact is, that when the honey is separated from the comb, and put into jars, it runs into fermentation, with a much less degree of heat than what takes place in a hive. This may be reckoned a nicety: but, independently of any nicety in the matter, I would ask what could the bee do with the honey, if it had not the wax? how, at least, could it store it up for winter? The wax, therefore, answers a purpose with respect to the honey; and the honey constitutes that purpose with respect to the wax. This is the relation between them. But the two substances, though, together, of the greatest use, and without each other, of little, come from a different origin. The bee finds the honey, but makes the wax. The honey is lodged in the nectaria of flowers, and probably undergoes little alteration; is merely collected: whereas the wax is a ductile, tenacious paste, made out of a dry powder, not simply by kneading it with a liquid, but, by a digestive process in the body of the bee. What account can be rendered of facts so circumstanced, but that the animal, being intended to feed upon honey, was, by a peculiar external configuration, enabled to procure it? That, moreover, wanting the honey when it could not be procured at all, it was further endued with the no less necessary faculty, of constructing repositories for its preservation? Which faculty, it is evident, must depend, primarily, upon the capacity of providing suitable materials. Two distinct functions go to make up the ability. First, the power in the bee, with respect to wax, of loading the farina of flowers, upon its thighs. Microscopic observers speak of the spoonshaped appendages with which the thighs of bees are beset for this very purpose; but, inasmuch as the art and will of the bee may be supposed to be concerned in this operation, there is, secondly, that which doth not rest in art or will,--a digestive faculty which converts the loose powder into a stiff substance. This is a just account of the honey, and the honey-comb: and this account, through every part, carries a creative intelligence along with it.

The *sting* also of the bee has this relation to the honey, that it is necessary for the protection of a treasure which invites so many robbers.

III. Our business is with mechanism. In the *panorpa* tribe of insects, there is a forceps in the tail of the male insect, with which he catches and holds the female. Are a pair of pincers more mechanical than this provision in its structure? or is any structure more clear and certain in its design?

IV. St. Pierre tells us(*Note:* Vol. i. p. 342.), that in a fly with six feet (I do not remember that he describes the species), the pair next the head and the pair next the tail, have brushes at their extremities, with which the fly dresses, as there may be occasion, the anterior or the posterior part of its body; but that the middle pair have no such brushes, the situation of these legs not admitting of the brushes, if they were there, being converted to the same use. This is a very exact mechanical distinction.

V. If the reader, looking to our distributions of science, wish to contemplate the chymistry, as well as the mechanism of nature, the insect creation will afford him an example. I refer to the light in the tail of a *glow-worm*. Two points seem to be agreed upon by naturalists concerning it: first, that it is phosphoric; secondly, that its use is to attract the male insect. The only thing to be inquired after, is the singularity, if any such there be, in the natural history of this animal, which should render a provision of this kind more necessary for it, than for other insects. That singularity seems to be the difference which subsists between the male and the female; which difference is greater than what we find in any other species of animal whatever. The glow-worm is a female *caterpillar;* the male of which is a *fly;* lively, comparatively small, dissimilar to the female in appearance, probably also as distinguished from her in habits, pursuits, and manners, as he is unlike in form and external constitution. Here then is the adversity of the case. The caterpillar cannot meet her

companion in the air. The winged rover disdains the ground. They might never therefore be brought together, did not this radiant torch direct the volatile mate to his sedentary female.

In this example, we also see the resources of art anticipated. One grand operation of chymistry is the making of phosphorus: and it was thought an ingenious device, to make phosphoric matches supply the place of lighted tapers. Now this very thing is done in the body of the glow-worm. The phosphorus is not only made, but kindled; and caused to emit a steady and genial beam, for the purpose which is here stated, and which I believe to be the true one.

VI. Nor is the last the only instance that entomology affords, in which our discoveries, or rather our projects, turn out to be imitations of nature. Some years ago, a plan was suggested, of producing propulsion by re-action in this way: By the force of a steamengine, a stream of water was to be shot out of the stern of a boat; the impulse of which stream upon the water in the river, was to push the boat itself forward; it is, in truth, the principle by which sky-rockets ascend in the air. Of the use or practicability of the plan, I am not speaking; nor is it my concern to praise its ingenuity: but it is certainly a contrivance. Now, if naturalists are to be believed, it is exactly the device, which nature has made use of, for the motion of some species of aquatic insects. The larva of the *dragon-fly*, according to Adams, swims by ejecting water from its tail; is driven forward by the re-action of water in the pool upon the current issuing in a direction backward from its body.

VII. Again: Europe has lately been surprised by the elevation of bodies in the air by means of a balloon. The discovery consisted in finding out a manageable substance, which was bulk for bulk, lighter than air: and the application of the discovery was, to make a body composed of this substance bear up, along with its own weight, some heavier body which was attached to it. This expedient, so new to us, proves to be no other than what the Author of nature has employed in the *gossamir spider*. We frequently see this spider's thread floating in the air, and extended from hedge to hedge, across a road or brook of four or five yards width. The animal which forms the thread, has no wings wherewith to fly from one extremity to the other of this line: nor muscles to enable it to spring or dart to so great a distance: yet its Creator hath laid for it a path in the atmosphere; and after this manner. Though the animal itself be heavier than air, the thread which it spins from its bowels is specifically lighter. This is its *balloon*. The spider, left to itself, would drop to the ground; but being tied to its thread, both are supported. We have here a very peculiar provision: and to a contemplative eye it is a gratifying spectacle, to see this insect wafted on her thread, sustained by a levity not her own, and traversing regions, which, if we examined only the body of the animal, might seem to have been forbidden to its nature.

I must now crave the reader's permission to introduce into this place, for want of a better, an observation or two upon the tribe of animals, whether belonging to land or water, which are covered by *shells*.

I. The *shells* of *snails* are a wonderful, a mechanical, and, if one might so speak concerning the works of nature, an original contrivance. Other animals have their proper retreats, their hybernacula also, or winter-quarters, but the snail carries these about with him. He travels with his tent; and this tent, though, as was necessary, both light and thin, is completely impervious either to moisture or air. The young snail comes out of its egg with the shell upon its back; and the gradual enlargement which the shell receives, is derived from the slime excreted by the animal's skin. Now the aptness of this excretion to the purpose, its property of hardening into a shell, and the action, whatever it be, of the animal, whereby it avails itself of its gift, and of the constitution of its glands (to say nothing of the work being commenced before the animal is born), are things which can, with no probability, be referred to any other cause than to express design; and that not on the part of the animal alone, in which design, though it might build the house, could not have supplied the material. The will of the animal could not determine the quality of the excretion. Add

to which, that the shell of a snail, with its pillar and convolution, is a very artificial fabric; whilst a snail, as it should seem, is the most numb and unprovided of all artificers. In the midst of variety, there is likewise a regularity, which would hardly be expected. In the same species of snail, the number of turns is usually, if not always, the same. The sealing up of the mouth of the shell by the snail, is also well calculated for its warmth and security; but the cerate is not of the same substance with the shell.

II. Much of what has been observed of snails, belongs to *shell-fish*, and their *shells*, particularly to those of the univalve kind; with the addition of two remarks: one of which is upon the great strength and hardness of most of these shells. I do not know whether, the weight being given, art can produce so strong a case as are some of these shells. Which defensive strength suits well with the life of an animal, that has often to sustain the dangers of a stormy element, and a rocky bottom, as well as the attacks of voracious fish. The other remark is, upon the property, in the animal excretion, not only of congealing, but of congealing, or, as a builder would call it, *setting*, in water, and into a cretaceous substance, firm and hard. This property is much more extraordinary, and, chymically speaking, more specific than that of hardening in the air; which may be reckoned a kind of exsiccation, like the drying of clay into bricks. III. In the *bivalve* order of shell-fish, cockles, muscles, oysters, &c. what contrivance can be so simple or so clear, as the insertion, at the back, of a tough tendinous substance, that becomes at once the ligament which binds the two shells together, and the *hinge* upon which they open and shut?

IV. The shell of a lobster's tail, in its articulations and overlappings, represents the jointed part of a coat of mail; or rather, which I believe to be the truth, a coat of mail is an imitation of a lobster's shell. The same end is to be answered by both; the same properties, therefore, are required in both, namely, hardness and flexibility, a covering which may guard the part without obstructing its motion. For this double purpose, the art of man, expressly exercised upon the subject, has not been able to devise any thing better than what nature presents to his observation. Is not this therefore mechanism, which the mechanic, having a similar purpose in view, adopts? Is the structure of a coat of mail to be referred to art? Is the same structure of the lobster, conducing to the same use, to be referred to any thing less than art?

Some, who may acknowledge the imitation, and assent to the inference which we draw from it, in the instance before us, may be disposed, possibly, to ask, why such imitations are not more frequent than they are, if it be true, as we allege, that the same principle of intelligence, design, and mechanical contrivance, was exerted in the formation of natural bodies, as we employ in the making of the various instruments by which our purposes are served? The answers to this question are, first, that it seldom happens, that precisely the same purpose, and no other, is pursued in any work which we compare, of nature and of art; secondly, that it still more seldom happens, that we *can* imitate nature, if we would. Our materials and our workmanship are equally deficient. Springs and wires, and cork and leather, produce a poor substitute for an arm or a hand. In the example which we have selected, I mean a lobster's shell compared with a coat of mail, these difficulties stand less in the way, than in almost any other that can be assigned: and the consequence is as we have seen, that art gladly borrows from nature her contrivance, and imitates it closely.

BUT to return to insects. I think it is in this class of animals above all others, especially when we take in the multitude of species which the microscope discovers, that we are struck with what Cicero has called "the *insatiable* variety of nature." There are said to be six thousand species of flies; seven-hundred and sixty butterflies; each different from all the rest. (St. Pierre.) The same writer tells us, from his own observation, that thirty-seven species of winged insects, with distinctions well expressed, visited a single strawberry-plant in the course of three weeks(*Note:* Vol. i. p. 3.). Ray observed, within the compass of a mile or two of his own house, two hundred kinds of butterflies, nocturnal and diurnal. He likewise asserts, but, I think, without any grounds of

exact computation, that the number of species of insects, reckoning all sorts of them, may not be short of ten thousand(*Note:* Wisd. of God, p. 23.). And in this vast variety of animal forms (for, the observation is not confined to insects, though more applicable perhaps to them than to any other class), we are sometimes led to take notice of the different methods, or rather of the studiously diversified methods, by which one and the same purpose is attained. In the article of breathing, for example, which was to be provided for in some way or other, besides the ordinary varieties of lungs, gills, and breathing-holes (for, insects in general respire, not by the mouth, but through holes in the sides), the nymphæ of gnats have an apparatus to raise their *backs* to the top of the water, and so take breath. The hydrocanthari do the like by thrusting their *tails* out of the water(*Note:* Derham, p. 7.). The maggot of the eruca labra has a long tail, one part sheathed within another (but which it can draw out at pleasure), with a starry tuft at the end, by which *tuft*, when expanded upon the surface, the insect both supports itself in the water, and draws in the air which is necessary. In the article of natural clothing, we have the skins of animals, invested with scales, hair, feathers, mucus, froth; or itself turned into a shell or crust: in the no less necessary article of offence and defence, we have teeth, talons, beaks, horns, stings, prickles, with (the most singular expedient for the same purpose) the power of giving the electric shock, and, as is credibly related of some animals, of driving away their pursuers by an intolerable fœtor, or of blackening the water through which they are pursued. The consideration of these appearances might induce us to believe, that *variety* itself, distinct from every other reason, was a motive in the mind of the Creator, or with the agents of his will.

To this great variety in organized life, the Deity has given, or perhaps there arises out of it, a corresponding variety of animal *appetites*. For the final cause of this, we have not far to seek. Did all animals covet the same element, retreat, or food, it is evident how much fewer could be supplied and accommodated, than what at present live conveniently together, and find a plentiful subsistence. What one nature rejects, another delights in. Food, which is nauseous to one tribe of animals, becomes, by that very property which makes it nauseous, an alluring dainty to another tribe. Carrion is a treat to dogs, ravens, vultures, fish. The exhalations of corrupted substances, attract flies by crowds. Maggots revel in putrefaction.

CHAPTER XX.
OF PLANTS.

I THINK a designed and studied mechanism to be, in general, more evident in animals than in *plants:* and it is unnecessary to dwell upon a weaker argument, where a stronger is at hand. There are, however, a few observations upon the vegetable kingdom, which lie so directly in our way, that it would be improper to pass by them without notice.

The one great intention of nature in the structure of plants seems to be the perfecting of the *seed;* and, what is part of the same intention, the preserving of it until it be *perfected*. This intention shows itself, in the first place, by the care which appears to be taken, to protect and ripen, by every advantage which can be given to them of situation in the plant, those parts which most immediately contribute to fructification, viz. the antheræ, the stamina, and the stigmata. These parts are usually lodged in the centre, the recesses, or the labyrinths of the flower; during their tender and immature state, are shut up in the stalk, or sheltered in the bud; as soon as they have acquired firmness of texture sufficient to bear exposure, and are ready to perform the important office which is assigned to them, they are disclosed to the light and air, by the bursting of the stem, or the expansion of the petals; after which they have, in many cases, by the very form of the flower during its blow, the light and warmth reflected upon them from the concave side of the cup. What is called also the *sleep* of plants, is the leaves or petals disposing themselves in such a manner as to shelter the young stem, buds, or fruit. They turn up, or they fall down, according as this purpose renders either change of position requisite. In the growth of corn, whenever the plant

begins to shoot, the two upper leaves of the stalk join together, embrace the ear, and protect it till the pulp has acquired a certain degree of consistency. In some water-plants, the flowering and fecundation are carried on *within* the stem, which afterwards opens to let loose the impregnated seed(*Note:* Philes. Transact. part. ii. 1796; p. 502.). The *pea* or papilionaceous tribe, enclose the parts of fructification within a beautiful folding of the internal blossom, sometimes called, from its shape, the boat or keel; itself also protected under a penthouse formed by the external petals. This structure is very artificial; and what adds to the value of it, though it may diminish the curiosity, very general. It has also this further advantage (and it is an advantage strictly mechanical), that all the blossoms turn their *backs* to the wind, whenever the gale blows strong enough to endanger the delicate parts upon which the seed depends. I have observed this a hundred times in a field of peas in blossom. It is an aptitude which results from the figure of the flower, and, as we have said, is strictly mechanical; as much so, as the turning of a weather-board or tin cap upon the top of a chimney. Of the *poppy*, and of many similar species of flowers, the head while it is growing, hangs down, a rigid curvature in the upper part of the stem giving to it that position; and in that position it is impenetrable by rain or moisture. When the head has acquired its size, and is ready to open, the stalk *erects* itself, for the purpose, as it should seem, of presenting the flower, and with the flower, the instruments of fructification, to the genial influence of the sun's rays. This always struck me as a curious property; and specifically, as well as originally, provided for in the constitution of the plant: for, if the stem be only bent by the weight of the head, how comes it to straighten itself when the head is the heaviest? These instances show the attention of nature to this principal object, the safety and maturation of the parts upon which the seed depends.

In *trees*, especially in those which are natives of colder climates, this point is taken up earlier. Many of these trees (observe in particular the *ash* and the *horse-chesnut)* produce the embryos of the leaves and flowers in one year, and bring them to perfection the following. There is a winter therefore to be gotten over. Now what we are to remark is, how nature has prepared for the trials and severities of that season. These tender embryos are, in the first place, wrapped up with a compactness, which no art can imitate: in which state, they compose what we call the bud. This is not all. The bud itself is enclosed in scales; which scales are formed from the remains of past leaves, and the rudiments of future ones. Neither is this the whole. In the coldest climates, a third preservative is added, by the bud having a *coat*of gum or rosin, which, being congealed, resists the strongest frosts. On the approach of warm weather, this gum is softened, and ceases to be a hindrance to the expansion of the leaves and flowers. All this care is part of that system of provisions which has for its object and consummation, the production and perfecting of the seeds.

The SEEDS themselves are packed up in a *capsule*, a vessel composed of coats, which, compared with the rest of the flower, are strong and tough. From this vessel projects a tube, through which tube the farina, or some subtile fecundating effluvium that issues from it, is admitted to the seed. And here also occurs a mechanical variety, accommodated to the different circumstances under which the same purpose is to be accomplished. In flowers which are erect, the pastil is shorter than the stamina; and the pollen, shed from the antheræ into the cup of the flower, is caught, in its descent, by the head of the pistil, called the stigma. But how is this managed when the flowers hang down (as does the crown imperial for instance), and in which position, the farina, in its fall, would be carried from the stigma, and not towards it? The relative strength of the parts is now inverted. The pistil in these flowers is usually longer instead of shorter, than the stamina, that its protruding summit may receive the pollen as it drops to the ground. In some cases (as in the *nigella)*, where the shafts of the pistils or stiles are disproportionably long, they bend down their extremities upon the antheræ, that the necessary approximation may be effected.

But (to pursue this great work in its progress), the impregnation, to which all this machinery relates, being completed, the other parts of the flower fade and drop off, whilst the *gravid seed-vessel*, on the contrary, proceeds to increase its bulk, always to a great, and in some species (in the

gourd, for example, and melon), to a surprising comparative size; assuming in different plants an incalculable variety of forms, but all evidently conducing to the security of the seed. By virtue of this process, so necessary, but so diversified, we have the seed, at length, in stone-fruits and nuts, incased in a strong shell, the shell itself enclosed in a pulp or husk, by which the seed within is, or hath been, fed; or, more generally (as in grapes, oranges, and the nnmerous kinds of berries), plunged overhead in a glutinous syrup, contained within a skin or bladder: at other times (as in apples and pears) embedded in the heart of a firm fleshy substance; or (as in strawberries) pricked into the surface of a soft pulp.

These and many more varieties exist in what we call *fruits*(*Note:*

From the conformation of fruits alone, one might be led, even without experience, to suppose, that part of this provision was destined for the utilities of animals. As limited to the plant, the provision itself seems to go beyond its object. The flesh of an apple, the pulp of an orange, the meat of a plum, the fatness of the olive, appear to be *more* than sufficient for the nourishing of the seed or kernel. The event shows, that this redundancy, if it be one, ministers to the support and gratification of animal natures; and when we observe a provision to be more than sufficient for one purpose, yet wanted for another purpose, it is not unfair to conclude that both purposes were contemplated together. It favours this view of the subject to remark, that fruits are not (which they might have been) ready altogether, but that they ripen in succession throughout a great part of the year; some in summer; some in autumn; that some require the slow maturation of the winter, and supply the spring; also that the coldest fruits grow in the hottest places. Cucumbers, pine-apples, melons, are the natural produce of warm climates, and contribute greatly, by their coolness, to the refreshment of the inhabitants of those countries.

I will add to this note the following observation communicated to me by Mr. Brinkley:

"The eatable part of the cherry or peach first serves the purposes of perfecting the seed or kernel, by means of vessels passing through the stone, and which are very visible in a peach-stone. After the kernel is perfected, the stone becomes hard, and the vessels cease their functions. But the substance surrounding the stone is not then thrown away as useless. That which was before only an instrument for perfecting the kernel, now receives and retains to itself the whole of the sun's influence, and thereby becomes a grateful food to man. Also what an evident mark of design is the stone protecting the kernel! The intervention of the stone prevents the second use from interfering with the first."

). In pulse, and grain, and grasses; in trees, and shrubs, and flowers; the variety of the seed-vessels is incomputable. We have the seeds (as in the peatribe) regularly disposed in parchment pods, which, though soft and membranous, completely exclude the wet even in the heaviest rains; the pod also, not seldom (as in the bean), lined with a fine down; at other times (as in the senna) distended like a brown bladder: or we have the seed enveloped in wool (as in the cotton plant), lodged (as in pines) between the hard and compact scales of a cone, or barricadoed (as in the artichoke and thistle) with spikes and prickles; in mushrooms, placed under a penthouse; in fearns, within slits in the back part of the leaf; or (which is the most general organization of all) we find them covered by strong, close tunicles, and attached to the stem according to an order appropriated to each plant, as is seen in the several kinds of grains and of grasses.

In which enumeration, what we have first to notice is, unity of purpose under variety of expedients. Nothing can be more *single*than the design; more *diversified* than the means. Pellicles, shells, pulps, pods, husks, skin, scales armed with thorns, are all employed in prosecuting the same intention. Secondly; we may observe, that, in all these cases, the purpose is fulfilled within a just and *limited* degree. We can perceive, that if the seeds of plants were more strongly guarded than

they are, their greater security would interfere with other uses. Many species of animals would suffer, and many perish, if they could not obtain access to them. The plant would overrun the soil; or the seed be wasted for want of room to sow itself. It is, sometimes, as necessary to destroy particular species of plants, as it is, at other times, to encourage their growth. Here, as in many cases, a balance is to be maintained between opposite uses. The provisions for the preservation of seeds appear to be directed, chiefly against the inconstancy of the elements, or the sweeping destruction of inclement seasons. The depredation of animals, and the injuries of accidental violence, are allowed for in the abundance of the increase. The result is, that, out of the many thousand different plants which cover the earth, not a single species, perhaps, has been lost since the creation.

When nature has perfected her seeds, her next care is to disperse them. The seed cannot answer its purpose, while it remains confined in the capsule. After the seeds therefore are ripened, the pericarpium opens to let them out; and the opening is not like an accidental bursting, but, for the most part, is according to a certain rule in each plant. What I have always thought very extraordinary; nuts and shells, which we can hardly crack with our teeth, divide and make way for the little tender sprout which proceeds from the kernel. Handling the nut, I could hardly conceive how the plantule was ever to get out of it. There are cases, it is said, in which the seed-vessel by an elastic jerk, at the moment of its explosion, casts the seeds to a distance. We all however know, that many seeds (those of most composite flowers, as of the thistle, dandelion, &c.) are endowed with what are not improperly called *wings;*that is, downy appendages, by which they are enabled to float in the air, and are carried oftentimes by the wind to great distances from the plant which produces them. It is the swelling also of this downy tuft within the seed-vessel, that seems to overcome the resistance of its coats, and to open a passage for the seed to escape.

But the *constitution* of seeds is still more admirable than either their preservation or their dispersion. In the body of the seed of every species of plant, or nearly of every one, provision is made for two grand purposes: first, for the safety of the *germ;* secondly, for the temporary support of the future plant. The sprout, as folded up in the seed, is delicate and brittle beyond any other substance. It cannot be touched without being broken. Yet, in beans, peas, grass-seeds, grain, fruits, it is so fenced on all sides, so shut up and protected, that, whilst the seed itself is rudely handled, tossed into sacks, shoveled into heaps, the sacred particle, the miniature plant, remains unhurt. It is wonderful also, how long many kinds of seeds, by the help of their integuments, and perhaps of their oils, stand out against decay. A grain of mustard-seed has been known to lie in the earth for a hundred years; and, as soon as it had acquired a favourable situation, to shoot as vigorously as if just gathered from the plant. Then, as to the second point, the temporary support of the future plant, the matter stands thus. In grain, and pulse, and kernels, and pippins, the germ composes a very small part of the seed. The rest consists of a nutritious substance, from which the sprout draws its aliment for some considerable time after it is put forth: viz. until the fibres, shot out from the other end of the seed, are able to imbibe juices from the earth, in a sufficient quantity for its demand. It is owing to this constitution, that we see seeds sprout, and the sprouts make a considerable progress, without any earth at all. It is an œconomy also, in which we remark a close analogy between the seeds of plants, and the eggs of animals. The same point is provided for, in the same manner, in both. In the egg, the residence of the living principle, the cicatrix, forms a very minute part of the contents. The white and the white only, is expended in the formation of the chicken. The yolk, very little altered or diminshed, is wrapped up in the abdomen of the young bird, when it quits the shell; and serves for its nourishment, till it have learnt to pick its own food. This perfectly resembles the first nutrition of a plant. In the plant, as well as in the animal, the structure has every character of contrivance belonging to it: in both it breaks the transition from prepared to unprepared aliment; in both, it is prospective and compensatory. In animals which suck, this intermediate nourishment is supplied by a different source.

In all subjects, the most common observations are the best, when it is their truth and strength which have made them common. There are, of this sort, *two* concerning plants, which it falls within our plan to notice. The *first* relates to, what has already been touched upon, their germination. When a grain of corn is cast into the ground, this is the change which takes place. From one end of the grain issues a green sprout; from the other, a number of white fibrous threads. How can this be explained? Why not sprouts' from both ends? why not fibrous threads from both ends? To what is the difference to be referred, but to design; to the different uses which the parts are thereafter to serve; uses which discover themselves in the sequel of the process? The sprout, or plumule, struggles into the air; and becomes the plant, of which, from the first, it contained the rudiments: the fibres shoot into the earth; and, thereby, both fix the plant to the ground, and collect nourishment from the soil for its support. Now, what is not a little remarkable, the parts issuing from the seed take their respective directions, into whatever position the seed itself happens to be cast. If the seed be thrown into the wrongest possible position, that is, if the ends point in the ground, the reverse of what they ought to do, every thing, nevertheless, goes on right. The sprout, after being pushed down a little way, makes a bend, and turns upwards; the fibres, on the contrary, after shooting at first upwards, turn down. Of this extraordinary vegetable fact, an account has lately been attempted to be given. "The plumule (it is said) is stimulated by the *air* into action, and elongates itself when it is thus most excited; the radicle is stimulated by *moisture*, and" elongates itself when *it* is thus most excited. Whence one of these grows upward in quest of its adapted object, and the other downward(*Note:* Darwin's Phytologia, p. 144.). Were this account better verified by experiment than it is, it only shifts the contrivance. It does not disprove the contrivance; it only removes it a little further back. Who, to use our author's own language, "*adapted* the objects?" Who gave such a quality to these connate parts, as to be susceptible of *different* "stimulation;" as to be "excited" each only by its own element, and precisely by that, which the success of the vegetation requires? I say, "which the success of the vegetation requires:" for, the toil of the husbandman would have been in vain; his laborious and expensive preparation of the ground in vain; if the event must, after all, depend upon the position in which the scattered seed was sown. Not one seed out of a hundred would fall in a right direction.

Our *second* observation is upon a general property of climbing plants, which is strictly mechanical. In these plants, from each knot or joint, or, as botanists call it, axilla of the plant, issue, close to each other, two shoots: one bearing the flower and fruit: the other, drawn out into a wire, a long, tapering, spiral tendril, that twists itself round any thing which lies within its reach. Considering, that in this class two purposes are to be provided for (and together), fructification and support, the fruitage of the plant, and the sustentation of the stalk, what means could be used more effectual, or, as I have said, more mechanical, than what this structure presents to our eyes? Why, or how, without a view to this double purpose, do two shoots, of such different and appropriate forms, spring from the same joint, from contiguous points of the same stalk? It never happens thus in robust plants, or in trees. "We see not (says Ray) so much as one tree, or shrub, or herb, that hath a firm and strong stem, and that is able to mount up and stand alone without assistance, *furnished with these tendrils.*" Make only so simple a comparison as that between a pea and a bean. Why does the pea put forth tendrils, the bean not; but because the stalk of the pea cannot support itself, the stalk of the bean can? We may add also, as a circumstance not to be overlooked, that in the peatribe, these clasps do not make their appearance till they are wanted; till the plant has grown to a height to stand in need of support.

This word "support" suggests to us a reflection upon a property of grasses, of corn, and canes. The hollow stems of these classes of plants are set, at certain intervals, with joints. These joints are not found in the trunks of trees, or in the solid stalks of plants. There may be other uses of these joints; but the fact is, and it appears to be, at least, one purpose designed by them, that they *corroborate*the stem; which, by its length and hollowness, would otherwise be too liable to break or bend.

Grasses are Nature's care. With these she clothes the earth; with these she sustains its inhabitants. Cattle feed upon their leaves; birds upon their smaller seeds; men upon the larger: for, few readers need be told that the plants, which produce our bread-corn, belong to this class. In those tribes, which are more generally considered as grasses, their extraordinary means and powers of preservation and increase, their hardiness, their almost unconquerable disposition to spread, their faculties of reviviscence, coincide with the intention of nature concerning them. They thrive under a treatment by which other plants are destroyed. The more their leaves are consumed, the more their roots increase. The more they are trampled upon, the thicker they grow. Many of the seemingly dry and dead leaves of grasses revive, and renew their verdure, in the spring. In lofty mountains, where the summer heats are not sufficient to ripen the seeds, grasses abound, which are viviparous, and consequently able to propagate themselves without seed. It is an observation, likewise, which has often been made, that herbivorous animals attach themselves to the leaves of grasses; and, if at liberty in their pastures to range and choose, leave untouched the straws which support the flowers(*Note:* Withering, Bot. Arr. vol. i. p. 28, ed. 2d.).

The GENERAL properties of vegetable nature, or properties common to large portions of that kingdom, are almost all which the compass of our argument allows to bring forward. It is impossible to follow plants into their several species. We may be allowed, however, to single out three or four of these species as worthy of a particular notice, either by some singular mechanism, or by some peculiar provision, or by both.

I. In Dr. Darwin's Botanic Garden (l. 395, note), is the following account of the *vallisneria*, as it has been observed in the river Rhone.--"They have roots at the bottom of the Rhone. The flowers of the *female plant*float on the surface of the water, and are furnished with an *elastic*, *spiral stalk*, which extends or contracts as the water rises or falls; this rise or fall, from the torrents which flow into the river, often amounting to many feet in a few hours. The flowers of the *male plant* are produced under water; and, as soon as the fecundating farina is mature, they separate themselves from the plant; rise to the surface; and are wafted by the air, or borne by the currents, to the female flowers." Our attention in this narrative will be directed to two particulars: first, to the mechanism, the "elastic, spiral stalk,"which lengthens or contracts itself according as the water rises or falls; secondly, to the provision which is made for bringing the male flower, which is produced *under* water, to the female flower which floats upon the surface.

II. My second example I take from Withering's Arrangement, vol. ii. p. 209. ed. 3. "The *cuscuta europœa* is a parasitical plant. The seed opens, and puts forth a *little spiral body*, which does NOT seek the earth, to take root; but *climbs* in a spiral direction, from"

"" right to left, up other plants, from which, by means of vessels, it draws its nourishment. The "little spiral body" proceeding from the seed, is to be compared with the fibres which seeds send out in ordinary cases: and the comparison ought to regard both the form of the threads and the direction. They are straight: this is spiral. They shoot downwards; this points upwards. In the rule, and in the exception, we equally perceive design.

III. A better known parasitical plant is the ever-green shrub, called the *misseltoe*. What we have to remark in it, is a singular instance of *compensation*. No art hath yet made these plants take root in the earth. Here therefore might seem to be a mortal defect in their constitution. Let us examine how this defect is made up to them. The seeds are endued with an adhesive quality so tenacious, that, if they be rubbed upon the smooth bark of almost any tree, they will stick to it. And then what follows? Roots springing from these seeds, insinuate their fibres into the woody substance of the tree; and the event is, that a misseltoe plant is produced next winter(*Note:* Withering, Bot. Arr.

vol. i. p. 203, ed. 2d.). Of no other plant do the roots refuse to shoot in the ground; of no other plant do the seeds possess this adhesive, generative quality, when applied to the bark of trees.

IV. Another instance of the *compensatory*system is in the autumnal crocus, or meadow saffron *(cholcicum autumnale)*. I have pitied this poor plant a thousand times. Its blossom rises out of the ground in the most forlorn condition possible; without a sheath, a fence, a calyx, or even a leaf to protect it: and that, not in the spring, not to be visited by summer suns, but under all the disadvantages of the declining year. When we come, however, to look more closely into the structure of this plant, we find that, instead of its being neglected, Nature has gone out of her course to provide for its security, and to make up to it for all its defects. The seed-vessels, which in other plants is situated within the cup of the flower, or just beneath it, in this plant lies buried ten or twelve inches under ground within the bulbous root. The tube of the flower, which is seldom more than a few tenths of an inch long, in this plant extends down to the root. The stiles in all cases reach the seed-vessel; but it is in this, by an elongation unknown to any other plant. All these singularities contribute to one end. "As this plant blossoms late in"

"" the year, and, probably, would not have time to ripen its seeds before the access of winter, which would destroy them; Providence has contrived its structure such, that this important office may be performed at a depth in the earth out of reach of the usual effects of frost(*Note:* Withering, ubi supra, p. 360.). That is to say, in the autumn nothing is done above ground but the business of impregnation; which is an affair between the antheræ and the stigmata, and is probably soon over. The maturation of the impregnated seed, which in other plants proceeds within a capsule, exposed together with the rest of the flower to the open air, is here carried on, and during the whole winter, within the heart, as we may say, of the earth, that is, "out of the reach of the usual effects of frost." But then a new difficulty presents itself. Seeds, though perfected, are known not to vegetate at this depth in the earth. Our seeds, therefore, though so safely lodged, would, after all, be lost to the purpose for which all seeds are intended. Lest this should be the case, "a second admirable provision is made to raise them above the surface when they are perfected, and to sow them at a proper distance:" viz. the germ grows up *in the spring*, upon a fruit-stalk, accompanied with leaves. The seeds now, in common with those of other plants, have the benefit of the summer, and are sown upon the surface. The order of vegetation externally is this:--The plant produces its flowers in September; its leaves and fruits in the spring following.

V. I give the account of the *dionœ muscipula*, an extraordinary American plant, as some late authors have related it: but whether we be yet enough acquainted with the plant, to bring every part of this account to the test of repeated and familiar observation, I am unable to say. "Its leaves are jointed and furnished with two rows of strong prickles; their surfaces covered with a number of minute glands, which secrete a sweet liquor that allures the approach of flies. When these parts are touched by the legs of flies, the two lobes of the leaf instantly spring up, the rows of prickles lock themselves fast together, and squeeze the unwary animal to death(*Note:* Smellie's Phil. of Nat. Hist. vol. i. p. 5.)." Here, under a new model, we recognize the ancient plan of nature, viz. the relation of parts and provisions to one another, to a common office, and to the utility of the organized body to which they belong. The attracting syrup, the rows of strong prickles, their position so as to interlock, the joints of the leaves; and, what is more than the rest, that singular irritability of their surfaces, by which they close at a touch; all bear a contributory part in producing an effect, connected either with the defence or with the nutrition of the plant.

CHAPTER XXI.
THE ELEMENTS.

WHEN we come to the elements, we take leave of our mechanics; because we come to those things, of the organization of which, if they be organized, we are confessedly ignorant. This

ignorance is implied by their name. To say the truth, our investigations are stopped long before we arrive at this point. But then it is for our comfort to find, that a knowledge of the constitution of the elements is not necessary for us. For instance, as Addison has well observed, "we know *water* sufficiently, when we know how to boil, how to freeze, how to evaporate, how to make it fresh, how to make it run or spout out, in what quantity and direction we please,"

"" without knowing what water is. The observation of this excellent writer has more propriety in it now, than it had at the time it was made: for the constitution, and the constituent parts, of water, appear in some measure to have been lately discovered; yet it does not, I think, appear, that we can make any better or greater use of water since the discovery, than we did before it.

We can never think of the elements, without reflecting upon the number of distinct uses which are *consolidated* in the same substance. The *air* supplies the lungs, supports fire, conveys sound,

reflects light, diffuses smells, gives rain, wafts ships, bears up birds. '

: *water*, besides maintaining its own inhabitants, is the universal nourisher of plants, and through them of terrestrial animals; is the basis of their juices and fluids; dilutes their food; quenches their thirst, floats their burthens. *Fire*warms, dissolves, enlightens; is the great promoter of vegetation and life, if not necessary to the support of both.

We might enlarge, to almost any length we pleased, upon each of these uses; but it appears to me almost sufficient to state them. The few remarks, which I judge it necessary to add, are as follow: I. AIR is essentially different from earth. There appears to be no necessity for an atmosphere's investing our globe; yet it does invest it; and we see how many, how various, and how important are the purposes which it answers to every order of animated, not to say of organized, beings, which are placed upon the terrestrial surface. I think that every one of these uses will be understood upon the first mention of them, except it be that of *reflecting* light, which may be explained thus. If I had the power of seeing only by means of rays coming directly from the sun, whenever I turned my back upon the luminary, I should find myself in darkness. If I had the power of seeing by reflected light, yet by means only of light reflected from solid masses, these masses would shine indeed, and glisten, but it would be in the dark. The hemisphere, the sky, the world, could only be *illuminated*, as it is illuminated, by the light of the sun being from all sides, and in every direction, reflected to the eye, by particles, as numerous, as thickly scattered, and as widely diffused, as are those of the air.

Another general quality of the atmosphere is the power of evaporating fluids. The adjustment of this quality to our use is seen in its action upon the sea. In the sea, water and salt are mixed together most intimately; yet the atmosphere raises the water, and leaves the salt. Pure and fresh as drops of rain descend, they are collected from brine. If evaporation be solution (which seems to be probable), then the air dissolves the water, and not the salt. Upon whatever it be founded, the distinction is critical; so much so, that when we attempt to imitate the process by art, we must regulate our distillation with great care and nicety, or, together with the water, we get the bitterness, or, at least the distastefulness, of the marine substance: and, after all, it is owing to this original elective power in the air, that we can effect the separation which we wish, by any art or means whatever.

By evaporation, water is carried up into the air; by the converse of evaporation, it falls down upon the earth. And how does it fall? Not by the clouds being all at once re-converted into water, and descending like a sheet; not in rushing down in columns from a spout; but in moderate drops, as from a colander. Our watering-pots are made to imitate showers of rain. Yet, à priori, I should have thought either of the two former methods more likely to have taken place than the last.

By respiration, flame, putrefaction, air is rendered unfit for the support of animal life. By the constant operation of these corrupting principles, the whole atmosphere, if there were no restoring causes, would come at length to be deprived of its necessary degree of purity. Some of these causes seem to have been discovered; and their efficacy ascertained by experiment. And so far as the discovery has proceeded, it opens to us a beautiful and a wonderful œconomy. *Vegetation*proves to be one of them. A sprig of mint, corked up with a small portion of foul air placed in the light, renders it again capable of supporting life or flame. Here therefore is a constant circulation of benefits maintained between the two great provinces of organized nature. The plant purifies, what the animal has poisoned; in return, the contaminated air is more than ordinarily nutritious to the plant. *Agitation with water*turns out to be another of these restoratives. The foulest air, shaken in a bottle with water for a sufficient length of time, recovers a great degree of its purity. Here then again, allowing for the scale upon which nature works, we see the salutary effects of *storms*and *tempests*. The yesty waves, which confound the heaven and the sea, are doing the very thing which was done in the bottle. Nothing can be of greater importance to the living creation, than the salubrity of their atmosphere. It ought to reconcile us therefore to these agitations of the elements, of which we sometimes deplore the consequences, to know, that they tend powerfully to restore to the air that purity, which so many causes are constantly impairing.

II. In water, what ought not a little to be admired, are those negative qualities which constitute its *purity*. Had it been vinous, or oleaginous, or acid; had the sea been filled, or the rivers flowed, with wine or milk; fish, constituted as they are, must have died; plants, constituted as they are, would have withered; the lives of animals which feed upon plants, must have perished. Its very *insipidity*, which is one of those negative qualities, renders it the best of all menstrua. Having no taste of its own, it becomes the sincere vehicle of every other. Had there been a taste in water, be it what it might, it would have infected every thing we ate or drank, with an importunate repetition of the same flavour. Another thing in this element, not less to be admired, is the constant *round* which it travels; and by which, without suffering either adulteration or waste, it is continually offering itself to the wants of the habitable globe. From the sea are exhaled those vapours which form the clouds: these clouds descend in showers, which, penetrating into the crevices of the hills, supply springs: which springs flow in little streams into the valleys; and there uniting, become rivers; which rivers, in return, feed the ocean. So there is an incessant circulation of the same fluid; and not one drop probably more or less now than there was at the creation. A particle of water takes its departure from the surface of the sea, in order to fulfil certain important offices to the earth; and, having executed the service which was assigned to it, returns to the bosom which it left.

Some have thought, that we have too much water upon the globe, the sea occupying above three-quarters of its whole surface. But the expanse of ocean, immense as it is, may be no more than sufficient to fertilize the earth. Or, independently of this reason, I know not why the sea may not have as good a right to its place as the land. It may proportionably support as many inhabitants; minister to as large an aggregate of enjoyment. The land only affords a habitable surface; the sea is habitable to a great depth.

III. Of fire, we have said that it *dissolves*. The only idea probably which this term raised in the reader's mind, was that of fire melting metals, resins, and some other substances, fluxing ores, running glass, and assisting us in many of our operations, chymical or cu inary. Now these are only uses of an occasional kind, and give us a very imperfect notion of what fire does for us. The grand importance of this dissolving power, the great office indeed of fire in the œconomy of nature is keeping things in a state of solution, that is to say, in a state of fluidity. Were it not for the presence of heat, or of a certain degree of it, all fluids would be frozen. The ocean itself would be a quarry of ice; universal nature stiff and dead.

We see, therefore, that the elements bear not only a strict relation to the constitution of organized bodies, but a relation to each other. Water could not perform its office to the earth without air; nor exist, as water, without fire.

IV. Of Light (whether we regard it as of the same substance with fire, or as a different substance), it is altogether superfluous to expatiate upon the use. No man disputes it. The observations, therefore, which I shall offer, respect that little which we seem to know of its constitution.

Light travels from the sun at the rate of twelve millions of miles in a minute. Urged by such a velocity, with what *force* must its particles drive against (I will not say the eye, the tenderest of animal substances, but) every substance, animate or inanimate, which stands in its way! It might seem to be a force sufficient to shatter to atoms the hardest bodies.

How then is this effect, the consequence of such prodigious velocity, guarded against? By a proportionable *minuteness* of the particles of which light is composed. It is impossible for the human mind to imagine to itself any thing so small as a particle of light. But this extreme exility, though difficult to conceive, it is easy to prove. A drop of tallow, expended in the wick of a farthing candle, shall send forth rays sufficient to fill a hemisphere of a mile diameter; and to fill it so full of these rays, that an aperture not larger than the pupil of an eye, wherever it be placed within the hemisphere, shall be sure to receive some of them. What floods of light are continually poured from the sun, we cannot estimate; but the immensity of the sphere which is filled with its particles, even if it reached no farther than the orbit of the earth, we can in some sort compute: and we have reason to believe, that, throughout this whole region, the particles of light lie, in latitude at least, near to one another. The spissitude of the sun's rays at the earth is such, that the number which falls upon a burning-glass of an inch diameter, is sufficient, when concentrated, to set wood on fire.

The tenuity and the velocity of particles of light, as ascertained by separate observations, may be said to be proportioned to each other; both surpassing our utmost stretch of comprehension; but proportioned. And it is this proportion alone, which converts a tremendous element into a welcome visitor.

It has been observed to me by a learned friend, as having often struck his mind, that, if light had been made by a common artist, it would have been of one uniform *colour:* whereas, by its present composition, we have that variety of colours, which is of such infinite use to us for the distinguishing of objects; which adds so much to the beauty of the earth, and augments the stock of our innocent pleasures.

With which may be joined another reflection, *viz.* that, considering light as compounded of rays of seven different colours (of which there can be no doubt, because it can be resolved into these rays by simply passing it through a prism), the constituent parts must be well mixed and blended together, to produce a fluid, so clear and colourless, as a beam of light is, when received from the sun.

CHAPTER XXII.
ASTRONOMY.

(*Note:* For the articles in this chapter, marked with an asterisk, I am indebted to some obliging communications received (through the hands of the Lord Bishop of Elphin) from the Rev. J. Brinkley, M.A., Andrew's Professor of Astronomy in the University of Dublin.)

MY opinion of Astronomy has always been, that it is *not* the best medium through which to prove the agency of an intelligent Creator; but that, this being proved, it shows, beyond all other sciences, the magnificence of his operations. The mind which is once convinced, it raises to sublimer views of the Deity than any other subject affords; but it is not so well adapted, as some other subjects are, to the purpose of argument. We are destitute of the means of examining the constitution of the heavenly bodies. The very simplicity of their appearance is against them. We see nothing, but bright points, luminous circles, or the phases of spheres reflecting the light which falls upon them. Now we deduce design from relation, aptitude, and correspondence of *parts*. Some degree therefore of *complexity* is necessary to render a subject fit for this species of argument. But the heavenly bodies do not, except perhaps in the instance of Saturn's ring, present themselves to our observation as compounded of parts at all. This, which may be a perfection in them, is a disadvantage to us, as inquirers after their nature. They do not come within our mechanics.

And what we say of their forms, is true of their *motions*. Their motions are carried on without any sensible intermediate apparatus; whereby we are cut off from one principal ground of argumentation and analogy. We have nothing wherewith to compare them; no invention, no discovery, no operation or resource of art, which, in this respect, resembles them. Even those things which are made to imitate and represent them, such as orreries, planetaria, cœlestial globes, &c. bear no affinity to them, in the cause and principle by which their motions are actuated. I can assign for this difference a reason of utility, *viz*. a reason why, though the action of *terrestrial* bodies upon each other be, in almost all cases, through the intervention of solid or fluid substances, yet central attraction does not operate in this manner. It was necessary that the intervals between the planetary orbs should be devoid of any *inert*matter either fluid or solid, because such an intervening substance would, by its resistance, destroy those very motions, which attraction is employed to preserve. This may be a final cause of the difference; but still the difference destroys the analogy.

Our ignorance, moreover, of the *sensitive*natures, by which other planets are inhabited, necessarily keeps from us the knowledge of numberless utilities, relations, and subserviences, which we perceive upon our own globe.

After all; the real subject of admiration is, that we understand so much of astronomy as we do. That an animal confined to the surface of one of the planets; bearing a less proportion to it than the smallest microscopic insect does to the plant it lives upon; that this little, busy, inquisitive creature, by the use of senses which were given to it for its domestic necessities, and by means of the assistance of those senses which it has had the art to procure, should have been enabled to observe the whole system of worlds to which its own belongs; the changes of place of the immense globes which compose it; and with such accuracy, as to mark out beforehand, the situation in the heavens in which they will be found at any future point of time; and that these bodies, after sailing through regions of void and trackless space, should arrive at the place where they were expected, not within a minute, but within a few seconds of a minute, of the time prefixed and predicted: all this is wonderful, whether we refer our admiration to the constancy of the heavenly motions themselves, or to the perspicacity and precision with which they have been noticed by mankind. Nor is this the whole, nor indeed the chief part of what astronomy teaches. By bringing reason to bear upon observation (the acutest reasoning upon the exactest observation), the astronomer has been able, out of the "mystic dance,"and the confusion (for such it is) under which the motions of the heavenly bodies present themselves to the eye of a mere gazer upon the skies, to elicit their order and their real paths.

Our knowledge therefore of astronomy is admirable, though imperfect: and, amidst the confessed desiderata and desideranda, which impede our investigation of the wisdom of the Deity, in these

the grandest of his works, there are to be found, in the phænomena, ascertained circumstances and laws, sufficient to indicate an intellectual agency in three of its principal operations, *viz*. in choosing, in determining, in regulating; in *choosing*, out of a boundless variety of suppositions which were equally possible, that which is beneficial; in *determining*, what, left to itself, had a thousand chances against conveniency, for one in its favour; in *regulating*subjects, as to quantity and degree, which, by their nature, were unlimited with respect to either. It will be our business to offer, under each of these heads, a few instances, such as best admit of a popular explication.

I. Amongst proofs of choice, one is, fixing the source of light and heat in the *centre* of the system. The sun is ignited and luminous; the planets, which move round him, cold and dark. There seems to be no antecedent necessity for this order. The sun might have been an opaque mass; some one, or two, or more, or any, or all, the planets, globes of fire. There is nothing in the nature of the heavenly bodies, which requires that those which are stationary should be on fire, that those which move should be cold: for, in fact, comets are bodies on fire, or at least capable of the most intense heat, yet revolve round a centre: nor does this order obtain between the primary planets and their secondaries, which are all opaque. When we consider, therefore, that the sun is one; that the planets going round it are, at least, seven; that it is indifferent to their nature, which are luminous and which are opaque; and also, in what order, with respect to each other, these two kinds of bodies are disposed; we may judge of the improbability of the present arrangement taking place by chance.

If, by way of accounting for the state in which we find the solar system, it be alleged (and this is one amongst the guesses of those who reject an intelligent Creator), that the planets themselves are only cooled or cooling masses, and were once, like the sun, many thousand times hotter than red-hot iron; then it follows, that the sun also himself must be in his progress towards growing cold; which puts an end to the possibility of his having existed, as he is, from eternity. This consequence arises out of the hypothesis with still more certainty, if we make a part of it, what the philosophers who maintain it have usually taught, that the planets were originally masses of matter, struck off in a state of fusion, from the body of the sun by the percussion of a comet, or by a shock from some other cause, with which we are not acquainted: for, if these masses, partaking of the nature and substance of the sun's body, have in process of time lost their heat, that body itself, in time likewise, no matter in how much longer time, must lose its heat also, and therefore be incapable of an eternal duration in the state in which we see it, either for the time to come, or the time past.

The preference of the present to any other mode of distributing luminous and opaque bodies I take to be evident. It requires more astronomy than I am able to lay before the reader, to show, in its particulars, what would be the effect to the system, of a dark body at the centre, and of one of the planets being luminous: but I think it manifest, without either plates or calculation, first, that supposing the necessary proportion of magnitude between the central and the revolving bodies to be preserved, the ignited planet would not be sufficient to illuminate and warm the rest of the system; secondly, that its light and heat would be imparted to the other planets much more irregularly than light and heat are now received from the sun.

(*) II. Another thing, in which a choice appears to be exercised, and in which, amongst the possibilities out of which the choice was to be made, the number of those which were wrong, bore an infinite proportion to the number of those which were right, is in what geometricians call the *axis of rotation*. This matter I will endeavour to explain. The earth, it is well known, is not an exact globe, but an oblate spheroïr, something like an orange. Now the axes of rotation, or the diameters upon which such a body may be made to turn round, are as many as can be drawn through its centre to opposite points upon its whole surface: but of these axes none are *permanent*, except either its shortest diameter, *i. e*. that which passes through the heart of the orange from the place where the stalk is inserted into it, and which is but one; or its longest diameters, at right angles

with the former, which must all terminate in the single circumference which goes round the thickest part of the orange. The shortest diameter is that upon which in fact the earth turns; and it is, as the reader sees, what it ought to be, a permanent axis; whereas, had blind chance, had a casual impulse, had a stroke or push at random, set the earth aspinning, the odds were infinite, but that they had sent it round upon a wrong axis. And what would have been the consequence? The difference between a permanent axis and another axis is this: When a spheroïd in a state of rotatory motion gets upon a permanent axis, it keeps there; it remains steady and faithful to its position; its poles preserve their direction with respect to the plane and to the centre of its orbit: but, whilst it turns upon an axis which is *not* permanent (and the number of those we have been infinitely exceeds the number of the other), it is always liable to shift and vacillate from one axis to another, with a corresponding change in the inclination of its poles. Therefore, if a planet once set off revolving upon any other than its shortest, or one of its longest axes, the poles on its surface would keep perpetually changing, and it never would attain a permanent axis of rotation. The effect of this unfixedness and instability would be, that the equatorial parts of the earth might become the polar, or the polar the equatorial; to the utter destruction of plants and animals, which are not capable of interchanging their situations, but are respectively adapted to their own. As to ourselves, instead of rejoicing in our temperate zone, and annually preparing for the moderate vicissitude, or rather the agreeable succession of seasons, which we experience and expect, we might come to be locked up in the ice and darkness of the arctic circle, with bodies neither inured to its rigours, nor provided with shelter or defence against them. Nor would it be much better, if the trepidation of our pole, taking an opposite course, should place us under the heats of a vertical sun. But if it would fare so ill with the human inhabitant, who can live under greater varieties of latitude than any other animal; still more noxious would this translation of climate have proved to life in the rest of the creation; and, most perhaps of all, in plants. The habitable earth, and its beautiful variety, might have been destroyed, by a simple mischance in the axis of rotation.

(*) III. All this, however, proceeds upon a supposition of the earth having been formed at first an oblate spheroïd. There is another supposition; and perhaps our limited information will not enable us to decide between them. The second supposition is, that the earth, being a mixed mass somewhat fluid, took, as it might do, its present form, by the joint action of the mutual gravitation of its parts and its rotatory motion. This, as we have said, is a point in the history of the earth, which our observations are not sufficient to determine. For a very small depth below the surface (but extremely small, less, perhaps, than an eight-thousandth part, compared with the depth of the centre), we find vestiges of ancient fluidity. But this fluidity must have gone down many hundred times further than we can penetrate, to enable the earth to take its present oblate form: and whether any traces of this kind exist to that depth, we are ignorant. Calculations were made a few years ago, of the mean density of the earth, by comparing the force of its attraction with the force of attraction of a rock of granite, the bulk of which could be ascertained: and the upshot of the calculation was, that the earth upon an average, through its whole sphere, has twice the density of granite, or about five times that of water. Therefore it cannot be a hollow shell, as some have formerly supposed; nor can its internal parts be occupied by central fire, or by water. The solid parts must greatly exceed the fluid parts: and the probability is, that it is a solid mass throughout, composed of substances more ponderous the deeper we go. Nevertheless, we may conceive the present face of the earth to have originated from the revolution of a sphere, covered by a surface of a compound mixture; the fluid and solid parts separating, as the surface becomes quiescent. Here then comes in the *moderating*hand of the Creator. If the water had exceeded its present proportion, even but by a trifling quantity compared with the whole globe, all the land would have been covered: had there been much less than there is, there would not have been enough to fertilize the continent. Had the exsiccation been progressive, such as we may suppose to have been produced by an evaporating heat, how came it to stop at the point at which we see it? Why did it not stop sooner: why at all? The mandate of the Deity will account for this; nothing else will.

IV. OF CENTRIPETAL FORCES. By virtue of the simplest law that can be imagined, *viz*. that a body *continues* in the state in which it is, whether of motion or rest; and, if in motion, goes on in the line in which it was proceeding, and with the same velocity, *unless* there be some cause for change: by virtue, I say, of this law, it comes to pass (what may appear to be a strange consequence), that cases arise, in which attraction, incessantly drawing a body towards a centre, never brings, nor ever will bring, the body to that centre, but keep it in eternal circulation round it. If it were possible to fire off a cannon-ball with a velocity of five miles in a second, and the resistance of the air could be taken away, the cannon-ball would for ever wheel round the earth, instead of falling down upon it. This is the principle which sustains the heavenly motions. The Deity, having appointed this law to matter (than which, as we have said before, no law could be more simple), has turned it to a wonderful account in constructing planetary systems.

The actuating cause in these systems, is an attraction which varies reciprocally as the square of the distance; that is, at double the distance, has a quarter of the force; at half the distance, four times the strength; and so on. Now, concerning this law of variation, we have three things to observe: First; that attraction, for any thing we know about it, was just as capable of one law of variation, as of another: Secondly; that, out of an infinite number of possible laws, those which were admissible for the purpose of supporting the heavenly motions, lay within certain narrow limits: Thirdly; that of the admissible laws, or those which come within the limits prescribed, the law that actually prevails is the most beneficial. So far as these propositions can be made out, we may be said, I think, to prove *choice* and *regulation:* choice, out of boundless variety; and regulation, of that which, by its own nature, was, in respect of the property regulated, indifferent and indefinite.

I. First then, attraction, for any thing we know about it, was originally indifferent to all laws of variation depending upon change of distance, *i. e.* just as susceptible of one law as of another. It might have been the same at all distances; it might have increased as the distance increased: or it might have diminished with the increase of the distance, yet in ten thousand different proportions from the present; it might have followed no stated law at all. If attraction be what Cotes, with many other Newtonians, thought it to be, a primordial property of matter, not dependent upon, or traceable to, any other material cause; then, by the very nature and definition of a primordial property, it stood indifferent to all laws. If it be the agency of something immaterial, then also, for any thing we know of it, it was indifferent to all laws. If the revolution of bodies round a centre depend upon vortices, neither are these limited to one law more than another.

There is, I know, an account given of attraction, which should seem, in its very cause, to assign to it the law which we find it to observe; and which, therefore, makes that law, a law, not of choice, but of necessity: and it is the account, which ascribes attraction to an *emanation* from the attracting body. It is probable, that the influence of such an emanation will be proportioned to the spissitude of the rays of which it is composed; which spissitude, supposing the rays to issue in right lines on all sides from a point, will be reciprocally as the square of the distance. The mathematics of this solution we do not call in question: the question with us is, whether there be any sufficient reason for believing that attraction is produced by an emanation. For my part, I am totally at a loss to comprehend how particles streaming *from* a centre should draw a body *towards* it. The impulse, if impulse it be, is all the other way. Nor shall we find less difficulty in conceiving a conflux of particles, incessantly flowing to a centre, and carrying down all bodies along with it, that centre also itself being in a state of rapid motion through absolute space; for, by what source is the stream fed, or what becomes of the accumulation? Add to which, that it seems to imply a contrariety of properties, to suppose an æthereal fluid to *act*, but not to *resist;* powerful enough to carry down bodies with great force towards a centre, yet, inconsistently with the nature of inert matter, powerless and perfectly yielding with respect to the motions which result from the projectile impulse. By calculations drawn from ancient notices of eclipses of the moon, we can prove that, if such a fluid exist at all, its resistance has had no sensible effect upon the moon's

motion for two thousand five hundred years. The truth is, that, except this one circumstance of the variation of the attracting force at different distances agreeing with the variation of the spissitude, there is no reason whatever to support the hypothesis of an emanation; and, as it seems to me, almost insuperable reasons against it.

II. (*) Our second proposition is, that, whilst the possible laws of variation were infinite, the *admissible* laws, or the laws compatible with the preservation of the system, lie within narrow limits. If the attracting force had varied according to any *direct* law of the distance, let it have been what it would, great destruction and confusion would have taken place. The direct simple proportion of the distance would, it is true, have produced an ellipse: but the perturbing forces would have acted with so much advantage, as to be continually changing the dimensions of the ellipse, in a manner inconsistent with our terrestrial creation. For instance; if the planet Saturn, so large and so remote, had attracted the earth, both in proportion to the quantity of matter contained in it, which it does; and also in any proportion to its distance, *i. e.* if it had pulled the harder for being the further off (instead of the reverse of it), it would have dragged out of its course the globe which we inhabit, and have perplexed its motions, to a degree incompatible with our security, our enjoyments, and probably our existence. Of the *inverse* laws, if the centripetal force had changed as the cube of the distance, or in any higher proportion, that is (for I speak to the unlearned), if, at double the distance, the attractive force had been diminished to an eighth part, or to less than that, the consequence would have been, that the planets, if they once began to approach the sun, would have fallen into his body; if they once, though by ever so little, increased their distance from the centre, would for ever have receded from it. The laws therefore of attraction, by which a system of revolving bodies could be upholden in their motions, lie within narrow limits, compared with the possible laws. I much under-rate the restriction, when I say that, in a scale of a mile, they are confined to an inch. All direct ratios of the distance are excluded, on account of danger from perturbing forces: all reciprocal ratios, except what lie beneath the cube of the distance, by the demonstrable consequence, that every the least change of distance, would, under the operation of such laws, have been fatal to the repose and order of the system. We do not know, that is, we seldom reflect, how interested we are in this matter. Small irregularities may be endured; but, changes within these limits being allowed for, the permanency of our ellipse is a question of life and death to our whole sensitive world.

III. (*) That the subsisting law of attraction falls within the limits which utility requires, when these limits bear so small a proportion to the range of possibilities upon which chance might equally have cast it, is not, with any appearance of reason, to be accounted for, by any other cause than a regulation proceeding from a designing mind. But our next proposition carries the matter somewhat further. We say, in the third place, that, out of the different laws which lie within the limits of admissible laws, the *best* is made choice of; that there are advantages in this particular law which cannot be demonstrated to belong to any other law; and, concerning some of which, it can be demonstrated that they do not belong to any other.

(*) 1. Whilst this law prevails between each particle of matter, the *united* attraction of a sphere, composed of that matter, observes the same law. This property of the law is necessary, to render it applicable to a system composed of spheres, but it is a property which belongs to no other law of attraction that is admissible. The law of variation of the united attraction is in no other case the same as the law of attraction of each particle, one case excepted, and that is of the attraction varying directly as the distance; the inconveniency of which law in other respects, we have already noticed.

We may follow this regulation somewhat further, and still more strikingly perceive that it proceeded from a designing mind. A law both admissible and convenient was requisite. In what way is the law of the attracting globes obtained? Astronomical observations and terrestrial experiments

show that the attraction of the globes of the system is made up of the attraction of their parts; the attraction of each globe being compounded of the attractions of its parts. Now the admissible and convenient law which exists, could not be obtained in a system of bodies gravitating by the united gravitation of their parts, unless each particle of matter were attracted by a force varying by one particular law, *viz.* varying inversely as the square of the distance: for, if the action of the particles be according to any other law whatever, the admissible and convenient law, which is adopted, could not be obtained. Here then are clearly shown regulation and design. A law both admissible and convenient was to be obtained: the mode chosen for obtaining that law was by making *each*particle of matter act. After this choice was made, then further attention was to be given to each particle of matter, and one, and one only particular law of action to be assigned to it. No other law would have answered the purpose intended.

(*) 2. All systems must be liable to *perturbations*. And therefore, to guard against these perturbations, or rather to guard against their running to destructive lengths, is perhaps the strongest evidence of care and foresight that can be given. Now, we are able to demonstrate of our law of attraction, what can be demonstrated of no other, and what qualifies the dangers which arise from cross but unavoidable influences, that the action of the parts of our system upon one another will not cause permanently increasing irregularities, but merely periodical or vibratory ones; that is, they will come to a limit, and then go back again. This we can demonstrate only of a system, in which the following properties concur, *viz.* that the force shall be inversely as the square of the distance; the masses of the revolving bodies small, compared with that of the body at the centre; the orbits not much inclined to one another; and their eccentricity little. In such a system, the grand points are secure. The mean distances and periodic times, upon which depend our temperature, and the regularity of our year, are constant. The eccentricities, it is true, will still vary, but so slowly, and to so small an extent, as to produce no inconveniency from fluctuation of temperature and season. The same as to the obliquity of the planes of the orbits. For instance, the inclination of the ecliptic to the equator will never change above two degrees (out of ninety), and that will require many thousand years in performing. It has been rightly also remarked, that, if the great planets, Jupiter and Saturn, had moved in lower spheres, their influences would have had much more effect as to disturbing the planetary motions, than they now have. While they revolve at so great distances from the rest, they act almost equally on the Sun and on the inferior planets; which has nearly the same consequence as not acting at all upon either.

If it be said, that the planets might have been sent round the Sun in exact circles, in which case, no change of distance from the centre taking place, the law of variation of the attracting power, would have never come in question, one law would have served as well as another; an answer to the scheme may be drawn from the consideration of these same perturbing forces. The system retaining in other respects its present constitution, though the planets had been at first sent round in exact circular orbits, they could not have kept them: and if the law of attraction had not been what it is, or, at least, if the prevailing law had transgressed the limits above assigned, every evagation would have been fatal: the planet once drawn, as drawn it necessarily must have been, out of its course, would have wandered in endless error.

(*) V. What we have seen in the law of the centripetal force, *viz.* a choice guided by views of utility, and a choice of one law out of thousands which might equally have taken place, we see no less in the *figures* of the planetary orbits. It was not enough to fix the law of the centripetal force, though by the wisest choice; for, even under that law, it was still competent to the planets to have moved in paths possessing so great a degree of eccentricity, as, in the course of every revolution, to be brought very near to the Sun, and carried away to immense distances from him. The comets actually move in orbits of this sort: and, had the planets done so, instead of going round in orbits nearly circular, the change from one extremity of temperature to another must, in ours at least, have destroyed every animal and plant upon its surface. Now, the distance from the centre at

which a planet sets off, and the absolute force of attraction at that distance, being fixed, the figure of his orbit, its being a circle, or nearer to, or further off from a circle, *viz.*a rounder or a longer oval, depends upon two things, the velocity with which, and the direction in which, the planet is projected. And these, in order to produce a right result, must be both brought within certain narrow limits. One, and only one, velocity, united with one, and only one, direction, will produce a perfect circle. And the velocity must be near to this velocity, and the direction also near to this direction, to produce orbits, such as the planetary orbits are, nearly circular; that is, ellipses with small eccentricities. The velocity and the direction must *both* be right. If the velocity be wrong, no direction will cure the error; if the direction be in any considerable degree oblique, no velocity will produce the orbit required. Take for example the attraction of gravity at the surface of the earth. The force of that attraction being what it is, out of all the degrees of velocity, swift and slow, with which a ball might be shot off, none would answer the purpose of which we are speaking, but what was nearly that of five miles in a second. If it were less than that, the body would not get round at all, but would come to the ground: if it were in any considerable degree more than that, the body would take one of those eccentric courses, those long ellipses, of which we have noticed the inconveniency. If the velocity reached the rate of seven miles in a second, or went beyond that, the ball would fly off from the earth, and never be heard of more. In like manner with respect to the *direction*, out of the innumerable angles in which the ball might be sent off (I mean angles formed with a line drawn to the centre), none would serve but what was nearly a right one; out of the various directions in which the cannon might be pointed, upwards and downwards, every one would fail, but what was exactly or nearly horizontal. The same thing holds true of the planets: of our own amongst the rest. We are entitled therefore to ask, and to urge the question, Why did the projectile velocity and projectile direction of the earth happen to be nearly those which would retain it in a *circular* form? Why not one of the infinite number of velocities, one of the infinite number of directions, which would have made it approach much nearer to, or recede much further from, the sun?

The planets going round, all in the same direction, and all nearly in the same plane, afforded to Buffon a ground for asserting, that they had all been shivered from the sun by the same stroke of a comet, and by that stroke projected into their present orbits. Now, beside that this is to attribute to chance the fortunate concurrence of velocity and direction which we have been here noticing, the hypothesis, as I apprehend, is inconsistent with the physical laws by which the heavenly motions are governed. If the planets were struck off from the surface of the sun, they would return to the surface of the sun again. Nor will this difficulty be got rid of, by supposing that the same violent blow which shattered the sun's surface, and separated large fragments from it, pushed the sun himself out of his place: for, the consequence of this would be, that the sun and system of shattered fragments, would have a progressive motion, which, indeed, may possibly be the case with our system; but then each fragment would, in every revolution, return to the surface of the sun again. The hypothesis is also contradicted by the vast difference which subsists between the *diameters* of the planetary orbits. The distance of Saturn from the sun (to say nothing of the Georgium Sidus) is nearly five-and-twenty times that of Mercury; a disparity, which it seems impossible to reconcile with Buffon's scheme. Bodies starting from the same place, with whatever difference of direction or velocity they set off, could not have been found at these different distances from the centre, still retaining their nearly circular orbits. They must have been carried to their proper distances, before they were projected(*Note:* "If we suppose the matter of the system to be accumulated in the centre by its gravity, *no* mechanical principles, with the assistance of this power of gravity, could separate the vast mass into such parts as the sun and planets; and, after carrying them to their different distances, project them in their several directions, preserving still the quality of action and re-action, or the state of the centre of gravity of the system. Such an exquisite structure of things could only arise from the contrivance and powerful influences of an intelligent, free, and most potent agent. The same powers, therefore, which, at present, govern the material universe, and conduct its various motions, are *very different* from those, which were

necessary, to have produced it from nothing, or to have disposed it in the admirable form in which it now proceeds."--*Maclaurin's Account of Newton's Philos*. p. 407. ed. 3.).

To conclude: In astronomy, the great thing is to raise the imagination to the subject, and that oftentimes in opposition to the impression made upon the senses. An illusion, for example, must be gotten over, arising from the distance at which we view the heavenly bodies, *viz*. the apparent *slowness*of their motions. The moon shall take some hours in getting half a yard from a star which it touched. A motion so deliberate, we may think easily guided. But what is the fact? The moon, in fact, is, all this while, driving through the heavens, at the rate of considerably more than two thousand miles in an hour; which is more than double of that, with which a ball is shot off from the mouth of a cannon. Yet is this prodigious rapidity as much under government, as if the planet proceeded ever so slowly, or were conducted in its course inch by inch. It is also difficult to bring the imagination to conceive (what yet, to judge tolerably of the matter, it is necessary to conceive) how *loose*, if we may so express it, the heavenly bodies are. Enormous globes, held by nothing, confined by nothing, are turned into free and boundless space, each to seek its course by the virtue of an invisible principle; but a principle, one, common, and the same in all; and ascertainable. To preserve such bodies from being lost, from running together in heaps, from hindering and distracting one another's motions, in a degree inconsistent with any continuing order; *h*. *e*. to cause them to form planetary systems, systems that, when formed, can be upheld, and, most especially, systems accommodated to the organized and sensitive natures, which the planets sustain, as we know to be the case, where alone we can know what the case is, upon our earth: all this requires an intelligent interposition, because it can be demonstrated concerning it, that it requires an adjustment of force, distance, direction, and velocity, out of the reach of chance to have produced; an adjustment, in its view to utility similar to that which we see in ten thousand subjects of nature which are nearer to us, but in power, and in the extent of space through which that power is exerted, stupendous.

But many of the heavenly bodies, as the sun and fixed stars, are *stationary*. Their rest must be the effect of an absence or of an equilibrium of attractions. It proves also, that a projectile impulse was originally given to some of the heavenly bodies, and not to others. But further; if attraction act at all distances, there can only be one quiescent centre of gravity in the universe: and all bodies whatever must be approaching this centre, or revolving round it. According to the first of these suppositions, if the duration of the world had been long enough to allow of it, all its parts, all the great bodies of which it is composed, must have been gathered together in a heap round this point. No changes however which have been observed, afford us the smallest reason for believing, that either the one supposition or the other is true: and then it will follow, that attraction itself is controlled or suspended by a superior agent; that there is a power above the highest of the powers of material nature; a will which restrains and circumscribes the operations of the most extensive.(*Note:* It must here however be stated, that many astronomers deny that any of the heavenly bodies are absolutely stationary. Some of the brightest of the fixed stars have certainly small motions; and of the rest the distance is too great and the intervals of our observation too short, to enable us to pronounce with certainty that they may not have the same. The motions in the fixed stars which have been observed, are considered either as proper to each of them, or as compounded of the motion of our system, and of motions proper to each star. By a comparison of these motions, a motion in our system is supposed to be discovered. By continuing this analogy to other, and to all systems, it is possible to suppose that attraction is unlimited, and that the whole material universe is revolving round some fixed point within its containing sphere of space.).

CHAPTER XXIII.

OF THE PERSONALITY OF THE DEITY. CONTRIVANCE, if established, appears to me to prove every thing which we wish to prove. Amongst other things, it proves the *personality* of the Deity, as distinguished from what is sometimes called nature, sometimes called a principle: which terms, in

the mouths of those who use them philosophically, seem to be intended, to admit and to express an efficacy, but to exclude and to deny a personal agent. Now that which can contrive, which can design, must be a person. These capacities constitute personality, for they imply consciousness and thought. They require that which can perceive an end or purpose; as well as the power of providing means, and of directing them to their end(*Note:* Priestley's Letters to a Philosophical Unbeliever, p. 153, ed. 2.). They require a centre in which perceptions unite, and from which volitions flow; which is mind. The acts of a mind prove the existence of a mind: and in whatever a mind resides, is a person. The seat of intellect is a person. We have no authority to limit the properties of mind to any particular corporeal form, or to any particular circumscription of space. These properties subsist, in created nature, under a great variety of sensible forms. Also every animated being has its *sensorium*, that is, a certain portion of space, within which perception and volition are exerted. This sphere may be enlarged to an indefinite extent; may comprehend the universe; and, being so imagined, may serve to furnish us with as good a notion, as we are capable of forming, of the *immensity* of the Divine Nature, *i. e.* of a Being, infinite, as well in essence as in power; yet nevertheless a person.

"No man hath seen God at any time." And this, I believe, makes the great difficulty. Now it is a difficulty which chiefly arises from our not duly estimating the state of our faculties. The Deity, it is true, is the object of none of our senses: but reflect what limited capacities animal senses are. Many animals seem to have but one sense, or perhaps two at the most; touch and taste. Ought such an animal to conclude against the existence of odours, sounds, and colours? To another species is given the sense of smelling. This is an advance in the knowledge of the powers and properties of nature: but, if this favoured animal should infer from its superiority over the class last described, that it perceived every thing which was perceptible in nature, it is known to us, though perhaps not suspected by the animal itself, that it proceeded upon a false and presumptuous estimate of its faculties. To another is added the sense of hearing; which lets in a class of sensations entirely unconceived by the animal before spoken of; not only distinct, but remote from any which *it* had ever experienced, and greatly superior to them. Yet this last animal has no more ground for believing, that its senses comprehend all things, and all properties of things, which exist, than might have been claimed by the tribes of animals beneath it; for we know, that it is still possible to possess another sense, that of sight, which shall disclose to the percipient a new world. This fifth sense makes the animal what the human animal is: but to infer, that possibility stops here; that either this fifth sense is the last sense, or that the five comprehend all existence; is just as unwarrantable a conclusion, as that which might have been made by any of the different species which possessed fewer, or even by that, if such there be, which possessed only one. The conclusion of the one-sense animal, and the conclusion of the five-sense animal, stand upon the same authority. There may be more and other senses than those which we have. There may be senses suited to the perception of the powers, properties, and substance of spirits. These may belong to higher orders of rational agents: for there is not the smallest reason for supposing that we are the highest, or that the scale of creation stops with us.

The great *energies* of nature are known to us only by their effects. The substances which produce them, are as much concealed from our senses as the Divine essence itself. *Gravitation*, though constantly present, though constantly exerting its influence, though every where around us, near us, and within us; though diffused throughout all space, and penetrating the texture of all bodies with which we are acquainted, depends, if upon a fluid, upon a fluid which, though both powerful and universal in its operation, is no object of sense to us; if upon any other kind of substance or action, upon a substance and action, from which *we* receive no distinguishable impressions. Is it then to be wondered at, that it should, in some measure, be the same with the Divine nature? Of this however we are certain, that whatever the Deity be, neither the *universe*, nor any part of it which we see, can be He. The universe itself is merely a collective name: its parts are all which are real; or which are *things*. Now inert matter is out of the question: and organized substances include

marks of contrivance. But whatever includes marks of contrivance, whatever, in its constitution, testifies design, necessarily carries us to something beyond itself, to some other being, to a designer prior to, and out of, itself. No animal, for instance, can have contrived its own limbs and senses; can have been the author to itself of the design with which they were constructed. That supposition involves all the absurdity of self-creation, *i. e.* of acting without existing. Nothing can be God, which is ordered by a wisdom and a will, which itself is void of; which is indebted for any of its properties to contrivance *ab extra*. The *not* having that in his nature which requires the exertion of another prior being (which property is sometimes called self-sufficiency, and sometimes self-comprehension), appertains to the Deity, as his essential distinction, and removes his nature from that of all things which we see. Which consideration contains the answer to a question that has sometimes been asked, namely, Why, since something or other must have existed from eternity, may not the present universe be that something? The contrivance perceived in it, proves that to be impossible. Nothing contrived, can, in a strict and proper sense, be eternal, forasmuch as the contriver must have existed before the contrivance.

Wherever we see marks of contrivance, we are led for its cause to an *intelligent* author. And this transition of the understanding is founded upon uniform experience. We see intelligence constantly contriving, that is, we see intelligence constantly producing effects, marked and distinguished by certain properties; not certain particular properties, but by a kind and class of properties, such as relation to an end, relation of parts to one another, and to a common purpose. We see, wherever we are witnesses to the actual formation of things, nothing except intelligence producing effects so marked and distinguished. Furnished with this experience, we view the productions of nature. We observe *them*also marked and distinguished in the same manner. We wish to account for their origin. Our experience suggests a cause perfectly adequate to this account. No experience, no single instance or example, can be offered in favour of any other. In this cause therefore we ought to rest; in this cause the common sense of mankind has, in fact, rested, because it agrees with that, which, in all cases, is the foundation of knowledge,--the undeviating course of their experience. The reasoning is the same, as that, by which we conclude any ancient appearances to have been the effects of volcanoes or inundations, namely, because they resemble the effects which fire and water produce before our eyes; and because we have never known these effects to result from any other operation. And this resemblance may subsist in so many circumstances, as not to leave us under the smallest doubt in forming our opinion. Men are not deceived by this reasoning: for whenever it happens, as it sometimes does happen, that the truth comes to be known by direct information, it turns out to be what was expected. In like manner, and upon the same foundation (which in truth is that of experience), we conclude that the works of nature proceed from intelligence and design, because, in the properties of relation to a purpose, subserviency to a use, they resemble what intelligence and design are constantly producing, and what nothing except intelligence and design ever produce at all. Of every argument, which would raise a question as to the safety of this reasoning, it may be observed, that if such argument be listened to, it leads to the inference, not only that the present order of nature is insufficient to prove the existence of an intelligent Creator, but that no imaginable order would be sufficient to prove it; that *no* contrivance, were it ever so mechanical, ever so precise, ever so clear, ever so perfectly like those which we ourselves employ, would support this conclusion. A doctrine, to which, I conceive, no sound mind can assent.

The force however of the reasoning is sometimes sunk by our taking up with mere names. We have already noticed(*Note:* Ch. J. sect. vii.), and we must here notice again, the misapplication of the term "law," and the mistake concerning the idea which that term expresses in physics, whenever such idea is made to take the place of power, and still more of an intelligent power, and, as such, to be assigned for the cause of any thing, or of any property of any thing, that exists. This is what we are secretly apt to do, when we speak of organized bodies (plants for instance, or animals), owing their production, their form, their growth, their qualities, their beauty, their use, to any law

or laws of nature; and when we are contented to sit down with that answer to our inquiries concerning them. I say once more, that it is a perversion of language to assign any law, as the efficient, operative cause of any thing. A law presupposes an agent, for it is only the mode according to which an agent proceeds; it implies a power, for it is the order according to which that power acts. Without this agent, without this power, which are both distinct from itself, the "law" does nothing; is nothing.

What has been said concerning "law,"holds true of *mechanism*. Mechanism is not itself power. Mechanism, without power, can do nothing. Let a watch be contrived and constructed ever so ingeniously; be its parts ever so many, ever so complicated, ever so finely wrought or artificially put together, it cannot *go* without a weight or spring, *i. e.*without a force independent of, and ulterior to, its mechanism. The spring acting at the centre, will produce different motions and different results, according to the variety of the intermediate mechanism. One and the self-same spring, acting in one and the same manner, *viz.* by simply expanding itself, may be the cause of a hundred different and all useful movements, if a hundred different and well-devised sets of wheels be placed between it and the final effect; *e. g.* may point out the hour of the day, the day of the month, the age of the moon, the position of the planets, the cycle of the years, and many other serviceable notices; and these movements may fulfil their purposes with more or less perfection, according as the mechanism is better or worse contrived, or better or worse executed, or in a better or worse state of repair: *but in all cases, it is necessary that the spring act at the centre*. The course of our reasoning upon such a subject would be this. By inspecting the watch, even when standing still, we get a proof of contrivance, and of a contriving mind, having been employed about it. In the form and obvious relation of its parts, we see enough to convince us of this. If we pull the works in pieces, for the purpose of a closer examination, we are still more fully convinced. But, when we see the watch *going*, we see proof of another point, *viz.* that there is a power somewhere, and somehow or other, applied to it; a power in action;--that there is more in the subject than the mere wheels of the machine;--that there is a secret spring, or a gravitating plummet;--in a word, that there is force, and energy, as well as mechanism. So then, the watch in motion establishes to the observer two conclusions: One; that thought, contrivance, and design, have been employed in the forming, proportioning, and arranging of its parts; and that whoever or wherever he be, or were, such a contriver there is, or was: The other; that force or power, distinct from mechanism, is, at this present time, acting upon it. If I saw a hand-mill even at rest, I should see contrivance: but if I saw it grinding, I should be assured that a hand was at the windlass, though in another room. It is the same in nature. In the works of nature we trace mechanism; and this alone proves contrivance: but living, active, moving, productive nature, proves also the exertion of a power at the centre: for, wherever the power resides, may be denominated the centre.

The intervention and disposition of what are called "*second causes*" fall under the same observation. This disposition is or is not mechanism, according as we can or cannot trace it by our senses and means of examination. That is all the difference there is; and it is a difference which respects our faculties, not the things themselves. Now where the order of second causes is mechanical, what is here said of mechanism strictly applies to it. But it would be always mechanism (natural chymistry, for instance, would be mechanism), if our senses were acute enough to descry it. Neither mechanism, therefore, in the works of nature, nor the intervention of what are called second causes (for I think that they are the same thing), excuses the necessity of an agent distinct from both.

If, in tracing these causes, it be said, that we find certain general properties of matter which have nothing in them that bespeaks intelligence, I answer, that, still, the *managing*of these properties, the pointing and directing them to the uses which we see made of them, demands intelligence in the highest degree. For example; suppose animal secretions to be elective attractions, and that such and such attractions universally belong to such and such substances; in all which there is no

intellect concerned; still the choice and collocation of these substances, the fixing upon right substances, and disposing them in right places, must be an act of intelligence. What mischief would follow, were there a single transposition of the secretory organs; a single mistake in arranging the glands which compose them!

There may be many second causes, and many courses of second causes, one behind another, between what we observe of nature, and the Deity: but there must be intelligence somewhere; there must be more in nature than what we see; and, amongst the things unseen, there must be an intelligent, designing author. The philosopher beholds with astonishment the production of things around him. Unconscious particles of matter take their stations, and severally range themselves in an order, so as to become collectively plants or animals, *i. e.* organized bodies, with parts bearing strict and evident relation to one another, and to the utility of the whole: and it should seem that these particles could not move in any other way than as they do; for, they testify not the smallest sign of choice, or liberty, or discretion. There may be particular intelligent beings, guiding these motions in each case: or they may be the result of trains of mechanical dispositions, fixed beforehand by an intelligent appointment, and kept in action by a power at the centre. But, in either case, there must be intelligence.

The minds of most men are fond of what they call a *principle*, and of the appearance of simplicity, in accounting for phænomena. Yet this principle, this simplicity, resides merely in the *name;* which name, after all, comprises, perhaps, under it a diversified, multifarious, or progressive operation, distinguishable into parts. The power in organized bodies, of producing bodies like themselves, is one of these principles. Give a philosopher this, and he can get on. But he does not reflect, what this mode of production, this principle (if such he choose to call it) requires; how much it presupposes; what an apparatus of instruments, some of which are strictly mechanical, is necessary to its success; what a train it includes of operations and changes, one succeeding another, one related to another, one ministering to another; all advancing, by intermediate, and, frequently, by sensible steps, to their ultimate result! Yet, because the whole of this complicated action is wrapped up in a single term, *generation*, we are to set it down as an elementary principle: and to suppose, that when we have resolved the things which we see into this principle, we have sufficiently accounted for their origin, without the necessity of a designing, intelligent Creator. The truth is, generation is not a principle, but a *process*. We might as well call the casting of metals a principle; we might, so far as appears to me, as well call spinning and weaving principles: and then, referring the texture of cloths, the fabric of muslins and calicoes, the patterns of diapers and damasks, to these, as principles, pretend to dispense with intention, thought, and contrivance, on the part of the artist; or to dispense, indeed, with the necessity of any artist at all, either in the manufacturing of the article, or in the fabrication of the machinery by which the manufacture was carried on.

And, after all, how, or in what sense, is it true, that animals produce their *like?* A butterfly, with a proboscis instead of a mouth, with four wings and six legs, produces a hairy caterpillar, with jaws and teeth, and fourteen feet. A frog produces a tadpole. A black beetle, with gauze wings, and a crusty covering, produces a white, smooth, soft worm; an ephemeron fly, a cod-bait maggot. These, by a progress through different stages of life, and action, and enjoyment (and, in each state, provided with implements and organs appropriated to the temporary nature which they bear), arrive at last at the form and fashion of the parent animal. But all this is process, not principle; and proves, moreover, that the property of animated bodies, of producing their like, belongs to them, not as a primordial property, not by any blind necessity in the nature of things, but as the effect of œconomy, wisdom, and design; because the property itself assumes diversities, and submits to deviations dictated by intelligible utilities, and serving distinct purposes of animal happiness.

The opinion, which would consider "generation"as a *principle* in nature; and which would assign this principle as the cause, or endeavour to satisfy our minds with such a cause, of the existence of organized bodies, is confuted, in my judgement, not only by every mark of contrivance discoverable in those bodies, for which it gives us no contriver, offers no account whatever; but also by the farther consideration, that things generated, possess a clear relation to things *not* generated. If it were merely one part of a generated body bearing a relation to another part of the same body, as the mouth of an animal to the throat, the throat to the stomach, the stomach to the intestines, those to the recruiting of the blood, and, by means of the blood, to the nourishment of the whole frame: or if it were only one generated body bearing a relation to another generated body, as the sexes of the same species to each other, animals of prey to their prey, herbivorous and granivorous animals to the plants or seeds upon which they feed, it might be contended, that the whole of this correspondency was attributable to generation, the common origin from which these substances proceeded. But what shall we say to agreements which exist between things generated and things *not generated?* Can it be doubted, was it ever doubted, but that the *lungs* of animals bear a relation to the *air*, as a permanently elastic fluid? They act in it and by it; they cannot act without it. Now, if generation produced the animal, it did not produce the air: yet their properties correspond. The *eye* is made for *light*, and light for the eye. The eye would be of no use without light, and light perhaps of little without eyes; yet one is produced by generation; the other not. The *ear* depends upon *undulations* of air. Here are two sets of motions: first, of the pulses of the air; secondly, of the drum, bones, and nerves of the ear; sets of motions bearing an evident reference to each other: yet the one, and the apparatus for the one, produced by the intervention of generation; the other altogether independent of it.

If it be said, that the air, the light, the elements, the world itself, is *generated;* I answer, that I do not comprehend the proposition. If the term mean any thing, similar to what it means, when applied to plants or animals, the proposition is certainly without proof; and, I think, draws as near to absurdity, as any proposition can do, which does not include a contradiction in its terms. I am at a loss to conceive, how the formation of the world can be compared to the generation of an animal. If the term generation signify something quite different from what it signifies on ordinary occasions, it may, by the same latitude, signify any thing. In which case, a word or phrase taken from the language of Otaheite, would convey as much theory concerning the origin of the universe, as it does to talk of its being generated.

We know a cause (intelligence) adequate to the appearances, which we wish to account for: we have this cause continually producing similar appearances: yet, rejecting this cause, the sufficiency of which we know, and the action of which is constantly before our eyes, we are invited to resort to suppositions, destitute of a single fact for their support, and confirmed by no analogy with which we are acquainted. Were it necessary to inquire into the *motives* of men's opinions, I mean their motives separate from their arguments; I should almost suspect, that, because the proof of a Deity drawn from the constitution of nature is not only popular but vulgar (which may arise from the cogency of the proof, and be indeed its highest recommendation), and because it is a species almost of *puerility* to take up with it; for these reasons, minds, which are habitually in search of invention and originality, feel a resistless inclination to strike off into other solutions and other expositions. The truth is, that many minds are not so indisposed to any thing which can be offered to them, as they are to the *flatness* of being content with common reasons: and, what is most to be lamented, minds conscious of superiority, are the most liable to this repugnancy.

The "suppositions" here alluded to, all agree in one character: they all endeavour to dispense with the necessity in nature, of a particular, personal intelligence; that is to say, with the exertion of an intending, contriving mind, in the structure and formation of the organized constitutions which the world contains. They would resolve all productions into *unconscious* energies, of a like kind, in that respect, with attraction, magnetism, electricity, &c.; without any thing further.

In this, the old system of atheism and the new agree. And I much doubt, whether the new schemes have advanced any thing upon the old, or done more than changed the terms of the nomenclature. For instance, I could never see the difference between the antiquated system of atoms, and Buffon's organic molecules. This philosopher, having made a planet by knocking off from the sun a piece of melted glass, in consequence of the stroke of a comet; and having set it in motion, by the same stroke, both round its own axis and the sun, finds his next difficulty to be, how to bring plants and animals upon it. In order to solve this difficulty, we are to suppose the universe replenished with particles, endowed with life, but without organization or senses of their own; and endowed also with a tendency to marshal themselves into organized forms. The concourse of these particles, by virtue of this tendency, but without intelligence, will, or direction (for I do not find that any of these qualities are ascribed to them), has produced the living forms which we now see.

Very few of the conjectures, which philosophers hazard upon these subjects, have more of pretension in them, than the challenging you to show the direct impossibility of the hypothesis. In the present example, there seemed to be a positive objection to the whole scheme upon the very face of it; which was that, if the case were as here represented, *new* combinations ought to be perpetually taking place; new plants and animals, or organized bodies which were neither, ought to be starting up before our eyes every day. For this, however, our philosopher has an answer. Whilst so many forms of plants and animals are already in existence, and, consequently, so many "internal moulds," as he calls them, are prepared and at hand, the organic particles run into these moulds, and are employed in supplying an accession of substance to them, as well for their growth, as for their propagation. By which means, things keep their ancient course. But, says the same philosopher, should any general loss or destruction of the present constitution of organized bodies take place, the particles, for want of "moulds" into which they might enter, would run into different combinations, and replenish the waste with new species of organized substances.

Is there any history to countenance this notion? Is it known, that any destruction has been so repaired? any desert thus re-peopled?

So far as I remember, the only natural appearance mentioned by our author, by way of fact whereon to build his hypothesis, is the formation of *worms* in the intestines of animals, which is here ascribed to the coalition of superabundant organic particles, floating about in the first passages; and which have combined themselves into these simple animal forms, for want of internal moulds, or of vacancies in those moulds, into which they might be received. The thing referred to, is rather a species of facts, than a single fact; as some other cases may, with equal reason, be included under it. But to make it a fact at all, or, in any sort, applicable to the question, we must begin with asserting an *equivocal*generation, contrary to analogy, and without necessity: contrary to an analogy, which accompanies us to the very limits of our knowledge or inquiries; for wherever, either in plants, or animals, we are able to examine the subject, we find procreation from a parent form: without necessity; for I apprehend that it is seldom difficult to suggest methods, by which the eggs, or spawn, or yet invisible rudiments of these vermin, may have obtained a passage into the cavities in which they are found(*Note:* I trust I may be excused, for not citing, as another fact which is to confirm the hypothesis, a grave assertion of this writer, that the branches of trees upon which the stag feeds, break out again in his horns. Such *facts* merit no discussion.). Add to this, that their *constancy to their species*, which, I believe, is as regular in these as in the other vermes, decides the question against our philosopher, if in truth, any question remained upon the subject.

Lastly; these wonder-working instruments, these "internal moulds," what are they after all? what, when examined, but a name without signification; unintelligible, if not self-contradictory; at the best, differing in nothing from the "essential forms" of the Greek philosophy? One short sentence of Buffon's work exhibits his scheme as follows: "When this nutritious and prolific matter, which is

diffused throughout all nature, passes through the *internal mould* of an animal or vegetable, and finds a proper matrix, or receptacle, it gives rise to an animal or vegetable of the same species." Does any reader annex a meaning to the expression "internal mould,"in this sentence? Ought it then to be said, that, though we have little notion of an internal mould, we have not much more of a designing mind? The very contrary of this assertion is the truth. When we speak of an artificer or an architect, we talk of what is comprehensible to our understanding, and familiar to our experience. We use no other terms, than what refer us for their meaning to our consciousness and observation; what express the constant objects of both: whereas names, like that we have mentioned, refer us to nothing; excite no idea; convey a sound to the ear, but I think do no more.

Another system, which has lately been brought forward, and with much ingenuity, is that of *appetencies*. The principle, and the short account, of the theory, is this: Pieces of soft, ductile matter, being endued with propensities or appetencies for particular actions, would, by continual endeavours, carried on through a long series of generations, work themselves gradually into suitable forms: and, at length, acquire, though perhaps by obscure and almost imperceptible improvements, an organization fitted to the action which their respective propensities led them to exert. A piece of animated matter, for example, that was endued with a propensity to *fly*, though ever so shapeless, though no other we will suppose than a round ball, to begin with, would, in a course of ages, if not in a million of years, perhaps in a hundred millions of years (for our theorists, having eternity to dispose of, are never sparing in time), acquire *wings*. The same tendency to locomotion in an aquatic animal, or rather in an animated lump which might happen to be surrounded by water, would end in the production of *fins*: in a living substance, confined to the solid earth, would put out *legs* and *feet*; or, if it took a different turn, would break the body into ringlets, and conclude by *crawling*upon the ground.

Although I have introduced the mention of this theory into this place, I am unwilling to give to it the name of an *atheistic* scheme, for two reasons; first, because, so far as I am able to understand it, the original propensities and the numberless varieties of them (so different, in this respect, from the laws of mechanical nature, which are few and simple), are, in the plan itself, attributed to the ordination and appointment of an intelligent and designing Creator: secondly, because, likewise, that large postulatum, which is all along assumed and presupposed, the faculty in living bodies of producing other bodies organized like themselves, seems to be referred to the same cause; at least is not attempted to be accounted for by any other. In one important respect, however, the theory before us coincides with atheistic systems, *viz*. in that, in the formation of plants and animals, in the structure and use of their parts, it does away final causes. Instead of the parts of a plant or animal, or the particular structure of the parts, having been intended for the action or the use to which we see them applied, according to this theory, they have themselves grown out of that action, sprung from that use. The theory therefore dispenses with that which we insist upon, the necessity, in each particular case, of an intelligent, designing mind, for the contriving and determining of the forms which organized bodies bear. Give our philosopher these appetencies; give him a portion of living irritable matter (a nerve, or the clipping of a nerve), to work upon; give also to his incipient or progressive forms, the power, in every stage of their alteration, of propagating their like; and, if he is to be believed, he could replenish the world with all the vegetable and animal productions which we at present see in it.

The scheme under consideration is open to the same objection with other conjectures of a similar tendency, *viz*. a total defect of evidence. No changes, like those which the theory requires, have ever been observed. All the changes in Ovid's Metamorphoses might have been effected by these appetencies, if the theory were true: yet not an example, nor the pretence of an example, is offered of a single change being known to have taken place. Nor is the order of generation obedient to the principle upon which this theory is built. The mammæ(*Note:* I confess myself totally at a loss to guess at the reason, either final or efficient, for this part of the animal frame, unless there be

some foundation for an opinion, of which I draw the hint from a paper of Mr. Everard Home, (Phil. Transact. 1799, p. 2.) *viz.* that the mammæ of the fœtus may be formed, before the sex is determined.) of the male have not vanished by inusitation; *nec curtorum, per multa sœcula, Judœorum propagini deest præputium*. It is easy to say, and it has been said, that the alterative process is too slow to be perceived; that it has been carried on through tracts of immeasurable time; and that the present order of things is the result of a gradation, of which no human record can trace the steps. It is easy to say this; and yet it is still true, that the hypothesis remains destitute of evidence.

The *analogies* which have been alleged, are of the following kind: The *bunch* of a camel, is said to be no other than the effect of carrying burthens; a service in which the species has been employed from the most ancient times of the world. The first race, by the daily loading of the back, would probably find a small grumous tumour to be formed in the flesh of that part. The next progeny would bring this tumour into the world with them. The life to which they were destined, would increase it. The cause which first generated the tubercle being continued, it would go on, through every succession, to augment its size, till it attained the form and the bulk under which it now appears. This may serve for one instance; another, and that also of the passive sort, is taken from certain species of birds. Birds of the *crane*kind, as the crane itself, the heron, bittern, stork, have, in general, their thighs bare of feathers. This privation is accounted for from the habit of wading in water, and from the effect of that element to check the growth of feathers upon these parts: in consequence of which, the health and vegetation of the feathers declined through each generation of the animal; the tender down, exposed to cold and wetness, became weak, and thin, and rare, till the deterioration ended in the result which we see, of absolute nakedness. I will mention a third instance, because it is drawn from an active habit, as the two last were from passive habits; and that is the *pouch* of the pelican. The description which naturalists give of this organ, is as follows: "From the lower edges of the under-chap, hangs a bag, reaching from the whole length of the bill to the neck, which is said to be capable of containing fifteen quarts of water. This bag, the bird has a power of wrinkling up into the hollow of the under-chap. When the bag is empty it is not seen: but when the bird has fished with success, it is incredible to what an extent it is often dilated. The first thing the pelican does in fishing, is to fill the bag; and then it returns to digest its burthen at leisure. The bird preys upon the large fishes, and hides them by dozens in its pouch. When the bill is opened to its widest extent, a person may run his head into the bird's mouth; and conceal it in this monstrous pouch, thus adapted for very singular purposes(*Note:* Goldsmith, vol. vi. p. 52.)." Now this extraordinary conformation is nothing more, say our philosophers, than the result of habit: not of the habit or effort of a single pelican, or of a single race of pelicans, but of a habit perpetuated through a long series of generations. The pelican soon found the conveniency of reserving in its mouth, when its appetite was glutted, the remainder of its prey, which is fish. The fulness produced by this attempt, of course stretched the skin which lies between the under-chaps, as being the most yielding part of the mouth. Every distension increased the cavity. The original bird, and many generations which succeeded him, might find difficulty enough in making the pouch answer this purpose: but future pelicans, entering upon life with a pouch derived from their progenitors, of considerable capacity, would more readily accelerate its advance to perfection, by frequently pressing down the sac with the weight of fish which it might now be made to contain.

These, or of this kind, are the analogies relied upon. Now, in the first place, the instances themselves are unauthenticated by testimony; and, in theory, to say the least of them, open to great objections. Who ever read of camels without bunches, or with bunches less than those with which they are at present usually formed? A bunch, not unlike the camel's, is found between the shoulders of the buffalo; of the origin of which it is impossible to give the account here given. In the second example; Why should the application of water, which appears to promote and thicken the growth of feathers upon the bodies and breasts of geese, and swans, and other water-fowls, have divested of this covering the thighs of cranes? The third instance, which appears to me as

plausible as any that can be produced, has this against it, that it is a singularity restricted to the species; whereas, if it had its commencement in the cause and manner which have been assigned, the like conformation might be expected to take place in other birds, which fed upon fish. How comes it to pass, that the pelican alone was the inventress, and her descendants the only inheritors of this curious resource?

But it is the less necessary to controvert the instances themselves as it is a straining of analogy beyond all limits of reason and credibility, to assert that birds, and beasts, and fish, with all their variety and complexity of organization, have been brought into their forms, and distinguished into their several kinds and natures, by the same process (even if that process could be demonstrated, or had it ever been actually noticed) as might seem to serve for the gradual generation of a camel's bunch, or a pelican's pouch.

The solution, when applied to the works of nature *generally*, is contradicted by many of the phænomena, and totally inadequate to others. The *ligaments* or strictures, by which the tendons are tied down at the angles of the joints, could, by no possibility, be formed by the motion or exercise of the tendons themselves; by any appetency exciting these parts into action; or by any tendency arising therefrom. The tendency is all the other way; the *conatus* in constant opposition to them. Length of time does not help the case at all, but the reverse. The *valves*also in the blood-vessels, could never be formed in the manner which our theorist proposes. The blood, in its right and natural course, has no tendency to form them. When obstructed or refluent, it has the contrary. These parts could not grow out of their use, though they had eternity to grow in.

The *senses* of animals appear to me altogether incapable of receiving the explanation of their origin which this theory affords. Including under the word "sense" the organ and the perception, we have no account of either. How will our philosopher get at *vision*, or make an eye? How should the blind animal affect sight, of which blind animals, we know, have neither conception nor desire? Affecting it, by what operation of its will, by what endeavour to see, could it so determine the fluids of its body, as to inchoate the formation of an eye? or, suppose the eye formed, would the perception follow? The same of the other senses. And this objection holds its force, ascribe what you will to the hand of time, to the power of habit, to changes too slow to be observed by man, or brought within any comparison which he is able to make of past things with the present: concede what you please to these arbitrary and unattested suppositions, how will they help you? Here is no inception. No laws, no course, no powers of nature which prevail at present, nor any analogous to these, would give commencement to a new sense. And it is in vain to inquire, how that might proceed, which could never *begin*.

I think the senses to be the most inconsistent with the hypothesis before us, of any part of the animal frame. But other parts are sufficiently so. The solution does not apply to the parts of animals, which have little in them of motion. If we could suppose joints and muscles to be gradually formed by action and exercise, what action or exeroise could form a skull, or fill it with brains? No effort of the animal could determine the clothing of its skin. What *conatus* could give prickles to the porcupine or hedgehog, or to the sheep its fleece?

In the last place; What do these appetencies mean when applied to plants? I am not able to give a signification to the term, which can be transferred from animals to plants; or which is common to both. Yet a no less successful organization is found in plants, than what obtains in animals. A solution is wanted for one, as well as the other.

Upon the whole; after all the schemes and struggles of a reluctant philosophy, the necessary resort is to a Deity. The marks of *design* are too strong to be gotten over. Design must have had a designer. That designer must have been a person. That person is GOD.

CHAPTER XXIV.
OF THE NATURAL ATTRIBUTES OF THE DEITY.

IT is an immense conclusion, that there is a GOD; a perceiving, intelligent, designing, Being; at the head of creation, and from whose will it proceeded. The *attributes* of such a Being, suppose his reality to be proved, must be adequate to the magnitude, extent, and multiplicity of his operations: which are not only vast beyond comparison with those performed by any other power, but, so far as respects our conceptions of them, infinite, because they are unlimited on all sides.

Yet the contemplation of a nature so exalted, however surely we arrive at the proof of its existence, overwhelms our faculties. The mind feels its powers sink under the subject. One consequence of which is, that from painful abstraction the thoughts seek relief in sensible images. Whence may be deduced the ancient, and almost universal propensity to idolatrous substitutions. They are the resources of a labouring imagination. False religions usually fall in with the natural propensity; true religions, or such as have derived themselves from the true, resist it.

It is one of the advantages of the revelations which we acknowledge, that, whilst they reject idolatry with its many pernicious accompaniments, they introduce the Deity to human apprehension, under an idea more personal, more determinate, more within its compass, than the theology of nature can do. And this they do by representing him exclusively under the relation in which he stands to ourselves; and, for the most part, under some precise character, resulting from that relation, or from the history of his providences. Which method suits the span of our intellects much better than the universality which enters into the idea of God, as deduced from the views of nature. When, therefore, these representations are well founded in point of authority (for all depends upon that), they afford a condescension to the state of our faculties, of which, they who have most reflected on the subject, will be the first to acknowledge the want and the value.

Nevertheless, if we be careful to imitate the documents of our religion, by confining our explanations to what concerns ourselves, and do not affect more precision in our ideas than the subject allows of, the several terms which are employed to denote the attributes of the Deity, may be made, even in natural religion, to bear a sense consistent with truth and reason, and not surpassing our comprehension.

These terms are; Omnipotence, omniscience, omnipresence, eternity, self-existence, necessary existence, spirituality.

"Omnipotence," "omniscience," "infinite"power, "infinite" knowledge, are *superlatives;*expressing our conception of these attributes in the strongest and most elevated terms which language supplies. We ascribe power to the Deity under the name of "omnipotence,"the strict and correct conclusion being, that a power which could create such a world as this is, must be, beyond all comparison, greater than any which we experience in ourselves, than any which we observe in other visible agents; greater also than any which we can want, for our individual protection and preservation, in the Being upon whom we depend. It is a power, likewise, to which we are not authorized, by our observation or knowledge, to assign any limits of space or duration.

Very much of the same sort of remark is applicable to the term "omniscience," infinite knowledge, or infinite wisdom. In strictness of language, there is a difference between knowledge and wisdom; wisdom always supposing action, and action directed by it. With respect to the first, viz. *knowledge*, the Creator must know, intimately, the constitution and properties of the things which he created; which seems also to imply a foreknowledge of their action upon one another, and of their changes; at least, so far as the same result from trains of physical and necessary causes. His

omniscience also, as far as respects things present, is deducible from his nature, as an intelligent being, joined with the extent, or rather the universality, of his operations. Where he acts, he is; and where he is, he perceives. The *wisdom* of the Deity, as testified in the works of creation, surpasses all idea we have of wisdom, drawn from the highest intellectual operations of the highest class of intelligent beings with whom we are acquainted; and, which is of the chief importance to us, whatever be its compass or extent, which it is evidently impossible that we should be able to determine, it must be adequate to the conduct of that order of things under which we live. And this is enough. It is of very inferior consequence, by what terms we express our notion, or rather our admiration, of this attribute. The terms, which the piety and the usage of language have rendered habitual to us, may be as proper as any other. We can trace this attribute much beyond what is necessary for any conclusion to which we have occasion to apply it. The degree of knowledge and power, requisite for the formation of created nature, cannot, with respect to us, be distinguished from infinite.

The Divine "omnipresence" stands, in natural theology, upon this foundation. In every part and place of the universe with which we are acquainted, we perceive the exertion of a power, which we believe, mediately or immediately, to proceed from the Deity. For instance; in what part or point of space, that has ever been explored, do we not discover attraction? In what regions do we not find light? In what accessible portion of our globe, do we not meet with gravity, magnetism, electricity; together with the properties also and powers of organized substances, of vegetable or of animated nature? Nay further, we may ask, What kingdom is there of nature, what corner of space, in which there is any thing that can be examined by us, where we do not fall upon contrivance and design? The only reflection perhaps which arises in our minds from this view of the world around us is, that the laws of nature every where prevail; that they are uniform and universal. But what do we mean by the laws of nature, or by any law? Effects are produced by power, not by laws. A law cannot execute itself. A law refers us to an agent. Now an agency so general, as that we cannot discover its absence, or assign the place in which some effect of its continued energy is not found, may, in popular language at least, and, perhaps, without much deviation from philosophical strictness, be called universal: and, with not quite the same, but with no inconsiderable propriety, the person, or Being, in whom that power resides, or from whom it is derived, may be taken to be *omnipresent*. He who upholds all things by his power, may be said to be every where present.

This is called a virtual presence. There is also what metaphysicians denominate an essential ubiquity; and which idea the language of Scripture seems to favour: but the former, I think, goes as far as natural theology carries us.

"Eternity" is a negative idea, clothed with a positive name. It supposes, in that to which it is applied, a present existence; and is the negation of a beginning or an end of that existence. As applied to the Deity, it has not been controverted by those who acknowledge a Deity at all. Most assuredly, there never was a time in which nothing existed, because that condition must have continued. The universal *blank* must have remained; nothing could rise up out of it; nothing could ever have existed since; nothing could exist now. In strictness, however, we have no concern with duration prior to that of the visible world. Upon this article therefore of theology, it is sufficient to know, that the contriver necessarily existed before the contrivance.

"Self-existence" is another negative idea, *viz*. the negation of a preceding cause, as of a progenitor, a maker, an author, a creator.

"Necessary existence" means demonstrable existence.

"Spirituality" expresses an idea, made up of a negative part, and of a positive part. The negative part consists in the exclusion of some of the known properties of matter, especially of solidity, of the *vis inertiæ*, and of gravitation. The positive part comprises perception, thought, will, power, *action*, by which last term is meant, the origination of motion; the quality, perhaps, in which resides the essential superiority of spirit over matter, "which cannot move, unless it be moved; and cannot but move, when impelled by another(*Note:* Bishop Wilkins's Principles of Natural Religion, p. 106.)." I apprehend that there can be no difficulty in applying to the Deity both parts of this idea.

CHAPTER XXV.

THE UNITY OF THE DEITY. OF the "Unity of the Deity," the proof is, the *uniformity* of plan observable in the universe. The universe itself is a system; each part either depending upon other parts, or being connected with other parts by some common law of motion, or by the presence of some common substance. One principle of gravitation causes a stone to drop towards the earth, and the moon to wheel round it. One law of attraction carries all the different planets about the sun. This philosophers demonstrate. There are also other points of agreement amongst them, which may be considered as marks of the identity of their origin, and of their intelligent author. In all are found the conveniency and stability derived from gravitation. They all experience vicissitudes of days and nights, and changes of season. They all, at least Jupiter, Mars, and Venus, have the same advantages from their atmosphere as we have. In all the planets, the axes of rotation are permanent. Nothing is more probable than that the same attracting influence, acting according to the same rule, reaches to the fixed stars: but, if this be only probable, another thing is certain, *viz.* that the same element of light does. The light from a fixed star affects our eyes in the same manner, is refracted and reflected according to the same laws, as the light of a candle. The velocity of the light of the fixed stars is also the same, as the velocity of the light of the sun, reflected from the satellites of Jupiter. The heat of the sun, in kind, differs nothing from the heat of a coal fire.

In our own globe, the case is clearer. New countries are continually discovered, but the old laws of nature are always found in them: new plants perhaps, or animals, but always in company with plants and animals which we already know; and always possessing many of the same general properties. We never get amongst such original, or totally different, modes of existence, as to indicate, that we are come into the province of a different Creator, or under the direction of a different will. In truth, the same order of things attend us, wherever we go. The elements act upon one another, electricity operates, the tides rise and fall, the magnetic needle elects its position, in one region of the earth and sea, as well as in another. One atmosphere invests all parts of the globe, and connects all; one sun illuminates; one moon exerts its specific attraction upon all parts. If there be a variety in natural effects, as, *e. g.* in the tides of different seas, that very variety is the result of the same cause, acting under different circumstances. In many cases this is proved; in all, is probable.

The inspection and comparison of *living*forms, add to this argument examples without number. Of all large terrestrial animals, the structure is very much alike; their senses nearly the same; their natural functions and passions nearly the same; their viscera nearly the same, both in substance, shape, and office: digestion, nutrition, circulation, secretion, go on, in a similar manner, in all: the great circulating fluid is the same; for, I think, no difference has been discovered in the properties of *blood*, from whatever animal it be drawn. The experiment of transfusion proves, that the blood of one animal will serve for another. The *skeletons* also of the larger terrestrial animals, show particular varieties, but still under a great general affinity. The resemblance is somewhat less, yet sufficiently evident, between quadrupeds and birds. They are all alike in five respects, for one in which they differ.

In *fish*, which belong to another department, as it were, of nature, the points of comparison become fewer. But we never lose sight of our analogy, *e. g.* we still meet with a stomach, a liver, a spine; with bile and blood; with teeth; with eyes (which eyes are only slightly varied from our own, and which variation, in truth, demonstrates, not an interruption, but a continuance of the same exquisite plan; for it is the adaptation of the organ to the element, *viz.* to the different refraction of light passing into the eye out of a denser medium). The provinces, also, themselves of water and earth, are connected by the species of animals which inhabit both; and also by a large tribe of aquatic animals, which closely resemble the terrestrial in their internal structure; I mean the cetaceous tribe, which have hot blood, respiring lungs, bowels, and other essential parts, like those of land-animals. This similitude, surely, bespeaks the same creation and the same Creator.

Insects and *shell-fish* appear to me to differ from other classes of animals the most widely of any. Yet even here, beside many points of particular resemblance, there exists a general relation of a peculiar kind. It is the relation of inversion; the law of contrariety: namely, that, whereas, in other animals, the bones, to which the muscles are attached, lie *within* the body; in insects and shell-fish, they lie on the *outside* of it. The shell of a lobster performs to the animal the office of a *bone*, by furnishing to the tendons that fixed basis or immoveable fulcrum, without which, mechanically, they could not act. The crust of an insect is its shell, and answers the like purpose. The shell also of an oister stands in the place of a *bone;* the bases of the muscles being fixed to it, in the same manner, as, in other animals, they are fixed to the bones. All which (under wonderful varieties, indeed, and adaptations of form) confesses an imitation, a remembrance, a carrying on, of the same plan.

The observations here made, are equally applicable to plants; but, I think, unnecessary to be pursued. It is a very striking circumstance, and alone sufficient to prove all which we contend for, that, in this part likewise of organized nature, we perceive a continuation of the *sexual* system.

Certain however it is, that the whole argument for the divine unity, goes no further than to a unity of counsel.

It may likewise be acknowledged, that no arguments which we are in possession of, exclude the ministry of subordinate agents. If such there be, they act under a presiding, a controlling will; because they act according to certain general restrictions, by certain common rules, and, as it should seem, upon a general plan: but still such agents, and different ranks, and classes, and degrees of them, may be employed.

CHAPTER XXVI.
THE GOODNESS OF THE DEITY.

THE proof of the *divine goodness* rests upon two propositions; each, as we contend, capable of being made out by observations drawn from the appearances of nature.

The first is, "that, in a vast plurality of instances in which contrivance is perceived, the design of the contrivance is *beneficial*."

The second, "that the Deity has superadded *pleasure* to animal sensations, beyond what was necessary for any other purpose, or when the purpose, so far as it was necessary,"

"" might have been effected by the operation of pain.

First, "in a vast plurality of instances in which contrivance is perceived, the design of the contrivance is *beneficial*."

No production of nature display contrivance so manifestly as the parts of animals; and the parts of animals have all of them, I believe, a real, and, with very few exceptions, all of them a known and intelligible subserviency to the use of the animal. Now, when the multitude of animals is considered, the number of parts in each, their figure and fitness, the faculties depending upon them, the variety of species, the complexity of structure, the success, in so many cases, and felicity of the result, we can never reflect, without the profoundest adoration, upon the character of that Being from whom all these things have proceeded: we cannot help acknowledging, what an exertion of benevolence creation was; of a benevolence how minute in its care, how vast in its comprehension!

When we appeal to the parts and faculties of animals, and to the limbs and senses of animals in particular, we state, I conceive, the proper medium of proof for the conclusion which we wish to establish. I will not say, that the insensible parts of nature are made solely for the sensitive parts: but this I say, that, when we consider the benevolence of the Deity, we can only consider it in relation to sensitive being. Without this reference, or referred to any thing else, the attribute has no object; the term has no meaning. Dead matter is nothing. The parts, therefore, especially the limbs and senses, of animals, although they constitute, in mass and quantity, a small portion of the material creation, yet, since they alone are instruments of perception, they compose what may be called the whole of visible nature, estimated with a view to the disposition of its author. Consequently, it is in *these* that we are to seek his character. It is by these that we are to prove, that the world was made with a benevolent design.

Nor is the design abortive. It is a happy world after all. The air, the earth, the water, teem with delighted existence. In a spring noon, or a summer evening, on whichever side I turn my eyes, myriads of happy beings crowd upon my view. "The insect youth are on the wing." Swarms of newborn *flies* are trying their pinions in the air. Their sportive motions, their wanton mazes, their gratuitous activity, their continual change of place without use or purpose, testify their joy, and the exultation which they feel in their lately discovered faculties. A *bee*amongst the flowers in spring, is one of the most cheerful objects that can be looked upon. Its life appears to be all enjoyment; so busy, and so pleased: yet it is only a specimen of insect life, with which, by reason of the animal being half domesticated, we happen to be better acquainted than we are with that of others. The *whole winged* insect tribe, it is probable, are equally intent upon their proper employments, and, under every variety of constitution, gratified, and perhaps equally gratified, by the offices which the Author of their nature has assigned to them. But the atmosphere is not the only scene or enjoyment for the insect race. Plants are covered with aphides, greedily sucking their juices, and constantly, as it should seem, in the act of sucking. It cannot be doubted but that this is a state of gratification. What else should fix them so close to the operation, and so long? other species are *running about*, with an alacrity in their motions, which carries with it every mark of pleasure. Large patches of ground are sometimes half covered with these brisk and sprightly natures. If we look to what the *waters* produce, shoals of the fry of fish frequent the margins of rivers, of lakes, and of the sea itself. These are so happy, that they know not what to do with themselves. Their attitudes, their vivacity, their leaps out of the water, their frolics in it (which I have noticed a thousand times with equal attention and amusement), all conduce to show their excess of spirits, and are simply the effects of that excess. Walking by the sea-side, in a calm evening, upon a sandy shore, and with an ebbing tide, I have frequently remarked the appearance of a dark cloud, or, rather, very thick mist, hanging over the edge of the water, to the height, perhaps, of half a yard, and of the breadth of two or three yards, stretching along the coast as far as the eye could reach, and always retiring with the water. When this cloud came to be examined, it proved to be nothing else than so much space, filled with young *shrimps*, in the act of bounding into the air from the shallow margin of the water, or from the wet sand. If any motion of a mute animal could express delight, it was this: if they had meant to make signs of their happiness, they

could not have done it more intelligibly. Suppose then, what I have no doubt of, each individual of this number to be in a state of positive enjoyment; what a sum, collectively, of gratification and pleasure have we here before our view!

The *young* of all animals appear to me to receive pleasure simply from the exercise of their limbs and bodily faculties, without reference to any end to be attained, or any use to be answered by the exertion. A child, without knowing any thing of the use of language, is in a high degree delighted with being able to speak. Its incessant repetition of a few articulate sounds, or, perhaps, of the single word which it has learned to pronounce, proves this point clearly. Nor is it less pleased with its first successful endeavours to walk, or rather to run (which precedes walking), although entirely ignorant of the importance of the attainment to its future life, and even without applying it to any present purpose. A child is delighted with speaking, without having any thing to say; and with walking, without knowing where to go. And, prior to both these, I am disposed to believe, that the waking hours of infancy are agreeably taken up with the exercise of vision, or perhaps, more properly speaking, with learning to see.

But it is not for youth alone that the great Parent of creation hath provided. Happiness is found with the purring cat, no less than with the playful kitten; in the armchair of dozing age, as well as in either the sprightliness of the dance, or the animation of the chase. To novelty, to acuteness of sensation, to hope, to ardour of pursuit, succeeds, what is, in no inconsiderable degree, an equivalent for them all, "perception of ease." Herein is the exact difference between the young and the old. The young are not happy, but when enjoying pleasure; the old are happy, when free from pain. And this constitution suits with the degrees of animal power which they respectively possess. The vigour of youth was to be stimulated to action by impatience of rest; whilst to the imbecility of age, quietness and repose become positive gratifications. In one important respect the advantage is with the old. A state of ease is, generally speaking, more attainable than a state of pleasure. A constitution, therefore, which can enjoy ease, is preferable to that which can taste only pleasure. This same perception of ease oftentimes renders old age a condition of great comfort; especially when riding at its anchor after a busy or tempestuous life. It is well described by Rousseau, to be the interval of repose and enjoyment, between the hurry and the end of life. How far the same cause extends to other animal natures, cannot be judged of with certainty. The appearance of satisfaction, with which most animals, as their activity subsides, seek and enjoy rest, affords reason to believe, that this source of gratification is appointed to advanced life, under all, or most, of its various forms. In the species with which we are best acquainted, namely our own, I am far, even as an observer of human life, from thinking that youth is its happiest season, much less the only happy one: as a Christian, I am willing to believe that there is a great deal of truth in the following representation given by a very pious writer, as well as excellent man(*Note:* Father's Instructions; by Dr. Percival of Manchester. p. 317): "To the intelligent and virtuous, old age presents a scene of tranquil enjoyments, of obedient appetite, of well-regulated affections, of maturity in knowledge, and of calm preparation for immortality. In this serene and dignified state, placed as it were on the confines of two worlds, the mind of a good man reviews what is past with the complacency of an approving conscience; and looks forward, with humble confidence in the mercy of God, and with devout aspirations towards his eternal and ever-increasing favour." What is seen in different stages of the same life, is still more exemplified in the lives of different animals. Animal enjoyments are infinitely *diversified*. The modes of life, to which the organization of different animals respectively determines them, are not only of various but of opposite kinds. Yet each is happy in its own. For instance; animals of prey live much alone; animals of a milder constitution, in society. Yet the herring, which lives in shoals, and the sheep, which lives in flocks, are not more happy in a crowd, or more contented amongst their companions, than is the pike, or the lion, with the deep solitudes of the pool, or the forest.

But it will be said, that the instances which we have here brought forward, whether of vivacity or repose, or of apparent enjoyment derived from either, are picked and favourable instances. We answer, first, that they are instances, nevertheless, which comprise large provinces of sensitive existence; that every case which we have described, is the case of millions. At this moment, in every given moment of time, how many myriads of animals are eating their food, gratifying their appetites, ruminating in their holes, accomplishing their wishes, pursuing their pleasures, taking their pastimes! In each individual, how many things must go right for it to be at ease; yet how large a proportion out of every species is so in every assignable instant! Secondly, we contend, in the terms of our original proposition, that throughout the whole of life, as it is diffused in nature, and as far as we are acquainted with it, looking to the average of sensations, the plurality and the preponderancy is in favour of happiness by a vast excess. In our own species, in which perhaps the assertion may be more questionable than in any other, the prepollency of good over evil, of health, for example, and ease, over pain and distress, is evinced by the very notice which calamities excite. What inquiries does the sickness of our friends produce! what conversation their misfortunes! This shows that the common course of things is in favour of happiness: that happiness is the rule, misery the exception. Were the order reversed, our attention would be called to examples of health and competency, instead of disease and want.

One great cause of our insensibility to the goodness of the Creator, is the very *eatensiveness*of his bounty. We prize but little what we share only in common with the rest, or with the generality of our species. When we hear of blessings, we think forthwith of successes, of prosperous fortunes, of honours, riches, preferments, *i. e.* of those advantages and superiorities over others, which we happen either to possess, or to be in pursuit of, or to covet. The common benefits of our nature entirely escape us. Yet these are the great things. These constitute what most properly ought to be accounted blessings of Providence; what alone, if we might so speak, are worthy of its care. Nightly rest and daily bread, the ordinary use of our limbs, and senses, and understandings, are gifts which admit of no comparison with any other. Yet, because almost every man we meet with possesses these, we leave them out of our enumeration. They raise no sentiment; they move no gratitude. Now, herein, is our judgment perverted by our selfishness. A blessing ought in truth to be the *more* satisfactory, the bounty at least of the donor is rendered more conspicuous, by its very diffusion, its commonness, its cheapness; by its falling to the lot, and forming the happiness, of the great bulk and body of our species, as well as of ourselves. Nay, even when we do not possess it, it ought to be matter of thankfulness that others do. But we have a different way of thinking. We court distinction. That is not the worst: we *see* nothing but what has distinction to recommend it. This necessarily contracts our views of the Creator's beneficence within a narrow compass; and most unjustly. It is in those things which are so common as to be no distinction, that the amplitude of the Divine benignity is perceived.

But pain, no doubt, and privations exist, in numerous instances, and to a degree, which, collectively, would be very great, if they were compared with any other thing than with the mass of animal fruition. For the application, therefore, of our proposition to that *mixed* state of things which these exceptions induce, two rules are necessary, and both, I think, just and fair rules. One is, that we regard those effects alone which are accompanied with proofs of intention: The other, that when we cannot resolve all appearances into benevolence of design, we make the few give place to many; the little to the great; that we take our judgment from a large and decided preponderancy, if there be one.

I crave leave to transcribe into this place, what I have said upon this subject in my Moral Philosophy:--

"When God created the human species,"

"" either he wished their happiness, or he wished their misery, or he was indifferent and unconcerned about either.

"If he had wished our misery, he might have made sure of his purpose, by forming our senses to be so many sores and pains to us, as they are now instruments of gratification and enjoyment: or by placing us amidst objects, so ill suited to our perceptions as to have continually offended us, instead of ministering to our refreshment and delight. He might have made, for example, every thing we tasted, bitter; every thing we saw, loathsome; every thing we touched, a sting; every smell, a stench; and every sound, a discord."

"If he had been indifferent about our happiness or misery, we must impute to our good fortune (as all design by this supposition is excluded) both the capacity of our senses to receive pleasure, and the supply of external objects fitted to produce it."

"But either of these, and still more both of them, being too much to be attributed to accident, nothing remains but the first supposition, that God, when he created the human species, wished their happiness; and made for them the provision which he has made, with that view and for that purpose." "The same argument may be proposed in different terms; *thus:* Contrivance proves design: and the predominant tendency of the contrivance indicates the disposition of the designer. The world abounds with contrivances: and all the contrivances which we are acquainted with, are directed to beneficial purposes. Evil, no doubt, exists; but is never, that we can perceive, the *object* of contrivance. Teeth are contrived to eat, not to ache; their aching now and then is incidental to the contrivance, perhaps inseparable from it: or even, if you will, let it be called a defect in the contrivance: but it is not the object of it. This is a distinction which well deserves to be attended to. In describing implements of husbandry, you would hardly say of the sickle, that it is made to cut the reaper's hand; though, from the construction of the instrument, and the manner of using it, this mischief often follows. But if you had occasion to describe instruments of torture or execution; this engine you would say, is to extend the sinews: this to dislocate the joints; this to break the bones; this to scorch the soles of the feet. Here, pain and misery are the very objects of the contrivance. Now, nothing of this sort is to be found in the works of nature. We never" discover a train of contrivance to bring about an evil purpose. No anatomist ever discovered a system of organization calculated to produce pain and disease; or, in explaining the parts of the human body, ever said, this is to irritate; this to inflame; this duct is to convey the gravel to the kidneys; this gland to secrete the humour which forms the gout; if by chance he come at a part of which he knows not the use, the most he can say is, that it is useless; no one ever suspects that it is put there to incommode, to annoy, or to torment.

The TWO CASES which appear to me to have the most of difficulty in them, as forming the most of the appearance of exception to the representation here given, are those of *venomous* animals, and of animals *preying*upon one another. These properties of animals, wherever they are found, must, I think, be referred to design; because there is, in all cases of the first, and in most cases of the second, an express and distinct organization provided for the producing of them. Under the first head, the fangs of vipers, the stings of wasps and scorpions, are as clearly intended for their purpose, as any animal structure is for any purpose the most incontestably beneficial. And the same thing must, under the second head, be acknowledged of the talons and beaks of birds, of the tusks, teeth, and claws of beasts of prey, of the shark's mouth, of the spider's web, and of numberless weapons of offence belonging to different tribes of voracious insects. We cannot, therefore, avoid the difficulty by saying, that the effect was not intended. The only question open to us is, whether it be ultimately evil. From the confessed and felt imperfection of our knowledge, we ought to presume, that there may be consequences of this œconomy which are hidden from us; from the benevolence which pervades the general designs of nature, we ought also to presume, that these consequences, if they could enter into our calculation, would turn the balance on the favourable

side. Both these I contend to be reasonable presumptions. Not reasonable presumptions, if these two cases were the only cases which nature presented to our observation; but reasonable presumptions under the reflection, that the cases in question are combined with a multitude of intentions, all proceeding from the same author, and all, except these, directed to ends of undisputed utility. Of the vindications, however, of this œconomy, which we are able to assign, such as most extenuate the difficulty are the following.

With respect to *venomous* bites and stings, it may be observed,--

1. That, the animal itself being regarded, the faculty complained of is *good:* being conducive, in all cases, to the defence of the animal; in some cases, to the subduing of its prey; and, in some, probably, to the killing of it, when caught, by a mortal wound, inflicted in the passage to the stomach, which may be no less merciful to the victim, than salutary to the devourer. In the viper for instance, the poisonous fang may do that which, in other animals of prey, is done by the crush of the teeth. Frogs and mice might be swallowed alive without it.

2. But it will be said, that this provision, when it comes to the case of bites, deadly even to human bodies and to those of large quadrupeds, is greatly *overdone;* that it might have fulfilled its use, and yet have been much less deleterious than it is. Now I believe the case of bites, which produce death in large animals (of stings I think there are none), to be very few. The experiments of the Abbé Fontana, which were numerous; go strongly to the proof of this point. He found that it required the action of five exasperated vipers to kill a dog of a moderate size; but that, to the killing of a mouse or a frog, a single bite was sufficient; which agrees with the use which we assign to the faculty. The Abbé seemed to be of opinion, that the bite even of the rattle-snake would not usually be mortal; allowing, however, that in certain particularly unfortunate cases, as when the puncture had touched some very tender part, pricked a principal nerve for instance, or, as it is said, some more considerable lymphatic vessel, death might speedily ensue.

3. It has been, I think, very justly remarked, concerning serpents, that, whilst only a few species possess the venomous property, that property guards the whole tribe. The most innocuous snake is avoided with as much care as a viper. Now the terror with which large animals regard this class of reptiles, is its protection; and this terror is founded in the formidable revenge, which a few of the number, compared with the whole, are capable of taking. The species of serpents, described by Linnæus, amount to two hundred and eighteen, of which thirty-two only are poisonous.

4. It seems to me, that animal constitutions are provided, not only for each element, but for each state of the elements, *i. e.* for every climate, and for every temperature; and that part of the mischief complained of, arises from animals (the human animal most especially) occupying situations upon the earth, which do not belong to them, nor were ever intended for their habitation. The folly and wickedness of mankind, and necessities proceeding from these causes, have driven multitudes of the species to seek a refuge amongst burning sands, whilst countries, blessed with hospitable skies, and with the most fertile soils, remain almost without a human tenant. We invade the territories of wild beasts and venomous reptiles, and then complain that we are infested by their bites and stings. Some accounts of Africa place this observation in a strong point of view. "The deserts," says Adanson, "are entirely barren, except where they are found to produce serpents; and in such quantities, that some extensive plains are almost entirely covered with them." These are the natures appropriated to the situation. Let them enjoy their existence; let them have their country. Surface enough will be left to man, though his numbers were increased a hundred fold, and left to him, where he might live, exempt from these annoyances.

The SECOND CASE, *viz.* that of animals *devouring* one another, furnishes a consideration of much larger extent. To judge whether, as a general provision, this can be deemed an *evil*, even so far as

we understand its consequences, which, probably, is a partial understanding, the following reflections are fit to be attended to.

1. Immortality upon this earth is out of the question. Without death there could be no generation, no sexes, no parental relation, *i. e.* as things are constituted, no animal happiness. The particular duration of life, assigned to different animals, can form no part of the objection; because, whatever that duration be, whilst it remains finite and limited, it may always be asked, why it is no longer. The natural age of different animals varies, from a single day to a century of years. No account can be given of this; nor could any be given, whatever other proportion of life had obtained amongst them.

The term then of life in different animals being the same as it is, the question is, what mode of taking it away is the best even for the animal itself. Now, according to the established order of nature (which we must suppose to prevail, or we cannot reason at all upon the subject), the three methods by which life is usually put an end to, are acute diseases, decay, and violence. The simple and natural life of *brutes*, is not often visited by acute distempers; nor could it be deemed an improvement of their lot, if they were. Let it be considered, therefore, in what a condition of suffering and misery a brute animal is placed, which is left to perish by *decay*. In human sickness or infirmity, there is the assistance of man's rational fellow-creatures, if not to alleviate his pains, at least to minister to his necessities, and to supply the place of his own activity. A brute, in his wild and natural state, does every thing for himself. When his strength, therefore, or his speed, or his limbs, or his senses fail him, he is delivered over, either to absolute famine, or to the protracted wretchedness of a life slowly wasted by the scarcity of food. Is it then to see the world filled with drooping, superannuated, half-starved, helpless, and unhelped animals, that you would alter the present system, of pursuit and prey?

2. Which system is also to them the spring of motion and activity on both sides. The pursuit of its prey, forms the employment, and appears to constitute the pleasure, of a considerable part of the animal creation. The using of the means of defence, or flight, or precaution, forms also the business of another part. And even of this latter tribe, we have no reason to suppose, that their happiness is much molested by their fears. Their danger exists continually; and in some cases they seem to be so far sensible of it as to provide, in the best manner they can, against it; but it is only when the attack is actually made upon them, that they appear to suffer from it. To contemplate the insecurity of their condition with anxiety and dread, requires a degree of reflection, which (happily for themselves), they do not possess. A *hare*, notwithstanding the number of its dangers and its enemies, is as playful an animal as any other.

3. But, to do justice to the question, the system of animal *destruction* ought always to be considered in strict connexion with another property of animal nature, viz. *superfecundity*. They are countervailing qualities. One subsists by the correction of the other. In treating, therefore, of the subject under this view (which is, I believe, the true one), our business will be, first, to point out the advantages which are gained by the powers in nature of a superabundant multiplication; and, then, to show, that these advantages are so many reasons for appointing that system of national hostilities, which we are endeavouring to account for.

In almost all cases, nature produces her supplies with profusion. A single cod-fish spawns, in one season, a greater number of eggs, than all the inhabitants of England amount to. A thousand other instances of prolific generation might be stated, which, though not equal to this, would carry on the increase of the species with a rapidity which outruns calculation, and to an immeasurable extent. The advantages of such a constitution are two: first, that it tends to keep the world always full; whilst, secondly, it allows the proportion between the several species of animals to be differently modified, as different purposes require, or as different situations may afford for them

room and food. Where this vast fecundity meets with a vacancy fitted to receive the species, there it operates with its whole effect: there it pours in its numbers, and replenishes the waste. We complain of what we call the exorbitant multiplication of some troublesome insects; not reflecting, that large portions of nature might be left void without it. If the accounts of travellers may be depended upon, immense tracts of forest in North America would be nearly lost to sensitive existence, if it were not for *gnats*. "In the thinly inhabited regions of America, in which the waters stagnate and the climate is warm, the whole air is filled with crowds of these insects." Thus it is, that where we looked for solitude and death-like silence, we meet with animation, activity, enjoyment; with a busy, a happy, and a peopled world. Again; hosts of *mice*are reckoned amongst the plagues of the north-east part of Europe; whereas vast plains in Siberia, as we learn from good authority, would be lifeless without them. The Caspian deserts are converted by their presence into crowded warrens. Between the Volga and the Yaik, and in the country of Hyrcania, the ground, says Pallas, is in many places *covered* with little hills, raised by the earth cast out in forming the burrows. Do we so envy these blissful abodes, as to pronounce the fecundity by which they are supplied with inhabitants, to be an evil; a subject of complaint, and not of praise? Further; by virtue of this same superfecundity, what we term destruction, becomes almost instantly the parent of life. What we call blights, are, oftentimes, legions of animated beings, claiming their portion in the bounty of nature. What corrupts the produce of the earth to us, prepares it for them. And it is by means of their rapid multiplication, that they take possession of their pasture; a slow propagation would not meet the opportunity.

But in conjunction with the occasional use of this fruitfulness, we observe, also, that it allows the proportion between the several species of animals to be differently modified, as different purposes of utility may require. When the forests of America come to be cleared, and the swamps drained, our gnats will give place to other inhabitants. If the population of Europe should spread to the north and the east, the mice will retire before the husbandman and the shepherd, and yield their station to herds and flocks. In what concerns the human species, it may be a part of the scheme of Providence, that the earth should be inhabited by a shifting, or perhaps a circulating population. In this œconomy, it is possible that there may be the following advantages: When old countries are become exceedingly corrupt, simpler modes of life, purer morals, and better institutions, may rise up in new ones, whilst fresh soils reward the cultivator with more plentiful returns. Thus the different portions of the globe come into use in succession as the residence of man; and, in his absence, entertain other guests, which, by their sudden multiplication, fill the chasm. In domesticated animals, we find the effect of their fecundity to be, that we can always command *numbers*; we can always have as many of any particular species as we please, or as we can support. Nor do we complain of its excess; it being much more easy to regulate abundance, than to supply scarcity.

But then this *superfecundity*, though of great occasional use and importance, exceeds the ordinary capacity of nature to receive or support its progeny. All superabundance supposes destruction, or must destroy itself. Perhaps there is no species of terrestrial animals whatever, which would not overrun the earth, if it were permitted to multiply in perfect safety; or of fish, which would not fill the ocean: at least, if any single species were left to their natural increase without disturbance or restraint, the food of other species would be exhausted by their maintenance. It is necessary, therefore, that the effects of such prolific faculties be curtailed. In con junction with other checks and limits, all subservient to the same purpose, are the *thinnings* which take place among animals, by their action upon one another. In some instances we ourselves experience, very directly, the use of these hostilities. One species of insects rids us of another species; or reduces their ranks. A third species, perhaps, keeps the second within bounds: and birds or lizards are a fence against the inordinate increase by which even these last might infest us. In other, more numerous, and possibly more important, instances, this disposition of things, although less necessary or useful to us, and of course less observed by us, may be necessary and useful to certain other species; or even for the

preventing of the loss of certain species from the universe: a misfortune which seems to be studiously guarded against. Though there may be the appearance of failure in some of the details of Nature's works, in her great purposes there never are. Her species never fail. The provision which was originally made for continuing the replenishment of the world, has proved itself to be effectual through a long succession of ages.

What further shows, that the system of destruction amongst animals holds an express relation to the system of fecundity; that they are parts indeed of one compensatory scheme; is, that, in each species, the fecundity bears a proportion to the smallness of the animal, to the weakness, to the shortness of its natural term of life, and to the dangers and enemies by which it is surrounded. An elephant produces but one calf; a butterfly lays six hundred eggs. Birds of prey seldom produce more than two eggs: the sparrow tribe, and the duck tribe, frequently sit upon a dozen. In the rivers, we meet with a thousand minnows for one pike; in the sea, a million of herrings for a single shark. Compensation obtains throughout. Defencelessness and devastation are repaired by fecundity.

We have dwelt the longer on these considerations, because the subject to which they apply, namely, that of animals *devouring* one another, forms the chief, if not the only instance, in the works of the Deity, of an œconomy, stamped by marks of design, in which the character of utility can be called in question. The case of *venomous* animals is of much inferior consequence to the case of prey, and, in some degree, is also included under it. To both cases it is probable that many more reasons belong, than those of which we are in possession.

Our FIRST PROPOSITION, and that which we have hitherto been defending, was, "that, in a vast plurality of instances, in which *contrivance* is perceived, the design of the contrivance is beneficial."

Our SECOND PROPOSITION is, "that the Deity has added *pleasure* to animal sensations, beyond what was necessary for any other purpose, or when the purpose, so far as it was necessary, might have been effected by the operation of pain."

This proposition may be thus explained: The capacities, which, according to the established course of nature, are *necessary* to the support or preservation of an animal, however manifestly they may be the result of an organization contrived for the purpose, can only be deemed an act or a part of the same will, as that which decreed the existence of the animal itself; because, whether the creation proceeded from a benevolent of a malevolent being, these capacities must have been given, if the animal existed at all. Animal properties, therefore, which fall under this description, do not strictly prove the goodness of God: they may prove the existence of the Deity; they may prove a high degree of power and intelligence: but they do not prove his goodness; forasmuch as they must have been found in any creation which was capable of continuance, although it is possible to suppose, that such a creation might have been produced by a being whose views rested upon misery.

But there is a class of properties, which may be said to be superadded from an intention expressly directed to happiness; an intention to give a happy existence distinct from the general intention of providing the means of existence; and that is, of capacities for pleasure, in cases wherein, so far as the conservation of the individual or of the species is concerned, they were not wanted, or wherein the purpose might have been secured by the operation of pain. The provision which is made of a variety of objects, not necessary to life, and ministering only to our pleasures; and the properties given to the necessaries of life themselves, by which they contribute to pleasure as well as preservation; show a further design, than that of giving existence(*Note:* See this topic considered in Dr. Balguy's Treatise upon the Divine Benevolence. This excellent author first, I think, proposed it;

and nearly in the terms in which it is here stated. Some other observations also under this head are taken from that treatise.).

A single instance will make all this clear. Assuming the necessity of food for the support of animal life; it is requisite, that the animal be provided with organs, fitted for the procuring, receiving, and digesting of its food. It may be also necessary, that the animal be impelled by its sensations to exert its organs. But the pain of hunger would do all this. Why add pleasure to the act of eating; sweetness and relish to food? why a new and appropriate sense for the perception of the pleasure? Why should the juice of a peach, applied to the palate, affect the part so differently from what it does when rubbed upon the palm of the hand? This is a constitution which, so far as appears to me, can be resolved into nothing but the pure benevolence of the Creator. Eating is necessary; but the pleasure attending it is not necessary: and that this pleasure depends, not only upon our being in possession of the sense of taste, which is different from every other, but upon a particular state of the organ in which it resides, a felicitous adaptation of the organ to the object, will be confessed by any one, who may happen to have experienced that vitiation of taste which frequently occurs in fevers, when every taste is irregular, and every one bad.

In mentioning the gratifications of the palate, it may be said that we have made choice of a trifling example. I am not of that opinion. They afford a share of enjoyment to man; but to brutes, I believe that they are of very great importance. A horse at liberty passes a great part of his waking hours in eating. To the ox, the sheep, the deer, and other ruminating animals, the pleasure is doubled. Their whole time almost is divided between browsing upon their pasture and chewing their cud. Whatever the pleasure be, it is spread over a large portion of their existence. If there be animals, such as the lupous fish, which swallow their prey whole, and at once, without any time, as it should seem, for either drawing out, or relishing, the taste in the mouth, is it an improbable conjecture, that the seat of taste with them is in the stomach; or, at least, that a sense of pleasure, whether it be taste or not, accompanies the dissolution of the food in that receptacle, which dissolution in general is carried on very slowly? If this opinion be right, they are more than repaid for the defect of palate. The feast lasts as long as the digestion.

In seeking for argument, we need not stay to insist upon the comparative importance of our example; for, the observation holds equally of all, or of three at least, of the other senses. The necessary purposes of hearing might have been answered without harmony; of smell, without fragrance; of vision without beauty. Now, "if the Deity had been indifferent about our happiness or misery, we must impute to our good fortune (as all design by this supposition is excluded), both the capacity of our senses to receive pleasure, and the supply of external objects fitted to excite it." I allege these as *two* felicities, for they are different things, yet both necessary: the sense being formed, the objects, which were applied to it, might not have suited it; the objects being fixed, the sense might not have agreed with them. A coincidence is here required, which no accident can account for. There are three possible suppositions upon the subject, and no more. The first; that the sense, by its original constitution, was made to suit the object: The second; that the object, by its original constitution, was made to suit the sense: The third; that the sense is so constituted, as to be able, either universally, or within certain limits, by habit and familiarity, to render every object pleasant. Which-ever of these suppositions we adopt, the effect evinces, on the part of the Author of nature, a studious benevolence. If the pleasures which we derive from any of our senses, depend upon an original congruity between the sense and the properties perceived by it, we know only experience, that the adjustment demanded, with respect to the qualities which were conferred upon the objects that surround us, not only choice and selection, out of a boundless variety of possible qualities with which these objects might have been endued, but a *proportioning also of degree*, because an excess or defect of intensity spoils the perception, as much almost as an error in the kind and nature of the quality. Likewise the degree of dulness or acuteness in the sense itself, is no arbitrary thing, but, in order to preserve the congruity here spoken of, requires to be in

an exact or near correspondency with the strength of the impression. The dulness of the senses forms the complaint of old age. Persons in fevers, and, I believe, in most maniacal cases, experience great torment from their preternatural acuteness. An increased, no less than an impaired sensibility, induces a state of disease and suffering.

The doctrine of a specific congruity between animal senses and their objects, is strongly favoured by what is observed of insects in the election of their food. Some of these will feed upon one kind of plant or animal, and upon no other: some caterpillars upon the cabbage alone; some upon the black currant alone. The species of caterpillar which eats the vine, will starve upon the elder; nor will that which we find upon fennel, touch the rose-bush. Some insects confine themselves to two or three kinds of plants or animals. Some again show so strong a preference, as to afford reason to believe that, though they may be driven by hunger to others, they are led by the pleasure of taste to a few particular plants alone: and all this, as it should seem, independently of habit or imitation.

But should we accept the third hypothesis, and even carry it so far, as to ascribe every thing which concerns the question to habit (as in certain species, the human species most particularly, there is reason to attribute something), we have then before us an animal capacity, not less perhaps to be admired than the native congruities which the other scheme adopts. It cannot be shown to result from any fixed necessity in nature, that what is frequently applied to the senses should of course become agreeable to them. It is, so far as it subsists, a power of accommodation provided in these senses by the Author of their structure, and forms a part of their perfection. In which-ever way we regard the senses, they appear to be specific gifts, ministering, not only to preservation, but to pleasure. But what we usually call the *senses*, are probably themselves far from being the only vehicles of enjoyment, or the whole of our constitution which is calculated for the same purpose. We have many internal sensations of the most agreeable kind, hardly referable to any of the five senses. Some physiologists have holden, that all secretion is pleasurable; and that the complacency which in health, without any external assignable object to excite it, we derive from life itself, is the effect of our secretions going on well within us. All this may be true: but if true, what reason can be assigned for it, except the will of the Creator? It may reasonably be asked, Why is any thing a pleasure? and I know no answer which can be returned to the question, but that which refers it to appointment.

We can give no account whatever of our pleasures in the simple and original perception; and, even when physical sensations are assumed, we can seldom account for them in the secondary and complicated shapes, in which they take the name of diversions. I never yet met with a sportsman, who could tell me in what the sport consisted: who could resolve it into its principle, and state that principle. I have been a great follower of fishing myself, and in its cheerful solitude have passed some of the happiest hours of a sufficiently happy life; but, to this moment, I could never trace out the source of the pleasure which it afforded me.

The "quantum in rebus inane!" whether applied to our amusements, or to our graver pursuits (to which, in truth, it sometimes equally belongs), is always an unjust complaint. If trifles engage, and if trifles make us happy, the true reflection suggested by the experiment, is upon the tendency of nature to gratification and enjoyment; which is, in other words, the goodness of its Author towards his sensitive creation.

Rational natures also, as such, exhibit qualities which help to confirm the truth of our position. The degree of understanding found in mankind, is usually much greater than what is necessary for mere preservation. The pleasure of choosing for themselves, and of prosecuting the object of their choice, should seem to be an original source of enjoyment. The pleasures received from things, great, beautiful, or new, from imitation, or from the liberal arts, are, in some measure, not only

superadded, but unmixed, gratifications, having no pains to balance them(*Note:* Balguy on the Divine Benevolence.).

I do not know whether our attachment to *property* be not something more than the mere dictate of reason, or even than the mere effect of association. Property communicates a charm to whatever is the object of it. It is the first of our abstract ideas; it cleaves to us the closest and the longest. It endears to the child its plaything, to the peasant his cottage, to the landholder his estate. It supplies the place of prospect and scenery. Instead of coveting the beauty of distant situations, it teaches every man to find it in his own. It gives boldness and grandeur to plains and fens, tinge and colouring to clays and fallows.

All these considerations come in aid of our *second* proposition. The reader will now bear in mind what our two propositions were. They were, firstly, that in a vast plurality of instances, in which contrivance is perceived, the design of the contrivance is beneficial: secondly, that the Deity has added pleasure to animal sensations beyond what was necessary for any other purpose; or when the purpose, so far as it was necessary, might have been effected by the operation of pain.

Whilst these propositions can be maintained, we are authorized to ascribe to the Deity the character of benevolence: and what is benevolence at all, must in him be *infinite* benevolence, by reason of the infinite, that is to say, the incalculably great, number of objects, upon which it is exercised.

Of the ORIGIN OF EVIL, no universal solution has been discovered; I mean, no solution which reaches to all cases of complaint. The most comprehensive is that which arises from the consideration of *general rules*. We may, I think, without much difficulty, be brought to admit the four following points: first, that important advantages may accrue to the universe from the order of nature proceeding according to general laws: secondly, that general laws, however well set and constituted, often thwart and cross one another: thirdly, that from these thwartings and crossings, frequent particular inconveniencies will arise: and, fourthly, that it agrees with our observation to suppose, that some degree of these inconveniencies takes place in the works of nature. These points may be allowed; and it may also be asserted, that the general laws with which we are acquainted, are directed to beneficial ends. On the other hand, with many of these laws we are not acquainted at all, or we are totally unable to trace them in their branches, and in their operation; the effect of which ignorance is, that they cannot be of importance to us as measures by which to regulate our conduct. The conservation of them may be of importance in other respects, or to other beings, but we are uninformed of their value or use; uninformed, consequently, when, and how far, they may or may not be suspended, or their effects turned aside, by a presiding and benevolent will, without incurring greater evils than those which would be avoided. The consideration, therefore, of general laws, although it may concern the question of the origin of evil very nearly (which I think it does), rests in views disproportionate to our faculties, and in a knowledge which we do not possess. It serves rather to account for the obscurity of the subject, than to supply us with distinct answers to our difficulties. However, whilst we assent to the above-stated propositions as principles, whatever uncertainty we may find in the application, we lay a ground for believing, that cases of apparent evil, for which *we* can suggest no particular reason, are governed by reasons, which are more general, which lie deeper in the order of second causes, and which on that account, are removed to a greater distance from us.

The doctrine of *imperfections*, or, as it is called, of evils of imperfection, furnishes an account, founded, like the former, in views of universal nature. The doctrine is briefly this:--It is probable, that creation may be better replenished by sensitive beings of different sorts, than by sensitive beings all of one sort. It is likewise probable, that it may be better replenished, by different orders of beings rising one above another in gradation, than by beings possessed of equal degrees of

perfection. Now, a gradation of such beings, implies a gradation of imperfections. No class can justly complain of the imperfections which belong to its place in the scale, unless it were allowable for it to complain, that a scale of being was appointed in nature; for which appointment there appear to be reasons of wisdom and goodness.

In like manner, *finiteness*, or what is resolvable into finiteness, in inanimate subjects, can never be a just subject of complaint, because if it were ever so, it would be always so: we mean, that we can never reasonably demand that things should be larged or more, when the same demand might be made, whatever the quantity or number was.

And to me it seems, that the sense of mankind has so far acquiesced in these reasons, as that we seldom complain of evils of this class, when we clearly perceive them to be such. What I have to add, therefore, is that we ought not to complain of some other evils, which stand upon the same foot of vindication as evils of confessed imperfection. We never complain, that the globe of our earth is too small: nor should we complain, if it were even much smaller. But where is the difference to us, between a less globe, and part of the present being uninhabitable? The inhabitants of an island may be apt enough to murmur at the sterility of some parts of it, against its rocks, or sands, or swamps: but no one thinks himself authorized to murmur, simply because the island is not large than it is. Yet these are the same griefs.

The above are the two metaphysical answers which have been given to this great question. They are not the worse for being metaphysical, provided they be founded (which I think they are) in right reasoning: but they are of a nature too wide to be brought under our survey, and it is often difficult to apply them in the detail. Our speculations, therefore, are perhaps better employed when they confine themselves within a narrower circle.

The observations which follow, are of this more limited, but more determinate kind.

Of *bodily pain*, the principal observation, no doubt, is that which we have already made, and already dwelt upon, *viz*. "that it is seldom the object of contrivance; that when it is so, the contrivance rests ultimately in good."

To which, however, may be added, that the annexing of pain to the means of destruction is a salutary provision; inasmuch as it teaches vigilance and caution; both gives notice of danger, and excites those endeavours which may be necessary to preservation. The evil consequence, which sometimes arises from the want of that timely intimation of danger which pain gives, is known to the inhabitants of cold countries by the example of frost-bitten limbs. I have conversed with patients who have lost toes and fingers by this cause. They have in general told me, that they were totally unconscious of any local uneasiness at the time. Some I have heard declare, that, whilst they were about their employment, neither their situation, nor the state of the air, was unpleasant. They felt no pain; they suspected no mischief; till, by the application of warmth, they discovered, too late, the fatal injury which some of their extremities had suffered. I say that this shows the use of pain, and that we stand in need of such a monitor. I believe also that the use extends further than we suppose, or can now trace; that to disagreeable sensations we, and all animals owe or have owed, many habits of action which are salutary, but which are become so familiar, as not easily to be referred to their origin.

PAIN also itself is not without its *alleviations*. It may be violent and frequent; but it is seldom both violent and long-continued: and its pauses and intermissions become positive pleasures. It has the power of shedding a satisfaction over intervals of ease, which, I believe, few enjoyments exceed. A man resting from a fit of the stone or gout, is, for the time, in possession of feelings which undisturbed health cannot impart. They may be dearly bought, but still they are to be set against

the price. And, indeed, it depends upon the duration and urgency of the pain, whether they be dearly bought or not. I am far from being sure, that a man is not a gainer by suffering a moderate interruption of bodily ease for a couple of hours out of the four-and-twenty. Two very common observations favour this opinion: one is, that remissions of pain call forth, from those who experience them, stronger expressions of satisfaction and of gratitude towards both the author and the instruments of their relief, than are excited by advantages of any other kind; the second is, that the spirits of sick men do not sink in proportion to the acuteness of their sufferings; but rather appear to be roused and supported, not by pain, but by the high degree of comfort which they derive from its cessation, or even its subsidency, whenever that occurs: and which they taste with a relish, that diffuses some portion of mental complacency over the whole of that mixed state of sensations in which disease has placed them.

In connexion with bodily pain may be considered bodily *disease*, whether painful or not. Few diseases are fatal. I have before me the account of a dispensary in the neighbourhood, which states six years' experience as follows: Admitted ..... 6,420 *Cured* ..... 5,476 Dead 234

And this I suppose nearly to agree with what other similar institutions exhibit. Now, in all these cases, some disorder must have been felt, or the patients would not have applied for a remedy; yet we see how large a proportion of the maladies which were brought forward, have either yielded to proper treatment, or, what is more probable, ceased of their own accord. We owe these frequent recoveries, and, where recovery does not take place, this patience of the human constitution under many of the distempers by which it is visited, to two benefactions of our nature. One is, that she works within certain limits; allows of a certain latitude within which health may be preserved, and within the confines of which it only suffers a graduated diminution. Different quantities of food, different degrees of exercise, different portions of sleep, different states of the atmosphere, are compatible with the possession of health. So likewise is it with the secretions and excretions, with many internal functions of the body, and with the state, probably, of most of its internal organs. They may vary considerably, not only without destroying life, but without occasioning any high degree of inconveniency. The other property of our nature, to which we are still more beholden, is its constant endeavour to restore itself, when disordered, to its regular course. The fluids of the body appear to possess a power of separating and expelling any noxious substance which may have mixed itself with them. This they do, in eruptive fevers, by a kind of despumation, as Sydenham calls it, analogous in some measure to the intestine action by which fermenting liquors work the yest to the surface. The solids, on their part, when their action is obstructed, not only resume that action, as soon as the obstruction is removed, but they struggle with the impediment. They take an action as near to the true one, as the difficulty and the disorganization, with which they have to contend, will allow of.

Of *mortal* diseases, the great use is to reconcile us to death. The horror of death proves the value of life. But it is in the power of disease to abate, or even extinguish, this horror; which it does in a wonderful manner, and, oftentimes, by a mild and imperceptible gradation. Every man who has been placed in a situation to observe it, is surprised with the change which has been wrought in himself, when he compares the view which he entertains of death upon a sick-bed, with the heart-sinking dismay with which he should some time ago have met it in health. There is no similitude between the sensations of a man led to execution, and the calm expiring of a patient at the close of his disease. Death to him is only the last of a long train of changes; in his progress through which, it is possible that he may experience no shocks or sudden transitions.

Death itself, as a mode of removal and of succession, is so connected with the whole order of our animal world, that almost every thing in that world must be changed, to be able to do without it. It may seem likewise impossible to separate the fear of death from the enjoyment of life, or the

perception of that fear from rational natures. Brutes are in a great measure delivered from all anxiety on this account by the inferiority of their faculties; or rather they seem to be armed with the apprehension of death just sufficiently to put them upon the means of preservation, and no further. But would a human being wish to purchase this immunity at the expense of those mental powers which enable him to look forward to the future? Death implies *separation:* and the loss of those whom we love, must necessarily, so far as we can conceive, be accompanied with pain. To the brute creation, nature seems to have stepped in with some secret provision for their relief, under the rupture of their attachments. In their instincts towards their offspring, and of their offspring to them, I have often been surprised to observe how ardently they love, and how soon they forget. The pertinacity of human sorrow (upon which, time also, at length, lays its softening hand) is probably, therefore, in some manner connected with the qualities of our rational or moral nature. One thing however is clear, *viz*. that it is better that we should possess affections, the sources of so many virtues, and so many joys, although they be exposed to the incidents of life, as well as the interruptions of mortality, than, by the want of them, be reduced to a state of selfishness, apathy, and quietism.

Of other external evils (still confining ourselves to what are called physical or natural evils), a considerable part come within the scope of the following observation:--The great principle of human satisfaction is *engagement*. It is a most just distinction, which the late Mr. Tucker has dwelt upon so largely in his works, between pleasures in which we are passive, and pleasures in which we are active. And, I believe, every attentive observer of human life will assent to his position, that, however grateful the sensations may occasionally be in which we are passive, it is not these, but the latter class of our pleasures, which constitute satisfaction; which supply that regular stream of moderate and miscellaneous enjoyments, in which happiness, as distinguished from voluptuousness, consists. Now for rational occupation, which is, in other words, for the very material of contented existence, there would be no place left, if either the things with which we had to do were absolutely impracticable to our endeavours, or if they were too obedient to our uses. A world, furnished with advantages on one side, and beset with difficulties, wants, and inconveniences on the other, is the proper abode of free, rational, and active natures, being the fittest to stimulate and exercise their faculties. The very *refractoriness* of the objects they have to deal with, contributes to this purpose. A world in which nothing depended upon ourselves, however it might have suited an imaginary race of beings, would not have suited mankind. Their skill, prudence, industry; their various arts, and their best attainments, from the application of which they draw, if not their highest, their most permanent gratifications, would be insignificant, if things could be either moulded by our volitions, or, of their own accord, conformed themselves to our views and wishes. Now it is in this refractoriness that we discern the seed and principle of *physical*evil, as far as it arises from that which is external to us.

Civil evils, or the evils of civil life, are much more easily disposed of, than physical evils: because they are, in truth, of much less magnitude, and also because they result, by a kind of necessity, not only from the constitution of our nature, but from a part of that constitution which no one would wish to see altered. The case is this: Mankind will in every country *breed up* to a certain point of distress. That point may be different in different countries or ages, according to the established usages of life in each. It will also shift upon the scale, so as to admit of a greater or less number of inhabitants, according as the quantity of provision, which is either produced in the country, or supplied to it from other countries, may happen to vary. But there must always be such a point, and the species will always breed up to it. The order of generation proceeds by something like a geometrical progression. The increase of provision, under circumstances even the most advantageous, can only assume the form of an arithmetic series. Whence it follows, that the population will always overtake the provision, will pass beyond the line of plenty, and will continue to increase till checked by the difficulty of procuring subsistence(*Note:* See a statement of this subject, in a late treatise upon population.). Such difficulty therefore, along with its attendant

circumstances, *must* be found in every old country: and these circumstances constitute what we call poverty, which, necessarily, imposes labour, servitude, restraint.

It seems impossible to people a country with inhabitants who shall be all easy in circumstances. For suppose the thing to be done, there would be such marrying and giving in marriage amongst them, as would in a few years change the face of affairs entirely; *i. e.* as would increase the consumption of those articles, which supplied the natural or habitual wants of the country, to such a degree of scarcity, as must leave the greatest part of the inhabitants unable to procure them without toilsome endeavours, or, out of the different kinds of these articles, to procure any kind except that which was most easily produced. And this, in fact, describes the condition of the mass of the community in all countries: a condition unavoidably, as it should seem, resulting from the provision which is made in the human, in common with all animal constitutions, for the perpetuity and multiplication of the species.

It need not however dishearten any endeavours for the public service, to know that population naturally treads upon the heels of improvement. If the condition of a people be meliorated, the consequence will be, either that the *mean* happiness will be increased, or a greater number partake of it; or which is most likely to happen, that both effects will take place together. There may be limits fixed by nature to both, but they are limits not yet attained, nor even approached, in any country of the world.

And when we speak of limits at all, we have respect only to provisions for animal wants. There are sources, and means, and auxiliaries, and augmentations of human happiness, communicable without restriction of numbers; as capable of being possessed by a thousand persons as by one. Such are those, which flow from a mild, contrasted with a tyrannic government, whether civil or domestic; those which spring from religion; those which grow out of a sense of security; those which depend upon habits of virtue, sobriety, moderation, order; those, lastly, which are found in the possession of well-directed tastes and desires, compared with the dominion of tormenting, pernicious, contradictory, unsatisfied, and unsatisfiable passions.

The *distinctions* of civil life are apt enough to be regarded as evils, by those who sit under them; but, in my opinion, with very little reason.

In the first place, the advantages which the higher conditions of life are supposed to confer, bear no proportion in value to the advantages which are bestowed by nature. The gifts of nature always surpass the gifts of fortune. How much, for example, is activity better than attendance; beauty than dress; appetite, digestion, and tranquil bowels, than all the studies of cookery, or than the most costly compilation of forced, or far-fetched dainties!

Nature has a strong tendency to equalization. Habit, the instrument of nature, is a great leveller; the familiarity which it induces, taking off the edge both of our pleasures and our sufferings. Indulgences which are habitual, keep us in ease, and cannot be carried much further. So that, with respect to the gratifications of which the senses are capable, the difference is by no means proportionable to the apparatus. Nay, so far as superfluity generates fastidiousness, the difference is on the wrong side.

It is not necessary to contend, that the advantages derived from wealth are none (under due regulations they are certainly considerable), but that they are not greater than they ought to be. *Money* is the sweetener of human toil; the substitute for coercion; the reconciler of labour with liberty. It is, moreover, the stimulant of enterprise in all projects and undertakings, as well as of diligence in the most beneficial arts and employments. Now did affluence, when possessed, contribute nothing to happiness, or nothing beyond the mere supply of necessaries; and the secret

should come to be discovered; we might be in danger of losing great part of the uses, which are, at present, derived to us through this important medium. Not only would the tranquillity of social life be put in peril by the want of a motive to attach men to their private concerns; but the satisfaction which all men receive from success in their respective occupations, which collectively constitutes the great mass of human comfort, would be done away in its very principle.

With respect to *station*, as it is distinguished from riches, whether it confer authority over others, or be invested with honours which apply solely to sentiment and imagination, the truth is, that what is gained by rising through the ranks of life, is not more than sufficient to draw forth the exertions of those who are engaged in the pursuits which lead to advancement, and which, in general, are such as ought to be encouraged. Distinctions of this sort are subjects much more of competition than of enjoyment: and in that competition their use consists. It is not, as hath been rightly observed, by what the *Lord Mayor* feels in his coach, but by what the *apprentice* feels who gazes at him, that the public is served.

As we approach the summits of human greatness, the comparison of good and evil, with respect to personal comfort, becomes still more problematical; even allowing to ambition all its pleasures. The poet asks, "What is grandeur, what is power?" The philosopher answers, "Constraint and plague:"

"" *et in maximâ quâque fortunâ minimum licere*. One very common error misleads the opinion of mankind on this head, *viz.* that, universally, authority is pleasant, submission painful. In the general course of human affairs, the very reverse of this is nearer to the truth. Command is anxiety, obedience ease.

Artificial distinctions sometimes promote real quality. Whether they be hereditary, or be the homage paid to office, or the respect attached by public opinion to particular professions, they serve to *confront* that grand and unavoidable distinction which arises from property, and which is most overbearing where there is no other. It is of the nature of property, not only to be irregularly distributed, but to run into large masses. Public laws should be so constructed as to favour its diffusion as much as they can. But all that can be done by laws consistently with that degree of government of his property which ought to be left to the subject, will not be sufficient to counteract this tendency. There must always therefore be the difference between rich and poor: and this difference will be the more grinding, when no pretension is allowed to be set up against it.

So that the evils, if evils they must be called, which spring either from the necessary subordinations of civil life, or from the distinctions which have, naturally, though not necessarily, grown up in most societies, so long as they are unaccompanied by privileges injurious or oppressive to the rest of the community, are such, as may, even by the most depressed ranks, be endured with very little prejudice to their comfort.

The mischiefs of which mankind are the occasion to one another, by their private wickednesses and cruelties; by tyrannical exercises of power; by rebellions against just authority; by wars; by national jealousies and competitions operating to the destruction of third countries; or by other instances of misconduct either in individuals or societies, are all to be resolved into the character of man as a *free agent*. Free agency in its very essence contains liability to abuse. Yet, if you deprive man of his free agency, you subvert his nature. You may have order from him and regularity, as you may from the tides or the trade-winds, but you put an end to his moral character, to virtue, to merit, to accountableness, to the use indeed of reason. To which must be added the observation, that even the bad qualities of mankind have an origin in their good ones. The case is this: human passions are either necessary to human welfare, or capable of being made, and, in a great majority of instances, in fact, made, conducive to its happiness. These passions are strong

and general; and, perhaps, would not answer their purpose unless they were so. But strength and generality, when it is expedient that particular circumstances should be respected, become, if left to themselves, excess and misdirection. From which excess and misdirection, the vices of mankind (the causes, no doubt, of much misery) appear to spring. This account, whilst it shows us the principle of vice, shows us, at the same time, the province of reason and of self-government: the want also of every support which can be procured to either from the aids of religion; and it shows this, without having recourse to any native, gratuitous malignity in the human constitution. Mr. Hume, in his posthumous dialogues, asserts, indeed, of *idleness*, or aversion to labour (which he states to lie at the root of a considerable part of the evils which mankind suffer), that it is simple and merely bad. But how does he distinguish idleness from the love of ease? or is he sure, that the love of ease in individuals is not the chief foundation of social tranquillity? It will be found, I believe, to be true, that in every community there is a large class of its members, whose idleness is the best quality about them, being the corrective of other bad ones. If it were possible, in every instance, to give a right determination to industry, we could never have too much of it. But this is not possible, if men are to be free. And without this, nothing would be so dangerous, as an incessant, universal, indefatigable activity. In the civil world, as well as in the material, it is the *vis inertiæ* which keeps things in their places.

NATURAL THEOLOGY has ever been pressed with this question; Why, under the regency of a supreme and benevolent Will, should there be, in the world, so much, as there is, of the appearance of *chance?*

The question in its whole compass lies beyond our reach: but there are not wanting, as in the origin of evil, answers which seem to have considerable weight in particular cases, and also to embrace a considerable number of cases.

I. There must be *chance* in the midst of design: by which we mean, that events which are not designed, necessarily arise from the pursuit of events which are designed. One man travelling to York, meets another man travelling to London. Their meeting is by chance, is accidental, and so would be called and reckoned, though the journeys which produced the meeting, were, both of them, undertaken with design and from deliberation. The meeting, though accidental, was nevertheless hypothetically necessary (which is the only sort of necessity that is intelligible): for, if the two journeys were commenced at the time, pursued in the direction, and with the speed, in which and with which they were in fact begun and performed, the meeting could not be avoided. There was not, therefore, the less necessity in it for its being by chance. Again, the rencountre might be most unfortunate, though the errands, upon which each party set out upon his journey, were the most innocent or the most laudable. The bye effect may be unfavourable, without impeachment of the proper purpose, for the sake of which the train, from the operation of which these consequences ensued, was put in motion. Although no cause act without a good purpose; accidental consequences, like these, may be either good or bad.

II. The *appearance of chance* will always bear a proportion to the ignorance of the observer. The cast of a die as regularly follows the laws of motion, as the going of a watch; yet, because we can trace the operation of those laws through the works and movements of the watch, and cannot trace them in the shaking and throwing of the die (though the laws be the same, and prevail equally in both cases), we call the turning up of the number of the die chance, the pointing of the index of the watch, machinery, order, or by some name which excludes chance. It is the same in those events which depend upon the will of a free and rational agent. The verdict of a jury, the sentence of a judge, the resolution of an assembly, the issue of a contested election, will have more or less of the appearance of chance, might be more or less the subject of a wager, according as we were less or more acquainted with the reasons which influenced the deliberation. The difference resides

in the information of the observer, and not in the thing itself; which, in all the cases proposed, proceeds from intelligence, from mind, from counsel, from design.

Now when this one cause of the appearance of chance, *viz*. the ignorance of the observer, comes to be applied to the operations of the Deity, it is easy to foresee how fruitful it must prove of difficulties, and of seeming confusion. It is only to think of the Deity, to perceive what variety of objects, what distance of time, what extent of space and action, his counsels may, or rather must, comprehend. Can it be wondered at, that, of the purposes which dwell in such a mind as this, so small a part should be known to us? It is only necessary, therefore, to bear in our thought, that in proportion to the inadequateness of our information, will be the quantity, in the world, of apparent chance.

III. In a great variety of cases, and of cases comprehending numerous subdivisions, it a pears, for many reasons, to be better that events rise up by *chance*, or, more properly speaking with the appearance of chance, than according to any observable rule whatever. This is not seldom the case even in human arrangements. Each person's place and precedency, in a public meeting, may be determined by *lot*. Work and labour may be *allotted*. Tasks and burthens may be *allotted:*-- "--Operumque laborem Partibus æquabat justis, aut *sorte* trahebat."Military service and station may be *allotted*. The distribution of provision may be made by *lot*, as it is in a sailor's mess; in some cases also, the distribution of favours may be made by *lot*. In all these cases, it seems to be acknowledged, that there are advantages in permitting events to chance, superior to those, which would or could arise from regulation. In all these cases, also, though events rise up in the way of chance, it is by appointment that they do so.

In other events, and such as are independent of human will, the reasons for this preference of uncertainty to rule, appear to be still stronger. For example, it seems to be expedient that the period of human life should be *uncertain*. Did mortality follow any fixed rule, it would produce a security in those that were at a distance from it, which would lead to the greatest disorders; and a horror in those who approached it, similar to that which a condemned prisoner feels on the night before his execution: But, that death be uncertain, the young must sometimes die, as well as the old. Also were deaths never *sudden*, they who are in health, would be too confident of life. The strong and the active, who want most to be warned and checked, would live without apprehension or restraint. On the other hand, were sudden deaths very frequent, the sense of constant jeopardy would interfere too much with the degree of ease and enjoyment intended for us; and human life be too precarious for the business and interests which belong to it. There could not be dependence either upon our own lives, or the lives of those with whom we were connected, sufficient to carry on the regular offices of human society. The manner, therefore, in which death is made to occur, conduces to the purposes of admonition, without overthrowing the necessary stability of human affairs.

Disease being the forerunner of death, there is the same reason for its attacks coming upon us under the appearance of chance, as there is for uncertainty in the time of death itself.

The *seasons* are a mixture of regularity and chance. They are regular enough to authorize expectation, whilst their being, in a considerable degree, irregular, induces, on the part of the cultivators of the soil, a necessity for personal attendance, for activity, vigilance, precaution. It is this necessity which creates farmers; which divides the profit of the soil between the owner and the occupier; which by requiring expedients, by increasing employment, and by rewarding expenditure, promotes agricultural arts and agricultural life, of all modes of life the best, being the most conducive to health, to virtue, to enjoyment. I believe it to be found in fact, that where the soil is the most fruitful, and the seasons the most constant, there the condition of the cultivators of the earth is the most depressed. Uncertainty, therefore, has its use even to those who sometimes

complain of it the most. Seasons of scarcity themselves are not without their advantages. They call forth new exertions; they set contrivance and ingenuity at work; they give birth to improvements in agriculture and œconomy; they promote the investigation and management of public resources.

Again; there are strong intelligible reasons, why there should exist in human society great disparity of *wealth* and *station;*not only as these things are acquired in different degrees, but at the first setting out of life. In order, for instance, to answer the various demands of civil life, there ought to be amongst the members of every civil society a diversity of education, which can only belong to an original diversity of circumstances. As this sort of disparity, which ought to take place from the beginning of life, must, *ex hypothesi*, be previous to the merit or demerit of the persons upon whom it falls, can it be better disposed of than by chance? *Parentage* is that sort of chance: yet it is the commanding circumstance which in general fixes each man's place in civil life, along with every thing which appertains to its distinctions. It may be the result of a beneficial rule, that the fortunes or honours of the father devolve upon the son; and, as it should seem, of a still more necessary rule, that the low or laborious condition of the parent be communicated to his family; but with respect to the successor himself, it is the drawing of a ticket in a lottery. Inequalities, therefore, of fortune, at least the greatest part of them, *viz.* those which attend us from our birth, and depend upon our birth, may be left, as they are left, to *chance*, without any just cause for questioning the regency of a supreme Disposer of events.

But not only the donation, when by the necessity of the case they must be gifts, but even the *acquirability* of civil advantages, ought, perhaps, in a considerable degree, to lie at the mercy of chance. Some would have all the virtuous rich, or, at least, removed from the evils of poverty, without perceiving, I suppose, the consequence, that all the poor must be wicked. And how such a society could be kept in subjection to government, has not been shown: for the poor, that is, they who seek their subsistence by constant manual labour, must still form the mass of the community; otherwise the necessary labour of life could not be carried on; the work would not be done, which the wants of mankind in a state of civilization, and still more in a state of refinement, require to be done.

It appears to be also true, that the exigencies of social life call not only for an original diversity of *external* circumstances, but for a mixture of different faculties, tastes, and tempers. Activity and contemplation, restlessness and quiet, courage and timidity, ambition and contentedness, not to say even indolence and dulness, are all wanted in the world, all conduce to the well going on of human affairs, just as the rudder, the sails and the ballast of a ship, all perform their part in the navigation. Now, since these characters require for their foundation different original talents, different dispositions, perhaps also different bodily constitutions; and since, likewise, it is apparently expedient, that they be promiscuously scattered amongst the different classes of society: can the distribution of talents, dispositions, and the constitutions upon which they depend, be better made than by *chance?*

The *opposites* of apparent chance, are constancy and sensible interposition; every degree of *secret* direction being consistent with it. Now of *constancy*, or of fixed and known rules, we have seen in some cases the inapplicability: and inconveniences which we do not see, might attend their application in other cases.

Of *sensible* interposition we may be permitted to remark, that a Providence, always and certainly distinguishable, would be neither more nor less than miracles rendered frequent and common. It is difficult to judge of the state into which this would throw us. It is enough to say, that it would cast us upon a quite different dispensation from that under which we live. It would be a total and radical change. And the change would deeply affect, or perhaps subvert, the whole conduct of human affairs. I can readily believe, that, other circumstances being adapted to it, such a state

might be better than our present state. It may be the state of other beings; it may be ours hereafter. But the question with which we are now concerned is, how far it would be consistent with our condition, supposing it in other respects to remain as it is? And in this question there seem to be reasons of great moment on the negative side. For instance, so long as bodily labour continues, on so many accounts, to be necessary for the bulk of mankind, any dependency upon supernatural aid, by unfixing those motives which promote exertion, or by relaxing those habits which engender patient industry, might introduce negligence, inactivity, and disorder, into the most useful occupations of human life; and thereby deteriorate the condition of human life itself.

As moral agents, we should experience a still greater alteration; of which, more will be said under the next article.

Although therefore the Deity, who possesses the power of winding and turning, as he pleases, the course of causes which issue from himself, do in fact interpose to alter or intercept effects, which without such interposition would have taken place; yet it is by no means incredible, that his Providence, which always rests upon final good, may have made a *reserve* with respect to the manifestation of his interference, a part of the very plan which he has appointed for our terrestrial existence, and a part conformable with, or, in some sort, required by, other parts of the same plan. It is at any rate evident, that a large and ample province remains for the exercise of Providence, without its being naturally perceptible by us: because obscurity, when applied to the interruption of laws, bears a necessary proportion to the imperfection of our knowledge when applied to the laws themselves, or rather to the effects which these laws, under their various and incalculable combinations, would of their own accord produce. And if it be said, that the doctrine of Divine Providence, by reason of the ambiguity under which its exertions present themselves, can be attended with no *practical* influence upon our conduct; that, although we believe ever so firmly that there is a. Providence, we must prepare, and provide, and act, as if there were none; I answer, that this is admitted: and that we further allege, that so to prepare, and so to provide, is consistent with the most perfect assurance of the reality of a Providence: and not only so, but that it is, probably, one advantage of the present state of our information, that our provisions and preparations are not disturbed by it. Or if it be still asked, Of what use at all then is the doctrine, if it neither alter our measures nor regulate our conduct? I answer again, that it is of the greatest use, but that it is a doctrine of sentiment and piety, not (immediately at least) of action or conduct; that it applies to the consolation of men's minds, to their devotions, to the excitement of gratitude, the support of patience, the keeping alive and the strengthening of every motive for endeavouring to please our Maker; and that these are great uses.

OF ALL VIEWS under which human life has ever been considered, the most reasonable in my judgement is that, which regards it as a state of *probation*. If the course of the world was separated from the contrivances of nature, I do not know that it would be necessary to look for any other account of it, than what, if it may be called an account, is contained in the answer, that events rise up by chance. But since the contrivances of nature decidedly evince *intention;* and since the course of the world and the contrivances of nature have the same author; we are, by the force of this connexion, led to believe, that the appearance, under which events take place, is reconcileable with the supposition of design on the part of the Deity. It is enough that they be reconcileable with this supposition; and it is undoubtedly true, that they may be reconcileable, though we cannot reconcile them. The mind, however, which contemplates the works of nature, and, in those works, sees so much of means directed to ends, of beneficial effects brought about by wise expedients, of concerted trains of causes terminating in the happiest results; so much, in a word, of counsel, intention, and benevolence: a mind, I say, drawn into the habit of thought which these observations excite, can hardly turn its view to the condition of our own species, without endeavouring to suggest to itself some purpose, some desiga, for which the state in which we are placed is fitted, and which it is made to serve. Now we assert the most probable supposition to be,

that it is a state of moral probation; and that many things in it suit with this hypothesis, which suit no other. It is not a state of unmixed happiness, or of happiness simply: it is not a state of designed misery, or of misery simply: it is not a state of retribution: it is not a state of punishment. It suits with none of these suppositions. It accords much better with the idea of its being a condition calculated for the production, exercise, and improvement of moral qualities, with a view to a future state, in which these qualities, after being so produced, exercised, and improved, may, by a new and more favouring constitution of things, receive their reward, or become their own. If it be said, that this is to enter upon a religious rather than a philosophical consideration, I answer, that the name of Religion ought to form no objection, if it shall turn out to be the case, that the more religious our views are, the more probability they contain. The degree of beneficence, of benevolent intention, and of power, exercised in the construction of sensitive beings, goes strongly in favour, not only of a creative, but of a continuing care, that is, of a ruling Providence. The degree of chance which appears to prevail in the world, requires to be reconciled with this hypothesis. Now it is one thing to maintain the doctrine of Providence along with that of a future state, and another thing without it. In my opinion, the two doctrines must stand or fall together. For although more of this apparent chance may perhaps, upon other principles, be accounted for, than is generally supposed, yet a future state alone rectifies all disorders: and if it can be shown, that the appearance of disorder is consistent with the uses of life as a *preparatory* state, or that in some respects it promotes these uses, then so far as this hypothesis may be accepted the ground of the difficulty is done away. In the wide scale of human condition, there is not perhaps one of its manifold diversities, which does not bear upon the design here suggested. Virtue is infinitely various. There is no situation in which a rational being is placed, from that of the best-instructed Christian, down to the condition of the rudest barbarian, which affords not room for moral agency; for the acquisition, exercise, and display of voluntary qualities, good and bad. Health and sickness, enjoyment and suffering, riches and poverty, knowledge and ignorance, power and subjection, liberty and bondage, civilization and barbarity, have all their offices and duties, all serve for the *formation* of character: for when we speak of a state of trial, it must be remembered, that characters are not only tried, or proved, or detected, but that they are generated also, and *formed*, by circumstances. The best dispositions may subsist under the most depressed, the most afflicted fortunes. A West-Indian slave, who, amidst his wrongs, retains his benevolence, I for my part, look upon, as amongst the foremost of human candidates for the rewards of virtue. The kind master of such a slave, that is, he, who in the exercise of an inordinate authority, postpones, in any degree, his own interest to his slave's comfort, is likewise a meritorious character: but still he is inferior to his slave. All however which I contend for, is, that these destinies, opposite as they may be in every other view, are both *trials;* and equally such. The observation may be applied to every other condition; to the whole range of the scale, not excepting even its lowest extremity. *Savages* appear to us all alike; but it is owing to the distance at which we view savage life, that we perceive in it no discrimation of character. I make no doubt, but that moral qualities, both good and bad, are called into action as much, and that they subsist in as great variety, in these inartificial societies, as they are, or do, in polished life. Certain at least it is, that the good and ill treatment which each individual meets with, depends more upon the choice and voluntary conduct of those about him, than it does or ought to do, under regular civil institutions, and the coercion of public laws. So again, to turn our eyes to the other end of the scale, namely, that part of it which is occupied by mankind, enjoying the benefits of learning, together with the lights of revelation, there also, the advantage is all along *probationary*. Christianity itself, I mean the revelation of Christianity, is not only a blessing but a trial. It is one of the diversified means by which the character is exercised: and they who require of Christianity, that the revelation of it should be universal, may possibly be found to require, that one species of probation should be adopted, if not to the exclusion of others, at least to the narrowing of that variety which the wisdom of the Deity hath appointed to this part of his moral economy(*Note:* The reader will observe, that I speak of the revelation of Christianity as distinct from Christianity itself. The *dispensation*may already be universal. That part of mankind which never heard of CHRIST'S name, may nevertheless be

redeemed, that is, be placed in a better condition, with respect to their future state, by his intervention; may be the objects of his benignity and intercession, as well as of the propitiatory virtue of his passion. But this is not "natural theology;" therefore I will not dwell longer upon it.)

Now if this supposition be well founded: that is, if it be true, that our ultimate, or our most permanent happiness, will depend, not upon the temporary condition into which we are cast, but upon our behaviour in it; then is it a much more fit subject of *chance* than we usually allow or apprehend it to be, in what manner, the variety of external circumstances, which subsist in the human world, is distributed amongst the individuals of the species. "This life being a state of probation,"

"" it is immaterial, says Rousseau, "what kind of trials we experience in it, provided they produce their effects." Of two agents who stand indifferent to the moral Governor of the universe, one may be exercised by riches, the other by poverty. The treatment of these two shall appear to be very opposite, whilst in truth it is the same: for though, in many respects, there be great disparity between the conditions assigned, in one main article there may be none, *viz*. in that they are alike trials; have both their duties and temptations, not less arduous or less dangerous, in one case than the other; so that if the final award follow the character, the original distribution of the circumstances under which that character is formed, may be defended upon principles not only of justice but of equality. What hinders therefore, but that mankind may draw lots for their condition? They take their portion of faculties and opportunities, as any unknown cause, or concourse of causes, or as causes acting for other purposes, may happen to set them out; but the event is governed by that which depends upon themselves, the application of what they have received. In dividing the talents, no rule was observed; none was necessary: in rewarding the use of them, that of the most correct justice. The chief difference at last appears to be, that the right use of more talents, *i. e*. of a greater trust, will be more highly rewarded, than the right use of fewer talents, *i. e*. of a less trust. And since for other purposes, it is expedient, that there be an inequality of concredited talents here, as well, probably, as an inequality of conditions hereafter, though all remuneratory, can any rule, adapted to that inequality, be more agreeable, even to our apprehensions of distributive justice, than this is?

We have said, that the appearance of *casualty*, which attends the occurrences and events of life, not only does not interfere with its uses, as a state of probation, but that it promotes these uses.

Passive virtues, of all others the severest and the most sublime; of all others, perhaps, the most acceptable to the Deity; would, it is evident, be excluded from a constitution, in which happiness and misery regularly followed virtue and vice. Patience and composure under distress, affliction, and pain; a steadfast keeping up of our confidence in God, and of our reliance upon his final goodness, at the time when every thing present is adverse and discouraging; and (what is no less difficult to retain) a cordial desire for the happiness of others, even when we are deprived of our own: these dispositions, which constitute, perhaps, the perfection of our moral nature, would not have found their proper office and object in a state of avowed retribution; and in which, consequently, endurance of evil would be only submission to punishment.

Again: one man's sufferings may be another man's trial. The family of a sick parent is a school of filial piety. The charities of domestic life, and not only these, but all the social virtues, are called out by distress. But then, misery, to be the proper object of mitigation, or of that benevolence which endeavours to relieve, must be really or apparently casual. It is upon such sufferings alone that benevolence can operate. For were there no evils in the world, but what were punishments, properly and intelligibly such, benevolence would only stand in the way of justice. Such evils, consistently with the administration of moral government, could not be prevented or alleviated, that is to say, could not be remitted in whole or in part, except by the authority which inflicted

them, or by an appellate or superior authority. This consideration, which is founded in our most acknowledged apprehensions of the nature of penal justice, may possess its weight in the Divine councils. Virtue perhaps is the greatest of all ends. In human beings, relative virtues form a large part of the whole. Now relative virtue presupposes, not only the existence of evil, without which it could have no object, no material to work upon, but that evils be, apparently at least, *misfortunes;* that is, the effects of apparent chance. It may be in pursuance, therefore, and in furtherance of the same scheme of probation, that the evils of life are made *so*to present themselves.

I have already observed, that, when we let in religious considerations, we often let in light upon the difficulties of nature. So in the fact now to be accounted for, the *degree*of happiness, which we usually enjoy in this life, may be better suited to a state of trial and probation, than a greater degree would be. The truth is, we are rather too much delighted with the world, than too little. Imperfect, broken, and precarious as our pleasures are, they are more than sufficient to attach us to the eager pursuit of them. A regard to a *future* state can hardly keep its place as it is. If we were designed therefore to be influenced by that regard, might not a more indulgent system, a higher, or more uninterrupted state of gratification, have interfered with the design? At least it seems expedient, that mankind should be susceptible of this influence, when presented to them: that the condition of the world should not be such, as to exclude its operation, or even to weaken it more than it does. In a religious view (however we may complain of them in every other) privation, disappointment, and satiety, are not without the most salutary tendencies.

CHAPTER XXVII.
CONCLUSION.

IN all cases, wherein the mind feels itself in danger of being confounded by variety, it is sure to rest upon a few strong points, or perhaps upon a single instance. Amongst a multitude of proofs, it is *one* that does the business. If we observe in any argument, that hardly two minds fix upon the same instance, the diversity of choice shows the strength of the argument, because it shows the number and competition of the examples. There is no subject in which the tendency to dwell upon select or single topics is so usual because there is no subject, of which, in its full extent, the latitude is so great, as that of natural history applied to the proof of an intelligent Creator. For my part, I take my stand in human anatomy: and the examples of mechanism I should be apt to draw out from the copious catalogue, which it supplies, are the pivot upon which the head turns, the ligament within the socket of the hip-joint, the pulley or trochlear muscles of the eye, the epiglottis, the bandages which tie down the tendons of the wrist and instep, the slit or perforated muscles at the hands and feet, the knitting of the intestines to the mesentery, the course of the chyle into the blood, and the constitution of the sexes as extended throughout the whole of the animal creation. To these instances, the reader's memory will go back, as they are severally set forth in their places; there is not one of the number which I do not think decisive; not one which is not strictly mechanical; nor have I read or heard of any solution of these appearances, which, in the smallest degree, shakes the conclusion that we build upon them.

But, of the greatest part of those, who, either in this book or any other, read arguments to prove the existence of a God, it will be said, that they leave off only where they began; that they were never ignorant of this great truth, never doubted of it; that it does not therefore appear, what is gained by researches from which no new opinion is learnt, and upon the subject of which no proofs were wanted. Now I answer that, by *investigation*, the following points are always gained, in favour of doctrines even the most generally acknowledged, (supposing them to be true), *viz*. stability and impression. Occasions will arise to try the firmness of our most habitual opinions. And upon these occasions, it is a matter of incalculable use to feel our foundation; to find a support in argument for what we had taken up upon authority. In the present case, the arguments upon which the conclusion rests, are exactly such, as a truth of universal concern ought to rest upon. "They are

sufficiently open to the views and capacities of the unlearned, at the same time that they acquire new strength and lustre from the discoveries of the learned." If they had been altogether abstruse and recondite, they would not have found their way to the understandings of the mass of mankind; if they had been merely popular, they might have wanted solidity.

But, secondly, what is gained by research in the stability of our conclusion, is also gained from it in *impression*. Physicians tell us, that there is a great deal of difference between taking a medicine, and the medicine getting into the constitution. A difference not unlike which, obtains with respect to those great moral propositions, which ought to form the directing principles of human conduct. It is one thing to assent to a proposition of this sort; another, and a very different thing, to have properly imbibed its influence. I take the case to be this: perhaps almost every man living has a particular train of thought, into which his mind glides and falls, when at leisure from the impressions and ideas that occasionally excite it; perhaps, also, the train of thought here spoken of, more than any other thing, determines the character. It is of the utmost consequence, therefore, that this property of our constitution be well regulated. Now it is by frequent or continued meditation upon a subject, by placing a subject in different points of view, by induction of particulars, by variety of examples, by applying principles to the solution of phænomena, by dwelling upon proofs and consequences, that mental exercise is drawn into any particular channel. It is by these means, at least, that we have any power over it. The train of spontaneous thought, and the choice of that train, may be directed to different ends, and may appear to be more or less judiciously fixed, according to the purpose, in respect of which we consider it: but, in a *moral view*, I shall not, I believe, be contradicted when I say, that, if one train of thinking be more desirable than another, it is that which regards the phænomena of nature with a constant reference to a supreme intelligent Author. To have made this the ruling, the habitual sentiment of our minds, is to have laid the foundation of every thing which is religious. The world thenceforth becomes a temple, and life itself one continued act of adoration. The change is no less than this, that, whereas formerly God was seldom in our thoughts, we can now scarcely look upon any thing without perceiving its relation to him. Every organized natural body, in the provisions which it contains for its sustentation and propagation, testifies a care, on the part of the Creator, expressly directed to these purposes. We are on all sides surrounded by such bodies; examined in their parts, wonderfully curious; compared with one another, no less wonderfully diversified. So that the mind, as well as the eye, may either expatiate in variety and multitude, or fix itself down to the investigation of particular divisions of the science. And in either case it will rise up from its occupation, possessed by the subject, in a very different manner, and with a very different degree of influence, from what a mere assent to any verbal proposition which can be formed concerning the existence of the Deity, at least that merely complying assent with which those about us are satisfied, and with which we are too apt to satisfy ourselves, will or can produce upon the thoughts. More especially may this difference be perceived, in the degree of admiration and of awe, with which the Divinity is regarded, when represented to the understanding by its own remarks, its own reflections, and its own reasonings, compared with what is excited by any language that can be used by others. The works of nature want only to be contemplated. When contemplated, they have every thing in them which can astonish by their greatness: for, of the vast scale of operation, through which our discoveries carry us, at one end we see an intelligent Power arranging planetary systems, fixing, for instance, the trajectory of *Saturn*, or constructing a ring of two hundred thousand miles diameter, to surround his body, and be suspended like a magnificent arch over the heads of his inhabitants; and, at the other, bending a hooked tooth, concerting and providing an appropriate mechanism, for the clasping and reclasping of the filaments of the feather of the humming-bird. We have proof, not only of both these works proceeding from an intelligent agent, but of their proceeding from the same agent; for, in the first place, we can trace an identity of plan, a connexion of system, from Saturn to our own globe: and when arrived upon our globe, we can, in the second place, pursue the connexion through all the organized, especially the animated, bodies which it supports. We can observe marks of a common relation, as well to one another, as to

the elements of which their habitation is composed. Therefore one mind hath planned, or at least hath prescribed, a general plan for all these productions. One Being has been concerned in all.

Under this stupendous Being we live. Our happiness, our existence, is in his hands. All we expect must come from him. Nor ought we to feel our situation insecure. In every nature, and in every portion of nature, which we can descry, we find attention bestowed upon even the minutest arts. The hinges in the wings of an *earwig*, and the joints of its antennæ, are as highly wrought, as if the Creator had nothing else to finish. We see no signs or diminution of care by multiplicity of objects, or of distraction of thought by variety. We have no reason to fear, therefore, our being forgotten, or overlooked, or neglected.

The existence and character of the Deity, is, in every view, the most interesting of all human speculations. In none, however, is it more so, than as it facilitates the belief of the fundamental articles of *Revelation*. It is a step to have it proved, that there must be something in the world more than what we see. It is a further step to know, that, amongst the invisible things of nature, there must be an intelligent mind, concerned in its production, order, and support. These points being assured to us by Natural Theology, we may well leave to Revelation the disclosure of many particulars, which our researches cannot reach, respecting either the nature of this Being as the original cause of all things, or his character and designs as a moral governor; and not only so, but the more full confirmation of other particulars, of which, though they do not lie altogether beyond our reasonings and our probabilities, the certainty is by no means equal to the importance. The true theist will be the first to listen to *any* credible communication of Divine knowledge. Nothing which he has learned from Natural Theology, will diminish his desire of further instruction, or his disposition to receive it with humility and thankfulness. He wishes for light: he rejoices in light. His inward veneration of this great Being, will incline him to attend with the utmost seriousness, not only to all that can be discovered concerning him by researches into nature, but to all that is taught by a revelation, which gives reasonable proof of having proceeded from him.

But, above every other article of revealed religion, does the anterior belief of a Deity bear with the strongest force upon that grand point, which gives indeed interest and importance to all the rest,--the resurrection of the human dead. The thing might appear hopeless, did we not see a power at work adequate to the effect, a power under the guidance of an intelligent will, and a power penetrating the inmost recesses of all substance. I am far from justifying the opinion of those, who "thought it a thing incredible, that God should raise the dead:" but I admit, that it is first necessary to be persuaded, that there *is* a God, to do so. This being thoroughly settled in our minds, there seems to be nothing in this process (concealed as we confess it to be) which need to shock our belief. They who have taken up the opinion, that the acts of the human mind depend upon *organization*, that the mind itself indeed consists in organization, are supposed to find a greater difficulty than others do, in admitting a transition by death to a new state of sentient existence, because the old organization is apparently dissolved. But I do not see that any impracticability need be apprehended even by these; or that the change, even upon their hypothesis, is far removed from the analogy of some other operations, which we know with certainty that the Deity is carrying on. In the ordinary derivation of plants and animals, from one another, a particle, in many cases, minuter than all assignable, all conceivable dimension; an aura, an effluvium, an infinitesimal; determines the organization of a future body: does no less than fix, whether that which is about to be produced, shall be a vegetable, a merely sentient, or a rational being: an oak, a frog, or a philosopher; makes all these differences; gives to the future body its qualities, and nature and species. And this particle, from which springs, and by which is determined a whole future nature, itself proceeds from, and owes its constitution to, a prior body: nevertheless, which is seen in plants most decisively, the incepted organization, though formed within, and through, and by a preceding organization, is not corrupted by its corruption, or destroyed by its dissolution: but, on the contrary, is sometimes extricated and developed by those very causes; survives and comes into

action, when the purpose, for which it was prepared, requires its use. Now an œconomy which nature has adopted, when the purpose was to transfer an organization from one individual to another, may have something analogous to it, when the purpose is to transmit an organization from one state of being to another state: and they who found thought in organization, may see something in this analogy applicable to their difficulties; for, whatever can transmit a similarity of organization will answer their purpose, because, according even to their own theory, it may be the vehicle of consciousness, and because consciousness carries identity and individuality along with it through all changes of form or of visible qualities. In the most general case, that, as we have said, of the derivation of plants and animals from one another, the latent organization is either itself similar to the old organization, or has the power of communicating to new matter the old organic form. But it is not restricted to this rule. There are other cases, especially in the progress of insect life, in which the dormant organization does not much resemble that which encloses it, and still less suits with the situation in which the enclosing body is placed, but suits with a different situation to which it is destined. In the larva of the libellula, which lives constantly, and has still long to live, under water, are descried the wings of a fly, which two years afterwards is to mount into the air. Is there nothing in this analogy? It serves at least to show, that even in the observable course of nature, organizations are formed one beneath another; and, amongst a thousand other instances, it shows completely, that the Deity can mould and fashion the parts of material nature, so as to fulfil any purpose whatever which he is pleased to appoint.

They who refer the operations of mind to a substance totally and essentially different from matter, (as most certainly these operations, though affected by material causes, hold very little affinity to any properties of matter with which we are acquainted), adopt perhaps a juster reasoning and a better philosophy: and by these the considerations above suggested are not wanted, at least in the same degree. But to such as find, which some persons do find, an insuperable difficulty in shaking off an adherence to those analogies, which the corporeal world is continually suggesting to their thoughts; to such, I say, every consideration will be a relief, which manifests the extent of that intelligent power which is acting in nature, the fruitfulness of its resources, the variety, and aptness, and success of its means; most especially every consideration, which tends to show that, in the translation of a conscious existence, there is not, even in their own way of regarding it, any thing greatly beyond, or totally unlike, what takes place in such parts (probably small parts) of the order of nature, as are accessible to our observation.

Again; if there be those who think, that the contractedness and debility of the human faculties in our present state, seem ill to accord with the high destinies which the expectations of religion point out to us, I would only ask them, whether any one, who saw a child two hours after its birth, could suppose that it would ever come to understand *fluxions* (*Note:* See Search's Light of Nature, *passim*.); or who then shall say, what farther amplification of intellectual powers, what accession of knowledge, what advance and improvement, the rational faculty, be its constitution what it will, may not admit of, when placed amidst new objects, and endowed with a sensorium adapted, as it undoubtedly will be, and as our present senses are, to the perception of those substances, and of those properties of things, with which our concern may lie.

Upon the whole; in every thing which respects this awful, but, as we trust, glorious change, we have a wise and powerful Being, (the author, in nature, of infinitely various expedients for infinitely various ends), upon whom to rely for the choice and appointment of means, adequate to the execution of any plan which his goodness or his justice may have formed, for the moral and accountable part of his terrestrial creation. That great office rests with *him:* be it *ours* to hope and to prepare, under a firm and settled persuasion, that, living and dying, we are his; that life is passed in his constant presence, that death resigns us to his merciful disposal.

FINIS.

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François de Salignac de La Mothe Fénelon, French Cleric and Philosopher
De L'existence Et Des Attributs De Dieu
Book

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Première Partie - Démonstration De L'existence De Dieu - Tirée Du Spectacle De La Nature Et De La Connoissànce De L'homme

Chapitre Premier - Univers Est Une Représentation Sensible De La Divinité

Je ne puis ouvrir les yeux sans admirer l'art qui éclate dans toute la nature: le moindre coup-d'oeuil suffit pour apercevoir la main qui a fait tout. Que les hommes accoutumés à méditer les vérités abstraites, et à remonter aux premiers principes, connoissent la Divinité par son idée: c'est un chemin sûr pour arriver à la source de toute vérité. Mais plus ce chemin est droit et court, plus il est rude et inaccessible au commun des hommes qui dépendent de leur imagination.

C'est une démonstration si simple, qu'elle échappe par sa simplicité aux esprits incapables des opérations purement intellectuelles. Plus cette voie de trouver le premier Etre est parfaite, moins il y a d'esprits capables de la suivre.

Mais il y a une autre voie moins parfaite, et qui est proportionnée aux hommes les plus médiocres. Les hommes les moins exercés au raisonnement et les plus attachés aux préjugés sensibles, peuvent d'un seul regard découvrir celui qui se peint dans tous ses ouvrages. La sagesse et la puissance qu'il a marquées dans tout ce qu'il a fait se font voir comme dans un miroir à ceux qui ne le peuvent contempler dans sa propre idée. C'est une philosophie sensible et populaire, dont tout homme sans passions et sans préjugés est capable (i).

Si un grand nombre d'hommes d'un esprit subtil et pénétrant n'ont pas trouvé Dieu par ce coup-d'œil jeté sur toute la nature, il ne faut pas s'en étonner: les passions qui les ont agités leur ont donné des distractions continuelles; ou bien les faux préjugés qui naissent des passions ont fermé leurs yeux à ce grand spectacle. Un homme passionné pour une grande affaire qui emporteroit toute l'application de son esprit, passeroit plusieurs jours dans une chambre en négociation pour ses intérêts, sans regarder ni les proportions de la chambre, ni les ornements de la cheminée, ni les tableaux qui seroient autour de lui: tous ces objets seroient sans cesse devant ses yeux, et aucun d'eux ne feroit impression sur lui.

Ainsi vivent les hommes, Tout leur présente Dieu, et ils ne le voient nulle part. I l étoit dans le monde, et le monde a été fait par lui: et cependant le monde 11e l'a point connu (1). Ils passent leur vie sans avoir aperçu cette représentation si sensible de la Divinité: tant la fascination du monde obscurcit leurs yeux (2). Souvent même ils ne veulent pas les ouvrir, et ils affectent de les tenir fermés, de peur de trouver celui qu'ils ne cherchent pas. Enfin, ce qui devroit le plus servir à leur ouvrir les yeux ne sert qu'à les leur fermer davantage, je veux dire la constance et la régularité des mouvements que la suprême Sagesse a mis dans l'univers.

Saint Augustin dit que ces merveilles se sont avilies par leur répétition continuelle (3). Cicéron parle précisément de même. A force de voir tous les jours les mêmes choses, l'esprit s'y accoutume aussi bien que les yeux: il n'admire ni n'ose se mettre en aucune manière en peine de chercher la

cause des effets qu'il voit toujours arriver de la même sorte; comme si c'était la nouveauté et non pas la grandeur de la chose même qui dût nous porter à faire cette recherche.

Mais enfin, toute la nature montre l'art infini de son auteur. Quand je parle de l'art, je veux dire un assemblage de moyens choisis tout exprès pour parvenir à une fin précise: c'est un ordre, un arrangement, une industrie, un dessein suivi. Le hasard est tout au contraire une cause aveugle et nécessaire, qui ne prépare, qui ne choisit rien, et qui n'a ni volonté ni intelligence. Or, je soutiens que l'univers porte le caractère d'une cause infiniment puissante et industrieuse. Je soutiens que le hasard, c'est-à-dire le concours aveugle et fortuit des causes nécessaires et privées de raison, ne peut avoir formé ce tout. C'est ici qu'il est bon de rappeler les célèbres comparaisons des anciens.

Qui croira que l'Iliade d'Homère, ce poème si parfait, n'ait jamais été composé par un effort du génie d'un grand poète: et que les caractères de l'alphabet ayant été jetés en confusion, un coup de pur hasard, comme un coup de dés, ait rassemblé toutes les lettres précisément dans l'arrangement nécessaire pour décrire dans des vers pleins d'harmonie et de variété tant de grands événements, pour les placer et pour les lier si bien tous ensemble, pour peindre chaque objet avec tout ce qu'il a de plus gracieux, de plus noble et de plus touchant; enfin, pour faire parler chaque personne selon son caractère, d'une manière si naïve et si passionnée? Qu'on raisonne et qu'on subtilise tant qu'on voudra, jamais on ne persuadera à un homme sensé que l'Iliade n'ait point d'autre auteur que le hasard. Cicéron en disoit autant des Annales d'Ennius; et il ajoutoit que le hasard ne feroit jamais un seul vers, bien loin de faire tout un poème. Pourquoi donc cet homme sensé croiroit-il de l'univers, sans doute encore plus merveilleux que l'Iliade, ce que son bon sens ne lui permettra jamais de croire de ce poème? Mais passons à une autre comparaison, qui est de S. Grégoire de Nazianze.

Si nous entendions dans une chambre, derrière un rideau, un instrument doux et harmonieux, croirions nous que le hasard, sans aucune main d'homme, pût avoir formé cet instrument? Dirions-nous que les cordes d'un violon seroient venues d'elles-mêmes se ranger et s'étendre sur un bois dont les pièces se seroient collées ensemble pour former une cavité avec des ouvertures régulières? Soutiendrions-nous que l'archet, formé sans art, seroit poussé par le vent pour toucher chaque corde si diversement et avec tant de justesse? Quel esprit raisonnable pourroit douter sérieusement si une main d'homme toucheroit cet instrument avec tant d'harmonie? Ne s'écrieroit-il pas qu'une main savante le toucheroit? Ne nous lassons point de faire sentir la même vérité.

Qui trouverait dan* une île déserte et inconnue à tous les hommes une belle statue de marbre, diroit aussitôt: Sans doute il y a eu ici autrefois des hommes, je reconnois la main d'un habile sculpteur; j'admire avec quelle délicatesse il a su proportionner tous les membres de ce corps pour leur donner tant de beauté, de grâces, de majesté, de vie, de tendresse, de mouvement et d'action.

Que répondroit un homme si quelqu'un s'avisoit de lui dire: Non, un sculpteur ne fit jamais cette statue. Elle est faite, il est vrai, selon le goût le plus exquis et dans les règles de la perfection: mais c'est le hasard tout seul qui l'a faite. Parmi tant de morceaux de marbre, il y en a eu un qui s'est formé ainsi de lui-même; les pluies et les vents l'ont détaché de la montagne; un orage très violent l'a jeté tout droit sur ce piédestal, qui s'étoit préparé de lui-même dans cette place. C'est un Apollon parfait comme celui du Belvédère: c'est une Vénus qui égale celle de Médicis: c'est un Hercule qui ressemble à celui de Farnèse. Vous croiriez, il est vrai, que cette figure marche, qu'elle vit, qu'elle pense, et qu'elle va parler: mais elle ne doit rien à l'art; et ■ c'est un coup aveugle du hasard, qui l'a si bien finie et placée.

Si on avoit devant les yeux un beau tableau qui représentât, par exemple, le passage de la mer Rouge avec Moïse, à la voix duquel les eaux se fendent et s'élèvent comme deux murs pour faire

passer les Israélites à pied sec au travers des abîmes; on verroit d'un côté cette multitude innombrable de peuple plein de confiance et de joie, levant les mains au ciel; de l'autre côté on apercevroit Pharaon avec les Égyptiens, pleins de trouble et d'effroi à la vue des vagues qui se rassemblement pour les engloutir.

En vérité, où seroit l'homme qui osât dire qu'une servante barbouillant au hasard cette toile avec un balai, les couleurs se seroient rangées d'elles-mêmes pour former ce vif coloris, ces attitudes si variées, ces airs de tête si passionnés, cette belle ordonnance de figures en si grand nombre sans confusion, cet accommodement de draperies, ces distributions de lumière, ces dégradations de couleurs, cette exacte perspective, enfin tout ce que le plus beau génie d'un peintre peut rassembler? Encore s'il n'étoit question que dur. peu d'écume à la bouche d'un cheval, j'avoue, suivant l'histoire qu'on en raconte, et que je suppose sans l'examiner, qu'un coup de pinceau jeté de dépit par le peintre pourroit une seule fois dans la suite des siècles la bien représenter. Mais au moins le peintre avoit-il déjà choisi avec dessein les couleurs les plus propres à représenter cette écume pour les préparer au bout du pinceau. Ainsi ce n'est qu'un peu de hasard qui a achevé ce que l'art avoit déjà commencé.

De plus, cet ouvrage de l'art et du hasard tout ensemble n'étoit qu'un peu d'écume, objet confus, et propre à faire honneur à un coup de hasard; objet informe, qui ne demande qu'un peu de couleur blanchâtre échappée au pinceau, sans aucune figure précise ni aucune correction de dessein. Quelle comparaison de cette écume avec tout un dessein d'histoire suivie, où l'imagination la plus féconde et le génie le plus hardi, étant soutenus par la .science des règles, suffisent à peine pour exécuter ce qui compose un tableau excellent?

Je- ne puis me résoudre à quitter ces exemples sans prier le lecteur de remarquer que les hommes les plus sensés ont naturellement une peine extrême à croire que les bêtes n'aient aucune connoissance, et qu'elles soient de pures machines. D'où -vient cette répugnance invincible en tant de bons esprits? C'est qu'ils supposent avec raison que des mouvements si justes et d'une si parfaite mécanique ne peuvent se faire sans aucune industrie, et que la matière seule, sans art, ne peut faire ce qui marque tant de connoissance. On voit par-là que la raison la plus droite conclut naturellement que la matière seule ne peut, ni par les lois simples du mouvement, ni par les coups capricieux du hasard, faire des animaux qui ne soient que de pures machines. Les philosophes même qui n'attribuent aucune connoissance aux animaux, ne peuvent éviter de reconnoître que ce qu'ils supposent aveugle et sans art dans ces machines est plein de sagesse et d'art dans le premier moteur qui en a fait les ressorts et qui en a réglé les mouvements. Ainsi, les philosophes les plus opposés reconnoissent également que la matière et le hasard ne peuvent produire sans art tout ce qu'on voit dans les animaux.

CHAPITRE II - Description de l'univers

Après ces comparaisons, sur lesquelles je prie le lecteur de se consulter simplement soi-même sans raisonner, je crois qu'il est temps d'entrer dans le détail de la nature. Je ne prétends pas la pénétrer toute entière; qui le pourroit? Je ne prétends même entrer dans aucune discussion de physique: ces discussions supposeroient certaines connoissances approfondies, que beaucoup de gens d'esprit n'ont jamais acquises; et je ne veux leur proposer que le simple coup-d'œil de la face de la nature; je ne veux leur parler que de ce que tout le monde sait, et qui ne demande qu'un peu d'attention tranquille et sérieuse.

Arrêtons-nous d'abord au grand objet qui attire nos premiers regards, je veux dire la structure générale de l'univers. Jetons les yeux sur cette terre qui nous porte; regardons cette voûte immense des cieux qui nous couvre, ces abîmes d'air et d’eau qui nous environnent, et ces astres qui nous éclairent. Un homme qui vit sans réflexion ne pense qu'aux espaces qui sont auprès de lui

ou qui ont quelque rapport à ses besoins: il ne regarde la terre que comme le plancher de sa chambre, et le soleil qui l'éclairé pendant le jour, que comme la bougie qui l'éclairé pendant la nuit: ses pensées se renferment dans le lieu étroit qu'il habite. Au contraire, l'homme accoutumé à faire des réflexions étend ses regards plus loin, et considère avec curiosité les abîmes presque infinis dont il est environné de toutes parts: un vaste royaume ne lui paroît alors qu'un petit coin de la terre; la terre elle-même n'est à ses yeux qu'un point dans la masse de l'univers; et il admire de s'y voir placé, sans savoir comment il y a été mis.

Qui est-ce qui a suspendu ce globe de la terre qui est immobile? Qui est-ce qui en a posé les fondements? Rien n'est, ce semble, plus vil qu'elle, les plus malheureux la foulent aux pieds. Mais c'est pourtant pour la posséder qu'on donne les plus grands trésors. Si elle étoit plus dure, l'homme ne pourroit en ouvrir le sein pour la cultiver; si elle étoit moins dure, elle ne pourroit le porter, il enfonceroit partout, comme il enfonce dans le sable ou dans un bourbier. C'est du sein inépuisable de la terre que sort tout ce qu'il y a de plus précieux. Cette masse informe, vile et grossière, prend toutes les formes les plus diverses, et elle seule donne tour à tour tous les biens que nous lui demandons: cette boue si sale se transforme en mille beaux objets qui charment les yeux: en une seule année elle devient branches, boutons, feuilles, fleurs, fruits et semences, pour renouveler ses libéralités en faveur des hommes. Rien ne l'épuisé. Plus on déchire ses entrailles, plus elle est libérale.

Après tant de siècles, pendant lesquels tout est sorti d'elle, elle n'est point encore usée: elle ne ressent aucune vieillesse; ses entrailles sont encore pleines des mêmes trésors. Mille générations ont passé dans son sein: tout vieillit, excepté elle seule; elle rajeunit chaque année au printemps. Elle ne manque point aux hommes: mais les hommes insensés se manquent à eux-mêmes en négligeant de la cultiver; c'est par leur paresse et par leurs désordres qu'ils laissent croître les ronces et les épines en la place des vendanges et des moissons: ils se disputent un bien qu'ils laissent perdre. Les conquérants laissent «n friche la terre pour la possession de laquelle ils ont fait périr tant de milliers d'hommes, et ont passé leur vie dans une si terrible agitation. Les hommes ont devant eux des terres immenses qui sont vides et incultes; et ils renversent le genre humain pour un coin de tette terre si négligée.

La terre, si elle étoit bien cultivée, nourrirait cent fois plus d'hommes qu'elle n'en nourrit. L'inégalité même des terroirs, qui paroît d'abord un défaut, se tourne en ornement et en utilité. Les montagnes se sont élevées, et les vallons sont descendus en la place que le Seigneur leur a marquée. Ces diverses terres, suivant les divers aspects du soleil, ont leurs avantages. Dans ces profondes vallées on voit croître l'herbe fraîche pour nourrir les troupeaux: auprès d'elles s'ouvrent de vastes campagnes revêtues de riches moissons. Ici des coteaux s'élèvent comme un amphithéâtre, et sont couronnés /de vignobles et d'arbres fruitiers: là de hautes montagnes vont porter leur front glacé jusque dans les nues, et les torrents qui en tombent sont les sources des rivières. Les rochers, qui montrent leur cime escarpée, soutiennent la terre des montagnes comme les os du corps humain en soutiennent les chairs. Cette variété fait le charme des paysages, et en même temps elle satisfait aux divers besoins des peuples.

D n'y a point de terroir si ingrat qui n'ait quelque propriété. Non seulement les terres noires et fertiles, mais encore les argileuses et les graveleuses, récompensent l'homme de ses peines: les marais desséchés deviennent fertiles: lés sables ne couvrent d'ordinaire que la surface de la terre; et quand le laboureur a la patience d'enfoncer, il trouve un terroir neuf qui se fertilise à mesure qu'on le remue et qu'on l'expose aux rayons du soleil.

Il n'y a presque point de sens entièrement ingrate, si l'homme ne se lasse point de la remuer pour l'exposer au soleil, et s'il ne lui demande que ce qu'elle est propre à porter. Au milieu des pierres et des rochers on trouve d'excellents pâturages; il y a dans leurs cavités des veines que les rayons du

soleil pénètrent, et qui fournissent aux plantes pour nourrir les troupeaux des sucs très savoureux. Les côtes même qui paraissent les plus stériles et les plus sauvages offrent souvent des fruits délicieux ou des remèdes très salutaires qui manquent dans les pays les plus fertiles.

D'ailleurs, c'est par un effet de la providence divine que nulle terre ne porte tout ce qui sert à la vie humaine; car le besoin invite les hommes au commerce pour se donner mutuellement ce qui leur manque, et 'besoin est le lien naturel de la société entre les sens: autrement tous les peuples du monde seraient réduits aune seule sorte d'habits et d'aliments, rien ne les inviteroit à se connoître et à s'entrevoir.

Tout ce que la terre produit se corrompant rentre dans son sein, et devient le germe d'une nouvelle fécondité. Ainsi elle reprend tout ce qu'elle a donné pour le rendre encore. Ainsi la corruption des plantes et les excréments des animaux qu'elle nourrit la nourrissent elle-même, et perfectionnent sa fertilité. Ainsi plus elle donne, plus elle reprend; et elfe ne s'épuise jamais, pourvu qu'on sache dans sa culture lui rendre ce qu'elle a donné. Tout sort de son sein, tout y rentre, et rien ne s'y perd. Toutes les semences qui y retournent se multiplient. Confiez à la terre des grains de blé; en se pourrissant ils germent, et cette mère féconde nous rend avec usure plus d'épis qu'elle n'a reçu de grains. Creusez dans ses entrailles, vous y trouverez la pierre et le marbre pour les plus superbes édifices. Mais qui est-ce qui a renfermé tant de trésors dans son sein, à condition qu'ils se reproduisent sans cesse? Voyez tant de métaux précieux et utiles, tant de minéraux destinés à la commodité de l'homme.

Admirez les plantes qui naissent de la terre; elles fournissent des aliments aux sains et des remèdes aux malades. Leurs espèces et leurs vertus sont innombrables; elles ornent la terre; elles donnent de la verdure, des fleurs odoriférantes et des fruits délicieux? Voyez vous ces vastes forêts qui paroissent aussi anciennes que le monde? Ces arbres s'enfoncent dans la terre parleurs racines, comme leurs branches s'élèvent vers le ciel; leurs racines les défendent contre les vents, et vont chercher, comme par de petits tuyaux souterrains, tous les sucs destinés à la nourriture de leur tige; la tige elle-même se revêt d'une dure écorce qui met le bois tendre à l'abri des injures de l'air; les branches distribuent en divers canaux la sève que les racines avoienl réunie dans le tronc. En été, ces rameaux nous protègent de leur ombre contre les rayons du soleil: en hiver, ils nourrissent la flamme qui conserve en nous la chaleur naturelle.

Leur bois n'est pas seulement utile pour le feu; c'est une matière douce, quoique solide et durable, à laquelle la main de l'homme donne sans peine toutes les formes qu'il lui plaît pour les plus grands ouvrages de l'architecture et de la navigation. De plus, les arbres fruitiers, en penchant leurs rameaux vers la terre, semblent offrir leurs fruits à l'homme. Les arbres et les plantes, en laissant tomber leurs fruits ou leurs graines, se préparent autour d'eux une nombreuse postérité. La plus foible plante, le moindre légume contient en petit volume dans une graine le germe de tout ce qui se déploie dans les plus hautes plantes et dans les plus grands arbres. La terre, qui ne change jamais, fait tous ces changements dans son sein.

Regardons maintenant ce qu'on appelle l'eau: c'est un corps liquide, clair et transparent. D'un côté il coule, il échappe, il s'enfuit; de l'autre il prend toutes les formes des corps qui l'environnent, n'en ayant aucune par lui-même. Si l'eau étoit un peu plus raréfiée, elle deviendrait une espèce d'air; toute la face de la terre seroit sèche et stérile; il n'y auroit que des animaux volatiles, nulle espèce d'animal ne pourroit nager, nul poisson ne pourroit vivre; il n'y auroit aucun commerce par la navigation. Quelle main industrieuse a su épaissir l'eau en subtilisant l'air, et distinguer si bien ces deux espèces de corps fluides?

Si l'eau étoit un peu plus raréfiée, elle ne pourroit plus soutenir ces prodigieux édifices flottants qu'on nomme vaisseaux; les corps les moins pesants s'enforceroient d’abord dans l'eau. Qui est-ce

qui a pris le soin de choisir une si juste configuration de parties et un degré si précis de mouvement pour rendre l'eau si fluide, si insinuante, si propre à échapper, si incapable de toute consistance, et néanmoins si forte pour porter, et si impétueuse pour entraîner les plus pesantes masses? Elle est docile; l'homme la mène comme un cavalier mène son cheval sur la pointe des rênes; il la distribue comme il lui plaît; il l'élève sur les montagnes escarpées, et se sert de son poids pour lui faire faire des chutes qui la font remonter autant qu'elle est descendue. Mais l'homme qui mène les eaux avec tant d'empire est à son tour mené par elles.

L'eau est une des plus grandes forces mouvantes que l'homme sache employer pour suppléer à ce qui lui manque dans les arts les plus nécessaires, par la petitesse et par lu foiblesse de son corps. Mais ces eaux qui, nonobstant leur fluidité, sont des masses si pesantes, ne laissent pas de s'élever au - dessus de nos têtes, et d'y demeurer longtemps suspendues. Voyez vous ces nuages qui volent comme sur les ailes des vents? S'ils tomboient tout à coup par de grosses colonnes d'eaux, rapides comme des torrents, ils submergeroient et détruiroient tout dans l'endroit de leur chute, et le reste des terres demeureroit aride. Quelle main les tient dans ces réservoirs suspendus, et ne leur permet de tomber que goutte à goutte, comme si on les distilloit par un arrosoir?

D'où vient qu’en certains pays chauds où il ne pleut presque jamais, les rosées de la nuit sont si abondantes qu'elles suppléent au défaut de la pluie; et qu'en d'autres pays, tels que les bords du Nil et du Gange, l'inondation régulière des fleuves en certaines saisons pourvoit à point nommé aux besoins des peuples pour arroser les terres? Peut-on s'imaginer des mesures mieux prises pour rendre tous les pays fertiles?

Ainsi l'eau désaltère non seulement les hommes, mais encore les campagnes arides; et celui qui nous a donné ce corps fluide l'a distribué avec soin sur la terre comme les canaux d'un jardin. Les eaux tombent des hautes montagnes où leurs réservoirs sont placés; elles s'assemblent en gros ruisseaux dans les vallées: les rivières serpentent dans les vastes campagnes pour les mieux arroser; elles vont enfin se précipiter dans la mer pour en faire le centre du commerce à toutes les nations. Cet océan, qui semble mis au milieu des terres pour en faire une éternelle séparation, est au contraire le rendez-vous de tous les peuples, qui ne pourraient aller par terre d'un bout du monde à l'autre qu'avec des fatigues, des longueurs et des dangers incroyables. C'est par ce chemin sans trace, au travers des abîmes, que l'ancien monde donne la main au nouveau, et que le nouveau prête à l'ancien tant de commodités et de richesses.

Les eaux distribuées avec tant d'art font une circulation dans la terre comme le sang circule dans le corps humain; mais, outre cette circulation perpétuelle de l'eau, il y a encore le flux et reflux de la mer. Ne cherchons point les causes de cet effet si mystérieux. Ce qui est certain, c'est que la mer vous porte et reporte précisément aux mêmes lieux à certaines heures. Qui est-ce qui la fait se retirer et puis revenir sur ses pas avec tant de régularité? Un peu plus, un peu moins de mouvement dans cette masse fluide déconcerterait toute la nature: un peu plus de mouvement dans les eaux qui remontent inonderoit des royaumes entiers. Qui est-ce qui a su prendre des mesures si justes dans des corps immenses? Qui est-ce qui a su éviter le trop et le trop peu? Quel doigt a marqué à la mer la borne immobile qu'elle doit respecter dans la suite de tous les siècles, en lui disant: là vous viendrez briser l'orgueil de vos vagues?

Mais ces eaux si coulantes deviennent tout à coup, pendant l'hiver, dures comme des rochers: les sommets des hautes montagnes ont même en tout temps des glaces et des neiges qui sont les sources des rivières, et qui, abreuvant les pâturages, les rendent plus fertiles. Ici les eaux sont douces pour désaltérer l'homme; là elles ont un sel qui assaisonne et rend incorruptibles nos aliments. Enfin si je lève la tête j'aperçois dans les nues qui volent au-dessus de nous des espèces de mers suspendues pour tempérer l'air, pour arrêter les rayons enflammés du soleil, et pour arroser la terre quand elle est trop sèche. Quelle main a pu suspendre sur nos têtes ces grands

réservoirs d'eaux? Quelle main prend soin de ne les jamais laisser tomber que par des pluies modérées?

Après avoir considéré les eaux, appliquons-nous à examiner d'autres masses encore plus étendues. Voyez-vous ce que l'on nomme l'air? C'est un corps si pur, si subtil et si transparent, que les rayons des astres situés dans une distance presque infinie de nous le percent tout entier sans peine et en un seul instant pour venir éclairer nos yeux. Un peu moins de subtilité dans ce corps fluide nous auroit dérobé le jour, ou ne nous auroit laissé tout au plus qu'une lumière sombre et confuse, comme quand l'air est plein de brouillards épais. Nous vivons plongés dans des abîmes d'air, connus les poissons dans des abîmes d'eau.

Die même que l'eau, si elle se subtilisoit, deviendroit une espèce d'air qui feroit mourir les poissons, l'air, de son côté, nous ôteroit la respiration s'il devenoit plus épais et plus humide: alors nous nous noierions dans les flots de cet air épaissi, comme un animal terrestre se noie dans la mer. Qui est-ce qui a purifié avec, tant de justesse cet air que nous respirons? S'il étoit plus épais il nous suffoqueroit; comme s'il étoit plus subtil il n'auroit pas cette douceur qui fait une nourriture continuelle du dedans de l'homme: nous éprouverions partout ce qu'on éprouve sur le sommet des montagnes les plus hautes, où la subtilité de l'air ne fournit rien d'assez humide et d'assez nourrissant pour les poumons.

Mais quelle puissance invisible excite et apaise si soudainement les tempêtes de ce grand corps fluide? Celles de la mer n'en sont que les suites. De quel trésor sont tirés les vents qui purifient l'air, qui attiédissent les saisons brûlantes, qui tempèrent la rigueur des hivers, et qui changent en un instant la face du ciel? Sur les ailes de ces vents volent les nuées d'un bout de l'horizon à l'autre. On sait que certains vents règnent en certaines mers dans des saisons précises: ils durent un temps réglé, et il leur en succède d'autres comme tout exprès pour rendre les navigations commodes et régulières. Pourvu que les hommes soient patients et aussi ponctuels que les vents, ils feront sans peine les plus longues navigations.

Voyez-vous ce feu qui paroît allumé dans les astres, et qui répand partout sa lumière? Voyez-vous cette flamme que certaines montagnes vomissent, et que la terre nourrit de soufre dans ses entrailles? Ce même feu demeure paisiblement caché dans les veines des cailloux, et il y attend à éclater jusqu'à ce que le choc d'un autre corps l'excite pour ébranler les villes et les montagnes. L'homme a su l'allumer et l'attacher à tous ses usages pour plier les plus durs métaux, et pour nourrir avec du bois, jusques dans les climats les plus glacés, une flamme qui lui tienne lieu de soleil quand le soleil s'éloigne de lui. Cette flamme se glisse subtilement dans toutes les semences; elle est comme l'âme de tout ce qui vit; elle consume tout ce qui est impur, et renouvelle ce qu'elle a purifié. Le feu prête sa force aux hommes trop foibles; il enlève tout à coup les édifices et les rochers. Mais veut - on le borner à un usage plus modéré? Il réchauffe l'homme, il cuit les aliments. Les anciens,.admirant le feu, ont cru que c'étoit un trésor céleste que l'homme avoit dérobé aux dieux.

Il est temps d'élever nos yeux vers le ciel. Quelle puissance a construit au-dessus de nos têtes une si vaste et si superbe voûte! Quelle étonnante variété d'admirables objets? C'est pour nous donner un beau spectacle qu'une main toute-puissante a mis devant nos yeux de si grands et de si éclatants objets. C'est pour nous faire admirer le ciel, dit Cicéron, que Dieu a fait l'homme autrement que le reste des animaux. D est droit, et lève la tête pour être occupé de ce qui est au-dessus de lui. Tantôt nous voyons un azur sombre, ' où les feux les plus purs étincèlent: tantôt nous voyons dans un ciel tempéré les plus douces couleurs avec des nuances que la peinture ne peut imiter: tantôt nous voyons des nuages de toutes les figures et de toutes les couleurs les plus vives qui changent à chaque moment cette décoration par les plus beaux accidents de lumière.

La succession régulière des jours et des nuits, que fait-elle entendre? Le soleil ne manque jamais, depuis tant de siècles, à servir les hommes qui ne peuvent se passer de lui. L'aurore, depuis des milliers d'années, n'a pas manqué une seule fois d'annoncer le jour: elle le commence à point nommé au moment et au heu réglé. Le soleil, dit l'Ecriture, sait où il doit se coucher chaque jour. Par-là il éclaire tour à tour les deux côtés du monde, et visite tous ceux auxquels il doit ses rayons. Le jour est le temps de la société et du travail: la nuit, enveloppant de ses ombres la terre, finit tour à tour toutes les fatigues et adoucit toutes les peines: elle suspend, elle calme tout: elle répand le silence et le sommeil: en délassant les corps, elle renouvelle les esprits. Bientôt le jour revient pour rappeler l'homme au travail, et pour ranimer toute la nature.

Mais outre le cours si constant qui forme les jours et les nuits, le soleil nous en montre un autre par lequel il s'approche pendant six mois d'un pôle, et au bout de six mois revient avec la même diligence sur ses pas pour visiter l'autre. Ce bel ordre fait qu'un seul soleil suffit à toute la terre. S'il étoit plus grand dans la même distance, il embraserait tout le monde, la terre s'en irôit en poudre; si, dans la même distance, il étoit moins grand, la terre seroit toute glacée et inhabitable; si, dans la même grandeur, il étoit plus voisin de nous, il nous enflammeroit; si, dans la même grandeur, il étoit plus éloigné de nous, nous ne pourrions subsister dans le globe terrestre faute de chaleur. Quel compas, dont le tour embrasse le ciel et la terre, a pris des mesures si justes?

Cet astre ne fait pas moins de bien à la partie dont il s'éloigne pour la tempérer, qu'à celle dont il s'approche pour la favoriser de ses rayons: ses regards bienfaisants fertilisent tout ce qu'il voit. Ce changement fait celui des saisons, dont la variété est si agréable. Le printemps fait taire les vents glacés, montre les fleurs, et promet les fruits. L'été donne les riches moissons. L'automne répand les fruits promis par le printemps. L'hiver, qui est une espèce de nuit où l'homme se délasse, ne concentre tous les trésors de la terre qu'a ce que le printemps suivant les déploie avec toutes les grâces de la nouveauté. Ainsi la nature diversement parée donne tour à tour tant de beaux spectacles, qu'elle ne laisse jamais à l'homme le temps de se dégoûter de ce qu'il possède.

Mais comment est-ce que le cours du soleil peut-être si régulier? Il paroît que cet astre n'est qu'un globe de flamme très subtile, et par conséquent très fluide. Qui est-ce qui tient cette flamme, si mobile et si impétueuse, dans les bornes précises d'un globe parfait? Quelle main conduit cette flamme dans un chemin si droit, sans qu'elle s'échappe d'aucun côté? Cette flamme ne tient à rien, et il n'y a aucun corps qui pût ni la guider, ni la tenir assujettie. Elle consumeroit bientôt tout corps qui la tiendroit renfermée dans son enceinte. Où va-t-ell? Qui lui a appris à tourner sans cesse et si régulièrement dans des espaces où rien ne la gêne? Ne circule-t-elle pas autour de nous tout exprès pour nous servir?

Que si cette flamme ne tourne pas, et si au contraire c'est nous qui tournons autour d'elle, je demande d'où vient qu'elle est si bien placée dans le centre de l'univers, pour être comme le foyer ou le cœur de toute la nature. Je demande d'où vient que ce globe d'une matière si subtile ne s'échappe jamais d'aucun côté dans ces espaces immenses qui l'environnent, et où tous les corps qui sont fluides semblent devoir céder à l'impétuosité de cette flamme.

Enfin je demande d'où vient que le globe de la terre qui est si dure tourne si régulièrement autour de cet astre, dans des espaces où nul corps solide ne le tient assujetti pour régler son cours. Qu'on cherche tant qu'on voudra dans la physique les raisons les plus ingénieuses pour expliquer ce fait: toutes ces raisons, supposé même qu'elles soient vraies, se tourneront en preuves de la Divinité. Plus ce ressort qui conduit la machine de l'univers est juste, simple, constant, assuré, et fécond en effets utiles; plus il faut qu'une main très puissante et très industrieuse ait su choisir ce ressort le plus parfait de tous.

Mais regardons encore une fois ces voûtes immenses où brillent les astres, et qui couvrent nos têtes. Si ce sont des solides, qui en est l'architecte? Qui est-ce qui a attaché tant de grands corps lumineux à certains endroits de ces voûtes, de distance en distance? Qui est-ce qui fait tourner ces voûtes si régulièrement autour de nous? Si au contraire les cieux ne sont que des espaces immenses remplis de corps fluides comme l'air qui nous environne, d'où vient que tant de corps solides y flottent sans s'enfoncer jamais, et sans se rapprocher jamais les uns des autres? Depuis tant de siècles que nous avons des observations astronomiques, on est encore à découvrir le moindre dérangement dans les deux. Un corps fluide donné-t-il un arrangement si constant et si régulier aux corps qui nagent circulairement dans son enceinte?

Mais que signifie cette multitude presque innombrable d'étoiles? La profusion avec laquelle la main de Dieu les a répandues sur son ouvrage fait voir qu'elles ne coûtent rien à sa puissance. Il en a semé les cieux, comme un prince magnifique répand l'argent à pleines mains, ou comme il met des pierreries sur un habit. Que quelqu'un dise, tant qu'il lui plaira, que ce sont autant de inondes, semblables à la terre que nous habitons; je le suppose pour un moment. Combien doit être puissant et sage celui qui fait des mondes aussi innombrables que les grains de sable qui couvrent les rivages des mers, et qui conduit sans peine, pendant tant de siècles, tous ces mondes errants, comme un berger conduit un troupeau! Si au contraire ce sont seulement des flambeaux allumés pour luire à nos yeux dans ce petit globe qu'on nomme la terre, quelle puissance, que rien ne lasse, et à qui rien ne coûte! Quelle profusion, pour donner à l'homme, dans ce petit coin de l'univers, un spectacle si étonnant!

Mais parmi ces astres j'aperçois la lune qui semble partager avec le soleil le soin de nous éclairer. Elle se montre à point nommée, avec toutes les étoiles, quand le soleil est obligé d'aller ramener le jour dans l'autre hémisphère. Ainsi la nuit même, malgré ses ténèbres, a une lumière, sombre à la vérité, mais douce et utile. Cette lumière est empruntée du soleil, quoique absent. Ainsi tout est ménagé dans l'univers avec un si bel art, qu'un globe voisin de la terre et aussi ténébreux qu'elle par lui-même sert néanmoins à lui renvoyer par réflexion les rayons qu'il reçoit du soleil; et que ce soleil éclaire par la lune les peuples qui ne peuvent le voir, pendant qu'il doit en éclairer d'autres.

Le mouvement des astres, dira-t-on, est réglé par des lois immuables. Je suppose le fait. Mais c'est ce fait même qui prouve ce que je veux établir. Qui est-ce qui a donné à toute la nature des lois tout ensemble si constantes et si salutaires; des lois si simples, qu'on est tenté de croire qu'elles s'établissent d'elles-mêmes, et si fécondes en effets utiles, qu'on ne peut s'empêcher d'y reconnoître un art merveilleux? D'où nous vient la conduite de cette machine universelle qui travaille sans cesse pour nous sans que nous y pensions? A qui attribuerons-nous l'assemblage de tant de ressorts si profonds et si bien concertés, et de tant de corps, grands et petits, visibles et invisibles, qui conspirent également pour nous servir? Le moindre atome de cette machine, qui viendrait à se déranger, démonteroit toute la nature. Les ressorts d'une montre ne sont point liés avec tant d'industrie et de justesse. Quel est donc ce dessein si étendu, si suivi, si beau, si bienfaisant? La nécessité de ces lois, loin de m'empêcher d'en chercher l'auteur, ne fait qu'augmenter ma curiosité et mon admiration. Il falloit qu'une main également industrieuse et puissante mit dans son ouvrage un ordre également simple et fécond, constant et utile. Je ne crains donc pas de dire avec l'Écriture que chaque étoile se hâte d'aller où le Seigneur l'envoie; et que, quand il parle, elles répondent avec tremblement: Nous voici, (Ecce ad sumus.)

Mais tournons nos regards vers les animaux, encore plus dignes d'admiration que les cieux et les astres. Il y en a des espèces innombrables. Les uns n'ont que deux pieds, d'autres en ont quatre, d'autres en ont un très grand nombre. Les uns marchent; les autres rampent; d'autres volent; d'autres nagent; d'autres volent, marchent, et nagent tout ensemble. Les ailes des oiseaux et les nageoires des poissons sont comme des rames qui fendent la vague de l'air ou de l'eau, et qui conduisent le corps flottant de l'oiseau ou du poisson dont la- structure est semblable à celle d'un

navire. Mais les ailes des oiseaux ont des plumes avec un duvet qui s'enfle à l'air, et qui s'appesantiroit dans les eaux: au contraire, les nageoires des poissons ont des pointes dures et sèches, qui fendent l'eau sans en être imbibées, et qui ne s'appesantissent point quand on les mouille.

Certains oiseaux qui nagent, comme les cygnes, élèvent en haut leurs ailes, et tout leur plumage, de peur de le mouiller, et afin qu'il leur serve comme dévoiles. Ils ont l'art de tourner ce plumage du côté du vent, et d'aller comme les vaisseaux, à la bouline, quand le vent ne leur est pas favorable. Les oiseaux aquatiques, tels que les canards, ont aux pattes de grandes peaux qui s'étendent et qui font des raquettes à leurs pieds, pour les empêcher d'enfoncer dans les bords marécageux des rivières.

Parmi ces animaux, les bêtes féroces, telles que les lions, sont celles qui ont des muscles les plus gros aux épaules, aux cuisses, et aux jambes: aussi ces animaux sont-ils souples, agiles, nerveux, et prompts à se lancer. Les os de leurs mâchoires sont prodigieux, à proportion du reste de leur corps. Ils ont des dents et des griffes, qui leur servent d'armes terribles pour déchirer et pour dévorer les autres animaux.

Par la même raison les oiseaux de proie, comme les aigles, ont un bec et des ongles qui percent tout. Les muscles de leurs ailes sont d'une extrême grandeur, et d'une chair très dure, afin que leurs ailes aient un mouvement plus fort et plus rapide. Aussi ces animaux, quoiqù'assez pesants, s'élèvent - ils sans peine jusque dans les nues, d'où ils s'élancent, comme la foudre, sur toute proie qui peut les nourrir.

D'autres animaux ont des cornes. La plus grande force des uns est dans les reins et dans le cou: d'autres ne peuvent que ruer. Chaque espèce a ses armes offensives et défensives. Leurs chasses sont des espèces de guerre qu'ils font les uns contre les autres pour les besoins de la vie.

Ils ont aussi leurs règles et leur police. L'un porte, comme la tortue, sa maison dans laquelle il est né: l'autre bâtit la sienne, comme l'oiseau, sur les plus hautes branches des arbres, pour préserver ses petits de l'insulte des animaux qui ne sont point ailés. Il pose même son nid dans les feuillages les plus épais, pour le cacher à ses ennemis.

Un autre, comme le castor, va bâtir jusqu'au fond des eaux d’un étang l'asile qu'il se prépare, et sait élever des digues pour le rendre inaccessible par l'inondation.

Un autre, comme la taupe, naît avec un museau si pointu et si aiguisé, qu'il perce en un moment le terrain le plus dur pour se faire une retraite souterraine.

Le renard sait creuser un terrier avec deux issues, pour n'être point surpris, et pour éluder les pièges du chasseur.

Les animaux reptiles sont d'une autre fabrique. Ils se plient et replient par les évolutions de leurs muscles; ils gravissent, ils embrassent, ils serrent, ils accrochent les corps qu'ils rencontrent, ils se glissent subtilement partout Leurs organes sont presque indépendants les uns des autres: aussi vivent-ils encore après qu'on les a coupés.

Les oiseaux, dit Cicéron, qui ont les jambes longues, ont aussi le cou long à proportion, pour pouvoir abaisser leur bec jusqu'à terre, et y prendre leurs aliments. Le chameau est de même. L'éléphant, dont le cou seroit trop pesant par sa grosseur, s'il étoit aussi long que celui du chameau, a été pourvu d'une trompe, qui est un tissu de nerfs et de muscles, qu'il allonge, qu'il retire, qu'il

replie en tout sens,pour saisir les corps, pour les enlever et pour les repousser: aussi les Latins ont-ils appelé cette trompe une main.

Certains animaux paroissent faits pour l'homme. Le chien est né pour le caresser; pour se dresser comme il,lui plaît; .pour lui donner une image agréable de société, d'amitié, de fidélité et de tendresse; pour garder tout ce qu'on lui confie; pour prendre à la course beaucoup d'autres bêtes avec, ardeur, et pour les laisser ensuite à l'homme, sans en rien retenir. »

Le cheval et les autres animaux semblables se trouvent sous la main de l'homme, pour le soulager dans son travail et pour se charger de mille fardeaux. Ils sont nés pour porter, pour marcher, pour soulager l'homme dans sa foiblesse, et pour obéir à tous ses mouvements.

Les bœufs ont la force et la patience en partage, pour traîner la charrue et pour labourer. Les vaches donnent des ruisseaux de lait.

Les moutons ont dans leur toison un superflu qui n'est pas pour eux, et qui se renouvelle pour inviter l'homme à les tondre toutes les années. Les chèvres même fournissent un crin long, qui leur est inutile, et dont l'homme fait des étoffes pour se couvrir. Les peaux des animaux fournissent à l'homme les plus belles fourrures dans les pays les plus éloignés du soleil. Ainsi l'auteur de la nature a vêtu les bêtes selon leur besoin; et leurs dépouilles servent encore ensuite d'habits aux hommes pour les réchauffer dans ces climats glacés.

Les animaux qui n'ont presque point de poil ont une peau très épaisse et très dure comme des écailles; d'autres ont des écailles même qui se couvrent les unes les autres, comme les tuiles d'un toit, et qui s'entrouvrent ou se resserrent suivant qu'il convient à l'animal de se dilater ou de se resserrer. Ces peaux et ces écailles servent aux besoins des hommes.

Ainsi, dans la nature, non seulement les plantes, mais encore les animaux, sont faits pour notre usage. Les bêtes farouches même s'apprivoisent, ou du moins craignent l'homme. Si tous les pays étoient peuplés et policés comme ils devroient l'être, il n'y en auroit point où les bêtes attaquassent les hommes: on ne trouverait plus d'animaux féroces que dans les forêts reculées; et on les réserver oit pour exercer la hardiesse, la force et l'adresse du genre humain, par un jeu qui représenteroit la guerre, sans qu'on eût jamais besoin de guerre véritable entre les nations.

Mais observez que les animaux nuisibles à l'homme sont les moins féconds, et que les plus utiles sont ceux qui se multiplient davantage. On tue incomparablement plus de bœufs et de moutons qu'on ne tue d'ours et de loups: il y a néanmoins incomparablement moins d'ours et de loups que de bœufs et de moutons sur la terre. Remarquez encore, avec Cicéron, que les femelles de chaque espèce ont des mamelles dont le nombre est proportionné à celui des petits qu'elles portent ordinairement. Plus elles portent de petits, plus la nature leur a fourni de sources de lait cour les allaiter.

Pendant que les moutons font croître leur laine pour nous, les vers à soie nous filent à l'envi de riches étoffes, et se consument pour nous les donner. Ils se font de leur coque une espèce de tombeau, où ils se renferment dans leur propre ouvrage; et ils renaissent sous une figure étrangère pour se perpétuer.

D'un autre côté, les abeilles vont recueillir avec soin le suc des fleurs odoriférantes pour en composer leur miel, et elles le rangent avec un ordre qui nous peut servir de modèle. Beaucoup d'insectes se transforment, tantôt en mouches, et tantôt en vers. Si on les trouve inutiles, on doit considérer que ce qui fait partie du grand spectacle de la nature, et qui contribue à sa variété, n'est point sans usage pour les hommes tranquilles et attentifs.

Qu'y a-t-il de plus beau et de plus magnifique que ce grand nombre de républiques d'animaux si bien policées, et dont chaque espèce est d'une construction différente des autres? Tout montre combien la façon de l'ouvrier surpasse la vile matière qu'il a mise en œuvre; tout m'étonne, jusqu'aux moindres moucherons. Si on les trouve incommodes, on doit remarquer que l'homme a besoin de quelques peines mêlées avec ses commodités. Il s'amolliroit, il s'oublieroit lui-même, s'il n'avoit rien qui modérât ses plaisirs et qui exerçât sa patience.

Considérons maintenant les merveilles qui éclatent également dans les plus grands corps et dans les plus petits. D'un côté je vois le soleil tant de milliers de fois plus grand que la terre; je le vois qui circule dans des espaces en comparaison desquels il n'est lui-même qu'un atome brillant. Je vois d'autres astres, peut-être encore plus grands que lui, qui roulent dans d'autres espaces encore plus éloignés de nous. Au-delà de tous ces espaces, qui échappent déjà à toute mesure, j'aperçois encore confusément d'autres astres qu'on ne peut plus compter ni distinguer. La terre, où je suis, n'est qu'un point à proportion de ce tout où l'on ne trouve jamais aucune borne. Cela est si bien arrangé, qu'on n'y pourroit déplacer le seul atôe sans déconcerter toute cette immense machine^,et il se meut avec un si bel ordre, que ce mouvement soit perpétue la variété et la perfection. Il faut qu'une main à qui rien ne coûte ne se lasse point de conduire cet ouvrage depuis tant de siècles, et que- ses doigts se jouent de l'univers, pour parler comme l'Écriture.

D'un autre côté l'ouvrage n'est pas moins admirable en petit qu'en grand. Je ne trouve pas moins en petit une espèce d'infini qui m'étonne et qui me surmonte. Trouver dans un ciron, comme dans un éléphant ou dans une baleine, des membres parfaitement organisés, et trouver une tête, un corps, des jambes, des pieds formés comme ceux des plus grands animaux! 11 y a dans chaque partie de ces atomes vivants, des muscles, des veines, des artères, du sang; dans ce sang, des esprits, des parties rameuses et des humeurs'; dans ces humeurs, des gouttes composées elles-mêmes de diverses parties, sans qu'on puisse jamais s'arrêter dans cette composition infinie d'un tout si infini.

Le microscope nous découvre dans chaque objet comme mille objets qui ont échappé à notre connoissance. Combien y a-t-il, dans chaque objet découvert par le microscope, d'autres objets que le flouroscope lui-même ne peut découvrir! Que ne verrions-nous pas, si nous pouvions subtiliser toujours de plus en plus les instrumens qui viennent au secours de notre vue trop foible et trop grossière? Mais suppléons par l'imagination à ce qui nous manque du côté des yeux; et que notre imagination elle-même soit une espèce de microscope qui nous représente en chaque atome mille mondes nouveaux et invisibles: elle pourra passer figurer sans cesse de nouvelles' découvertes dans les petits corps; elle se lassera; il y faudra quelle 'arrête, qu'elle succombe, et quelle laisse enfin dans le plu» petit organe d'un corps mille merveilles inconnues.

Chapitre III - Des Animaux.

ENFERMONS-NOUS dans la machine de l'animal: elle a trois choses qui ne peuvent être trop admirées; i ° elle a en elle-même de quoi se défendre contre ceux qui l'attaquent pour la détruire; a° elle a de quoi se renouveler par la nourriture; 3° elle a de quoi perpétuer son espèce par la génération. Examinons un peu ces trois choses.

Les animaux ont ce qu'on nomme un instinct et pour s'approcher des objets utiles et pour fuir ceux qui peuvent leur nuire. Ne cherchons point en quoi consiste cet instinct; contentons-nous du simple fait sans raisonner.

Le petit agneau sent de loin sa mère, et court au-devant d'elle. Le mouton est saisi d'horreur aux approches 3ï loup, et s'enfuit avant que de l'avoir pu discerner Le chien de chasse est presque infaillible pour découvrir par la seule odeur le chemin du cerf. Il y a typifiés chaque en animal un

ressort impétueux qui rassemble tout à coup les' esprits, qui tend tous les nerfs, qui ^ rend toutes les jointures plus souples, qui augmente d'une manière incroyable, dans les périls soudains, la force, l'agilité, la vitesse et les ruses, pour fuir l'objet qui le menace de sa perte. Il n'est pas question ici de savoir si les bêtes ont de la connoissance: je ne prétends entrer en aucune question de philosophie.

Les mouvements dont je parle sont entièrement indélibérés, même, dans la machine de l'homme. Si un homme qui danse sur la corde raisonnoit sur les règles de l'équilibre, son raisonnement lui feroit perdre l'équilibre qu'il garde merveilleusement sans raisonner, et la raison ne lui servirait qu'à tomber par terre.

Il en est de même des bêtes. Dites, si vous le voulez, qu'elles raisonnent comme les hommes: en le disant vous n'affoiblissez en rien ma preuve. Leur raisonnement ne peut jamais servir à expliquer les mouvements que nous admirons le plus en elles. Dira-t-on qu'elles savent les plus fines règles de la mécanique, qu'elles observent avec une justesse si parfaite quand il est question de courir, de sauter, de nager, de se cacher, de se replier, de dérober leur piste aux chiens, ou de se servir de la partie de leur corps la plus forte pour se défendre? Dira-t-on qu'elles savent naturellement les mathématiques que les hommes ignorent? Osera-t-on dire qu'elles font avec délibération et avec science tous les mouvements si impétueux et si justes que les hommes mêmes fout sans étude et sans y penser? Leur donnera-t-on de la raison dans les mouvements mêmes où il est certain que l'homme n'en a pas?

C'est l'instinct, dira-t-on, qui conduit les bêtes. Je le veux: c'est en effet un instinct; mais cet instinct est une sagacité et une dextérité admirable, non dans les bêtes qui ne raisonnent ni ne peuvent 'avoir le loisir de raisonner, mais dans la sagesse supérieure qui les conduit. Cet instinct ou cette sagesse qui pense et qui veille pour la bête dans les choses indélibérées, où elle ne pourrait ni veiller ni penser quand même elle seroit aussi raisonnable que nous, ne peut être que la sagesse de l'ouvrier qui a fait cette machine.

Qu'on ne parle donc plus d'instinct ni de nature: ces noms ne sont que de beaux noms dans la bouche de ceux qui les prononcent. Il y a, dans ce qu'ils appellent nature et instinct, un art et une industrie supérieure dont l'invention humaine n'est que l'ombre. Ce qui est indubitable, c'est qu'il y a dans les bêtes un nombre prodigieux de mouvements entièrement indélibérés, qui sont exécutés selon les plus fines règles de la mécanique. C'est la machine seule qui suit ces règles. Voilà le fait indépendant de toute philosophie; et le fait seul décide.

Que penseroit-on d'une montre qui fuiroit à propos, qui se replieroit, qui se défendroit, et échapperoit pour se conserver quand on voudroit la rompre? N’admireroit-on pas l'art de l'ouvrier? Croiroit-on que les ressorts de cette montre se seroient formés, proportionnés, arrangés et unis par un pur hasard? Croiroit-on avoir expliqué nettement ces opérations si industrieuses, en parlant de l'instinct et de la nature de cette montre qui marqueroit précisément les heures à son maître, et qui échapperoit à ceux qui voudraient briser ses ressorts?

Qu'y a-t-il de plus beau qu'une machine qui se répare et se renouvelle sans cesse elle-même? L'animal, borné dans ses forces, s'épuise bientôt par le travail; mais plus il travaille, plus il se sent pressé de se dédommager de son travail par une abondante nourriture. Les aliments lui rendent chaque jour la force qu'il a perdue. Il met au dedans de son corps une substance étrangère, qui devient la sienne par une espèce de métamorphose. D'abord elle est broyée et se change en une liqueur; puis elle se purifie, comme si on la passoit par un tamis pour eu séparer tout ce qui est trop grossier; ensuite elle parvient au centre ou foyer des esprits, où elle se subtilise et devient du sang: enfin elle coule et s'insinue par des rameaux innombrables pour arroser tous les membres; elle se filtre Jans les chairs; elle devient chair elle-même.

Tant d'aliments et de liqueurs de couleurs si différentes ne sont plus qu'une même chair. L'aliment, qui étoit un corps inanimé, entretient l'animal et devient l'animal même. Les parties qui le composoient se sont exhalées par une insensible et continuelle transpiration. Ce qui étoit, il y a quatre ans, un tel cheval, n'est plus que de l'air ou du fumier. Ce qui étoit alors du, foin ou du fumier est devenu ce même cheval si fier et si vigoureux; du moins il passe pour le même cheval, malgré ce changement insensible de sa substance.

A la nourriture se joint le sommeil. L'animal interrompt non seulement tous les mouvements extérieurs, mais encore toutes les principales opérations du dedans qui pourroient agiter et dissiper trop les esprits; il ne lui reste que la respiration et la digestion; c'est-à-dire que tout mouvement qui useroit ses forces est suspendu, et que tout mouvement propre à les renouveler s'exerce seul, et librement. Ce repos, qui est une espèce d'enchantement, revient toutes les nuits pendant que les ténèbres empêchent le travail. Qui est-ce qui a inventé cette suspension? Qui est-ce qui a si bien choisi les opérations qui doivent continuer? Et qui est-ce qui a exclu, avec un si juste discernement, toutes celles qui ont besoin d'être interrompues?

Le lendemain toutes les fatigues passées se sont anéanties. L'animal travaille comme s'il n'avoit jamais travaillé, et il a une vivacité qui l'invite à un travail nouveau par ce renouvellement. Les nerfs sont toujours pleins d'esprits, les chairs sont souples, la peau demeure entière, quoiqu'elle dût, ce semble, s'user. Le corps vivant de l'animal use bientôt les corps inanimés, même les plus solides, qui sont autour de lui, et il ne s'use point. La peau d'un cheval use plusieurs selles. La chair d'un enfant, quoique si tendre et si délicate, use beaucoup d'habits pendant qu'elle se fortifie tous les jours. Si ce renouvellement étoit parfait, ce seroit l'immortalité et le don d'une jeunesse éternelle; mais comme ce renouvellement n'est qu'imparfait, l'animal perd insensiblement ses forces et vieillit, parce que tout ce qui "est créé doit porter la marque du néant d'où il est sorti, et avoir une fin.

Qu'y a-t-il de plus admirable que la multiplication des animaux? Regardez les individus; nul animal n'est immortel: tout vieillit, tout passe, tout disparoît, tout est anéanti. Regardez les espèces; tout subsiste, tout est permanent et immuable dans une vicissitude continuelle. Depuis qu'il y a sur la terre des hommes soigneux de conserver la mémoire des faits, on n'a vu ni lions, ni tigres, ni sangliers, ni ours se former par hasard dans les antres ou dans les forêts. Oh ne voit point aussi de productions fortuites de chiens ou de chats. Les bœufs et les moutons ne naissent jamais d'eux-mêmes dans les étables et dans les pâturages. Chacun de ces animaux doit sa naissance à un certain mâle et à une certaine femelle de son espèce.

Toutes ces différentes espèces se conservent à peu près de même dans tous les siècles- On ne voit point que depuis trois mille ans aucune soit périe; on ne voit point aussi qu'aucune se multiplie avec un excès incommode pour les autres. Si les espèces des lions, des ours et des tigres se multiplioient à un certain point, ils détruiraient les espèces des cerfs, des daims, des moutons, des chèvres et des bœufs; ils prévaudroient même sur le genre humain, et dépeupleroient la terre. Qui est-ce qui tient la mesure si juste, pour n'éteindre jamais ces espèces, et pour ne les laisser jamais trop multiplier?

Mais enfin cette propagation continuelle de chaque espèce est une merveille à laquelle nous sommes trop accoutumés. Que penseroit-on d'un horloger, s'il savoit faire des montres qui d'elles-mêmes en produisissent d'autres à l'infini, en sorte que deux premières montres fussent suffisantes pour multiplier et perpétuer l'espèce sur toute la terre? Que diroit-on d'un architecte, s'il avoit l'art de faire des maisons qui en fissent d'autres pour renouveler l'habitation des hommes avant qu'elles fussent prêtes à tomber en ruine? Voilà ce qu'on voit parmi les animaux. Ils ne sont, si vous le

voulez, que de pures machines comme les montres; mais enfin l'auteur de ces machines, a mis en elles de quoi se reproduire à l'infini par l'assemblage de deux sexes.

Dites tant qu'il vous plaira que cette génération d'animaux se fait par des moules ou par une configuration expresse de chaque individu. Lequel des deux qu'il vous plaise de dire, vous n'épargnez rien, et l'art de l'ouvrier n'en éclate pas moins. Si vous supposez qu'à chaque génération l'individu reçoit, sans aucun moule, une configuration faite exprès, je demande qui est-ce qui conduit la configuration d'une machine si composée, et où éclate une si grande industrie. Si au contraire, pour n'y reconnoître aucun art, vous supposez que les moules déterminent tout, je remonte à ces moules mêmes. Qui est-ce qui les a préparés? Us sont encore bien plus étonnants que les machines qu'on en veut faire éclore.

Qu'on imagine donc des moules dans les animaux qui vivoient il y a quatre mille ans, et qu'on assure, si on le veut, qu'ils étoient tellement renfermés les uns dans les autres à l'infini, qu'il y en a eu pour toutes les générations de ces quatre mille années, et qu'il y en a encore de préparés pour la formation de tous les animaux qui conserveront l'espèce dans la suite de tous les siècles. Ces moules, qui ont toute la forme de l'animal par leur configuration, comme je viens de le remarquer, ont déjà autant de difficulté à être expliqués que les animaux mêmes: mais ils ont d'ailleurs des merveilles bien plus inexplicables. An moins la configuration de chaque animal en particulier ne demanderoit-elle qu'autant d'art et de puissance qu'il en faut pour exécuter tous les ressorts qui composent cette machine.

Mais quand on suppose les moules, i° il faut dire que chaque moule contient en petit, avec une délicatesse inconcevable, tous les ressorts de la machine même; or il y a plus d'industrie à faire un ouvrage composé en si petit volume, qu'à le faire plus grand: 20 il faut dire que chaque moule, qui est un individu préparé pour une première génération, renferme distinctement au dedans de soi d'autres moules contenus les uns dans les autres à l'infini pour toutes les générations possibles dans la suite de tous les siècles. Qu'y a-t-il de plus industrieux et de plus étonnant, en matière d'art, que cette préparation d'un nombre infini d'individus tous formés par avance dans un seul dont il doivent éclore? Les moules ne servent donc de rien pour expliquer les générations des animaux sans avoir besoin d'y reconuoître aucun art: au contraire, les moules montreroient un plus grand artifice et une plus étonnante composition.

Ce qu'il y a de manifeste et d'incontestable, indépendamment de tous les systèmes des philosophes, c'est que le concours fortuit des atomes ne produit jamais sans généraliser, en aucun endroit de la terre, ni lions, ni tigres, ni ours, ni éléphants, ni cerfs,ni bœufs, ni moutons, ni chats, ni chiens, ni chevaux: ils ne sont jamais produits que par l'accouplement de leurs semblables. Les deux animaux qui en produisent un troisième ne sont point les véritables auteurs de l'art qui éclate dans la composition de l'être engendré par eux. Loin d'avoir l'industrie de l'exécuter, ils ne savent pas même comment est composé l'ouvrage qui résulte de leur génération; ils n'en connoissent aucun ressort particulier: ils n'ont été que des instruments aveugles et involontaires appliqués à l'exécution d'un art merveilleux qui leur est absolument étranger et inconnu.

D'où vient-il cet art si merveilleux qui n'est point le leur? Quelle puissance et quelle industrie sait employer, pour des ouvrages d'un dessein si ingénieux, des instruments si incapables de savoir ce qu'ils font, ni d'en avoir aucune vue? Il est inutile de supposer que les bêtes ont de la connoissance. Donnez-leur-en tant qu'il vous plaira dans les autres choses; du moins il faut avouer qu'elles n'ont dans la génération aucune part à l'industrie qui éclate dans la composition des animaux qu'elles produisent.

Allons même plus loin, et supposons tout ce qu'on raconte de plus étonnant de l'industrie des animaux. Admirons tant qu'on le voudra la certitude avec laquelle un chien s'élance dans le

troisième chemin, dès qu'il a senti que la bête qu'il poursuit n'a laissé aucune odeur dans les deux premiers. Admirons la biche, qui jette, dit-on, loin d'elle son petit faon dans quelque lieu caché, afin que les chiens ne puissent le découvrir par la senteur de sa piste. Admirons jusqu'à l'araignée, qui tend par ses filets des pièges subtils aux moucherons pour les enlacer et pour les surprendre avant qu'ils puissent se débarrasser. Admirons encore, s'il le faut, le héron, qui met, dit-on, sa tête sous son aile pour cacher dans ses plumes son bec, dont il veut percer l'estomac de l'oiseau de proie qui fond sur lui. Supposons tous ces faits merveilleux.

La nature entière est pleine de ces prodiges. Mais qu'en faut-il conclure? Sérieusement, si on y prend bien garde, ils prouveront trop. Dirons-nous que les botes ont plus de raison que nous? Leur instinct a sans doute plus de certitude que nos conjectures. Elles n'ont étudié ni dialectique ni géométrie; elles n'ont aucune méthode, aucune science, aucune culture: ce qu'elles font, elles le font sans l'avoir étudié ni préparé; elles le font tout d'un coup, et sans tenir conseil. Nous nous trempons à toute heure, après avoir bien raisonné ensemble: pour elles, sans raisonner, elles exécutent à toute heure ce qui pourroit demander le plus de choix et de justesse; leur instinct est infaillible en beaucoup de choses.

Mais ce nom d'instinct n'est qu'un beau nom vide de sens: car que peut-on entendre par un instinct plus juste, plus précis et plus sur que la raison même, sinon une raison plus parfaite? Il faut donc trouver une merveilleuse raison, ou dans l'ouvrage ou dans l'ouvrier, ou dans la machine, ou clans celui qui l'a composée. Par exemple, quand je vois dans une montre une justesse sur les heures qui surpasse toutes mes connoissances, je conclus que si la montre ne raisonne pas, il faut qu'elle ait été formée par un ouvrier qui raisonnoit en ce genre plus juste que moi. Tout de même, quand je vois des bêtes qui font à toute heure des choses où il paroît une industrie plus sûre que la mienne, j'en conclus aussitôt que cette industrie si " merveilleuse doit être nécessairement ou dans la machine, ou dans l'inventeur qui l'a fabriquée. Est - elle dans l'animal même? Quelle apparence y a-t-il qu'il soit si savant et si infaillible- en certaines choses? Si cette industrie n'est pas en lui, il faut qu'elle soit dans l'ouvrier qui a fait cet ouvrage, comme tout l'art est dans la tête de l’horloger.

Ne me répondez point que l'instinct des bêtes est fautif eu certaines choses. Il n'est pas étonnant que les bêtes ne soient pas infaillibles en tout; mais il est étonnant qu'elles le soient en plusieurs cas. Si elles l'étoient en tout, elles auroient une raison infiniment parfaite, elles seroient des divinités. Il ne peut y avoir dans les ouvrages d'une puissance infinie qu'une perfection finie, autrement Dieu feroit des créatures semblables à lui; ce qui est impossible. Il ne peut donc mettre de la perfection ni par conséquent de la raison dans ses ouvrages qu'avec quelques bornes. La borne n'est donc pas une preuve que l'ouvrage soit sans ordre et sans raison. De ce que je me trompe quelquefois, il ne s'ensuit pas que je ne sois point raisonnable, et que tout se fasse en moi par un pur hasard; il s'ensuit seulement que ma raison est bornée et imparfaite. Tout de même, de ce qu'une bête n'est pas infaillible en tout par son instinct, quoiqu'elle le soit en beaucoup de choses, il ne s'ensuit pas qu'il n'y ait aucune raison en cette machine; il s'ensuit seulement que cette machine n'a point une raison sans bornes. Mais enfin le fait est constant, savoir, qu'il y a dans les opérations de cette machine une conduite réglée, un art merveilleux, une industrie qui va jusqu'à l'infaillibilité dans certaines choses. À qui la donnerons-nous cette industrie infaillible? À l'ouvrage, ou à son ouvrier?

Si vous dites que les bêtes ont des âmes différentes de leurs machines, je vous demanderai aussitôt: De quelle nature sont ces âmes entièrement différentes des corps, et attachées à eux? Qui est-ce qui a su les attacher à des natures si différentes? Qui est-ce -qui a eu un empire si absolu sur des natures si diverses, pour les mettre dans une société si régulière, si constante, et où la correspondance est si prompte?

Si au contraire vous voulez que la même matière puisse tantôt penser, et tantôt ne penser pas, suivant les divers arrangements et configurations des parties qu'on peut lui donner, je ne vous dirai point ici que la matière ne peut penser, et qu'on ne sauroit concevoir que les parties d'une pierre pussent jamais, sans y rien ajouter, se connoître elles-mêmes, quelque degré de mouvement et quelque figure que vous leur donniez: maintenant je me borne à vous demander en quoi consiste cet arrangement et cette configuration précise des parties que vous alléguez. Il faut, selon vous, qu'il y ait un degré de mouvement où la matière ne raisonne pas encore, et puis un autre à peu près semblable où elle commence tout à coup à raisonner et à se connoître.?

Qui est-ce qui a su choisir ce degré précis de mouvement? Qui est-ce qui a découvert la ligue selon laquelle les parties doivent se mouvoir? Qui est-ce qui a pris les mesures pour trouver au juste la grandeur et la figure que chaque partie a besoin d'avoir pour garder toutes les proportions entre elles dans ce tout? Qui est-ce qui a réglé la figure extérieure par laquelle tous ces corps doivent être bornés? En un mot, qui est-ce qui a trouvé toutes les combinaisons dans lesquelles la matière pense, et dont la moindre ne pourroit être retranchée et que la matière cessât aussitôt de penser? Si vous dites que c'est le hasard, je réponds que vous faites ce hasard raisonnable jusqu'au point d'être la source de la raison même. Étrange prévention de ne pas vouloir reconuoître une cause très intelligente, d'où nous vienne toute intelligence, et d'aimer mieux dire que la plus pure raison n'est qu'un effet de la plus aveugle de toutes les causes dans un sujet tel que la matière, qui par lui-même est incapable de connoissance! En vérité, il n'y a rien qu'il ne vaille mieux admettre que de dire des choses si insoutenables.

La philosophie des anciens, quoique très imparfaite, avoit néanmoins entrevu cet inconvénient; aussi vouloit-élle que l'esprit divin, répandu dans tout l'univers, fût une sagesse supérieure qui agît sans cesse dans toute la nature, et surtout dans les animaux, comme les âmes agissent dans les corps, et que cette impression continuelle de l'esprit divin, que le vulgaire nommable instinct sans entendre le vrai sens de ce terme, fût la vie de tout ce qui vit.

Ils ajoutaient que ces étincelles de l'esprit divin étoient le principe de toutes les générations; que les animaux les recevoient dans leur conception et à leur naissance, et qu'au moment de leur mort ces particules divines se détachoient de toute la matière terrestre pour s'envoler au ciel, où elles rouloient au nombre des astres. C'est cette philosophie, tout ensemble si magnifique et si fabuleuse, que Virgile exprime avec tant de grâce par ces vers sur les abeilles, où il dit que tontes les merveilles qu'on y admire ont fait dire à plusieurs qu'elles étoient animées par un souffle divin et par une portion de la divinité, dans la persuasion où ils étoient que Dieu remplit la terre, la mer et le ciel; que c'est de là que les bêtes, les troupeaux et les hommes reçoivent la vie en naissant, et que c'est là que toutes choses rentrent et retournent lorsqu'elles viennent à se détruire, parce que les âmes, qui sont le principe de la vie, loin d'être anéanties par la mort, s'envolent au nombre des astres, et vont établir leur demeure dans le ciel .

Cette sagesse divine, qui meut toutes les parties du mondé, avoit tellement frappé les Stoïciens, et avant eux Platon, qu'ils croyoient que le monde entier étoit un animal, mais un animal raisonnable, philosophe, sage, enfin le Dieu suprême. Cette philosophie réduisoit la multitude des Dieux à un seul; et ce seul Dieu, à la nature, qui étoit éternelle, infaillible, intelligente, toute-puissante et divine. Ainsi les philosophes, à force de s'éloigner des poètes, retomboient dans toutes les imaginations poétiques: ils donnoient, comme les auteurs des fables, une vie, une intelligence, un art, un dessein à toutes les parties de l'univers qui paroissent les plus inanimées. Sans doute ils avoient bien senti l'art qui est dans la nature, et ils ne se trompoient qu'en attribuant à l'ouvrage l'industrie de l'ouvrier.

Chapitre IV - De l'Homme

JN E nous arrêtons pas davantage aux animaux inférieurs à l'homme: il est temps d'étudier le fond de l'homme même, pour découvrir en lui celui dont on dit qu'il est l'image. Je ne connois dans toute la nature que deux sortes d'êtres; ceux qui ont de la connoissance, et ceux qui n'en ont pas. L'homme rassemble en lui ces deux manières d'être: il a un corps comme les êtres corporels les plus inanimés; il a un esprit, c'est-à-dire,,,une pensée par laquelle il se connoît et aperçoit ce, qui est autour de lui. S'il est, vrai qu'il y ait un premier être qui ait tiré tous les autres du néant, l'homme est véritablement son image; car il rassemble comme lui dans sa nature tout ce qu'il y a de perfection réelle dans ces deux diverses manières d'être: mais l'image n'est qu'une image, elle ne peut être qu'une ombre du véritable être parfait.

Commençons l'étude de l'homme par la considération de son corps. Je ne sais, disoit une mère à ses enfants dans l'Écriture sainte (i), comment vous vous êtes formés dans mon sein. En effet, ce n'est point la sagesse des parents qui forme un ouvrage si composé et si singulier; ils n'ont aucune part à cette industrie. Laissons-les donc, et remontons plus haut.

Article Premier - Du corps humain.

Le corps est pétri de boue, mais admirons la main qui l'a façonné. Le sceau de l'ouvrier est empreint sur son ouvrage; il semble avoir pris plaisir à faire un chef-d'œuvre avec une matière si vile. Jetons les yeux sur ce corps, où les os soutiennent les chairs qui les enveloppent; les nerfs qui y sont tendus en font toute la force; et lés muscles où les nerfs s'entrelacent, eh s'enflant ou en s'alongeant, font les mouvements les plus justes et les plus réguliers. Les os sont brisés de distance en distance; ils ont des jointures où ils s'emboîtent les uns dans les autres, et ils sont liés par des nerfs et par des tendons. Cicéron admire avec raison le bel artifice qui lie ces os. Qu'y a-t-il de plus simple pour tous les divers mouvements? Mais qu'y a-t-il de plus ferme et de plus durable?

Après même qu'un corps est mort, et que ses parties sont séparées par la corruption, on voit encore ces jointures et ces liaisons qui ne peuvent qu'à peine se détruire. Ainsi cette machine est droite ou repliée, roide ou souple, comme l'on veut. Du cerveau, qui est la source de tous les nerfs, partent les esprits. Us sont si subtils qu'on ne peut les voir, et néanmoins si réels et d'une action si forte, qu'ils font tous les mouvements de la machine et toute sa force. Ces esprits sont en un instant envoyés jusqu'aux extrémités des membres: tantôt ils coulent doucement et avec uniformité; tantôt ils ont, selon tes besoins, une impétuosité irrégulière; et ils varient à l'infini les postures, les gestes et les actions du corps.

Regardons cette chair: elle est couverte en certains endroits d'une peau tendre et délicate pour l'ornement du corps. Si cette peau, qui rend l'objet si agréable et d'un si doux coloris, étoit enlevée, le même objet seroit lùdeux, et feroit horreur. En d'autres endroits cette même peau est plus dure et plus épaisse pour résister aux fatigues de ces parties. Par exemple, combien la peau de la plante des pieds est-elle plus grossière que celle du visage! Combien celle du derrière de la tête l'est-elle plus que celle du devant! Cette peau est percée partout comme un crible; mais ces trous, qu'on nomme pores, sont insensibles. Quoique la sueur et la transpiration s'exhalent par ces pores, le sang ne s'échappe jamais par-là. Cette peau a toute la délicatesse qu'il faut pour être transparente et pour donner au visage un coloris vif, doux et gracieux. Si la peau étoit moins serrée et moins unie, le visage paroîtroit sanglant et comme écorché. Qui est-ce qui a su tempérer et mélanger ces couleurs pour faire une si belle carnation, que les peintres admirent, et n'imitent jamais qu'imparfaitement?

On trouve dans le corps humain des rameaux innombrables: les uns portent le sang du centre aux extrémités, et se nomment artères; les autres le rapportent des extrémités au centre, et se nomment veines. Par ces divers rameaux coule le sang, liqueur douce, onctueuse, et propre par

cette onction à retenir les esprits les plus déliés, comme on conserve dans des corps gommeux les essences les plus subtiles et les plus spiritueuses. Ce sang arrose la chair, comme les fontaines et les rivières arrosent la terre. Après s'être filtré dans les chairs, il revient à la source plus lente et moins pleine d'esprit; mais il se renouvelle et se subtilise encore de nouveau dans cette source pour circuler sans fin.

Voyez-vous cet arrangement et cette proportion dès membres? Les jambes et lés cuisses sont de grands os emboîtés les uns sur les autres, et liés par des nerfs: ce sont deux espèces de colonnes égales et régulières qui s'élèvent pour soutenir tous l'édifice; mais ces colonnes se plient, et la??? a genou est un os d'une figure à peu près ronde, qui est mis tout exprès dans la jointure pour la remplir-, et pour la défendre quand les os se replient pour le fléchissement du genou. Chaque colonne a son piédestal qui est composé de pièces rapportées, et si bien jointes ensemble, qu'elles peuvent se plier ou se tenir roides selon le besoin. Le piédestal tourne quand on le veut sous la colonne. Dans ce pied on ne voit que nerfs, que tendons, que petits os étroitement liés, afin que cette partie soit tout en semble plus souple et plus ferme selon les divers besoins: les doigts même des pieds, avec leurs articles et leurs ongles, servent à tâter le terrain sur lequel on marche, à s'appuyer avec plus adresse et d'agilité, à garder mieux l'équilibre du corps, à se hausser ou à se pencher. Les deux pieds s'étendent en avant pour empêcher que le corps ne tombe de ce côté-là quand il se penche ou qu'il se plie. Les deux colonnes se réunissent par le haut pour porter le reste du corps; et elles sont encore brisées dans cette extrémité, afin que cette jointure donne à l'homme la commodité de se reposer en s'asseyant sur les deux plus gros muscles de tout le corps.

Le corps de l'édifice est proportionné à la hauteur des colonnes: il contient toutes les parties qui sont nécessaires à la vie, et qui par conséquent doivent être placées au centre, et renfermées dans le lieu le plus sûr. C'est pourquoi deux rangs de côtes assez serrées, qui sortent de l'épine du dos, comme les branches d'un arbre naissent du tronc, forment une espèce de cercle pour cacher et tenir à l'abri ces parties si nobles et si délicates: mais comme les côtes ne pourroient fermer entièrement ce! centre' du corps humain sans empêcher, la dilatation de l'estomac et des entrailles, elles n'achèvent de former le cercle que jusqu'à un certain endroit, au-dessous duquel elles laissent un vide, afin que le dedans puisse s'élargir avec facilité pour la respiration et pour la nourriture.

Pour l'épine du dos, on ne voit rien dans tous les ouvrages des hommes qui soit travaillé avec un tel art: elle seroit trop roide et trop fragile, si elle n'éioit faite que d'un seul os; en ce cas les hommes ne pourroient jamais se plier. L'auteur de cette machine a remédié à cet inconvénient en formant des vertèbres qui, s'emboîtant les unes dans les autres, font un tout de pièces rapportées, qui a plus de force qu'un tout d'une seule pièce. Ce composé est tantôt souple, et tantôt roide: il se redresse et se replie en un moment comme on le veut. Toutes ces vertèbres ont dans le milieu une ouverture qui sert pour faire passer un allongement de la substance du cerveau jusqu'aux extrémités du corps, et pour y envoyer promptement des esprits par ce canal.

Mais qui n'admirera la nature des os? Ils sont très durs, et on voit que la corruption même de tout le reste du corps ne les altère en rien. Cependant ils sont pleins de trous innombrables qui les rendent plus légers; et ils sont même dans le milieu pleins de la moelle qui doit les nourrir. Ils sont percés précisément dans les endroits où doivent passer les ligaments qui les attachent les uns aux autres. De plus, leurs extrémités sont plus grosses que le milieu, et font comme deux tètes à demi rondes pour faire tourner plus facilement un os avec un autre, afin que le tout puisse se replier sans peine.

Dans l'enceinte des côtes sont placés avec ordre tons les grands organes, tels que ceux qui servent à faire respirer l'homme, ceux qui digèrent les aliments, et ceux qui font un sang nouveau. La respiration est nécessaire pour tempérer la chaleur interne causée par le bouillonnement du sang et par le cours impétueux des esprits. L'air est comme un aliment dont l'animal se nourrit, et par le

moyen duquel il se renouvelle dans tous les moments de sa vie. La digestion n'est pas moins nécessaire pour préparer les aliments sensibles à être changés en sang. Le sang est une liqueur propre à s'insinuer partout, et à s'épaissir en chair dans les extrémités, pour réparer dans tous les membres ce qu'ils perdent sans cesse par la transpiration et par la dissipation des esprits. Les poumons sont comme de grandes enveloppes, qui, étant spongieuses, se dilatent et se compriment facilement; et comme ils prennent et rendent sans cesse beaucoup d'air, ils forment une espèce de soufflet en mouvement continuel.

L'estomac a un dissolvant qui cause la faim, et qui avertit l'homme du besoin de manger. Ce dissolvant qui picote l'estomac lui prépare par ce mésaise un plaisir très vif, lorsqu'il est apaisé par les aliments. Alors l'homme se remplit délicieusement d'une matière étrangère qui lui feroit horreur, s'il la pouvoit voir dès qu'elle est introduite dans son estomac, et qui lui déplaît même quand il la voit étant déjà rassasié.. L'estomac est fait comme une poche. Là les aliments, changés par une prompte coction, se confondent tous en une liqueur douce, qui devient ensuite une espèce dé lait nommé chyle; et qui, parvenant enfin au cœur, y reçoit par l'abondance des esprits, la vivacité et la couleur de sang. Mais pendant que le suc le plus pur des aliments passe de l'estomac dans les canaux destinés à faire le chyle et le sang, lés parties grossières de ces mêmes aliments sont séparées, comme le son l'est de la fleur de farine par le tamis, et elles sont rejetées en bas, pour en délivrer le corps par les issues les plus cachées et les plus reculées des organes des sens, de peur qu'ils n'en soient incommodés. Ainsi les merveilles de cette machine sont si grandes, qu'on en trouve d'inépuisables, même dans les fonctions les plus humiliantes, que l'on n'oseroit expliquer en détail.

Il est vrai que les parties internes de l'homme ne sont pas agréables à voir comme les extérieures: mais remarquez qu'elles ne sont pas faites pour être vues. I l falloit même, selon le but de l'art, qu'elles ne pussent être découvertes sans horreur; et qu'ainsi un homme ne pût les découvrir, et entamer cette machine dans un autre homme, qu'avec une violente répugnance. C'est cette horreur qui prépare la compassion et l'humanité dans les cœurs, quand un homme en voit un autre qui est blessé. Ajoutez avec saint Augustin qu'il y a dans ces parties internes une proportion, un ordre et une industrie qui charment encore plus l'esprit attentif, que la beauté extérieure ne sauroit plaire aux yeux du corps. Ce dedans de l'homme, qui est tout ensemble si hideux et si admirable, est précisément comme il le doit être pour montrer une boue travaillée de main divine. On y voit tout ensemble et la fragilité de la créature et l'art du créateur.

Du haut de cet ouvrage si précieux que nous avons dépeint, pendent les deux bras, qui sont terminés par les mains, et qui ont une parfaite symétrie entre eux. Les bras tiennent aux épaules, de sorte qu'ils ont un mouvement libre dans cette jointure. Ils sont encore brisés au coude et au poignet, pour pouvoir se plier et se retourner avec promptitude. Les bras sont de la juste longueur qu'il faut pour atteindre à toutes les parties du corps. Ils sont nerveux et pleins de muscles, afin qu'ils puissent, avec les reins, être souvent en action, et soutenir les plus grandes fatigues de tout le corps. Les mains sont un tissu de nerfs et d'osselets enchâssés les uns dans les autres, qui ont toute la force et toute la souplesse convenable pour tâter les corps voisins, pour les saisir, pour s'y accrocher, pour les lancer, pour les attirer, pour les repousser, pour les démêler et pour les détacher les uns des autres. Les doigts, dont les bouts sont armés d'ongles, sont faits pour exercer, par la délicatesse et la variété de leurs mouvements, les arts les plus merveilleux. Les bras et les mains servent encore, suivant qu'on les étend ou qu'on les replie, à mettre le corps en état de se pencher, sans s'exposer à aucune chute. La machine a en elle-même, indépendamment de toutes les pensées qui viennent après coup, une espèce de ressort qui lui fait trouver soudainement l'équilibre dans tous ses contrastes.

Au-dessus du corps s'élève le cou, ferme ou flexible, selon qu'on le vent. Est-il question de porter un pesant fardeau sur la tête; le cou devient roide comme s'il n'étoit que d'un seul os. Faut-il

pencher ou tourner la tête; le cou se plie en tous sens, comme si on en démontoit tous les os. Ce cou, médiocrement élevé au-dessus des épaules, porte sans peine la tête qui règne sur tout le corps. Si elle étoit moins grosse, elle n'auroit aucune proportion avec le reste de la machine. Si elle étoit plus grosse, outre qu'elle seroit disproportionnée et difforme, sa pesanteur accablerait le cou, et elle courroit risque de faire tomber l'homme du côté où elle pencheroit un peu trop.

Cette tête, fortifiée de tous côtés par des os très épais et très durs pour mieux conserver le précieux trésor qu'elle renferme, s'emboîte dans les vertèbres du cou3 et a une communication très prompte avec toutes les autres parties du corps: elle contient le cerveau, dont la substance humide, molle et spongieuse, est composée de fils tendres et entrelacés. C'est là le centre des merveilles dont nous parlerons dans la suite. Le crâne se trouve percé régulièrement avec une proportion et une symétrie exacte, pour les deux yeux, pour les deux oreilles, pour la bouche et pour le nez. Il y a des nerfs destinés aux sensations qui s'exercent dans la plupart de ces conduits. Le nez, qui n'a point de nerfs pour sa sensation, a un os cribleux pour faire passer les odeurs jusqu'au cerveau.

Parmi les organes de ces sensations, les principaux sont doubles, pour conserver dans un côté ce qui pourroit manquer dans l'autre par quelque accident. Ces deux organes d'une même sensation sont mis en symétrie, sur le devant ou sur les côtés, afin que l'homme en puisse faire un plus facile usage, ou à droite ou à gauche, ou vis-à-vis de lui, c'est-à-dire vers l'endroit où ses jointures dirigent sa marche et toutes ses actions. D'ailleurs la flexibilité du cou fait que tous ces organes Se tournent en un instant de quelque côté qu'il veut.

Tout le derrière de la tête, qui est le moins en état de se défendre, est le plus épais: il est' orné de cheveux, qui servent en même temps à fortifier la tête contre les injures de l'air. Mais les cheveux viennent sur le devant pour accompagner le visage et lui donner plus de grâce

Le visage est le côté de la tête qu'on pomme le devant, et où les principales sensations sont rassemblées avec un ordre et une proportion qui le rendent très beau, à moins que quelque accident n'altère un ouvrage si régulier. Les deux yeux sont égaux, placés vers le milieu et aux deux côtes de la tète, afin qu'ils puissent découvrir sans peine de loin, à droite 4t à gauche, tous les objets étrangers, et qu'ils puissent veiller commodément pour la sûreté de toutes les parties du corps. L'exacte symétrie avec laquelle ils sont placés fait l'ornement du visage. Celui qui les a faits y a allumé je ne sais quelle flamme céleste, à laquelle rien ne ressemble dans tout le reste de la nature. Ces yeux sont des espèces de miroirs, où se peignent tour à tour et sans confusion, dans le fond de la rétine, tous les objets du monde entier, afin que ce qui pense dans l'homme puisse les voir dans ces miroirs. Mais quoique nous apercevions tous les objets par un double organe, nous ne voyons pourtant jamais les objets comme doubles, parce que les deux nerfs qui servent à la vue dans nos yeux ne sont que deux branches qui se réunissent dans une même tige, comme les deux branches des lunettes se réunissent dans la partie supérieure qui les joint. Les deux yeux sont ornés de deux sourcils égaux; et afin qu'ils puissent s'ouvrir et se fermer, ils sont enveloppes de paupières bordées d'un poil qui défend une partie si délicate.

Le front donne de la majesté et de la grâce à tout le visage; il sert à en relever les traits. Sans le nez posé, dans le milieu, tout le visage seroit plat et difforme. On peut juger de cette difformité quand on a vu des hommes en qui cette partie du visage est mutilée. Il est placé immédiatement au-dessus de la bouche, pour discerner plus commodément par les odeurs tout ce qui est propre à nourrir l'homme. Les deux narines servent tout ensemble à la respiration et à l'odorat. Voyez les lèvres: leur couleur vive, leur fraîcheur, leur figure, leur arrangement et leur proportion avec les autres traits, embellissent tout le visage. La bouche, par la correspondance de ses mouvements avec ceux des yeux, l'anime, l'égaie, l'attriste, l'adoucit, le trouble, et exprime chaque passion par des marques sensibles. Outre que les lèvres s'ouvrent pour recevoir l'aliment, elles servent encore

par leur souplesse et par la variété de leurs mouvements à varier les sons qui font la parole. Quand elles s'ouvrent, elles découvrent un double rang de dents dont la bouche est ornée: ces dents sont de petits os enchâssés avec ordre dans les deux mâchoires qui ont un ressort pour s'ouvrir, et un pour se fermer, en sorte que les dents brisent comme un moulin les aliments pour en préparer la digestion. Mais ces aliments ainsi brisés passent dans l'estomac par un conduit différent de celui de la respiration; et ces deux canaux, quoique si voisins, n'ont rien de commun.

La langue est un tissu de petits muscles et de nerfs si souples, qu'elle se replie, comme un serpent, avec une mobilité et une souplesse inconcevable: elle fait dans la bouche ce que font les doigts, ou ce que fait l'archet d'un maître sur un instrument de musique; elle va frapper tantôt les dents et tantôt le palais. Il y a un conduit qui va au-dedans du cou, depuis le palais jusqu'à la poitrine: ce sont des anneaux de cartilages enchâssés très juste les uns dans les autres, et garnis au-dedans d'une tunique ou membrane très polie, pour faire mieux résonner l'air poussé par les poumons. Ce conduit a du côté du palais un bout qui n'est ouvert que comme une flûte, par une fente qui s'élargit ou qui se resserre à propos, pour grossir la voix ou pour la rendre plus claire. Mais de peur que les aliments, qui ont leur canal séparé, ne se glissent dans celui delà respiration, il y a une espèce de soupape, qui fait sur l'orifice du conduit de la voix comme un pont-avis pour faire passer les aliments sans qu'il en tombe aucune parcelle subtile ni aucune goutte par la fente dont je viens de parler. Cette espèce de soupape est très mobile, et se replie très subtilement: de manière qu'en tremblant sur cet orifice entr'ouvert, elle fait toutes les plus douces modulations de la voix. Ce petit exemple suffit pour montrer en passant, et sans entrer d'ailleurs dans aucun détail de l'anatomie, combien est merveilleux l'art des parties internes. Cet organe, tel que je viens de le représenter, est le plus parfait de tous les instruments de musique; et tous les autres ne sont parfaits qu'autant qu'ils l'imitent.

Qui pourroit expliquer la délicatesse des organes par lesquels l'homme discerne les saveurs et les odeurs innombrables des corps? Mais comment se peut-il faire que tant de voix frappent ensemble mon oreille sans se confondre, et que ces sons me laissent, après qu'ils ne sont plus, des ressemblances si vives et si distinctes de ce qu'ils ont été? Avec quel soin l'ouvrier qui a fait nos corps a-t-il donné à nos yeux une enveloppe humide et coulante pour les fermer, et pourquoi a-t il laissé nos oreilles ouvertes? C'est(i), dit Cicéron, que les yeux ont besoin de se fermer à la lumière pour le sommeil, et que les oreilles doivent demeurer ouvertes pendant que les yeux se ferment, pour nous avertir, et pour nous éveiller par le bruit, quand nous courons risque d'être surpris.

Qui est-ce, qui grave dans mon œil, en un instant, le ciel, la mer, la terre, situés dans une distance presque infinie? Comment peuvent se ranger et se démêler dans un si petit organe les images fidèles de tous les objets de l'univers, depuis le soleil jusqu'à des atomes? La substance du cerveau, qui conserve avec ordre des représentations si naïves de tant d'objets dont nous avons été frappas depuis que nous sommes au monde, n'est-elle pas le prodige le plus étonnant?

On admire avec raison l'invention des livres, où l'on conserve l'histoire de tant de faits, et le recueil de tant de pensées; mais quelle comparaison peut-on faire entre le plus beau livre et le cerveau d'un homme savant? Sans doute ce cerveau est un recueil infiniment plus précieux et d'une plus telle invention que ce livre. C'est dans ce petit réservoir qu'on trouve h point nommée toutes les images dont on a besoin. On les appelle; elles viennent: on les renvoie; elles se renfoncent je ne sais où, et disparoissent pour laisser la place à d'autres. On ferme et on ouvre son imagination comme un livre: on en tourne, pour ainsi dire, ses feuillets; on passe soudainement d'un bout à l'autre: on a même des espèces de tables dans la mémoire, pour indiquer les lieux où se trouvent certaines images reculées. Ces caractères innombrables, que l'esprit de l'homme lit intérieurement avec tant de rapidité, ne laissent aucune trace distincte dans un cerveau qu'on ouvre. Cet admirable livre n'est qu'une substance molle, ou une espèce de peloton composé de fils tendres et entrelacés. Quelle main a su cacher dans cette espèce de boue, qui paroît si informe, des images si

précieuses et rangées avec un si bel art? Tel est le corps de l'homme en gros. Je n'entre point dans le détail de l'anatomie: car mon dessein n'est que de découvrir l'art qui est dans la nature, par le simple coup-d'œil, sans aucune science. Le corps de l'homme pourroit sans doute être beaucoup plus grand et beaucoup plus petit. S'il n'avoit, par exemple, qu'un pied de hauteur, il seroit insulté par la plupart des animaux, qui l'écraseroient sous leurs pieds. S'il étoit haut comme les plus grands clochers, un petit nombre d'hommes consumeroit en peu de jours tous les aliments d'un pays; ils ne pourraient trouver ni chevaux, ni autres bêtes de charge qui pussent les porter ni les tramer dans aucune machine roulante: ils ne pourraient trouver assez de matériaux pour bâtir des maisons proportionnées à leur grandeur; il ne pourroit y avoir qu'un petit nombre d'hommes sur la terre, et ils manqueroient de la plupart des commodités.

Qui est-ce qui a réglé la taille de l'homme à une mesure précise? Qui est-ce qui a réglé celle de tous les autres animaux avec proportion à celle de l'homme? L'homme est le seul de tous les animaux qui est droit sur ses pieds. Par-là il a une noblesse et une majesté qui le distinguent, même au dehors, de tout ce qui vît sur la terre: non seulement sa figure est la pins noble, mais encore il est le plus fort et le plus adroit de tous les animaux à proportion de sa grandeur.

Qu'on examine de près la pesanteur et la masse de la plupart des bêtes les plus terribles; on trouvera qu'elles ont plus de matière que le corps d'un homme; et cependant un homme vigoureux a plus de force de corps que la plupart des bêtes farouches: elles ne sont redoutables pour lui que par leurs dents et par leurs griffes. Mais l'homme, qui n'a point dans ses membres de si fortes armes naturelles, a des mains dont la dextérité surpasse, "pour se faire des armes, tout ce que la nature a donné aux bêtes. Ainsi l'homme perce de ses traits, ou fait tomber dans ses pièges, et' enchaîne les animaux les plus forts et les plus furieux: il sait même les apprivoiser dans leur captivité, et s'en jouer comme il lui plaît; il se fait flatter par les lions et par les tigres; il monte sur les éléphants.

Article II - De l'Ame

Mais le corps de l'homme, qui paroît le chef-d'œuvre de la nature, n'est point comparable à sa pensée. I l est certain qu'il y a des corps qui ne pensent pas: on n'attribue aucune connoissance à la pierre, au bois, aux métaux, qui sont néanmoins certainement des corps. I l est même si naturel de croire que la matière ne peut penser, que tous les hommes sans prévention ne peuvent s'empêcher de rire quand on leur soutient que les bêtes ne sont que de pures machines, parce q'ils ne sauraient concevoir que de pures machines puissent avoir les connoissances qu'ils prétendent apercevoir dans les ' bêtes: ils trouvent que c'est faire des jeux d'enfants qui parlent avec leurs poupées, que de vouloir donner quelque connoissance à de pures machines.

De là vient que les anciens, qui ne connoissoient rien de réel qui ne fut un corps, vouloient néanmoins que âme de t'homme fût d'un cinquième élément, ou d'une espèce de quintessence sans nom, inconnue ici-bas, indivisible et immuable -, toute céleste et toute divine, parce qu'ils ne pouvoient concevoir que la matière terrestre des quatre éléments pût penser et se connoître elle-même (i).

Mais supposons tout ce qu'on voudra, et ne contestons contre aucune secte de philosophes. Voici une alternative que nul philosophe ne peut éviter. Ou la matière peut devenir pensante sans y rien ajouter; ou bien la matière ne sauroit penser, et ce qui pense en nous est un être distingué d'elle, et qui lui est uni.

Si la matière peut devenir pensante sans y rien ajouter, il faut au moins avouer que toute matière n'est point pensante, et que la matière même qui pense aujourd'hui ne pensoit point il y a cinquante ans: par exemple, la matière du corps d'un jeune homme ne pensoit point dix ans avant sa naissance: il faudra donc dire que la matière peut acquérir la pensée par un certain arrangement

et par un certain mouvement de ses parties. Prenons, par exemple, la matière d'une pierre ou d'un amas de sable: cette portion de matière ne pense nullement. Pour la faire commencer à penser, il faut figurer, arranger, mouvoir en un certain sens, et à certain degré, toutes ses parties. Qui est-ce qui a su trouver avec tant de justesse cette proportion, cet arrangement, ce mouvement en tel sens, et point en un autre; ce mouvement à un tel degré, au-dessus et au-dessous duquel la matière ne penserait jamais? Qui est-ce qui a donné toutes ces modifications si justes et si précises à une matière vile et informe, pour en former le corps d'un enfant, et pour le rendre peu à peu raisonnable?

Si, au contraire, on dit que la matière ne peut être pensante sans y rien ajouter, et qu'il faut un autre être qui s'unisse à elle, je demande quel sera cet autre être qui pense, pendant que la matière à laquelle il est uni ne fait que se mouvoir. Voilà deux natures bien dissemblables. Nous ne connoissons l'une que par des figures et des mouvements locaux; nous ne connoissons l'autre que par des perceptions et par des raisonnements. L'une ne donne point l'idée de l'autre, et leurs idées n'ont rien de commun.

Premier - De l'union de âme et du corps

D'où vient que des êtres si dissemblables sont si intimement unis ensemble dans l'homme? D'où vient que les mouvements du corps donnent si promptement et si infailliblement certaines pensées à âme? D'où vient que les pensées de lame donnent si promptement et si infailliblement certains mouvements au corps? D'où vient cette société si régulière de soixante - dix ou quatre-vingts ans sans aucune interruption? d'où vient que cet assemblage de deux êtres et de deux opérations si différentes fait un composé si juste, que tant de gens sont tentés de croire que c'est un tout simple et indivisible?

Quelle main a pu lier ces deux extrémités? Elles ne se sont point liées d'elles - mêmes. La matière n'a pu faire un pacte avec l'esprit; car elle n'a par elle-même ni pensée ni volonté peur faire des conditions^ D'un autre côté, l'esprit ne se souvient point d'avoir fait un pacte avec la matière; et il ne pourrait être assujetti à ce pacte s'il l'avoit oublié. S'il avoit résolu librement et par lui-même de s'assujettir à la matière, il ne s'y assujettirait que quand il s'en souviendrait et quand il lui plairoit. Cependant il est certain qu'il dépend malgré lui du corps, et qu'il ne peut s'en délivrer à moins qu'il ne détruise lés organes du corps par une mort violente. D'ailleurs, quand même l'esprit se seroit assujetti volontairement à la matière, il ne s'ensuivrait pas que la matière fût mutuellement assujettie à l'esprit. L'esprit aurait, à la vérité, certaines pensées quand le corps auroit certains mouvements; mais le corps ne seroit point déterminé à avoir à son tour certains mouvements dès que l'esprit aurait certaines pensées.

Or il est certain que cette dépendance est réciproque. Rien n'est plus absolu que l'empire de l'esprit sur le corps. L'esprit veut, et tous les membres du corps se remuent à l'instant, comme 'ils étoient entraînés par les]«lu,s puissantes machines. D'un autre côté, rien n'est plus .manifeste que le pouvoir du corps sur l'esprit. Le corps se meut, et à l'instant l'esprit est forcé de penser avec plaisir ou avec douleur à certains objets. Quelle main également puissante sur ces deux natures si diverses a pu leur imposer ce joug, et les tenir captives dans une société si exacte et si inviolable? Dira-t-on que c'est le hasard? Si on le dit, entendra-t-on ce qu'on dira, et le pourra-t-on faire entendre aux autres? Le hasard a-t-il accroché par un concours atomes les parties du corps avec l'esprit? Si l'esprit peut s'accrocher à des parties du corps, il faut qu'il ait des parties lui-même, et par conséquent qu'il soit un vrai corps; auquel cas nous retombons dans la première réponse que j'ai déjà réfutée. Si au contraire l'esprit n'a point de parties, rien ne peut l'accrocher avec celles du corps, et le hasard n'a pas de quoi les attacher ensemble.

Enfin mon alternative revient toujours, et elle est décisive. Si l'esprit et le corps ne sont qu'un tout composés de matière, d'où vient que cette matière, qui ne pensoit pas hier, a commencé à penser aujourd'hui? Qui est-ce qui lui a donné ce qu'elle n'avoit pas, et qui est incomparablement plus noble qu'elle quand elle est sans pensée? Ce qui lui donne la pensée ne l'a-t-il point lui-même? Et comment la donnera-t-il sans l'avoir? Supposé même que la pensée résulte d'une certaine configuration, d'un certain arrangement et d'un certain degré de mouvement en un certain sens, de toutes les parties de la matière, quel ouvrier a su trouver toutes ces combinaisons si justes et si précises pour faire une machine pensante? Si au contraire l'esprit et le corps sont deux natures différentes, quelle puissance supérieure a pu les attacher ensemble sans que l'esprit y ait aucune part, ni qu'il sache comment cette union s'est faite? Qui est-ce qui commande ainsi, avec cet empire suprême, aux esprits et aux corps, pour les tenir dans une correspondance et dans une espèce de police si incompréhensibles?'

Remarquez que l'empire de mon esprit sur mon corps est souverain dans son étendue bornée, puisque ma .simple volonté, sans effort et sans préparation, fait mouvoir tout à coup immédiatement tous les membres de mon corps selon les règles de la mécanique. Comme l'Écriture nous représente Dieu, qui dit après la création de l'univers: « Que la lumière soit, et elle fut »; de même la seule parole intérieure de mon âme, sans effort et sans préparation, fait ce qu'elle dit. Je dis en moi-même, par cette parole si intérieure, si simple et si momentanée: que mon corps se meuve, et il se meut. A cette simple et intime volonté toutes les parties de mon corps travaillent: déjà tous les nerfs sont tendus, tous les ressorts se hâtent de concourir ensemble, et toute la machine obéit comme si chacun de ces organes les plus secrets entendoit une voix souveraine et toute-puissante. Voilà sans doute la puissance la plus simple et la plus efficace qu'on puisse concevoir. Il n'y en a aucun exemple dans tous les êtres que nous connaissons. C'est précisément celle que les hommes, persuadés de la divinité, lui attribuent dans tout l'univers.

L'attribuerai-je à mon foible esprit,,ou plutôt à la puissance,qu'il a sur mou corps, qui est si différente de loi? Croirai-je que ma volonté a cet empire suprême par son propre fonds, elle qui est si foible (et si imparfaite? Mais d'où vient que, parmi tant 4e corps, elle ^'a ce pouvoir que sur un seul? Nul autre corps ne se,remue selon ses désirs. Qui lui a donné sur un seul corps ce qu'elle n'a sur aucun autre? oserai on encore revenir à nous alléguer le hasard?

Cette puissance, qui est si souveraine, est en même temps aveugle. Le paysan le plus ignorant sait aussi bien mouvoir son corps que le philosophe le mieux instruit de l'anatomie. L'esprit du paysan commande à se; nerfs, à ses muscles, à ses tendons qu'il ne connoît pas, et dont il n'a jamais ouï parler: sans pouvoir lei distinguer, et sans savoir où ils sont, il les trouve, il s'adresse précisément à ceux dont il a besoin, et il ne prend point les uns pour les autres.

Un danseur de corde ne fait que vouloir, et à l'instant les esprits coulent avec impétuosité, tantôt dans certains nerfs, et tantôt en d'autres; tous ses nerfs se tendent ou se relâchent à propos. Demandez-lui quels sont ceux qu'il a mis en mouvement, et par où il a commencé à les ébranler; il ne comprend pas même ce que vous voulez lui dire; il ignore profondément ce qu'il a fait dans tous les ressorts intérieurs de sa machine.

Le joueur de luth, qui connoît parfaitement toutes les cordes de son instrument, qui les voit de ses yeux, les touche l'une après l'autre de ses doigts, s'y méprend: mais âme, qui gouverne la machine du corps humain, en meut tous les ressorts, à propos sans lès voir, sans les discerner, sans en savoir ni la figure, ni là situation, ni la force; et elle ne s'y mécompte point. Qu’el prodige! mon esprit commande à ce qu'A ne connoît pas, et qu'il né peut voir, à ce qui ne connaît point, et qui est incapable de cônnoissance; et il est infailliblement obéi. Que d'aveuglement! que de paissance I

L'aveuglelissement est de l'homme; mais la puissance, de qui est-ce? à qui attribuerons-nous, si ce n'est à celui, qui Volt ce que l'homme ne voit pas, et qui fait en lui de "qui le Surpasse? Mon âme a beau vouloir remuer les corps qui l'environnent et qu'elle connoît très distinctement, aîicun rie se fémue, elle n'a aucun pouvoir pour ébranler le moindre atome par sa volonté: il n'y a qu'un seul corps, que quelque puissance supérieure doit loi avoir rendu propre. A l'égard de ce corps, elle n'a qu'à vouloir, et tous les ressorts de cette machine, qui lui sont inconnus, se meuvent à propos et de concert pour lui obéir.

Saint Augustin qui a fait ces réflexions les a parfaitement exprimées: « Les parties internes de nos corps, « dit-il, ne peuvent être vivantes que par nos âmes; « mais nos âmes les animent bien plus facilement qu'elles ne peuvent les connoître âme ne connoît point

« le corps qui lui est soumis Elle ne sait point pourquoi elle ne met les nerfs en mouvement que quand « il lui plaît, et pourquoi au contraire la pulsation des « veines est sans interruption, quand elle ne le vont droit pas. Elle ignore quelle est la première partie « du corps qu'elle remue immédiatement pour mouvoir

« par celle-là toutes les autres Elle ne sait point

« pourquoi elle sent malgré elle, et ne meut les membres que quand il lui plaît. C'est elle qui fait ces « choses dans le corps. D'où vient qu'elle ne sait ni ce qu'elle fait, ni comment elle le fait? Ceux qui s'instruisent de l'anatomie, dit encore ce père, apprennent d'autrui ce qui se passe en eux, et qui est fait par eux-mêmes. Pourquoi, dit-il, n'ai-je aucun besoin « de leçon pour savoir qu'il y a dans le ciel, à une prodistance de moi, un soleil et des étoiles? et pourquoi ai-je besoin d'un maître pour apprendre par où commence le mouvement? Quand je remue « le doigt, je ne sais comment se fait ce que je fais « moi-même au dedans de moi. Nous sommes trop élevés à l'égard de nous-mêmes, et nous ne saurions « nous comprendre.

En effet, nous ne saurions trop admirer cet empire absolu de âme sur des organes corporels qu'elle ne connoît pas, et l'usage continuel qu'elle en fait sans les discerner. Cet empire se montre principalement par rapport aux images tracées dans notre cerveau. Je connois tous les corps de l'univers qui ont frappé mes sens depuis un grand nombre d'années; j'en ai des images distinctes qui me les représentent, en sorte que je crois les voir lors même qu'ils ne sont plus. Mon cerveau est comme un cabinet de peintures, dont tous les tableaux se remueroient et se rangeraient au gré du maître de la maison. Les peintres, par leur art, n'atteignent jamais qu'à une ressemblance imparfaite; pour les portraits que j'ai dans la tête, ils sont si fidèles, que c'est en les consultant que j'aperçois tous les défauts de ceux des peintres, et que je les corrige en moi-même.

Ces images, plus ressemblantes que les chefs-d'œuvre de l'art des peintres, se gravent-elles dans ma tête sans aucun art? est-ce un livre dont tous les caractères se soient rangés d'eux-mêmes? S'il y a de l'art, il ne vient pas de moi; car je trouve au dedans de moi ce recueil d'images, sans avoir jamais pensé ni à les graver, ni à les mettre on ordre. Mais encore toutes ces images se présentent et se retirent comme il me plaît, sans faire aucune confusion: je les rappelle, elles viennent; je les renvoie, elles se renfoncent je ne sais où: elles s'assemblent ou se séparent comme je le veux. Je ne sais où elles demeurent, ni ce qu'elles sont: cependant je les trouve toujours prêtes.

L'agitation de tant d'images anciennes et nouvelles qui se réveillent, qui se joignent, qui se séparent, ne trouble point un certain ordre qu'elles ont. Si quelques unes ne se présentent pas au premier ordre, du moins je suis assuré qu'elles ne sont pas loin: il faut qu'elles soient cachées dans certains recoins enfoncés. Je ne les. ignore point comme les choses que je n'ai jam.iis connues; au contraire, je sais confusément-ce que je cherche. Si quelque autre image se présente en la place de celle que j'ai appelée, je la renvoie sans hésiter, en lui disant: ce n'est pas vous dont j'ai besoin.

Mais où sont donc les objets à demi oubliés? Us sont présents au dedans de moi, puisque je les cherche, et que je les y trouve. Enfin, comment y sont-ils, puisque je les cherche longtemps en vain? Où vont-ils?

Et Je ne suis plus, dit saint Augustin, ce que j'étois, « lorsque je pensois à ce que je n'ai pu retrouver. Je « ne sais, continue ce père, comment il arrive que je « sois ainsi soustrait à moi-même et privé de moi, ni « comment est-ce que je suis ensuite comme rapporté et « rendu à moi-même. Je suis comme un autre homme, « et transporté ailleurs, quand je cherche, et que je « ne trouve pas ce que j'avois confié à ma mémoire. « Alors nous ne pouvons arriver jusqu'à nous; nous a sommes comme si nous étions des étrangers éloignés « de nous: nous n'y arrivons que quand nous trouvons « ce que nous cherchons. Mais où est ce que nous « cherchons, si ce n'est au dedans de nous? et qu'est-ce« que nous cherchons, si ce n'est nous-mêmes?

Une telle profondeur nous étonne. Je me souviens distinctement d'avoir connu ce que je ne connois plus; je me souviens de mon oubli même; je me rappelle les portraits de chaque personne en chaque âge de la vie où je l'ai vue autrefois. La même personne repasse plusieurs fois dans ma tête: d'abord je la vois enfant, puis jeune, et enfin âgée. Je place des rides sur le même visage, où je vois d'un autre côté les grâces tendres de l'enfance; je joins ce qui n'est plus avec ce qui est encore, sans confondre ces extrémités. Je conserve un je ne sais quoi qui est tour à tour toutes les choses que j'ai connues depuis que je suis au monde: de ce trésor inconnu sortent tous les parfums, toutes les harmonies, tous les goûts, tous les degrés de lumière, toutes les couleurs et toutes leurs nuances; enfin toutes les figures qui ont passé par mes sens, et qu'ils ont confiées à mon cerveau.

Je renouvelle quand il me plaît la joie que j'ai ressentie il y a trente ans: elle revient; mais quelquefois c'en est plus elle-même; elle paroît sans me réjouir: je me souviens d'avoir été bien aise, et je ne le suis point actuellement dans ce souvenir. D'un autre côté, je renouvelle d'anciennes douleurs: elles sont présentes; car je les aperçois distinctement telles qu'elles ont été en leur temps: rien ne m'échappe de leur amertume, et de la vivacité de leurs sentiments; mais elles ne sont plus elles-mêmes, elles ne me troublent plus, elles sont émoussées. Je vois toute leur rigueur sans la ressentir; ou si je la ressens, ce n'est que par représentation, et cette représentation d'une peine autrefois cuisante n'est plus qu'un jeu; l'image des douleurs passées me réjouit. I l en est de -même des plaisirs. Un cœur vertueux s'afflige en rappelant le souvenir de ses plaisirs déréglés: ils sont présents, car ils se montrent avec tout ce qu'ils ont eu de plus doux et de plus flatteur: mais ils ne sont plus eux-mêmes; et de telles joies ne reviennent que pour affliger.

Voilà donc deux merveilles également incompréhensibles: l'une, que mon cerveau soit une espèce de livre, où il y ait un nombre presque infini d'images et de caractères rangés avec un ordre que je n'ai point fait, et que le hasard n'a pu faire; car je n'ai jamais eu la moindre pensée ni d'écrire rien dans mon cerveau, ni d'y donner aucun ordre aux images et aux caractères que j'y traçois: je ne songeois qu'à voir les objets lorsqu'ils frappoient mes sens. Le. hasard n'a pu non plus faire un si merveilleux livre; tout l'art môme des hommes est trop imparfait pour atteindre jamais à une si haute perfection. Quelle main a donc pu le composer?

La seconde merveille que je trouve dans mon cerveau, est de voir que mon esprit lise avec tant de facilité tout ce qu'il lui plaît dans ce livre intérieur: il lit des caractères qu'il ne connoît point. Jamais je n'ai vu les traces empreintes dans mon cerveau; et la substance de mon cerveau elle-même y qui est comme le papier du livre, m'est entièrement inconnue: tous ces caractères innombrables se transposent, et puis reprennent leur rang pour m'obéir. J'ai une puissance comme divine sur un ouvrage que je ne connois point, et qui est incapable de connoissance: ce qui n'entend rien, entend ma pensée, et l'exécute dans le moment. La pensée de L'homme n'a aucun empire sur les corps; je le vois en parcourant toute la nature. Il n'y a qu'un seul corps que ma simple volonté

remue, comme si elle étoit une divinité; et elle en remue tous les ressorts les plus subtils sans les connoître. Qui est-ce qui l'a unie à ce corps, et lui a donné tant d'empire sur lui?

De Lesprit De L'homme De L'idée De F Infini Et Des Idées En Général

Finissons ces remarques par une courte réflexion sur le fond de notre esprit: j'y trouve un mélange incompréhensible de grandeur et de foiblesse. Sa grandeur est réelle; il rassemble sans confusion le p;ssé avec le présent, et il perce par ses raisonnements jusque dans l'avenir; il a l'idée des corps et celle des esprits; il a l'idée de l'infini même, car il en affirme tout ce qui lui convient, et il en nie tout ce qui ne lui convient pas. Dites-lui que l'infini est triangulaire; il vous répondra sans hésiter que ce qui n'a aucune borne ne peut avoir aucune figure. Demandez-lui qu'il vous assigne la première des unités qui composent un nombre infini; il vous répondra d'abord qu'il ne peut y avoir ni commencement, ni fin, ni nombre dans l'infini, parce que si on pouvoit y remarquer une première ou une dernière unité, on pourvoit ajouter quelque autre unité à celle-là, et par conséquent augmenter le nombre: or un nombre ne peut être infini lorsqu'il peut recevoir quelque addition, et qu'on peut lui assigner une borne, du côté où il peut recevoir un accroissement.

C'est même dans l'infini que mon esprit connoît le fini. Qui dit un homme malade, dit un homme qui n'a pas la santé; qui dit un homme foible, dit un homme qui n'a pas de force. On ne conçoit la maladie, qui n'est qu'une privation de la santé, qu'en se représentant la santé même comme un bien réel dont cet homme est prive; on ne conçoit la foiblesse qu'en se représentant la force comme un avantage réel que cet homme n'a pas; on ne conçoit les ténèbres, qui ne sont rien de positif, qu'eu niant, et par conséquent en concevant la lumière du jour qui est très réelle et très positive: tout de même on ne conçoit le fini qu'en lui attribuant une borne', qui est une pure négation d'une plus grande étendue

Ce n'est donc que la privation de l'infini. Or on ne pourroit jamais se représenter la privation de l'infini, si on ne concevoit l'infini même; comme on ne pourroit concevoir la maladie, si on ne concevoit la santé dont elle n'est que la privation. D'où vient cette idée de l'infini en nous?

0 que l'esprit de l'homme est grand! il porte en lui de quoi s'étonner et se surpasser infiniment lui-même: ses idées sont universelles, éternelles et immuables. Elles sont universelles; car lorsque je dis: il est impossible d'être et de n'être pas; le tout est plus grand que sa partie; une ligne parfaitement circulaire n'a aucunes parties droites; entre deux points donnés, la ligne droite est la plus courte; le centre d'un cercle parfait est également éloigné de tous les points de la circonférence; un triangle équilatéral n'a aucun angle obtus ni droit: toutes ces vérités ne peuvent souffrir aucune exception; il ne pourra jamais y avoir d'être, de ligne, de cercle, d'angle, qui ne soit suivant ces règles. Ces règles sont de tous les temps, ou, pour mieux dire, elles sont avant tous les temps, et seront toujours au-delà de toute durée compréhensible.

Que l'univers se bouleverse et s'anéantisse, qu'il n'y ait plus même aucun esprit pour raisonner sur les êtres, sur les lignes, sur les cercles et sur les triangles, il sera toujours également vrai en soi que la même chose ne peut tout ensemble être et n'être pas; qu'un cercle parfait ne peut avoir aucune portion de ligne droite; que le centre d'un cercle parfait ne peut être plus près d'un côté de la circonférence que de l'autre. On peut bien ne penser pas actuellement à ces vérités; et il pourroit même se faire qu'il n'y auroit ni univers, ni esprits capables de penser à ces vérités: mais enfin ces vérités n'en seroient pas moins constantes en elles-mêmes, quoique nul esprit ne les connût; comme les rayons du soleil n'en seroient pas moins véritables, quand même tous les hommes seroient aveugles, et que personne n'auroit des yeux pour en être éclairé.

En assurant que deux et deux font quatre, dit saint Augustin (1), non seulement on est assuré de dire vrai; mais on ne peut douter que cette proposition n'ait été toujours également vraie, et

qu'elle ne doive l'être éternellement. Ces idées, que nous portons au fond de nous-mêmes, n'ont point de bornes et n'en pouvant souffrir. On ne peut point dire que ce que j'ai avancé sur le centre des cercles parfaits ne soit vrai que pour un certain nombre de cercles: cette proposition est vraie par une nécessité évidente pour tous les cercles à l'infini.

Ces idées sans bornes ne peuvent jamais ni changer, ni s'effacer en nous, ni être altérées: elles sont le fond de notre raison. Il est impossible, quelque effort qu'on fasse sur son propre esprit, de parvenir à douter jamais sérieusement de ce que ces idées nous représentent avec clarté. Par exemple, je ne puis entrer dans un doute sérieux, pour savoir si le tout est plus grand qu'une de ses parties; si le centre d'un cercle parfait est également éloigné de tous les points de la circonférence. L'idée de l'infini est en moi comme celle des nombres, des lignes, des cercles, d'un tout et d'une partie. Changer nos idées, ce seroit anéantir la raison même. Jugeons de notre grandeur par l'infini immuable qui est empreint au dedans de nous, et qui ne peut jamais y être effacé. Mais de peur qu'une grandeur si réelle ne nous éblouisse et ne nous flatte dangereusement, hâtons-nous de jeter les yeux sur notre foiblesse..

Ce même esprit qui voit sans cesse l'infini,. et dans la règle de l'infini toutes les choses finies, ignore aussi à l'infini tous les objets qui l'environnent: il s'ignore profondément lui-même; il marche comme à tâtons dans un abîme de ténèbres: il ne sait ce qu'il est, ni comment il est attaché à un corps, ni comment il a tant d'empire sur tous les ressorts de ce corps qu'il ne connoît point. Il ignore ses propres pensées et ses propres volontés: il ne sait avec certitude ni ce qu'il croit ni ce qu'il veut. Souvent il s'imagine croire et vouloir ce qu'il n'a ni cru ni voulu.,11 se trompe; et ce qu'il a de meilleur, c'est de le reconnoître. Il joint à l'erreur des pensées le dérèglement de la volonté: il est réduit à gémir dans l'expérience de sa corruption.

Voilà l'esprit de l'homme, faible, incertain, borné, plein d'erreurs. Qui est-ce qui a mis l'idée de l'infini, c'est-à-dire du parfait, dans un sujet si borné et si rempli d'imperfection? Se l'est-il donnée lui-même, cette idée si haute et si pure, cette idée qui est elle-même une espèce d'infini en représentation? Quel être fini, distingué de lui, a pu lui donner ce qui est si disproportionné avec ce qui est renfermé dans quelque borne? Supposons que l'esprit de l'homme est comme un miroir où lés images de tous les corps voisins viennent s'imprimer: quel être a pu mettre en nous l'image de l'infini, si l'infini ne fut jamais? Qui peut mettre dans «n miroir l'image d'un objet chimérique, qui n'est point, '« qui n'a jamais été vis-à-vis de la glace d'une miroir? Cette image de l'infini n'est point un amas confus d'objets finis, que l'esprit prenne mal à propos pour l'infini véritable: c'est le vrai infini dont nous avons la pensée. Nous le connoissons si bien, que nous le distinguons précisément de tout ce qu'il n'est pas, et que nulle subtilité ne peut nous mettre aucun objet en sa place. Nous le connoissons si bien, que nous rejetons de lui toute propriété qui marque la moindre borne. Enfin nous le connoissons si bien, que c'est en lui seul que nous connoissons tout le reste, comme on connoît la nuit par le jour, et là maladie par la santé.

Encore une fois d'où vient une image si grande? La prend-on dans le néant? L'être borné peut-il imaginer et inventer l'infini,- si l'infini n'est point? Notre esprit si foible et si court ne peut se former par lui-même cette image, qui n'auroit aucun patron. Aucun des objets extérieurs ne peut nous donner cette image: car ils ne peuvent nous donner l'image que de ce qu'ils sont; et ils ne sont rien que de borné et d'imparfait. Où la prenons-nous donc cette image distincte qui ne ressemble à rien dé tout ce que nous sommes, et de tout ce que nous connoissons ici-bas hors de nous? D'où nous vient-elle? Où est donc cet infini que nous ne pouvons comprendre, parce qu'il est réellement inr fini, et que nous ne pouvons néanmoins méconnoître, parce que nous le distinguons de tout ce qui lui est inférieur? Où est-il? S'il n'étoit pas, pourroit-il se venir graver au fond de notre esprit?'

Mais outre l'idée de l'infini, j'ai encore des notions ' universelles et immuables qui sont fa règle de tous mes jugements: je. ne puis juger d'aucune chose qu'en les consultant ■> et il ne dépend pas de

moi de juger contre ce qu'elles me représentent. Mes pensées, loin de pouvoir corriger ou former cette règle, sont elles-mêmes corrigées malgré moi par cette règle supérieure; et elles sont invinciblement assujetties à sa décision.

Quelque effort d'esprit que je fasse, je ne puis jamais parvenir, comme je viens de le remarquer, à douter que deux et deux ne fassent quatre; que le tout ne soit plus grand que sa partie; que le centre d'un cercle parfait ne soit également distant de tous les points de la circonférence. Je ne suis point libre de nier ces propositions; et si je nie ces vérités, ou d'autres à peu près semblables, j'ai en moi quelque chose qui est au-dessus de moi, et qui me ramène par force au but. Cette règle fixe et immuable est si intérieure et si intime, que je suis tenté de la prendre pour moi-même: mais elle est au-dessus de moi, puisqu'elle me corrige, me redresse, me met en défiance contre moi-même, et m'avertit de mon impuissance. C'est quelque chose qui m'inspire à toute heure, pourvu que je l'écoute; et je ne me trompe jamais qu'en ne l'écoutant pas.

Ce qui m'inspire, me préserveroit sans cesse de toute erreur, si j'étois docile et sans précipitation: car cette inspiration intérieure m'apprendroit à bien juger des choses qui sont à ma portée, et sur lesquelles j'ai besoin de former quelque jugement. Pour les autres, elle m'apprendroit à n'en juger pas: et cette seconde sorte de leçon n'est pas moins importante que la première. Cette règle intérieure est ce que je nomme ma raison: mais je parle de ma raison sans pénétrer la force de ces termes, comme je parle de la nature et de l'instinct, 6ans entendre ce que signifient ces expressions.

De La Raison De L'Homme

A la vérité ma raison est en moi: car il faut que je rentre sans cesse en moi-même pour la trouver: mais la raison supérieure qui me corrige dans le besoin, et que je consulte, n'est point à moi, et elle ne fait point partie de moi-même. Cette règle est parfaite et immuable: je suis changeant et imparfait. Quand je me trompe, elle ne perd pas sa droiture: quand je me détrompe, ce n'est pas elle qui revient au but; c'est elle qui, sans s'en être jamais écartée, a l'autorité sur moi de m'y rappeler et de m'y faire revenir: c'est un maître intérieur, qui me fait taire, qui me fait parler, qui me fait croire, qui me fait douter, qui me fait avouer mes erreurs ou confirmer mes jugements: en l'écoutant, je m'instruis; en m'écoutant moi-même, je m'égare. C» maître est partout; et sa voix se fait entendre d'un bout de l'univers à l'autre à tous les hommes comme à moi. Pendant qu'il me corrige en France, il corrige d'autres hommes à la Chine, au Japon, dans le Mexique et dans le Pérou, par les mêmes principes.

Deux hommes qui ne se sont jamais vus, qui n'ont jamais entendu parler l'un de l'autre, et qui n'ont jamais eu de liaison, avec aucun autre homme qui ait pu leur donner des notions communes, parlent aux deux extrémités de la terre sur un certain nombre de vérités, comme s'ils étoient de concert. On sait infailliblement par avance dans un hémisphère ce qu'on répondra dans l'autre sur ces vérités. Les hommes de tous les pays et de tous les temps, quelque éducation qu'ils aient reçue, se sentent invinciblement assujettis à penser et à parler de même. Le maître qui nous enseigne sans cesse, nous fait penser tous de la même façon. Dès que nous nous hâtons de juger, sans écouter sa voix avec défiance de nous-mêmes, nous pensons et nous disons des songes pleins d'extravagances.

Ainsi ce qui paroît le plus à nous, et être le fond de nous-mêmes, je veux dire notre raison, est ce qui nous est le moins propre, et qu'on doit croire le plus emprunté. Nous recevons sans cesse et à tout moment une raison supérieure à nous, comme nous respirons sans cesse l'air, qui est un corps étranger, ou comme nous voyons sans cesse tous les objets voisins de nous à la lumière du soleil, dont les rayons sont des corps étrangers à nos yeux.

Cette raison supérieure domine jusqu'à un certain point, avec un empire absolu, tous les hommes les moins raisonnables, et fait qu'ils sont toujours tous d'accord, malgré eux, sur ces points. C'est elle qui fait qu'un sauvage du Canada pense beaucoup de choses comme les philosophes grecs et latins les ont pensées. C'est elle qui fait que les géomètres chinois ont trouvé à peu près les mêmes vérités que les européens, pendant que ces peuples si éloignés étoient inconnus les uns aux autres. C'est elle qui fait qu'on juge au Japon comme en France, que deux et deux font quatre; et il ne faut pas craindre qu'aucun peuple change jamais d'opinion là-dessus. C'est elle qui fait que les hommes pensent encore aujourd'hui sur divers points comme on pensoit il y a quatre mille ans.

C'est elle qui donne des pensées uniformes aux hommes les plus jaloux et les plus irréconciliables entre eux: c'est elle par qui les hommes de tous les siècles et de tous les pays sont comme enchaînés autour d'un certain centre immobile, et qui les tient unis par certaines règles invariables, qu'on nomme les premiers principes, malgré les variations infinies d'opinions qui naissent en eux de leurs passions, de leurs distractions et de leurs caprices, pour tous leurs autres jugements moins clairs. C'est elle qui fait que les hommes, tout dépravés qu'ils sont, n'ont point encore osé donner le nom de vertu au vice, et qu'ils sont réduits à faire semblant d'être justes, sincères, modérés, bienfaisants, pour s'attirer l'estime les uns des autres.

On ne parvient point à estimer ce qu'on voudrait pouvoir estimer, ni à mépriser ce qu'on voudroit pouvoir mépriser. On ne peut forcer cette barrière éternelle de la vérité et de la justice. Le maître intérieur qu'on nomme raison le reproche intérieurement avec un empire absolu. Il ne le souffre pas; et il sait borner la folie la plus impudente des hommes. Après tant de. siècles de règne effréné du vice, la vertu est encore nommée vertu; et elle ne peut être dépossédée de son nom par ses ennemis les plus brutaux et les plus téméraires.

De là vient que le vice, quoique triomphant dans le monde, est encore réduit à se déguiser sous le masque de l'hypocrisie, ou de la fausse probité, pour s'attirer une estime qu'il n'ose espérer en se montrant à découvert. Ainsi, malgré toute son impudence, il rend un hommage forcé à la vertu, en voulant se parer de ce qu'elle a de plus beau pour recevoir les honneurs qu'elle se fait rendre. On critique, il est vrai, les hommes vertueux, et ils sont effectivement toujours répréhensibles en cette vie par leurs imperfections: mais les hommes les plus vicieux ne peuvent venir à bout d'effacer en eux l'idée de la vraie vertu. Il n'y a point encore eu d'homme sur la terre qui ait pu gagner, ni sur les autres, ni"sur lui-même, d'établir dans le monde qu'il est plus estimable d'être trompeur que d'être sincère; d'être emporté et malfaisant, que d'être modéré et de faire du bien.

Le maître intérieur et universel dit donc toujours et partout les mêmes vérités. Nous ne sommes point ce maître: il est vrai que nous parlons souvent sans lui y et plus haut que lui; mais alors nous nous trompons, nous bégayons, nous ne nous entendons pas nous-mêmes: nous craignons même de voir que nous nous sommes trompés, et nous fermons l'oreille de peur d'être humiliés par ses corrections. Sans doute l'homme qui craint d'être corrigé par cette raison incorruptible, et qui s'égare toujours en ne la suivant pas, n'est pas cette raison parfaite, universelle, immuable, qui le corrige malgré lui.

En toutes choses nous trouvons comme deux principes au dedans de nous; l'un donne, l'autre reçoit; l'un manque, l'autre supplée; l'un se trompe, l'autre corrige; l'un va de travers par sa pente, l'autre le redresse: c'est cette expérience mal prise et mal entendue qui avoit fait tomber dans l'erreur les Marcionites et les Manichéens. Chacun sent en soi une raison bornée et subalterne qui s'égare dès qu'elle échappe à une entière subordination, et qui ne se corrige qu'en rentrant sous le joug d'une autre raison supérieure, universelle et immuable. Ainsi tout porte en nous la marque d'une raison subalterne, bornée, participée, empruntée, et qui a besoin qu'une autre la redresse à chaque moment. Tous les hommes sont raisonnables de la même raison qui se communique à eux selon

divers degrés: il y a un certain nombre de sages; mais la sagesse où ils puisent, comme dans la source, et qui les fait ce qu'ils sont, est unique.

Où est-elle cette sagesse? Où est-elle cette raison commune et supérieure tout ensemble à toutes les raisons bornées et imparfaites du genre humain? Où est-il donc cet oracle qui ne se tait jamais, et contre lequel ne peuvent jamais rien tous les vains préjugés des peuples? Où est-elle cette raison qu'on a sans cesse besoin de consulter, et qui nous prévient pour nous inspirer le désir d'entendre sa voix? Où est-elle cette vive lumière qui illumine tout homme venant en ce" monde? Où est-elle cette pure et douce lumière qui non seulement éclaire les yeux ouverts, mais qui ouvre les yeux fermés, qui guérit les yeux malades, qui donne des yeux à ceux qui n'en ont pas pour la voir, enfin qui inspire le désir d'être éclairé par elle, et qui se fait aimer par ceux mêmes qui craignoient de la voir?

Tout œil la voit; et il ne verroit rien s'il ne la voyoit pas, puisque c'est par elle et à la faveur de ses purs rayons qu'il voit toutes choses. Comme le sole sensible éclaire tous les corps, de même ce soleil d'intelligence éclaire tous les esprits. La substance de l'œil de l'homme n'est point la lumière; au contraire l'œil emprunte à chaque moment la lumière des rayons du soleil. Tout de même mon esprit n'est point la raison primitive, la vérité universelle et immuable; il est seulement l'organe par où passe cette lumière originale, et qui en est éclairé.

H y a un soleil des esprits, qui les éclaire tous beaucoup mieux que le soleil visible n'éclaire les corps: ce soleil des esprits nous donne tout ensemble et sa lumière et l'amour de sa lumière pour la chercher. Ce soleil de vérité ne laisse aucune ombre, et il luit en même temps dans les deux hémisphères . il brille autant sur nous la Huit que le jour: ce n'est point au dehors qu il répand ses rayons; il habite en chacun de nous. Un homme ne peut jamais dérober ses rayons à un autre bomme: on le voit également en quelque coin de l'univers qu'on soit caché: un homme n'a jamais besoin de dire à un autre: retirez-vous pour me laisser voir ce soleil; vous me dérobez ses rayons; vous enlevez la portion qui m'est due.

Ce soleil ne se couche jamais, et ne souffre aucun nuage que ceux qui sont formés par. nos passions: c'est un jour sans ombre: il éclaire les sauvages mêmes dans les antres les plus profonds et les plus obscurs: il n'y a que les yeux malades qui se ferment à sa lumière; et encore n'y a-t-il point d'homme si malade et si aveugle, qui ne marche encore à la lueur de quelque lumière sombre qui lui reste de ce soleil intérieur des consciences. Cette lumière universelle découvre et représente à nos esprits tous les objets-, et" nous ne pouvons rien juger que par elle, comme nous ne pouvons discerner aucun corps qu'aux rayons du soleil/ *

Les hommes peuvent nous parler pour nous instruire; mais nous ne pouvons les croire qu'autant que nous trouvons une certaine conformité entre ce qu'ils nous disent et ce que nous dit le maître intérieur. Après qu'ils ont épuisé tons leurs raisonnements, il faut toujours revenir à lui, et l'écouter pour la décision. Si un homme nous disoit qu'une partie égale le tout dont elle: est partie, nous ne pourrions nous empêcher de rire, et il se rendroit méprisable, au lieu de nous persuader: c'est au fond de nous-mêmes, par la consultation du maître intérieur, que nous avons besoin de trouver les vérités qu'on nous enseigne, c'est-à-dire qu'on nous propose extérieurement.

Ainsi, à proprement parler, il n'y a qu'un seul véritable maître qui enseigne tout, et sans lequel on n'apprend rien. Les autres maîtres nous ramènent toujours dans cette école intime où il parle seul. C'est là que nous recevons ce que nous n'avions pas; c'est là que nous apprenons ce que nous avions ignoré; c'est là que nous retrouvons ce que nous avions perdu par l'oubli; c'est dans le fond intime de nous-mêmes qu'il nous garde certaines connoissances comme ensevelies, qui se réveillent au besoin; c'est là que nous rejetons le mensonge que nous avions cru.

Loin de juger ce maître, c'est par lui seul que nous sommes jugés souverainement en toutes choses. C'est un juge désintéressé et supérieur à nous. Nous pouvons refuser de l'écouter, et nous étourdir;.mais en l'écoutant nous ne pouvons le contredire. Rien ne ressemble moins à l'homme que ce maître invisible qui l'instruit et qui le juge avec tant de rigueur et de perfection. Ainsi notre raison, bornée, incertaine, fautive, n'est qu'une inspiration foible et momentanée d'une raison primitive, suprême et immuable, qui se communique avec mesure à tous les êtres intelligents.

On ne peut point dire que l'homme se donne lui-même les pensées qu'il n'avoit pas: on peut encore moins dire qu'il les reçoive des autres hommes, puisqu'il est certain qu'il n'admet, et ne peut rien admettre du dehors, sans le trouver aussi dans son propre fonds, en consultant au dedans de soi les principes de la raison, pour voir si ce qu'on lui dit y répugne. II y a donc une école intérieure où l'homme reçoit ce qu'il ne peut ni se donner, ni attendre des autres hommes qui vivent d'emprunt comme lui.

Voilà donc deux raisons que je trouve en moi; l'une est moi-même; l'autre est au-dessus de moi. Celle qui est moi, est très imparfaite, prévenue, précipitée, sujette à s'égarer, changeante, opiniâtre, ignorante et bornée; enfin, elle ne possède jamais rien que d'emprunt. L'autre est commune à tous les hommes, supérieure à eux; elle est parfaite, éternelle, immuable, toujours prête à se communiquer en tous lieux, et à redresser tous les esprits qui se trompent; enfin incapable d'être jamais ni épuisée ni partagée, quoiqu'elle se donne à tous ceux qui la veulent. Où est-elle cette raison parfaite, qui est si près de moi, et si différente de moi? Où est-elle? Il faut qu'elle soit quelque chose de réel; car le néant ne peut être parfait, ni perfectionner les natures imparfaites. Où est-elle cette raison suprême? N'est-elle pas le Dieu que je cherche?

De L'idée De L'unité

Je trouve encore d'autres traces de la divinité en moi; en voici une bien touchante.

Je connois des nombres prodigieux avec les rapports qui sont entre eux. Par où me vient cette connoissance ' Elle est si distincte que je n'en puis douter sérieusement, et que je redresse d'abord, sans hésiter, tout homme qui manque à la suivre en supputant.

Si un homme me dit que 17 et 3 font 22; je me hâte' de lui dire, 17 et 3 ne font que 20: aussitôt il est vaincu par sa propre lumière, et il acquiesce à ma correction. Le même maître qui parle en moi pour le corriger, parle aussitôt en lui pour lui dire qu'il doit se rendre. Ce ne sont point deux maîtres qui soient convenus de nous accorder; c'est quelque chose d'indivisible, d'éternel, d'immuable, qui parle en même temps avec une persuasion invincible dans tous les deux. Encore une fois, d'où me vient cette notion si juste des nombres? Les nombres ne sont tous que des unités répétées. Tout nombre n'est qu'une composition ou une répétition d'unités. Le nombre de deux n'est que deux unités; le nombre de 4 se réduit à 1 répété quatre fois. On ne peut donc concevoir aucun nombre, sans concevoir l'unité qui est le fondement essentiel de tout nombre possible. On ne peut donc concevoir aucune répétition d'unité, sans concevoir l'unité même qui en est le fond.

Mais par où est-ce que je puis connoître quelque unité réelle? Je n'en ai jamais vu, ni même imaginé par le rapport de mes sens. Que je prenne le plus subtil atome; il faut qu'il ait une figure, une longueur, une largeur et une profondeur; un dessus, un dessous, un côté gauche, un autre droit; et le dessus n'est point le dessous; un côté n'est point l'autre. Cet atome n'est donc pas véritablement un; il est composé de parties. Or le composé est un nombre réel, et une multitude d'êtres: ce n'est point une unité réelle; c'est un assemblage d'êtres dont l'un n'est pas l'autre.

Je n'ai donc jamais appris ni par mes yeux, ni par mes oreilles, ni par mes mains, ni même par mon imagination, qu'il y ait dans la nature aucune réelle unité; au contraire, mes sens et mon

imagination ne me présentent jamais rien que de composé, rien qui ne soit un nombre réel, rien qui ne soit une multitude. Toute unité m'échappe sans cesse; elle me fuit comme par une espèce d'enchantement. Puisque je la cherche dans tant de divisions d'un atome, j'en ai certainement l'idée distincte; et ce n'est que par sa simple et claire idée que je parviens, en répétant, à connoître tant d'autres nombres. Mais puisqu'elle m'échappe dans toutes les divisions des corps de la nature, il s'ensuit clairement que je ne l'ai jamais connue par le canal de mes sens et de mon imagination. Voilà donc une idée qui est en moi indépendamment des sens, de l'imagination, et des impressions des corps.

De plus, quand même je ne voudrais pas reconnoître de bonne foi que j'ai une idée claire de l'unité, qui est le fond de tous les nombres, parce qu'ils ne sont que des répétitions ou des collections d'unités; il faudrait au moins avouer que je connois beaucoup de nombres avec leurs propriétés et leurs rapports. Je sais, par exemple, combien font 6oooooooo joints avec 800000000 d'une autre somme. Je ne m'y trompe point; et je redresserois d'abord avec certitude un autre homme qui s'y tromperait. Cependant ni mes sens ni mon imagination n'ont jamais pu me présenter distinctement tous ces millions rassemblés. L'image qu'ils m'en présenteraient ne ressemblerait pas même davantage à dix-sept cent millions qu'à un nombre très inférieur. .

D'où me vient donc une idée si distincte des nombres, que je n'ai jamais pu ni sentir ni imaginer? Ce& idées indépendantes des corps ne peuvent ni être corporelles, ni être reçues dans un sujet corporel: elles me découvrent la nature de mon âme, qui reçoit ce qui est incorporel, et qui le reçoit au dedans de soi d'une manière incorporelle. D'où me vient une idée si incorporelle des corps mêmes? Je ne puis la porter par ma propre nature au dedans de moi, puisque ce qui connoît en moi les corps est incorporel,. et qu'il les connoît sans que cette connoissance lui vienne par le canal des organes corporels, tels que les sens et l'imagination. Il faut que ce qui pense en moi soit pour ainsi dire un néant de nature corporelle. Comment ai-je pu connoître des êtres qui n'ont aucuns rapports de nature avec mon être pensant? Il faut sans doute qu'un être supérieur à ces deux natures si diverses, et qui les renferme toutes deux dans son infini, les ait jointes dans mon âme, et . m'ait étonné l'idée d'une nature toute différente de celle qui pense en moi.

Pour les unités, quelqu'un dira peut-être que je ne les connois point par les corps, mais seulement par les esprits; et qu'ainsi mon esprit étant un, et m'étant véritablement connu, c'est par-là, et non par les corps, que 'j'ai l'idée de l'unité. Mais voici ma réponse.

Il s'ensuivra du moins de là que je connois des substances qui n'ont rien d'étendu ni de divisible, et qui sont présentes. Voilà déjà des natures purement incorporelles, au nombre desquelles je dois mettre mon âme. Qui est-ce qui l'a unie à mon corps? Cette âme n'est point un être infini, elle n'a pas toujours été, elle pense dans certaines bornes. Qui est-ce qui l'a faite? qui est-ce qui lui fait connoître les corps si différents d'elle? qui est-ce qui lui donne tant d'empire sur un certain corps, et qui donne réciproquement à ce corps tant d'empire sur elle? De plus, comment sais-je si cette âme qui j»ense est réellement une, ou bien si elle a des parties? Je ne vois point cette âme. Dira-t-on que c'est dans une chose si invisible et si impénétrable que je vois clairement ce que c'est qu'unité? Loin d'apprendre par mon âme ce que c'est que d'être un, c'est au contraire par l'idée claire que j'ai déjà de l'unité que j'examine si mon âme est une ou divisible.

Ajoutez que j'ai au dedans de moi une idée claire d'une unité parfaite qui est bien au-dessus de celle que je puis trouver dans mon âme: elle se trouve souvent comme partagée entre deux opinions, entre deux inclinations, entre deux habitudes contraires. Ce partage que je trouve au fond de moi-même ne marque-t-il point quelque multiplicité ou composition de parties? L'ame d'ailleurs a tout au moins une composition successive de pensées dont l'une est très différente de l'autre. Je conçois une unité infiniment plus une, s'il m'est permis de parler ainsi; je conçois un être qui ne change jamais de pensée, qui pense toujours toutes choses tout à la fois, et en qui on ne

peut trouver aucune composition même successive. Sans doute c'est cette idée de la parfaite et suprême unité qui me fait tant chercher quelque unité dans les esprits, et même dans les corps.

Cette idée, toujours présente au fond de moi-même, est née avec moi; elle est le modèle parfait sur lequel je cherche partout quelque copie imparfaite de l'unité. Cette idée de ce qui est un, simple et indivisible par excellence, ne peut être que l'idée de Dieu. Je connois donc Dieu avec une telle clarté, que c'est en le connoissant que je cherche dans toutes les créatures et en moi-même quelque image et quelque ressemblance de son unité. Les corps ont, pour ainsi dire, quelque vestige de cette unité, qui échappe toujours dans la division de ses parties; et les esprits en ont une plus grande ressemblance, quoiqu'ils aient une composition successive de pensées.

De La Dépendance De L'homme

Mais voici un autre mystère que je porte au dedans de moi, et qui me rend incompréhensible à moi-même; c'est que d'un côté je suis libre, et que de l'autre je suis dépendant. Examinons ces deux choses, pour voir s'il est possible de les accorder.

Je suis un être dépendant: l'indépendance est la suprême perfection. Etre par soi-même, c'est porter en soi-même la source de son propre être, c'est ne rien emprunter d'aucun être différent de soi,. Supposez un être qui rassemble toutes les perfections que vous pourrez concevoir, mais qui sera un être emprunté et dépendant, il sera moins parfait qu'un autre être en qui vous ne mettrez que la simple indépendance: car il n'y a aucune comparaison à faire entre un être qui est par soi, et un être qui n'a rien que d'emprunté, et qui n'est en lui que comme par prêt.

Ceci me sert à reconnoître l'imperfection de ce que j'appelle mon âme. Si elle étoit par elle-même, elle n'emprunteroit rien d'autrui, elle n'auroit besoin ni de s'insctruire dans ses ignorances, ni de se redresser dans ses erreurs; rien ne pourroit ni la corriger de ses vices, ni lui inspirer aucune vertu, ni rendre sa volonté meilleure qu'elle ne se trouveroit d'abord r cette âme posséderait toujours tout ce qu'elle seroit capable d'avoir, et ne pourroit jamais rien recevoir du dehors. En même temps il seroit certain qu'elle ne pourroit rien perdre; car ce qui est par soi est toujours nécessairement tout ce qu'il est. Ainsi mon âme ne pourroit tomber ni dans l'ignorance, ni dans l'erreur, ni dans le vice, ni dans aucune diminution de bonne volonté: elle ne pourroit aussi ni s'instruire, ni se corriger, ni devenir meilleure qu'elle n'est. Or j'éprouve tout le contraire. J'oublie, je me trompe, je m'égare, je perds la vue de la vérité et l'amour du bien; je me corromps, je me diminue. D'un autre côté, je m'augmente en acquérant la sagesse et la bonne volonté que je u'avois jamais eue. Cette expérience intime me convainc que mon âme n'est point un être par soi et indépendant, c'est-à-dire nécessaire et immuable en tout ce qu'il possède. Par où me peut venir cette augmentation de moi-même? qui est-ce qui peut perfectionner mon être en me rendant meilleur, et par conséquent en me faisant être plus que je t'étois?

La volonté ou capacité de vouloir est sans doute un degré d'être et de bien ou de perfection; mais la bonne volonté ou le bon vouloir est un autre degré de bien supérieur: car on peut abuser de la bonne volonté pour vouloir mal, pour tromper, pour nuire, pour faire l'injustice; au lieu que le bon vouloir est le bon usage de la volonté même, lequel ne peut être que bon. Le bon vouloir est donc ce qu'il y a de plus précieux dans l'homme; c'est ce qui donne le prix à tout le reste; c'est là, pour ainsi dire, tout l'homme (1).

Nous venons de voir que ma volonté n'est point par elle-même, puisqu'elle est sujette à perdre et à recevoir des degrés de bien ou de perfection: nous. avons vu qu'elle est un bien inférieur au bon vouloir, parce qu'il est meilleur de bien vouloir que d'avoir simplement une volonté susceptible du bien et du mal. Comment pourrois-je croire que moi, être foible, imparfait, emprunté et dépendant, je me donne à moi-même le plus haut degré de perfection, pendant qu'il est visible que

l'inférieur me vient d'un premier être? Puis-je m'imaginer que Dieu me donne le moindre bien, et que je me donne sans lui le plus grand? Où prendrois-je ce haut degré de perfection pour me le donner? seroit-ce dans le néant, qui est mon propre fond? Dirai-je que d'autres esprits à peu près égaux au mien me le donnent? Mais puisque ces êtres bornés et dépendants comme le mien ne peuvent se rien donner à eux-mêmes, ils peuvent 'encore moins donner à autrui. N'étant point par eux-mêmes, ils n'ont par eux-mêmes aucun vrai pouvoir ni sur moi, ni sur les choses qui sont imparfaites en moi ni sur eux-mêmes. Il faut donc, sans s'arrêter à eux, remonter plus haut, et trouver une cause première qui soit féconde et toute-puissante pour donner à mon âme le bon vouloir qu'elle n'a pas.

Ajoutons encore une réflexion. Ce premier être est la cause de toutes les modifications de ses créatures. L'opération suit l'être, comme disent les philosophes. L'être qui est dépendant dans le fond de son être, ne peut être pie dépendant dans toutes ses opérations. L'accessoire suit le principal. L'auteur du fond de l'être l'est donc aussi de toutes les modifications ou manières d'être des créatures. C'est ainsi que Dieu est la cause réelle et immédiate de toutes les configurations, combinaisons et mouvements de tous les corps de l'univers: c'est à l'occasion d'un corps qu'il a mû qu'il en meut un autre; c'est lui qui a tout créé, et c'est lui qui fait tout dans son ouvrage.

Or le vouloir est la modification des volontés, comme le mouvement est la modification des corps. Dirons-nous qu'il est la cause réelle, immédiate et totale du mouvement de tous les cor] s, et qu'il n'est pas autant la cause réelle et immédiate du bon vouloir des volontés? Cette modification, la plus excellente de toutes, sera-t-elle la seule que Dieu ne fera point dans son ouvrage, et que l'ouvrage se donnera lui-même avec indépendance? Qui le peut penser? Mon bon vouloir que je n'avois pas hier, et que j'ai aujourd'hui, n'est donc pas une chose que je me donne: il me vient de celui qui m'a donné la volonté et l'être.

Comme vouloir est plus parfait qu'être simplement, bien vouloir est plus parfait que vouloir. .Le passage de la puissance à l'acte vertueux est ce qu'il y a de plus parfait dans l'homme. La puissance n'est qu'un équilibre entre la vertu et le vice, qu'une suspension entre le bien et le mal Le passage à l'acte est la décision pour le bien, et par conséquent le bien supérieur. La puissance susceptible du bien et du mal vient de Dieu. Nous avons fait voir qu'on n'en pouvoit douter. Dirons-nous que le coup décisif qui détermine au plus grand bien ne vient pas de lui, ou en vient meins? Tout ceci prouve évidemment ce que dit l'apôtre; savoir, que Dieu donne le vouloir et le faire selon son bon plaisir. Voilà la dépendance de l'homme; cherchons sa liberté.

De la liberté de l'homme

Je suis libre, et je n'en puis douter: j'ai une conviction intime et inébranlable que je puis vouloir et ne vouloir pas, qu'il y a en moi une élection, son seulement entre le vouloir et le non vouloir, mais encore entre diverses volontés sur la variété des objets qui se présentent. Je sens, comme dit l'Écriture, que je suis dans la main de mon conseil (1). En voilà déjà assez pour me montrer que mon aine n'est point corporelle. Tout ce qui est corps ou corporel ne se détermine en rien soi-même, et est au contraire déterminé en tout par des lois qu'on nomme physiques, qui sont nécessaires, invincibles, et contraires à ce que j'appelle liberté. De là je conclus que mon âme est d'une nature entièrement différente de celle de mon corps. Qui est-ce qui a pu unir d'une union réciproque deux natures si différentes, et les tenir dans un concert si juste pour toutes leurs opérations? Ce lien ne peut être formé, comme nous lavons déjà remarqué, que par un être supérieur qui réunisse ces deux genres de perfections dans sa perfection infinie.

Il «'en est pas de même de cette modification de mon âme qu'on nomme vouloir, comme des - modifications des corps. Un corps ne se modifie en rien lui-même; il est modifié par la seule puissait de Dieu: il ne se meut point, il est mû; il n'agit en rien, il est seulement agi, s'il m'est

permis de parler de la sorte. Ainsi Dieu est l'unique cause réelle et immédiate de toutes les différentes modifications des corps. Pour les esprits, il n'en est pas de même; ma volonté se détermine elle-même. Or, se déterminer à un "vouloir, c'est se modifier: ma volonté se modifie donc elle-même. Dieu peut prévenir mon âme, mais il ne lui donne point le vouloir de la même manière dont il donne le mouvement aux corps. Si c'est Dieu qui me modifie, je me modifie moi-même avec lui; je suis cause réelle avec lui de mon propre vouloir. Mon vouloir est tellement à moi, qu'on ne peut s'en prendre qu'à moi, si je ne veux pas ce qu'il faut vouloir. Quand je veux une chose,, je suis maître de ne la vouloir pas; quand je ne la veux pas, je suis maître de la vouloir. Je ne suis pas contraint dans mon vouloir, et je ne saurais l'être; car je ne saurais vouloir malgré moi ce que je veux, puisque le vouloir que je suppose exclut évidemment toute contrainte.

Outre l'exemption de toute contrainte, j'ai encore l'exemption de toute nécessité. Je sens que j'ai un vouloir, pour ainsi dire, à deux tranchants, qui peut se tourner à son choix vers le oui et vers le non, vers \m objet ou vers un autre; je ne connois point d'autre rai, son de mon vouloir que mon vouloir même; je veux une chose, parce que je veux bien la vouloir, et que rien n'est tant en ma puissance que de vouloir ou de ne vouloir pas. Quand même ma volonté ne serait pas contrainte, si elle étoit nécessitée, elle serait aussi invinciblement déterminée à vouloir que les corps le sont à se mouvoir. La nécessité invincible tomberait autant sur le vouloir pour l'es esprits qu'elle tombe sur le mouvement pour les corps. Alors il ne faudroit pas s'en prendre davantage aux volontés de ce qu'elles voudroient, qu'aux corps de ce qu'ils se mouvroient.

Il est vrai que les volontés voudroient vouloir ce qu'elles voudroient; mais les corps se meuvent du mouvement dont ils se meuvent, comme les volontés veulent du vouloir dont elles veulent. Si le vouloir est nécessité comme le mouvement, il n'est ni plus digne de louange, ni plus digne de blâme. Le vouloir nécessité, pour être un vrai vouloir non contraint, n'en est pas moins un vouloir qu'on ne peut s'abstenir d'avoir, et duquel on ne peut se prendre à celui qui l'a. La connoissance précédente ne donne point de liberté véritable; car un vouloir peut être précédé de la connoissance de divers objets, et n'avoir pourtant aucune réelle élection. La délibération même n'est qu'un jeu ridicule, si je délibère entre deux partis, étant dans l'impuissance actuelle de prendre l'un, et dans la nécessité actuelle de prendre l'antre. Enfin il n'y a aucune élection sérieuse et véritable entre deux objets, s'ils ne sont tous deux actuellement tout prêts, en sorte que je puisse laisser et prendre celui qu'il me plaira.

En disant que je suis libre > je dis donc que mon vouloir est pleinement en ma puissance, et que Dieu même me le laisse pour le tourner où je voudrai; que je ne suis point déterminé comme les autres êtres,- et que je me détermine moi-même. Je conçois que si ce premier être me prévient pour m'inspirer une bonne volonté, je demeure le maître de rejeter (i) son actuelle inspiration, quelque forte qu'elle soit; de la frustrer de son effet, €t de se refuser mon consentement. Je conçois aussi que quand je rejette son inspiration pour le bien, j'ai le vrai et actuel pouvoir de ne la rejeter pas, comme j'ai le pouvoir actuel et immédiat de me lever quand je demeure assis, et de fermer les yeux quand je les ai ouverts. Les objets peuvent me solliciter par tout ce qu'ils ont d'agréable à les vouloir. Les raisons de vouloir peuvent se présenter à moi avec ce qu'elles ont de plus vif et de plus touchant. Le premier être peut aussi m'attirer par ses plus persuasives inspirations. Mais enfin dans cet attrait actuel des objets, des raisons, et même de l'inspiration d'un être supérieur, je demeure -encore maître de ma volonté pour vouloir ou ne vouloir pas.

C'est cette exemption non seulement de toute contrainte, mais encore de toute nécessite, et cet empire sur mes propres actes, qui fait que je suis inexcusable quand je veux ■nul, et que je suis louable quand je veux bien. Voilà le fond du mérite et du démérite; voilà ce qui rend juste ou la punition ou la récompense; voilà ce «jui fait qu'on exhorte, qu'on reprend, qu'on menace, qu'on promet. C'est là le fondement de toute police, de toute instruction et de toute règle de meeurs. Tout se réduit, dans la vie humaine, à supposer comme le -fondement de tout, que rien n'est tant,

en la puissance de notre volonté que notre propre vouloir, et que nous avons ce libre arbitre, ce pouvoir, pour ainsi dire, à deux tranchants, cette vertu élective entre deux partis qui sont immédiatement comme sous notre main.

C'est ce que les bergers et les laboureurs chantent sur les montagnes, ce que les marchands et les artisans supposent dans leur négoce, ce que les acteurs représentent dans les spectacles, ce que les magistrats croient dans leurs conseils, ce que les docteurs enseignent dans leurs écoles, ce que nul homme sensé ne peut révoquer en doute sérieusement. Cette vérité, imprimée au fond de nos cœurs, est supposée dans la pratique par les philosophes mêmes qui voudraient l'ébranler par de creuses spéculations. L'évidence intime de cette vérité est comme celle des premiers principes, qui n'ont besoin d'aucunes preuves, et qui servent eux-mêmes de preuves aux autres vérités moins claires. Comment le premier être peut-il avoir fait une créature qui soit ainsi l'arbitre de ses propres actes?

Rassemblons maintenant ces deux vérités également certaines. Je suis dépendant d'un premier être dans mon vouloir même, et néanmoins je suis libre. Quelle est donc cette liberté dépendante? Comment peut-on comprendre un vouloir qui est libre, et qui est donné par un premier être? Je suis libre dans mon vouloir, comme Dieu dans le sien. C'est en cela principalement que je suis son image, et que je lui ressemble. Quelle grandeur qui tient de l'infini! Voilà le trait de la divinité même. C'est une espèce de puissance divine que j'ai sur mon vouloir; mais je ne suis qu'une simple image de cet être si libre et si puissant.

L'image de l'indépendance divine n'est pas la réalité de ce qu'elle représente; ma liberté n'est qu'une ombre de celle de ce premier être par qui je suis et par qui j'agis. D'un coté, le pouvoir que j'ai de vouloir mal est moins un vrai pouvoir qu'une foiblesse et une fragilité de mon vouloir: c'est un pouvoir de déchoir, de roe dégrader, de diminuer mou degré de perfection et d'être. D'un autre côté, le pouvoir que j'ai de bien vouloir n'est point un pouvoir absolu, puisque je ne l'ai point de moi-même. La liberté n'étant donc autre chose que ce pouvoir, le pouvoir emprunté ne peut faire qu'une liberté empruntée et dépendante. Un être si imparfait et si emprunté ne peut donc être que dépendant. Comment est-il libre? Quel profond mystère! Sa liberté, dont je ne puis douter, montre sa perfection; sa dépendance montre le néant dont il est sorti.

Conclusion des chapitres précédents.

Nous venons de voir les traces de la divinité, ou, pour mieux dire, le sceau de Dieu même, dans tout ce qu'on appelle les ouvrages de la nature. Quand on ne veut point subtiliser, on remarque du premier coup-d'œil une main qui est le premier mobile dans toutes les parties de l'univers. Les cieux, la terre, les astres, les plantes, les animaux, nos corps, nos esprits; tout marque un ordre, une mesure précise, un art, une sagesse, un esprit supérieur à nous, qui est comme l'ame du monde entier, et qui mène tout à ses fins avec une force douce et insensible, mais toute-puissante. Nous avons vu, pour ainsi dire, l'architecture de l'univers, la juste proportion de toutes ses parties; et le simple coup-d'œil nous a suffi partout pour trouver dans une fourmi, encore plus que dans le soleil, une sagesse et une puissance qui se plaît à éclater en façonnant ses plus vils ouvrages. Voilà ce qui se présente d'abord sans discussion aux hommes les plus ignorants. Que seroit-ce si nous entrions dans les secrets de la physique, et si nous faisions la dissection des parties internes des animaux, pour y trouver la plus parfaite mécanique?

Chapitre V - Examen des deux principales objections des Epicuriens

J'entends certains philosophes qui me répondent que tout ce discours sur l'art qui éclate dans toute la nature n'est qu'un sophisme perpétuel. Toute la nature, diront-ils, est à l'usage de l'homme, il est vrai; mais vous en concluez mal à propos qu'elle a été faite avec art pour l'usage,de l'homme. C'est

être ingénieux à se tromper soi-même pour trouver ce qu'on cherche, et qui ne fut jamais. Il est vrai, continueront-ils, que l'industrie de l'homme se sert d'une infinité de choses que la nature lui fournit, et qui lui sont commodes; mais la nature n'a point fait exprès ces choses pour sa commodité. Par exemple, des villageois grimpent tous les jours par certaines pointes de rochers au sommet d'une montagne; il ne s'ensuit pas néanmoins que ces pointes de rochers aient été taillées avec art comme un escalier pour la commodité des hommes.

Tout de même, quand on est à la campagne pendant un orage, et qu'on rencontre une caverne, on s'en sert comme d'une maison, pour se mettre à couvert. Il n'est pourtant pas vrai que cette caverne ait été faite exprès pour servir de maison aux hommes. Il en est de même du monde entier: il a été formé par le hasard et sans dessein; mais les hommes le trouvant tel qu'il est, ont eu l'invention de le tourner à leurs usages. Ainsi l'art que vous voulez admirer dans l'ouvrage et dans son ouvrier, n'est que dans les hommes, qui savent après coup se servir de tout ce qui les environne. Voilà sans doute la plus forte objection que ces philosophes puissent faire; et je crois qu'ils ne peuvent point se plaindre, que je l'aie affoiblie. Mais nous allons voir combien elle est foible en elle-même, quand on l'examine de près: la simple répétition de ce que j'ai déjà dit suffira pour le démontrer.

Que diroit-on d'un homme qui se piqueroit d'une philosophie subtile, et qui, entrant dans une maison, soutiendroit qu'elle a été faite par le hasard, et que l'industrie n'y a rien mis pour en rendre l'usage commode aux hommes, à cause qu'il y a des cavernes qui ressemblent en quelque chose à cette maison, et que l'art des hommes n'a jamais creusées?

On montreroit à celui qui raisonneroit de la sorte toutes les parties de cette maison. Voyez-vous, lui diroit-on, cette grande porte de la cour? elle est plus grande que toutes les autres, afin que les carrosses y puissent entrer. Cette cour est assez spacieuse pour y faire tourner les carrosses avant qu'ils sortent. Cet escalier est composé de marches basses, afin qu'on puisse monter sans effort; il tourne suivant les appartements et les étages pour lesquels il doit servir. Les fenêtres, ouvertes ■de distance en distance, éclairent tout le bâtiment; elles sont vitrées, de peur que le vent n'entre avec la lumière; on peut les ouvrir quand on veut, pour respirer un air doux dans la belle saison. Le toit est fait pour défendre tout bâtiment des injures de l'air. La charpente est en pointe, afin que la pluie et la neige s'y écoulent facilement des deux côtés. Les tuiles portent les unes sur les autres, pour mettre à couvert le bois de la charpente. Les divers planchers des étages servent à multiplier les logements dans un petit espace, en les faisant les uns au-dessus des autres. Les cheminées sont faites pour allumer du feu en hiver sans brûler la maison, et pour faire exhaler la fumée sans la laisser sentir à ceux qui se chauffent. Les appartements sont distribués de manière qu'ils ne sont point engagés les uns dans les autres, que toute une famille nombreuse y petit loger sans jouer les uns aient besoin de passer par les chambres des autres, et que le logement du maître est le principal: on y voit des cuisines, des offices, des écuries, des remises de carrosses: les chambres sont garnies de lits pour se coucher, de chaises pour s'asseoir, de tables pour écrire et pour manger.

Il faut, diroit-on à ce philosophe, que cet ouvrage ait été conduit par quelque habile architecte; car tout v est agréable, riant, proportionné, commode: il faut même quil ait eu sous lui d'excellents ouvriers. Nullement, répondroit ce philosophe; vous êtes ingénieux à vous tromper vous-mêmes. 11 est vrai que cette maison est riante, agréable, proportionnée, commode; mais efle s'est faite d'elle-même avec toutes ses proportions. Le hasard en a assemblé les pierres avec ce bel ordre; il a élevé les murs, assemblé et posé la charpente, percé les fenêtres, placé l'escalier. Gardez-vous bien de croire qu'aucune main d'homme y ait eu aucune part: les hommes ont seulement profité de. cet ouvrage, quand ils l'ont trouvé fait. Ils s'imaginent qu'il est fait pour eux, parcequ'ils y remarquent des choses qu'ils savent tourner à leurs commodités; mais tout ce qu'ils attribuent au dessein d'un architecte imaginaire, n'est que l'effet de leurs inventions après coup. Cette maison si régulière et

si bien entendue il s'est faite que comme une caverne; et les hommes, la trouvant faite, s'en servent comme ils se serviraient, pendant un orage, d'un autre qu'ils trouveroient sous un rocher au milieu d'un désert.

Que peuseroit-on de ce bizarre philosophe, s'il s'obstinoit à soutenir sérieusement que cette maison ne mon- I tre aucun art? Quand on lit la fable d'Amphion qui, par un miracle de l'harmonie, faisoit élever avec ordre et symétrie les pierres les unes sur les autres pour former les murailles de Thèbes, on se joue de cette fiction poetique; mais cette fiction n'est pas si incroyable que celle que l'homme que nous supposons oseroit défendre. Au moins pourroit-on s'imaginer que l'harmonie, qui consiste dans un mouvement local de certains corps, pourroit, par quelques-unes de ces vertus secrètes qu'on admire dans la nature sans les entendre, ébranler les pierres avec un certain ordre, et une espèce de cadence qui feroit quelque régularité dans l'édifice.

Cette explication choque néanmoins, et révolte la raison; mais enfin elle est encore moins extravagante que celle que je viens de mettre dans la bouche d'un philosophe. Qu'y a-t-il de plus absurde que de se représenter des pierres qui se taillent, qui sortent de la carrière, qui montent les unes sur les autres sans laisser de vide, qui portent avec elles leur ciment pour leur liaison, qui s'arrangent pour distribuer les appartements, qui reçoivent au-dessus d'elles le bois d'une charpente avec les tuiles, pour mettre l'ouvrage à couvert? Les enfants même qui bégaient encore ribbient si on leur proposoit sérieusement cette fable.

Mais pourquoi rira-t-on moins d'entendre dire que le monde s'est fait de lui-même comme cette maison fabuleuse? Il ne s'agit pas de comparer le monde à une caverne informe qu'on suppose faite par le hasard; il s'agit de le comparer à une maison où éclateroit la plus parfaite architecture. Le moindre animal est d'une structure et d'un art infiniment plus admirable que la plus belle de toutes les maisons.

Un voyageur entrant dans le Saïde, qui est le pays de l'ancienne Thèbes à cent portes, et qui est maintenant désert, y trouveroit des colonnes, des pyramides, des obélisques, des inscriptions en caractères inconnus. Diroit-il aussitôt: Les hommes n'ont jamais habité ces lieux; aucune main d'homme n'a travaillé ici; c'est le hasard qui a formé ces colonnes, qui les a posées sur leurs piédestaux, et qui les a couronnées de leurs chapiteaux avec des proportions si justes; c'est le hasard qui a lié si solidement les morceaux dont ces pyramides sont composées; c'est le hasard qui a taillé ces obélisques d'une seule pierre, et qui y a gravé tous ces caractères? Ne diroit-il pas au contraire, avec toute la certitude dont l'esprit de l'homme est capable: Ces magnifiques débris sont les restes d'une majestueuse architecture qui florissoit dans l'ancienne Egypte.

Voilà ce que la simple raison fait dire au premier coup-d'œil, et sans avoir besoin de raisonner. Il en est de même du premier coup-d'œil jeté sur l'univers-. On peut s'embrouiller soi-même après coup par de vains raisonnements pour obscurcir ce qu'il y a de plus clair; mais le simple coup-d'œil est décisif. Un ouvrage tel que le monde ne se fait jamais de lui-même: les os, les tendons, les veines, les artères, les nerfs, les muscles, qui composent le corps de l'homme, ont plus d'art et de proportion que toute l'architecture des anciens Grecs et Égyptiens. L'œil du moindre animal surpasse la mécanique de tous les artisans ensemble. Si on trouvoit une montre dans les sables d'Afrique, on n'oseroit dire sérieusement que le hasard l'auroit formée dans ces lieux déserts; et on n'a point de honte de dire que les corps des animaux, à l'art desquels nulle montre ne peut jamais être comparée, sont des caprices du hasard!

Je n'ignore pas un raisonnement que les Epicuriens peuvent faire. Les atomes, diront-ils, ont un mouvement éternel; leur concours fortuit doit avoir déjà épuisé, dans cette éternité, des combinaisons infinies. Qui dit l'infini, dit quelque chose qui comprend tout sans exception. Parmi ces combinaisons infinies des atomes qui sont déjà arrivées successivement, il faut nécessairement

qu'on y trouve toutes celles qui sont possibles. S'il y en avoit une seule de possible au-delà de celles qui sont contenues dans cet infini, il ne seroit plus un infini véritable, parcequ'on pourroit y ajouter quelque chose, et que ce qui peut être augmenté, ayant une borne par le côté susceptible d'accroissement, n'est point véritablement infini.

Il faut donc que la combinaison des atomes, qui fait le système présent du monde, soit une des combinaisons que les atomes ont eues successivement. Ce principe étant posé, faut-il s'étonner que le monde soit tel qu'il est? Il a dû prendre cette forme précise un peu plus tôt, ou un peu plus tard. Il falloit bien qu'il parvînt, dans quelques uns de ses changements infinis, à cette combinaison qui le rend aujourd'hui si régulier, puisqu'il doit avoir déjà eu tour à tour toutes les combinaisons concevables. Dans le total de l'éternité sont renfermés tous les systèmes. Il n'y en a aucun que le concours des atomes ne forme et n'embrasse tôt ou tard. Dans cette variété infinie de nouveaux spectacles de la nature, celui-ci a été formé en son rang: il a trouvé place à son tour. Nous nous trouvons actuellement dans ce système. Le concours des atomes qui l'a fait le défera ensuite, pour en faire d'autres à l'infini de toutes les espèces possibles. Ce système ne pouvoit manquer de trouver sa place, puisque tous, sans exception, doivent recouvrer la leur chacun à son tour. C'est en vain qu'on cherche un art chimérique dans un ouvrage que le hasard a dû faire tel qu'il est.

Un exemple achèvera d'éclaircir ceci. Je suppose un nombre infini de combinaisons des lettres de l'alphabet formées successivement par le hasard: toujes les combinaisons possibles sont sans doute renfermées dans ce total qui est véritablement infini. Or est-il que l'Iliade d'Homère n'est qu'une combinaison de lettres? L'Iliade d'flomère est donc renfermée dans ce recueil infini de combinaisons des caractères «le l'alphabet. Ce fait étant supposé, un homme qui voudra trouver de l'art sans qu’ils raisonnera très mal.

Il aura beau admirer l'harmonie des vers, la justesse et la magnificence des expressions, la naïveté des peintures, la proportion des parties du poème, son unité parfaite et sa conduite «imitable; en vain il se récriera que le hasard ne peut jamais faire rien de si parfait, et que le dernier effort de l'art humain peut à peine achever un si bel ouvrage; tout ce raisonnement si spécieux portera visiblement à faux. Il sera certain que le hasard ou concours fortuit des caractères les assemblant tour à tour avec une variété infinie, il a faim que la combinaison préciserai fait l'Iliade vînt à son tour un peu plus tôt ou un peu plus tard. Elle est enfin venue; et l'Iliade entière se trouve parfaite, sans que l'art- d'un homme* s'en soit mêlé. Voilà l'objection rapportée de bonne foi, sans l'affoiblir en rien. Je demande au lecteur une attention suivie pour les réponses que j'y vais faire.

Rien n'est plus absurde que de parler de combinaisons successives des atomes qui soient infinies en nombre. L'infini ne peut jamais être successif ni divisible. Donnez-moi un nombre que vous prétendrez être infini, je pourrai toujours faire deux choses qui démontreront que ce n'est pas un infini véritable, si J'en puis retrancher une unité: alors il deviendra moindre qu'il n'étoit, et sera certainement fini; car tout ce qui est moindre que l'infini a une borne par l'endroit où l'on s'arrête, et où l'on pourroit aller au-delà: or le nombre qui est fini, dès qu'on en retranche une seule unité, ne pouvoit pas être infini avant ce retranchement. Une seule unité est certainement finie: or un fini, joint à un autre fini, ne sauroit faire l'infini. Si une seule unité ajoutée à un nombre fini faisoit l'infini, il faudroit dire que le fini égaleroit presque l'infini; ce qui est le comble de l'absurdité.

Je puis ajouter une unité à ce nombre, et par conséquent l'augmenter: or ce qui peut être augmenté n'est point infini; car l'infini ne peut avoir aucune borne; et ce qui peut recevoir de l'augmentation est borné par l'endroit où l'on s'arrête, pouvant aller plus loin, et y ajouter quelque unité. Il est donc évident que nul composé divisible ne peut être l'infini véritable.

Ce fondement étant posé, tout le roman de la philosophie épicurienne disparoît en un moment. Il ne peut jamais y avoir aucun corps divisible qui soit véritablement infini en étendue, ni aucun

nombre ni aucune succession qui soit un infini véritable. De là il s'ensuit qu'il ne peut jamais y avoir un nombre successif de combinaisons d'atomes qui soit infini. Si cet infini chimérique étoit véritable, toutes les combinaisons possibles et concevables d'atomes s'y rencontreroient, j'en conviens; par conséquent il seroit vrai qu'on y trouveroit toutes les combinaisons qui semblent demander la plus grande industrie: ainsi on pourroit attribuer au pur hasard tout ce que l'art fait de plus merveilleux.

Si on voyoit des palais d'une parfaite architecture, des meubles, des montres, des horloges, et toutes sortes de machines les plus composées, dans une île déserte, il ne seroit plus permis de conclure qu'il y a eu des hommes dans cette île, et qu'ils ont fait tous ces beaux ouvrages -, il faudrait dire: peut-être qu'une des combinaisons infinies des atomes, que le hasard a faites successivement, a formé tous ces composés dans cette île déserte, sans que l'industrie d'aucun homme s'en soit mêlée. Ce discours ne seroit qu'une conséquence très bien tirée du principe des Épicuriens: mais l'absurdité de la conséquence sert à faire sentir celle du principe qu'ils veulent poser.

Quand les hommes, par la droiture naturelle de leur sens commun, concluent que ces sortes d'ouvrages ne peuvent venir du hasard, ils supposent visiblement, quoique d'une manière confuse, que les atomes ne sont point éternels, et qu'ils n'ont point eu dans leur concours fortuit une succession de combinaisons infinie-, car si on supposoit ce principe, on ne pourroit plus distinguer jamais les ouvrages de l'art d'avec ceux d' ces combinaisons, qui seroient fortuites comme des . ■coups de dés.

Tous les hommes qui supposent naturellement une différence sensible entre les ouvrages de l'art et ceux du hasard, supposent donc, sans l'avoir approfondi-, que les combinaisons d'atomes n'ont point été infinies; et leur supposition est juste. Cette succession infinie de combinaisons d'atomes est, comme je l'ai déjà montré, ■une chimère plus absurde que toutes les absurdités qu'on voudroit expliquer par ce faux principe. Aucun nombre, ni successif ni continu, ne peut être infini: d'où il s'ensuit que les atomes ne peuvent être infinis en nombre, que la succession de leurs divers mouvements et de leurs combinaisons n'a pu être infinie, que le monde n'a pu être éternel, et qu'il faut trouver un commencement précis et fixe de ces combinaisons successives: il faut trouver un premier individu dans les générations de chaque espèce; il faut de même trouver la première forme qu'a eue chaque portion de matière 'qui fait partie de l'univers: et comme les changements successifs de cette matière n'ont pu avoir qu'un nombre î»orné, il ne faut admettre dans ces différentes combinaisons que celles que le hasard produit d'ordinaire, à moins qu'on ne reconnoisse une sagesse supérieure qui 'ait fait avec un art parfait les arrangements que le hasard n'auroit su faire.

Les .philosophes épicuriens sont si foîbles dans leur système, qu'ils ne peuvent venir à bout de le former ■qu'autant qu'on leur donne sans preuves tout ce qu'ils demandent de plus fabuleux. Ils supposent d'abord des atomes éternels.; c'est supposer ce qui-est en question. Où prennent-ils que les atomes ont toujours été, et sont par eux-mêmes? Être par soi-même, c'est la suprême perfection. Be quel droit supposent-ils sans preuves que les atomes ont un être parfait, éternel, immuable dans leur propre fond? Trouvent-ils cette perfection dans l'idée qu'ils ont de chaque atome -eu particulier? Un atome n'étant pas l'autre, et étant absolument distingué de lui, il faudrait que chacun d'eux portât en soi l’éternité et l'indépendance à l'égard de tout autre être. Encore une fois, est-ce dans l'idée qu'ils ont de chaque atonie, que ces philosophes trouvent cette perfection? Mais donnons leur là-dessus tout ce qu'ils demanderont, et ce qu'ils ne devroient pas même oser demander. Supposons donc que les atomes sont éternels, existants par eux-mêmes, indépendants de tout autre être, et par conséquent entièrement parfaits.

Faudra-t-il supposer encore qu'ils ont par eux-mêmes le mouvement? Le supposera-t-on à plaisir pour réaliser un système plus chimérique que les contes des fées? Consultons l'idée que nous avons d'un corps. Nous le concevons parfaitement sans supposer qu'il se meuve; mais nous le représentons en repos: et l'idée n'en est pas moins claire on cet étal; il n'en a pas moins ses parties, sa figure et ses dimensions. C'est en vain qu'on veut supposer que tous les corps sont sans cesse en quelque mouvement sensible ou insensible; et que si quelques portions dela matière sont dans un moindre mouvement que les autres, du moins la masse universelle de la matière a toujours dans sa totalité le même mouvement.

Parler ainsi, c'est parier en l'air, et vouloir être cru sur tout ce qu'on s'imagine. Où prend-on que la masse de la matière a toujours dans sa totalité le même mouvement? qui est-ce qui en a fait l'expérience? Ose-t-on appeler philosophie cette fiction téméraire qui suppose ce qu'on ne peut jamais vérifier? N'y a-t-il qu'à supposer tout ce qu'on veut pour éluder les vérités les plus simples et les plus constantes? De quel droit suppose-t-on que tous les corps se meuvent sans cesse sensiblement ou insensiblement? Quand je vois une pierre qui paroît immobile, comment me prouvera-t-on qu'il n’y a aucun atome dans cette pierre qui ne se meuve actuellement? Ne me donnera-t-on jamais, pour preuves décisives, que des suppositions sans vraisemblance?

Allons encore plus loin. Supposons, par un excès de complaisance, que tous les corps de la nature se meuvent actuellement; s'ensuit-il que le mouvement soit essentiel à toute portion de matière? D'ailleurs, si tous les corps ne se meuvent pas également; si les uns se meuvent plus sensiblement et plus fortement que les autres; si le même corps peut se mouvoir tantôt plu* £t tantôt moins; si un corps qui se meut communique son mouvement au corps voisin qui étoit en repos, ou dans un mouvement tellement inférieur, qu'il étoit sensible; il faut avouer qu'une manière d'être qui tantôt augmente et tantôt diminue dans les corps ne leur est pas essentielle.

Ce qui est essentiel à un être, est toujours le même en lui. Le mouvement qui varie dans les corps, et qui, après avoir augmenté, se ralentit jusqu'à paroître absolument anéanti; le mouvement qui se perd, qui se communique, qui passe d'un corps dans un autre comme une chose étrangère, ne peut être de l'essence des corps. Je dois donc conclure que les corps sont parfaits dans leur essence, sans qu'on leur attribue aucun mouvement: s'ils ne l'ont point par leur essence, ils ne l'ont que par accident; s'ils ne l'ont que par accident, il faut remonter à la vraie cause de cet accident.

Il faut, ou qu'ils se donnent eux-mêmes le mouvement, ou qu'ils le reçoivent de quelque autre être. Il est évident qu'ils ne se le donnent point eux-mêmes; nul être ne se peut donner ce qu'il n'a pas en soi. Nous voyons même qu'un corps qui est en repos, demeure toujours immobile, si quelque autre corps voisin ne vient l'ébranler. Il est donc vrai que nul corps ne se meut par soi-même, et n'est mû que par quelque autre corps qui lui communique son mouvement. Mais d'où vient qu'un corps en peut mouvoir un autre? d'où vient qu'une boule, qu'on fait rouler sur une table unie, ne peut en aller toucher un autre sans la remuer? Pourquoi n'auroit-il pas pu-se faire que le mouvement ne se communiquât jamais d'un corps à un autre? En ce cas, une boule mue s'arrêteroit auprès d'une autre en la rencontrant, et ne l'ébranleroit jamais.

On me répondra que les lois du mouvement entre les corps décident que l'un ébranle l'autre. Mais où sont-elles écrites ces lois du mouvement? qui est-ce qui les a faites, et qui les rend si inviolables? Elles ne sont point de l'essence des corps; car on peut concevoir les corps en repos, et on conçoit même des corps dont les uns ne communiqueraient point leur mouvement aux autres, si ces règles, dont la source est inconnue, ne les y assujettissoient. D'où vient cette police, pour ainsi dire, arbitraire pour le mouvement entre tous les corps? D'où viennent ces lois si ingénieuses, si justes)v si bien assorties les unes aux autres, et dont la moindre altération renverseroit tout à coup tout le bel ordre de l'univers?

Un corps étant entièrement distingué de l'autre, il est par le fond de sa nature absolument indépendant de lui en tout: d'où il s'ensuit qu'il ne doit rien recevoir de lui, et qu'il ne doit être susceptible d'aucune de ses impressions. Les modifications d'un corps ne sont point une raison pour modifier de même un autre corps dont l'être est entièrement indépendant de l'être du premier. C'est en vain qu'on allègue que les masses les plus solides et les plus pesantes entraînent celles qui sont les moins grosses et les moins solides, et que, suivant cette règle, une grosse boule de plomb doit ébranler une grosse boule d'ivoire.

Nous ne parlons point du fait; nous en cherchons la cause. Le fait est constant; la cause en doit aussi être Certaine et précise. Cherchons-la sans aucune prévention, et dans un plein doute sur tout préjugé. D'où vient qu'un gros corps en entraîne un petit? La chose pourrait se faire tout aussi naturellement d'une autre façon; il pourrait tout aussi bien se faire que le corps le plus solide ne put jamais ébranler aucun autre corps, c'est-à-dire que le mouvement fut incommunicable. îl n'y a «pie l'habitude qui nous assujettisse à supposer que la nature doit agir ainsi.

De plaœ, nous avons vu que la matière ne peut être ni infinie ni éternelle. Il faut donc trouver un premî-atome par où le mouvement aura commencé dans un moment précis, et un premier concours des atomes qui aura formé une première combinaison. Je demande quel moteur a mù ce premier atome, et a donné ce premier branle à la machine de l'univers. Il n'est pas permis d'éluder une question si précise par un cercle sans fin. Ce cercle, dans un tout fini, doit avoir une fin certaine: il faut trouver le premier atome ébranlé, et le premier moment de cette première motion, avec le premier moteur dont la main a fait ce premier coup.

Parmi les lois du mouvement, il faut regarder comme arbitraires toutes celles dont on ne trouve pas la raison dans l'essence même des corps. Nous avons déjà vu que nul mouvement n'est essentiel à aucun corps. Donc toutes ces lois, qu'on suppose comme éternelles et immuables, sont au contraire arbitraires, accidentelles et instituées sans nécessité; car il n'y en a aucune dont on trouve la raison dans l'essence d'aucun corps.

S'il y avoit quelque règle du mouvement qui fût essentielle aux corps, ce seroit sans doute celle qui fait que les masses moins grandes et moins solides sont mues par celles qui ont plus de grandeur et de solidité: or nous avons vu que celle-là même n'a point de raison dans l'essence des corps. Il y en a une autre qui sembleroit encore être très naturelle; c'est celle que le» corps se meuvent toujours plutôt en ligne directe qu'en ligne détournée, à moins qu'ils ne soient contraints dans leur mouvement par la rencontre d'autres corps: mais cette règle même n'a aucun fondement réel dans l'essence de la matière. Le mouvement est tellement accidentel et surajouté à la nature des corps, que cette nature des corps ne nous montre point une règle primitive et immuable suivant laquelle ils doivent se mouvoir, et encore moins se mouvoir suivant certaines règles.

De même que les corps auroient pu ne se mouvoir jamais, ou ne se communiquer jamais de mouvement' les uns aux autres, ils auraient pu aussi ne se mouvoir jamais qu'en ligne circulaire; et ce mouvement aurait été aussi naturel que le mouvement en ligne directe. Qui est-ce qui a choisi entre ces deux règles également possibles? Ce que l'essence des corps ne décide point, ne peut avoir été décidé que par celui qui a donné aux corps le mouvement qu'ils n'avoient point par leur essence: d'ailleurs ce mouvement en ligne directe pourrait être de bas en haut ou de haut en bas, du côté droit au côté gauche, ou du côté gauche au droit, ou en ligne diagonale. Qui est-ce qui a déterminé le sens dans lequel la ligne droite seroit suivie?

Ne nous lassons point de suivre les Épicuriens dans leurs suppositions les plus fabuleuses. Poussons la fiction jusqu'au dernier excès de complaisance. Mettons le mouvement dans l'essence des corps. Supposons à leur gré que le mouvement en ligne directe est encore de l'essence de tous les atomes. Donnons aux atomes une intelligence et une volonté, comme les poètes en ont donné aux rochers

et aux fleuves. Accordons-leur le choix du sens dans lequel ils commenceront leur ligne droite. Quel fruit retireront ces philosophes de tout ce que je leur aurai donné contre toute évidence? 11 faudrait, i° que tous les atomes se mussent de toute éternité; 2° qu'ils se mussent tous également; 3° qu'ils se mussent tous en ligne droite; 4° qu'ils le fissent par une règle immuable et essentielle.

Je veux bien encore, par grâce, supposer que ces atomes sont de figures différentes; car je laisse supposer à nos adversaires tout ce qu'ils seraient obligés de prouver, et sur quoi ils n'ont pas même l'ombre d'une preuve. On ne sauroit trop donner à des gens qui ne peuvent jamais rien conclure de tout ce qu'on leur donnera. Plus ou leur passe d'absurdités, plus ils sont pris par leurs propres principes.

Ces atomes de tant de bizarres figures, les uns ronds, les autres crochus, les autres en triangle, etc., sont obligés par leur essence d'aller toujours tout droit, sans pouvoir jamais fléchir ni à droite ni à gauche. Ils ne peuvent donc jamais s'accrocher, ni faire ensemble aucune composition. Mettez tant qu'il vous plaira les crochets les plus aiguisés auprès d'autres crochets semblables: si chacun d'eux ne se meut jamais qu'en ligne véritablement directe, ils se mouvront éternellement tout auprès les uns des autres sur des lignes parallèles, sans pouvoir se joindre et s'accrocher. Les deux lignes droites qu'on suppose parallèles, quoique immédiatement voisines, ne se couperont jamais, quand même on les pousserait à l'infini. Ainsi pendant toute l'éternité il ne peut résulter aucun accrochement, ni par conséquent aucune composition, de ce mouvement des atomes en ligne directe.

Les Épicuriens, ne pouvant fermer les yeux à l'évidence de cet inconvénient qui sape le fondement de tout leur système, ont encore inventé comme une dernière ressource ce que Lucrèce nomme clinamen. C'est un mouvement qui décline un peu de la ligne droite, et qui donne moyen aux atomes de se rencontrer. Ainsi ils les tournent suivant leur imagination comme il leur plaît, pour parvenir à quelque but. Mais où prennent-ils cette petite inflexion des atomes, qui vient si à propos pour sauver leur système? Si la ligne droite pour le mouvement est essentielle aux corps, rien ne peut les fléchir, ni par conséquent les joindre pendant toute l'éternité; le clinamen viole l'essence de la matière, et ces philosophes se contredisent sans pudeur. Si au contraire la ligne droite pour le mouvement n'est pas essentielle à tous les corps, pourquoi nous allègue-t-on d'un ton si affirmatif des lois éternelles, nécessaires et immuables, pour le mouvement de6 atomes, sans recourir à un premier moteur? et pourquoi élève-t-on tout un système de philosophie sur le fondement d'une fable ridicule? Sans le dinamen la. ligue droite ne peut jamais rien faire, et le système tombe par terre. Avec le clinamen, inventé comme les fables des poètes, la ligue droite est violée,et le système se tourne en dérision.

L'un et l'autre, c'est-à-dire la ligne droite et le clinamen^ sont des suppositions en l'air, et de purs songes. Mais ces deux songes s'entre-détruisent; et voilà à quoi aboutit la licence effrénée que les esprits se donnent de supposer comme vérité éternelle tout ce que leur imagination leur fournit pour autoriser une fable, pendant qu'ils refusent de reconnoître l'art avec lequel toutes les parties de l'univers ont été formées et mises en leurs places.

Pour dernier prodige d'égarement, il falloit que les Epicuriens osassent expliquer encore par le clinamen, qui est lui-même si inexplicable, ce que nous appelons l'ame de l'homme, et son libre arbitre. Ils sont donc réduits à dire que c'est dans ce mouvement où les atomes sont dans une espèce d'équilibre entre la ligne droite et la ligne un peu courbée, que consiste la volonté humaine.

Étrange philosophie! Les atomes, s'ils ne vont qu'en ligne droite, sont inanimés, incapables de tout degré de connoissance et de volonté: mais les mêmes atomes, s'ils ajoutent à la ligne droite un peu de déclinaison, deviennent tout à coup animés, pensants et raisonnables; ils sont eux-mêmes des âmes intelligentes, qui se connoissent, qui réfléchissent, qui délibèrent, et qui sont libres dans ce

qu'elles font. Quelle métamorphose plus absurde! Que diroit-on de la religion, si elle avoit besoin pour être prouvée de principes aussi puériles que ceux de la philosophie qui ose la combattre sérieusement?

Mais remarquons à quel point ces philosophes s'imposent à eux-mêmes. Qu'est-ce qu'ils peuvent trouver dans le clinamen, qui explique avec quelque couleur la liberté de l'homme? Cette liberté n'est point imaginaire, et il faudrait douter de tout ce qui nous est le plus intime et le plus certain, pour douter de notre libre arbitre. Je sens que je suis libre de demeurer assis, quand je me lève pour marcher; je le sens avec une si pleine certitude, qu'il n'est pas en mon pouvoir d'en douter jamais sérieusement, et que je me démentirois moi-même, si j'osois dire le contraire.

Peut-on pousser plus loin l'évidence de la preuve de . la religion? Il faut douter de notre liberté même, pour pouvoir douter de la divinité: d'où je conclus qu'on ne sauroit douter de la divinité sérieusement; car personne ne peut entrer en un doute sérieux sur sa propre liberté. Si au contraire on avoue de bonne foi que les hommes sont véritablement libres, rien n'est plus facile que de montrer que la liberté de la volonté ne peut consister en aucune combinaison des atomes.

S'il n'y a aucun premier moteur qui ait donné à la matière des lois arbitraires pour son mouvement, il faut que le mouvement soit essentiel aux corps, et que toutes les lois du mouvement soient aussi nécessaire que les essences des natures le sont. Tous les mouvements des corps doivent donc, suivant ce système, se faire par des lois constantes, nécessaires, et immuables. La ligne droite doit donc être essentielle à tous les atomes qui ne sont pas détournés par d'autres atomes. La ligne droite doit être essentielle, ou de bas en haut, ou de haut en bas, ou de droite à gauche, ou de gauche à droite, ou de quelque sens de diagonale qui soit précis et immuable. D'ailleurs il est évident que nul atome ne peut être détourné par un autre; car cet autre atome porte aussi dans son essence la même détermination invincible et éternelle à suivre la ligne directe dans le même sens.

D'où il s'ensuit que tous les atomes d'abord posés sur différentes lignes doivent parcourir à l'infini ces mêmes lignes parallèles, sans s'approcher jamais, et que ceux qui sont dans la même ligne doivent se suivre les uns les autres à l'infini, sans pouvoir s'attraper. Le clinamen ^ comme nous l'avons déjà dit, est manifestement impossible; mais supposant, contre la vérité évidente, qu'il soit possible, il faudrait alors dire que le clinamen n'est pas moins nécessaire, immuable et essentiel aux atomes, que la ligne droite.

Dira-t-on qu'une loi essentielle et immuable du mouvement local des atomes explique la véritable liberté de l'homme? Ne voit-on pas que le clinamen ne peut pas mieux l'expliquer que la ligne directe même? Le clinamen, s'il étoit vrai, seroit aussi nécessaire que la ligne perpendiculaire par laquelle une pierre tombe du haut d'une tour dans la rue. Cette pierre est-elle libre dans sa chute? La volonté de l'homme, selon le principe du clinamen, ne l'est pas davantage. Est-ce ainsi que l'homme ose démentir son propre cœur sur son libre arbitre, de peur de reconnoître son Dieu? D'un côté, dire que la liberté de l'homme est imaginaire, c'est étouffer la voix et le sentiment de toute la nature; c'est se démentir sans pudeur; c'est nier ce qu'on porte de plus certain au fond de soi-même; c'est vouloir réduire un homme à croire qu'il ne peut jamais choisir entre les deux partis sur lesquels il délibère de bonne foi en toute occasion. Rien n'est plus glorieux à la religion que de voir qu'il faille tomber dans des excès si monstrueux, dès qu'on veut révoquer en doute ce qu'elle enseigne. D'un autre côté, avouer que l'homme est véritablement libre, c'est reconnoître en lui un principe qui ne peut jamais être expliqué sérieusement par les combinaisons d'atomes, et par les lois du mouvement local, qu'on doit supposer toutes également nécessaires et essentielles à la matière dès qu'on nie le premier moteur. 11 faut donc sortir de toute l'enceinte de la matière, et chercher loin des atomes combinés quelque principe incorporel, pour expliquer le libre arbitre, dès qu'on l'admet de bonne foi.

Tout ce qui est matière et atome ne se meut que par des lois nécessaires, immuables et invincibles. La liberté ne peut donc se trouver, ni dans les corps, ni dans aucun mouvement local; il faut donc la chercher dans quelque être incorporel. Cet être incorporel qui doit se trouver en moi uni à mon corps, quelle main l'a attaché et assujetti aux organes de cotte machine corporelle? Où est l'ouvrier qui lie des natures si différentes? Ne faut-il pas une puissance supérieure aux corps et aux esprits, pour les tenir dans cette union avec un empire si absolu?

Deux atomes crochus, dit un Épicurien, s'accrochent ensemble. Tout cela est faux selon son système; car j'ai prouvé que ces deux atomes crochus ne s'accrochent jamais, faute de se rencontrer. Mais enfin, après avoir supposé que deux atomes crochus s'unissent en s'accrochant, il faudra que l'Épicurien avoue que l'être pensant qui est libre dans ses opérations, et qui par conséquent n'est point un amas d'atomes toujours mus par des lois nécessaires, est incorporel, et qu'il n'a pu s'accrocher par sa figure au corps qu'il anime. Ainsi l'Épicurien, de quelque côté qu'il se tourne, renverse de ses propres mains son système. Mais gardons-nous bien de vouloir confondre les hommes qui se trompent, puisque nous sommes hommes comme eux, et aussi capables de nous tromper; plaignons-les: ne songeons qu'à les éclairer avec patience, qu'à les édifier, qu'à prier pour eux, et qu'à conclure en faveur d'une vérité évidente.

Conclusion Générale

Tout porte donc la marque divine dans l'univers; les deux, la terre, les plantes, les animaux et les hommes plus que tout le reste. Tout nous montre un dessein suivi, un enchaînement de causes subalternes conduites avec ordre par une cause supérieure.

Il n'est point question de critiquer ce grand ouvrage. Les défauts qu'on y trouve viennent de la volonté libre et déréglée de l'homme, qui les produit par son dérèglement; ou de celle de Dieu, toujours sainte et toujours juste, qui veut tantôt punir les hommes infidèles, et tantôt exercer par les méchants les bons qu'il veut perfectionner. Souvent même ce qui paroît défaut à notre esprit borné, dans un endroit séparé de l'ouvrage, est un ornement par rapport au dessein général, que nous ne sommes pas capables de regarder avec des vues assez étendues et assez simples pour connoître la perfection du tout. N'arrive-t-il pas tous les jours qu'on blâme témérairement certains morceaux des ouvrages des hommes, faute d'avoir assez pénétré toute l'étendue de leurs desseins? C'est ce qu'on éprouve tous les jours pour les ouvrages des peintres et des architectes.

Si des caractères d'écriture étoient d'une grandeur immense, chaque caractère regardé de près oecuperoit toute la vue d'un homme; il ne pourroit en apercevoir qu'un seul à la fois, et il ne pourroit lire, c'est-à-dire assembler les lettres, et découvrir le sens de tous ces caractères rassemblés. Il en est de même des grands traits que la Providence forme dans la conduite du monde entier pendant la longue suite des siècles. Il n'y a que le tout qui soit intelligible, et le tout est trop vaste pour être vu de près. Chaque événement est comme un caractère particulier qui est trop grand pour la petitesse de nos organes, et qui ne signifie rien, s'il est séparé des autres. Quand nous verrons en Dieu à la fin des siècles, dans son vrai point de vue, le total des événements du genre humain, depuis le premier jusqu'au dernier jour de l'univers, et leurs proportions par rapport aux desseins de Dieu, nous nous écrierons: Seigneur, il n'y a que vous de juste et de sage.

On ne juge des ouvrages des hommes qu'en examinant le total: chaque partie ne doit point avoir toute perfection, mais seulement celle qui lui convient dans l'ordre et dans la proportion des différentes parties qui composent le tout. Dans un corps humain, il ne faut pas que tons les membres soient des yeux; il faut aussi des pieaset des mains. Dans l'univers, il faut un soleil pour le jour; mais il faut aussi une lune pour la nuit(i). C'est ainsi qu'il faut juger de chaque partie par rapport au tout: toute autre vue est courte et trompeuse. Mais qu'est-ce que les foibles desseins

des hommes, si on les compare avec celui de la création et du gouvernement de l'univers? Autant que le ciel est élevé au-dessus de la terre, autant, dit Dieu dans les écritures, mes voies et mes pensées sont-elles élevées au-dessus des vôtres. Que l'homme admire donc ce qu'il entend, et qu'il se taise sur ce qu'il n'entend pas.

Mais, après tout, les vrais défauts mêmes de cet ouvrage ne sont que des imperfections que Dieu y a laissées pour nous avertir qu'il l'avoit tiré du néant. Il n'y a rien dans l'univers qui ne porte et qui ne doive porter également ces deux caractères si opposés; d'un côté le sceau de l'ouvrier sur son ouvrage; de l'autre côté la marque du néant d'où il est tiré, et où il peut retomber à toute heure. C'est un mélange incompréhensible de bassesse et de grandeur, de fragilité dans la matière, et d'art dans la façon. La main de Dieu éclate partout, jusque dans un ver de terre. Le néant se fait sentir partout, jusque dans les plus vastes et les plus sublimes génies.

Tout ce qui n'est point Dieu ne peut avoir qu'une perfection bornée; et ce qui n'a qu'une perfection bornée demeure toujours imparfait, par l'endroit où la borne se fait sentir, et avertit que l'on y pourroit encore beaucoup ajouter. La créature seroit le créateur même, s'il ne lui manquoit rien; car elle auroit la plénitude de la perfection, qui est la divinité même: dès qu'elle ne peut être infinie, il faut qu'elle soit bornée en perfection, c'est-à-dire imparfaite par quelque côté. Elle peut avoir plus ou moins d'imperfection; mais enfin il faut toujours qu'elle soit imparfaite. I l faut qu'on puisse toujours marquer l'endroit précis où elle manque, et que la critique puisse dire: voilà ce qu'elle pouvoit encore avoir, et ce qu'elle n'a pas.

Concluons-nous qu'un ouvrage de peinture est fait par le hasard, quand on y remarque des ombres, ou même quelque négligence de pinceau? Le peintre, diton, auroit pu finir davantage ces carnations, ces draperies, ces lointains. I l est vrai que ce tableau n'est point parfait selon les règles. Mais quelle folie seroit-ce de dire: ce tableau n'est point absolument parfait; donc ce n'est qu'un amas de couleurs formé par le hasard, et la main d'aucun peintre n'y a travaillé! Ce qu'on rougiroit de dire d'un tableau mal fait et presque sans art, on n'a pas de honte de le dire de l'univers, où éclate une foule de merveilles incompréhensibles avec tant d'ordre et de proportion.

Qu'on étudie le monde tant qu'on voudra; qu'on descende au dernier détail; qu'on fasse l'anatomie du plus vil animal; qu'on regarde de près le moindre grain de blé semé dans la terre, et la manière dont ce germe se multiplie; qu'on observe attentivement les précautions avec lesquelles un bouton de rose s'épanouit au soleil, et se referme vers la nuit: on y trouvera plus de dessein, de conduite et d'industrie, que dans tous les ouvrages de l'art. Ce que l'on appelle même l'art des hommes n'est qu'une foible imitation du grand art qu'on nomme les lois de la nature,-et que les impies n'ont pas eu honte d'appeler le hasard aveugle.

Faut-il donc s'étonner si les poètes ont animé tout l'univers, s'ils ont donné des ailes aux vents, et des flèches au soleil; s'ils ont peint les fleuves qui se hâtent de se précipiter dans la mer, et les arbres qui montent vers le ciel, pour vaincre les rayons du soleil par l'épaisseur de leurs ombrages? Ces figures ont passé même dans le langage vulgaire: tant il est naturel aux hommes de sentir l'art dont toute la nature est pleine. La poésie n'a fait qu'attribuer aux créatures inanimées le dessein du créateur, qui fait tout en elles. Du langage figuré des poètes, ces idées ont passé dans la théologie des païens, dont les théologiens furent les poètes. Ils ont supposé un art, une puissance, une sagesse, qu'ils ont nommé numèn, dans les créatures même les plus privées d'intelligence: chez eux les fleuves ont été des dieux, et les fontaines des naïades: les bois, les montagnes ont eu leurs divinités particulières: les fleurs ont eu Flore, et les fruits Pomone. Plus on contemple sans prévention toute la nature, plus on y découvre par-tout un fonds inépuisable dé sagesse, qui est comme l'âme de l'univers.

Que s'ensuit-il delà? La conclusion vient d'elle-même. S'il faut tant de sagesse et de pénétration, dit Minutais Félix, même pour remarquer l'ordre et le dessein merveilleux de la structure du monde, combien à pins forte raison en a-t-il fallu pour le former! Si on admire tant les philosophes parce qu'ils découvrent une petite partie des secrets de celte sagesse quia tout fait, il faut être bien aveugle pour ne pas l'admirer elle-même.

Voilà le grand objet du monde entier, où Dieu, comme dans un miroir, se présente au genre humain. Mais les uns (je parle des philosophes) se sont évanouis dans leurs pensées; tout s'est tourné pour eux en vanité. A force de raisonner subtilement, plusieurs d'entre eux ont perdu même une vérité qu'on trouve naturellement et simplement en soi. sans avoir besoin de philosophie.

Les autres, enivrés par leurs passions, vivent toujours distraits. Pour apercevoir Dieu dans ses ouvrages, il faut au moins y être attentif. Les passions aveuglent à un tel point, non seulement les peuples sauvages, mais encore les nations qui semblent les mieux policées, qu'elles ne voient pas la lumière même qui les éclaire. A cet égard, les Égyptiens, les Grecs et les Romains n'ont pas été moins aveuglés et moins abrutis que les sauvages les plus grossiers;ils se sont ensevelis comme eux dans les choses sensibles, sans remonter plus haut, et ils n'ont cultivé leur esprit que pour se flatter par de plus douces sensations, sans vouloir remarquer de quelle source elles venoient.

Ainsi vivent les hommes sur la terre: ne leur dites rien; ils ne pensent à rien, excepté à ce qui flatte leurs passions grossières ou leur vanité: leurs âmes s'appesantissent tellement, qu'ils ne peuvent plus s'élever à aucun objet incorporel: tout ce qui n'est point palpable, et qui ne peut être ni vu, ni goûté, ni entendu, ni senti, ni compté, leur semble chimérique. Cette foiblesse de l'ame, se tournant en incrédulité, leur paroît une force, et leur vanité s'applaudit de résister à ce qui frappe naturellement le reste des hommes. C'est comme si un monstre se glorifioit de n'être pas formé selon les règles communes de la nature; ou comme si un aveugle-né triomphoit de ce qu'il seroit incrédule pour la lumière et pour les couleurs, que le reste des hommes aperçoit.

Prière A Dieu

O mon Dieu! si tant d'hommes ne vous découvrent point dans ce beau spectacle que vous leur donnez de la nature entière, ce n'est pas que vous soyez loin de chacun de nous. Chacun de nous vous touche comme avec la main; mais les sens, et les passions qu'ils excitent, emportent toute l'application de l'esprit. Ainsi, Seigneur, votre lumière luit dans les ténèbres, et les ténèbres sont si épaisses, qu'elles ne la comprennent pas: vous vous montrez par-tout, et par-tout les hommes distraits négligent de vous apercevoir. Toute la nature parle de vous, et retentit de votre saint nom; mais elle parle à des sourds, dont la surdité vient de ce qu'ils s'étourdissent toujours eux-mêmes. Vous êtes auprès d'eux et au dedans d'eux; mais ils sont fugitifs et errants hors d'eux-mêmes. Ils vous trouveroient, ô douce lumière, ô éternelle beauté toujours ancienne et toujours, nouvelle, ô fontaine des chastes délices, ô vie pure et bienheureuse de tous ceux qui vivent véritablement, s'ils vous cherchoient au dedans d'eux-mêmes; mais les impies ne vous perdent qu'en se perdant. Hélas! vos dons qui leur montrent la main d'où ils viennent, les amusent jusqu'à les empêcher de la voir: ils vivent de vous, et ils vivent sans penser à vous: ou plutôt ils meurent auprès de la vie, faute de s'en nourrir; car quelle mort n'est-ce point de vous ignorer! Ils s'endorment dans votre sein tendre et paternel; et pleins des songes trompeurs qui les agitent pendant leur sommeil, ils ne sentent pas la main puissante qui les porte. Si

vous étiez un corps stérile, impuissant et inanimé, tel qu'une fleur qui se flétrit, une rivière qui coule, une maison qui va tomber en ruine, un tableau qui n'est qu'un amas de couleurs pour frapper l'imagination, ou un métal inutile qui n'a qu'un peu d'éclat, ils vous apercevraient, et vous attribueraient follement la puissance de leur donner quelque plaisir, quoiqu'en effet le plaisir ne puisse venir des choses inanimées qui ne l'ont pas, et que vous en soyez l'unique source. Si vous

n'étiez donc qu'un être grossier, fragile et inanimé, qu'une masse sans vertu, qu'une ombre de l'être, votre nature vaine occuperoit leur vanité; vous seriez un objet proportionné à leurs pensées basses et brutales: mais parce que vous êtes trop au dedans d'eux-mêmes, où ils ne rentrent jamais, vous leur êtes un Dieu caché; car ce fond intime d'eux-mêmes est le lieu le plus éloigné de leur vue, dans l'égarement où ils sont. L'ordre et la beauté que vous répandez sur la face de vos créatures sont comme un voile qui vous dérobe à leurs yeux malades. Quoi donc! la lumière qui devroit les éclairer les aveugle! et les rayons du soleil même empêchent qu'ils ne l'aperçoivent! Enfin, parce que vous êtes une vérité trop haute et trop pure pour passer par les sens grossiers, les hommes rendus semblables aux bêtes ne peuvent vous concevoir: comme si l'homme ne connoissoit pas tous les jours la sagesse et la vertu, dont aucun de ses sens néanmoins ne peut lui rendre témoignage; car elles n'ont ni son, ni couleur, ni odeur, ni goût, ni figure,ni aucune qualité sensible. Pourquoi donc,ô mon Dieu, douter plutôt de vous que de ces autres choses très réelles et très manifestes dont on suppose la vérité. certaine dans toutes les affaires les plus sérieuses de la vie, et lesquelles, aussi bien que vous, échappent à nos faibles sens? O misère, ô nuit affreuse qui enveloppe les enfants d'Adam! ô monstrueuse stupidité! 6 renversement de tout l'homme! l'homme n'a des jeux que pour voir des ombres, et la vérité lui paroît un fantôme: ce qui n'est rien est tout pour lui; ce qui est tout ne lui semble rien. Que vois-je dans toute la nature? Dieu, Dieu partout, et encore Dieu seul. Quand je pense, Seigneur, que tout l'être est en vous, vous épuisez et vous engloutissez, 6 abîme de vérité, toute ma pensée;■ je ne sais ce que je deviens: tout ce qui n'est point vous disparoit, et à peine me reste-t-il de quoi me trouver encore moi-même. Qui ne vous voit point n'a rien vu; qui ne vous goûte point n'a jamais rien senti: il est ■ comme s'il n'étoit pas; sa vie entière n'est qu'un songe. Levez-vous, Seigneur, levez vous; qu'à votre face vos ennemis se fondent comme la cire, et s'évanouissent comme la fumée. Malheur à lame impie qui, loin de Tous, est sans Dieu, sans espérance, sans éternelle consolation! déjà heureuse celle qui vous cherche, qui soupire, et qui a soif de vous! mais pleinement heureuse celle sur qui rejaillit la lumière de votre face, dont votre main a essuyé les larmes, et dont votre amour a déjà comblé les désirs! Quand sera-ce, Seigneur?0 beau jour sans nuage et sans fin, dont vous serez vous-même le soleil, et où vous coulerez au travers de mon cœur comme un torrent de volupté! A cette douce espérance, mes os tressaillent, et s'écrient: Qui est semblable à vous? Mon cœur se fond, et ma chair tombe en défaillance . O Dieu de mon cœur, et mon éternelle portion!

1815
Jacques-Henri-Bernadin de Saint-Pierre, French Botanist
Harmonies De La Nature
Book on Botany and Natural Theology

Link at Google Book

L'auteur de la nature a subordonné d'abord les puissances élémentaires à la puissance végétale. Il dit à la terre, revêtue des simples éléments: » Produise* des plantes avec leurs fruits, s chacune suivant non genre. Aussitôt l'organisation se forma de la pensée du Tout-puissant, et la vie sortit de sa parole. Les plaines se rouvrirent de graminées ondoyantes, et les montagnes de majestueuses forêts; les saules argentés et les peupliers pyramidaux bordèrent les rivages des fleuves, et ombragèrent jusqu'à leurs embouchures. L'Océan même eut ses végétaux; de l'algue pourprée furent suspendues en guirlandes aux flancs de ses rochers; et des fucus, semblables à de longs câbles, s'élevèrent du fond de ses Abymes, et se jouèrent dans les flots azurés. Des cèdres et des sapins entourèrent de leur sombre verdure la région des neiges, et agitèrent leurs cimes autour des glaciers qui couronnent les pôles du monde. Chaque végétal eut sa température, depuis la mousse, qui, ne vivant que des reflets de l'astre du jour, tapisse les granits du nord, et offre, au sein de la zone glaciale, une chaude litière au renne qui voiture et nourrit le Lapon, jusqu'au palmier, qui, bravant les ardeurs de la zone torride, donne de l'ombre et des fruits rafraîchissants à l'Arabe et à

son chameau: chaque site eut son végétal, chaque animal son aliment, et chaque homme son empire.

Heureux qui a vu, dans, une île inhabitée et parée encore de ses grâces virginales, quelques-uns des genres innombrable des plantes que la nature y a déposés, suivant ses plans primitifs! Jamais la main d'une bergère n'assortit avec autant de goût, pour plaire à son amant, les fleurs de sa tête et de son sein, que la nature en a mis à grouper les diverses espèces de végétaux, depuis ses sables marins jusqu'aux sommets de ses montagnes, pour les besoins et les plaisirs des animaux et des hommes qui devaient y aborder.

Quel serait notre ravissement si nous pouvions voir la sphère entière des végétaux qui entourent le globe, avec les harmonies qui circonscrivent chacun de ses climats, et rayonnent .sous tous ses méridiens I Mais si nous ne pouvons voyager sur la terre, la terre voyage pour nous. Après nous avoir mis sous le ciel de la zone glaciale, elle nous transporte peu à peu sous celui de la torride, et nous offre tour à tour les végétaux de ses hivers et de ses étés. Déjà, dans sa course annuelle, elle tourne vers le soleil son pôle boréal, appesanti par une coupole de glaces de quatre à cinq mille lieues de tom'; et par une nuit et un hiver de six mois, perd sous l'équateur I équilibre de $c& deux hémisphères; elle en éloigne ensuite le pôle opposé, allégé de ses congélations par un jour et un été d'une durée presque égale. Notre hémisphère s'échauffe dans toute sa circonférence. Déjà la zone immense de neige qui couvrait l'Europe, la Sibérie, les vastes plaines de la Tartarie, les monts escarpés du Kamtchatka, et les sombres forêts de l'Amérique septentrionale, s'écoule au sein de l'Océan; le Groenland, le Spitsberg, la Nouvelle-Zemble, voient l'astre de la lumière tourner sans cesse autour de leur horizon. Des torrents larges et profonds comme des mers se dégorgent des détroits de Badin, de Davis, de Hudson, de Hischinbrock, de Waigats, et de celui du Nord, qui sépare l'Asie de l'Europe; ils entraînent en mugissant, vers l'équateur, des lies flottantes de glaces élevées comme des montagnes et nombreuses comme des archipels. Souvent elles s'échouent à douze cents pieds de profondeur. Cependant, soit qu'elles voguent avec les courants, soit qu'elles restent immobiles, elles se fondent et renouvellent les mers. De bruyantes cataractes se précipitent de leurs sommets, et dès brumes ténébreuses s'élèvent de leurs flancs; les vents étendent dans l'atmosphère leurs vapeurs à demi glacées, et les attiédissent aux rayons du soleil; ils les voiturent dans le sein des continents, et les roulent comme des voiles autour des pics des montagnes qui les attirent. Les unes remplissent les source* des fleuves; d'autres, suspendues au-dessus des vastes campagnes, se saturent des feux de l'astre du jour, et étincellent d'éclairs; le tonnerres,' fait entendre, et réjouit le laboureur. Des pluies fumes et tièdes . Pénètrent le sein des guérets; le blé forme son épi; il reçoit du ciel, dans ses feuilles étagées, de longs filets d'eau que, l'hiver, il ne pompait de la terre que par ses racines. Les feuilles naissantes, plissées avec un art céleste, rompent leurs étuis résineux, écailleux, laineux, qui les préservaient du choc des vents et de la morsure des gelées. Le gemma empourpré de la vigne, et le bourgeon cotonneux du pommier, se gonflent et se crèvent. Les rameaux des arbres, d'un beau rouge,sont parsemés dégouttes de verdure, et de boutons de fleurs blanches et cramoisies. La végétation, au berceau, entrouvre les bourcets de son enfance, et montre partout son visage riant. Des bouffées de parfum* s'élèvent du sein des prairies et des forêts avec les concerts des oiseaux. La vie végétale est descendue des cieux.

O toi, qui d'un sourire si naître le printemps, douce Aphrodite, belle Vénus, sois-moi favorable! Tu sors du sein des flots, entourée de Zéphyrs et d'Amours; fille du Soleil et de la Mer, brillante Aurore de l'année, viens me ranimer avec toute la nature! Les pointes et les peintres te représentent, sur notre horizon, devançant le char de ton père, attelé de chevaux fougueux conduits par les Heures; mais, lorsque tu te montres à l'équateur, sur l'horizon de notre pôle, tu es la mère de toutes les aurores qui doivent y apparaître. .Elles sortent de dessous ton manteau de pourpre, couvertes de perles orientales, et vêtues de robes de mille couleurs; les jours et les nuits les dispersent sur tous les sites du globe, au sommet des rochers, sur la surface des lacs, parmi les roseaux des fleuves,

dans les clairières des forêts. Pour toi, suivie des Saisons, tu couvres d'un seul jet les flancs cristallisés du pôle et ses vastes campagnes de neige, de ton voile de safran et de vermillon. Mère du printemps, couronne de tes roses naissantes ma tête, couverte de soixante-trois hivers; console-moi des ressouvenirs du passé, du malaise du présent, et des inquiétudes de l'avenir; ramène ma vieillesse à ces moments heureux de mon adolescence, lorsque, levé à tes premières clartés pour étudier de tristes leçons, l'âme flétrie par des maîtres imbéciles et cruels, à la vue de tes rayons je sentais encore que j'avais un cœur. Apparais-moi comme tu apparus à la création, lorsque notre globe terrestre, à ton premier aspect, tourna sur ses pôles et se couvrit de verdure; montre-toi à moi comme tu t'y montreras lorsque, dégagée du poids de mon argile, mon âme, s'élevant de la terre vers le soleil, abordera aux rivages d'un orient éternel!

Viens me guider dans ces vallées de ténèbres et sur ces champs de boue, que toi seule vivifies. Je désire rappeler a des hommes ingrats la route du bonheur qu'ils ont perdue, et la tracer à leurs enfants innocents. Je vais, à ta lumière, leur montrer sur la terre une divinité bienfaisante. Ma théologie n'aura rien de triste et d'obscur: mon école est au sein des prairies, des bois et des vergers; mes livres sont des fleurs et des fruits, et mes arguments des jouissances.

Je me suis étonné bien des fois de l'indifférence avec laquelle nous considérions le ciel, source de toutes nos richesses actuelles et de nos espérances futures. Nous serions ravis de joie, si nous voyions la sphère des végétaux qui couvrent la terre passer sous nos pieds; et nous regardons de sang-froid celle des astres rouler sur nos têtes!

Une fleur nous intéresse plus qu'une étoile, et le plus petit jardin que tout le firmament. Tous les arts nous développent dans les plantes une foule de propriétés et de formes charmantes; et nos sciences ne nous montrent dans les corps célestes que des globes arrondis par les lois uniformes de l'attraction. Faibles et vains, nous circonscrivons dans une seule idée ce que nous voyons d'un seul coup-d'œil: nous établissons le système de l'univers sur un aperçu. La plus petite mousse, par ses harmonies, élève notre intelligence jusqu'à l'intelligence qui veille aux destins de toute la terre, et l'astronomie fait descendre le matérialisme des astres jusque dans notre botanique, et l'apathie qu'elle leur suppose jusque dans noire morale.

Cependant, ce n'est que pour recueillir les diverses influences du soleil fixées dans les végétaux, et en alimenter notre vie, que nous labourons la terre, que nous bâtissons des magasins, que nos manufactures travaillent, et que nos vaisseaux traversent les mers. Mais, malgré tant de correspondances entre toutes les nations, tant d'observations mises bout à bout, tant de besoins qui devraient étendre nos lumières, les plantes ne sont guère mieux connues que les étoiles. La botanique, avec ses systèmes, ne nous présente, comme l'astronomie, qu'une triste et sèche nomenclature, et que des divisions sans intention et sans but.

Sans doute, il ne nous est pas donné de connaître sur la terre les harmonies des puissances sidérales. Celles qui ont des rapports avec nous par leur lever, leur coucher, leurs apparitions et leurs éclipses, et que nous prédisons des siècles h l'avance, sont au fond si superficielles, qu'elles ne méritent d'être mises en ligne de compte qu'à cause de notre extrême ignorance et de nos misères. Fussions-nous des Copernic, des Newtons, des Herschells, nous ne pouvons pas plus nous vanter de les connaître, que de pauvres mendiants les grands seigneurs qui, en passant à des jours réglés sur leur chemin, leur jettent de loin quelques aumônes,sans qu'ils sachent les noms, les caractères et les occupations de leurs bienfaiteurs: encore savent-ils que ce sont des hommes comme eux. Mais comment pourrions-nous connaître la nature du soleil, quand nous ignorons celle d'un grain de sable? Cependant, puisque la puissance végétale est à notre égard la médiatrice de ses bienfaits, et que c'est sur elle qu'est greffée la vie des animaux et la nôtre, servons-nous-en pour nous élever jusqu'à lui. Nous essaierons de connaître la nature de l'astre du jour par l'examen de tant de fleurs

et de fruits qu'il fait éclore pour nos besoins, et qu'il met en évidence dans toute la circonférence du globe. La cause qui les développe pourra nous servir à les étudier eux-mêmes.

Le nombre prodigieux des végétaux jetés comme au hasard dans les prairies et dans les forêts, nous présente un spectacle très agréable. Je ne doute pas qu'il n'y ait entre les fleurs un véritable ordre au milieu même de leur confusion apparente; mais je ne sais par où je dois commencer à le développer.

Cherchons d'abord les deux bouts du fil qui doit nous guider dans ce labyrinthe.

Il est évident que le soleil est la première cause de la végétation, et que l'homme en est la dernière fin. L'homme seul, des âtres vivants, ramène à son usage toutes les latitudes, tous les sites, tous les végétaux, tous les animaux: telles sont les deux extrémités de la chaîne des puissances, qui forme, par sa révolution, la sphère des harmonies. Le soleil en est la circonférence, et l'homme le centre: c'est à l'homme qu'en aboutissent tous les rayons. Ceci posé, je considère l'homme sous l'influence directe du soleil, au milieu de la zone torride, où il a dû d'abord prendre naissance, parce que là seulement se trouvent tous les végétaux nécessaires à ses premiers besoins, et qu'il ne lui faut aucune industrie pour en faire usage. En observant donc sa constitution, je le trouve composé de plusieurs substances et humeurs qui doivent sans cesse se renouveler comme sa vie: tels sont les nerfs, les os, les chairs, la peau, les veines, la lymphe, le sang, la bile, le chyle, et plusieurs autres fluides dont les rapports sont aussi peu connus que les vaisseaux mêmes où ils circulent. Pour fournir à leur réparation journalière, la nature a créé d'abord des aliments qui leur étaient analogues, tels que les farineux, les rafraîchissants, les sucrés, les vineux, les huileux, les aromatisés, etc. Elle les a renfermés tout préparés dans les fruits du bananier, de l'oranger, dans la canne à sucre, dans ceux du manguier, du cocotier, des arbres à épices, etc. Elle y a joint, pour ses besoins extérieurs, d'autres arbres, pour lui fournir des toits, des vêtements et des meubles: tels sont les palmiers de tant d'espèces si variées; le cotonnier, dont la bourre est si propre à lui fournir des étoffes légères; le bambou, dont les scions sont si flexibles; et le calebassier, dont le fruit est susceptible de prendre la forme de toutes sortes de vases. Mais le bananier aurait pu suffire seul à toutes les nécessités du premier homme. Il produit le plus salutaire des aliments dans ses fruits farineux, succulents, sucrés, onctueux et aromatiques, du diamètre de la bouche, et groupés comme les doigts d'une main. Une seule de ses grappes fait la charge d'un homme. Il présente un magnifique parasol dans sa cime étendue et peu élevée, et d'agréables ceintures dans ses feuilles d'un beau vert, longues, larges et satinées: aussi ce végétal, le plus utile de tous les végétaux, porte-t-il le nom de figuier d'Adam. C'est sous son délicieux ombrage, et au moyen de ses fruits qu'il renouvelle sans cesse par ses rejetons, que le bramine prolonge souvent au-delà d'un siècle le cours d'une vie sans inquiétude. Un bananier, sur le bord d'un ruisseau, pourvoit à tous ses besoins.

Mais, soit que le bananier n'ait été créé que pour le sage qui aime la vie sédentaire et méditative, soit qu'il ne puisse pas croître même dans son climat lorsqu'il n'a pas d'eau en abondance, soit plutôt que la nature ait voulu servir sur la table de l'homme des aliments aussi variés par leur saveur que l'organe de son goût en est susceptible; il est certain que les arbres de la zone torride portent des fruits délicieux de divers genres, dont les espèces sont innombrables.

Il est digne d'observation que la substance farineuse fait la base de la plupart de ces fruits, tels que ceux de l'arbre à pain; même dans les huileux, comme ceux du cocotier; qu'elle est renfermée en masse dans un grand nombre de racines, comme les Cambas, les ignames, les maniocs, les patates; et dans les troncs même de quelques arbres, comme dans celui du palmier sagou; dans les graines d'une infinité de plantes, telles que les légumineuses, et sur - tout dans celles des graminées, comme les riz, les maïs, les blés, etc. Elle y est assaisonnée, tantôt avec le sucre, tantôt avec le vin, tantôt avec l'huile; et elle y est relevée, dans chaque espèce de fruit, par un aromate qui lui est propre, et qui en détermine le goût. Il y a plus, c'est que de la substance farineuse toute pure,

l'art peut extraire, par la fermentation, une partie des saveurs primitives qu'y a déposées la nature, telles que les sucrées, les vineuses, les acides, les huileuses même, comme le prouvent les divers états par où passe la bière, qui, comme on sait, se fabrique avec l'orge. Il n'est pas douteux que notre estomac ne décomposé cette substance encore mieux que les meilleurs alambics. Je pense donc qu'elle a des analogies particulières avec nos solides et nos fluides, puisqu'elle est si répandue dans la puissance végétale.

Les besoins de l'homme varient avec les latitudes. Est-il dans les zones tempérées? Je vois s'élever pour lui des blés et des plantes légumineuses de diverses espèces; des châtaigniers, des vignes, des pommiers, des oliviers, des noyers, etc., et dans les végétaux qui doivent le mettre à l'abri des éléments, des lins et des chanvres pour le vêtir, et des chênes et des hêtres qui lui présentent des toits inébranlables. Porte-t-il ses pas jusque dans les zones glaciales, où semble expirer la végétation? Je vois la folle avoine border les fleuves du nord de l'Amérique, et les champignons et les mousses, dont quelques espèces sont comestibles, tapisser les rochers de la Finlande et de la Laponîc. Des forêts de sapins résineux et pyramidaux, et des bouleaux inflammables, lui donnent des abris contre les neiges,et fournissent des aliments à son foyer. La nature vient encore a son secours, en lui présentant des chasses abondantes d'animaux revêtus d'épaisses fourrures, et des pêches de poissons innombrables, dont les saveurs sont souvent préférées à celles des meilleurs fruits; mais son plus riche présent est sans doute le renne, qui lui fournit son lait comme la vache, son poil laineux comme la brebis, et sa force et sa vitesse comme le cheval.

Ce que la nature a fait en général pour l'homme, elle l'a fait en particulier pour les animaux. Chacun de leur genre, dans les quadrupèdes, oiseaux, reptiles, insectes et poissons, a une espèce de végétal réservée à ses besoins: de manière, toutefois, que l'homme a au moins, dans chaque genre, une espèce qui lui est assignée, et qui est le prototype de ce genre: tels sont le blé dans les graminées, le dattier dans les palmiers, et les autres végétaux qu'il cultive, et que, pour cette raison, on peut appeler domestiques. Il en est de même des animaux qui en portent le nom, et qui, par la supériorité de leurs qualités, paraissent être aussi les prototypes de leur genre: tels sont la poule dans les gallinacés, la vache dans les herbivores, le renne dans les cerfs, le chien dans les carnivores, etc. Mais ne sortons point ici des limites de l'harmonie végétale.

On peut conclure de tout ce que nous venons de dire, qu'il y a encore beaucoup de végétaux utiles qui nous sont inconnus; car il s'en faut bien que chaque genre de végétaux nous fournisse, par toute la terre, une espèce en rapport immédiat avec nos besoins, En Europe, chaque génération semble en apporter quelques - uns de nouveaux, mais dont plusieurs n'ont que des usages relatifs. Nous usons, depuis trois siècles, du thé de la Chine, du café de l'Arabie, des sels de la canne- à sucre de l'Inde, du cacao et de la vanille du Mexique; du tabac et de la pomme de terre de l'Amérique septentrionale, que nous avons naturalisés: mais il en est d'autres, sans doute, à découvrir dans notre propre climat. Pourquoi, par exemple, les peuples du nord de l'Europe ne trouveraient-ils pas dans le genre si varié des pins qui couvrent leurs terres, une espèce dont les pignons fussent comestibles, ou qu'après diverses préparations ils pourraient appliquera leur usage? C'est ainsi que les Orientaux ont tiré parti de la graine coriace et acerbe du café par la torréfaction, et les peuples méridionaux de l'Europe, du fruit amer de l'olivier par des lessives.

Si, d'un côté, les divers genres des végétaux, et leurs espèces, ont des rapports déterminés avec l'homme et les animaux, de l'autre, ils en ont avec le soleil, suivant les latitudes où ils croissent. Un des plus apparents est celui de leurs fleurs. Les fleurs ont des réverbères ou des pétales pour révéler les rayons de l'astre du jour sur leurs parties sexuelles, afin d'en accélérer la fécondation. En général, celles-ci, dans les zones froides, sont adossées à des épis ou à des cônes perpendiculaires, solides et caverneux, qui reçoivent les rayons du soleil, depuis l'instant où il apparaît sur l'horizon, jusqu'à celui où il se couche, et pendant tout l'été, ils jouissent de sa chaleur, qu'ils réfléchissent sur les anthères, les stigmates et les ovaires de la fleur. Dans les noues

tempérées, les réverbères eu pétales sont en général horizontaux et passagers: de sorte qu'ils ne réfléchissent la lumière du soleil que lorsqu'il est élevé sur l'horizon, et seulement un petit nombre de jours;mais leurs reflets sont plus ou moins concentrés, suivant les sites qu'ils doivent occuper: tels sont ceux des radiées, qui sont eu miroirs plans; des rosacées, en portions sphériques, des liliacées en ellipses. L'ordonnance de leurs fleurs suit les mêmes dispositions; car il y en a d'agrégées en ombelles, en grappes, en sphères, en hémisphères et an corymbes. Dans la zone torride, les fleurs à grands pétales sont en moindre nombre, et n'éclosent guère qu'a l'ombre même des rameaux qui les portent, ou bien elles ont des courbes paraboliques et divergentes comme celles de la capucine du Pérou, ou elles sont papilionacées, et leurs parties sexuelles sont recouvertes par une carène; ce genre produit les grains légumineux, et présente des espèces très nombreuses. Les épis des graminées se subdivisent en une multitude d'épillets divergents; de sorte qu'ils ont peu de réflexion: tel est celui du riz. Celui du maïs, au contraire, y est revêtu de plusieurs pellicules. Enfin, le port même des arbres les plus communs dans la zone glaciale et dans la zone torride, parait soumis aux mêmes harmonies; car les sapins de la première sont perpendiculaires et pyramidaux, comme leurs cônes, qu'ils exposent, par étages, à tous les aspects du soleil, tandis que les palmiers de la seconde ont des cimes étendues qui en tempèrent les ardeurs, et ombragent leurs fruits en grappes pendantes. La nature emploie aussi les différentes nuances des couleurs pour accroître ou affaiblir les réverbérations des pétales, suivant les sites, les climats et les saisons; de manière que plusieurs végétaux naturels au Nord et au Midi peuvent croître dans les climats tempérés, et réciproquement. Mais nous avons parlé suffisamment de ces rapports solaires et de leurs compensations dans nos Etudes de la Nature. Puisque les formes et les couleurs des fleurs du végétaux sont en harmonie avec le soleil, et lui doivent leurs développements, je suis porté à croire que leurs fruits, et même leurs tiges entières, lui sont redevables de leurs vertus harmonises avec les divers besoins des tempéraments de l'homme et des animaux. Puisque le cours annuel du soleil ajoute, chaque année, un cercle au tronc des arbres, et que ses rayons colorent de blanc, de jaune, d'orangé, de rouge, de pourpre et de bleu, le sein de leurs fleurs, suivant leurs genres, pourquoi ne transmettraient - ils pas les saveurs acides, sucrées, vineuses, huileuses, aromatisées, dans le sein des fruits, dont les fleurs ne sont que les berceaux? Tous les végétaux ont, sans doute, dans chaque genre, des caractères déterminés, qui se reproduisent par des sexes, et qui sent fixés d'une manière invariable par l'auteur de la nature: mais leurs sexes mêmes pourraient fort bien n'être que des agents des influences du soleil, qui s'harmonient en saveur dans leur ovaire, comme sa lumière s'harmonie en couleur dans leurs pétales. En effet, les qualités des plantes paraissent plutôt solaires que terrestres. On n'en doutera pas si on se souvient que leurs saveurs sont bien plus développées dans la zone torride que dans les autres zones. C'est là que se trouvent, par excellence et en plus grand nombre, celles qui renferment des acides, du sucre, des huiles, des épiceries, des parfums, comme nous le vert avons ailleurs. Il y a plus, c'est que toutes les qualités des plantes en général sont si passagères, qu'elles s'évanouissent entièrement par leur décomposition. Leur analyse chimique ne présente que des captd mortuum et des résultats semblables, soit qu'elles soient alimentaires, ou vénéneuses Le savant chimiste Homberg a prouvé cette vérité par des expériences réitérées qu'il a faites sur un millier de nos végétaux. J'en conclus donc que leurs vertus, si variées, et si actives tandis qu'elles existent, ne sont que des émanations du soleil, fugitives comme la vie qu'il leur prête.

Cependant la puissance végétale se combine aussi avec les autres puissances. Pour nous former une idée de leurs divers rapports, nous en allons présenter l'ensemble; nous entrerons ensuite dans de plus grands détails, et nous fuirons, suivant notre plan général, par appliquer toutes ces puissances aux besoins des hommes, objets principaux de nos études.

La puissance végétale présente, comme chacune des autres puissances, treize harmonies. La première est céleste, ou soli lunaires; six sont physiques, et six sont morales. J'appelle les premiers soli lunaires, parce que la lune influe sur elle conjointement avec le soleil. Dans les six physiques, trois sont élémentaires, l'aérienne, l'aquatique, la terrestre; trois sont organisées, la végétale,

l'animale et l'humaine. Dans les murales, il y en a pareillement trois élémentaires, la fraternelle, la conjugale, la maternelle; et trois organisées ou sociales, la spécifiant, la générique et l'asphérique.

Ces harmonies vont eu progression de puissance, de manière que la seconde réunit en elle et accroît les facultés de la première; lu troisième, celles de la seconde; ainsi de suite jusqu'à la sphérique, qui non seulement se compose de celles des espèces et des genres, mais, pur ses révolutions, tend sans cesse vers l'infini.

Ces harmonies sont si vieilles et si constantes, que les différents systèmes des botanistes reposent tous sur quelques-unes d'entre elles, comme nous le verrons; et s'ils sont restés imparfaits, c'est qu'ils ne les ont pas embrassées en entier.

Quelque étendu pic soit l'ordre harmonique, nous espérons en donner une idée précise, en fixant d'abord l'attention de nos lecteurs sur la plante qui produit le blé: elle est la plus facile à saisir par la simplicité de ses formes. Nous la regardons comme le prototype du genre des graminées, dont les espèces sont si nombreuses; et, sans contredit, de toutes les plantes, c'est celle qui nous intéresse davantage. Pourquoi, d'ailleurs, irions - nous chercher des preuves d'une Providence dans les cèdres du nord, ou dans les palmiers de la zone torride, quand l'ordre général de l'univers est à nos pieds, et peut se démontrer dans une paille?

Le blé a des harmonies avec le soleil, par le peu d'élévation de sa plante, qui en est échauffée dans toute sa circonférence par ses feuilles linéaires et un peu concaves, qui en réfléchissent les rayons à son centre; par les reflets de la terre qui l'environne et qui renvoie sur lui la chaleur dont elle se pénètre. C'est un des avantages des sites humbles sur ceux qui sont élevés, de jouir des plus petites faveurs des éléments, et d'être à l'abri de leurs révolutions. Aussi les herbes poussent-elles plus tôt et plus vite que les arbres. Le blé a encore d'autres rapports avec l'astre du jour par l'élévation de sa tige, couronnée d'un épi mobile, caverneux, et à plusieurs faces, qu'il présente dans une attitude perpendiculaire a ces rayons du soleil, afin qu'ils le réchauffent depuis l'aurore jusqu'au couchant. Les reflets de la chaleur y sont si sensibles, que, lorsqu'on observe une moisson en plein midi, il semble qu'il en sorte une flamme et que les épis soient lumineux. On peut trouver aussi des harmonies lunaires dans le nombre de nœuds qui divisent la paille du blé. Ils sont en nombre égal à celui des mois lunaires pendant lesquels elle a poussé, jusqu'à la formation de son épi; mais nous parlerons, à l'harmonie des genres, de celle des végétaux avec l'astre des nuits.

Le blé a des harmonies aériennes, par ses trachées, qui, comme nous l'avons dit ailleurs, sont les poumons des plantes; par ses feuilles linéaires et horizontales, qui ne donnent point de prise aux vents; par sa tige conique, élastique et creuse, fortifiée de nœuds plus fréquents vers sa racine, où elle avait plus besoin de force que vers son épi. Chacun de ses nœuds est encore fortifié par une feuille, dont la partie inférieure lui sert de gaine. Au moyen de ces dispositions, elle joue sans cesse avec les zéphyrs, qui lui font décrire les courbes les plus agréables, et elle résiste aux tempêtes qui renversent les chênes.

Les harmonies aquatiques du blé se manifestent dans ses feuilles, creusées en échoppe, qui conduisent l'eau des pluies vers ses racines, qui, de leur côté, pompent l'eau souterraine, dont les vapeurs forment les rosées. Ce dernier moyen suffit à sa nutrition. On en voit la preuve en Egypte, qui produit de si belles moissons, et où il ne pleut presque jamais; mais la terre est abreuvée par les débordements du Nil. J'ai vu moi-; même des exemples remarquables de l'action des seules rosées dans le sol toujours altéré des environs de Paris. J'y ai vu un été si sec, qu'il ne tomba pas une goutte de pluie dans les mois de mars, d'avril et de mai; cependant la récolte du blé fut encore assez bonne. Sa paille était courte, mais son grain était bien nourri. Il a aussi des harmonies négatives avec l'eau par les balles de son épi. Ces balles sont ce que les botanistes appellent calices dans les autres Heurs. (Se sont des espèces d'étuis polis, minces et élastiques, qui paraissent

destiné* à plusieurs usages. Elles sont disposées par sillons droits ou en spirales, qui réverbèrent les rayons du soleil sur les fleurs. Elles enveloppent les grains, et les empêchent d'être endommagés dans leur croissance, par le choc mutuel de leurs épis agités par les vents. Enfin, chacune d'elles est surmontée souvent par une longue aiguille molle, appelée barbe, qui paraît destinée, non à éloigner les oiseaux, comme dit Océron, mais a diviser les gouttes de pluie, qui feraient couler les Heurs, comme il arrive presque toujours à celles du sommet, qui en sont les moins abritées. Os balles, avec leurs barbes, sont des espèces d'aiguilles anti-hydrauliques. En effet, on les emploie dans les emballages, pour préserver les corps secs de l'humidité. Mais lorsqu'elles s'ente ouvrent dans la maturité du grain, et que des pluies trop abondantes, réunies à de grands vents, comme celles des orages en été, viennent à tomber sur les campagnes, alors elles se remplissent d'eau; la paille, surchargée par son épi, s'incline, e\ la moisson verse. Elle se relève toutefois, lorsqu'elle n'a pas été semée trop épaisse, ou que le champ n'a pas été trop fumé; car alors les tiges, un peu fortes, étant inclinées, se servent mutuellement d'obstacles. J'ai remarqué, même dans les moissons versées, que les tiges isolées se maintenaient toujours debout. Ainsi, la nature a mis en rapport les proportions de cette faible plante avec la fureur des éléments.

Le blé a des harmonies avec la terre par ses racines, divisées par filaments, qui y pompent leur nourriture. Elles ne sont ni longues ni nombreuses; mais elles y adhèrent si fortement, qu'on ne peut les enlever sans emporter une portion du sol, ni rompre la paille, à cause de sa dureté. Voilà, sans doute, les raisons qui obligent les laboureurs de scier ce végétal plutôt que de l'arracher. Ces rapports terrestres lui sont communs' avec beaucoup d'autres végétaux; mais ce qu'il a de particulier, c'est qu'il n'y a aucune partie du globe où ne puisse croître, quelqu'une de ses espèces, depuis le riz du Gange jusqu'à l'orge de la Finlande. Il est cosmopolite comme l'homme: aussi Homère, si heureux dans ses épithètes, appelle la terre porte blé.

Telles sont les harmonies soli lunaires, et les aériennes, aquatiques et terrestres du blé. Celles qu'il a avec les puissances organisées sont au nombre de trois, comme les élémentaires proprement dites: ce sont la végétale, l'animale et l'humaine.

Les harmonies végétales du blé sont celles que les différentes parties de sa plante ont entre elles, et qui en constituent les proportions, l'ensemble, le port et les attitudes. Les botanistes ne les ont encore guère étudiées; cependant ce sont elles qui, du premier coup-d'œil, la font connaître aux paysans. Elles la distinguent de toutes les autres graminées, et lui composent un caractère propre. Telles sont, par exemple, les distances proportionnelles qui sont entre ses nœuds, dont les tuyaux sont d'autant plus courts qu'ils sont puis voisins de sa racine; les couleurs de ses feuilles, les formes de son épi, la touffe de sa plante, qui produit plusieurs tiges. Le blé a encore des relations en consonance avec les individus de sa propre espèce; leur réunion forme des tapis du plus beau vert, et de vastes moissons ondoyantes sous le souffle des vents. Enfin, il en a en contraste avec des plantes d'un autre genre, telles que les cou vol vu lus, les bluets, les coquelicots; mais sur-' tout avec les légumineuses, comme nous le verrons dans les harmonies morales.

Les harmonies animales du blé consistent principalement dans la longueur de ses feuilles, dans la souplesse et la tendreté de ses tiges, qui invitent tous les animaux pâturants à le brouter, et même à y faire leur litière. Au milieu de ses tiges, plus nombreuses et plus rapprochées que les arbres d'une forêt, il offre des asiles assurés au lièvre peureux, qui y fait son gîte; il en donne aussi à plusieurs oiseaux, qui y déposent leurs nids, tels que la caille voyageuse, la perdrix domiciliée, l'alouette, etc. C'est là qu'ils trouvent des subsistances eu tout temps, d'abord dans ses feuilles et dans leurs insectes, puis dans son grain farineux, dont la forme oblongue semble taillée pour leur bec.

Le blé a des rapports encore plus marquas et plus étendus avec les hommes. Ce sont eux seuls qui en ont couvert, par la culture, une grande partie du globe; el il est bien remarquable qu'il ne se

ressème point de lui-même comme tant d'autres plantes. Et dis-je des botanistes assurent qu'on ne le trouve nulle part dans son état naturel: comme si la Providence s'était reposée sur les hommes seuls du soin de le perpétuer, l'effet, il leur fournit les moyens de satisfaire, par toute la terre, aux principaux besoins de la vie. Ils trouvent dans sa paille le premier aliment du feu, des lits, des toits, des liens, des nattes, des' paniers, et des trajectiles même pour passer les fleuves, à cause de l'air renfermé dans ses chalumeaux. Sa farine leur donne, dans le pain, la plus substantielle et la plus durable des nourritures végétales. Ils en tirent une multitude de préparations agréables et de- boissons cordiales, par les arts de la boulangerie, de la pâtisserie, de la brasserie et de la distillation. Ils peuvent nourrir, avec des aliments tirés du blé seul, tous les animaux domestiques, soutiens de leur vie; i,

pore, la poule, le canard, le pigeon, la brebis, la chèvre, le cheval, la vache, le chat et le chien, qui, par une métamorphose merveilleuse, leur rendent en retour des œufs, du lait, du lard, de la laine, des services, des affections et de la reconnaissance. Le blé a non seulement rassemblé autour des hommes des animaux de différents genres, mais il est devenu le premier lien des sociétés humaines, parce que sa culture et ses préparations exigent de grands travaux et des services mutuels. Or, comme aucune société ne peut subsister sans lois, c'est donc au blé qu'en est due l'origine. C'est par cette raison, sans doute, que les anciens ont appelé Cérès législatrice.

Telles sont les harmonies solaires et physiques, tant élémentaires qu'organisées, du blé. Elles existent pareillement dans les autres espèces et genres de végétaux; mais elles y éprouvent une infinité de modifications qui les diversifient. Nous tâcherons d'en donner un aperçu, aux harmonies spécifiant et génériques. Bornons-nous ici aux harmonies morales du blé, afin de, fixer notre attention sur un seul objet. Elles sont au nombre de six, comme les physiques. Trois sont élémentaires, comme elles: la fraternelle, la conjugale, la maternelle; et trois sont sociales ou agrégées: la spécifiant, la générique et la sphérique.

Avant d'en présenter le développement, nous nous permettrons quelques réflexions sur la différence des harmonies physiques aux morales. Les physiques appartiennent aux végétaux en particulier; et les morales, à la puissance en général. Les physiques leur sont relatives et nécessaires; elles varient d'espèce à espèce et de genre a genre; les morales leur sont propres et essentielles: les physiques diffèrent dans chaque puissance, et les morales sont communes à toutes. Par exemple, une plante ne voit, n'entend et ne se meut point comme un animal; mais elle a comme lui ses amours, sa postérité, sa tribu. On entrevoit déjà que les lois physiques sont d'un ordre inférieur aux lois morales, puisque celles-ci constituent les puissances, les propagent, les spécifient, les engendrent, et les assemblent toutes par des harmonies semblables. Les harmonies physiques semblent appartenir aux éléments, qui ne leur donnent que des développements passagers, tandis que les morales tirent du ciel leur origine et une constitution permanente, en rapport avec celle qui harmonie, le soleil avec les corps planétaires. Ces caractères célestes se montrent surtout dans les puissances organisées, qui tirent sans cesse une vie nouvelle du soleil, et qui n'apparaissent sur la terre que pour l'accroître de leurs débris. Le soleil semble être le berceau de toutes leurs vies, tandis que la terre n'est que le tombeau de toutes leurs morts.

Mais laissons là ces harmonies, qui sont au-dessus de la conception humaine. Bornons-nous à celles du blé. La première de ses harmonies morales est la fraternelle; c'est celle qui a d'abord assemble chaque individu dans les puissances organisées en deux parties égales, afin qu'elles puissent s'entraider. Elle se manifeste premièrement dans cette sphère vivante du soleil, divisible en une infinité de moitiés parfaitement égales. On peut l'entrouvert aussi dans l'harmonie de l'astre des jours et de celui des nuits, inégaux sans doute en grandeur et en puissances, mais qui apparaissent sur les horizons de la terre avec des diamètres égaux, et lui distribuent tour à tour des influences fraternelles et sororales. Notre globe même présente quelques apparences de cette harmonie dans ses deux hémisphères, oriental et occidental; mais l'ancien monde y est plus étendu que le

nouveau, et leurs projections sont différentes, quoique leurs parties principales soient semblables. Aucun minéral, d'ailleurs, ne présente de pareilles consommateurs: elles n'appartiennent qu'aux êtres doués d'une vie organisée. Elles sont en évidence dans les feuilles, les fleurs, les anthères, les semences des végétaux, formés chacun de deux moitiés égales. Cet équilibre de parties doubles est encore plus général dans Us animaux, dont tous les membres se correspondent exactement; et il y est si nécessaire, que sans lui ils ne pourraient ni voler, ni marcher, ni manger. L'homme en présente le plus parlait modèle dans tes proportions. Imitateur dire par sentiment, de tons les ouvrages de la nature, il a puisé dans cet équilibre l'idée de la symétrie, qui n'est que la correspondance fraternelle de deux moitiés égales. Elle apparaît dans les formes qu'il donne à ses meubles, à son habitation, à ses monuments. Il trouve par tout des images de cette double consonance répandue parmi les êtres organisés. La nature a suspendu d'abord la lampe de la vie à deux chaînes pour l'affermir, et ensuite a quatre pour la propager: ainsi elle a fait précéder l'harmonie conjugale par l'harmonie fraternelle.

Cette première consonance est si évidente dans les végétaux même, que Linneus en a faits un des principaux caractères de son système botanique, sous le nom grec qui signifie ‘fraternité.’ Il ne la rapporte qu’à l'assemblage des anthems en un même corps; mais il ne lui a pas donné assez d'étendue. Elle établit d'abord l'organisation de toute espèce de végétal. Elle existe dans la feuille, la paille, l'épi, les anthères et les grains du blé, tous divisibles en deux moitiés communautés et égales, suivant leur direction verticale ou céleste: ce qui est très remarquable, car ces parties ne présentent que des moitiés contrastantes, suivant leurs dix liens horizontales ou terrestres. L'adelphique se manifeste également dans les rejetons de la touffe du Lié, qui poussent des feuilles, des tiges, des épis semblables, et forment entre eux une famille dont les individus s'entre supporte mutuellement.

Les harmonies conjugales du blé sont renfermées dans sa fleur. La fleur est l'organe de la fécondation de la plante en rapport avec le soleil; elle a souvent une corolle, ou petite couronne, formée de feuilles appelées pétales, qui réfléchissent les rayons sur ses parties sexuelles. Elle a souvent aussi un calice, ou enveloppe extérieure, pour la préserver du choc des vents, surtout dans les végétaux dont les tiges sont longues et mobiles. Quant aux parties sexuelles, elles sont au centre de la fleur, comme dans un foyer de réverbère. Elles sont composées d'une partie mule et d'une partie femelle; la partie mâle s'appelle étamine. Elle est formée de l'anthère, ainsi nommée du mot grec un des noms de l'Amour. Cette anthère est un corps pour l'ordinaire oblong, divisé en deux lobes, et porté en équilibre par un fort filet, délié à son extrémité. Lorsque le soleil a exercé sur lui son action, ses lobes se remplissent d'une poussière prolifique appelée pollen. Le pollen, dont le nom vient de polaire, pouvoir, féconde le pistil. Le pistil est l'organe femelle de la fleur qui surmonte l'ovaire: il se prolonge ordinairement en un ou plusieurs styles ou filets, terminés par un ou plusieurs stigmates. Le stigmate est une petite ouverture qui reçoit le pollen, pour féconder l'ovaire, et y former lu semence au sein d'un réceptacle, appelé aussi placenta. On entrevoit déjà que les parties sexuelles des plantes ont une grande analogie avec celles des animaux, et que la génération doit s'y opérer par les mêmes lois. Ces sexes, qui sont séparés dans quelques végétaux, comme dans les animaux, sont réunis dans la plante du blé. Ie blé a des caractères qui lui sont communs avec toutes les graminées, dans ses antlières, qui sortent de sa Heur et y sont suspendues, afin sans doute qu'elles fussent plus, exposées à l'action du soleil; dans non calice, de deux parties, et dans sa corolle, divisée en deux valvules unies, enlevés et creusées en courbes, cou caves et réverbérantes; mais elle en a qui lui sont propres, en ce qu'elle a quatre Heurs renfermées dans un seul calice. Cette configuration en forme d'épi,est la plus convenable aux Heurs des plantes des pays froids, parce que leurs pétales, quoique moins apparents, y sont solides et durables: aussi y este Ile la plus commune, Lorsque les blés sont en Heur, c'est alors qu'ils sont revêtus de' toute leur magnificence. Le coquelicot éblouissant, le Iduet azuré, la nielle pourprée, le liseron couleur de chair, relèvent de l'éclat de leurs Heurs l'aimable verdure des guérets. Les perdrix et les cailles y décèlent leurs doux asiles par leurs chants amoureux; tandis que l'alouette, suspendue au-dessus de

sa compagne et de son nid, fait entendre les siens au haut des airs. L'époque de la beauté, dans tous les êtres organisés, est celle de leurs amours.

Les harmonies maternelles du blé consistent dans les précautions avec lesquelles la nature a recouvert son grain, et pourvu au développement de son germe. Tantôt, suivant les espèces, son calice, qui lui tient lieu de placenta i lui est adhérent, et le transporte au loin, comme une voile, par l'entremise des vents; tantôt, par la barbe qui termine son calice, il s'accroche aux poils des quadrupèdes et voyage avec eux. Il reste aussi indigestible dans l'estomac de ceux qui ne ruminent pas, et se ressème avec leurs excréments. Enfin, sa forme carénée le rend propre à flotter longtemps sur les eaux, comme il arrive, par les mauvaises administrations, à celui qui est jeté dans les rivières. Son grain est revêtu d'une peau épaisse, appelée son, lorsqu'elle est séparée de sa farine. Il renferme, à une de ses extrémités, un germe revêtu d'une petite gaine, qui, en se gonflant par la chaleur et l'humidité, entrouvre une ouverture ménagée au-dessus d'elle, perce la terre, et devient une feuille séminale, appelée cotylédon. Cette feuille séminale est son unique mamelle, qui s'alimente d'un côté de se farine du grain, et pousse de l'autre une radicule qui doit bientôt trouver des sucs>plus abondants dans le sein de la terre. Malgré les attentions maternelles de la nature pour le ressemer, au moyen des vents, des eaux et des quadrupèdes, on assure qu'on ne le trouve nulle part indigène. Pour moi, je suis porté à croire que, par toute terre où il tombe, il prend racine; mais que, si elle manque d'engrais, il dégénère en quelque espèce de graminée, telle que l'ivraie. Ce qui me fait adopter cette opinion, c'est qu'il ne peut croître plusieurs années de suite dans le même champ, si ce champ n'a été bien labouré et bien fumé. Sa dégénération en ivraie est regardée comme certaine par plusieurs cultivateurs, et elle semble confirmée par l'observation du célèbre naturaliste Bonnet. Il rapporte, dans ses Recherches sur les Feuilles, qu'il trouva un jour une plante de froment d'une seule tige, qui portait, à son extrémité, un épi médiocre de véritable froment, et sur un de ses nœuds, un second tuyau terminé par un bel épi d'ivraie. A la vérité, Duhamel attribua la formation de cette plante, mi-partie de blé et d'ivraie, à la confusion des poussières de leurs étamines; mais, d'un autre côté, Linnieus a confirmé la possibilité de la transformation des parties des végétaux sur le même individu, en parties d'espèces différentes, par l'exemple d'une fleur en gueule de la linaire, qui se métamorphose en monopétale. Tout ce que nous pouvons conclure de celle du blé en ivraie, c'est que la nature a souvent associé la puissance de l'homme à celle des éléments, et que la main du laboureur peut seule conserver au froment ses principaux caractères. C'est à la maturité des blés, et aux approches de la faucille du moissonneur, qu'on voit émigrer une foule de petits êtres de. Leurs nids maternels. C'est alors que la nombreuse famille de la caille songe à fonder de nouvelles tribus dans des contrées éclairées par de nouveaux soleils, et que, comme le dit le bon La Fontaine, les petits de l'alouette,

Se poussant, se culbutant,
Délogent tous sans trompette.

Venons maintenant aux harmonies sociales de la puissance végétale: ce sont celles qui assemblent les familles des végétaux en espèces, en genres et en sphères. Nous les distinguerons donc en spécifiant, en générique et en sphérique.

L'harmonie spécifiant est la cause du plaisir que nous donne l'assemblage des végétaux de la quatième espèce. En voyant, par exemple, un champ de blé s'étendre par longs sillons, comme un beau tapis vert, nous éprouvons une sensation plus agréable que celle que nous donne sa tige ou sa simple touffe isolée. Ce plaisir s'accroît, si la plaine est couverte d'espèces de blés différents, comme d'épeautres, de blés barbus et non barbus, de seigles, d'orges. Enfin il augmente encore, s'il s'y joint quelque vallon couvert de diverses espèces de graminées. Le vent vient-il à souffler, toute la campagne ressemble alors à une mer ondoyante de verdure, dont les flots sont d'une infimité de nuances. Leurs reflets fugitifs, leurs murmures lointains, font passer dans nos sens le calme et le doux sommeil, ami du sentiment confus de l'infini. La première cause de ces sensations

voluptueuses est l'ordre même dans lequel ces graminées croissent. Il est très remarquable que le plaisir que nous font éprouver les groupes si variés des végétaux, a lieu principalement lorsqu'ils sont plantés sur le terrain, dans le même ordre que leurs semences ont été arrangées dans leur placenta. Ainsi, par exemple, un champ de blé nous plaît, parce que ses plantes y sont rangées par sillons, dans le même ordre que ses grains dans leur épi; et une prairie, au contraire, parce que ses diverses graminées y sont éparses comme leurs semences dans leurs panicules divergentes. C'est par cette même raison que le chêne, qui ne porte que deux ou trois glands réunis ensemble, ou même qu'un seul, nous fait plaisir ù voir dans ses groupes de deux ou trois arbres, ou même tout-a-fait isolé. Nous avons alors, pour ainsi dire, une sensation de la force de cet arbre vigoureux, auquel la nature a donné de pouvoir résister seul aux tempêtes. Au contraire, nous aimons à voir les sapins pyramidaux et conifères s'appuyer mutuellement, par leurs bases, autour des sommets des hautes montagnes, dans le même ordre que leurs pignons sont disposés dans leurs cônes. Nous voyons de même avec plaisir les ceps de la vigne entourer de leurs pampres les flancs d'une colline arrondie, et en former, pour ainsi dire, une seule grappe comme ses grains. Cette loi harmonique s'étend à tous les groupes des végétaux, dont les uns nous plaisent, disposés en rond, d'autres en longues avenues, d'autres épars çà et là. Le plan de leur semis est dans leurs berceaux. Cette loi embrasse aussi les individus de toutes les puissances. Elle est la source, ignorée jusqu'ici, de nos jouissances les plus douces, dans l'architecture, la musique, la peinture, la poésie, l'éloquence. Il n'y a point de plaisir dans les arts dont la raison ne soit dans la nature. Mous en parlerons en détail aux harmonies fraternelles. Linnaus, comme nous l'avons dit, les avait entrevues dans l'assemblage des anthères sur un même corps, auquel il a donné, par cette raison, le nom d'adelphic. C'est un des caractères principaux de son système botanique: mais il a oublié de l'étendre au végétal entier, à sa famille, à sa tribu, à ses diverses espèces, et aux genres même opposas. Quelle harmonie entre eux, et dont elle tire de si charmants accords! Cendant, ce n'est pas seulement pour le plaisir des yeux, ni pour donner aux végétaux des supports mutuels, que la nature les diversifie et les groupe fraternellement. Elle a varié les blés suivant les diverses latitudes de la terre, pour donner partout a l'homme le même aliment farineux. Elle a diversifié leurs espèces, par rapport aux éléments, en mettant le froment en Europe, les rias aquatiques en Asie, le panis sec en Afrique, le maïs en Amérique. Elle a varié de même les espèces si nombreuses des germinées, par rapport aux divers besoins et espères de quadrupèdes, d'oiseaux, d'insectes, et même de poissons. En effet, les graminées forment le genre de végétaux le plus étendu et le plus varié en espèces qu'il y ait sur la terre. On sent que, pour caractériser chacune d'elles en particulier, il faut la rapporter, d'une part, à une des harmonies de la nature, et de l'autre, à l'être sensible auquel clic est particulièrement destinée. Les botanistes ont fait des graminées plusieurs genres, divisés en espèces et en variétés; mais dans notre ordre harmonique, nous n'en formons que des espèces réunies en un seul genre. On en compte dans notre climat plus de trois cents, dont il y en a trente à quarante dans nos prairies. Les principales sont les gazons proprement dits, les Phalaris, les queues de renard, les queues de chat, les chiendents, les brises ou chevelures des dames, les amourettes tremblantes, les pâturins ou posa, les festons, les bromes, les orges de murailles et de prairies, les roseaux aux quenouilles garnies de laine, les cynosures ou queues de chien, les sursis odorants ou herbes du printemps, les Cinna, les houques molles, auxquelles se joignent les joncs des marais et les spathes des montagnes, les souchets, les glaïeuls. Mais ce ne sont là que les graminées de nos contrées. On y doit ajouter, sans doute, celles qui s'étendent de la zone torride jusqu'aux pôles; les bananiers, espèces de glaïeuls dont ses fruits, les tiges et les feuilles engaînées donnèrent à l'homme ses premiers aliments, des parasols et des ceintures; les cannes à sucre, les bambous de l'Inde orientale, les cannes du Mississipi et celles de l'Amazone, dont les sommets servent, dans les débordements, asiles aux fourmis; les joncs papyracés des bords du Nil, les gramen glauques et rampants qui bordent les rivages des îles torridoniennes, et une foule d'autres inconnues, disposées le long des fleuves, dans l'intérieur des terres et dans toute l'étendue des continents. J'aime à me figurer notre globe couvert des seules graminées, en déployer toutes les espèces sur ses vastes amphithéâtres. Ici, les vents font ondoyer les posa dans les prairies, les amourettes tremblantes sur les flancs des montagnes, et les spathes sur leurs sommets arides: Chaque fleuve a ses roseaux,

depuis ceux qui, couverts de neige une partie de l'année, s'élèvent à peine sur les bords silencieux de J'iris, jusqu'aux forêts toujours murmurantes des bambous du Gange, dont quelques espèces s'élèvent à plus de cent pieds de hauteur. La terre oppose à l'océan fluide qui l'environne, un océan de végétaux mobiles, et des flots verts à des flots azurés. Ici, les tempêtes ne présentent point de naufrages. Les nids trouvent sous les tiges toujours flexibles, de doux asiles et des subsistances assurées. Peut-être le seul genre des graminées pourrait-il fournir aux besoins de tous les animaux. Mais la nature, dans sa magnificence, en variant à l'infini le pain qu'elle distribue à ses innombrables convives, ne se borne pas à ne servir qu'un seul aliment sur leur table commune. Elle a renfermé la farine dans les épis des graminées; mais elle a suspendu aux végétaux de^ autres genres, les huiles, les sucres, les vins, les épiceries qui en devaient varier les assaisonnements.

La nature a donc formé plusieurs sortes de farines dans les grains de blé et des autres graminées, depuis ceux du froment jusqu'à ceux des amourettes, destinées aux plus petits oiseaux. L'homme aussi, à son imitation, manipule, avec la seule farine de froment, une multitude de pâtisserie», de vermicelles et de gimblettes. Mais toutes ces modifications ne sont que des espèces d'un seul genre dans la puissance végétale. Passons maintenant à ses genres proprement dits.

Les botanistes emploient le mot de genre d'une manière très vague et souvent contradictoire. Ils l'attribuent à une famille, à une classe, à une section, â une espèce même, et lui donnent bien rarement sa signification propre. Tâchons d'être plus exacts. Le mot de genre vient d'engendrer: or, engendrer, dans un ordre de choses,signifie créer. Le genre, est donc un ordre nouveau, qui a des caractères essentiellement distincts des autres ordres dans la même puissance. Le genre, selon nous, se rapporte, d'une part, à une des harmonies principales de la nature, et, de l'autre, à un des premiers besoins de l'homme. L'espèce n'est qu'une modification du genre, et se rapporte aux besoins d'un animal. Comme les harmonies générales de la nature sont à la fois positives et négatives, ou actives et passives, et qu'il en est de même des besoins de l'homme, il en résulte que les genres contrastent,deux h deux,dans la même puissance, et que les espèces consonnent dans le même genre. On en peut conclure aussi qu'il y a vingt-six genres généraux, puisqu'il y a treize harmonies générales. Les espèces sont donc des consonances, et les genres des contrastes. De la réunion de ces contrastes, deux à deux, insulte la plus agréable des harmonies. Par exemple, le genre qui contraste le plus avec celui des graminées, est celui des légumineuses. En considérant celui des graminées sous ses rapports principaux avec l'harmonie aérienne, à laquelle il parait appartenir, nous lui en trouvons de positifs avec elle par ses feuilles en linéaires ou rubans, qui échappent aux vents; par ses fleurs peu apparentes, adossées à des épis; par ses tiges perpendiculaires, creuses, fortifiées de nœuds, et élastiques, qui se redressent sans cesse, malgré les tempêtes qui les agitent et le poids des quadrupèdes qui les foulent. Le genre des légumineuses, au contraire, a des harmonies négatives avec les vents. Il rampe a terre, ou il s'accroche par des vrilles aux graminées elles-mêmes. Ses feuilles larges sont pour l'ordinaire agrégées au nombre de trois par des espèces de queues souples. Ses tiges branchues sont pleines de moelle, ses fleurs sont apparentes et papilionacées; mais les parties sexuelles y sont abritées par une carène. Elles sont supportées par des queues recourbées, et élastiques comme des ressorts; de manière qu'au moindre vent, elles se tournent comme des girouettes et lui opposent leur calice. Elles sont groupées en forme de grappes, et donnent, dans des capsules qui les abritent, des semences en forme de reins ou arrondies, telles que les haricots et les pois. Le poil des graminées est perpendiculaire, celui des légumineuses est horizontal; de manière que les premières passent aisément à travers |es autres, ou les supportent, si ces dernières sont pourvues de mains. Pour nous former une idée de leurs harmonies, commençons par celles des blés. Les mêmes campagnes qui sont couvertes de moissons, le sont aussi de haricots et de pois, qui, par leur feuillage, leur verdure et leurs fleurs, forment avec elles les plus agréables contrastes. L'harmonie de ces deux genres est encore plus sensible dans les cultures des Sauvages de l'Amérique septentrionale. Ils sèment leur maïs en rond sur de petites mottes de terre, au nombre de neuf grains. Ils y joignent autant de haricots, dont les tiges viennent s'attacher à celles du maïs, et forment toutes ensemble un

charmant bouquet, par les oppositions de toutes leurs parties. Nous observerons ici que les haricots entrent, comme aliments, en harmonie avec les blés, chez tous les peuples. Us forment avec le pain la principale nourriture du nôtre. Les Chinois en tirent une liqueur appelée soui, qu'ils emploient comme assaisonnement dans la plupart de leurs mets. Il semble que le goût des animaux se rapproche en cela de celui des hommes, à en juger par les cultures destinées à nos animaux domestiques. Si les prés se couvrent pour eux de graminées, les champs voisins produisent aussi pour eux des vesces, des systèmes, des sainfoins. Celle des prairies artificielles qui leur plat le plus, est celle qu'on nomme drogue, mélangée de pois «t d'avoine; que dis-je! Nos prés sont semés à la fois par la nature, de graminées et de trèfles, et leurs douces harmonies s'étendent jusque dans les clairières de l'île de Tinian, au sein de la vaste mer du Sud. L'amiral Anson s'y été transporté dans une ferme de l'Angleterre, à la vue des pâturages semés de ces deux végétaux, où paissaient de magnifiques et nombreux taureaux blancs, et qui retentissaient du chant des coqs. Si les Espagnols en avaient transporté les bestiaux, il est certain que les prairies n'avaient été entourées de bols et ensemencées que par la nature. Pour moi, qui n'ai eu que ça et là des aperçus de ses harmonies innombrables, dans des contrées souvent dégradées lier la main de l'homme, j'ai vu, à l'Ile-de-ronnce, des agatis, petits arbres, à fleurs légumineuses de couleur lilas, former, par leurs contrastes,des bosquets charmants avec les bambous, qui sont- les plus grandes des graminées. C'est ainsi que, dans le* Alpes, les ébéniers au*fleurs jaunes forment des berceaux ravissants autour des sapins conifères.

Maintenant, pour nous former une idée des genres de la puissance végétale, nous en choisirons les prototypes ou premiers modèles sous l'équateur: nous les rapporterons aux premiers besoins de l'homme, et nous en déterminerons les genres, en les rapportant successivement aux treize harmonies actives et passives.

Les premières de ces harmonies sont les quatre élémentaires, la solaire, l'aérienne, l'aquatique et la terrestre. Elles se manifestent dans la division générale des végétaux en arbres, en herbes, en algues ou plantes aquatiques, et en mousses. Quoique cette division ne soit pas adoptée par les naturalistes, c'est celle que nous présente la puissance végétale au premier coup-d'œil; et elle est saisie par tous les peuples. Elle s'étend aux deux autres puissances organisées: dans l'animale, aux quadrupèdes, aux oiseaux, aux poissons et aux insectes; et dans l'homme, à ses quatre tempéraments, le bilieux, le sanguin, le flegmatique et le mélancolique. Ces quatre harmonies se correspondent dans les trois puissances organisées. Le soleil, comme nous Talions voir, influe particulièrement sur les arbres, les quadrupèdes, et les tempéraments bilieux; l'air, sur les herbes, les oiseaux, et les sanguins; l'eau, sur les algues, les poissons, et les flegmatiques; la terre, sur les mousses qui la tapissent, les insectes innombrables qui s'y creusent des retraites, et les mélancoliques qui y cherchent aussi des asiles On peut étendre cette division élémentaire au genre humain en entier, qui. Comme un simple individu, nous présentons quatre tempéraments différents dans ses peuples méridionaux, montagnards ou septentrionaux, maritimes, et cultivateurs ou terrestres. Enfin, le dolie lui-même est divisé en quatre parties principales, dont chacune est en rapport particulier avec un des éléments: l'Afrique brûlante avec le soleil; l'Europe, toujours mobile et inquiète, avec l'air tempétueux qui l'environne; l'Amérique t pratique, arrosée paf les plus grands fleuves, avec les eaux; l'Asie, grave et mélancolique, avec la terre, dont elle renferme la plus grande étendue daris sa circonférence.

Les peuples de ces quatre parties du monde ont des caractères analogues aux quatre divisions de la puissance animale. Les noirs de l'Afrique sont robustes comme les quadrupèdes; les Européens, actifs, sont devenus les plus hardis des navigateurs,en tirant, comme l'oiseau, parti des vents; les Américains voguent et nagent comme les poissons; les Asiatiques, populeux comme les insectes, labourent la terre avec la mime patience, et offrent, dans les Indiens et les Chinois, les plus habiles des cultivateurs. Mais ne sortons point ici des divisions de la puissance végétale.

En commençant par son harmonie solaire, nous verrons que les arbres sont en rapport immédiat avec le soleil, par les cercles concentriques de leurs troues. Ces cercles sont toujours en nombre égal à celui des années que les arbres ont vécu, c'est-à-dire, à celui des révolutions annuelles de l'astre du jour. Ils sont vivaces, c'est à dire qu'ils vivent depuis une année jusqu'à plusieurs siècles. Enfin, leurs genres sont beaucoup plus nombreux dans la zone torride, que dans les zones tempérées. J'ai rapporté quarante – deux échantillons, différents de ceux des forets de l'Ile-de-France, qui n'a guère plus de douze lieues de diamètre; tandis qu'on n'en compte que seize ou dix-sept genres dans toutes les forêts de la France. Les genres des herbes, au contraire, sont plus nombreux dans les zones tempérées, et ceux des mousses dans les glaciales. La nature, qui met les fruits rafraîchissants, vineux, aromatiques, sur des arbres dans la zone torride, tels que les calebasses, les melons du papayer, les épiceries, les fait croître souvent sur des tiges humbles et rampantes dans nos climats: tels sont ceux des cucurbitées, des sarriettes, des thyms, des basilics, et elle en répand les saveurs et les parfums jusque dans les mousses du Nord. Les herbes même de nos contrées produisent des espèces qui atteignent à la grandeur des arbres, au sein de la zone torride: tels sont le bambou de l'Inde, dans le genre des graminées: la mauve d'Afrique, dans celui des mal lacées test le bananier, dans celui des glaïeuls. Il est possible que quelque espèce de mousse parvienne à une grandeur arborescente dans quelques parties de la zone torride, et qu'on l'y ait confondue avec celles des fougères, qui y sont si communes et si élevées; mais les mousses n'en appartiennent pas moins aux climats du Nord. J'en ai vu des variétés innombrables dans la Finlande, quoique je n'y aie péut-étré tout au plus qu'au soixante-deuxième degré de latitude.

Si le soleil donne tant d'activité à la végétation dans la zone torride, et s'il imprime les cercles annuels de son cours dans le tronc de tous les arbres, par toute la terre; la lune, de son côté, paraît étendre son influence sur les herbes. J'ai remarqué dans les racines de celles de nos jardins des couches concentriques en nombre toujours égal à celui des mois lunaires qu'elles avaient mis à croître: c'est ce qu'on peut voir surtout dans celles des carottes, des betteraves, et dans les bulbes des ognons. Peut-être était-ce à cause de ces rapports lunaires, que les Egyptiens avaient consacrés l'ognon à Isis, ou à la lune, qu'ils adoraient sous le nom de cette déesse. Ce qu'il y a de certain, c'est que ces racines ont pour l'ordinaire sept cercles concentriques, c'est-à-dire autant qu'ils ont été de mois à croître, depuis le commencement de mars où on les sème, jusqu'à la fin de septembre où on les recueille. Dans les pays où la végétation des herbes dure plus de sept mois, je suis porté à croire que leurs racines ont plus de couches, et que leur nombre égale celui des mois de l'année. C'est sans doute par cette raison que les ognons de l'Egypte sont remarquables par leur grosseur, ainsi que les racines de toutes les plantes bulbeuses de l'Afrique et des pays torridoniens. Ces périodes lunaires sont remarquables aussi dans les nœuds des tiges de la plupart des graminées. Elles sont si sensibles dans les pousses de toutes les herbes en général, que je crois y trouver un caractère invariable pour les distinguer des arbres proprement dits, quoiqu'elles parviennent quelquefois à leur hauteur dans les pays chauds. Le bambou des Indes pousse un rejeton tous les mois, suivant Kumphius. François Pyrard assure qu'aux Maldives, le cocotier produit régulièrement, chaque mois, une grappe de cocos, de manière qu'il en porte douze à la fois, dont la première commence à poindre, la deuxième sort de son étui, la troisième bourgeonne, la quatrième fleurit, la cinquième noue, et la dernière est en maturité. Le latanier ou palmier à éventail, qui croit aussi sur les bords de la mer, donne chaque mois une feuille nouvelle. Les palmiers, en .effet, comme le savent les naturalistes, n'ont point de couches annuelles concentriques. Leur tronc n'est point de vrai bois; ce n'est qu'une colonne de fibres, dont le milieu ne renferme qu'une espèce de moelle. A la différence de celui des arbres proprement dits, il sort de terre avec toute la grosseur qu'il doit avoir; ils n'ont de plus qu'un cotylédon, et ce caractère leur sont communs avec les seules graminées. Les palmiers ne sont donc que de grandes herbes, en rapport, comme elles, par leurs pousses, avec le cours de la lune; tandis que les arbres, même les plus petits, le sont avec celui du soleil, comme on le voit à leurs cercles annuels. On doit ranger aussi parmi les végétaux soumis immédiatement aux influences de l'astre des nuits, les mousses, dont la plupart ne végètent, ne fleurissent et ne grènent qu'en hiver, lorsque la lune est dans notre hémisphère. Peut-être en est-il de même des algues. Les naturalistes, qui attribuent un si grand empire à la lune sur l'Océan, ne

peuvent lui refuser quelque action sur les végétaux, et même sur les poissons qu'il nourrit. Ce qu'il y a de certain, c'est qu'elle agit sensiblement sur les quatre ordres de la puissance animale, et même sur l'humaine. Les quadrupèdes entrent en amour et mettent bas leurs petits à certaines périodes lunaires; il en est de même des pontes des oiseaux, dont les os, de plus, se renouvellent périodiquement, comme le prouvent les couches intermittentes de rouge et de blanc de ceux des poulets qui mangent par intervalles de la garance. Des couches semblables se trouvent en rapport avec les mois lunaires dans plusieurs coquillages, entre autres dans l'écaille de l'huître: de manière que leur nombre marque celui des mois qu'elle a vécu. Ces mêmes rapports lunaires existent dans les générations des insectes, et enfin dans les mois des filles nubiles; mais nous en parlerons plus au long aux puissances animale et humaine.

Quoique les arbres soient en harmonie immédiate avec le soleil par les anneaux concentriques de leurs troncs, ils le sont aussi avec la lune par les feuillets de leur écorce et par ceux de leurs fruits. J'ai remarqué sept de ces feuillets dans l'écorce du bouleau, et même je crois les avoir entrevus dans chacun des cercles annuels des arbres. Je crois aussi les avoir distingués dans quelques fruits, surtout dans la pomme de reinette. Ils apparaissent lorsqu'on ouvre ce fruit obliquement, et plutôt quand on le mord que quand on le coupe. Voilà donc de nouveaux rapports lunaires dans les arbres même; car on sait que le temps de leur végétation et de la maturité de leurs fruits ne dure tout au plus que sept mois dans nos climats.

Non seulement tous les végétaux ont des harmonies soli lunaires, dans leurs racines, leurs tiges, leurs écorces et l'intérieur de leurs fruits; mais ils en ont d'apparentes dans leurs pétales ou les feuilles de leurs fleurs. Ce sont ces pétales qui, comme des miroirs, réfléchissent les rayons du soleil et ceux de la lune sur les parties sexuelles de la fleur. Nous remarquerons d'abord que le plan de la plupart des fleurs est circulaire, et que leurs parties sexuelles sont au centre. Quelquefois leur disque est relevé en hémisphère; et quand il est entouré de pétales plans et divergents, comme dans les radiées, il ne représente pas mal la forme d'un astre. Cette configuration sidérale est si marquée dans quelques espèces, que les botanistes les ont classées sous le nom d'aster; mais elle est répandue dans la plupart des fleurs apparentes, qui toutes, comme nous l'avons dit, affectent dans leurs plans la forme circulaire, quoique leurs tiges et leurs feuilles en aient de très différentes. Il ne faut pas douter que cette forme ne soit la plus favorable pour réverbérer les rayons du soleil vers un centre commun, et que la même main qui a façonné en lunes, en anneaux, et en d'autres courbes qui nous sont inconnues, les réverbères des planètes, pour réfléchir sur elles les rayons du soleil, n'ait varié pour une fin semblable les pétales des fleurs. Il est certain que c'est à cette réverbération que les fleurs doivent l'éclat qui les fait paraître en quelque sorte lumineuses. Pour moi, quand je vois celles qui entaillent une prairie, et dont les formes et les couleurs sont si variées, je suis tenté de croire qu'elles ont quelque ressemblance avec les astres qui nous sont inconnus. Pourquoi la nature n'aurait-elle pas mis sur la terre, dans des fleurs, les images des objets qu'elle a placés en réalité dans les cieux, puisqu'elle a mis dans l'homme, aussi passager qu'elles, le sentiment de l'intelligence qui gouverne l'univers?

Mais combien de vérités ne foule-t-il pas aux pieds comme les fleurs? Il a marché sur celles-ci, depuis un grand nombre de siècles, sans les connaître. Presque tous les cultivateurs ignorent encore qu'elles ont des sexes. Que dis-je? Lorsque le botaniste Le Vaillant en introduisit la théorie dans l'école du Jardin des Plantes, le célèbre Tournefort l'obligea de la supprimer, et ne voulut jamais la reconnaître, sans doute parce que, le premier, il n'en avait pas fait la découverte. Les botanistes modernes rejettent, peut-être par les mêmes raisons, les harmonies des pétales avec le soleil, dont j'ai apporté tant de preuves dans mes Études de la Nature. Ils les reconnaissent toutefois comme les caractères les plus apparents des fleurs, qu'ils classent en monopétales, en polypétales, et celles-ci en radiées, en liliacées, en rosacées, en papilionacées, etc., mais sans intention et sans but. Cependant tout leur démontre que la nature n'a rien fait en vain.

Pour éviter l'obscurité de leurs systèmes, nous nous guiderons sur le flambeau du jour. Les pétales des fleurs sont disposés en épis perpendiculaires, tels que celui du blé; en radiées ou miroirs plans, comme dans la marguerite; eu portions sphériques, comme dans la rose; en elliptiques, comme dans le lis, ou paraboliques, comme dans la capucine: ce sont là leurs formes principales. D'autres, en grand nombre, appartiennent à des courbes inconnues et non encore calculées; mais toutes sont engendrées de la sphère. Il est remarquable que lorsque les pétales sont radias et en miroirs plans, le disque de la Heur est en hémisphère pour recevoir leurs réverbérations: tris sont ceux de la marguerite et de la camomille. Ils se renversent ou tombent quand la fécondation est achevée. Ce disque est un peu concave dans le tournesol; aussi arrive-t-il souvent que les fleurons de son centre avortent et ne dorment point de graine. S'a concavité vient peut-être du changement de climat, car cette plante est originaire de l'Amérique. Les réverbères des racées ont un foyer commun, les l'Hiacées en ont deux, les paraboliques renvoient les rayons parallèlement, comme la vigne. Il y a des fleurs en grappes, en ombellifères, telles que celles de la carotte; en hémisphères, en cercles et en demi-cercles, comme celles de plusieurs sortes de trèfles; en rayons divergents, telles que celles des choux et de la plupart des minées. Si les fleurs ont des rapports positifs avec le soleil, elles en ont aussi de négatifs. Il y en a de labiées, qui ne montrent que l'extrémité de leurs anthères, et de papilionacées, qui les cachent au moyen d'une carène; d'autres même ne fleurissent que la nuit: telle est celle du jalap du Pérou ou belle-de-nuit, celle de l'arbre triste de l'Inde, qui s'ouvre dans les ténèbres et tombe au point du jour; du convolvulus nocturne, également originaire de l'Inde. D'autres fleurissent renversées et a l'ombre de leurs feuilles, telles que celles de l'impériale et de beaucoup de fleurs torridoniennes Linnaus avait déjà entrevu les rapports des pétales avec la présence et l'absence du soleil. Il avait observé que plusieurs d'entre elles s'ouvraient et se fermaient à différentes heures du jour, telles que celles du pissenlit, de la chicorée sauvage, et que la plupart se fermaient à l'entrée de la nuit: il en avait formé une horloge botanique. Il n'avait qu'un pas de plus à faire pour voir que leurs pétales étaient de véritables réverbères en harmonie avec le soleil, et dont la durée était en raison inverse de leur action sur leurs parties sexuelles. Les rosacées, qui sont celles qui ont le plus d'activité, parce qu'elles renvoient tous les rayons solaires vers un centre commun, sont aussi celles qui durent le moins. La rose ne dure qu'un jour, et sert souvent d'image aux philosophes pour exprimer la rapidité de nos plaisirs et de notre existence.

On voit donc qu'on peut diviser la puissance végétale, par rapport au soleil, en végétaux des zones torride, tempérées et glaciales, d'été et d'hiver, de jour et de nuit. Il en résulte un grand nombre de genres positifs et négatifs, dans les arbres, les herbes, les algues et les mousses.

J'ai déjà montré quelques-uns des rapports que le bananier avait avec tous les besoins et les divers tempéraments de l'homme. Ces rapports semblent se multiplier sous les yeux de l'observateur; et ce végétal offre un exemple si merveilleux de la prévoyance de la nature, qu'il serait inutile d'en présenter un autre. Sa tige peut avoir neuf à dix pieds d'élévation; elle est formée d'un paquet de feuilles tournées en cornets, qui sortent les unes des autres, et, en s'étendant au sommet du bananier, y forment un magnifique parasol. Ces feuilles, d'un beau vert satiné, ont environ un pied de large et six pieds de long; elles s'abaissent par leurs extrémités, et forment par leurs courbures un berceau charmant, impénétrable au soleil et à la pluie. Comme elles sont fort souples dans leur fraîcheur, les Indiens en font toutes sortes de vases pour mettre de l'eau et des aliments; ils en couvrent leurs cases, et ils tirent un paquet de fil de la tige, en la faisant sécher. Une seule de ces feuilles donne à un homme une ample ceinture; mais deux peuvent le couvrir de la tête aux pieds, par-devant et par-derrière. Un jour que je me promenais à l'Ile-de-France, près de la mer, parmi des rochers marquas de caractères rouges et noirs, je vis deux nègres tenant à la main, l'un une pioche, l autre une bêche, qui portaient sur leurs épaules un bambou auquel était attaché un long paquet, enveloppé de deux feuilles de bananier. Je crus d'abord que c'était un grand poisson qu'ils venaient de pécher; mais c'était le corps d'un de leurs infortunés compagnons d'esclavage, auquel

ils allaient rendre les derniers devoirs dans ces lieux écartés. Ainsi le bananier seul donne à I homme de quoi le nourrir, le loger, le meubler, l'habiller et l'ensevelir.

Ce n'est pas tout. Cette belle plante, qui ne produit son fruit, dans nos serres, qu'au bout de trois ans, comme je l'ai vu dans celles du Jardin des Plantes de Paris, le donne, sous la Ligne, dans le cours d'un an, après lequel la tige qui l'a porté se flétrit; mais elle est entourée d'une douzaine de rejetons de diverses grandeurs, qui en portent successivement: de sorte qu'il y en a en tout temps, et qu'il en paraît un nouveau tous les mois, comme les grappes lunaires du cocotier. Je parle ici des bananiers qui croissent sous la Ligne, et sur le bord des ruisseaux, leur clément naturel. Il y a plus, il y a une multitude d'espèces de bananiers de différentes grandeurs, depuis celle d'un enfant jusqu'au double de celle d'un homme, et depuis la longueur du pouce jusqu'à

Celle du bras; de sorte qu'il y en a pour tous les âges. J'ai vu, à l'Ile-de-France, des bananiers nains, et d'autres gigantesques, originaires de Madagascar, dont les fruits, longs et courbés, s'appellent cornes de bœuf. Un homme peut les cueillir aisément en grimpant le long de leur tige, où les queues de ses anciennes feuilles forment des saillies, ou en faisant monter sa femme sur ses épaules. Une seule de leurs bananes peut le nourrir un repas, et une de leurs pâtes tout un jour. Il y a des bananes de saveurs très variées. Quoique je n'en aie mangé qu'à l'Ile-de-France, qui, comme on sait, est à l'extrémité de la zone torride australe, j'y en ai goûté de l'espèce naine, qui avaient de plus que les autres un goût très agréable de safran. L'espèce commune, appelée figue banane, est onctueuse, sucrée, farineuse, et offre une saveur mélangée de celles de la poire de bon-chrétien et de la pomme de reinette. Elle est de la consistance du beurre frais en hiver, de sorte qu'il n'est pas besoin de dents pour y mordre, et qu'elle convient également aux enfants du premier âge et aux vieillards édentés. Elle ne porte point de semences apparentes ni de placenta: comme si la nature avait voulu en ôter tout ce qui pouvait apporter le plus léger obstacle à l'aliment de l'homme. C'est de toutes les fructifications la seule que je connaisse qui jouisse de cette prérogative. Elle en a encore quelques-unes non moins rares, c'est que quoiqu'elle ne soit revêtue que d'une peau, elle n'est jamais attaquée, avant sa maturité parfaite, par les insectes et par les oiseaux, et qu'en cueillant son régime un peu auparavant, il mûrit parfaitement dans la maison, et se conserve un mois dans toute sa bonté.

Les espèces de bananes sont très variées en saveurs. Elles sont d'autant meilleures qu'elles croissent plus près de l'équateur, sous l'influence directe du soleil. Il y en a de délicieuses aux Moluques, dont les unes sont aromatisées d'ambre et de cannelle, d'autres de fleur d'orange. On trouve des bananiers dans toute la zone torride, en Afrique, en Asie et dans les deux Amériques, dans les îles de leurs mers, et jusque dans les plus reculées de la mer du Sud. Le rima, qui porte le fruit à pain dans l'île de Tahiti, ne lui est pas comparable, quoique quelques philosophes modernes nous présentent cet arbre comme nouvellement découvert, et comme le don le plus précieux que la nature ait fait aux hommes. Il y a longtemps qu'il croît aux Moluques, et que d'anciens voyageurs en ont parlé. D'ailleurs, ses usages, relativement à l'homme, sont bien plus circonscrits. Il ne lui fournit ni logement, ni vêtements, ni meubles. Il lui faut d'abord six ou sept ans pour produire ses fruits, qu'il ne donne ensuite que huit mois, chaque année. Et s'il a présenté le premier modèle du pain dans sa pâte, qui, cuite au four, se change en mie et en croûte, le bananier donne la sienne tout assaisonnée de .beurre, de sucre et d'aromates. Le rima porte des petits pains, et le bananier de la pâtisserie.

C'est donc avec raison que le voyageur Dampier, qui a fait le tour du monde avec tant d'intelligence, appelle le bananier le roi des végétaux, à l'exclusion du cocotier, que les marins honorent de ce titre, parce qu'ils ne jugent que de ce qui est à leur portée. Il observe qu'une infinité de familles, entre les deux tropiques, ne vivent que de bananes. Cet utile et agréable végétal a tant de rapports avec les premiers besoins de l'homme dans l'état d'innocence et d'inexpérience, que j'ai déjà fait remarquer qu'on l'appelle aux Indes le figuier d'Adam. Les

Portugais superstitieux qui y abordèrent les premiers, crurent apercevoir, en coupant son fruit transversalement, le signe de la rédemption dans une croix que je n'y ai jamais vue. A la vérité, cette plante présente, dans ses feuilles larges et longues, les ceintures du premier homme, et figure assez bien, dans son régime hérissé de fruits, et terminé par un gros cône violet qui renferme les corolles de ses fleurs, le corps et la tête du serpent qui le tenta. Les bramines, au moyen de ses fruits salubres et de son délicieux ombrage, vivent au-delà d'un siècle. Elle croît non seulement dans toute la zone torride, mais plus de six degrés au-dehors. Les Arabes lui donnent le nom de musa, que nos naturalistes ont adopté; et comme ces peuples ont répandu en Europe les premiers éléments des sciences et des arts après les Romains, je suis tenté de croire que la déclinaison du nom de musa, qui commence le rudiment très rude de nos enfants, a dû signifier, non une muse dont ils ne peuvent avoir d'idée, mais le bananier, dont les fruits leur seraient si agréables. Pour moi, en le considérant pour la première fois avec toutes ses convenances, je me dis: Voilà le vrai végétal de l'homme.

La nature ne s'est pas bornée à enrichir une seule plante de tout ce qui pouvait convenir à nos besoins dans la zone torride. En réunissant dans un seul fruit le beurre, le sucres le vin, la farine, elle a voulu nous engager à en faire nous-mêmes les combinaisons, en mettant ces substances séparées et pures dans des végétaux d'un autre genre. Elle a créé pour cet effet le palmier, avec ses espèces si diverses en productions. Le bananier, que je regarde comme du genre des glaïeuls, ne réussit bien qu'au fond des vallées, sur le bord des ruisseaux, à l'abri des grands vents, qui déchirent en lanières transversales ses tendres feuilles. Le palmier, au contraire, avec ses feuilles lignées, croît dans les lieux les plus exposés aux tempêtes, depuis le sommet des montagnes jusque sur le bord des mers. Le bananier n'a que des variétés qui, par la ressemblance de leurs fruits, ne conviennent qu'aux besoins d'une seule famille. Le palmier a des espèces qui, par la diversité de leurs productions, peuvent satisfaire à tous ceux d'une tribu.

Il est vrai qu'en considérant le bananier comme une espèce de glaïeul, on peut y joindre, dans le même climat, les balisiers, qui portent différentes sortes de grains, et dont les feuilles larges, tournées en cornets, sont engagées les unes dans les autres; mais ils ne se développent point en parasol, et ils ne présentent point à l'homme des rapports immédiats avec ses besoins.

Tous les végétaux que je viens de nommer, sans en excepter les palmiers, malgré la magnificence de leur port, paraissent du genre des graminées, parce que leur semence, ou première pousse, n'a qu'un cotylédon, que leurs feuilles sont renfermées les unes dans les autres, et n'éprouvent, en croissant, qu'un simple développement, d'où il résulte que leur tige, à sa naissance, a le même diamètre à sa base que lorsqu'elle a atteint toute sa hauteur. D'ailleurs elle est sans écorce,et ne contient point de véritable bois. Les troncs des palmiers ne sont que des paquets de fibres sans cercles concentriques,et dont le centre est plus tendre que la circonférence. C'est tout le contraire dans les arbres proprement dits. Leurs troncs augmentent de diamètre chaque

Année, et leurs accroissements y sont marqués intérieurement par des cercles; ils sont revêtus d'écorce; l'aubier de leur bois est à leur circonférence, et la partie la plus dure au centre. Les palmiers ne paraissent donc être que de grandes plantes du genre des graminées, et soumises comme elles aux influences de la lune, dans la pousse de leurs feuilles et de leurs fruits. Mais, si les arbres portent au-dedans des anneaux en rapport avec les périodes annuelles du soleil, les palmiers en montrent de semblables au-dehors. Les premiers se composent, chaque année, de colonnes concentriques; les seconds, de tambours posés les uns sur les autres. Les arbres cachent les dates de leur âge, les palmiers les mettent en évidence. Chaque mois lunaire, ceux-ci poussent une feuille, comme le latanier, ou un régime de fruits, comme le cocotier, et leur tête entière s'é'leve d'un cran. Lorsque les nouvelles palmes .-Mi développent, les inférieures, qui sont les plus anciennes, tombent, et laissent sur le tronc des espèces de hoches raboteuses et annulaires, qui servent à la fois de marques chronologiques, et de degrés pour monter à son sommet. Le palmier

est par excellence le végétal du soleil; c'est un gnomon qui marque les heures par son ombre, les mois lunaires par ses feuilles nouvelles, les années par les vieux cercles de sa tige. Ses espèces,dont les botanistes connaissent au moins quatre-vingts, qui ont chacune plusieurs variétés très distinctes, sont répandues autour du globe, dans toute la zone torride, et même quelques-unes plus de six degrés au - delà. Il y en a sans doute encore beaucoup d'inconnues. Enfin il n'est aucun végétal qui manifeste autant que lui les harmonies soli lunaires.

Celles qu'il a avec l'homme ne sont pas moins nombreuses et remarquables. La circonférence des plus gros n'a pas plus d'amplitude que celle de ses bras. Lorsqu'il veut y grimper, il se fait, avec une des palmes tombées, une ceinture dont il s'entoure avec le tronc, et, en s'aidant des pieds et des mains, au moyen des anneaux qui lui servent d'appui, il s'élève jusqu'au sommet pour en tirer du vin, ou pour en cueillir les fruits. C'est ainsi qu'à l'Ile-de-France j'ai vu les noirs monter au sommet des cocotiers avec la plus grande facilité.

Il y a un grand nombre de rapports très marqués entre les fruits du palmier et plusieurs parties du corps humain. Le coco simple, dépouillé de sa chaire, offre, avec ses trois trous, une parfaite ressemblance avec une tête de nègre. Celui des Maldives, qui est double, a une ressemblance encore plus frappante avec les parties antérieure et postérieure du corps d'une négresse à sa bifurcation. Comme les cocotiers sont assez connus, je chercherai quelques-uns de ces rapports humains dans le dattier. Ce magnifique végétal réunit en lui la plupart des avantages des autres palmiers, dont son espèce semble le prototype; il porte dans ses fruits un aliment délicieux, et qui exhale les plus doux parfums. Sa tige toujours droite, en contraste avec celle du cocotier, souvent courbée par les vents, s'élève au moins à quarante pieds de hauteur. Son sommet, ou chapiteau, a environ six pieds, et est revêtu de longues branches feuillées, appelées palmes: elles ont plus de quinze pieds de long. Les feuilles qui les garnissent sont placées obliquement et alternativement, à-peu-près comme les barbes d'une plume. Elles ont une coudée de longueur et deux pouces de largeur; elles sont pointues, ligneuses, et ressemblent à la lame d'un poignard, ou à la feuille d'un roseau. Les palmes qui les portent sont pour l'ordinaire au nombre de cent vingt, dont quatre-vingts sont inclinées et horizontales, et quarante perpendiculaires: de manière qu'elles forment, au sommet du palmier, une tel circulaire par son plan et conique par son élévation. Des aisselles des palmes supérieures, naissent de grosses enveloppes ou gaines, appelées éclatés, au nombre de huit ou neuf, très fermes au-dehors, et très polies au-dedans. Ces éclatés s'entrouvrent, et il sort de chacun d'eux une grappe, ou régime de fleurs, qui se changent en fruits, lorsqu'elles ont été fécondées par les fleurs du palmier mâle. Ces fruits, appelés dattes, sont de la forme de la bouche, disposés deux à deux sur des cordons en zigzags; chaque grappe en porte près de deux cents, qui sont verts dans leur croissance, et dorés dans leur maturité. Us sont d'un goût délicieux dans leur fraîcheur, et ils se conservent un an dans leur sécheresse: mais quoique très nourrissants alors et pectoraux, leur goût diffère autant des premiers,'que le goût des figues sèches diffère de celui des figues fraîches. Toutes ces grappes, de la grandeur d'un homme, chargées de leurs beaux fruits couleur d'or, pendent comme des lustres autour de la cime du palmier, surmontées de ses belles palmes verdoyantes, qui forment au-dessus d'elles un dais magnifique. Enfin la nature prévoyante a fortifié les bases des feuilles et des grappes du palmier, souvent agité des vents, par trois ou quatre espèces d'enveloppes à réseaux, fortes comme des brins de chanvre, et semblables à de grosses étoupes jaunes. Souvent des tourterelles font leurs nids dans les replis de ces enveloppes, comme dans ceux d'une draperie.

Je ne m'arrêterai pas ici aux productions du palmier, qui sert aux besoins journaliers d'une multitude de peuples. Les Arabes et les Indiens s'alimentent de ses fruits, emploient ses durs noyaux, après les avoir fait bouillir- ^ la nourriture de leurs chameaux; font?' es avec ses éclatés, des toiles avec sa bourre, la charpente de leurs maisons avec son trône, et leurs toits avec ses feuilles. On peut lire les détails de ses usages, et de ceux du cocotier, dans les voyageurs, entre autres dans François Pyrard, qui n'a rien omis sur le palmier maritime; mais je parlerai des

proportions du dattier, dont personne n'a rien dit que je sache. Si le cocotier a servi de modèle à l'architecture navale, par la forme carénée de ses fruits, le dattier en a servi à sou tour à l'architecture terrestre.

J'observerai d'abord que la largeur de la tête du dattier est égale à la hauteur de sa tige sous les feuilles. La chose est évidente; car si vous prenez la largeur de sa tête, de l'extrémité d'une des palmes horizontales à celle qui lui est diamétralement opposée, vous aurez seize pieds pour chacune d'elles, et deux pieds pour l'épaisseur du tronc qui les porte; ce qui fait en tout un diamètre de trente - quatre pieds, égal à la hauteur de la tige sous les feuilles. Le couronnement de cette tige, formé par les palmes, a en élévation la moitié de son diamètre, c'est-à-dire environ dix-sept pieds; car les palmes en ont seize, et le chapiteau qui les porte en a six; ce qui ferait vingt-deux. Mais comme les palmes y sont rangées par étages, les inférieures, qui ont tout leur développement, ont seules seize pieds; tandis que celles du sommet, qui ne font que se développer. En ont tout au plus onze, qui, avec les six du chapiteau qu'elles terminent, font, en tout, dix-sept pieds d'élévation. Cette proportion est à-peu-près la même dans le bananier, dont les feuilles, de six pieds de longueur, couronnent une tige de douze pieds de hauteur. Mais, comme elles partent du même centre, elles ont un peu moins d'élévation à leur sommet. Us ont, l'un et l'autre, une hauteur qui est une fois et demie leur largeur.

J'ai remarqué que cette proportion du palmier était la plus agréable de toutes, soit dans les berceaux et les avenues formés par des arbres, soit dans les salons. Elle produit, par son élévation, le sentiment de l'infini. C'est celle qu'affectait l'architecture gothique de nos temples, dont les voûtes élevées, supportées par des colonnes sveltes, présentaient, comme la cime des palmiers, une perspective aérienne et céleste qui nous remplit d'un sentiment religieux. L'architecture grecque, au contraire, malgré la régularité de ses ordres et la beauté de ses colonnes, offre souvent, dans ses voûtes, un aspect lourd et terrestre, parce qu'elles ne sont pas assez élevées par rapport à leur largeur.

Enfin, les proportions du palmier se retrouvent dans l'homme même, qui réunit en lui les plus belles de la nature; car ses bras étendus ont une longueur égale à sa hauteur, et sa tête ombragées d'une chevelure flottante imite en quelque sorte la cime ondoyante de ce bel arbre.

Si le palmier, dans sou ensemble, présente la plus belle des proportions pour l'élévation et la largeur des voûtes, il offre également dans sa lige le plus beau modèle des colonnes qui doivent les supporter. Les Grecs, qui ont voulu s'approprier l'invention de tous les arts libéraux, ont prétendu qu'ils avaient imaginé les ordres toscan, dorique, ionique et corinthien; qu'ils avaient pris les proportions de la colonne ionique et des volutes de son chapiteau d'après la taille et la coiffure d'une fille ionienne, et le chapiteau corinthien, d'après une plante d'acanthe sur laquelle on avait posé par hasard un panier. Mais, bien longtemps avant eux, la nature en avait offert les divers modèles, dans le palmier dattier, aux peuples de l'Asie, comme on le voit encore dans les ruines de Persépolis à Chelmina, dont les colonnes ont des chapiteaux à feuilles de palmier. Quant aux volutes et proportions de la colonne ionique, il est certain qu'elles n'ont aucun rapport à la coiffure d'une fille, ni à sa taille, qui n'a jamais été tout d'une venue.

Je ne rejette point les harmonies des végétaux avec l'homme, et celles de l'homme avec les végétaux: au contraire, j'en recueille autant que je peux; je suis même persuadé qu'il en existe un très-grand nombre que je ne connais pas; mais je nVn veux admettre aucune qui soit douteuse. Il est possible qu'en comparant la hauteur d'une jeune tille avec la largeur de son visage, on trouve que dans l'enfance elle ait sept fois le diamètre, huit fois dans l'adolescence, neuf fois dans la jeunesse, et dix fois dans l'âge mur. Il est possible encore qu'on ait rapporté ces proportions a celles des différents ordres; car, comme on sait, c'est le rapport de la hauteur de la colonne A sa largeur qui les constitue. Mais il est sans vraisemblance que des Grecques au sein de la liberté et du

goule, aient donné à une poutre verticale destinée a porter des fardeaux, les proportions d'une jeune fille; qu'ils aient cru imiter sa taille en formant un cylindre, les plis de ses vêlements par des cannelures, et les contours de sa coiffure par des volutes. Il est évident, au contraire, que la tige du palmier a donné le premier modèle de la colonne, pur son attitude perpendiculaire et l'égalité de ses diamètres; celui des tambours cylindriques, dans l'ordre toscan rustiqué, par ses anneaux circulaires et annuels; des cannelures du lui - par les crevasses verticales de son écorce, qui portent à sa racine l'eau des pluies qui tombent sur ses feuilles; des volutes du chapiteau ionique, par les premières sphères de ses éclatés; du chapiteau corinthien, par le feuillage de ses palmes; des proportions des divers ordres, parla haineuse de son tronc à différents âges; enfin, de l'accouple ment même des colonnes, par la manière dont les palmiers se groupent naturellement.

La tige du dattier d'abord semble faite pour porter un grand fardeau, à cause de sa large cime, sinon pesante par elle-même, qui le devient au moins par les secousses des vents auxquelles elle est exposée. Elle ne se plaît que le long des ruisseaux, dans les déserts orageux de l'Arabie, où les vents élèvent des tempêtes de sable, qui ensevelissent quelquefois des caravanes entières. Il en est de même des autres espèces de palmiers, qui aiment tous les climats exposés au vent, tels que le cocotier qui croît sur les écueils de la mer, le latanier sur ses rivages, et le palmiste au sommet des montagnes. C'est sans doute par cette raison, que les tiges de toutes ces espèces, si différentes en productions, sont composées d'un paquet de fibres plus fortes à leur extérieur que dans leur intérieur, et que les feuilles dont elles sont couronnées sont, non seulement ligneuses, mais élastiques et filamenteuses comme des cordes. Le dattier, ainsi que les autres espèces de palmiers, a, dès sa naissance, un diamètre qui ne change point, à quelque hauteur que sa tige s'élève; tandis que celui des troncs des arbres croît avec eux. Ce diamètre, invariable dans le dattier, a donc déjà un rapport très marqué avec le diamètre ou module de la colonne, qui ne varie jamais, et qui sert à fixer les proportions de sa hauteur. La colonne a sept fois son diamètre dans l'ordre toscan, huit dans le dorique, neuf dans l'ionique, dix dans le corinthien. C’est, je le répète, les seuls rapports de sa hauteur à sa largeur qui constituent les différents ordres. C'est par cette raison que les habiles architectes les réduisent à quatre, et rejettent le composite, parce que ses proportions sont les mêmes que celles du corinthien. Quant à ce nombre de quatre, auquel ils fixent leurs ordres, ils disent que la colonne paraît trop grosse au-dessous de sept modules, et trop menue au-dessus de dix; mais ils n'en donnent pas la raison. Pour moi, je sens bien comme eux, par rapport aux colonnes isolées; mais comme je suis persuadé que la raison de nos sentiments est toujours dans la nature, je crois avoir indiqué celle des différentes proportions de la hauteur de la colonne à sa largeur, dans les quatre ordres, en les rapportant à celle de la hauteur de l'homme à la largeur de sa tête, dans les quatre périodes de son accroissement.

Au reste, nous les trouverons bien marquées dans les développements même du dattier. En le .supposant planté de semence dans le terrain et le climat qui lui sont les plus favorables, il n'a guère moins de deux pieds de diamètre à sa naissance au sortir de la terre. Il est d'abord près de sept ans à se former dans le sein de sa mère, et à acquérir deux à trois pieds de hauteur. Son tronc alors paraît à peine, et ne porte guère qu'une grosse touffe; mais il croit ensuite avec plus de rapidité. A huit ans, il sort, pour ainsi dire, de l'enfance: il peut avoir six pieds de haut, ou la hauteur d'un homme. Il prend successivement, huit pieds à neuf ans, dix pieds à dix ans, douze pieds à onze ans, quatorze pieds à douze, seize pieds à treize, dix-huit pieds à quatorze, époque à laquelle il laisse paraître ses premiers régimes, et où une jeune fille commence à être nu hile; vingt pieds à quinze ans, âge où il porte des fruits fécondés par le dattier mâle, et où une jeune fille a acquis ses plus belles proportions, et est propre au mariage. Homère a bien senti ces convenances virginales et conjugales, lorsqu'il fait dire par Ulysse à la princesse Nausicaa qu'il aperçoit au bord de la mer: » L'enchantement que j'éprouve à votre aspect, n'est comparable qu'à celui que je ressentis en voyant, à Délos, ce jeune et magnifique palmier qui s'était élevé tout à coup auprès de l'autel d'Apollon.

C'est à l'âge où le palmier se trouve dans la fleur de sa jeunesse, qu'il offre le plus beau modèle de la colonne. Alors ses belles palmes, toujours vertes, prennent chaque jour de l'accroissement, et, »'élevant vers les cieux, malgré les tempêtes, elles deviennent les symboles de la gloire et de l'immortalité. C'est à cette élévation que les tourterelles, rassurées, viennent déposer leurs nids dans ses draperies, et que les architectes corinthiens fixèrent les hauteurs des colonnes dont ils décorèrent les temples des dieux et de la déesse des amours.

Des Italiens, en voyant une vigne chargée de pampres et de raisins, former d'agréables spirales autour du tronc nu du palmier, crurent imiter ses grâces en tordant la colonne elle-même; mais ils ne produisirent qu'un monstre sur le premier des autels de Rome: on corrompit la nature en s'écartant de ses lois.

Le dattier continue d'élever sa tige, dans sa simplicité majestueuse, jusqu'au-delà de quarante pieds de hauteur. Cette proportion svelte présente dans ses accouplements de nouvelles beautés à l'architecture gothique. Perrault en avait entrevu les effets, lorsqu'en accouplant deux à deux les colonnes du péristyle du Louvre, il leur donna un demi module de plus. Il sentit que chaque couple ne faisant, pour ainsi dire, qu'un seul corps, il fallait ajouter à sa hauteur une partie de ce qu'il acquérait en largeur.

Quant à l'ordre le plus agréable dans lequel on doit grouper les colonnes, il est le même que celui dans lequel les dattiers croissent naturellement. En effet, les palmiers ont beaucoup d'agrément lorsqu'ils forment une longue perspective sur les bonis d'un ruisseau sinueux comme leur régime, rangés deux à deux, l'un rentrant, l'autre saillant: il semble alors qu'on envoie une forci. C'est le même point de vue que présente une double colonnade circulaire, ou un péristyle dans sa longueur. Cette série d'accouplements fraternels est un des grands charmes de celui du l^ouvre. Il a encore quelques rapports qui ajoutent à sa beauté: nous en parlerons aux harmonies fraternelles et conjugales.

Si le dattier donne à l'homme en société des fruits sucrés, onctueux et farineux, réunis a toutes les commodités et à la magnificence de l'ameublement et du logement, les autres espèces de palmiers les lui présentent en détail. Dans toutes les parties de la zone torride, le cocotier, qui croit sur tous les rivages de cette zone, renferme du lait et de l'huile dans ses gros cocos; et le palmiste, habitant des montagnes, un chou excellent dans son sommet. Le latanier lui présente des éventails sur ses rochers marins. Il a cela de particulier en Afrique, dont le dattier paraît originaire, qu'il donne aux noirs du vin, du vinaigre et du sucre dans sa sève. Dans les îles de l'Asie, le sagou contient dans son tronc épais une farine abondante, et l'arec un aromate dans ses noix. En Amérique, le palmier marécageux de l'Orénoque, pendant les débordements périodiques de ce grand fleuve, offre à ses habitants de* fruits succulents, et des asiles dans son feuillage. Tous ensemble fournissent à des tribus entières, des subsistances, des vêtements, des toits, des meubles, des outils de toutes les sortes, des tablettes pour écrire, des râbles, des voiles, des mâts, des bateaux pour voguer d'Ile en ble. Il y a plus de soixante-dix espèces connues de palmiers, mais un grand nombre ne le est pas. Quoique tout et* ensemble elles ne forment, par des caractères qui leur sont communs, qu'un genre primitif qui appartient a la zone torride, elles différent tellement par leurs fleurs et leurs fruits, qu'on peut les regarder connue des genres secondaires, harmonie'.*,d'une part, avec les différents besoins de l'homme en société dans les divers sites torridoniens, et de l'autre, répartis, par leurs variétés, Aux diverses tribus d'animaux qui y *out répandus. En effet, il y a des palmiers que j'appellerai solaires, parce qu'ils croissent sous l'influence la plus active du soleil, au sein des sables brûlants de l'Afrique, tels que les dattiers. Il y a des palmiers de montagnes,et en quelque sorte aériens par la longueur de leurs flèches, qui s'élèvent bien au-dessus des forêts, tels que les palmistes, qui ont quelquefois plus de cent pieds de hauteur. Il y eu a d'aquatiques, qui croissent dans les marais d'eau douce, comme ceux de l'Orénoque; ou dans ceux de la mer, comme les cocotiers; ou sur les rivages et jusque dans les rochers, comme les lataniers et les vaquas. Entre les

tropiques, partout où il y a de l'eau, soit douce ou salée, soit apparente ou souterraine, soit stagnante ou courante, il y croît une espèce particulière de palmier assortie à quelque besoin de l'homme pour ce site-là, et qui, dans chacune de ses variétés, nourrit au moins une espèce particulière de quadrupède, d'oiseau et d'insecte. C'est par cette raison que la nature a donné aux animaux qui en sont les habitants naturels, tels que les singes, de fortes dents canines, et aux perroquets des becs courbés et pointus, laits comme des tenailles, et capables de rompre les noix de toutes les espèces de palmiers mucifères. Enfin, comme les tribus de ces animaux sont infiniment variées, il ne faut pas douter qu'elles ne Soient en rapport avec celles des palmiers: de sorte qu'on peut dire qu'il n'y a pas une seule île dans l'Océan indien, qui n'ait son palmier particulier, comme elle a son singe et son perroquet.

La nature, non contente de suspendre, dans la zone torride, ses bienfaits à ces magnifiques végétaux, les a versés dans le sein des humbles graminées avec non moins de profusion. Elle a mis le sucre tout pur dans la sève d'un roseau, et la farine dans les gros épis encapuchonnés du maïs, et dans ceux du riz et du millet, qui sont divergents. Elle a étendu ensuite ces substances primitives dans les blés des zones tempérées, qui, par leurs diverses fermentations, donnent des aliments farineux et des boissons vineuses, spiritueuses et cordiales. L'orge croît jusqu'au sein de la zone glaciale. Ainsi, les plus mobiles des herbes sont les premiers supports de la vie humaine et de celle des animaux.

Non seulement la nature a satisfait à tous les besoins des êtres sensibles avec des graminées, gladiolées, palmifères, arundinacées, jonchées; mais elle y a encore pourvu par des végétaux de divers genres, dont les prototypes humains sont aussi dans la zone torride. Nous mettons au premier rang les lianes: les tiges en spirales et armées de crochets s'harmonient parfaitement avec les troncs perpendiculaires et raboteux des palmiers ou des autres végétaux. Telles sont celles du bétel avec l'arec, du poivrier avec la canne à sucre, de la vanille avec le cacaotier, de la liane à eau avec le palmiste, et de la liane à vin, ou vigne, qui, dans nos climats se mariant avec l'orme, trouve des supports dans ses branches et des tonneaux dans son tronc.

D'autres genres de végétaux forment les arbres proprement dits, et, avec d'autres combinaisons, pourvoient à tous les besoins de l'homme, suivant les divers sites qu'il occupe. La terre est une vaste table, où la nature sert à ses convives plusieurs services dans des palais de différentes architectures. Elle leur présente, sous l'équateur, des substances farineuses dans le fruit à pain du rima, et dans le pain d’épice du courbari; des sucs rafraîchissants dans l'orange et le citron; des crèmes parfumées dans l'atte, le jacot et le durion; des melons dans la papaye; des confitures, des gelées et des conserves dans les litchis, le mangoustans, les rangoustans, les mangues, les abricots de Saint-Domingue; des fondans dans les corossols et les pommes d'acajou; des onctueux échauffants dans les amandes du badanier; des stomachiques dans le café et le cacao; des cordiaux dans les épiceries du cannellier, du muscadier, du giroflier, et du ravins ara qui en réunit toutes les saveurs. De tous ces arbres, il n'y en a pas un qui se ressemble par ses feuilles, ses fleurs, ses fruits, sa verdure et son attitude. Dans ce magnifique banquet, les buffets e t la vaisselle sont variés comme les mets: je n'en nomme cependant que la plus petite partie. Il n'y a pas moins de prodigalité dans l'habitation de l'homme; c'est un palais garni de tous ses ameublements. Il trouve des urnes de toutes les grandeurs suspendues au calebassier; une citerne entière au sein des sables brûlants d'Afrique,dans le tronc caverneux du baobab; un parasol capable de couvrir la plus nombreuse famille, dans la feuille du tallipot; une laine blanche et légère, propre à ses vêtements et à son lit, dans les gousses du cotonnier; des appartements entiers de verdure, avec leurs cabinets, leurs salons, leurs galeries, sous les arcades du figuier des Banians; une multitude de fruits agrestes dans ces arbres et dans leurs diverses espèces, pour captiver les animaux domestiques par des bienfaits qui ne lui coûtent rien; et une foule d'arbres et d'arbrisseaux épineux, armés de poinçons, d'alênes, de lancettes, de hallebardes, pour servir de remparts à sou habitation et en éloigner les animaux sauvages.

Ces mêmes prévoyances se présentent, avec d'autres combinaisons, dans les arbres des zones tempérées. La nature les proportionne à nos besoins suivant le cours des saisons. Dans les chaleurs ardentes de l'été, les tribus nombreuses de cerisiers, de pruniers, d'abricotiers, de pêchers, nous donnons des fruits rafraîchissants et fondants; et celles des mûriers et des figuiers, des aliments sucrés et pectoraux. Toutes ces productions sont fugitives comme les beaux jours: mais lorsque le soleil s'éloigne de nous avec elles, elles sont remplacées par d'autres, qui sont stationna ires, et qui suppléent à son absence par leurs sucs réchauffant et nourriciers. Les poiriers et les pommiers nous présentent, vers la fin de l'été, leurs fruits vineux. Quand l'automne voile de ses brouillards froids l'astre de la lumière et de la chaleur, les chênes verts et les châtaigniers se hâtent de nous donner leurs glands farineux et substantiels; les pistachiers, les oliviers, les amandiers, les noisetiers, les noyers, leurs huiles savoureuses; et les vignes, dans le jus fermenté de leurs grappes, les plus puissants des cordiaux. Les épiceries même apparaissent dans l'arbre de Winster, au détroit de Magellan; si toutefois on peut mettre dans la zone tempérée ce climat, désolé toute l'année par les vents, les brumes et les neiges. Enfin, les frênes, les tilleuls, les saules, les ormes, les hêtres, les chênes, et une foule d'arbres de divers genres, qui nous ont donné sous leurs charmants feuillages des abris contre les ardeurs de l'été, nous fournissent, dans leurs rameaux et leurs vastes flancs, des toits, des charpentes, des foyers contre les rigueurs de l'hiver.

Souvent les dons que la nature a suspendus aux arbres, sont déposés sur de simples herbes; soit que celles-ci soient des consonances des genres arborescents, comme les graminées le sont des palmiers, et que la nature les ait destinées à croître sur des sols qui ont peu de profondeur; soit plutôt qu'elles forment une seconde table de réserve, à l'abri des injures des éléments. En effet, un arbre est plusieurs années à donner ses premiers fruits, et quelquefois un âge d'homme à parvenir à sa dernière hauteur, tandis que l'herbe atteint à sa perfection dans le cours d'une année. Si l'un et l'autre sont détruits par des incendies ou des ouragans, il y a un intervalle immense entre leur reproduction. Il faut un siècle pour former une forêt, et un seul printemps pour faire croître une prairie. C'est sans doute par cette raison que la nature a quelquefois attachée sous terre, à de simples racines, des fruits qu'elle avait suspendus aux rameaux les plus élevés dans la région des tempêtes.

Quoique nous ayons observé que les espèces des herbes étaient plus nombreuses que celles des arbres dans les zones tempérées, leurs prototypes croissent dans la zone torride, où sont réunies toutes les richesses de la puissance végétale, ainsi que celles des autres puissances. On trouve des farineux sucrés dans le bulbe de la patate et de l'igname; des épiceries dans les pâtes du gingembre; des huiles dans les capsules souterraines de la fausse pistache, remplies d'amandes très savoureuses lorsqu'elles sont grillées. Ces mêmes substances se montrent en évidence dans les aromates des graines de la cardamome et de l'anis, dans les semences farineuses et huileuses d'une multitude d'herbes à fleurs papilionacées eteruciées. Les teintures bleues se manifestent dans la couleur glauque de l'herbe de l'indigo; on peut trouver encore des vases dans les eucurbitees, des retraites et des habitations dans quantité d'herbes sarmenteuses; des haies et des remparts dans les épines des tribus nombreuses des nopals, des raquettes, des aloès, des cactus, qui forment des forêts dans le Mexique. Ce genre épineux de végétaux, aussi étendu que celui des palmiers, semble appartenir aux arbres par son élévation; il s'élance à des hauteurs prodigieuses, et végète pendant des siècles. Mais comme il est dépourvu de branches, qu'il n'a que des fils et des pulpes dans ses tiges, et qu'il croît sur les sols les moins profonds, nous le plaçons au rang des herbes. Lui seul pourrait suffire aux principaux besoins de l'homme; car il lui donne des espèces de figues dans les pommes de raquettes, un fruit délicieux dans l'ananas, qui semble être une espèce d'aloès, et des fils de pite très forts dans les feuilles de l'aloès de la grande espèce. Ce genre est très répandu dans l'Amérique.

Nous retrouverons quelques productions des arbres torridoniens, dans les herbes annuelles et bisannuelles de nos climats. Le goût du fruit de l'arbre à pain se retrouve dans celui du cul d'artichaut; le melon du 'papayer et la courge du calebassier rampent sur les couches de nos jardins; la pulpe fondante et parfumée du corossol reparaît dans la fraise qui tapisse nos bois, et celle du litchi dans le framboisier. Les saveurs aromatiques des épiceries se font sentir dans nos piments, nos sarriettes, nos thyms, nos basilics. Mais qui pourrait nombrer les substances farineuses des pommes de terre, aphrodisiaques de la truffe, alealines de l'ognon, sucrées et pulpeuses des carottes et des betteraves, huileuses du colza; et toutes les herbes qui servent à nos aliments, à nos vêlements et à notre industrie, comme les légumineuses, les chanvres, les lins, les garances, les chardons même épineux et les orties piquantes!' Il semble que l'Abondance a épuise une de ses cornes dans nos jardins et dans nos campagnes.

Cependant, il ne faut pas s'imaginer même les contrées boréales soit dépourvues de végétaux. J'ai vu croître en Finlande, au-delà du soixante et unième degré de latitude, plusieurs plantes légumineuses et potagères de nos climats, telles que les choux et les pois. J'y ai même vu cultiver le tabac, et le cerisier y porter des fruits. On y récolte l'avoine et l'orge. Il n'est pas douteux qu'un grand nombre de nos plantes annuelles pourraient y venir à l'abri et dans les reflets de ses roches. Nos climats s'enrichiraient à leur tour des végétaux qui leur sont indigènes, entre autres, du chou-rave d'Archangel, dont la pomme solide, colorée en dehors des plus vives teintureé de la pourpre et du vermillon, renferme au dedans la saveur de l'artichaut. Plusieurs arbrisseaux et arbres même de nos montagnes y perfectionnent leurs qualités. Le genévrier aromatique y parvient à plus de douze pieds de hauteur: ses rameaux hérissés de feuilles piquantes, et ses grains noirs glacés d'azur, contrastent de la manière la plus agréable avec le sorbier au large feuillage et aux grappes écarlates. Tous deux conservent leurs fruits au sein des neiges, et dans les plus grandes rigueurs de l’hiver; et ils offrent à l'homme, par leur harmonie, le premier, dans l'aromate de ses grains, le second, dans le jus de ses baies, une eau-de-vie qui est un puissant et salutaire cordial. Les bois y sont tapissés de fraisiers, je croit y reconnaître le fruit de la vigne dans la vigne bleue et vineuse du myrtille, et celui du mûrier dans celle blanche et pourpre du kloukva, qui rampe au pied des roches, au sein d'un feuillage du plus beau vert. Si ces baies n'égalent pas en qualité celles dont elles imitent les formes et les couleurs, elles les surpassent en durée; car, lorsque l'hiver les a frappées de froid et ensevelies sous les neiges, elles s'y conservent jusqu'au printemps avec toute leur fraîcheur.

Si nos arbres fruitiers semblent expirer vers le Nord, ceux de ses forêts y prennent une nouvelle vigueur. La puissance végétale s'y montre à la fois dans une jeunesse toujours verdoyante, et dans la sombre majesté de l'âge avancé. Toutes les tribus des peupliers, dont le vaste bouleau paraît le chef, y contrastent avec celles des pins et des sapins, dont le cèdre est le prototype. Les premiers, à la cime étendue, au feuillage ondoyant, exhalent en été les parfums de la rose, et four tussent des eaux sucrées, du papier, des chaussures, des vases, des tonneaux, des nacelles imperméables à l'humidité. Les seconds donnent en hiver des fruits huileux, des flambeaux odorants dans leurs branches résineuses, des matelas dans les longues mousses qui en pendent jusqu'à terre, et nous offrent des toits sous leurs hautes pyramides. Si le palmier des zones torrides a sa tête en parasol hémisphérique pour donner de l'ombre, des palmes ligneuses pour résister aux vents, une tige nue pour donner passage à l'air si nécessaire dans les pays chauds; le sapin, au contraire, a des branches qui se relèvent par leurs extrémités, et laissent tomber leurs folioles à droite et à gauche, en forme de toit, pour faire glisser la neige. Il porte les plus basses à deux fois la hauteur de l'homme, pour lui faciliter le passage dans les forêts; mais il les élève quelquefois à plus de cent pieds, et les neiges forment autour de sa circonférence, un rempart contre l'âpreté de l'atmosphère. Le sapin du nord est vert ainsi que le palmier du midi. Si le sapin avait une cime large et touffue comme le palmier, il serait accablé par le poids des neiges, qui y séjourneraient; si le palmier portait la sienne en pyramide de feuilles comme le sapin, il serait renversé par la violence des ouragans, si terribles dans la zone torride. Cependant il y a des arbres dans cette zone, dont la forme est

pyramidale, tels que le badanier; et. Il en est dans la zone glaciale, dont la cime est hémisphérique, comme le pin nautique; mais les caties du badanier sont évidés et assez semblables à ceux d'un roi d'échecs, et la cime du pin est a jour, et n'est formée a sa base que de branches nues, disposées en parasol. Ainsi la nature a proportionné les feuillages et le port des arbres aux contrées où ils devaient croître.

Nous avons vu que les peuples du Midi avaient trouvé les proportions et les ornements de leur architecture dans les palmiers: ceux du Nord en pourraient trouver une plus convenable a leur climat, dans les sapins; elle ne manquerait pas d'agréments. Si le tronc du palmier a fourni aux premiers de liantes colonnes d'un diamètre égal, celui du sapin en donnerait aux seconds d'un diamètre qui irait toujours en diminuant de bas en haut, et augmenterait leur élévation par la perspective. Si les architectes grecs ont orné de palmes le chapiteau corinthien, s'ils y ont ajouté quelquefois les toiles à réseau de leurs bases, et les nids qu'y forment les colombes; les architectes du Nord pourraient couronner de même leur colonne de sapin de ses propres rameaux, les garnir de leurs mousses naturelles, et y figurer les écureuils qui les habitent, avec leurs queues relevées en forme de plumet sur leurs têtes.' Si la colombe est le plus aimable des oiseaux, l'écureuil est le plus agréable des quadrupèdes.

Le Nord aurait donc un ordre d'architecture à lui, puisque c'est le rapport de la hauteur de la colonne à sa largeur qui le constitue. C'est par cette raison que les habiles gens rejettent l'ordre composite, parce que sa colonne a les mêmes proportions que le corinthien. L'ordre septentrional, au contraire, varierait celles de sa colonne dans chacun de ses diamètres, suivant l'angle déterminé par la nature dans la diminution du tronc des sapins: j'en ignore la valeur, qui, ce me semble, est facile à connaître, si, comme je le crois, il est invariable. J'appellerais cet ordre conique ou pyramidal, comme on pourrait appeler cylindriques les quatre ordres grecs, d'après les formes de leurs colonnes; mais j'aime mieux trouver les choses que d'en chercher les noms, car la nature est très abondante, et la langue stérile.

Au lieu de disposer ces colonnes en longs péristyles, comme celles des Grecs, sans doute d'après l'ordre où sont rangées les dattes sur les grappes du palmier; je les grouperais en rotondes coniques, dans le même ordre où les semences du sapin sont rangées dans leur cône. Pour cet effet, je donnerais une élévation progressive aux colonnes du centre de la rotonde; ce qui en augmenterait l'étendue en perspective, par celles de la circonférence, qui seraient plus courtes et d'un moindre diamètre. Si le péristyle est favorable à la fraîcheur dans les pays chauds, parce qu'il offre une libre circulation; la rotonde conique ne l'est pas moins à la chaleur dans les pays froids, parce qu'elle la concentre au dedans, et qu'elle arrête le cours du vent au dehors. L'intérieur et l'extérieur de sa voûte figureraient les mailles et la forme ovoïde, si agréable, de la pomme de pin. Les neiges y trouveraient une pente facile, et ne s'y arrêteraient pas, comme sur les toits plats de Pétersbourg, où l'on a adopté l'architecture méridionale, si peu convenable aux pays froids. Les Grecs avaient entrevu les beautés qui pouvaient résulter des proportions et des productions du sapin, puisqu'ils les avaient ajoutées à la colonne imitée du palmier. Ils diminuaient le diamètre de celle-ci aux deux tiers de sa hauteur, afin d'accroître sans doute son élévation en perspective. Ils employaient fréquemment la pomme de sort pour ornement dans leur architecture, et surtout sur les tombeaux; ils donnaient même à leur rotonde la forme elliptique ou de cône, si agréable. Les Egyptiens adoptèrent la forme entière du sapin dans leurs pyramides et leurs obélisques. Quant aux Chinois, depuis longtemps ils donnent à leurs riches pavillons des troncs de sapin pour colonnes, et à leurs toits la forme d'un de ses rameaux, relevés aux extrémités. Dans leurs jardins, ils ornent l'entrée de leurs grottes, de cet arbre majestueux, dont la verdure est éternelle; et ils le regardent comme le symbole de l'immortalité.

C'est sous les ombrages de ce bel arbre, dans son atmosphère odorante et aux doux murmures de ses rameaux, que j'ai passé, dans la solitaire Finlande, des moments paisibles, souvent regrettés.

Mes yeux se promenaient avec délices sur les sommets arrondis de ces collines de granit pourpré, entourées de ceintures de mousses du plus beau vert, et émaillées de champignons de toutes les couleurs. Ces productions spontanées fournissent des mets exquis à ses habitants, dont rien n'égale l'innocence et l'hospitalité. Elles s'étendent vers le nord, bien au-delà de la région des sapins. Les mousses croissent sur les rochers les plus arides, et nulle part on n'en trouve en si grande abondance et d'espèces si variées, que dans les contrées les plus septentrionales. J'entrais jusqu'aux genoux dans celles qui tapissent le sol des forêts de la Russie; tandis que je n'ai trouvé que des lianes rampantes sur celui des bois de l'Ile-de-France. Il y a en Laponie plusieurs espèces de mousses comestibles, farineuses, sucrées, parfumées. La nature a mis dans ces climats un animal à cornes ramifiées, qui en tourne les substances aux principaux besoins de l'homme. Le renne moussivore offre au Lapon, dans ses quatre mamelles, un lait plus épais que celui de la vache; dans sa toison, une fourrure plus chaude que celle de la brebis; et dans sa course. Un service plus rapide que celui du cheval. Il y a. de plus, dans les lacs de la Laponie, une multitude d'oiseaux aquatiques et de poissons. J'ai vu dans ceux de la Finlande, qui en font partie, des quantités prodigieuses de canards et d'oies-' sauvages. Au printemps, l'air est rempli de ces oiseaux, ainsi que de bécasses et de cygnes qui vont faire leurs nids dans ces parages, et qui retournent, aux approches de l'hiver, vers des climats plus méridionaux.

Que dis-je! Au-delà de ces rivages, où toute végétation terrestre disparaît, des algues innombrables et de toutes sortes de formes sortent du fond des mers. Ces plantes pélagiennes peuvent, sans doute, fournir quelques subsistances à l'homme. Les Japonais savent tirer des aliments de celles de leurs îles. C'est dans les mers voisines des pôles, que des navigateurs ont péché le fucus giganteus, qui a plus de deux cents pieds de longueur. Les rivages du Groenland, du Spitzberg et de la Nouvelle-Zemble, sont tapissés d'herbes marines, où viennent s'échouer, comme sur des litières, les chevaux et les lions marins, semblables, par la mollesse et l'abondance de leur graisse, à des outres pleines d'huile. C'est dans les flancs de ces amphibies, que les Lapons et les Samoïèdes puisent les provisions de leurs lampes et de leurs foyers. Il en est parmi eux «Tassez hardis, pour aller les chercher au sein des mers et des glaces marines. C'est là qu'un simple pêcheur, dans un petit canot qu'il peut porter sur ses épaules, ose harponner l'énorme baleine, longue comme un vaisseau de guerre. En vain, dans sa douleur, elle bouleverse la mer de sa large queue et de ses grands ailerons; en vain elle se réfugie dans les rochers flottants de glaces, qu'elle rougit de son sang: il vogue à sa suite, attaché à elle par une simple ligne; et lorsqu'elle a perdues forces, il la remorque après lui, et l'amène sur le rivage, aux applaudissements de tous ses compatriotes. Ils trouvent des aliments dans sa chair, des huiles délicieuses à leur palais dans sa graisse, la matière de leurs foyers dans ses crottons, des vêtements dans ses intestins, la charpente de leurs canots dans ses fanons, et celle de leurs toits dans ses grands os. Le harponneur lapon, plus audacieux que tous les héros de l'antiquité, seul, au sein du plus terrible des climats et des éléments, d'un coup de trait perce un colosse formidable, et procure l'abondance à toute sa tribu.

Mais c'est la nature seule qui est digne de nos louanges et de notre admiration. C'est elle qui a fait vivre le plus grand des animaux aux lieux où expire la puissance végétale, et qui a renferme sous le cuir de la haleine tout ce qui était nécessaire aux besoins de l'homme, afin qu'il n'y eût pas sur le globe un point où un être intelligent et sensible ne pût jouir de ses harmonies. Le Groenlandais, arraché par l'avare et dur navigateur à son climat qui nous paraît affreux, devenu un objet de curiosité à la cour des rois, soupire, sous leurs lambris dorés, après les campagnes de neige, les montagnes de glace et les aurores boréales de sa patrie: et s'il entend par hasard les cris d'un nourrisson dans les bras de sa mère, il lève vers le ciel des yeux baignés de larmes, au souvenir de sa compagne fidèle et de ses chers enfants, qui l'appellent 'en vain sur les rivages brumeux et retentissants de son île fortunée.

Ce ne sont donc pas seulement les harmonies physiques qui nous attachent à la vie; les morales nous y lient bien davantage, en nous élevant vers les deux. Ce sont elles qui donnent tant de

charmes aux jouissances physiques, en se confondant avec elles. Elles ordonnent et elles assemblent toutes les harmonies des diverses puissances; et leur effet est si sensible, que les botanistes, qui n'ont point aperçu les rapports élémentaires, animaux et humains de la puissance végétale, en ont caractérisé les genres par des rapports moraux, comme nous l'allions voir.

Nous avons vu que l'harmonie fraternelle se manifestait dans chaque végétal par ses feuilles, ses fleurs, et ses semences, divisées pour l'ordinaire en deux parties égales, afin qu'elles pussent s'entraider. Elle reparaît encore dans les agrégations de ses rejetons ou de ses plants, dont elle forme des touffes ou des bocages. Enfin elle se montre dans ses espèces diverses, qui ne sont que des consonances et, pour ainsi dire, des fraternités du même genre. Mais les genres aussi s'unissent entre eux par leurs contrastes même; et c'est leur harmonie qui donne tant de charmes aux paysages. Dans la zone torride, un grand nombre d'arbres ont leur tronc perpendiculaire, et dépouillé de branches à leur partie inférieure et presque jusqu'à leur sommet, afin de n'être pas trop en prise aux ouragans. D'un autre côté, il y a une très-grande variété de lianes grimpantes, qui revêtissent de leurs feuillages les tiges nues des arbres. Les unes et les autres forment les plus charmants contrastes; car, feuilles, fleurs, fruits, attitudes, n'ont rien qui se ressemble. Je suis porté à croire que chaque genre d'arbre a son genre de lianes. Nous avons déjà dit qu'aux Indes, la plante sarmenteuse du bétel tournait en spirale autour du palmier arec; mais ce qu'il y a de particulier, c'est que la feuille du bétel et la noix de l'arec produisent, par leur mélange, une saveur très agréable aux Indiens. Ils en font un mâchicatoire dont ils usent sans cesse. Il en est de même de la canne à sucre et de la liane du poivre, qu'ils groupent souvent ensemble, et dont ils aiment également à mêler les saveurs. Les Indiens occidentaux retrouvent ces harmonies dans le cacaotier et la vanille.

Mais la terre est couverte de genres de végétaux fraternisant. En Italie, la vigne et l'orme; dans nos campagnes, les blés et les légumineuses; dans nos prairies, les graminées et les trèfles; sur les bords de nos rivières, les saules argentés et les aunes au vert sombre; au sein des ondes, les roseaux perpendiculaires et les nymphéa aux feuilles horizontales; dans nos forêts, les chênes et les châtaigniers; dans celles du nord, les sapins pyramidaux et les bouleaux à la large cime; sur les rochers de la Finlande, les champignons et les mousses; enfin sur ceux même du stérile Spitzberg, le cochléaria vert et l'oseille rouge; et une infinité d'autres, forment, jusqu'au fond des mers, par la fraternité de leurs genres, la plus agréable et sans doute la plus utile des harmonies végétales. Linnaeus l'avait entrevue, lorsqu'il a donné le nom d'adelphie ou de fraternité à l'assemblage des anthères dans les fleurs; mais il aurait dû l'étendre à celui des fleurs mêmes, des familles, des espèces et des genres, puisqu'elle y est encore plus apparente. Il n'a fait qu'une application particulière d'une loi générale. Ce que j'en dis n'est pas pour diminuer son mérite. La gloire d'une découverte appartient plus à celui qui aperçoit en mer la première pointe d'une île inconnue, qu'à celui qui en achève le tour. Pour moi, j'en côtoie seulement çà et là quelques rivages.

L'harmonie conjugale des genres est encore plus caractérisée que l'harmonie fraternelle, dans la puissance végétale, et n'en a pas moins été longtemps méconnue. On sait aujourd'hui qu'elle divise les végétaux, ainsi que les animaux, en deux grands genres, masculin et féminin, réunis à la vérité pour la plupart dans le même individu, et souvent dans la même fleur. Les pommiers, les pêchers, les pruniers, les vignes, les légumineuses, les graminées, et beaucoup d'autres, offrent dans leurs fleurs la réunion parfaite des deux sexes. Les cucurbitées, les noisetiers, les châtaigniers, etc., en présentent la division sur les rameaux du même individu; enfin les palmiers dattiers, les lataniers, les papayers, et dans nos climats les pistachiers, les ormes, les chanvres, les lychnis, en montrent la séparation totale sur des tiges isolées, et souvent fort éloignées les unes des autres. Il est aisé de sentir pourquoi la nature a réuni les deux sexes d'un végétal dans sa fleur. On voit que, n'étant pas susceptibles de déplacement, et privés d'ailleurs d'intelligence, ils ne pouvaient ni se chercher ni se rapprocher. Quant aux sexes qui sont séparés sur les branches du même végétal, ou qui sont même tout à fait isolés, j'avoue que j'en ignore la raison. Elle existe sans doute, et elle doit être très

curieuse à découvrir. L'exception d'une loi générale est souvent, dans la nature, le fondement d'une loi nouvelle. Quoi qu'il en soit, la fécondation des plantes qui se conjuguent de loin, n'est pas moins assurée que celle des sexes qui se conjuguent au sein des mêmes pétales. Ce sont les courants de l'air qui en sont les intermédiaires, comme ceux des eaux le sont du frai des poissons: ils portent le pollen des mâles aux stigmates des femelles, et en fécondent les ovaires. Au défaut des zéphyrs, plus inconstants que les ondes, les insectes ailés, et surtout les mouches garnies de poils, se chargent de cette poussière fécondante, en picorant les glandes nectars des fleurs mâles, et vont les déposer au loin, au sein des fleurs femelles. Souvent l'abeille sans sexe est involontairement la médiatrice de leurs amours. Au reste, malgré tant d'intrigues, les caractères conjugaux des genres sont inaltérables. On voit quelquefois des espèces métisses résulter d'espèces différentes. On cultive dans nos jardins l'abricot-pêche et .la prune abricotée; mais jamais on n'a vu dans nos forêts le chêne, voisin du châtaignier, porter des marrons; ni l'orme, le soutien de la vigne, des raisins. Linnaeus a senti toute l'étendue de l'harmonie conjugale des végétaux, et il en a tiré les caractères principaux de son système botanique, divisé en vingt-quatre classes. Il détermine les treize premières par le nombre des étamines, ou parties mâles, qu'il appelle andrie, du mot grec qui signifie mari. Telle est la classe de la monandre, ou des fleurs qui n'ont qu'un mari; celle de la diandrie, ou de deux maris; de la triandrie, ou de trois maris, etc., ainsi jusqu'à la treizième, qu'il appelle polyandrie, parce que ses fleurs renferment un grand nombre d'étamines. Il rapporte ensuite ses quatorzièmes et quinzièmes classes à la dynamie ou puissance génératrice, qui appartient aussi à l'harmonie conjugale, à moins qu'on ne veuille l'attribuer à l'harmonie maternelle, qui en est le résultat. Les seizième, dix-septième et dix-huitième sont comprises dans l'adelphie, ou fraternité; mais comme il n'applique cette harmonie qu'à l'agrégation des étamines, ou des maris, on sent qu'elle- est encore du ressort de la conjugale. Il en est de même de la dix-neuvième classe, qu'il nomme syngénésie, qui veut dire cum signo, j'engendre avec, parce que les parties mâles sont jointes ensemble; ainsi que de la vingtième, qu'il appelle gynandrie, de femme, et d'un type de mari, de la réunion des parties mâles aux femelles. Il donne à la vingt et unième et à la vingt-deuxième le nom commun specîe, de eixitt, maison; et il les divise en monœcie et en diœcie, parce que les mâles y sont sur un seul et même pied dans la première, et sur des pieds différents dans la seconde. Il fait de la vingt troisième une polygamie, de woxùc, plusieurs, et de yel/Aoç, noces, parce que les mâles et les femelles y sont réunis dans les mêmes fleurs. Enfin la vingt-quatrième classe est la cryptogamie, de xpÛTilu, je cache, yâ/moç, les noces, parce que la génération s'y fait d'une manière cachée. On voit donc que Linnaeus a rapporté toutes ses classes, sans exception, à l'harmonie conjugale et à ses diverses modifications.

L'harmonie maternelle des genres se retrouve dans les fruits ou les semences. Elle caractérise la prévoyance de la nature pour leur conservation, leur transport et leur développement. Ils sont revêtus de balles, comme les grains des graminées; de capsules, comme ceux des légumineuses; de cuir, comme les pépins; de coques pierreuses, comme les noyaux; d'étoupes solides ou cuirs, comme les cocos; de brou et de coques ligneuses, comme les noix; de cuirs et d'enveloppes épineuses, comme les châtaignes, etc. Les uns sont armés d'aigrettes, ou de volants, pour traverser les airs et se ressemer sur toutes les hauteurs, depuis celle d'une taupinière jusqu'à celle du mont Liban: telles sont les semences du pissenlit et du cèdre. D'autres sont renfermés dans des espèces de bateaux, pour voguer et se replanter le long des ruisseaux, des rivières, et des rivages de la mer, tels que la noisette, la noix et le coco. Quelques fruits, au lieu d'avoir leurs l'ormes carénées, les ont arrondies, afin de s'éloigner, en roulant, de la tige maternelle, et de pouvoir se reproduire sans obstacle: telles sont les pommes, les oranges, etc.; mais la plupart de ces rapports sont en quelque sorte élémentaires, quoique établis par une Providence très attentive a la reproduction de ses ouvrages. Il en est encore de plus maternels, ce sont les cotylédons. Le cotylédon est la feuille nourricière de l'embryon; c'est la mamelle de la jeune plante. Elle ne reste point attachée au sein maternel, comme dans les animaux: elle accompagne le fœtus, et émigre avec lui. Les graminées et les palmiers n'ont qu'un cotylédon dans leurs semences, qui, pour cette raison, n'appellent monocotylédones; celles des légumineuses en ont deux, et se nomment dicotylédones; d'autres en

ont plusieurs, et sont appelées polycotylédones; d'autres n'en ont point du tout, et sont dites acotylédones: telles sont celles des mousses, des champignons et de tous les cryptogames. Peut-être peut-on ranger dans ce dernier genre les aloès vivipares, et les rapporter à celui des champignons, comme les palmiers monocotylédones aux graminées. Quoi qu'il en soit, ces caractères maternels des cotylédons ont fourni aux célèbres botanistes l|ay, Haller et Jussieu, la première et principale division de leurs systèmes. Tournefort en a tiré d'autres des fruits mêmes. On peut concevoir encore d'autres harmonies maternelles dans la protection que des genres robustes donnent à des genres faibles, qui, par leurs disproportions, ne peuvent se rapporter aux fraternelles et aux conjugales. Telles sont celles des buissons épineux avec les violettes qui croissent à leur abri, comme Ai elles craignaient d'être foulées aux pieds. Telles sont encore celles des grands arbres avec les herbes, surtout avec celles appelées improprement parasites. J'ai remarqué, dans mes Etudes, que chaque arbre avait son espèce particulière de champignon. Celui de l'aune, arbre des fleuves, ressemble à un coquillage; les vieux troncs des peupliers portent souvent des touffes de scolopendre; ceux des pommiers, le gui aux perles argentées. Chaque arbre a aussi sa mousse. Le chêne donne souvent des supports au chèvrefeuille, au lierre et à plusieurs autres plantes rampantes. Ce sont ces harmonies maternelles du genre le plus fort au plus faible, et du plus élevé au plus humble, qui répandent tant de charmes dans nos antiques forêts.

L'harmonie spécifiant des genres est celle qui produit des genres secondaires, qui diffèrent des espèces proprement dites: ainsi, par exemple, le genre primitif des graminées donne les genres secondaire* des joncs, des glaïeuls, des roseaux, des palmiers. Ceux-ci, à leur tour, produisent des espèces diverses, telles que les joncs de montagnes creusas en gouttières, et ceux des marais, qui sont pleins; les glaïeuls, les iris, les alisiers, les bananiers, les roseaux, les typha, les bambous, les palmiers, les dattiers, les cocotiers, etc. Les espèces donnent des variétés primitives et secondaires. Chacun de ces genres, chacune de ces espèces et de ces variétés, peut se classer de la manière la plus exacte, en fixant d'abord son prototype à un des besoins de l'homme, et ses dérivés à ceux des animaux, et en les rapportant ensuite a chacune des harmonies, physique et morale. C'est ainsi que Linnon si rapporte au genre des pruniers, Non seulement les pruniers proprement dits, mais les pêchers, les abricotiers, et je crois même aussi, Ici Yerisiers. Ce qu'il y a de certain, c'est que Jean -Jacques m'a fait observer, au bas des feuilles de tous les fruits a noyau, deux petits tubercules, qui les caractérisent; ils diffèrent cependant essentiellement les uns des autres par leurs couleurs, leurs formes, leurs parfums, leurs saveurs, leurs qualités. On ne peut en établir les différences que par les moyens harmoniques que j'ai indiqués. Au reste, il n'y a point de genre primitif qui n'ait ses dérivés en, grand nombre, et qui ne les étende dans tous les sites, depuis la Ligne jusqu'aux pôles, pour les besoins de l'homme et de tous les animaux. Jo conçois donc, comme je l'ai déjà dit, que le seul genre des graminées suffirait pour revêtir en magnificence tous les théâtres de la végétation sur le globe, et y offrir des aliments, des boissons, des vêtements, des litieres, des toits, des foyers, des pelouses et des bocages.

L'harmonie générique des genres dans la puissance végétale, est celle qui résulte des contrastes de ses genres primitifs. Nous avons vu que le mot de genre vient d'engendrer. Le genre est donc une création primitive, qui renferme une génération espèces harmoniées aux divers besoins des animaux, et dont le prototype se rapporte à un des besoins principaux de l'homme. L'homme étant lui-même un être harmonique, ses besoins viennent d'excès ou de défaut dans chacun de ses tempéraments. Ainsi, par exemple, dans les pays méridionaux, tantôt le sang est trop échauffé, tantôt il ne Test pas assez: la nature a placé, d'une part, les fruits rafraîchissants et acides, comme les oranges et les citrons, et, d'une autre part, les échauffants, comme les sucrés et les aromatiques. On compose de leurs jus différents des sorbets délicieux. Les végétaux qui les produisent contrastent, comme leurs qualités, en feuillages, en fleurs, en fruits et en altitudes. Nous avons entrevu ces harmonies dans les palmiers et les lianes, les bouleaux et les sapins, les graminées et les légumineuses, et jusque dans les mousses et les champignons du Nord. Il y en a un grand nombre d'autres qui n'ont pas été observées, quoiqu'elles soient sous nos yeux. On peut

assurer que toutes les fois que nous éprouvons un sentiment extraordinaire de plaisir, à la vue d'une touffe de plantes diverses ou d'un bosquet d'arbres différents, il y a harmonie de genres. On en peut conclure que la même harmonie qui est dans leurs formes opposées, existe aussi dans leurs productions, de manière qu'il résulte de leur union, ou un aliment salutaire, ou un parfum agréable, ou une riche teinture. C'est ainsi que le cochléaria aux feuilles arrondies en cuiller, et l'oseille rouge aux feuilles pointues, qui croissent ensemble sur les rivages brumeux du Spitzberg, fournissent aux marins, par leur mélange, le plus puissant des antiscorbutiques. Quelle jeune fille n'a pris plaisir, au printemps, à former un bouquet de primevères éclatantes et de sombres violettes qui croissent, le long des bois, dans les mêmes touffes? Leurs doux parfums s'harmonient comme leurs couleurs et leurs formes. C'est sans doute avec des fleurs contrastantes, que Glycère composait ces charmantes guirlandes qui immortalisèrent les tableaux de son amant. Ces harmonies de genres se rencontrent fréquemment dans nos prairies, où se confondent les amourettes ondoyantes avec les trèfles empourprés, les pâquerettes, les orchis, les scabieuses au bleu mourant, et les adonis, ainsi appelés peut-être, parce que leurs petites fleurs ovales, fugitives, et d'un rouge vif, sont semblables aux gouttes tle sang ipie versa sur l'herbe le beau favori de Vénus. Le bluet et le coquelicot produisent ensemble une teinte pourpre dans le jaune doré de nos moissons. Ces harmonies se montrent de toutes pays sur les lisières des forêts et autour de leurs clairières, dans les rubuscl les épines blanches, les cornouillers et les genêts dorés, et dans une multitude de buissons qui entremêlent leurs rameaux. Elles décorent les ravins, les précipices, les bords des eaux, les rochers, et toutes les aspérités de la terre, Mais elles s'élèvent vers les cieux avec les hautes tiges harmoniées des frênes et des ormes, des pommiers sauvages et des châtaigniers, des peupliers et des sapins, des hêtres et des chênes. Rien n'égale la paix, la grâce et la magnificence de ces retraites. On n'y entend que les doux murmures des vents, et les chants des oiseaux. Ici, de vastes pelouses invitent aux danses les bergères; là, de longues galeries, de sombres portiques appellent aux douces rêveries les amants, les poètes et les philosophes. Ici et là, des temples majestueux de verdure, élevés par les siècles sur des troncs couvert* de mousse, dominent au-dessus de la forêt. Chaque arbre a son expression, et chaque groupe son concert. Des sentiments confus d'amour et de respect, de gaieté et de protection, de volupté et de mélancolie religieuse, semblent sortir de leurs flancs, et se succèdent tour à tour dans le cœur de tout être qui a aimé et souffert. Ces harmonies varient avec celles du soleil: elles sont autres à son aurore, à son midi, à son couchant. Elles diffèrent encore plus aux clartés silencieuses de la lune. Elles se manifestent cependant au sein même des nuits les plus obscures, lorsque les feuillages des arbres se confondent avec les constellations, et que leurs rameaux semblent porter des étoiles. Mais ce ne sont là que les harmonies d'un coin de terre, aperçues par un seul homme. Chaque site a les siennes qui lui sont propres, et les sites eux-mêmes sont variés comme elles dans toute la sphéricité du globe. L'harmonie sphérique des genres, dans la puissance végétale, s'étend depuis l'équateur jusqu'aux pôles, et depuis le sommet des plus hautes montagnes jusqu'au fond des mers. Ce sont les harmonies de tous les genres, de toutes les espèces et de toutes les variétés. Aucun œil humain n'en a^vu l'ensemble; mais quelques voyageurs en ont entrevu des portions, et nous en ont donné des esquisses pleines d'intérêt. Le marin Dampier, et son compatriote Cook qui a marché sur ses traces, nous en ont présenté quelques-unes de ravissantes, quoique prises au hasard sur les simples rivages de quelques îles désertes. Elles font le charme de leurs relations. Ces harmonies sont répandues dans l'intérieur de tous les continents, lorsqu'elles n'ont pas été altérées par la main des hommes. Pagès a vu dans celui du Mexique, et au sein de ses forêts solitaires, des arbres monstrueux, tout couverts de longues mousses grises, appelées barbes d'Espagnol, qui descendaient depuis le sommet de leurs branches jusqu'à terre. Ils ressemblaient à de grandes tours couvertes de crêpes, et ils étaient groupés sur le bord des fleuves, qui en reflétaient les images vénérables. D'un autre côté, il a trouvé, dans des lieux secs et arides de ces mêmes contrées, des cierges qui s'élevaient comme des obélisques de fleurs et d'épines, à plus de trente pieds de hauteur. Le paysage en était couvert en entier. Pagès dit que l'aspect si nouveau de ces forêts le comblait d'admiration et de plaisir, et le dédommageait, dans un instant, de toutes les fatigues de son voyage. Il l'avait entrepris seul et presque sans moyens, dans l'intention de connaître l'homme dans

l'état de nature. Il y rencontra, en effet, des familles d'Indiens logées entre les troncs de ces gros arbres, qu'ils abattaient par le moyen du feu. Elles fuyaient le joug des Espagnols, et recueillaient de la cochenille sur les cactus. Leur vie était pleine d'innocence et de bonne foi, et elles exercèrent la plus généreuse hospitalité à l'égard de cet Européen, qui devait leur être suspect à bien des litres. Pour moi, j'ai Mi aussi des végétaux doux les genres opposés étaient groupés par la seule nature, et je n'ai pas été moins sensible à leurs magiques effets. J'ai vu des portions de forets de la Finlande et de l'Ile-de-France avec toutes leurs beautés virginales; et je ne sais à laquelle des deux harmonies, de celle du Nord ou de celle du Midi, j'aurais donné la préférence. La partie de la Finlande que l'ai visiter, lorsque j'étais ingénieur au service de Russie, est celle qui est au nord de Wibourg, et' |'un est connue sous les noms de Lapland, de Can'lie et de Savalascie. Elle est comprise entre le 60eme degré et le 61eme de latitude nord; tandis que Ile-de-France est vers le 22eme degré de latitude sud. Il y a environ deux mille cent lieux de différence en latitude; et je puis dire n'avoir pas vu dams leurs végétaux indignes deux brins d'herbes semblables. Tout y diffère, jusqu'aux pierres et au sol du pays. En Finlande, ce sont, comme je l'ai dit ailleurs, des collines ovales de granit, dont les tilles chauves sont entourées de ceintures de mousses et de champignons, et dont les vallons sont remplis de bouleaux et de sapins. Ces genres de végétaux formaient, par leurs contrastes parfaits, les plus charmantes harmonies. On les retrouvait dans les chemins même de démarcation séparent la Sud de la Finlande russe; car ces routes sont si peu fréquentées, et les arbres du Nord y croissent si vite, que nous fûmes obligés, pour les parcourir, de quitter nos voitures, et d'envoyer en quelques endroits faire des abattis, afin d'y passer à cheval. Ainsi, Non seulement la nature a ordonné les harmonies végétales, mais elle s'occupe sans cesse à les entretenir, malgré les travaux des hommes. Elle réunit, par elles, les contrées qu'ils cherchent en vain à se partager. Nous apercevions souvent, entre les troncs sombres des sapins et blancs des bouleaux, un lac avec ses îles; ou bien nous entendions de loin les bruyantes cataractes, dont les eaux se précipitaient du nord au sud, comme toutes celles de ce pays, qui élève ses divers plans vers le pôle. L'Ile-de-France m'a offert des aspects tout différents. J'en ai fait le tour à pied, le long de la mer. Je marchais par un sentier frayé, au milieu d'une prairie d'un vert glauque, formée d'un chiendent maritime, dont les tiges rampantes, semblables à des paquets de ficelle, sont terminées par des houppes de feuilles dures et piquantes. Cette herbe, très propre à résister à la violence et à l'âpreté des vents de mer, forme une grande lisière autour de l'île, où elle n'est interrompue que par des bocages de lataniers, qui y donnent de l'ombre, et présentent la même résistance aux tempêtes. Les forêts de l'intérieur de l'île ne croissent pas à plus d'un quart de lieue du rivage. Souvent je les côtoyais, et j'y distinguais des groupes de benjoins et de tatamaques, de bois de fouge et de bois d'olives, de bois de ronde et d'ébéniers, et d'une multitude d'autres arbres dont les noms m'étaient inconnus. Des palmistes élevaient au milieu d'eux leurs longues flèches, surmontées de leurs panaches toujours mobiles, tandis que des lianes, grosses et longues comme des câbles, tapissaient leurs lisières de vastes courtines de feuillages, et s'enlaçant avec leurs troncs, les défendaient contre la fureur des ouragans. Des rivières qui descendaient en torrents des montagnes à travers ces bois, y ouvraient çà et là de profondes avenues d'eaux mugissantes sous de magnifiques arcades de verdure. Elles alimentaient des végétaux jusqu'à leur embouchure, souvent obstruée par des mangliers qu'agitaient les flots de la mer, tandis que des veloutiers voisins contrastaient avec eux au sein aride des roches. Plus d'une fois, assis au pied d'un arbre dans ces vastes forêts, je me suis livré aux plus douces méditations, à la vue de leurs rameaux couverts de fruits bercés par les brises marines, et peuplés de singes et d'oiseaux de toutes les couleurs. Ces murmures forestiers, ces cris et ces chants de joie et de reconnaissance, me disaient d'une manière bien intelligible: Il y a ici un Dieu prévoyant.

Harmonies Végétales Du Soleil Et De La Lune

Si les rayons du soleil et de la lune sont réfractés par l'air, reflétés par les eaux, réfléchis par la terre; s'ils sont réverbérés même par les simples murs des jardins et des maisons, de manière que l'atmosphère des villes en est sensiblement réchauffée; il n'est pas douteux que leur chaleur ne

doive s'accroître considérablement par les feuilles des végétaux, disposées par plans innombrables dans les herbes et dans les arbres. J'ai observé, en effet, que lorsque notre hémisphère se couvre de ces réverbères végétaux, au mois d'avril, l'accroissement de la chaleur est beaucoup plus rapide que dans les mois qui le précèdent et dans ceux qui le suivent. Cet adoucissement subit de température a fait donner à ce mois le nom d'avril, du mot latin ouvrir, et le surnom de doux, a cause de sa chaleur, qui le rend singulièrement remarquable au sortir de l'hiver. Il la doit à ce nombre infini de feuilles réverbérantes qui sortent toutes à la fois de leurs bourgeons, et qui réfléchissent les rayons du soleil par leurs plans. Nous avons remarqué, dans nos Etudes, que les arbres du Nord, tels que les sapins, avaient leurs tiges pyramidales et leurs feuilles vernissées, pour augmenter cette réverbération, et que la plupart des arbres à tête horizontale de la zone torride les avaient ternes en dessous pour l'affaiblir.

J'attribue à l'effet des premières une partie de la chaleur des étés du Nord; je l'ai trouvé si considérable en traversant les forêts de la Russie, de Moscou à Pétersbourg, que je ne doute pas qu'elle ne surpasse celle de la zone torride, que j'ai traversée deux fois. Je ne suis point surpris qu'un physicien anglais ait prétendu prouver, par les observations du thermomètre, que la somme de la chaleur était la même sous l'équateur el sous les cercles polaires. Elle est, sans contredit, plus grande au Nord en été, si l'on compare la température d'un lieu pris dans une forêt de sapins, à celle d'un lieu pris en pleine mer sous l'équateur, parce que les plans réverbérants des feuilles lustrées des sapins ont une bien plus grande étendue que la surface de l'Océan, dans un horizon de la même grandeur. 11 serait très curieux de calculer la somme et la différence; on pourrait en conclure celle de leur température. On sait que ce fut par le simple effet de miroirs plans dirigés vers un seul point, qu'Archimède brûla les vaisseaux des Romains les uns après les autres. Certainement on ne peut attribuer les chaleurs excessives de Pétersbourg, en été, à la simple action du soleil, qui n'est pas plus de vingt heures sur l'horizon. Il faut donc y ajouter quelque cause réverbérante, et on la trouvera dans les feuilles lustrées de ses forêts.

Il n'est pas douteux que les reflets de la terre n'augmentent la chaleur du soleil. Une lie est plus chaude que la mer qui l'environne; celle qui est montueuse* l'est plus que celle qui est unie, et celle qui est boisée que celle qui est nue. Il semble que la lumière sorte des végétaux éclairés du soleil en plein midi. Alors les sommités des épis d'un champ et des graminées d'une prairie paraissent toutes lumineuses; la végétation des plantes s'accroît par leurs reflets. Un épi de blé mûrit plus tôt dans une moisson qu'isolé, et les barbeaux fleurissent plus vite parmi les blés, qu'en bordure dans les jardins.

Mais ces effets de la réverbération sont surtout sensibles dans les fleurs. Ce sont des réverbères qui renvoient les rayons solaires de toutes parts. Elles paraissent proportionnellement plus grandes que le reste du végétal qui les porte. Voyez un rhododendron ou un rosier fleuri, vous croiriez qu'une flamme est attachée à chacune de leurs fleurs; une lumière sensible s'en fait apercevoir au loin. Il est impossible qu'il ne sorte pas aussi quelque chaleur des fleurs, façonnées en miroirs plans, concaves, paraboliques, et quelquefois vernissés, comme celles de nos bassinets. Elles produisent encore plus fortement que les simples feuilles, les effets des murs et des ados de nos jardins.

Il est possible qu'il y ait des fleurs entièrement patronnées sur le soleil. Nous en trouvons dans les orchis, qui imitent la forme d'une abeille, d'autres des figures humaines, et sont,' pour cet effet, appelées personnes. Pourquoi n'y eu aurait-il pas qui, dans leur intérieur, contiendraient une topographie de l'astre du jour,' qui a sur elles tant d'influence? Les asters sont rayonnants comme des astres, dont ils portent le nom. La marguerite, comme nous l'avons vu, imite dans sou disque entouré de pétales et couvert de fleurons, un des hémisphères de la terre avec son équateur et ses genres de végétaux disposés en spirale. Il est possible qu'une fleur renferme dans son sein le plan même du soleil, que nous refusent nos télescopes. Pourquoi n'y en aurait - il pas où seraient figurés les premiers linéaments de cet astre, lorsqu'il y en a tant qui nous représentent des ligures

d'insectes, d'oiseaux, et de têtes d'animaux et d'hommes? C'est aux botanistes qu'appartient le soin de ces recherches curieuses, quoique plusieurs fois ils aient foulé aux pieds les vérités les plus communes, sans les apercevoir,

. Nous avons vu, aux harmonies du soleil avec les végétaux, qu'ils en tiraient presque toutes leurs qualités; que les fleurs de quelques-uns, exposées tout le jour à la lumière, devenaient phosphoriques la nuit, telles que celles de là capucine bisannuelle; que c'était à lui, d'une part, et à l'homme de l'autre, que leurs genres étaient ordonnés; que leurs fruits lui devaient en grande partie leurs couleurs et leurs saveurs; que leurs bois étaient des espèces d'épongés qui s'imbibaient de ses rayons pendant l'été, et nous les rendaient en feu, l'hiver, dans nos foyers; que c'était à ces mêmes rayons qu'étaient dues leurs lueurs phosphoriques, lorsqu'ils se décomposent d'eux-mêmes; et qu'enfin ils portaient des marques évidentes des influences du soleil, par les couches annuelles dont ils se revêtent chaque année. Nous ne récapitulons ici ces harmonies passives, que pour réunir toutes celles de la puissance végétale avec le soleil. Nous en agirons de même pour celles qu'elle a avec les autres puissances.

Les végétaux ont aussi, comme nous l'avons vu ailleurs, des rapports très marqués avec la lune. J'ai parlé des cercles concentriques des racines de quelques plantes, qui expriment le nombre de leurs mois lunaires, comme ceux des arbres celui de leurs années solaires. Je vais ajouter ici une observation que j'ai faite depuis peu des harmonies Luni-solaires des arbres mêmes. J'ai remarqué dans un morceau de planche, de bols d'orme, bien poli, douze rangées de fiqres parallèles dans chacun des faisceaux qui composaient la coupe longitudinale des couches annuelles de son tronc. Sept ou huit de ces rangées de fibres étaient d'une largeur très sensible du cote' de l'intérieur de l'arbre, et les quatre ou cinq du coté de l'extérieur l'étaient à peine. J'en ai conclu que ces douze rangs marquaient les douze lunes de chaque année dans la couche annuelle solaire du tronc; que les sept ou huit intérieurs, les plus sensibles, avaient été produits par les lunes du printemps, de l'été et de l'automne, pendant lesquelles la végétation a beaucoup d'activité; et que les quatre ou cinq rangs extérieurs, a peine sensibles du lais) eau, étaient l'ouvrage des lunes inertes de l'hiver. Cette observation est certaine. Je ne doute pas qu'on ne la vérifie, non seulement sur le bois d'orme coupé dans sa longueur, mais aussi sur les fibres de beaucoup d'autres espèces de bois. Telle prouve évidemment sous les influences lunaires de chaque mois s'harmonient avec les influences solaires de chaque année, et qu'elles ne sont pas moins sensibles dans les troncs des arbres, que dan» les racines et les bulbes de plusieurs plantes que j'ai alléguées en preuve. Telles sont celles des ognons, des carottes, des betteraves, etc.., composées de couches qui ont toujours eu nombre égal à celui des mois lunaires pendant lesquels ces vitaux ont vécu. Il serait à souhaiter que de semblables observations se lissent sur des bois de la zone torride, où la végétation est en activité toute l'année. Peut-être trouverait-on dans les couches annuelles de quelques genres les douze rangées lunaires de fibres, bien distinctes. Peut-être seraient-elles confondues dans d'autres. Les couches annuelles ne paraissent presque point dans le bois d'ébène, dont l'aubier est tout blanc et le cœur tout noir. J'en ai vu une espèce à l'Ile-de-France, dont le blanc et le noir sont mêlés, non par cercles, mais par plaques irrégulières. Cependant les cercles annuels, avec leurs fibres mensales, sont très marqués dans les bois d'acajou et de rose.

Au reste, les feuilles et les fleurs de la plupart des végétaux reflètent les rayons de la lune comme ceux du soleil. C'est même particulièrement sous leur influence, que la belle-de-nuit et le convolvulus nocturne des Indes ouvrent leurs pétales, qu'ils ferment pendant le jour. J'ai éprouvé, une nuit, un effet enchanteur de ces reflets lunaires des végétaux. Quelques dames et quelques jeunes gens de mes amis, firent un jour avec moi la partie d'aller voir le tombeau de Jean-Jacques à Ermenonville: c'était au mois de mai. Nous prîmes la voiture publique de Soi*sons, et nous la quittâmes h dix lieues et demie de Paris, une lieue au-dessus de Dammartin. On nous dit que de là a Ermenonville, il n'y avait pas trois quarts de licuc. Le soleil allait se coucher lorsque nous mimes pied à terre au milieu des champs. Nous nous acheminâmes, par le sentier des guérets, sur la

gauche de la grande route, vers le couchant. Nous ne marchâmes plus d'une heure et demie dans un vaste compagne, sans rencontrer personne. Il faisait nuit obscure, et nous nous serions infailliblement égarés, si, par bonheur, nous n'eussions aperçu une lumière au fond d'un petit vallon. C'était la lampe qui éclairait la chaumière d'un paysan. Il n'y avait que sa femme, qui distribuait du lait a cinq ou six petits enfants de grand appétit. Comme nous mourions de faim et de soif, nous la priâmes de nous faire participer au souper de sa famille. Nos jeunes dames parisiennes se régalèrent avec clic de gros pain, de lait, et même de sucre dont il y avait une assez ample provision. Nous leur thunes bonne compagnie. Apres avoir bien reposé notre âme et notre corps parce festin champêtre, nous primes congé de notre hautesse, aussi contente de notre visite que nous étions satisfaits de sa réception. Elle nous donna pour guide l'aîné de ses garçons, qui, après une demi-heure de marche, nous conduisit à travers des marais, dans les bois d'Ermenonville. La lune, vers son plein, était déjà fort élevée sur l'horizon, et brillait de l'éclat le plus pur dans un ciel sans nuages. Elle répandait les flots de sa lumière sur les chênes et les hêtres alors bordaient les clairières de la forêt, et faisait apparaître leurs troncs comme les colonnes d'un péristyle. Les sentiers sinueux où nous marchions en silence, traversaient des bosquets fleuris de lilas, de troncs, d'éhéniers, tout brillants d'une lueur bleuâtre et. Céleste. Nos jeunes dames, vêtues de blanc, qui nous devançaient, paraissait, et puis disparaissaient tour à tour à travers ces massifs de fleurs, et ressemblaient aux ombres fortunées des Champs Ely Sées. Mais bientôt émues elles-mêmes par ces scènes religieuses de lumière et d'ombre, et surtout par le sentiment du tombeau de Jean-Jacques, elles se mirent à chanter une romance. Leurs voix douces se mêlant aux chants lointains des rossignols, me firent sentir que s'il y avait des harmonies entre la lumière de l'astre des nuits et les forêts, il y en avait encore de plus touchantes entre la vie et la mort, entre la philosophie et les amours.

Harmonies Végétales De L'air

Si la puissance végétale augmente la chaleur du soleil en la réverbérant, comme on n'en peut douter, elle doit étendre aussi son influence sur les couleurs de l'atmosphère, en y réfléchissant sa verdure. Je suis porté à attribuer à la couleur verte des végétaux qui couvrent, en été, une grande partie de notre hémisphère, cette belle teinte d'émeraude que l'on aperçoit quelquefois, dans cette saison, au firmament, vers le coucher du soleil. Elle est rare dans nos climats; mais elle est fréquente entre les tropiques, où l'été dure toute l'année. Je sais bien qu'on peut rendre raison de ce phénomène par la simple réfraction des rayons du soleil dans l'atmosphère, ce prisme sphérique de notre globe. Mais, outre qu'on peut objecter que la couleur verte ne se voit point en hiver dans notre ciel, c'est que je peux apporter à l'appui de mon opinion, d'autres faits qui semblent prouver que la couleur même azurée de l'atmosphère n'est qu'une réflexion de celle de l'Océan. En effet, les glaces flottantes qui descendent tous les ans du pôle nord, s'annoncent, avant de paraître sur l'horizon, par une lueur blanche qui éclaire le ciel jour et nuit, et qui n'est qu'un reflet des neiges cristallisées qui les composent. Cette lueur paraît semblable à celle de l'aurore boréale, dont le foyer est au milieu des glaces mêmes de notre pôle, mais dont la couleur blanche est mélangée de jaune, de rouge et de vert, parce qu'elle participe des couleurs du sol ferrugineux et de la verdure des forêts de sapins qui couvrent notre zone glaciale. La cause de cette variation de couleurs dans notre aurore boréale est d'autant plus vraisemblable, que l'aurore australe, comme l'a observé le capitaine Cook, en diffère en ce que sa couleur blanche n'est jamais mélangée que de teintes bleues, qui n'ont lieu, selon moi, que parce que les glaces du pôle austral, sans continent et sans végétaux, sont entourées de toutes parts de l'Océan, qui est bleu. Ne voyons-nous pas que la lune, que nous supposons couverte en grande partie de glaciers très élevés, nous renvoie, en lumière d'un blanc bleuâtre, les rayons du soleil, qui sont dorés dans notre atmosphère ferrugineuse? N'est-ce pas par la réverbération d'un sol composé de fer, que la planète de Mars nous réfléchit en tout temps une lumière rouge? N'est-il pas plus naturel d'attribuer ces couleurs constantes aux réverbérations du sol, des mers, et des végétaux de ces planètes, plutôt qu'aux réfractions variables des rayons du soleil dans leurs atmosphères, dont les couleurs devraient changer à toute

heure, suivant leurs différents aspects avec cet astre? Comme Mars apparaît constamment rouge à la terre, il est possible que la terre apparaisse à Mars comme une pierre brillante des couleurs de l'opale au pôle nord, de celles de l'aigue-marine au pôle sud, et tour à tour de celles du saphir et de l'émeraude dans le reste de sa circonférence. Mais, sans sortir de notre atmosphère, je crois que la terre y renvoie la couleur bleue de son océan avec des reflets de la couleur verte de ses végétaux, en tout temps dans la zone torride, et en été seulement dans nos climats, par la même raison que ses deux pôles y réfléchissent des aurores boréales différentes, qui participent des couleurs de la terre ou des mers qui les avoisinent.

Peut-être même, notre atmosphère réfléchit-elle quelquefois les formes des paysages, qui annoncent les îles aux navigateurs bien longtemps avant qu'ils puissent y aborder. Il est remarquable qu'elles ne se montrent, comme les reflets de verdure, qu'à l'horizon et du côté du soleil couchant. Je citerai, à ce sujet, un homme de l'Ile-de-France qui apercevait dans le ciel les images des vaisseaux qui étaient en pleine mer; le célèbre Vernet, qui m'a attesté avoir vu une fois dans les nuages les tours et les remparts d'une ville située à sept lieues de lui; et le phénomène du détroit de Sicile, connu sous le nom de Fée Morgane. Les nuages et les vapeurs de l'atmosphère peuvent fort bien réfléchir les formes et les couleurs des objets terrestres, puisqu'ils réfléchissent dans les parélies l'image du soleil, au point de la rendre ardente comme le soleil lui-même. Enfin les eaux de la terre répètent les couleurs et les formes des nuages de l'atmosphère: pourquoi les vapeurs de l'atmosphère, à leur tour, ne pourraient-elles pas réfléchir le bleu de la mer, la verdure et le jaune de la terre, ainsi que les couleurs chatoyantes des glaces polaires?

Au reste, je ne donne mon opinion que comme mon opinion. L'histoire de la nature est un édifice à peine commencé; ne craignons pas d'y poser quelques pierres d'attente: nos neveux s'en serviront pour l'agrandir, ou les supprimeront comme superflues. Si mon autorité est nulle dans l'avenir, peu importera que je me sois trompé sur ce point: mon ouvrage rentrera dans l'obscurité d'où il était sorti. Mais s'il est un jour de quelque considération, mon erreur en physique sera plus utile à la morale, qu'une vérité d'ailleurs indifférente au bonheur des hommes. On en conclura avec raison qu'il faut être en garde contre les écrivains même accrédités.

Si les couleurs atmosphériques reçoivent des modifications de la puissance végétale, la nature même de l'atmosphère n'en éprouve pas de moins sensibles. Les forets servent d'abord de remparts contre les vents, dont elles détournent quelquefois le cours. Des bois plantés ou abattus peuvent changer la température d'une grande contrée; mais lorsqu'au printemps tons les végétaux se couvrent de feuilles, que les herbes des prairies et les blés des guérets imitent les flots de la mer par leurs ondulations; lorsqu'un océan de verdure, si je puis dire, se répand sur une grande partie de notre hémisphère, et que les vents chargés de ses émanations les portent jusqu'au sein de l'oréan aquatique, alors les qualités de l'atmosphère même se revêtent de nouveaux caractères. L'air méphitique des marais se trouve converti en air pur, comme l'ont prouvé des expériences utiles et curieuses. L'air pur se remplit de qualités balsamiques, qui produisent d'heureuses révolutions dans tous les êtres sensibles qui le respirent. C’est alors que l'air seul des campagnes, et surtout celui des montagnes, guérit les maladies chroniques, et fortifie tous les convalescents; c'est alors que tous les animaux s'enflamment des feux de l'amour. .T'attribue les ardeurs de cette passion, qui les embrase la plupart au printemps, bien plus aux influences végétales dont l'air est pénétré, qu'à l'action même du soleil. L'augmentation de la simple chaleur ne suffit pas pour les faire naître. Les oiseaux, naturellement amoureux, tels que les serins et les tourterelles, passent l'hiver dans des poêles très chauds sans s'accoupler et sans faire leurs nids. Mais quand le soleil a rallumé les feux de la végétation, que les fleurs et les feuillages odorants exhalent de toutes parts leurs parfums: c'est alors que les premières étincelles de la vie sont disséminées dans les airs, que tous les êtres les respirent avec volupté, et qu'elles allument les feux de l'amour dans tous les cœurs. C'est aussi à l'époque où la plupart des plantes abandonnent aux vents les dépouilles de leurs tiges, que la plupart des animaux périssent, ou vont chercher un air végétal et de nouvelles

amours dans l'autre hémisphère, où le soleil rallume les feux de la végétation. Ils naissent, aiment et meurent avec les plantes auxquelles ils sont ordonnés. Les carnivores seuls font exception à cette loi, car ils s'accouplent en hiver dans la saison où périssent tant de frugivores, comme si la décomposition de ceux-ci produisait dans leur sang des émanations appropriées à leur nature. C'est peut-être par cette raison que l'homme, qui vit de végétaux comme les uns, et de chair comme les autres, est seul soumis, dans tout le cours de l'année, à l'empire de l'amour et à celui de la mort.

Harmonies Aériennes Du Soleil Et De La Lune

Notre pôle est le berceau des harmonies du globe, et le pôle austral, qui lui est opposé, en est le tombeau; c'est dans son hémisphère que viennent expirer, à diverses latitudes, tous les continents, au milieu d'un océan sans rivages: il n'y apparaît de loin en loin que quelques amas de sable stérile, ou quelques îles désolées, semblables à des écueils. Si, au sein de ses longs hivers, il brille de quelque lumière, ses feux ne sont ni dorés,ni pourprés, comme ceux qui annoncent, au pôle boréal, l'aurore de la vie, mais pâles et bleuâtres comme ceux qui suivent le couchant, et annoncent l'empire de la mort; ils le rendent semblable h une lampe funèbre qui luit au milieu des tombeaux.

Cependant le soleil les met tour à tour en activité, en les échauffant alternativement pendant six mois. Il en est de notre vie comme de notre globe: notre enfance est son premier pôle, et notre vieillesse en est le dernier; c'est sur eux que roulent toutes les harmonies de notre vie. Les premières sont développées par la chaleur et la surveillance maternelle; par qui seront renouvelées les dernières? Ah! Sans doute rien n'est impossible à la main qui divise et rapproche les éléments, et qui compose tous ses ouvrages des harmonies de la vie et de la mort!

Bornons - nous ici à celles de notre horizon. Déjà le soleil commence à répandre quelques couleurs dans l'atmosphère; le froid est moins rude; les ruisseaux reprennent leur cours; la terre, à demi couverte de neige, laisse apercevoir quelques lisières de verdure; les jeunes scions des arbres deviennent purpurins; les oiseaux aquatiques qui vivent sur les limites de l'hiver, se rapprochent du Nord. Le soleil est encore peu élevé à midi, mais un vent du sud-ouest nous apporte quelque bienfait de sa chaleur du sein des mers de l'Amérique méridionale, et souffle fréquemment dans cette saison.

Ces compensations viennent sans doute d'une main maternelle. C'est l'air qui nous voiture cette chaleur précoce; seul des éléments, il enveloppe tout le globe; la lumière n'en couvre guère a la fois que la moitié, l'Océan que les deux tiers, la terre qu'un tiers; mais l'air l'environne tout entier. Toutes ses parties se communiquent immédiatement; il est le médiateur de tous les autres éléments, et de la lumière même. S'il n'y avait point d'air, les rayons du soleil seraient sans chaleur, les rivières et même les mers sans sources, les terres sans pluies, par conséquent sans végétaux, sans animaux et sans hommes.

Nous pouvons concevoir l'atmosphère comme un grand verre convexe au dehors, et concave au dedans, qui entoure notre globe à plusieurs lieues de distance. Au moyen de cette disposition, elle rassemble les rayons du soleil qui s'écartent de notre terre, elle les réfracte et les réunit à sa surface. La partie inférieure de cette atmosphère est toujours chaude dans la zone torride; elle l'est aussi en été dans chacune des deux zones tempérées qui avoisinent celle-ci, et, dans cette même saison, dans la plus grande étendue des deux zones glaciales; mais sa partie supérieure est toujours froide, même dans la zone torride, comme on le voit par les sommets de ses montagnes, qui, en tout temps, sont couverts de neige, environ à une lieue perpendiculaire de hauteur.

L'air échappe à notre vue par sa transparence, et à notre toucher par sa ténuité. Il ne peut être saisi, ni par notre odorat, ni par notre goût, ni même par notre ouïe, à moins qu'il ne soit agité. Il est bon de faire observer aux enfants, et même aux hommes, que les puissances de la nature n'en

existent pas moins, quoiqu'elles échappent à la plupart de nos sens. Comme la vue est le premier sens de l'âme, et l'avant-coureur, pour ainsi dire, des autres, c'est à elle que nous rapportons d'abord les premiers degrés de noire certitude, parce que c'est par elle que nous nous formons une image des objets- C'est le sens par excellence de notre raison, parce qu'il nous présente a la fois plusieurs harmonies de l'existence, comme la couleur, la forme et le mouvement; c'est lui qui en est le principal juge, les autres sens n'en sont que les témoins. Il n'en faut pas conclure cependant que ce que nous ne voyons pas n'existe pas: cette manière de juger du vulgaire est quelque fois celle des philosophes. L'homme de France qui, à mon avis, a eu h; plus d'esprit, Voltaire, dans ses Questions sur l'Encyclopédie, a nié l'existence de l'air, parce que, dit-il, il ne le voyait pas. Il lui subsiste que des vapeurs aqueuses qu'il voit, et auxquelles il attribue les mêmes propriétés.

Ce système est déjà bien ancien: c'était celui de Thaïes, qui prétendait que tout était engendré par l'eau. Il n'admettait que cet élément sur le globe; la terre n'en était qu'un sédiment, et l'air une évaporation. Il n'y a pas de doute qu'il n'y ait beaucoup d'air renfermé dans l'eau, comme il y a beaucoup d'eau eu évaporation dans l'air. Mais, entre autres preuves que je pourrais apporter, de la différence essentielle de ces deux éléments, c'est que l'eau dissout la plupart des corps solides, tandis que l'air, Non seulement les consolide en les desséchant, mais donne de la solidité aux fluides. Ainsi, par exemple, lorsqu'on trouve les membranes occipitales du cachalot, l'huile, qui est renfermée dans leurs cellules, se fige et se cristallise aussitôt: il en est de même de la liqueur que renferme un certain zoophyte, fort commun sur les récifs de l'Ile-de-France. Lorsqu'on tire de l'eau cet animal, il lance une liqueur blanche, qui se change dans l'instant en un paquet de fils très déliés. La matière fluide du ver à soie, de l'araignée, et de plusieurs espèces de chenilles, acquiert tout à coup de la solidité en sortant de leur corps, et se change en soie par le simple contact de l'air. Ces effets n'auraient pas lieu, si l'air n'était qu'une eau évaporée: il ajouterait à la fluidité de ces matières.

Mais nous portons en nous-mêmes des preuves évidentes que l'air diffère essentiellement de l'eau: ce sont nos organes, que nous pourrions appeler aériens, tels que ceux de l'ouïe, de l'odorat et de la respiration. Il est remarquable qu'il n'y ait que les animaux qui vivent à l'air, qui aient des oreilles pour recevoir les vibrations du son, qui n'appartiennent qu'à l'air. L'organisation de l'ouïe ne se trouve point dans les poissons, si ce n'est dans les amphibies: cependant ils sont émus par le bruit, mais d'une manière différente. Au reste, le sens de l'ouïe, comme nous le verrons, est un sens moral qui appartient aux harmonies fraternelles: quant à celui de l'odorat, il est commua à tous les animaux, et est de plus en eux le précurseur du goût. L'organe de, la respiration, auquel on n'a point encore donné de nom, et que l'on ne compte pas même parmi les seas, quoiqu'il soit le plus nécessaire de tous, est lié immédiatement avec lui dans les animaux. Nous avons reçu, pour le respirer, un viscère appelé poumon, qui est en harmonie avec l'air, et non avec l'eau, qui empêche totalement ses fonctions. C'est par cette raison que la nature a donné aux poissons des ouïes d'une construction admirable, pour séparer l'air de l'eau; ce qu'elle n'eût pas fait, si ces deux éléments des anciens n'en avaient formé qu'un.

Il est très essentiel d'accoutumer les hommes à penser qu'il y a, dans la nature, des causes et des effets qui échappent à leur vue, et même à tous leurs sens. L'attraction, cette tendance des corps vers leur centre, et l'électricité, cette divergence du feu vers la circonférence, agissent sans cesse sur nous, sans se rendre sensibles que dans des circonstances particulières. Nous pouvons dire même que nous ne connaissons l'essence d'aucun principe; nous n'en saisissons que les harmonies; encore n'est-ce qu'au moyen des organes qui sont en rapports avec elles, et que la nature nous donne. Restons donc dans les ornières qu'elle nous a tracées, ou craignons de perdre notre chemin: nous ne saurions saisir avec nos sens les Causes premières. Dieu lui-même, qui est la cause de toutes les causes, échappe à tous nos organes; mais il a mis en harmonie avec lui notre âme, qui échappe aussi à tous nos sens, quoiqu'elle en soit le premier mobile.

Examinons maintenant les principales harmonies que l'air a avec le soleil. L'air est à la fois élastique et compressible. Nous observerons que cette dernière qualité le distingue encore de l'eau, qu'on ne peut réduire à un volume moindre que celui qu'elle a dans son état naturel. Quant à l'élasticité de l'air, la chaleur le développe au point de lui faire occuper un espace quatre mille fois plus grand que celui qu'il a dans l'atmosphère. C'est au ressort de l'air, détendu par le feu, qu'est due l'explosion de la poudre à canon. Si l'on met une bouteille pleine d'air et bien bouchée près du feu, l'air, échauffé, en se dilatant fait crever la bouteille.

Je ne doute pas que les physiciens n'aient inventé des machines anti-pneumatiques pour opérer la plus grande compression possible de l'air, et qu'ils n'y aient employé même l'action du froid. J'ignore jusqu'à quel degré ils l'ont portée; mais voici une observation qui prouve combien les agents de la nature sont supérieurs à nos instruments, et ses lois à nos systèmes; c'est que le feu du soleil, auquel nous attachons, avec raison, la dilatation de l'air dans l'atmosphère, le comprime au point de le réduire à l'état de solidité dans les végétaux. Quelques-uns, comme nous l'avons déjà dit, tels que le chêne et les pois, en contiennent le tiers de leur pesanteur: les expériences en ont été laites par les plus habiles chimistes, et sont rapportées dans l'Encyclopédie. Ce qu'il y a de plus étonnant, c'est que cet air n'y paraît point comprimé, puisqu'il n'y a pas de tube de fer qui put en renfermer seulement la vingtième partie de son poids sans éclater. L'air est donc engagé dans les végétaux sous une modification qui nous est inconnue. Peut-être y est-il réduit à ses premiers principes, ainsi que le feu lui-même qui y est renfermé, et qui se dégage par la combustion. Cette pensée, qui est celle des chimistes modernes, me semble d'accord avec l'expérience.

Après avoir parlé de la dilatation et de la compression de l'air, disons un mot des vents, qui en sont le résultat. L'air, raréfié par la chaleur du soleil dans une partie de l'atmosphère, perd son équilibre avec l'air environnant qui vient le remplacer; il résulte de ce mouvement un courant, auquel on a donné le nom de vent. On en distingue quatre principaux, qui empruntent leurs noms, comme leurs directions, du cours du soleil, leur premier mobile: ce sont les vents d'Orient, du Midi, d'Occident et du Septentrion. On substitue ordinairement à ces noms ceux d'Est, de Sud, d'Ouest et de Nord, peut-être parce qu'ils sont plus abrégés, ou qu'ils viennent originairement de la langue celtique, que parlaient les premiers marins du nord de l'Europe. Ce qu'il y a de certain, c'est que ceux d'aujourd'hui n'en emploient pas d'autres dans les relations de leurs voyages, qu'il est très intéressant de connaître. Mais, comme la première difficulté, et peut-être la plus grande qui se présente dans toute espèce de science, est de n'en pas savoir les termes techniques, c'est-à-dire, qui lui sont particuliers, parce qu'ils ne présentent aucun sens à celui qui les ignore, je rapporterai ici une ancienne étymologie, moitié latine, moitié française, des noms d'Est^de Sud et d'Ouest. Est vient du mot latin est, il est, le voilà; c'est là le lever du soleil ou l'Orient. Sud dérive de sudoral, sueur, à cause de la chaleur du soleil à midi. Ouest, pour objet, où est-il? C’est le côté où le soleil disparaît et se couche; c'est l'Occident. J'ignore l'étymologie du mot Nord, qui vient peut-être de la particule négative non, parce qu'on ne voit jamais le soleil dans celte partie du ciel. Quoi qu'il en soit, ces mots peuvent se fixer dans la mémoire des hommes, en leur présentant quelques images sensibles.

Il y a une chose bien remarquable, c'est que chacun de ces quatre vents a des qualités différentes, qui sont diamétralement opposées. Le vent d'est ou d'orient est sec, parce qu'il passe sur une grande étendue de terre avant de venir à nous; et le vent d'ouest ou d'occident est humide, parce qu'il souffle sur une grande étendue de mer, dont il nous apporte les vapeurs. Le vent du sud ou du midi est chaud, parait qu'il traverse la zone torride, que le soleil échauffe perpétuellement; et le vent du nord ou du septentrion est froid, parce qu'il part du pôle nord, couvert d'un grand océan de glaces. De ces quatre vents se composent toutes les températures du globe, que le soleil, par son cours, varie à chaque heure du jour, et chaque jour de l'année.

Les qualités de ces vents n'existent que dans notre hémisphère septentrional, car elles sont directement opposées dans l'hémisphère méridional; cependant leurs mêmes harmonies subsistent toujours. Là le vent du nord est chaud, et le vent du sud est froid; celui de l'est est humide, et celui de l'ouest est sec. Nous pouvons prendre pour exemple l'Amérique méridionale. Le vent du sud y est froid, parce qu'il y vient directement du pôle sud, encore plus couvert de glaces que le pôle nord, et le vent du nord y est chaud, parce qu'avant d'y arriver, il passe à travers la zone torride; l'est y est humide, parce qu'en soufflant sur la mer Atlantique, il se charge de vapeurs qui couvrent de neiges les sommets des Cordillères, et y entretiennent les sources des plus grands fleuves du monde, tels que l'Orénoque et l'Amazone; enfin l'ouest y est sec, parce que cette même chaîne des Cordillères, d'une hauteur prodigieuse, étant projetée le long de a mer du Sud, en arietc,tous les nuages.

Il y a ceci de très digne d'observation, c'est qu'il n'y a pas un seul lieu sur le globe où ces qualités contraires de chaud et de froid, d'humide et de sec, ne se rencontrent dans les vents qui y soufflent. Dans les contrées situées au centre des continents, il y a des Méditerranées ou des lacs qui leur donnent de l'humidité; dans les îles placées au sein des mers, il y a pour l'ordinaire des chaînes de montagnes qui en arrêtent les vapeurs, et procurent de la sécheresse à une portion de leur territoire, durant une partie de l'année; dans la zone glaciale, il y a des vallons, ou des plages sablonneuses, qui lancent des rayons de chaleur; enfin, la zone torride, éloignée des pôles, a quantité de montagnes à glace qui rafraîchissent son atmosphère. Il y a,de plus, dans l'atmosphère, deux couches d'air, l'une inférieure, pour l'ordinaire chaude ou tempérée; l'autre, supérieure, qui est toujours glaciale, et que les orages font descendre de temps en temps dans la couche inférieure. Il résulte de toutes ces dispositions, que les harmonies du chaud et du froid, du sec et de l'humide, existent dans chaque partie du globe dans des saisons différentes, et dans toute sa sphéricité à la fois, sous une infinité de modifications.

Nous entrevoyons déjà que les vents, qui nous semblent si inconstants, ne soufflent pas au hasard, et que les chaînes des montagnes et les bassins des mers, qui nous paraissent si irréguliers, sont disposés suivant des plans très sages: nous en parlerons aux harmonies morales. C'est là aussi que nous traiterons de plusieurs qualités de l'air, entre autres de sa sonorité, qui est en rapport avec l'harmonie fraternelle. C'est pour cette harmonie que les vents ont des murmures; les ruisseaux, des gazouillements; les montagnes, des échos; les forêts, des bruissements; les animaux, des voix et des oreilles; les hommes, des paroles qui expriment les affections de âme par toutes les modulations de l'air.

Harmonies Aériennes De L'eau

Non seulement l'air est susceptible de chaleur et de froid, de dilatation et de condensation, mais il est spongieux: il pompe l'eau. S'il passe sur un linge mouillé, il le sèche, parce qu'il se charge des particules d'eau qui le rendent humide. Ces particules d'eau, évaporées dans l'air, y sont invisibles tant qu'il est dilaté par la chaleur; mais s'il vient à être condensé par le froid, alors elles se manifestent en brouillards, en nuages, en gouttes de pluie, en grêle, en neige. L'éponge de l'air, comprimée par le froid, rend l'eau qu'elle a bue. J'ai éprouvé souvent cet effet, en hiver, dans les poêles de Russie. Lorsque je venais à en ouvrir la porte, les vapeurs qui provenaient de la transpiration de ceux qui y étaient, frappées tout à coup par le froid de l'air extérieur, se changeaient en neige sur mon chapeau et mon habit. Dans nos climats, nous voyons quelque chose de semblable sur les vitres de nos chambres; car les vapeurs qui y sont renfermées, ne s'y rassemblent en gouttes d'eau par la fraîcheur extérieure de l'air. La nature produit les mêmes effets en grand dans la couche supérieure de l'atmosphère, qui est toujours glaciale. L'air, par sa qualité spongieuse, aspire sans cesse en vapeurs les eaux de l'Océan, et il les expire en pluies et en neiges aux sommets des hautes montagnes, pour entretenir les lacs et les fleuves, qui tous y ont

leurs sources. L'atmosphère est en quelque sorte un grand poumon mis en action par le soleil, et qui a des analogies avec le nôtre, mu par notre cœur.

Je vais observer ici que les propriétés des éléments manquent de termes pour être entendues, tant elles ont été peu étudiées. Pourquoi ne diton pas la spongiosité de l'air, pour rendre la faculté qu'il a de s'imbiber d'eau et de l'exprimer, comme on dit son élasticité et sa condensation? Pour moi, je préviens mes lecteurs que j'emploierai tous les termes qui me conviendront pour rendre mes idées. Je me sers donc de ceux d'aspirer et d'expirer, faute de mieux, pour représenter les effets de la spongiosité de l'air par rapport à l'eau. Celui d'attirer ne lui convient pas, car il ne s'agit point ici d'attraction, et celui de pomper présente un résultat encore tout différent.

Si l'air aspire et expire l'eau, l'eau à son tour aspire et expire l'air: elle^n est tout imprégnée. Vous le voyez sortir par' petites bulles du fond d'un vase qui est sur le feu ou sous la pompe pneumatique. L'air pénètre jusqu'au fond de« mers; il y est respiré par les poissons, qui le dégagent de l'eau au moyen de leurs ouïes.

Mais voici une observation bien remarquable, qui prouve l'existence des lois harmoniques de la nature, et la nécessité de faire marcher ensemble l'étude de ses puissances. L'air aspire l'eau par l'action de la chaleur; l'eau, au contraire, aspire l'air par celle du froid; car c'est en se gelant qu'elle se remplit d'air, qu'elle occupe un plus grand volume, et qu'elle surnage d'un dixième environ de son épaisseur. D'un autre côté, l'air expire l'eau par l'action du froid, comme nous en voyons la preuve par les vapeurs d'une chambre qui s'attachent à ses vitres en hiver; et l'eau expire l'air par l'action de la chaleur, ainsi qu'on peut le voir dans un vase d'eau posé sur le feu. Ainsi, si l'air nous donne de l'eau et nous l'enlève, l'eau, de son côté, en fait autant par rapport à l'air. On peut tirer, de leurs qualités élémentaires en opposition, d'utiles résultats pour connaître l'harmonie du globe; car il s'ensuit qu'il y a deux atmosphères en congélation renfermées dans les deux Océans glacés qui couvrent les pôles de la terre, et que les glaces qui en descendent dans leurs étés renouvellent a la fois les mers et l'atmosphère de la zone torride. Ce sont des châteaux d'eau et en même' temps des éponges d'air. Il s'ensuit de plus qu'il y a un océan toujours en évaporation dans l'atmosphère de la zone torride, et que les nuages que les vents voiturent vers les pôles, sont des éponges d'eau qui en renouvellent les neiges et les glaces.

L'air a encore des rapports avec l'eau par l'attraction de la terre, c'est-à-dire par sa pesanteur, car la terre l'attire comme tous les corps. Il résulte de sa pesanteur des effets très intéressants pour l'étude de la nature et le mouvement de nos machines. Homberg, célèbre chimiste, a trouvé que l'air contenu dans un ballon de treize pouces de diamètre pesait une once. L'expérience était facile; car, en pompant l'air de ce ballon, le ballon pesait une once de moins. Voici les effets qui résultent de la pesanteur de l'air sur l'eau. Si vous aspire/- avec un chalumeau l'eau d'un vase, elle monte aussitôt dans le chalumeau, parce que l'atmosphère pèse sur l'eau de ce vase, et la force à monter dans le vide que vous avez formé. Le jeu de nos pompes aspirantes est fondé sur la même loi. Vous formez un vide dans le corps de la pompe en tirant son piston, et l'eau y monte, parce que le poids de l'atmosphère qui la presse au dehors la force de remplir ce vide. L'eau ne peut s'y élever qu'à trente-deux pieds, ce qui a fait conclure, avec raison, qu'une colonne d'eau de cette hauteur pesait autant qu'une colonne d'air de la même base et de toute la hauteur de l'atmosphère, puis qu'elles se tiennent en équilibre. C'est par la pesanteur de l'atmosphère qu'un enfant tette sa mère, car il fait un vide dans sa bouche en aspirant l'air lorsqu'il suce le mamelon: alors la mamelle, pressée par l'atmosphère, fait couler son lait pour remplir ce vide. Ainsi, la nature donne à l'enfant le sentiment d'une loi dont les anciens philosophes n'ont tiré aucune conséquence. Aristote connaissait la pesanteur de l'air, cependant il soutenait que l'eau ne s'élevait dans un tuyau sans air que parce que la nature avait horreur du vide.

Nous ne nous arrêterons ici qu'à tirer quelques conséquences de la pesanteur de l'air, sans rapporter l'expérience si connue de Du Perrier. Il s'ensuit de cette loi que la direction du vent se fait obliquement, de haut en bas par sa pesanteur, et de bas en haut par son élasticité. S'il soufflait horizontalement, comme la plupart des physiciens le supposent, les mers ne seraient pas sillonnées de flots, ni la terre nettoyée des vapeurs qu'il élève et soutient dans l'espace; il agirait toujours de niveau et parallèlement à la surface des eaux. Le vent donc souffle de haut en bas, et on en voit l'effet sur les navires, dont les voiles font le ventre dans leur partie inférieure, et dont les mâts de perroquet se courbent dans leur partie supérieure. D'un autre côté, la réflexion de l'air contre la terre élève les nuages, qui ne sont lamais à une plus grande élévation que quand il fait beaucoup de vent. C'est probablement l'impulsion du vent vers la terre, et sa répulsion vers le ciel qui les élèvent, les pelotonnent et leur donnent ces belles courbes que nous leur voyons; car ils devraient flotter dans l'air en surfaces planes et indécises, comme des brouillards; ce qui leur arrive en effet dans le calme. La direction du vent paraît composée de son mouvement horizontal de progression et de son mouvement perpendiculaire de pesanteur; et en y joignant sa réflexion élastique vers le ciel, elle doit former une parabole renversée. C'est en effet la forme que j'ai cru voir au creux des vagues dans les tempêtes.

Je me suis souvent arrêté avec plaisir sur les bonis d'une pièce d'eau, à voir les xéphyrs en rider la surface. Mais rien à cet égard n'offre un spectacle aussi varié et aussi intéressant que la mer. Vous y voyez toutes les modulations du vent; et ces deux éléments, quoique transparents, produisent par leur contact des harmonies très visibles. J'ai fait à ce sujet, dans mes différents voyages maritimes, où j'étais fort oisif, quelques observations que je ne crois pas indignes de l'attention de mes lecteurs. Lorsque, par un air bien calme, la surface de la mer, unie comme un miroir, est semblable à l'huile, comme disent les marins, j'ai observé qu'il y avait toujours une houle ou mouvement onduleux, qui provient ou de l'agitation précédente de ses flots, ou plutôt de ses courants. En effet, cette houle est toujours la môme après plusieurs jours de calme. Lorsqu'un vent léger commence à se faire sentir, vous voyez alors des rides sillonner la mer dans un des bords de l'horizon, et en parcourir çà et là toute la surface en très peu de moments. J'en ai conclu que la vitesse du vent ne dépendait point de sa force, et qu'elle était beaucoup plus considérable que les physiciens ne la supposaient ordinairement. Il m'a paru, par les traces que ces vents passagers imprimaient sur la mer, qu'ils en traversaient un horizon nautique, c'est-à-dire quatre à cinq lieues, en moins d'une minute. Lorsque ces vents ont de la tenue, et que leur force augmente par un courant d'air plus considérable, alors les rides qu'ils tracent çà et là sur la mer se succèdent immédiatement, et se changent en sillons réguliers semblables à ceux d'une terre labourée: tels sont en général les flots formés par les vents alizés sur les mers de la zone torride. Le vent vient-il à augmenter, les vagues deviennent plus espacées, plus creuses, et leurs sommets, moins épais que leurs bases, étant poussés plus vite en avant, se roulent sur eux - nuies et se précipitent en écume. Les marins disent alors que la mer moutonne, parce que .w* écumes blanches, éparses sur ses flots, ressemblent de loin à des moutons qui paissent sur cette grande plaine azurée; ce phénomène désigne un temps Irais. Le vent vient-il à se renforcer, plusieurs de ces lames se joignent, leurs intervalles sont plus grands et leurs cavités plus profondes. Elles se brisent sur le rivage en formant de grandes volutes écumeuses, dont le dos mêlé d'air est couleur d'émeraude; c'est le gros temps. Je me suis amusé à Dieppe à voir leurs effets, et à entendre leur bruit rauque sur les galets du pied de la plaine, au sein d'une petite grotte, qui en retentissait comme le tympan d'une oreille. Lors que le ciel est couvert de nuages bas et redoublés par un vent humide de nord-ouest, qui puisse sur la mer, alors les values, creusées et mugissantes, heurtent la poupe des vaisseaux à la cape, s'y brisent en gerbes d'écume qui s'élèvent jusqu'à leurs huniers et passent jusque sur leur arrière: c'est une tempête. Telle est,entre autres,celle que Réprouvai sur le cap Finistère, en allant à l'ile-de-France. Un coup de mer passa sur la proue du vaisseau, enfonça son pont, et, le traversant en diagonale, emporta sa yole et trois matelots. Cependant tous ces effets du vent et de la mer, calculés par des physiciens qui ne donnent quo sept à huit pieds à la hauteur des vagues, et que dix à douze lieues par heure à la rapidité du veut, mais très bien rendus par notre peintre Vernet, ne sont pas comparables aux

ouragans de ce* belles mers des Indes. Plus elles sont étendues, plus leurs vagues sont élevées; et plus elles ont été tranquilles, plus leurs révolutions sont terribles. Elles sont les images des sociétés humaines, où chaque individu est comme une goutte d'eau qui tend à se mettre de niveau. Quand nous eûmes doublé le cap de Bonne-Espérance, et que nous vîmes l'entrée du canal de Mozambique, le 23 de juin, vers le solstice d'été, nous fûmes assaillis par un vent épouvantable du sud. Le ciel était serein, on n'y voyait que quelques petits nuages cuivrés, semblables à des vapeurs rousses, qui le traversaient avec plus de vitesse que celle des oiseaux. Mais la mer était sillonnée par cinq ou six vagues longues et élevées., semblables à des chaînes de collines espacées entre elles par de larges et profondes vallées. Chacune de ces collines aquatiques était à deux ou trois étages. Le vent détachait de leurs sommets anguleux une espèce de crinière d'écume où se peignaient çà et là les couleurs de l'arc-en-ciel. Il en emportait aussi des tourbillons d'une poussière blanche, qui se répandait au loin dans leurs vallons, comme celle qu'il élève sur les grands chemins en été. Ce qu'il y avait de plus redoutable, c'est que quelques sommets de ces collines, poussés en avant de leurs bases par la violence du vent, se déferlaient en énormes voûtes, qui se roulaient sur elles-mêmes en mugissant et en écumant, et eussent englouti le plus grand vaisseau,s'il se fût trouvé sous Icare raines. L'état de notre vaisseau concourait avec celui de la mer à rendre notre situation affreuse. Notre grand mât avait été brisé la nuit par la foudre, et le mât de misaine, notre unique voile, avait été emporté le matin par le vent. Le vaisseau, incapable de gouverner, voguait en travers, jouet du vent et des lames. J'étais sur le gaillard d'arrière, me tenant accroché aux haubans du mât d'artimon, tâchant de me familiariser avec ce terrible spectacle. Quand une de ces montagnes approchait de nous, j'en voyais le sommet à la hauteur de nos huniers, c'est-à-dire à plus de cinquante pieds au-dessus de ma tête. Mais la base de cette effroyable digue venant à passer sous notre vaisseau, elle le faisait tellement pencher, que se$ grandes vergues trempaient à moitié dans la mer qui mouillait le pied de ses mâts, de sorte qu'il était au moment de chavirer. Quand il se trouvait sur sa crête, il se redressait et se renversait tout-â-coup en sens contraire sur sa pente opposée avec non moins de danger, tandis qu'elle s'écoulait de dessous lui avec la rapidité d'une écluse en large nappe d'écume. Nous restâmes ainsi entre la vie et la mort depuis le lever du soleil jusqu'à trois heures après midi.

Il était alors impossible de recevoir quelque consolation d'un ami ou de lui en donner. Le vent était si violent, qu'on ne pouvait entendre les paroles même qu'on se disait à l'oreille en criants toujours. L'air emportait la voix, et ne permettait d'ouïr que le sifflement aigu des vergues et des cordages, et les bruits rauques des Hull, semblables aux hurlements des bêtes féroces.

(Quoique je craigne beaucoup la mer, Dieu, en qui j'avais mis toute ma confiance, m'inspira du courage; car le matin je fus le premier a marcher pour targuer la voile de misaine, que If vent déchirait par lambeaux, non que je m'y crusse fort utile, mais pour donner l'exemple aux matelots effrayés, qui refusaient d'obéir aux ordres du capitaine. Ces pauvres gens étaient non seulement épouvantés à la vue de la proue que les lames couvraient sans cesse, mais aussi par le souvenir de leurs camarades qu'un coup de mer avait enlevés a ce même poste, dans une tempête bien moins violente. Le seul sentiment qui me rassurait dans un danger auquel personne ne croyait échapper, c'est que j'étais à ma place et dans l'exercice de mon devoir; Cm j'étais passé à l'Ile-de-France sans aucun dessein d'y faire fortune, mais avec des projets particuliers d'humanité par rapport aux noirs «V Madagascar. J'avais été destiné à l'établissement du fort Dauphin dans cette lie; mais je n'y fus point envoyé, et j'échappai moi-même aux malheurs de cette nouvelle colonie, qui y périt presque tout entier quelque temps après son arrivée. Ainsi, une Providence infiniment plus sage que ma volonté, empêcha ma ruine par des événements que j'avais regardés longtemps comme malheureux. Mais ils ne sont pas du ressort des révolutions de l'air et de la mer.

Ces tempêtes,appelées aux Indes ouragans, et typhons à la Chine, arrivent tous les ans vers les solstices, tandis qu'elles n'ont lieu dans notre zone tempérée que vers les équinoxes. On aura peine à croire qu'elles fassent partie des harmonies de la nature; car elles font les plus grands ravages sur

la terre comme sur la mer. Mais elles sont nécessaires dans les pays où il n'y a point d'hiver; elles y font périr une multitude d'insectes, qui multiplieraient à l'infini dans les climats chauds; les îles même deviendraient inabordables, et leurs rivières seraient obstruées par les bancs énormes de madrépores que des insectes marins élèvent autour de leurs rivages, si les ouragans ne les brisaient en partie tous les ans. C'est de leurs débris que sont formés les lits de sable calcaire qui entourent toutes les îles entre les tropiques, et qui contribuent sans doute à leur végétation et à leur accroissement.

Heureux qui n'étudie les harmonies aériennes de Peau que sur la terre ferme! Il ne connaît de tempêtes que celles de sou ruisseau. Cependant, sans sortir de sa place, il voit les nuages élevés de dessus les mers lointaines traverser son horizon pour aller fertiliser des terres inconnue* Souvent il les voit, au coucher du soleil, se rassembler sous les formes fantastiques de châteaux, de forêts, de montagnes escarpées, images fugitives de notre monde et de notre propre vie. Quelquefois elles se peignent à ses pieds au sein d'une onde transparente, et il admire à la fois de nouvelles terres dans les cieux et de nouveaux deux au fond des eaux. Mais nous indiqueront ailleurs les accords de la lumière et des eaux aériennes. L'air a encore des rapports plus intéressants avec la terre, les végétaux, les animaux et les hommes, qu'avec les mers. Nous en niions parler dans les paragraphes suivants.

Harmonies Aériennes De La Terre

La terre a aussi des espèces de fluides en harmonie avec l'air: ce sont ses sables. Les sables sont des débris de marnes, de roches, de coquillages, de cailloux ou galets, que l'Océan réduit sans cesse en poudre par le roulement perpétuel de ses flots au fond de son bassin, et surtout sur ses rivages. C'est là que vous voyez les grèves immenses grises, jaunes, rouges, blanches et de toutes couleurs, qui sont les principes des matières diverses que la terre renferme dans son sein, et même de l'humus qui la couvre, comme les eaux maritimes le sont de toutes les eaux douces qui l'arrosent. C'est l'atmosphère qui en est le véhicule. Si les vents portent au sommet des montagnes les nuages dont se forment les sources des rivières, il y voiture de même les terres que les eaux en dégradent sans cesse. Il est aussi, aisé au vent de charrier des montagnes de sable, grain à grain, des bords de là mer jusqu'au sommet des Alpes, que d'y transporter du sein de ses eaux, goutte à goutte, les glaces énormes qui les couronnent, et les grands fleuves qui en découlent Des puissances invisibles gouvernent le monde au physique comme au moral, et ne se rendent apparentes que par leurs effets. Si nous étions attentifs aux harmonies générales de la nature, nous pourrions dur, à la vue des nuages que les vents de l'ouest et du sud voiturent en hiver au haut des airs: Voilà des portions du Rhône, du Rhine, et de leurs glaciers; et voila les grèves de leurs rivages, en voyant ces tourbillons de sables que les vents du nord et de l'est élèvent en été sur nos chemins et sur les bords de nos mers. D'où viendraient même les sables marins qui composent en partie la terre végétale, si ce n'est de l'action des vents qui les apportent de fort loin 't Il y a des pluies de terre comme des pluies d'eau. Je ne citerai ici ni les orages de sable de la Libye, qui engloutissent des caravanes entières; ni les tourbillons de poussière des provinces septentrionales de la Chine, qui obligent les habitants de Pékin à se couvrir le visage d'un crêpe lorsqu'ils sortent de leurs maisons; ni ceux des bords de la mer Caspienne, dont le sable est si subtil, que les Turcs disent en proverbe qu'il pénètre à travers la coque d'un œuf; ni ceux que j'ai éprouvés moi - même au cap de lionne - Espérance, où, malgré les doubles châssis des fenêtres de chaque maison, le sable s'introduit dans l'intérieur des appartements, et se fut sentir dans tout ce qu'on mange. Nous pouvons ici nous former une idée de l'abondance de cette puissance volatile, par ses effets dans les chambres qui ne sont pas habitées. Quelque bien fermées qu'elles soient, en peu de temps les meubles en sont tout couverts. C'est cette poussière qui se dépose au haut de nos murs, sur les corniches des tours les plus élevées, s'engage dans les fentes de leurs pierres, et y entretient la végétation d»\s mousses, des pariétaires, des molles de veau, des giroflées jaunes, et quelquefois même celle des arbres. La nature avait sans doute prévu ces résultats, lorsqu'elle a donné des ailerons et des volants aux

semences des érables, des ormes et de quantité de végétaux saxatiles, et des noyaux indigestibles à celles des merisiers des prairies, afin de les transporter au sommet des roches par les estomacs et par les ailes des oiseaux.

La terre réagit aussi sur l'air par ses montagnes; ce sont leurs différents plans qui causent la grande variété des vents, par les divers entonnoirs de leurs vallées. Il y a plus, c'est que, lorsqu'elles sont échauffées du soleil, et qu'elles ont dilaté l'air qui les environne, les vents se dirigent vers elles et ne cessent d'y souiller pendant une partie du jour, (les effets se remarquent principalement le long des mages de la mer, dans la zone torride. Deux ou trois heures après le lever du soleil, lorsque la terre commence à être échauffée de ses rayons, les vents généraux de l'Océan se détournent de leur cours et soufflent vers elle pour en rafraîchir l'atmosphère. On appelle ces vents maritimes des brises du large; ils se font sentir tout le long de la côte d'Afrique, et autour des îles situées entre les tropiques. Ils apportent dans leurs climats brûlants, non seulement un air frais de la mer, mais les pluies nécessaires au renouvellement de leurs fleures et à leur végétation. C'est ainsi que la nature a balancé par des réactions les effets de ces lois générales, afin que toutes les latitudes participassent aux harmonies des éléments. Elle a opposé à la condensation de l'atmosphère glaciale du pôle qui pèse vers l'équateur, la dilatation de l'atmosphère ardente de la zone torride qui l'attire; et au cours général des vents alizés qui en résultent en pleine mer, les cours particuliers des vents qui soufflent le long des terres. l<a nature est consonante avec elle-même. Le soleil donne par sa chaleur, à l'atmosphère comme à l'Océan, des courants généraux, qui sont les vents alizés, et des marées en sens souvent contraires, qui sont les brises.

Comme les marées ont un flux et reflux, les brises ont aussi le leur. Les brises soufflent de la mer vers la terre pendant le jour; et pendant la nuit, elles soufflent de la terre vers la mer. Les unes et les autres varient suivant le cours du soleil; mais cette théorie des mouvements de l'air nous mènerait ici beaucoup trop loin. Contentons - nous d'ajouter qu'il y a des montagnes caverneuses qui envoient des vents, comme si elles les produisaient dans leurs flancs. Tels sont les monts Koliens d'Italie. Leurs effets sont aisés à expliquer par l'action du soleil qui les échauffe, dilate l'air qu'ils renferment et l'oblige d'en sortir pendant le jour; mais cet air y rentre ensuite condensé par la fraîcheur de la nuit. Nous verrons qu'il y a ailleurs qu'en Italie des monts Éoliens qui ne sont pas caverneux. Ils produisent des vents par la configuration de leurs vallons et la densité de leur atmosphère, sur laquelle le soleil agit comme sur celle des pôles. Il y a aussi des montagnes à glace, par le moyen desquelles le soleil produit des courants généraux et des flux et reflux dans les lacs qui sont a leurs pieds, comme il en produit dans l'Océan par le moyen des glaces polaires. Les montagnes ne sont pas de simples débris de la terre, ou des ouvrages des eaux faits au hasard, comme on le prétend; mais il y en a d'harmoniées positivement et négativement avec les éléments; il y en a de solaires et d'hyémales, de vulcaniennes, d'éoliennes; d'hydrauliques, qui attirent les eaux; de littorales, qu'elles repoussent, les unes maritimes, les autres fluviatiles; de métalliques, de végétales, etc. Elles sont aussi combinées entre elles sur différents plans. Nous donnerons une idée de leurs diverses espèces aux harmonies terrestres de la terre, et une idée de leur ensemble aux harmonies sociales ou morales.

L'air produit une infinité d'harmonies, non seulement à la surface de la terre, mais dans son intérieur. Les arbres par leurs racines, et les animaux par leurs travaux, l'y font pénétrer à de grandes profondeurs. Les vers de terre, les scarabées, les taupes, les lapins, etc., y creusent une multitude de souterrains; la vigne y fait descendre ses radicules à travers les carrières de pierres les plus dures. Non seulement les racines des arbres y font communiquer l'air, mais elles l'y pompent; car, sans lui, elles ne pourraient y végéter. En effet, l'air y est renfermé dans les bancs des pierres calcaires, toutes remplies de petits trous et de coquillages qui en contiennent dans leurs cavités. Mais c'est surtout dans les couches de sables où il est en abondance; il remplit les interstices qui sont entre ses grains. Ce n'est que par le moyen de cet air que l'eau y pénètre en tout sens, comme dans des tuyaux capillaires. Les sables sont des éponges à la fois remplies d'air et

d'eau, qui entretiennent la circulation de ces deux éléments dans l'intérieur du globe. L'inflammation des pyrites, à de grandes distances de sa surface, ne peut avoir lieu que par l'action de l'air, qui les décompose et les enflamme. Il n'y a point de feu sans air. C'est a l'action de cette atmosphère souterraine qu'il faut attribuer les volcans des bords de la mer, les tremblements de terre qui proviennent de sa dilatation, la circulation des eaux intérieures, les compositions et décompositions minéralogiques; enfin la température du globe, qu'on trouve de dix degrés environ ou fond de toutes les mines, et qui est la même que celle qui est an fond des mers. (l'est par cet air souterrain que la chaleur du soleil pénètre la terre dans toutes ses parties, et qu'elle se manifeste même sous les glaciers, d'où 1l sort toujours en hiver des courants d'eaux, et qui en été fondent principalement par leurs bases.

J'ai vu quelquefois, dans de fortes gelées, les pavés, et même les seuils des troncs, se soulever de manière à perdre tout a fait leur niveau. Cet effet est produit par la dilatation de l'eau ou du sol, occasionnée par le développement de l'air qu'elle renferme lorsqu'elle vient à se geler. Il est certain qui' l'eau en se gelant augmente de volume. Mark d'un autre côte, comme l'eau augmente encore da volume en se dilatant par la chaleur, comme on le voit aux tubes de nos baromètres, qui renferment souvent plus d'eau que d'esprit-de-vin, j'en ai tiré une singulière conclusion: c'est que le froid, agissant en hiver sur la couche supérieure de la terre toute pénétrée d'eau et d'air, doit dilater toute la partie septentrionale de notre hémisphère et en accroître la hauteur; niais la chaleur dilatant également l'Océan dans la zone torride, leur ancien niveau n'est point dérangé, et les eaux du pôle sud arrivent toujours par la même pente aux environs de notre pôle. Il est certain que la terre entière doit être sujette aux contractions et aux dilatations occasionnées par l'air qu'elle renferme dans sa masse, et que c'est peut-être à ces effets qu'il faut rapporter les fractures de tant de roches, dont les débris gisent à sa surface. Nous nous étendrons davantage, aux harmonies terrestres, sur ce sujet intéressant et tout neuf. Les philosophes ont imagine plusieurs systèmes pour expliquer la formation des planètes; mais je voudrais bien que, sans sortir de notre globe, ils voulussent nous dire seulement pourquoi tant de cailloux, de pierres et de roches sont rompus, et par éclats, dans presque toutes les parties du monde. Les frondes ont été les premières armes des hommes, et les lapidations leurs premiers supplices. Ils trouvent partout de quoi se tuer. Si l'attraction, les eaux, le temps, arrondissaient toutes choses, nos rochers ne seraient pas si anguleux et nos montagnes si raboteuses. Nous tâcherons de trouver une origine à une ruine en apparence universelle, et qui ne, nous semble qu'un résultat de l'harmonie qui conserve le monde en le renouvelant.

Les mêmes causes qui forment les minéraux, les brisent.

Non seulement la terre est en rapport avec l'air au dedans et au dehors, mais ses parties intrinsèques y sont aussi. Les marbres les plus durs sont criblés d'une multitude de pores; le microscope en découvre une infinité sur les métaux les plus polis.

On peut donner l'idée du microscope et de ses effets, par une goutte d'eau au sein d'une fleur, dont elle fait apercevoir les glandes nectars, invisibles à la vue. Quelquefois on trouve, après un brouillard, de ces gouttes d'eau enfilées comme des semences de perle à des fils d'araignée, et toutes brillantes au soleil des couleurs de l'arc-en-ciel. Elles grossissent prodigieusement l'insecte infortuné, encore plus brillant qu'elles, suspendu à la même toile. On peut donner de même une idée du télescope, qui agrandit les objets éloignés, d'après les effets d'un nuage transparent qui augmente la grandeur de la lune à l'horizon. Il est bien important de faire remarquer ici que l'homme n'a rien imaginé de lui-même, et qu'il n'a développé son intelligence que d'après celle de la nature.

Nous avons des microscopes qui font paraître les objets six mille fois plus gros qu'ils ne le sont. Une puce paraît plus grosse qu'un mouton, dans le microscope solaire .'Cependant cet instrument ne

peut nous faire voir une particule élémentaire d'air ou même d'eau: comment donc pourrait-il nous faire apercevoir le fluide qui environne une pierre d'aimant, et qui attire à elle, à plusieurs pouces de distance, des particules de fer? Il y a plus, ce fluide magnétique qui agit sans cesse autour de cette pierre, se communique à l'infini sans s'affaiblir. Il s'attache à tous les morceaux de fer qui en sont frottés, et leur donne la même vertu. 11 semble participer de la nature du feu, et il en diffère, en ce qu'il n'a pas besoin, comme lui, d'aliment, ou du moins qu'il ne le consomme pas. D'ailleurs, il se sépare pour toujours de son aimant par l'action même du feu. S'il est un corps, comment est-il invisible et impalpable comme un esprit? Et s'il est un esprit, comment peut-il s'attacher à des corps et les faire mouvoir? Il y a donc des principes de mouvement actifs par eux-mêmes, qui s'unissent à des corps, et qui échappent à tous nos sens, et même à nos raisonnements. Pourquoi n'y aurait-il pas aussi des principes de vie et d'intelligence qui existent par eux-mêmes, qui s'attachent à la matière, l'organisent, la font mouvoir, se propager, sentir, raisonner? Ils existent sans doute, car il y a des êtres matériels organisés qui se meuvent, se propagent, sont sensibles et raisonnables, et ne sont plus que de la matière lorsqu'ils sont séparés de l'âme qui les anime. Si tous les arts des hommes ne sont que de faibles imitations de la nature que nous voyons, cette nature elle-même n'est que le résultat de principes que nous ne voyons pas. Nous sommes environnés d'air, d'attractions, d'électricité, de magnétisme, d'êtres organisants, sensibles, passionnés, intelligents, tous invisibles par leur essence, et qui ne se manifestent à nos sens qu'en se combinant avec la matière. Mais ils n'en existent pas moins sans elle, comme elle existe sans eux. Il y en a sans doute d'une nature supérieure, qui échappent à nos sens, et qui se rendent sensibles à notre raison par l'existence des premiers. Tel est celui qui a formé les harmonies de cet univers, et qui les maintient pour nous, êtres passagers. Ses jouissances éternelles ne sont pas comparables aux nôtres. Elles doivent être immenses comme sa puissance infinie et son immortalité. Soyez donc certains que ce monde, comme l'a dit Platon, n'est qu'une ombre fugitive d'un autre monde habité par des êtres invisibles pour nous, mais bien supérieurs à nous.

Harmonies Aériennes Des Végétaux

Si les métaux les plus durs ont des rapports intérieurs avec l'air et avec d'autres éléments plus subtils, les végétaux en ont encore de plus étendus. Des expériences réitérées, faites par les plus habiles chimistes, entre autres par Homberg, prouvent que l'air entre comme matière solide dans la composition des plantes. Le chêne en contient le tiers de sa pesanteur; le feu l'en dégage. Lorsqu'on brûle une bûche de ce bois, on entend souvent de longs murmures sortir de ses flancs; c'est l'air qui s'échappe de ses trachées. Les pois renferment aussi un tiers de leur pesanteur d'air. Des tuyaux et des globes de fer n'en contiendraient pas la dixième partie de leur poids sans crever: il y a apparence même que toutes les forces humaines ne produiraient pas une pareille condensation; cependant elle est le résultat de l'action des rayons si légers du soleil. Ses feux sont les tisserands des éléments; ils les assemblent et les séparent; ils en sont à la fois la navette et les ciseaux. Nos instruments de physique n'opèrent rien de semblable. On ne peut L onc bien étudier la nature que dans la nature même.

Les végétaux ont des harmonies sensibles avec 'air par leur respiration. Si on frotte d'huile me plante vivante, on la fait nourrir presque subitement, tandis que par une semblable opération on préserve un morceau de fer de la rouille qui le détruit. Sur ce point, le végétal diffère donc essentiellement du métal. En effet, Le premier a les organes de la respiration, dont le dernier est privé. Les plantes ont des tuyaux par où l'air se communique dans tout leur intérieur. Malpighi est le premier qui a fait cette découverte et qui leur a donné le nom de trachées. « Ce sont, dit-il, des vaisseaux formés par les différents contours d'une lame fort mince, comme argentée, plate, assez large, élastique, qui, se roulant sur elle-même en ligne spirale ou en tire-bourre, forme un tuyau assez long et comme divisé dans sa longueur en plusieurs cellules. Ces lames sont composées de plusieurs pièces, divisées par écailles comme les trachées des insectes, ce qui leur en a fait donner

le nom. Quand on déchire ces vaisseaux, on s'aperçoit qu'ils ont une espèce de mouvement péristaltique.

Hales, dans sa Statique des Végétaux, observe que la spire de ces vaisseaux est dans un sens contraire au mouvement diurne du soleil. Cette observation est importante, et confirme ce que nous avons dit de l'influence de l'astre du jour sur toutes les puissances de la nature, dont il est le premier moteur. Les ressorts des plantes sont de petites roues de rencontre, mues par son cercle journalier, comme leurs harmonies le sont par son cercle annuel. Peut-être trouvera-t-on une disposition différente dans les spires des trachées des plantes nocturnes, c'est-à-dire, qui n'ouvrent leurs fleurs que la nuit, comme le jalap, une espèce de convolvulus, l'arbre triste des Moluques, etc.; celles-ci ont sans doute des harmonies lunaires qui leur sont propres.

Quoi qu'il en soit, on découvre facilement les trachées des plantes en cassant net des tendrons de vigne ou de jeunes branches de rosier, de tilleul, etc.: elles paraissent en forme de spirales de couleur argentée. Quand on déchire doucement une feuille, on en voit les trachées s'allongée, en écartant les portions de la feuille l'une de l'autre. Les trachées ont plus de diamètre que les autres vaisseaux des plantes; elles sont toujours placées autour des fibres ligneuses, et sont plus grandes dans les racines que dans les tiges. 11 n'y a pas de doute que ces tuyaux élastiques ne soient des véhicules de l'air, et qu'ils ne l'aspirent et ne l'expirent Leur ressort, mis en mouvement par celui du soleil, fait sans doute monter et circuler la sève par la médiation de la chaleur de l'air, et l'air lui même est peut-être composé de spirales élastiques comme les spires des trachées. Au reste, la plante aspire et expire l'air principalement par ses feuilles, criblées à cet effet d'une infinité de pores ou de petits trous: Leeuwenhoek en a compté plus de cent soixante-deux mille sur un seul côté d'une feuille de buis.

Les plantes cherchent à la fois l'air et la lumière: celles que l'on Cultive dans les appartements se tournent toujours vers les fenêtres; les plantes privées d'air et de lumière, telles que celles qui végètent dans les souterrains, s'étiolent, c'est-à-dire blanchissent. Tels sont les cardons et les chicorées que l'on conservé l'hiver dans des caves, et les laitues romaines dont, l'été, on lie les feuilles pour les attendrir. Tous ces végétaux artificiels, privés d'air et des rayons du soleil, ont peu de substance et de vertu. 11 en est de même de l'herbe qui croît à l'ombre des arbres; elle y devient longue et molle, et ce qu'on appelle, en Normandie, veule, c'est-à-dire flasque: les bestiaux refusent d'en manger: aussi on ne souffre point d'arbre, pas même de pommier, dans les riches pâturages de la Basse-Normandie. Il n'y a qu'un fort petit nombre de plantes qui prospèrent à l'ombre: telles sont l'anémone des forêts, qui, au printemps, couvre le sol de ses réseaux; et la pervenche des bois, toujours verte, qui donne en hiver ses fleurs bleues. On peut y joindre le framboisier du Canada, avec ses roses cramoisies; le grand convolvulus à cloches blanches, dont les fleurs éclatantes produisent de si charmants effets dans l'ombre; et le lierre surtout, qui couvre le sol des forêts humides d'un tapis toujours vert, au milieu même des neiges. Ce sont des beautés qui manquent souvent à nos jardins anglais, où les bosquets interceptent l'air et la lumière à la plupart des plantes.

Les végétaux sont si bien harmoniés avec l'atmosphère, qu'ils changent en air pur l'air méphitique, comme l'a fort bien prouvé le savant docteur lngenhousK. Cette régénération est encore l'ouvrage du soleil; car des plantes, et surtout des fleurs, mises en grande quantité dans une chambre fermée, en méprissent l'air au point de faire mourir les personnes qui le respirent, surtout la nuit. Des femmes ont péri pour avoir dormi dans une chambre où il y avait beaucoup de fleurs de lis. Nous ne saurions trop admirer L'influence de l'astre du jour sur tous les agents de la nature: toutes leurs harmonies sont suspendues ou troublées par son absence. Mais voyez comme l'auteur de la nature a bien combiné lui-même leurs différents effets. Les animaux corrompent l'air par leur transpiration, et les plantes destinées à leur nourriture le rétablissent dans toute sa pureté: il y a plus, elles changent les odeurs les plus fétides eu parfums délicieux. C'est sur di;s fumiers que

croissent les roses les plus odorantes, et sur des couches de matière fécale que les jardiniers cultivent, l'hiver, à Paris, les tubéreuses si suaves.

Les vitaux ont des harmonies avec l'air extérieur par leurs titres: d'abord, le côté qui est exposé au vent du midi est beaucoup plus dilate que celui qui est frappé du vent du nord, cette observation peut être utile pour s'orienter, si par hasard on se trouvait aéré dans un bois; car, en coupant une branche d'arbre, on connaîtrait le brillé qui regarde le midi, parce qu'il y a plus de distance de ce côté là, depuis la moelle de la branche jusqu'à son écorce. Les écorces mêmes des végétaux sont en harmonie avec les températures de l'atmosphère; ce sont des espèce d'habits pont la nature les a revêtus, davant les latitudes. Ceux des pays froids ont des iVotees fort épaisses, et souvent enduites de n’usine, comme les sapins; ceux des pays chauds les ont Iegers: ceux qui ne vivent que le Cours d'un été n'en ont presque point: telles soûl les gramim'es, qui n'ont, pour ainsi dire, que des épidermes. On peul aussi connaître, par la durcié et la finesse des feuilles, les végétaux qui croissent dans les lieux battus des vents. Les pins, les sapins, les cèdres, les nu'èses, pu se plaisent sur le siomnetdes montagnes, ont des feuilh'S menues et ligneuses: il en est de même des giroflées jaunes, qui viennent sur le haut des murailles; leurs feuilles ne donnent point de prise aux vents. Les végétaux qui les ont grandes et tendres, tels que nos figuiers et les bananiers des Indes, aiment à croître sur les bords des ruisseaux, à l'abri des rochers; tous ont leurs tiges en rapport avec la force des vents auxquels ils sont exposés. Le figuier a un bois très-fragile, et le bananier n'est formé que d'un paquet de feuilles. Ce sont des habitants des humbles vallées. Ceux qui s'élèvent sur les flancs des montagnes, résistent aux tempêtes par la roideur de leurs troncs: tclssont les ormes,les hêtres et les chênes; ils ne craignent pas de supporter un ample feuillage. Ceux qui ont un bois léger et cassant, comme les sapins et les peupliers d'Italie, portent leurs têtes en pyramides couvertes de feuilles minces et légères. Il est très remarquable que le peuplier de nos climats, qui supporte une large tête,a un bois beaucoup plus élastique que le peuplier pyramidal d'Italie; nos paysans emploient ses branches souples aux mêmes usages que l'osier. Les palmiers des Indes croissent dans des lieux exposés à toute la violence des ouragans de la zone torride: les uns sur les montagnes, comme les palmistes; les autres sur le bord des mers, comme les lataniers et les cocotiers. Tous ont leurs troncs formés, non d'un vrai bois, mais de fibres ligneuses très - élastiques; leurs longues feuilles, semblables à de longues branches empennées, sont de la même nature. Quand elles sont sèches, on s'en sert comme de tablettes, où l'on écrit avec un poinçon comme sur des lames de bois. Nous avons observé, en parlant de la direction oblique des vents vers la terre, qu'ils décrivaient une courbe composée de leur mouvement horizontal de progression et de leur mouvement perpendiculaire de pesanteur: il en résulte une parabole. Je m'arrête à cette idée, parce qu'elle peut servir à expliquer le renflement du tronc du palmier, d'après lequel les architectes grecs ont imité celui qu'ils donnent à la colonne, sans qu'ils en apportent d'autre raison, sinon que ce renflement, formé d'une courbe, lui donne meilleure grâce. Quoique les naturalistes disent que le palmier, à l'exception de toutes les autres espèces d'arbres, a son tronc partout d'un diamètre égal, j'ai cru observer sur des cocotiers, que leur tronc était renflé dans la colonne, aux deux tiers de sa hauteur. Cette céurbe sert à sa solidité, car elle se trouve en arc-boutant avec celle du vent, de quelque côté qu'il souffle.

On ne doutera pas de ces prévoyances de la nature pour raffermir les palmiers contre la violence des ouragans,par celles qu'elle prend dans les mêmes climats pour garantir les autres végétaux de leurs ravages. J'ai vu, à l'Ile-de-France, un arbre sur des rochers, où ses racines avaient bien de la peine à pénétrer, dont le tronc avait tout autour de longues côtes faites comme de larges planches, qui lui servaient d'étais et d'appuis; elles avaient, au niveau de la terre,plus de sept pieds de largeur, et elles s'élevaient le long de sa tige à plus de quinze pieds de hauteur. Elles laissaient entre elles, autour de l'arbre, plusieurs intervalles, dont on aurait pu faire autant de petites cabanes. Il sortait, de plus, des extrémités de ses branches des cordes végétales qui descendaient jusqu'à terre, y prenaient racine, et devenaient des troncs qui non seulement supportaient les branches qui les avaient produites, mais s'élevaient encore au-dessus. Le P. Dutcrtre en décrit un

semblable qu'il a vu à la Guadeloupe, dont les planches, ou arcs-boutants, s'éloignaient du pied de l'arbre de trente à quarante pieds; et son supérieur, dit-il, en voulait faire un couvent vivant, qui aurait eu ses cellules, sa chapelle et son réfectoire; mais il y avait trop d'humidité entre ses racines. Il appelle cet arbre figuier admirable. En effet, les extrémités des branches de celui que je vis à l'ile-de-France, étaient chargées de figues qui pendaient jusqu'à terre; mais ces fruits n'avaient pas de saveur.

La nature n'est pas encore satisfaite de ces précautions individuelles qui mettent les végétaux de ces climats en état de résister aux ouragans qui les agitent; elle garnit les lisières de leurs forêts de fortes lianes. Ce sont des plantes grimpantes, dont quelques-unes sont grosses comme la jambe, et dont l'écorce est élastique et forte comme du cuir: de sorte qu'une de leurs lanières est plus difficile à rompre qu'une corde de chanvre de la même grosseur. Ces lianes s'élèvent du pied des arbres jusqu'à leurs cimes, d'où elles redescendent, s'entrelaçant dans les arbres voisins, et les liant les uns aux autres comme des cordages, les rendent inébranlables à toutes les secousses de l'atmosphère. C'est dans ces forêts torridoniennes que des ouragans nécessaires, au défaut des hivers, détruisent en un jour des légions d'insectes qui y multiplient toute l'année. En secouant leurs vieux troncs caverneux, ils submergent au loin les vaisseaux sur les mers, et renversent sur la terre la plupart des monuments des hommes; mais leur voix mugissante annonce encore, au sein de la destruction, une Providence conservatrice de ses propres ouvrages: les tours s'écroulent, les arbres restent.

Si la nature a pourvu à la sûreté des forêts, elle n'a pas oublié celle des prairies. Les herbes ont, comme les arbres,leurs harmonies aériennes. Les graminées, les plus communes de toutes, ont des feuilles souples et menues qui ne donnent point de prise aux vents. Les humbles tiges qui portent leurs épis sont élastiques, cylindriques, et fortifiées de nœuds d'espace en espace. Elles s'appuient les unes contre les autres sans se briser, et lorsque les tempêtes les agitent, elles s'abaissent et se relèvent par de mutuels supports, en imitant par leurs ondulations les flots de la mer. Celles qui,suivant l'expression juste de La Fontaine, naissent sur les humides bords des royaumes du vent, ont des feuilles couchées à la surface des eaux, comme les nymphaea, ou qui se dressent en lames souples, comme les roseaux. Cependant, malgré les sages précautions de la nature, le chêne est quelquefois renversé par les tempêtes, tandis que le roseau leur échappe par sa faiblesse: image fidèle des conditions de la vie, et dont le bon La Fontaine a fait un apologue admirable.

Les harmonies aériennes de l'accroissement et de la conservation des plantes sont sans doute dignes d'admiration, mais celles de leur dépérissement ne le sont pas moins. Il est remarquable que les tiges sèches des herbes qui meurent tons les ans, et que les feuilles des arbres qui jonchent la terre à la fin de l'automne, résistent, malgré leur extrême fragilité, aux vents, aux pluies et aux neiges, qui font souvent tant de ravages sur les habitations de l'homme; mais elles se détruisent toutes au printemps. Les gousses des haricots et des pois; les grappes du sumac, du sorbier, du troene; les baies et beaucoup d'autres semences, restent suspendues tout l'hiver à leurs tiges, pour servir de nourriture aux oiseaux. Elles ne s'entrouvrent et ne tombent que dans la saison où elles doivent se reproduire. Les pailles des graminées, et les troncs des chênes morts de vieillesse, se décomposent alors en autant de temps qu'ils ont végété: les premières, en une demi année; les autres pendant des siècles. L'arbre desséché reste^ longtemps debout; mais la nature, qui voile partout la mort sur le théâtre de la vie, couvre encore ses branches arides des garlandes parfumées du chèvre-feuille ou du lierre toujours vert. Si l'arbre est renversé par les tempêtes, des agarics et des mousses de toutes couleurs dévorent et décorent iVla-ibis son vaste squelette. Quelle est donc l'intelligence qui a proportionné, dans chaque espèce de végétal, la force de ses fibres vivantes aux injures de l'atmosphère, et lu durée de ses fibres mortes à celle de son renouvellement? C'est sans doute celle qui a voulu, d'un côté, que la terre ne s'encombrât pas par les dépouilles permanentes des végétaux, et qui, d'un autre côté, a voulu qu'elles durassent assez pour offrir des litières, des abris

et des nourritures aux animaux pendant l'hiver. C'est enfin le Dieu qui a mis en harmonie les différents âges de la vie humaine et l'ignorance des enfants avec l'expérience des vieillards.

Qui pourrait décrire les mouvements que l'air communique aux végétaux? Combien de fois, loin des villes, dans le fond d'un vallon solitaire couronné d'une forêt, assis sur le bord d'une prairie agitée des vents, je me suis plu à voir les mélilo ts dorés, les trèfles empourprés et les vertes graminées, former des ondulations semblables à des flots, et présenter à mes yeux une mer agitée de fleurs et de verdure! Cependant les vents balançaient sur ma tête les cimes majestueuses des arbres. Le retroussis de leur feuillage faisait paraître chaque espèce de deux verts différents. Chacune a son mouvement. Le chêne au tronc roide ne courbe que ses branches, l'élastique sapin balance sa haute pyramide, le peuplier robuste agite son feuillage mobile, et le bouleau laisse flotter le sien dans les airs, comme une longue chevelure. Us semblent animés de passions: l'un s'incline profondément auprès de son voisin comme devant un supérieur, l'autre semble vouloir l'embrasser comme un ami; un autre s'agite en tout sens comme auprès d'un ennemi. Le respect, l'amitié, la colère, semblent passer tour à tour de l'un à l'autre, comme dans le cœur des hommes; et ces passions versatiles ne sont au fond que les jeux des vents. Quelquefois un vieux chêne élève au milieu d'eux ses longs bras dépouillés de feuilles et immobiles. Comme un vieillard, il ne prend plus de part aux agitations qui l'environnent: il a vécu dans un autre siècle. Cependant ces grands corps insensibles font entendre des bruits profonds et mélancoliques. Ce ne sont point des accents distincts; ce sont des murmures confus comme ceux d'un peuple qui célèbre au loin une fête par des acclamai ions. Il n'y a point de voix dominantes: ce sont des sons monotones, parmi lesquels se font entendre des bruits sourds et profonds, qui nous jettent dans une tristesse pleine de douceur. Ainsi les murmures d'une forêt accompagnent les accents du rossignol, qui, de son nid, adresse des veux reconnaissants aux Amours. C'est un fond de concert qui fait ressortir les chants éclatants des oiseaux, comme la douce verdure est un fond de couleurs sur lequel se détache l'éclat des fleure et des fruits.

Ce bruissement des prairies, ces gazouillements des bois, ont des charmes que je préfère aux plus brillants accords: mon âme s'y abandonne; elle se berce avec les feuillages ondoyants des arbres; elle s'élève avec leurs cimes vers les deux; elle se transporte dans les temps qui les ont vus naître et dans ceux qui les verront mourir; ils étendent dans l'infini mon existence circonscrite et fugitive. Il me semble qu'ils me parlent, comme ceux de Dodone, un langage mystérieux; ils me plongent dans d'ineffables rêveries, qui, souvent, ont fait tomber de mes mains les livres des philosophes. Majestueuses forêts, paisibles solitudes, qui plus d'une fois ave* calmé mes passions, puissent les cris de la guerre ne troubler jamais vos résonnantes clairières! N'accompagnez de vos religieux murmures que les chants des oiseaux, ou les doux entretiens des amis et des amants qui viennent se reposer sous vos ombrages.

1823
Thomas Jefferson (American Patriot, President, and Deist
Letter to John Adams

Jefferson's letter to John Adams, from Monticello, April 11, 1823

I think that every Christian sect gives a great handle to Atheism by their general dogma that, without a revelation, there would not be sufficient proof of the being of a god. Now one sixth of mankind only are supposed to be Christians: the other five sixths then, who do not believe in the Jewish and Christian revelation, are without a knowledge of the existence of a god! This gives completely a gain de cause to the disciples of Ocellus, Timaeus, Spinosa, Diderot and D'Holbach. The argument which they rest on as triumphant and unanswerable is that, in every hypothesis of Cosmogony you must admit an eternal pre-existence of something; and according to the rule of sound philosophy, you are never to employ two principles to solve a difficulty when one will suffice.

They say then that it is more simple to believe at once in the eternal pre-existence of the world, as it is now going on, and may for ever go on by the principle of reproduction which we see and witness, than to believe in the eternal pre-existence of an ulterior cause, or Creator of the world, a being whom we see not, and know not, of whose form substance and mode or place of existence, or of action no sense informs us, no power of the mind enables us to delineate or comprehend. On the contrary I hold (without appeal to revelation) that when we take a view of the Universe, in it's parts general or particular, it is impossible for the human mind not to perceive and feel a conviction of design, consummate skill, and indefinite power in every atom of it's composition. The movements of the heavenly bodies, so exactly held in their course by the balance of centrifugal and centripetal forces, the structure of our earth itself, with it's distribution of lands, waters and atmosphere, animal and vegetable bodies, examined in all their minutest particles, insects mere atoms of life, yet as perfectly organized as man or mammoth, the mineral substances, their generation and uses, it is impossible, I say, for the human mind not to believe that there is, in all this, design, cause and effect, up to an ultimate cause, a fabricator of all things from matter and motion, their preserver and regulator while permitted to exist in their present forms, and their regenerator into new and other forms. We see, too, evident proofs of the necessity of a superintending power to maintain the Universe in it's course and order. Stars, well known, have disappeared, new ones have come into view, comets, in their incalculable courses, may run foul of suns and planets and require renovation under other laws; certain races of animals are become extinct; and, were there no restoring power, all existences might extinguish successively, one by one, until all should be reduced to a shapeless chaos. So irresistible are these evidences of an intelligent and powerful Agent that, of the infinite numbers of men who have existed thro' all time, they have believed, in the proportion of a million at least to Unit, in the hypothesis of an eternal pre-existence of a creator, rather than in that of a self-existent Universe. Surely this unanimous sentiment renders this more probable than that of the few in the other hypothesis. Some early Christians indeed have believed in the coeternal pre-existence of both the Creator and the world, without changing their relation of cause and effect.

1829
Dugald Stewart (1753-1828)
The Evidences of Design exhibited in the Universe
Collected Works, Volume 6

The study of final causes may be considered in two different points of view, — first, as subservient to the evidences of natural religion; and, secondly, as a guide and auxiliary in the investigation of physical laws. Of these views it is the latter alone which is immediately connected with the principles of the inductive logic; and it is to this, accordingly, that I shall chiefly direct my attention in the following observations.

Teleology has proved a powerful, and perhaps indispensable, organ of physical discovery.

To understand the structure of an animal body, it is necessary not only to examine the conformation of the parts, but to consider their functions; or, in other words, to consider their ends and uses. Nor, indeed, does the most accurate knowledge of the former, till perfected by the discovery of the latter, afford satisfaction to an inquisitive and scientific mind. Every anatomist accordingly, whatever his metaphysical creed may be, proceeds in his researches upon the maxim, that no organ exists without its appropriate destination; and, although he may often fail in his attempts to ascertain what this destination is, he never carries his scepticism so far as for a moment to doubt the general principle. I am inclined to think, that it is in this way the most important steps in physiology have been gained; the curiosity being constantly kept alive by some new problem in the animal machine, and at the same time checked in its wanderings by an irresistible conviction that nothing is made in vain.

If we find one common effect constantly produced, though in a very different way, we may safely conclude that this is the use or function of the part. This reasoning can never betray us if we are but sure of the facts.

After all, it were to be wished that the scholastic phrase final cause could, without affectation, be dropped from our philosophical vocabulary, and some more unexceptionable mode of speaking be substituted instead of it. In this elementary work I have not presumed to lay aside entirely .-. form of expression consecrated in the writings of Newton and of his most eminent followers; but I am fully sensible of its impropriety, and um not without hopes that I may contribute something to encourage the gradual disuse of it by the indiscriminate employment of the words ends and uses to convey the same idea.

He was altogether too "indiscriminate " in the employment of the words "ends, "uses, "functions," and "purposes."

The proof of the existence of God drawn from the order of the universe is commonly called the argument from final causes.

This shows that his notions of teleology we're extremely vague. He threw in all sorts of design-arguments under final cause. In this, of course, he was no more to be blamed than Paley and the rest, unless by reason that his great powers of mind and high rank in metaphysical science entitle us to expect better things of him. If " final cause" ever had any legitimate meaning, it-had reference to an end, finis; that is, its meaning was teleological. "The proof of the existence of God drawn from the order of nature" is not teleological, and therefore does not belong to the doctrine of final causes. Neither is the expression "argument from final causes " an accurate one.

The course of nature, truly and properly speaking, is nothing else but the will of God producing certain effects in a continued, regular, constant, and uniform manner; which course or manner of acting, being in every moment perfectly arbitrary, is as easy to be altered at any time as to be preserved.

It appears to me that the evidences of design in the universe are alike obvious to the savage and to the philosopher; and that they are much more forcibly impressed on the minds of those whose understandings have been perverted by sceptical sophistry, by general views of nature, than by examining her works in detail. Or, if any person should think otherwise, it must at least be granted that any one organized and animated body furnishes just as complete evidence of this truth (i.e., design) as could be obtained from the most accurate examination of all the different subjects of natural history. That proper use of such speculations is not to refute the atheist, but to illustrate the wisdom and the unity of design displayed in the material and moral worlds; or rather to enlighten and exalt our own understandings by tracing with humility and reverence the operations of a wisdom which is infinite and divine. If there be any principle whatever which a philosopher is entitled to take for granted, it is certainly this, that there are marks of design in the objects around us and in our own frame; and to write large volumes in order to prove it, is to offer an insult to human reason.

I would not be understood by these remarks to- detract from the merit of the authors to whom they refer. I only complain of the form in which they have presented their observations to the world, — as demonstrations that a designing cause or designing causes exist, and not as an humble attempt to display to those who are already impressed with this conviction a few of those manifold indications of beneficent wisdom which the Author of all things has been pleased for our instruction to place within the reach of our researches. Many of the observations which they have collected in

the course of their inquiries are of inestimable value; but they have been frequently applied to an improper purpose, and hence very serious inconveniences have arisen. Among these inconveniences, there are two of such magnitude that I think it of importance to state them explicitly.

First, The size and number of the publications in question have led superficial thinkers to imagine that the existence of God was a truth winch required a multiplicity of proofs; and in consequence of this apprehension they have found their faith in it rather weakened than confirmed. While, on the other hand, those who were already convinced of this truth have turned aside with disgust from the perusal of so tedious a demonstration leading to so obvious a conclusion. No expedient more effectual could have been devised for destroying that interest which the mind spontaneously takes hi the details of natural philosophy and natural history, than to state them merely as premises subservient to the proof of the most incontestable of all propositions. Whereas, if the existence of an intelligent Cause be taken for granted, and if we study his works not as proofs of design, but as manifestations of his wisdom and revelations of his will, these branches of knowledge open inexhaustible sources of instruction and of delight to the mind. In the works of God we study the operations of his wisdom and goodness, as we study in the conduct and discourse of our fellow-creatures the peculiarities of their genius and characters; and, in proportion as our knowledge extends, we find our acquaintance with the plans of his providence become more intimate, and our conceptions of his nature more elevated and sublime. "Secondly, When we accumulate a number of particular observations as proofs of the existence of an intelligent Cause, we rest this important principle on a ground extremely open to the cavils of sceptics. In most cases, when we speculate concerning final causes, we are unable to do more than to suppose and to conjecture; and we are extremely apt, by indulging imagination too far, to bring ridicule on the cause we mean to support. Sometimes, too, it has happened that conjectures which at first appeared extremely plausible have been afterwards discovered to proceed on a misapprehension of facts. Such accidents never fail to furnish matter of triumph to the sceptic, as if the mistakes to which our limited faculties are liable in studying the works of God afforded any just ground for ascribing them to chance or to an unintelligent necessity. But if, on the other hand, we acquiesce in those evidences of design which a general survey of nature affords to the most common observer, the mistakes we may commit in the subsequent examination of her works will have no effect in suggesting doubts or scruples with respect to the truths of religion; but, impressed with a firm conviction that nothing is made in vain, we will consider every difficulty we meet with as a new reason of humility to ourselves, and a new illustration of the unsearchable wisdom displayed in the universe.

I have thought proper to premise these general reflections to the remarks I am now to make, in order to point out the particular purpose to which I mean to apply them, — not as proofs that there exist designing and intelligent causes in nature, but as illustrations of that unity of design which connects together things the most remote and apparently insulated as parts of one system, and of that infinite wisdom which contrived and which superintends the whole.

(1) Adaptation of the bodies and of the instincts of animals to the laws of the material world.

(2) Adaptation of the bodies and instincts of animals to those particular climates and districts of the earth for which they are destined.

To all this we may add the analogy among many of the phenomena and laws of the material world, a satisfactory proof of which may be derived from the effects which philosophical habits and scientific pursuits have in familiarizing the mind to the order of nature, and in improving its penetration and sagacity in anticipating those parts of it which are yet unknown.

I have only to add further, before leaving this subject, that the various remarks and reasonings which I have offered on the two general principles of our nature formerly mentioned, are not to be considered as forming any part of the argument for the existence of God, which, as I have said, is an immediate and necessary consequence of those principles. What I had in view was, not to confirm this important truth by reasoning, but to obviate the sceptical cavils which have been raised against it.

The " two general principles " alluded to are the law of causation, and the perception of design by intuition. The belief in the existence of God flows out of these as "an immediate and necessary consequence;" and he is not so foolish as to argue for the truth of an intuition. Oh, no! all he has been doing is to " obviate sceptical cavils." All the reasoning ever employed on this subject might be fairly brought under the head of answering the cavils of sceptics; for the mass of mankind have always firmly believed in God, in spite of all the illogical demonstrations of his existence, just as many people live to a good age in spite of medical quackery.

The observations which have been made not only establish the existence of a Deity, but contain the evidences of his unity, of his power, and of his wisdom.

1829
Alexander Crombie (1762 – 1840)
Natural Theology
Book

Several theologians and philosophers have attempted to demonstrate the existence of a Supreme Being, by reasoning, as it is termed, a priori, or by arguments purely metaphysical; and on this evidence solely have they rested the question. So confidently hag this mode of argumentation been employed, that it has even been asserted that no mathematical deduction or intuitive truth is accompanied with clearer evidence. Now, the existence of a Supreme Being is not a necessary truth; it is a question of fact. It cannot be demonstrated, that a Deity must be, or that the contrary proposition involves an absurdity. That something must have existed from eternity, is self-evident; and what this something is, constitutes the question between the Theist and the Atheist. The one asserts the eternity of matter; the other that of an Intelligent First Cause, the Author of all existence. The question of Deity then being a question of fact, and the subjects of metaphysical evidence being the necessary and immutable relations of our ideas, it is clear, that this species of argument is wholly inapplicable to this, as to every question, which relates to actual existence. These metaphysical reasonings, therefore, have failed to convince. They are not only abstruse and perplexing, but, when strictly examined, will be found inconclusive. Hence they have proved injurious to the doctrine which they have been offered to establish. With the exception of truths purely mathematical, or, to speak generally, those founded in necessary relation, there are few, if any, whose evidence is not weakened by the adduction of illogical arguments in their favour. If the reasoning is abstract and difficult to be comprehended, the reader is apt to conclude, that the doctrine to be established cannot be very clear, which requires such laborious efforts of intellect to confirm its truth. And, if the effort should be unsuccessful—if the attempt to prove, that the doctrine not only is, but must be true, should fail, when the invalidity of the argument is detected, a suspicion is sometimes created, that the doctrine may be false. Thus much is certain, that our belief in any moral or physical truth is necessarily weakened, by the refutation of an argument, on the authority of which partly the proposition gained our assent. And, if the reasoning which has been subverted should be that on which solely our conviction rested, we are too prone to conclude, from the refutation of the argument, that our opinion is false, or that the doctrine is doubtful.

It is also to be observed, that a fallacious argument has a direct and necessary tendency to diminish our confidence in the sagacity of its author, and naturally infuses into the mind some .doubt, whether his other reasoning has all the validity which it seems to nave, .and which it may really possess. When we perceive one stone crumbled at the foundation of an edifice, which, on a superficial inspection, had the appearance of soundness, it excites an apprehension, that others also may be in a similar condition; and that, if the structure were examined, it would be proved to be unstable. It is not then too much to affirm, that arguments a priori being clearly inapplicable to every question of actual existence, and when rigidly examined being detected to be fallacious, furnish the Atheist with a ground of exultation, and are injurious to the cause, which they are intended to support. We know, that when the shaft of an enemy misses its aim, his adversary naturally feels a triumph*. It is prudent in every man to abandon a position, which he is unable to defend, and the possession of which serves only to weaken his strength."—Vol. I. pp. 49—

When we inquire, then, into the existence of a First Cause, instead of looking for evidence which the subject excludes—instead of indulging in subtle and abstract discussions, which serve more to perplex than to convince, to confound than to enlighten the understanding—it would be. wisdom to fix our attention on those plain, simple, and obvious facts, which are constantly before us, and which are placed within the range of the narrowest comprehension. Man needs only to look at his own frame, to find wonders to excite his admiration. The heart that beats, the eye that sees, the ear that hears, the will that prompts, and the limb that moves, speak to him a language which it seems hardly possible to misapprehend. The facts are simple and unequivocal; the conclusion is clear and irresistible. Here there is no danger of mistake: here then let us rest. If we are convinced, that these facts furnish incontestible proofs of intelligence and design, if we firmly believe, that the eye was made for seeing, and the ear for hearing, we require no metaphysical abstractions to convince us, that man was formed by the wisdom of a superior Power. And when the Atheist acknowledges his belief in the existence of other animated and intellectual beings in the universe besides man, although he has not seen them, and of whose nature he admits that he may have no conception, we ask, with what consistency can he deny the existence of an Intelligent First Cause, merely because that Cause is not perceptible by sense, but an object of the understanding? Of all grounds of infidelity, this is the most irrational."— Vol. I pp. 57—59.

Metaphysical evidence, then, being entirely confined to abstract relations, is obviously inapplicable to every question of real existence—every question involving a subject external to ourselves. Fruitless, therefore, must be every attempt to demonstrate the existence of Deity as a necessary truth, or to show, as has been affirmed, that it is as impossible for him not to exist, as for two and two not to be four* Nor is it, perhaps, too much to assert, that metaphysical arguments in favour of Theism, notwithstanding the high authorities from which they have proceeded, and the confidence with which they have been urged, have generally failed to produce conviction, and on strict examination will be found to be inconclusive. It is justly observed by the late Professor Hutchison, that ' they are not adapted to the bulk of the capacities of mankind, and can afford no solid or permanent conviction to the learned themselves.' Every attempt to prove the existence of Deity to be a necessary truth must be unsuccessful, and a doctrine so momentous should not be submitted to reasoning, too obscure to be generally intelligible, or too questionable to be satisfactory. Nothing proves so injurious to truth, as the adduction of arguments, in its support, which are either inapplicable to the question, or which the adversary may retort, or metaphysical subtlety elude.

In favour of the opinion here offered respecting not merely the inutility, but also the injurious tendency, of attempting the proof of the Divine existence by metaphysical argument, it would be easy to cite many weighty authorities; but we shall rest satisfied with quoting that of the learned and profound Cudworth 'These atomic Atheists', observes the writer, ' utterly evacuate that grand argument for a God, taken from the phenomenon of the artificial frame of things, which has been so much insisted on in all ages, and which commonly makes the strongest impression of any other

upon the minds of men, they leaving only certain metaphysical arguments for a Deity, which though never so good, yet by reason of their subtlety can do but little execution on the minds of the generality, and even among the learned do oftentimes beget more of doubtful disputation and scepticism than of clear conviction and satisfaction, the Atheists in the meantime laughing in their sleeves, and not a little triumphing to see the cause of Theism betrayed by its professed friends and assertors, and the grand argument for the same totally slurred over, and so their work done, as it were, to their hands for them.' "—Intellectual System, i. 4. f " Hume's Dialogues on Natural Religion

The learned and sagacious Dr. Clarke, though he resorted to metaphysical reasoning, to demonstrate the existence of Deity, seems to have been fully aware, that this species of argumentation is much less calculated to produce conviction, than that, which is derived from the phenomena of nature. This is sufficiently manifest from a conversation, which passed between him and Mr. Whiston, on the subject of his celebrated work on the Being and Attributes of God. ' I was', says Whiston, 'in my garden, against St. Peter's College, Cambridge, where I then lived. Now I perceived, that in these sermons, he had dealt a great deal in abstract and metaphysical reasoning. I therefore asked him, how he ventured into such subtleties, which I never durst meddle with; and shewing him a nettle, or some contemptible weed in my garden, I told him, that weed contained better arguments for the being and attributes of God, than all his metaphysics. Clarke confessed it to be so; but alleged for himself, that since such philosophers as Hobbes and Spinoza had made use of those kinds of subtleties against, he thought it proper to shew, that the like way of reasoning might be made better use of on the tide of religion; which reason or excuse I allowed to be not inconsiderable.'

Such was the motive, it would appear, which induced Dr. Clarke to resort to the employment of abstract arguments, in order to overthrow the reasoning of these subtle metaphysicians, and to establish the doctrine of Theism. While we acknowledge the necessity of meeting an adversary on his own ground, we must at the same time remark, that it is one thing to expose his fallacies, and quite another thing to attempt the establishment of the doctrine, which he impugns, by arguments equally inapposite as his own.

It would exhaust the patience of the reader, were we to detail and examine the various hypotheses, by which it has been attempted to account for the construction of our system, without the aid of intelligence. The most extravagant whimsies have been indulged, each Atheist forming a world according to his own rambling fancy. Some of them tell us, in order to account for the production of organized beings, that germs existed from eternity, and having been thrown into moulds, fit for their reception, were, by favourable circumstances, evolved, expanded, and nourished. The hypothesis can only excite ridicule; it is unworthy of argument. Will the Atheist tell us, who fitted these moulds for the reception of these germs? Were they formed by accident? \\ ill he name any known mechanical or chemical law, (for the laws of animal life had then no existence,) by which the formation of such moulds could have been effected? He assumes the existence of sperms; but can he produce a single example of the existence of a sperm, anterior to that of an organized being? We know of no sperm, which has not issued from a vegetable or animal substance. The Atheist, without a single phenomenon to justify his opinion, gives the sperm existence, prior to an organism. To offer a visionary hypothesis, not only unsupported by any known physical fact, but contradicted by universal experience, is puerile, and reprehensible trifling.

Others maintain, that certain filaments, endowed with certain appetencies, can account for the production of vegetables and animals; while some assert the eternal existence of animated globules, which by certain assumed affinities, arranged themselves into the forms of organized beings. But have they adduced a single fact, in order to shew, how these globules, devoid of intelligence, without design, and without concert, arranged themselves in order, so as to produce a

regular and harmonious whole—how so many, as a celebrated physiologist (Dr. Barclay) observes, agreed to make a leg, so many to form the blood, and so many the bones and muscles; and that none of them encroached on the choice or operation of the rest. Nay, dismissing the folly of supposing, that unintelligent particles, globules, or filaments could harmoniously arrange themselves into organized forms, we ask how was intelligence produced? Could this be effected, but through the medium of intelligence? Nay, how were these globules and filaments protected, antecedently to their aggregation, from the effects of chemical agency? But it is time to dismiss these extravagant cosmogonies,—they resemble the dreams of a distempered fancy, more than the grave speculations of a rational and philosophic mind.

In reviewing the various hypotheses of Scepticism, nothing strikes us so forcibly, as the palpable discordancy of Atheists themselves, in their attempts to explain the formation of the universe, excluding the agency of a supreme and designing Cause. We should be pleased to know, whether this discordancy arises from their favourite principle, * a principle of order,' or of harmony; or, as matter obeys its own laws,' whether assent and dissent, agreement, and disagreement, be one and the same thing. The prodigies, too, of which they require our belief, shock the understanding, while they possess not the merit of amusing the fancy. Some of them, as we have seen, would persuade us, as they profess to believe, that all organic forms originated from atoms, diffused through the immensity of space, and accidentally conglomerated into plants and animals. If we ask, how these atoms were put in motion, their answer is as prompt, as if they had been, from eternity, eye-witnesses of the fact. They tell us, that they were eternally in motion. If we ask a proof, they give us assertion; if we want a fact, they are ready with a hypothesis. If we inquire how senseless atoms could arrange themselves into the forms, and possessing the powers, of sentient and intelligent beings, they have a personage at hand to solve the difficulty, and account for the miracle. This personage is an imaginary being, a creature of their own fancy, whom they sometimes call Nature, and sometimes Necessity. To the sole agency of some one or other of these convenient personages, are ascribed all the wonders of the universe. Attraction and repulsion, vegetation and generation, instinct and reason, in short, all the powers and operations of the physical and moral world are under her direction and control. If we inquire, what makes the earth to produce and sustain its productions, it is Nature, or it is Necessity. If we ask, what teaches the infant or the lamb to suck, or what nerves and muscles to use, in order to move a certain limb, it is Nature, or it is Necessity. What teaches them to avoid what is noxious, or painful, is it Nature or is it Necessity. And, if it did not sound as too absurd, we should be told, that Nature, or Necessity, teaches the sun and planets the art of gravitation.—Vol. I. pp. 207—211.

I base my argument *a posteriori* in favour of Deity on the two following propositions:

" 1st, Wherever we find order and regularity obtaining either uniformly, or in a vast majority of instances, where the possibilities of disorder are indefinitely numerous, we are justified in inferring from this fact an intelligent cause."—Vol I. pp. 386—389.

" 2d, Wherever we find numerous concurrences of means, various and complicated, towards the production of effects, we are justified in inferring an intelligent cause."—Vol. I. p. 399.

Whether the constitution of our system, and the phenomena of the universe, as far as we are capable of exploring them, furnish such examples of order, beauty, and harmony—such concurrences of means to ends, as to justify us in concluding with certainty that they are the productions of an Intelligent and Designing Cause.

We behold the sun, a body, which is a million times larger than our earth, placed in the centre, the source of light and heat. Here several questions naturally offer themselves which it is impossible to resolve, on the hypothesis of chance, or unintelligent necessity. Why is the sun a luminous body?

Why is he not, like the surrounding planets, opaque? If the universe was once a chaos of floating atoms, of one and the same simple nature, and afterwards conglomerated into masses, can our adversaries name any known law, by which light and heat could be generated, and made to centre in one sphere? Why is the sun placed in the middle, a situation the best adapted of all, for the communication of these fluids to the surrounding orbs? Why does he periodically give, and withdraw, his beams, to suit the necessities of labour and repose? Why is his distance such, that the stream of light and heat, issuing from his body, is so modified, as to be adapted to the constitution of every organic being on our planet? and that his rays, notwithstanding their immense velocity, are infinitesimally small, so as not to injure the organ of vision? Why is he so situated, that a due equilibrium is observed between the centripetal and centrifugal forces? Why is the earth accompanied with a satellite, which not only affords us light, in the absence of the sun, but likewise contributes essentially to our health and preservation? To the influence of the moon chiefly we are indebted for the constant agitation of the sea, which, notwithstanding its saline quality, if it were allowed to stagnate, would, by its noxious effluvia, scatter disease and death over the surface of the globe. Here we find adjustments by which good is effected, and evil excluded, inexplicable on any other hypothesis, than of an Intelligent and Designing Cause.

We see the great luminary encircled by eleven primary and eighteen secondary planets, the latter revolving along with the former round the sun, as a common centre, and also round their respective primaries. We behold these revolutions proceeding with uninterrupted order and regularity, from west to east, nearly all in the same direction, and all nearly in the same plane. Let the chance be calculated, that it might have been otherwise, and it may be left to any man, not blinded by invincible prejudice, or a love of paradoxical hypothesis, to decide, whether this order and regularity can be ascribed to accident. La Place supposing only seven primary planets, and including the direction of the sun's rotation, assuming also, that there are thirty-seven revolutions in the same direction, called direct, namely, of the seven primaries in their orbits, of the eighteen secondaries in their orbits, of five primaries and six secondaries about their axis, with the rotation of Saturn's ring, computes the probability, that by chance one of these would have been retrograde, to be WWHHH- And, though he is hence obliged to acknowledge, that this could not possibly be the result of accident, he ascribes it to the influence of a revolving fluid, determined, it would seem, rather than admit an Intelligent Cause, to adopt a gratuitous, an unsatisfactory, and, as Vince has shewn, an untenable hypothesis. Have we any evidence of the existence of such a fluid? It is mere conjecture. And if it did exist, would not the cause of its revolution require to be unfolded? Shall we rest satisfied with a hypothetical fact, as a solution of a difficulty, which is itself as unaccountable as the phenomenon which it is offered to explain? Do not the uniformity of its action, the direction of its force, and the rate of its velocity, so adjusted, as to produce a beneficial effect, require a regulating power? But this is not all. It is evident, that, as the supposed fluid acts by necessity, all its motions must be in one and the same direction. Any deviation would be impossible. The reader will observe, also, that it is from the universality of the effect, that the author infers the physical necessity of the cause. But it is ascertained, that these motions are not all direct, and that the six satellites, already mentioned, move in a" retrograde direction. We know likewise, that the orbits of the comets are extremely diversified, these bodies traversing the heavens in all points of the compass. These are facts manifestly irreconcilable with the existence of a revolving fluid. In these revolutions, we have such regularity as to indicate an Intelligent Cause, combined with such deviations, though few in number in the planetary motions, as to convince us, that this cause does not act by a physical necessity, but is capable of producing order and harmony by different means.-Vol. I. pp.435-440.

Every egg, almost immediately after impregnation, discovers a small speck on the yolk, which is called the cicatrice. In the centre of this appears a white circle, in the middle of which is a fluid matter, in which the embryo of the chick is observed to swim. In the extremity of the embryo is contained a bag, surrounded with a ligament, and in this the naval afterwards appears. This is all

that can be observed, before incubation takes place. When the hen has sitten about twelve hours, some lineaments of the body appear. A humid matter is perceived, having the form of a small head, on which vesicles are seen, that afterwards form the vertebra of the back. In thirty hours the eyes begin to be distinguishable. At the end of the second day, the heart begins to beat, and has the form of a horse-shoe; but no blood is yet seen. ' We discover, at the end of about 48 hours, two vesicles with blood, the pulsation of which is very evident. One of these is the left ventricle, the other is the root of the great artery. One auricle of the heart appears at the 50th hour, which resembles a lace folded back upon itself. The beating of the heart may now be observed in the auricle and afterwards in the ventricle. At the end of seventy hours, the two wings may be distinguished, and on the head two knobs for the brain, one for the bill, and two others for the fore and hind part of the head. Towards the end of the 4th day, the two auricles, now visible, approach nearer to the heart than before. The first auricle that appears, seems to have two horns; but it afterwards appears to be auricles. About the 5th day, the liver is seen. The first voluntary motion is observed at the end of 131 hours. At the end of 138 hours, the lungs and stomach become visible; and at the end of 142. the intestines, the loins, and the upper jaw. At the end of 144 hours, two ventricles may be discovered, and two drops of blood instead of one, which was seen at first. On the 7th day, the brain acquires some consistence. At the 190th hour of incubation, the bill opens, and the flesh appears on the breast. At the 194th hour, the sternum (i.e. the breast-bone) is seen. About e 820th hour, the ribs come out of the back; the bile and the gall bladder become visible. After the 236th hour, the bile becomes green; and if the chick be taken from the integuments, it can evidently move itself. The feathers begin to shoot towards the 240th hour, and the skull becomes gristly. At the 246th hour, the eyes appear, and the ribs are perfect at the 351st hour. At the end of 355 hours, the beak opens and shuts; and about the 18th day, the chick utters its first cry. Its strength then gradually increases, till it sets itself at liberty, by breaking the prison in which it was confined.'

Is it possible to contemplate this wonderful process, without profound admiration? Can we trace it, step by step, from its commencement to its completion, and not acknowledge the hand of intelligence and wisdom i That it can be the result of chance is demonstrably repugnant to all probability; and to attribute it to necessity, or unintelligent power, is to abandon the fundamental principle, on which we infer the nature of a cause from the character of its effect, and to contradict the universally acknowledged connection between intellectual qualities, and their visible results. That the several changes arise successively from immediate and necessary causes, is granted, each antecedent change necessarily introducing its consequent; but that the properties or powers, acting without intelligence, should be the sole or ultimate cause, is a notion which the mind instantaneously rejects, as utterly incredible. If we saw a shapeless lump of wood, placed on the ground, and drawn by a tackle, so as to be placed under the operation of a machine, and then mechanically carried from one part of it to another, until it came out a perfect shipblock, we might with strict propriety, when explaining the mechanical process, ascribe the operation to the brute agency of necessary causes, the ropes, the pulleys, the cranks, the saws, the chisels, the wimbles; but the ingenuity displayed in the application and management of these causes, would irresistibly lead to the conviction, that their immediate, though necessary agency, was ultimately referable to intelligence and design. The regularity and uniformity, with which the animal process in the egg is commenced and completed, may prove, that a connection is established between certain antecedents and certain consequents; but when we consider, that in the whole of this process there is nothing superfluous, nothing defective, and that it is the characteristic, not of ignorance, but of wisdom, to do nothing in vain, we cannot, without incurring the charge of gross inconsistency, attribute the establishment of this connection, to any, but an Intelligent Cause. If this single example of animal production, truly curious and wonderful, is not sufficient to evince wisdom and design, if there be any mind, so constituted by nature, or formed by habit, as to resist this evidence, it may be deemed folly to offer any other example. —Vol. I. pp.459—464.

The construction of the cells of bees has excited the wonder of philosophers and naturalists, both ancient and modern; but since the time of Newton, several facts have been discovered with regard to the contrivances of this little insect which appear almost incredible.

When we behold the hive-bee constructing its cell, to contain its winter stock, and constructing it of that form, which is demonstrably the strongest and the most convenient, it seems the extravagance of absurdity to suppose, that the instinct is the offspring of ignorance. It not only provides for futurity, as if gifted with a prescience of its future wants, but it builds its storehouse, as if consulting convenience, economy, and strength. This is indeed one of the most extraordinary phenomena, that the animal world presents to our contemplation. It exhibits to us a fact in the history of this little insect, calculated to excite admiration, and impress the firmest conviction of an Intelligent and Presiding Power.

It must be evident to every one, who has given the least attention to the obvious properties of different figures, that there are only three which will admit the junction of their sides, without any vacant spaces between them, namely the square, the equilateral triangle, and the hexedron; of these, the last is the strongest, and the most convenient. In this form, we find, that all the cells are constructed. This is a curious and wonderful fact. And, what is equally remarkable, the middle of every cell, on one side, is directly opposed to the point where the three partitions meet on the opposite side. By this position, the cell receives additional strength. < It is a curious mathematical problem,' says a late candid and sagacious philosopher, ' at what precise angle the three planes, which compose the bottom of a cell, ought to meet, in order to make the greatest possible saving, or the least expense of material and labour. This is one of those problems, belonging to the higher parts of mathematics, which are called problems of mamma and minima. It has been resolved by some mathematicians, particularly by the ingenious Mr. M'Laurin, by a fluxionary calculation, which is to be found in the Transactions of the Royal Society of London. He has determined precisely the angle required; and he found, by the most exact measuration the subject could admit, that it is the very angle in which the three planes in the bottom of the cell of a honey-comb do actually meet.

By whose instruction, or by what analytic process, did the bee arrive at the solution of a problem, which it required the genius of a M'Laurin to solve? ' Who taught it,' says the same author, ' the properties of solids, and to resolve problems of maxima and minima?. . . . Bees work most geometrically, without knowing any thing of geometry, somewhat like a child, who, by turning the handle of an organ, makes good music. The art is not in the child, but in him, who made the organ. In like manner, when the bee makes its comb so geometrically, the geometry is not in the bee, but in that great Geometrician, who made the bee, and made all things in number, weight, and measure.' To this conclusion, and no other, does this singular instinct irresistibly lead us; or we must believe, what no man can rationally believe, that the bee possesses a knowledge of mathematical science."—Vol. I. pp. 502—506.

The humble and truly philosophic Theist, contemplating the immensity of the works of God, and conscious of his utter incapacity to penetrate into the counsels of Eternal Wisdom, when he surveys the condition in which he is placed, will thus reason with himself:

In the phenomena of the universe I discover the grandest and most impressive evidences of stupendous power; and in that system to which I belong, I behold the most astonishing adjustments of causes and effects. In every thing around me, I perceive such congruities of relation, and such complicated concurrences of means, to useful and salutary ends, as no unintelligent agency can possibly explain. I therefore infer power, wisdom, and benevolence in the Cause. Nor can I draw any other conclusion, without abandoning the principles, on which all my reasonings are founded, and from which all my deductions proceed in the investigation of causes, in matters of fact. Amidst a vast preponderance of good, and an immense balance of order and regularity, I perceive, also,

evil and apparent accident. This chequered state of things would lead me to limit the power, or the wisdom or the goodness of the Cause. But, as it would be an egregious error to estimate the entire nature of any cause, by examining only a part of its effect, so I can form no correct conception of the power, wisdom, and goodness of the Creator from an experience, which, in respect to time, is as a point to eternity, and which does not extend beyond an atom in the universe. And, as it would be absurd to suppose a finite and dependent Being to have infinite perfections, I feel it equally absurd to suppose an eternal, or infinite and independent Being to have finite perfections. Nor can I admit the contradiction, that a possible perfection is yet impossible—that it may exist, yet exists not in the Being, in whom alone it can exist. In this dilemma then I feel myself placed. I must either believe, in opposition to appearances, that the attributes of the Divine Being are infinite, or I must believe absurdities and assent to contradictions. Can I hesitate, which alternative to prefer; or rather, I should say, can the constitution of my mind, and the unalterable laws of human belief permit me to choose? Whatever difficulties embarrass the one alternative, I cannot embrace the other. Man is susceptible of pain and subject to evil. It seems to be the will of his Maker, that it should be so. Why evil of any kind should be ordained, or permitted to enter into the scheme of the Divine economy, is to my finite understanding incomprehensible. But I can no more be persuaded, that malevolence is an attribute of the Divine nature, than I can believe, contrary to all experience, that the life of every sentient being is an uninterrupted series of pain and suffering. I can no more question the goodness of Deity than I can doubt of the enjoyment which I derive from the pleasures of sense, the gratifications of appetite, the beauties and sublimities of nature, the social affections, the acquisition of knowledge, and the delight arising from the cultivation of pious feelings and virtuous habits. And, if I repose confidence in the goodness and discretion of a wise and virtuous friend, even when I cannot reconcile his procedure with my notions of right and wrong, surely I cannot consistently withhold that confidence from the Wisest and Best of all beings.

In this manner he will reason with himself; and, if he beholds evils or defects, as he apprehends them, beholding at the same time an immense preponderance of good, and satisfied that malevolence, ignorance, or impotency are incompatible with the nature of an Eternal and Independent Being, he will regard every evil as an ordination for good, and ultimately to issue in higher enjoyment.

Where infinity is the subject, we are necessarily bewildered: but without perplexing ourselves with discussions, respecting the compatibility of evil with the infinitude of the Divine attributes, discussions, to which our limited faculties are wholly unequal, every reasonable man will feel his happiness sufficiently secured in the perfections of Deity, the source of all excellence, the most powerful, and, at the same time the wisest and best of all beings. The orbs that fly with inconceivable velocity through the regions of space, proclaim His power; the manifold adaptation of means to ends, in this our lower system, displays His wisdom; and we ourselves, with the sentient creatures around us, exhibit evidences of His goodness. Our enjoyments are numberless, our sufferings comparatively few.—Why the latter are not wholly excluded, or why an equal degree of happiness is not produced without the medium of evil, is a question, which we vainly essay to solve. Under the charge, however, of incomprehensible wisdom, inconceivable power, and unchangeable goodness, we need entertain no apprehensions, that our happiness will not be effectually consulted. God is powerful, wise, and benevolent. Here then let us confidently rest, submitting, with due humility, our weak reason to the counsels of Eternal and Unerring wisdom." —Vol. II. pp. 245—249.

The benevolence of the Deity, as displayed in the constitution of nature, furnishes alone a sufficient ground for believing, that there exists a wise and superintending Providence. It would be entirely irreconcileable with the goodness of the great Parent of all animated being, to suppose, that He would call a world of creatures into existence, susceptible of enjoyment, but subject also to suffering, and immediately abandon them to their own uncertain guidance, or to the

contingencies of chance. The presumption is, that He would either make a provision for their happiness in the constitution of their nature, and of that world in which he had placed them, or that His continual superintending care would watch over their concerns. If a human parent would be reprobated, who, though capable of providing for the wants of his child, should throw the infant, at its birth, on the mercy of the world, instead of sheltering it in his bosom, and nursing it with tenderness, can we, consistently with the Divine goodness everywhere conspicuous that she should not have compassion on the son of her womb; yea, they may forget, yet will I not forget thee.'

Let it not be urged, that parental affection may be an acquired feeling, the result of education, or the effect of example. This argument might have weight, if it were founded in fact; but we have evidence to prove, as has been already shewn, that this affection obtains in cases, in which education and example have no place. Examine the brute creation; the love of offspring is conspicuous in all. They provide for their progeny, until they can provide for themselves. Nay, do we not perceive animals, in other circumstances the most timid, exhibiting an intrepidity, and disregard of their own safety, truly astonishing, in defending their young against the attack of an enemy? When this instinct ceases to be necessary, it ceases to exist. How powerfully does this affection in the brute creation, evince the wisdom and goodness of a superintending Providence? The great Parent of the universe, from whose inspiration proceeds the instinctive affection of every secondary parent, cannot be regardless of the creatures of His hand. We have in His benevolence, then, a sufficient security, that our concerns are not overlooked by the Being who made us. To suppose that Goodness Unchangeable could prompt to create, and yet neglect to preserve, would be to suppose a contradiction. And the very existence of that instinct which impels every animal to foster its young, until they are capable of providing for themselves, inasmuch as this instinct is ascribable to His ordination, furnishes a conclusive evidence, that He makes provision for their preservation, and attends to their necessities. It is the essence of benevolence to delight in doing good, and diffusing happiness, as far as its capacities extend. We must either, therefore, deny the goodness of Deity, in opposition to invincible evidence, or we must admit the existence of a superintending Providence."—Vol. II. pp. 258—262.

I find myself here placed in a world where I am surrounded with phenomena, which excite my astonishment, and for which I have the fullest conviction, that it is impossible to account, unless here completely unfolded, that he has ulterior purposes to effect, and that the present is only preparatory to another state. To this conclusion I am led by the known attributes of the Divine Being, taken in connection with the general economy of the system to which I belong, and the peculiar circumstances in which I am placed. For I perceive in the constitution of nature, the most impressive displays of wisdom and goodness, in the adaptation of causes to effects. I find every thing suited to its purpose; and though my ignorance might, in a few instances, tempt me to conclude differently, I have the strongest reason for believing, that nothing is useless. Mutual aptitudes pervade the whole. In the animal creation, particularly, we observe the same congruities of relation. Every organ is accommodated to its function; every appetite is adapted to its purpose, and provided with its gratification. No desire is created in vain; nothing is superfluous, nothing defective. Can I believe, then, that man, the highest of animated beings on this globe, is to be an exception to this general ordination of his Maker?—That he is the only creature on earth, in whom these perfect adjustments do not exist, and in whose condition they were never intended to exist?—That the good and wise Author of his being, has given him a notion of an eternity, in which he is to have no share, an idea of a futurity, which is never to be his, a desire of immortality only to be disappointed, a hope of an hereafter, never to be realized? While I perceive every other animal adapted to its sphere, its desires confined to its present existence, having no notion of any condition higher than its own, satisfied with its lot, its appetites, and its gratifications being mutually adjusted, and at the same time observe the inadequacy of man's enjoyments to his capacities and desires, I find it impossible to account for this extraordinary exception to the

general economy, without either impeaching the consistency of the Divine Being, or concluding that the exception is only temporary, and that another destiny awaits us.

On the supposition of an Intelligent First Cause. I look especially at my own frame, and cannot but refer it to a wise and benevolent being, as its author. To tell me, that a structure so wonderful in all its powers, corporeal and mental, is the creature of blind necessity, is to insult my reason, by telling me, that it is, because it must be. It is to require of me to assent to the absurdity, that what has no intelligence may impart intelligence; that brute atoms, though incapable of design, may yet produce the effects of wisdom and contrivance; and that a senseless necessity can achieve what human ingenuity cannot accomplish, and what human sagacity cannot even comprehend. It is to offer a hypothesis, which satisfies no enquiry, and explains not a single fact. I feel, therefore, the irresistible conviction, that my existence, and that of the universe around me, must be ascribed to a wise and designing Power. I must believe, also, that the Author of all existence must be himself eternal, for this is a self-evident and necessary truth.

The properties of every cause, being inferred from its effects, I collect the attributes of this Being from the character of the system in which I am placed. And if, in every other instance, from complicated and numberless concurrences conducting to beneficial effects, I infer benevolence to prompt, wisdom to contrive, and power to execute, I must, if I reason consistently, come to a similar conclusion here. Malevolence cannot contrive happiness, nor ignorance act in wisdom. I conclude, therefore, that the Supreme First Cause is powerful, wise, and good.

But it is only a mere atom of the universe, with which I am acquainted; and finite effects cannot evince an infinite cause. Here reason steps in, and teaches me, that unless I assent to a contradiction, I must believe, that a Being, infinite in existence, must be infinite in all His attributes. But the evils, which I behold around me, seem at variance with this belief. Am I then to conclude, that the Deity is an imperfect Being? This inference my understanding instantly rejects, as involving the contradiction, that perfection is possible, yet impossible, and that an infinite being may have finite perfections. I must therefore infer, that I perceive only a part of His vast designs, that the counsels of His wisdom are not in the constitution also of that mind, which the Deity has given me, and in the ordinary course of His moral government, I find a rule prescribed for the general regulation of my conduct. Can I then believe, that for my conformity to a law, which he wills me to obey, a conformity which may be opposed to my immediate interest, He will subject me to suffering, without recompence, and without hope? And, if the price of obedience is the deprivation of life, where is the reward? Is he who reveres his Maker, and loves his neighbour, to share the same fate with him, who neither fears God, nor regards man P Is justice an empty name r Or if I regard this attribute as a modification of His benevolence, can I believe, that wisdom can display folly, goodness wantonly inflict suffering, or omnipotence not effect what benevolence and wisdom may direct? If I can believe this, I may assent to any absurdity. No. If man is doomed to suffer either here or hereafter, the benevolence of the Deity gives me reason to believe, that he will not suffer in vain, ' God is good; and His tender mercies are over all His works.' In His adorable attributes, then, I rest my hopes, firmly persuaded, that, however incomprehensible to me may be the means, He, who at first gave me life, is able to restore it, when death shall have dissolved my connection with the present world.

These, then, are the grounds of my expectation of another state of being, when we shall be delivered from the imperfections and evils inseparable from mortality, and fitted for a more intimate communion with our Maker; when it will be our occupation and delight to contemplate with improving faculties His stupendous works, and to adore with reverence His transcendent perfections; when we shall be re-united to those, whom we loved on earth, and join with them, and every human being, of every nation and every language, whatever sufferings here or hereafter

some, for their correction, may previously undergo, in the sublime offices of devotion to our Creator and Benefactor, through the never ending revolutions of eternity. Blessed state, whence every malignant passion is excluded, and where peace, harmony, and felicity for ever dwell! Happy is the man, who can oppose to the pains and sorrows of his present condition the animating hope of a glorious immortality, when this clouded scene shall have for ever closed. But, O happy, happy, thrice happy, is the Christian, who feels the full assurance, that death is only the gate to everlasting life, and to a state of enjoyment, ' which eye hath not seen, nor ear heard, nor hath it entered into the heart of man to conceive.'"—Vol. II. pp. 603—«IO.

1830
Joseph Smith, Translator
Book of Mormon Alma 30:44

44 But Alma said unto him: Thou hast had signs enough; will ye tempt your God? Will ye say, Show unto me a sign, when ye have the testimony of all these thy brethren, and also all the holy prophets? The scriptures are laid before thee, yea, and all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator.

1832
Joseph Smith
Earliest Account of First Vision

For I looked upon the sun the glorious luminary of the earth and also the moon rolling in their magesty through the heavens and also the stars shining in their courses and the earth also upon which I stood and the beast of the field and the fowls of heaven and the fish of the waters and also man walking forth upon the face of the earth in magesty and in the strength of beauty whose power and intiligence in governing the things which are so exceding great and marvilous even in the likeness of him who created ~~him~~ <them> and when I considered upon these things my heart exclaimed well hath the wise man said ~~the~~ <it is a> fool <that> saith in his heart there is no God my heart exclaimed all all these bear testimony and bespeak an omnipotant and omnipreasant power a being who makith Laws and decreeeth and bindeth all things in their bounds who filleth Eternity who was and is and will be fron all Eternity to Eternity and when I considered all these things and that <that> being seeketh such to worship him as worship him in spirit and in truth

January 1834
Joseph Smith
Teachings of the Prophet Joseph Smith, selected and arranged by Joseph Fielding Smith, p.56
What Is the Purpose of Existence?

Think for a moment, of the greatness of the Being who created the Universe; and ask, could He be so inconsistent with His own character, as to leave man without a law or rule by which to regulate his conduct, after placing him here, where, according to the formation of his nature he must in a short period sink into the dust? Is there nothing further; is there no existence beyond this veil of death which is so suddenly to be cast over all of us? If there is, why not that Being who had power to place us here, inform us something of the hereafter? If we had power to place ourselves in this

present existence, why not have power to know what shall follow when that dark veil is cast over our bodies? If in this life we receive our all; if when we crumble back to dust we are no more, from what source did we emanate, and what was the purpose of our existence? If this life were all, we should be led to query, whether or not there was really any substance in existence, and we might with propriety say, "Let us eat, drink, and be merry, for to-morrow we die!" But if this life is all, then why this constant toiling, why this continual warfare, and why this unceasing trouble? But this life is not all; the voice of reason, the language of inspiration, and the Spirit of the living God, our Creator, teaches us, as we hold the record of truth in our hands, that this is not the case, that this is not so; for, the heavens declare the glory of a God, and the firmament showeth His handiwork; and a moment's reflection is sufficient to teach every man of common intelligence, that all these are not the mere productions of chance, nor could they be supported by any power less than an Almighty hand; and He that can mark the power of Omnipotence, inscribed upon the heavens, can also see God's own handwriting in the sacred volume: and he who reads it oftenest will like it best, and he who is acquainted with it, will know the hand wherever he can see it; and when once discovered, it will not only receive an acknowledgment, but an obedience to all its heavenly precepts. For a moment reflect: what could have been the purpose of our Father in giving to us a law? Was it that it might be obeyed, or disobeyed? And think further, too, not only of the propriety, but of the importance of attending to His laws in every particular. If, then, there is an importance in this respect, is there not a responsibility of great weight resting upon those who are called to declare these truths to men? Were we capable of laying any thing before you as a just comparison, we would cheerfully do it; but in this our ability fails, and we are inclined to think that man is unable, without assistance beyond what has been given to those before, of expressing in words the greatness of this important subject. We can only say, that if an anticipation of the joys of the celestial glory, as witnessed to the hearts of the humble is not sufficient, we will leave to yourselves the result of your own diligence; for God ere long, will call all His servants before Him, and there from His own hand they will receive a just recompense and a righteous reward for all their labors.

March 1834

The Elders of the Church in Kirtland, To Their Brethren Abroad., Evening and Morning Star, vol. 2 (June 1833-September 1834), Vol. Ii. March, 1834. No. 18., p.143

No doubt, the course which we pursued in our last to you, is yet familiar to your minds; that we there endeavored to show, as far as our limits would extend, the propriety, in part of adhering to the law of heaven; and also, the consistency in looking to heaven for a law or rule to serve us as a guide in this present state of existence, that we may be prepared to meet that which inevitably awaits us, as well as all mankind.-There is an importance, perhaps, attached to this subject, which the world has not as fully examined as the importance of it requires. Think for a moment, of the greatness of the Being who created the universe; and ask, Could he be so inconsistant with his own character, as to leave man without a law or rule to regulate his conduct, after placing him here, where, according to the formation of his nature he must in a short period sink into the dust? Is there nothing further; is there no existence beyond this vail of death which is so suddenly to be cast over all of us? If there is, why not that Being who had power to place us here, inform us something concerning hereafter? If we had power to place ourselves in this present existence, why not have power to know what shall follow when that dark vail is cast over our bodies? If in this life we receive our all; if when we crumble back to dust we are no more, from what source did we emanate, and what was the purpose in our existence? If this were all, we should be led to query, whether there was really any substance in existence: and we might with propriety say, "Let us eat and drink; for tomorrow we die!" If this were really so, then why this constant toiling, why this continual warfare, and why this unceasing trouble? But this is not the case, the voice of REASON, the language of INSPIRATION, and the Spirit of the living GOD, our Creator, teaches us, as we hold

the record of truth in our hands, that this is not the case; that this is not so; for, the heavens declare the glory of a GOD, and the firmament shows his handy work; and a moment's reflection, is sufficient to teach every man of common intellect, that all these are not the mere production of chance, nor could they be supported by any power less than by an Almighty hand: and he that can mark the power of Omnipotence inscribed upon the heavens, can also see His own hand-writing in the sacred volume; and he who reads it oftenest will like it best, and he who is acquainted with it, will know the hand wherever he can see it; and when once discovered, it will not only receive an acknowledgment, but an obedience to all its heavenly precepts. For a moment reflect, what could have been the purpose in our Father in giving to us a law? Was it that it might be obeyed, or disobeyed? And think further too, not only the propriety, but the importance of attending to his laws in every particular. If, then, there is an importance in this respect, is there not a responsibility of great weight resting upon those who are called to declare these truths to men? Could we, or were we capable of laying any thing before you as a just comparison, we would cheerfully do it; but in this our capacity fails, and we are inclined to think, that man is unable, without an assistance beyond what has been given to those before us, of expressing in words the greatness of this important office. We can only say, that if an anticipation of the joys of the celestial glory, as witnessed to the hearts of the humble is not sufficient, we will leave with yourselves the result of your own diligence; for God ere long, will call all his servants before him, and there from His own hand they will receive a just recompense and a righteous reward for all their labors.

1834-1835
Joseph Smith and / or Sidney Rigdon
Lectures on Faith
In Original Doctrine and Covenants

Lecture 1 (Excerpts)

13. As we receive by faith all temporal blessings, so we in like manner receive by faith all spiritual blessings. But faith is not only the principle of action, it is also the principle of power in all intelligent beings, whether in heaven or on earth. Thus says the author of the epistle to the Hebrews:

14. "Through faith we understand that the worlds were framed by the word of God, so that things which are seen were not made of things which do appear" (11:3).

15. By this we understand that the principle of power which existed in the bosom of God, by which he framed the worlds, was faith; and that it is by reason of this principle of power existing in the Deity that all created things exist; so that all things in heaven, on earth, or under the earth exist by reason of faith as it existed in him.

16. Had it not been for the principle of faith, the worlds would never have been framed, neither would man have been formed of the dust. It is the principle by which Jehovah works and through which he exercises power over all temporal as well as eternal things. Take this principle or attribute (for it is an attribute) from the Deity and he would cease to exist.

17. Who cannot see that if God framed the worlds by faith, it is by faith that he exercises power over them, and faith is the principle of power? And if it is the principle of power in the Deity, it must be so in man as well? This is the testimony of all the sacred writers and the lesson which they have been endeavoring to teach to man.

21. Also Joshua, in the sight of all Israel, bade the sun and moon to stand still, and it was done (Joshua 10:12-13).

22. We here understand that the sacred writers say that all these things were done by faith. It was by faith that the worlds were framed-God spake, chaos heard, and worlds came into order by reason of the faith there was in him. So with men also, they spake by faith in the name of God and the sun stood still, the moon obeyed, mountains removed, prisons fell, lions' mouths were closed, the human heart lost its enmity, fire its violence, armies their power, the sword its terror, and death its dominion; and all this by reason of the faith which was in them.

23. Had it not been for the faith which was in men, they might have spoken to the sun, the moon, the mountains, prisons, lions, the human heart, fire, armies, the sword, or to death in vain!

24. Faith, then, is the first great governing principle which has power, dominion, and authority over all things. By it they exist; by it they are upheld; by it they are changed; or by it they remain, agreeable to the will of God. Without it there is no power, and without power there could be no creation nor existence!

Lecture 2 (Excerpts)
2. We here observe that God is the only supreme governor and independent being in whom all fulness and perfection dwell. He is omnipotent, omnipresent, and omniscient, without beginning of days or end of life. In him every good gift and every good principle dwell, and he is the Father of lights. In him the principle of faith dwells independently, and he is the object in whom the faith of all other rational and accountable beings centers for life and salvation.

3. In order to present this part of the subject in a clear and conspicuous point of light, it is necessary to go back and show the evidences which mankind have had to believe in the existence of a God and also to show the foundation on which these evidences are and have been based since the creation.
Larry E. Dahl and Charles D. Tate, Jr., eds., The Lectures on Faith in Historical Perspective, p.39 - 40

4. We do not mean those evidences which are manifested by the works of creation which we daily behold with our natural eyes. We are sensible that, after a revelation of Jesus Christ, the works of creation clearly exhibit his eternal power and Godhead throughout their vast forms and varieties. "For the invisible things of him from the creation of the world are clearly seen, being understood by the things that are made, even his eternal power and Godhead" (Rom 1:20). But we do mean those evidences by which the first thoughts were suggested to the minds of men that there was a God who created all things.

12. From the foregoing we learn of man's situation at his first creation, the knowledge with which he was endowed, and the high and exalted station in which he was placed-lord, or governor, of all things on earth, and at the same time enjoying communion and intercourse with his Maker, without a veil to separate between. We shall next proceed to examine the account given of his fall and of his being driven out of the garden of Eden and from the presence of the Lord.

18. Two important items are shown from the former quotations: First, after man was created, he was not left without intelligence or understanding to wander in darkness and spend an existence in ignorance and doubt on the great and important point which effected his happiness as to the real fact by whom he was created, or unto whom he was amenable for his conduct. God conversed with him face to face: in his presence he was permitted to stand, and from his own mouth he was permitted to receive instruction. He heard his voice, walked before him, and gazed upon his glory, while intelligence burst upon his understanding and enabled him to give names to the vast assemblage of his Maker's works.

19. Secondly, we have seen that though man did transgress, his transgression did not deprive him of the previous knowledge with which he had been endowed relative to the existence and glory of his Creator; for no sooner did he hear his voice than he sought to hide himself from his presence.

30. The object of the foregoing quotation is to show to this class that the way by which mankind were first made acquainted with the existence of a God was by a manifestation of God to man. Also after man's transgression God continued to manifest himself to him and to his posterity. And notwithstanding they were separated from his immediate presence so that they could not see his face, they continued to hear his voice.

31. Adam, thus being made acquainted with God, communicated the knowledge which he had unto his posterity. And it was through this means that the thought was first suggested to their minds that there was a God, which laid the foundation for the exercise of their faith, through which they could obtain a knowledge of his character and also of his glory.

33. From this we can see that the whole human family in the early age of their existence and in all their different branches had this knowledge disseminated among them; so that the existence of God became an object of faith in the early age of the world. And the evidence which these men had of the existence of a God was the testimony of their fathers, in the first instance.

34. The reason we have been thus particular on this part of our subject is that this class may see by what means it was that God became an object of faith among men after the Fall, and also may see what it was that stirred up the faith of multitudes to feel after him, to search after a knowledge of his character, perfections, and attributes, until they became extensively acquainted with him. Not only were they to commune with him and behold his glory, but they were also to be partakers of his power and stand in his presence.

35. Let this class mark particularly that the testimony which these men had of the existence of a God was the testimony of man. For previous to the time that any of Adam's posterity had obtained a manifestation of God to themselves, Adam, their common father, had testified unto them of the existence of God and of his eternal power and Godhead.

54. We have now shown how it was by reason of the manifestation which God first made to our father Adam, when he stood in his presence and conversed with him face to face at the time of his creation, that the first thought ever existed in the mind of any individual that there was such a being as a God who had created and did uphold all things.

55. Let us here observe that after any members of the human family are made acquainted with the important fact that there is a God who has created and does uphold all things, the extent of their knowledge respecting his character and glory will depend upon their diligence and faithfulness in seeking after him, until, like Enoch, the brother of Jared, and Moses, they shall obtain faith in God and power with him to behold him face to face.

56. We have now clearly set forth how it is, and how it was, that God became an object of faith for rational beings, and also, upon what foundation the testimony was based which excited the inquiry and diligent search of the ancient Saints to seek after and obtain a knowledge of the glory of God. We have also seen that it was human testimony, and human testimony only, that excited this inquiry in their minds in the first instance. It was the credence they gave to the testimony of their fathers, it having aroused their minds to inquire after the knowledge of God. That inquiry frequently terminated, indeed always terminated when rightly pursued, in the most glorious discoveries and eternal certainty.

Lecture 7 (Excerpts)

5. It is only necessary for us to say that the whole visible creation as it now exists is the effect of faith. It was faith by which it was framed, and it is by the power of faith that it continues in its organized form and by which the planets move round their orbits and sparkle forth their glory. So, then, faith is truly the first principle in the science of theology, and, when understood, it leads the mind back to the beginning and carries it forward to the end, or, in other words, from eternity to eternity.

6. As faith, then, is the principle by which the heavenly hosts perform their works and by which they enjoy all their felicity, we might expect to find it set forth in a revelation from God as the principle upon which his creatures here below must act to obtain the felicities enjoyed by the Saints in the eternal world. And when God would undertake to raise up men for the enjoyment of himself, he would teach them the necessity of living by faith, and the impossibility of their enjoying the blessedness of eternity without it, seeing that all the blessings of eternity are the effects of faith.

1835
Henry Lord Brougham
Discourse of Natural Theology

This discourse is not a treatise of natural theology: it has not for its design an exposition of the doctrines whereof natural theology consists. But its object is, first, to explain the nature of the evidence upon which it rests, — to show that it is a science, the truths of which are discovered by induction, like the truths of natural and moral philosophy; that it is a branch of science partaking of the nature of each of those great divisions f human knowledge, and not merely closely allied to them both. Secondly, the object of the discourse is to explain the advantages attending this study. The work, therefore, is a logical one.

But let us examine further this matter. The position which we reach by a strict process of induction is common to natural philosophy and natural theology; namely, that a given organ performs a given function, or a given arrangement possesses a certain stability by its adaptation to mechanical laws. We have said that the process of reasoning is short and easy, by which we arrive at the doctrine more peculiar to natural theology; namely, that some power, acquainted with and acting upon the knowledge of those laws, fashioned the organ with the intention of having the function performed, or constructed the system so that it might endure. Is not this last process as much one of strict induction as the other? It is plainly only a generalization of many particular facts,—a reasoning from things known to things unknown; an inference of a new or unknown relation from other relations formerly observed and known. . . . When we see that a certain effect—namely, distinct vision — is performed by an achromatic instrument, the eye, why do we infer that some one must have made it? Because we nowhere and at no time have had any experience of any one thing fashioning itself, and indeed cannot form to ourselves any distinct idea of what such a process as self-creation means; and, further, because when we ourselves would produce a similar result, we have recourse to like means. Again, when we perceive the adaptation of natural objects and operations to a perceived end, and from thence infer design in the maker of these objects and superintender of these operations, why do we draw this conclusion? Because we know by experience, that, if we ourselves desired to accomplish a similar purpose, we should do so by the like adaptation. We know by experience that this is design in us, and that our proceedings are the result of such design. We know that if some of our works were seen by others, who neither were aware of our having made them, nor of the intention with which we made them, they would be right should they, from seeing and examining them, both infer that we had made them, and conjecture why we had made them.

The same reasoning, by the help of experience, from what we know to what we cannot know, is manifestly the foundation of the inference, that the members of the body were fashioned for certain uses by a maker acquainted with their operations, and willing that those uses should be served.

Of Scientific Arrangement, And The Methods Of Analysis And Synthesis

Having shown that Natural Theology is a branch of inductive science—partly physical, partly intellectual and moral—it is of comparatively little importance to inquire whether or not it can be kept apart from the other branches of those sciences. In one view of this question we may say, that there is no more ground for the separation than there would be for making a distinct science of all the propositions in Natural Philosophy which immediately relate to the human body—whereby we should have portions of dynamics, pneumatics, optics, chemistry, electricity, and all human anatomy and pathology as contradistinguished from comparative, reduced under one and the same head—a classification, indeed, resembling Lord Bacon's. But in another, and, as it seems, the more just view, there is a sufficient number of resemblances and differences, and the importance of the subject is sufficient, to justify the making a separate head of Natural Theology. The question is entirely one of convenience; nothing of essential moment turns upon the classification; and there is obviously an advantage in having the truths collected in one body, though they are culled from the various parts of Physical and Metaphysical science to which they naturally belong. All that is needful is, constantly to keep in mind the identity of the evidence on which these truths rest, with that which is the groundwork of those other parts of philosophy.

Although, however, convenience and the paramount importance of the subject seem to require such a separation, it is manifest that much of theology must still be found intermingled with physics and psychology, and there only; for the truths of Natural Theology being sufficiently demonstrated by a certain induction of facts—a certain number of experiments and observations —no further proof is required; and to assemble all the evidence, if it were possible, would be only encumbering the subject with superfluous proofs, while the collection would still remain incomplete, as every day is adding to the instances discovered of design appearing in the phenomena of the natural and moral world. It has been said, indeed, that a single well-established proof of design is enough, and that no additional strength is gained to the argument by multiplying the instances. We shall afterwards show with what limitations this proposition is to be received; but for our present purpose it is sufficient, that, at all events, a certain definite number of instances are of force enough to work out the demonstration; and yet in every branch of physics and psychology new instances are presented at each step we make. These instances are of great importance; they are to be carefully noted and treasured up; they form most valuable parts of those scientific inquiries, conveying, in its purest form and in its highest degree, the gratification of contemplating abstract truths, in which consists the whole of the pleasure derived from science, properly so called— that is, from science as such, and as independent of its application to uses or enjoyments of a corporeal kind.

An apprehension has frequently been entertained by learned and pious men—men of a truly philosophical spirit—lest the natural desire of tracing design in the works of nature should carry inquirers too far, and lead them to give scope to their imagination rather than contain their speculations within the bounds of strict reasoning. They have dreaded the introduction of what Lord Bacon calls a "phantastic philosophy," and have also felt alarm at the injuries which religion may receive from being exposed to ridicule, in the event of the speculations proving groundless upon a closer examination. But it does not appear reasonable that philosophers should be deterred by such considerations from anxiously investigating the subject of Final Causes, and giving it the place which belongs to it in all their inquiries; provided that they do not suffer fancy to intermix with and disturb their speculations. If they do, they commit the greatest error of which reasoners

can be guilty—an error against which it is the very object of inductive philosophy to guard; but it is no more an error in this, than in the other investigations of science. He who imagines design where there is none; he who either assumes facts in order to build upon them an inference favourable to Natural Religion, or from admitted facts draws such an inference fancifully, and not logically, comes within the description of a false philosopher: he prefers the hypothetical to the inductive method; he cannot say with his master, "hypotheses non fingo;"* he renounces the modern, and recurs to the exploded modes of philosophising. But he is not the more a false philosopher, and does not the more sin against the light of improved science, for committing the offence in the pursuit of theological truth. He would have been liable to the same charge if he had resorted to his fancy instead of observation and experiment while in search of any other scientific truth, or had hypothetically assumed a principle of classifying admitted phenomena, instead of rigorously deducing it from examining their circumstances of resemblance and of diversity.

That any serious discredit can be brought upon the science of Natural Theology itself, from the failures to which such hypothetical reasonings may lead, seems not very easy to conceive. Vain and superficial minds may take any subject for their ridicule, and may laugh at the mechanician and the chemist as well as the theologian, when they chance to go astray in their searches after truth. Yet no one ever thought of being discouraged from experimental inquiries, because even the strictest prosecution of the inductive method cannot always guard against error. It is of the essence of all investigations of merely contingent truth, that they are exposed to casualties which do not beset the paths of the geometrician and the analyst. A conclusion from one induction of facts may be well warranted until a larger induction obliges us to abandon it, and adopt another. Yet no one deems chemistry discredited because a body considered in one state of our knowledge to be a compound acid has since appeared rather to be a simple substance, bearing to the acids no resemblance in its composition; nor would the optical discoveries of Sir Isaac Newton be discredited, much less the science he cultivated be degraded, if the undulatory hypothesis should, on a fuller inquiry, become established by strict proof. Yet such errors, or rather such imperfect and partial views, were the result of a strict obedience to the inductive rules of philosophising. How much less ground for cavil against either those rules, or the sciences to which they are applicable, would be afforded by the observations of those who had mistaken their way through a neglect of inductive principle, and by following blindly false guides!

While then, on the one hand, we allow Natural Theology to form a distinct head or branch, the other sciences must of necessity continue to class its truths among their own; and thus every science may be stated to consist of three divisions—1. The truths which it teaches relative to the constitution and action of matter or of mind;—2. The truths which it teaches relative to theology; and 3. The application of both classes of truths to practical uses, physical or moral. Thus, the science of pneumatics teaches, under the first head, the doctrine of the pressure of the atmosphere, and its connexion with respiration, and with the suspension of weights by the formation of a vacuum. Under the second head, it shows the adaptation of the lungs of certain animals to breathe the air, and the feet of others to support their bodies, in consequence of both being framed in accordance with the former doctrine—that is, with the law of pressure—and thus demonstrates a wise and beneficent design. Under the third head, it teaches the construction of barometers, steam-engines, &c, while the contemplation of the Divine wisdom and goodness inculcates piety, patience, and hope.

But it may be said, that in this classification of the objects of science, we omit one ordinarily reckoned essential — the explanation of phenomena. The answer is, that such a classification is not strictly accurate, as no definite line can be drawn between the explanation of phenomena and the analytical process by which the truths themselves are established: in a word, between analysis and synthesis in the sciences of contingent truth. For the same phenomena which form the materials of the analytical investigation—the steps that lead us to the proposition or discovery— would, in a

reversed order, become the subjects of the synthetical operation; that is, the things to be explained by means of the proposition or discovery, if we had been led to it by another route, in other words, if we had reached it by means of other phenomena of the like kind, referrible to the same class, and falling within the same principle or rule. Thus the experiments upon the prismatic spectrum prove the sun's light to be composed of rays of different refrangibility. This being demonstrated, we may explain by means of it the phenomena which form the proofs of the first proposition of the " Optics," that lights which differ in colour differ in refrangibility—as that a parallelogram of two colours refracted through a prism has its sides no longer parallel; or, having shown the different refrangibility by the prismatic phenomena, we may explain why a lens has the focus of violet rays nearer than the focus of red, while this experiment is of itself one of the most cogent proofs of the different refrangibility. It is plain that, in these cases, the same phenomenon may be made indiscriminately the subject matter either of analysis or synthesis. So, one of the proofs given of latent heat is, that after you heat a bar of iron once or twice by hammering it, the power of being thus heated is exhausted, until by exposing it to the fire that power is restored. Yet, suppose we had proved the doctrine of the absorption of heat by other experiments—as by the effects on the thermometer of liquids of different temperatures mixed together—the phenomenon of the iron bar would be explicable by that doctrine thus learnt. Again, another proof of the same truth is the production of heat by the sudden condensation of gaseous fluids, and of cold by evaporation, the evolution of heat being inferred from the former, and its absorption from the latter operation. But if the experiments upon the mixture of fluids of different temperatures, and other facts, had sufficiently proved the disappearance of heat in its sensible form, and its being held in a state in which it did not affect the thermometer, we should by means of that doctrine have been able to account for the refrigerating effect of evaporation, and the heating power of condensation.

It cannot, then, be a real and an accurate distinction, or one founded on the nature of the thing, which depends on the accident of the one set of facts having been chosen for the instruments of the analytical, and the other set for the subjects of the synthetical operation, each set being alike applicable to either use. For, in order that the synthesis may be correct, nay, in order that it may be strict and not hypothetical, it is obviously necessary that the phenomena should be of such a description as might have made them subservient to the analysis. In truth, both the operations are essentially the same—the generalization of particulars—the arranging or classifying facts so as to obtain a more general or comprehensive fact; and the explanation of phenomena is just as much a process of generalization or classification as the investigation of the proposition itself, by means of which you are to give the explanation. We do not perform two operations, but one, in these investigations. We do not in reality first find by the prism that light is differently refrangible, and then explain the rainbow—or show by the air-pump that the atmosphere presses with the weight of so many pounds upon a square foot, and then explain the steam engine and the fly's foot—or prove, by burning the two weighed gases together and burning iron in one of them, that water is composed of them both, and that rust is the metal combined with one, and then explain why iron rusts in water. But we observe all these several facts, and find that they are related to each other, and resolvable into three classes—that the phenomena of the prism and of the shower are the same, the spectrum and the rainbow being varieties of the same fact, more general than either, and comprehending many others, all reducible within its compass— that the air-pump, the steam-engine, the fly's foot, are all the same fact, and come within a description still more general and compendious—that the rusting of iron, the burning of inflammable air, and the partial consumption of the blood in the lungs, are likewise the same fact in different shapes, and resolvable into a fact much more comprehensive.

If, then, the distinction of investigation and explanation, or the analytical and synthetical process, is to be retained, it can only be nominal; and it is productive of but little if any convenience. On the contrary, it is calculated to introduce inaccurate habits of philosophising, and holds out a

temptation to hypothetical reasoning. Having obtained a general law, or theory, we are prone to apply it where no induction shows that it is applicable; and perceiving that it would account for the observed phenomena, if certain things existed, we are apt to assume their existence, that we may apply our explanation. Thus we know that if the walrus's foot, or the fly's, make a vacuum, the pressure of the air will support the animal's weight, and hence we assume that the vacuum is made. Yet it is clear that we have no right whatever to do so; and that the strict rules of induction require us to prove the vacuum before we can arrange this fact in the same class with the other instances of atmospheric pressure. But when we have proved it by observation, it will be said we have gained nothing by our general doctrine. True; but all that the science entitles us to do is, not to draw facts we are half acquainted with under the arbitrary sway of our rule, but to examine each fact in all its parts, and bring it legitimately within the rule by means of its ascertained resemblances—that is, classify it with those others to which it bears the common relation. Induction gives us the right to expect that the same result will always happen from the same action operating in like circumstances; but it is of the essence of this inference that the similarity be first shown.

It may be worth while to illustrate this further, as it is an error very generally prevailing, and leads to an exceedingly careless kind of inquiry. The fundamental rule of inductive science is, that no hypothesis shall be admitted—that nothing shall be assumed merely because, if true, it would explain the facts. Thus the magnetic theory of Epinus is admitted by all to be admirably consistent with itself, and to explain all the phenomena—that is, to tally exactly with the facts observed. But there is no proof at all of the accumulation of electrical or magnetic fluid at the one pole, and other fundamental positions; on the contrary the facts are rather against them: therefore, the theory is purely gratuitous; and although it would be difficult to find any other, on any subject, more beautiful in itself, or more consistent with all the phenomena, it is universally rejected as a mere hypothesis, of no use or value in scientific research. The inductive method consists in only admitting those things which the facts prove to be true, and excludes the supposing things merely because they square with the facts. Whoever makes such suppositions upon observing a certain number of facts, and then varies those suppositions when new facts come to his knowledge, so as to make the theory tally with the observation—whoever thus goes on touching and retouching his theory each time a new fact is observed which does not fall within the original proposition, is a mere framer of hypotheses, not an inductive inquirer—a fancier, and not a philosopher.

Now, this being the undoubted rule, does not the course of those fall exactly within it, who, having upon a certain class of phenomena, built a conclusion legitimately and by strict induction, employ that conclusion to explain other phenomena, which they have not previously shown to fall within the same description 1 Take the example of the Torricellian vacuum. Having by that experiment proved the weight of the atmosphere, we have a right to conclude that a tube filled with water forty feet high would have a vacuum in the uppermost seven feet — because we know the relative specific gravities of water and mercury, and might predict from thence that the lighter fluid would stand at the height of thirty-three feet; and this conclusion we have a right to draw, without any experiments to ascertain the existence of a vacuum in the upper part of the tube. But we should have no right whatever to draw this conclusion, without ascertaining the specific gravities of the two fluids: for if we did, it would be assuming that the two facts belonged to the same class. So respecting the power of the walrus or the fly to walk up a vertical plane. We know the effects of exhausting the air between any two bodies, and leaving the external atmosphere to press against them: they will cohere. But if from thence we explain the support given to the walrus or the fly without examining their feet, and ascertaining that they do exhaust or press out the air—if, in short, we assume the existence of a vacuum under their feet, merely because were there a vacuum the pressure of the air would produce the cohesion, and thus account for the phenomena—we really only propound a hypothesis. We suppose certain circumstances to exist, in order to classify the fact with other facts actually observed, and the existence of which circumstances is necessary, in order that the phenomena may be reducible under the same head.

There is no reason whatever for asserting that this view of the subject restricts the use of induction by requiring too close and constant a reference to actual observation. The inductive principle is this—that from observing a number of particular facts, we reason to others of the same kind—that from observing a certain thing to happen in certain circumstances, we expect the same thing to happen in the like circumstances. This is to generalize; but then this assumes that we first show the identity of the facts, by proving the similarity of the circumstances. If not, we suppose or fancy, and do not reason or generalize. The tendency of the doctrine that a proposition being demonstrated by one set of facts, may be used to explain another set, has the effect of making us suppose or assume the identity or resemblance which ought to be proved. The true principle is, that induction is the generalizing or classifying of facts by observed resemblances and diversities.

Nothing here stated has any tendency to shackle our experimental inquiries by too rigidly narrowing the proof. Thus, although we are not allowed to suppose any thing merely because, if it existed, other things would be explained; yet, when no other supposition will account for the appearances, the hypothesis is no longer gratuitous; and it constantly happens, that an inference drawn from an imperfect induction, and which would be, on that state of the facts, unauthorized because equivocal and not the only supposition on which the facts could be explained, becomes legitimate on a further induction, whereby we show that, though the facts first observed might be explained by some other supposition, yet those facts newly observed could to no other supposition be reconciled. Thus, the analytical experiment on the constitution of water, by passing steam over red hot iron, is not conclusive, because, although it tallies well with the position that water consists of oxygen and hydrogen, yet it would also tally with another supposition, that those gases were produced in the process and not merely separated from each other; so that neither oxygen nor hydrogen existed in the water any more than acid and water exist in coal and wood, but only their elements, and that, like the acid and water, the products of the destructive distillation of those vegetable substances, the oxygen and hydrogen, were compounded, and in fact produced by the process. But when, besides the analytical, we have the synthetical experiments of Mr. Cavendish and Dr. Priestley

Dr. Priestley drew no conclusion of the least value from his experiments. But Mr. Watt, after thoroughly weighing them, by careful comparison with other facts, arrived at the opinion that they proved the composition of water. This may justly be said to have been the discovery of that great truth in chemical science. I have examined the evidence, and am convinced that he was the first discoverer, in point of time, although it is very possible that when we find that by burning the two gases in a close vessel, they disappear, and leave a weight of water equal to their united weights—we have a fact not reconcilable to any other supposition, except that of the composition of this fluid. It is as when, in solving a problem, we fix upon a point in one line, curved or straight, because it answers one of the conditions—it may be the right point, or it may not, for all the other points of the line equally answer that condition; but when we also show that the remaining conditions require the point to be in another line, and that this other intersects the former in the very point we had assumed, then no doubt can exist, and the point is evidently the one required, none other fulfilling all the conditions.

We have used the words analytical and synthetical as applicable to the experiments of resolution and composition; and in this sense these terms are strictly correct in reference to inductive operations. But the use of the terms analysis and synthesis as applicable to the processes of.

Mr. Cavendish may have arrived at the same truth from his own experiments, without any knowledge of Mr. Watt's earlier process of reasoning.

induction—the former being the investigation of truths by experiment or observation, and the latter the explaining other facts by means of the truths so ascertained—is by no means so correct, and rests upon an extremely fallacious analogy, if there be indeed any analogy, for identity, or even resemblance, there is none. The terms are borrowed from mathematical science, where they denote the two kinds of investigation employed in solving problems and investigating theorems. When, in order to solve a problem, we suppose a thing done which we know not how to do, we reason upon the assumption that the prescribed conditions have been complied with, and proceed till we find something which Ave already possess the means of doing. This gives us the construction; and the synthetical demonstration consists in merely retracing the steps of the analysis. And so of a theorem: we assume it to be true, and reasoning on that assumption, we are led to something which we know from other sources to be true, the synthesis being the same operation reversed. The two operations consist here, of manifest necessity, of the very same steps—the one being the steps of the other taken in the reverse order. In Physics, to make the operations similar to these, the same facts should be the ground or component parts of both. In analysis, we should ascend not only from particulars to generals, but from the same particulars, and then the synthesis would be a descent through the same steps to the particular phenomena from the general fact. But it is a spurious synthesis, unlike the mathematical, and not warranted by induction, to prove the proposition by one set of facts, and by that proposition to explain—that is, classify—another set, without examining it by itself. If we do examine it by itself, and find that it is such as the proposition applies to, then also is it such as might prove the proposition; and the synthesis is here, as in the case of the mathematical investigation, the analysis reversed. As far as any resemblance or analogy goes, there is even a greater affinity between the inductive analysis and the geometrical synthesis, than between those operations which go by the same name; and I hardly know anything in experimental investigation resembling the mathematical analysis, unless it be when, from observing certain facts, we assume a position, and then infer, that if this be true, some other facts

must also exist, which we find (from other proofs) really do exist. This bears a resemblance rather to the analytical investigation than to the composition or synthetical demonstration of theorems in the ancient geometry. It is not the course of reasoning frequently pursued in experimental sciences; but a most beautiful example of it occurs in the Second Part of Dr. Black's experiments on Magnesia Alba and Quick Lime, the foundation of the modern gaseous chemistry.

Upon the whole, the use of these terms is apt to mislead; and, for the reasons which have been assigned, there seems no solidity in the division of inductive inquiry into the two classes.

When this section was written, I had not seen Mr. Stewart's learned remarks upon analysis and synthesis in the second volume of his Elements, nor was aware of the observations of Dr. Hook, quoted by him, and which show a remarkable coincidence with one of the observations in the text. Mr. Stewart's speculations do nut come upon the same ground with mine; but Dr. Hook having reversed the use of the terms analysis and synthesis in experimental science, affords a strong confirmation of the remark which I have ventured to make upon the inaccuracy of this application of mathematical language.—(See Elem. of Phil, of Human Mind, vol. ii. p. 354, 4to.)

Part The Second - Of The Advantages Of The Study Of Natural Theology

The uses of studying the science to which our inquiries have been directed now demand some consideration. These consist of > the pleasures which attend all scientific pursuits, the pleasures and the improvement peculiar to the study of Natural Theology, and the service rendered by this study to the doctrines of Revelation.

Section I - Of The Pleasures Of Science

As we have established the position that Natural Theology is a branch of Inductive Science, it follows that its truths are calculated to bestow the same kind of gratification which the investigation and the contemplation of scientific truth generally is fitted to give.

That there is a positive pleasure in such researches and such views, wholly independent of any regard to the advantages derived from their application to the aid of man in his physical necessities, is quite undeniable. The ascertaining by demonstration any of the great truths in the mathematics, or proving by experiment any of the important properties of matter, would give a real and solid pleasure, even were it certain that no practical use could be made of either the one or the other. To know that the square of the hypothenuse is always exactly equal to the sum of the squares of the sides of a right-angled triangle, whatever be its size, and whatever the magnitude of the acute angles, is pleasing; and to be able to trace the steps by which the absolute certainty of this proposition is established is gratifying, even if we were wholly ignorant that the art of guiding a ship through the pathless ocean mainly depends upon it. Accordingly we derive pleasure from rising to the contemplation of the much more general truth, of which the discovery of Pythagoras (the 47th proposition of the First Book of Euclid) is but a particular case, and which is also applicable to all similar triangles, and indeed to circles and ellipses also, described on the right-angled triangle's sides; and yet that general proposition is of no use in navigation, nor indeed in any other practical art. In like manner, the pleasure derived from ascertaining that the pressure of the air and the creation of a vacuum alike cause the rise of the mercury in the barometer, and give the power to flies of walking on the ceiling of a room, is wholly independent of any practical use obtained from the discovery, inasmuch as it is a pleasure superadded to that of contemplating the doctrine proved by the Torricellian experiment, which had conferred all its practical benefits long before the cause of the fly's power was found out. Thus again it is one of the most sublime truths in science, and the contemplation of which, as mere contemplation, affords the greatest pleasure, that the same power which makes a stone fall to the ground keeps the planets in their course, moulds the huge masses of those heavenly bodies into their appointed forms, and reduces to perfect order all the apparent irregularities of the system: so that the handful of sand which for an instant ruffles the surface of the lake, acts by the same law which governs, through myriads of ages, the mighty system composed of myriads of worlds. There is a positive pleasure in generalizing facts and arguments—in perceiving the wonderful production of most unlike results from a few very simple principles—in finding the same powers or agents re-appearing in different situations, and producing the most diverse and unexpected effects —in tracing unexpected resemblances and differences—in ascertaining that truths or facts apparently unlike are of the same nature, and observing wherein those apparently similar are various: and this pleasure is quite independent of all considerations relating to practical application; nay, the additional knowledge that those truths are susceptible of a beneficial application gives a further gratification of the like kind to those who are certain never to have the opportunity of sharing the benefits obtained, and who indeed may earnestly desire never to be in the condition of being able to share them. Thus, in addition to the pleasure received from contemplating a truth in animal physiology, we have another gratification from finding that one of its corollaries is the construction of an instrument useful in some painful surgical operation. Yet, assuredly, we have no desire ever to receive advantage from this corollary; and our scientific gratification was wholly without regard to any such view. In truth, generalizing—the discovery of remote analogies—of resemblances among unlike objects—forms one of the most pleasing employments of our faculties in every department of mental exertion, from the most severe investigation of the mathematician to the lightest efforts of the wit. To trace the same equality, or other relation between figures apparently unlike, is the chief glory of the geometrician; to bring together ideas of the most opposite description, and show them in unexpected, yet when suddenly pointed out, undeniable connexion, is the very definition of wit. Nay, the proposition which we have just enunciated is a striking instance of the same general truth; for we have been surveying the resemblance, or rather the identity, in one important particular of two pursuits, in all other, respects the most widely remote from each other —mathematics and wit.

If the mere contemplation of scientific truth is the source of real gratification, there is another pleasure, alike remote from all reference to practical use or benefit, and which is obtained by tracing the investigations and demonstration—the steps that lead analytically to the discovery, and synthetically to the proof of those truths. This is a source of pleasure, both by giving us the assurance that the propositions of generalization —the statements of resemblance and diversity—are true in themselves, and also by the consciousness of power which it imparts, and the feeling of difficulty overcome which it involves. We feel gratified when we have closely followed the brilliant induction which led Newton to the discovery that white is the union of all colours; and when we have accompanied him in the series of profound researches, from the invention of a new calculus or instrument of investigation, through innumerable original geometrical lemmas, to the final demonstration that the force of gravitation deflects the comet from the tangent of its elliptical orbit; and we feel the gratification because the pursuit of these investigations assures us that the marvellous propositions are indeed true—

because there is a consciousness of man's power in being able to penetrate so far into the secrets of nature, and search so far into the structure of the universe—and because there is a pleasure, which we enjoy individually, in having accomplished a task of considerable difficulty. In these gratifications, derived from the contemplation and the investigation of general laws, consists the Pleasure of Science properly so called, and apart from all views of deriving particular advantages from its application to man's use.

This pleasure is increased as often as we find that any scientific discovery is susceptible of practical applications. The contemplation of this adaptation is pleasing, independent of any regard to our own individual advantage, and even though we may desire never to be in a condition to reap benefit from it. We sympathize, perhaps, with those who may be so unfortunate as to require the aid afforded by such applications to relieve and assuage pain; but the mere knowledge that such a corollary follows from the discovery of the scientific truth is pleasing. Of course the gratification is increased, if we know that individually we shall profit by it, and we may perhaps always more or less contemplate this possibility; but this is a pleasure, properly speaking, of a different kind from that which science, as such, bestows.

The branch of science which we are here particularly considering differs in no respect from the other departments of philosophy in the kind of gratification which it affords to those who cultivate it. Natural Theology, like the other sciences, whether physical or mental, bestows upon the student the pleasures of contemplation — of generalization; and it bestows this pleasure in an eminent degree. To trace design in the productions and in the operations of nature, or in those of the human understanding, is, in the strictest sense of the word, generalization, and consequently produces the same pleasure with the generalizations of physical and of psychological science. Every part of the foregoing reasoning, therefore, applies closely and rigorously to the study of Natural Theology. Thus, if it is pleasing to find that the properties of two curves so exceedingly unlike as the ellipse and the hyperbola closely resemble each other, or that appearances so dissimilar as the motion of the moon and the fall of an apple from the tree are different forms of the same fact, it affords a pleasure of the same kind to discover that the light of the glow-worm and the song of the nightingale are both provisions of nature for the same end of attracting the animal's mate, and continuing its kind—that the peculiar law of attraction pervading all matter, the magnitude of the heavenly bodies, the planes they move in, and the directions of their courses, are all so contrived as to make their mutual actions, and the countless disturbances thence arising all secure a perpetual stability to the system which no other arrangement could attain. It is a highly pleasing contemplation of the self-same kind with those of the other sciences to perceive every where design and adaptation—to discover uses even in things apparently the most accidental—to trace this so constantly, that where peradventure we cannot find the purpose of nature, we never for a

moment suppose there was none, but only that we have hitherto failed in finding it out—and to arrive at the intimate persuasion that all seeming disorder is harmony—all chance, design—and that nothing is made in vain; nay, things which in our ignorance we had overlooked as unimportant, or even complained of as evils, fill us afterwards with contentment and delight, when we find that they are subservient to the most important and beneficial uses. Thus inflammation and the generation of matter in a wound we find to be the effort which Nature makes to produce new flesh, and effect the cure; the opposite hinges of the valves in the veins and arteries are the means of enabling the blood to circulate; and so of innumerable other arrangements of the animal economy. So, too, there is the highest gratification derived from observing that there is a perfect unity, or, as it has been called, a personality, in the kind of the contrivances in which the universe abounds; and truly this peculiarity of character, or of manner, as other writers have termed it, affords the same species of pleasure which we derive from contemplating general resemblances in the other sciences. We may close this branch of the subject with the observation that those other sciences have often in their turn derived aid from Natural Theology, at least from the speculation of Final Causes, for which they, generally speaking, lay the foundation. Many discoveries in the physiology both of animals and plants owe their origin

to some arrangement or structure being remarked, the peculiar object of which was not known, and the ascertaining of which led to the knowledge of an important truth. The well-known anecdote of Harvey related by Mr. Boyle, is the best example of this which can be given. In his tract on Final Causes he thus writes:—" I remember that when I asked our famous Harvey, in the only discourse I had with him, (which was but a while before he died,) what were the things that induced him to think of a circulation of the blood, he answered me, that when he took notice that the valves in the veins of so many parts of the body were so placed that they gave free passage to the blood towards the heart, but opposed the passage of the veinal blood the contrary way, he was incited to imagine that so provident a cause as Nature had not so placed so many valves without design, and no design seemed more probable than that since the blood could not well, because of the interposing valves, be sent by the veins to the limbs, it should be sent through the arteries, and return through the veins whose valves did not oppose its course that way."* Even the arts have borrowed from the observation of the animal economy. Those valves—the hollow bones of birds—the sockets of the joints—have all furnished suggestions upon which some of our most useful machinery is constructed. Nor can any abuse arise from this employment of the argument, so long as we take care only to let it occupy the subordinate place of a suggestor— an originator of inquiry—and never suffer it to usurp the station of a sole guide, or a substitute for that induction which alone can be relied on in forming our conclusions. The ancients were ignorant of this caution, and would probably have rested satisfied with the consideration which only set Harvey upon making experiments, instead of proving in this way what the argument from Final Causes only rendered probable. Hence much of what, as we have already explained, Lord Bacon has said upon the subject of this speculation, abused as it certainly has been in all ages, but especially in ancient times.

Section Ii - Of The Pleasure And Improvement Peculiar To Natural Theology

Hitherto we have only shown that the gratification which the contemplation of scientific truth is calculated to bestow belongs to Natural Theology, in common with the other branches of Philosophy. But there are several considerations which make it plain that the pleasure must be greater which flows from the speculations of this than any which the other sciences confer.

In the first place, the nature of the truths with which Natural Theology is conversant is to be considered. They relate to the evidences of design, of contrivance, of power, of wisdom, of goodness—but let us only say, of design or contrivance. Nothing can be more gratifying to the mind than such contemplations: they afford great scope to the reasoning powers; they exercise the resources of our ingenuity; they give a new aspect to the most ordinary appearances; they impart

life as it were to dead matter; they are continually surprising us with novel and unexpected proofs of intentions plainly directed to a manifest object. If some scoffers and superficial persons despise the enthusiasm with which these investigations have at times been pursued, and hold the exercise given by them to the ingenuity of inquirers to be rather a play of imagination than of reasoning, it is equally undeniable that in some of the most important and most practically useful of the sciences, design, so far from being a matter of fanciful conjecture, is always assumed as incontestable, and the inquiry, often with a merely practical view, is confined to discovering what the object of the design is. Thus, when the physiologist has discovered some part of the animal body before unknown, or observed some new operation of the known organs, he never doubts that design exists, and that some end is to be answered. This he takes for granted without any reasoning; and he only endeavours to find out what the purpose is—what use the part can have—what end the operation is intended to accomplish; never supposing it possible that either the part could be created, or the function appointed, without an object. The investigation conducted upon the assumption of this postulate has frequently led to the most brilliant discoveries—among others, as we have just seen, to by far the most important ever made in physiological science. For the mere exercise of the intellectual faculties, or gratification of scientific curiosity, we may refer to almost all the singular phenomena which form the bases of the reasonings as to design—the structure of the ear, and still more of the eye—the circulation of the blood— the physiology of the foetus in the uterus, as contrasted with the economy of the born animal, and the prospective contrivances of a system which until the birth is to be wholly useless— the structure of the eye and the nictitating membrane in different birds, and the haw in certain quadrupeds—the powers of the eye in birds of prey—perhaps more than any thing else, the construction of their cells by bees, according to the most certain principles discovered by men only with the help of the most refined analytical calculus. The atheist can only deny the wonderful nature of such operations of instinct by the violent assumption that the bee works as the heavenly bodies roll, and that its mathematically correct operations are no more to be wondered at than the equally mathematically adjusted movements of the planets—a truly violent assumption, and especially of those who angrily deny that men have a soul differing in kind from the sentient principle in the lower animals.

Secondly. The universal recurrence of the facts on which Natural Theology rests deserves to be regarded as increasing the interest of this science. The other sciences, those of Physics at least, are studied only when we withdraw from all ordinary pursuits, and give up our meditations to them. Those which can only be prosecuted by means of experiment can never be studied at all without some act of our own to alter the existing state of things, and place nature in circumstances which force her, by a kind of question, as Lord Bacon phrases it, to reveal her secrets. Even the sciences which depend on observation have their fields spread only here and there, hardly ever lying in our way, and not always accessible' when we would go out of our way to walk in them. But there is no place where the evidences of Natural Religion are not distributed in ample measure. It is equally true that those evidences continually meet us in all the other branches of science. A discovery made in these almost certainly involves some new proofs of design in the formation and government of the universe.

Thirdly and chiefly. Natural Theology stands far above all other sciences from the sublime and elevating nature of its objects. It tells of the creation of all things—of the mighty power that fashioned and that sustains the universe—of the exquisite skill that contrived the wings, and beak, and feet of insects invisible to the naked eye-— and that lighted the lamp of day, and launched into space comets a thousand times larger than the earth, whirling a million of times swifter than a cannon ball, and burning with a heat which a thousand centuries could not quench. It exceeds the bounds of material existence, and raises us from the creation to the Author of Nature. Its office is, not only to mark what things are, but for what purpose they were made by the infinite wisdom of an all-powerful being, with whose existence and attributes its high prerogative is to bring us acquainted. If we prize, and justly, the delightful contemplations of the other sciences; if we hold

it a marvellous gratification to have ascertained exactly the swiftness of the remotest planets—the number of grains that a piece of lead would weigh at their surfaces—and the degree in which each has become flattened in shape by revolving on its axis; it is surely a yet more noble employment of our faculties, and a still higher privilege of our nature, humbly, but confidently, to ascend from the universe to its Great First Cause, and investigate the unity, the personality, the intentions, as well as the matchless skill and mighty power of him who made and sustains and moves those prodigious bodies, and all that inhabit them.

Now, all the gratification of which we have been treating is purely scientific, and wholly independent of any views of practical benefit resulting from the science of Natural Theology. The pleasure in question is merely that double gratification which every science bestows—namely, the contemplation of truth, in tracing resemblances and differences, and the perception of the evidence by which that truth is established. Natural Theology gives this double pleasure, like all other branches of science—like the mathematics— like physics—and would give it if we were beings of an order different from man, and whose destinies never could be affected by the truth or the falsehood of the doctrines in question. Nay, we may put a still stronger case, one analogous to the instance given above of the pleasure derived from contemplating some fine invention of a surgical instrument. Persons of such lives as should make it extremely desirable to them that there was no God, and no Future State, might very well, as philosophers, derive gratification from contemplating the truths of Natural Theology, and from following the chain of evidence by which these are established, and might, in such sublime meditation, find some solace to the pain which reflection upon the past, and fears of the future are calculated to inflict upon them.

But it is equally certain that the science derives an interest incomparably greater from the consideration that we ourselves, who cultivate it, are most of all concerned in its truth—that our own highest destinies are involved in the results of the investigation. This, indeed, makes it, beyond all doubt, the most interesting of the sciences, and sheds on the other branches of philosophy an interest beyond that which otherwise belongs to them, rendering them more attractive in proportion as they connect themselves with this grand branch of human knowledge, and are capable of being made subservient to its uses. See only in what contemplations the wisest of men end their most sublime inquiries! Mark where it is that a Newton finally reposes after piercing the thickest veil that envelopes nature—grasping and arresting in their course the most subtle of her elements and the swiftest— traversing the regions of boundless space—exploring worlds beyond the solar way—giving out the law which binds the universe in eternal order! He rests, as by an inevitable necessity, upon the contemplation of the great First Cause, and holds it his highest glory to have made the evidence of his existence, and the dispensations of his power and of his wisdom, better understood by men.

If such are the peculiar pleasures which appertain to this science, it seems to follow that those philosophers are mistaken who would restrict us to a very few demonstrations, to one or two instances of design, as sufficient proofs of the Deity's power and skill in the creation of the world. That one sufficient proof of this kind is in a certain sense enough cannot be denied: a single such proof overthrows the dogmas of the atheist, and dispels the doubts of the sceptic; but is it enough to the gratification of the contemplative mind? The great multiplication of proofs undeniably strengthens our positions; nor can we ever affirm respecting the theorems in a science, not of necessary but of contingent truth, that the evidence is sufficiently cogent without variety and repetition. But, independently altogether of this consideration, the gratification is renewed by each instance of design which we are led to contemplate. Each is different from the other. Each step renews our delight. The finding that at every step we make in one science, and with one object in view, a new proof is added to those before possessed by another science, affords a perpetual source of new interest and fresh enjoyment. This would be true if the science in question were one of an ordinary description. But when we consider what its nature is—how intimately connected with

our highest concerns—how immediately and necessarily leading to the religious adoration of the Supreme Being—can we doubt that the perpetually renewed proofs of his power, wisdom, and goodness tend to fix and to transport the mind, by the constant nourishment thus afforded to feelings of pure and rational devotion? It is, in truth, an exercise at once intellectual and moral, in which the highest faculties of the understanding and the warmest feelings of the heart alike partake, and in which not only without ceasing to be a philosopher the student feels as a man, but in which the more warmly his human feelings are excited, the more philosophically he handles the subject. What delight can be more elevating, more truly worthy of a rational creature's enjoyment, than to feel, wherever we tread the paths ' of scientific inquiry, new evidence springing up around our footsteps—new traces of divine intelligence and power meeting our eye! We are never alone; at least, like the old Roman, we are never less alone than in our solitude. We walk with the Deity; we commune with the great First Cause, who sustains at every instant what the word of his power made. The delight is renewed at each step of our progress, though as

far as evidence is concerned we have long ago had proof enough. But that is no more a reason for ceasing to contemplate the subject in its perpetually renovated and varied forms, than it would be a reason for resting satisfied with once seeing a long lost friend, that his existence had been sufficiently proved by one interview. Thus, instead of restricting ourselves to the proofs alone required to refute atheism or remove scepticism, we should covet the indefinite multiplication of evidences of design and skill in the universe, as subservient in a threefold way to purposes of use and of gratification: first, as strengthening the foundation whereupon the system reposes; secondly, as conducive to the ordinary purposes of scientific gratification, each instance being a fresh renewal of that kind of enjoyment; and thirdly, as giving additional ground for devout, pleasing, and wholesome adoration of the Great First Cause, who made and who sustains all nature.

It is, therefore, manifest that instead of resting satisfied with details and reasons barely sufficient to prove the existence of design in the universe, the gratification of a laudable scientific curiosity, and the proper indulgence of rational devotion, require that every occasion should be taken of exhibiting those evidences upon which the system of Natural Theology rests. The professed treatises upon that science do not suffice for this purpose, although they ought unquestionably to enter largely, and with very great variety of illustration, into the proofs; but each several branch of science, natural and moral, should have a constant reference to this, and should never fail to apply its peculiar doctrines towards the proof and the illustration of the doctrines of Natural Theology.

Section III - Of The Connexion Between Natural And Revealed Religion

The ordinary arguments against Natural Theology with which we have to contend are those of atheists and sceptics; of persons who deny the existence of a First Cause, or who involve the whole question in doubt; of persons who think they see a balance of reason for denying the existence of a Deity, or who consider the reasons on both sides as so equally poised that they cannot decide either way. An objection of a very different nature has sometimes proceeded, unexpectedly, from a very different quarter—the friends of Revelation — who have been known, without due reflection, to contend that by the light of unassisted reason we can know absolutely nothing of God and a Future State. They appear to be alarmed lest the progress of Natural Religion should prove dangerous to the acceptance of Revealed; lest the former should, as it were, be taken as a substitute for the latter. They argue as if the two systems were rivals, and whatever credit the one gained, were so much lost to the other. They seem to think that if any discovery of a First Cause and another world were made by natural reason, it would no longer be true that " life and immortality were brought to light by the gospel." Although these reasoners are neither the most famous advocates of revelation, nor the most enlightened, we yet may do well to show the groundlessness of the alarms which they would excite.

1. In the first place, it is worthy of our consideration that the greatest advocates of Natural Theology have always been sincere and even zealous Christians. The names of Ray, Clarke, Derham, Keill, Paley, attest the truth of this assertion. None of these was likely to lend his support to any system the evidence of which put the outworks of Christianity in jeopardy. Some of them, as Clarke and Paley, have signalized themselves as strenuous and able defenders of the truth of Revelation. Derham actually delivered his celebrated work on the great truths of Natural Theology as a series of sermons preached in Bow Church, at a Lecture for the promotion of the Christian religion, founded by Mr. Boyle. At the same Lecture, in St. Paul's, was delivered Dr. Clarke's argument a priori, and indeed his whole "Evidence of Natural and Revealed Religion," as well as his " Demonstration of the Being and Attributes of God;" and Dr. Bentley, the first preacher upon that foundation, delivered in like manner as sermons his argument in favour of Natural Religion from the structure of the human mind, the animal body, and the universe at large.

This Lecture was expressly founded by Mr. Boyle in support of the Christian religion; and no reference to Natural Theology, apart from its uses in supporting Revelation, is to be found in the terms of the gift. The subject of the eight sermons is to be, in the words of the will, " The proof of the Christian religion against notorious infidels, viz. atheists, theists, Pagans, Jews, and Mahometans, not descending lower to any controversies that are among Christians themselves." Yet the great Christian divines whom we have named so construed these words as to include a proof of Natural Religion among the most essential arguments for Christianity; and almost as many of the sermons preached at the Boyle Lecture, during the first forty years after its foundation, relate to the doctrines of Natural Theology as to those of Revelation. So far were the divines of that day from holding the two subjects as hostile to each other.*

2. But, secondly, Natural Theology is most serviceable to the support of revelation. All the soundest arguments in behalf of the latter presuppose the former to be admitted. Witness the profound work of Butler, his " Analogy of Natural and Revealed Religion to the Order of Nature," the most argumentative and philosophical defence of Christianity ever submitted to the world. But Lardner and Paley, and all other writers on the same side, abound in references to Natural Theology, and in the course of their reasonings assume its truths as postulates.

We may suppose that those practised controversialists and zealous Christians did not make such assumptions gratuitously. We may safely give them credit for not resting their case upon more postulates than the exigency of the argument required. Such a course if unnecessary would have been most unskilful, and might have proved dangerous by opening the door to new attacks. But they are not peculiar in their view of the subject. Boyle and Newton were as sincerely attached to Christianity as any men in any age, and they are likewise the most zealous advocates of Natural Religion. Lord Bacon, though imbued perhaps with a certain degree of prejudice on this subject, but of a philosophical and not a polemical origin, distinctly places the truth of Natural Religion at the entrance of theological study, and regards the evidences of Revelation as founded upon the previous demonstration of Natural Theology. " The latter," he says, " is the key of the former, and opens our understanding to the genuine spirit of the scriptures, but also unlocks our belief, so that we may enter upon the serious contemplation of the divine Power, the characters of which are so deeply graven in the works of the creation.

If any one will read the vituperation rather than sermon against infidels with which Dr. Bentley commences his discourses upon Natural Religion, he will see no reason to doubt the zeal for Christianity of that most learned preacher. it down as clear that atheism is to be refuted not by miracles but by the contemplation of nature, and accurately takes the distinction between Revelation and Natural Religion; that the former declares the will of God as to the worship most acceptable, while the latter teaches his existence and powers, but is silent as to a ritual.*

3. Accordingly we proceed a step farther, and assert, thirdly, that it is a vain and ignorant thing to suppose that Natural Theology is not necessary to the support of Revelation. The latter may be untrue, though the former be admitted. It may be proved, or allowed, that there is a God, though it be denied that he sent any message to man, through men or other intermediate agents; as indeed the Epicureans believed in the existence of the gods, but held them to keep wholly aloof from human affairs, leaving the world, physical as well as moral, to itself, without the least interference in its concerns. But Revelation cannot be true if Natural Religion is false, and cannot be demonstrated strictly by any argument, or established by any evidence without proving or assuming the latter. A little attention to the subject will clearly prove this proposition.

Suppose it were shown by incontestable proofs that a messenger sent immediately from heaven had appeared on the earth; suppose, to make the case more strong against our argument, that this messenger arrived in our own days, nay appeared before our eyes, and shewed his divine title to have his message believed, by performing miracles in our presence. No one can by possibility imagine a stronger case; for it excludes all arguments upon the weight or the fallibility of testimony; it assumes all the ordinary difficulties in the way of Revelation to be got over. Now, even this strong evidence would not at all establish the truth of the doctrine promulgated by the messenger; for it would not show that the story he brought was worthy of belief in any one particular except his supernatural powers. These would be demonstrated by his working miracles. All the rest of his statement would rest on his assertion. But a being capable of working miracles might very well be capable of deceiving us. The possession of power does not of necessity exclude either fraud or malice. This messenger might come from an evil as well as from a good being; he might come from more beings than one; or he might come from one being of many existing in the universe. When Christianity was first promulgated, the miracles of Jesus were not denied by the ancients; but it was asserted that they came from evil beings, and that he was a magician. Such an explanation was consistent with the kind of belief to which the votaries of polytheism were accustomed. They were habitually credulous of miracles and of divine interpositions. But their argument was not at all unphilosophical. There is nothing whatever inconsistent in the power to work miracles being conferred upon a man or a minister by a supernatural being, who is either of limited power himself, or of great malignity, or who is one of many such beings. Yet it is certain that no means can be devised for attesting the supernatural agency of any one, except such a power of working miracles; therefore, it is plain that no sufficient evidence can ever be given by direct Revelation alone in favour of the great truths of religion. The messenger in question might have power to work miracles without end, and yet it would remain unproved, either that God was omnipotent, and one, and benevolent, or that he destined his creatures to a future state, or that he had made them such as they are in their present state. All this might be true, indeed; but its truth would rest only on the messenger's assertion, and upon whatever internal evidence the nature of his communication afforded; and it might be false, without the least derogation to the truth of the fact that he came from a superior being, and possessed the power of suspending the laws of nature. But the doctrines of the existence of a Deity and of his attributes, which Natural Religion teaches, preclude the possibility of such ambiguities and remove all those difficulties. We thus learn that the Creator of the world is one and the same; and we come to know his attributes, not merely of power, which alone the direct communication by miracles could convey, but of wisdom and goodness. Built upon this foundation, the message of Revelation becomes at once unimpeachable and invaluable. It converts every inference of reason into certainty, and, above all, it communicates the Divine Being's intentions respecting our own lot, with a degree of precision which the inferences of Natural Theology very imperfectly possess. This, in truth, is the chief superiority of Revelation, and this is the praise justly given to the Gospel in sacred writ—not that it teaches the being and attributes of God, but that it brings life and immortality to light.

It deserves, however, to be remarked, in perfect consistency with the argument which has here been maintained, that no mere revelation, no direct message, however avouched by miraculous

gifts, could prove the faithfulness of the promises held out by the messenger, excepting by the slight inference which the nature of the message might afford. The portion of his credentials which consisted of his miraculous powers could not prove it. For unless we had first ascertained . the unity and the benevolence of the being that sent him, as those miracles only prove power, he might be sent to deceive us; and thus the hopes held out by him might be delusions. The doctrines of Natural Religion here come to our aid, and secure our belief to the messenger of one Being, whose goodness they have taught us to trust.

4. In other respects, the services of Natural Religion are far from inconsiderable, as subsidiary to, and co-operative with, the great help of Revelation. Thus, were our whole knowledge of the Deity drawn from Revelation, its foundation must become weaker and weaker as the distance in point of time increases from the actual interposition. Tradition, or the evidence of testimony, must of necessity be its only proof: for perpetual miracles must be wrought to give us evidence by our own senses. Now, a perpetual miracle is a contradiction in terms; for the exception to, or suspension of, the laws of nature so often repeated would destroy the laws themselves, and with the laws the force of the exception or suspension. Upon testimony, then, all Revelation must rest. Every age but the one in which the miracles were wrought, and every country but the one that witnessed them—indeed, all the people of that country itself save those actually present—must receive the proofs which they afford of Divine interposition upon the testimony of eye-witnesses, and of those to whom eye-witnesses told it. Even if the miracles were exhibited before all the nations of one age, the next must believe upon the authority of tradition; and if we suppose the interposition to be repeated from time to time, each repetition would incalculably weaken its force, because the laws of nature, though not wholly destroyed, as they must be by a constant violation, would yet lose their prevailing force, and each exception would become a slighter proof of supernatural agency. It is far otherwise with the proofs of Natural Religion; repetition only strengthens and extends them. We are by no means affirming that Revelation would lose its sanction by lapse of time, as long as it had the perpetually new and living evidence of Natural Religion to support it. We are only shewing the use of that evidence to Revelation, by examining the inevitable consequences of its entire removal, and seeing how ill supported the truths of Revelation would be, if the prop were withdrawn which they borrow from Natural Theology; for then they would rest upon tradition alone.*

In truth, it is with Natural Religion as with many of the greatest blessings of our sublunary lot: they are so common, so habitually present to and enjoyed by us, that we become insensible of their value, and only estimate them aright when we lose them, or fancy them lost. Accustomed to handle the truths of Revelation in connexion with, and in addition to, those of Natural Theology, and never having experienced any state of mind in which we were without the latter, we forget how essential they are to the former. As we are wont to forget the existence of the air we constantly breathe until put in mind of it by some violent change threatening suffocation, so it requires a violent fit of abstraction to figure to ourselves the state of our belief in Revelation were the lights of natural religion withdrawn. The existence and attributes of a God are so familiarly proved by every thing around us, that we can hardly picture to ourselves the state of our belief in this great truth, if we only knew it by the testimony borne to miracles, which, however authentic, were yet wrought in a remote age and distant region.*

5. The use of Natural Theology to the believer in Revelation is equally remarkable in keeping alive the feelings of piety and devotion. As this topic has occurred under a former head, it is only to be presented here in close connexion with Revealed Religion. It may be observed, then, that even the inspired penmen have constant recourse to the views which are derived from the contemplation of nature when they would exalt the Deity by a description of his attributes, or indicate sentiments of devotion towards him. " How excellent," says the Psalmist, " is thy name in all the earth; thou hast set thy glory above the heavens. I will consider the heavens, even the work of thy fingers; the moon

and the stars which thou hast ordained." See also that singularly beautiful poem the 139th Psalm; and the Book of Job, from the 38th to the 41st chapter. *

It is remarkable how little is to be found of particularity and precision in any thing that has been revealed to us respecting the nature of the Godhead. For the wisest purposes it has pleased Providence to veil in awful mystery almost all the attributes of the Ancient of Days beyond what natural reason teaches. By direct interposition, through miraculous agency, we become acquainted with his will, and are made more certain of his existence; but his peculiar attributes are nearly the same in the volume of nature and in that of his revealed word.

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Treatise 1 - On The Adaptation Of External Nature To The Moral And Intellectual Constitution Of Man - By The Rev. T. Chalmers, D.D.

Chapter IV - On the Defects and the Uses of Natural Theology

1. We behold in the influence which the will has over the intellectual states, the same adaptations which we did in the influence of the will over the emotions. In the first place, it is well that the will should have a certain overruling power over the conclusions of the understanding, seeing that, if emotions supply the great impellent forces, doctrines, or the truths which are believed, supply the great principles of action. And secondly, there is a striking adaptation, in this part of our constitution, to the things and the objects which be around us. For, although there be much of truth, having that sort of immediate and resistless evidence which forces itself upon our convictions whether we will or not, there is also much, and that too practically the most momentous, of which we can only attain the conviction and the knowledge by a lengthened, often a laborious, process of inquiry. In like manner as of material objects, they may be seen but imperfectly at the first; and we become fully and minutely acquainted with their visible properties, only by a prolonged look, which is a sustained and voluntary act, so many are the objects of thought, both the reality and the nature of which are but dimly apprehended on the first suggestion of them; and of which we can only be made firmly to believe and thoroughly to know by means, of a prolonged attention, which is a sustained and voluntary act also. It is thus that the moral state determines the intellectual, for it is by the exercise of a strong and continuous will, upholding or perpetuating the attention, that what at the outset where the probabilities of a subject are at length brightened into its proofs, and the verisimilitudes of our regardful notice become the verities of our confirmed faith.

2. Of all the subjects to which the attention of the human mind can be directed, this principle admits of pre-eminent application to the subject of theology, as involving in it both the present duties and the final destinies of our race. In no other track of inquiry are the moral and the intellectual more thoroughly blended,, as might be evinced by tracing the whole progress, from the first or incipient disposition of mind towards the theme, to the devotedness of its confirmed assurance.

3. Going back then to the very earliest of our mental conceptions on this subject, we advert first to the distinction in point of real and logical import, between unbelief and disbelief. The former we apprehend, to be the furthest amount of the atheistical verdict on the question of a God. The atheist does not labour to demonstrate that there is no God. But he labours to demonstrate that there is no adequate proof of there being one. He does not positively affirm the position, that God is not; but he affirms the lack of evidence for the position, that God is. His verdict on the doctrine of a God is only that it is not proven. It is not that is not disproven. He is but an Atheist. He is not an Antitheist.

4. Now there is one consideration, which affiords the inquirer a singularly clear and commanding position, at the outset of this great question. It is this. We cannot, without a glaring contravention to all the principles of the experimental philosophy, recede to a further distance from the doctrine of a God, than to the position of simple atheism. We do not need to take our departure from any point further back than this, in the region of antitheism; for that region cannot possibly be entered by us but by an act of tremendous presumption, which it were premature to denounce as impious, but which we have the authority of all modern science for denouncing as unphilosophical. To make this palpable, we have only to contrast the two intellectual states, not of theism and atheism, but of theism and antitheism, along with the two processes, by which alone we can be logically and legitimately led to them.

5. To be able to say then that there is a God, we may have only to look abroad on some definite territory, and point to the vestiges that are given of His power and His presence somewhere. To be able to say that there is no God, we must walk the whole expanse of infinity, and ascertain, by observation, that such vestiges are to be found nowhere. Grant that no trace of Him can be discerned in that quarter of contemplation which our puny optics have explored, does it follow, that, throughout all immensity, a Being with the essence and sovereignty of a God is nowhere to be found? Because through our loopholes of communication with that small portion of external nature which is before us, we have not seen or ascertained a God, must we therefore conclude of every unknown and untrodden vastness in this illimitable universe, that no Divinity is there?, Or because, through the brief successions of our little day, these heavens have not once broken silence, is it therefore for us to speak to all the periods of that eternity which is behind us; and to say, that never hath a God come forth with the unequivocal tokens of His existence? Ere we can say that there is a God, we must have seen, on that portion of Nature to which we have access, the print of His footsteps; or have had direct intimation from himself; or been satisfied by the authentic memorials of His converse with our species in other days. But ere we can say that there is no God, we must have roamed over all nature, and seen that no mark of a Divine footstep was there; and we must have gotten intimacy with every existent spirit in the universe, and learned from each that never did a revelation of the Deity visit him; and we must have searched, not into the records of one solitary planet, but into the archives of all worlds, and thence gathered, that, throughout the wide realms of immensity, not one exhibition of a reigning and living God ever has been made. Atheism might plead a lack of evidence within its own field of observation. But antitheism pronounces both upon the things which are, and the things which are not within that field. It breaks forth and beyond all those limits that have been prescribed to man's excursive spirit, by the sound philosophy of experience; and by a presumption the most tremendous, even the usurpation of all space and of all time, it affirms that there is no God. To make this out, we should need to travel abroad over the surrounding universe till we had exhausted it, and to search backward through all the hidden recesses of eternity; to traverse in every direction the plains of infinitude, and sweep the outskirts of that space which is itself interminable; and then bring back to this little world of ours, the report of a universal blank, wherein we had not met with one manifestation or one movement of a presiding God. For man not to know of a God, he has only to sink beneath the level of our common nature. But to deny him, he must be a God himself. He must arrogate the ubiquity and omniscience of the Godhead.

6. It affords a firm outset to this investigation, that we cannot recede a greater way from the doctrine to be investigated, than to the simple point of ignorance or unbelief. We cannot, without making inroad on the soundest principles of evidence, move one step back from this, to the region of disbelief. We can figure an inquirer taking up his position in midway atheism. But he cannot, without defiance to the whole principle and philosophy of evidence, make aggression thence on the side of antitheism. There is a clear intellectual principle, which forbids his proceeding in that direction; and there is another principle equally clear, though not an intellectual but a moral one, which urges him, if not to move, at least to look in the opposite direction.

This idea has been powerfully rendered by Foster in the following passage extracted from one of his essays:

The wonder turns on the great process, by which a man could grow to the immense intelligence that can know there is no God. What ages and what lights are requisite for this attainment. This intelligence involves the very attributes of Divinity, while a God is denied. For unless this man is omnipresent, unless he is at this moment in very place in the Universe, he cannot know but there may be in some place manifestations of a Deity by which even he would be overpowered. If helloes not absolutely know every agent in the Universe, the one that he does not know may be God. If he is not himself the chief agent in the Universe, and does not know what is so, that which is so may be God. If he is not in absolute possession of all the propositions that constitute universal truth, the one which he wants may be that there is a God. If he cannot with certainty assign the cause of all that he perceives to exist, that cause may be a God. If he does not know every thing that has been done in the immeasurable ages that are past, some things may have been done by a God. Thus unless he knows all things, that is, pludes another Deity by being one himself, he cannot know that the Being whose existence he rejects, does not exist.

We are not asking him, situated where he is, to believe in God. For the time being, we as little expect a friendly as we desire a hostile decision upon the question. Our only demand for the present is, that he shall entertain the question. And to enforce the demand, we think that an effective appeal might be made to his own moral nature. We suppose him still to be an atheist, but no more than an atheist—for, in all right Baconian logic, the very farthest remove from theism, at which he or any man can be placed by the lack of evidence for a God, is at the point of simple neutrality. We might well assume this point, as the utmost possible extreme of alienation from the doctrine of a Creator, to which the mind of a creature can in any circumstances be legitimately carried. We cannot move from it, in the direction towards antitheism, without violence to all that is just in philosophy; and we might therefore commence with inquiring, whether, in this lowest state of information and proof upon the question, there can be anything assigned, which should lead us to move, or at least to look in the opposite direction.

7. In the utter destitution, for the present, of any argument, or even semblance of argument, that a God is, there is, perhaps, a certain duteous movement which the mind ought to take, on the bare suggestion that a God may be. The certainty of an actual God binds over to certain distinct and most undoubted proprieties. But so also may the imagination of a possible God, in which case, the very idea of a God, even in its most hypothetical form, might lay a responsibility, even upon atheists.

8. To make this palpable, we might imagine a family suffering under extreme destitution, and translated all at once into sufficiency or affluence by an anonymous donation. Had the benefactor been known, the gratitude that were due to him becomes abundantly obvious; and in the estimation of every conscience, nothing could exceed the turpitude of him who should regale himself on the bounties wherewith he had been enriched, and yet pass unheedingly by the giver of

them all. Yet does not a proportion of this very guilt rest upon him who knows not the hand that relieved him, yet cares not to inquire? It does not exonerate him from the burden of all obligation, that he knows not the hand which sustains him. He incurs a guilt, if he do not want to know. It is enough to convict him of a great moral delinquency, if he have gladly seized upon the liberalities which were brought in secret to his door, yet seeks not after the quarter whence they have come, willing that the hand of the dispenser should remain for ever unknown, and not wanting any such disclosures as would lay a distinct claim or obligation upon himself. He altogether lives by the bounty of another; yet would rather continue to live without the burden of those services or acknowledgments that are due to him. His ignorance of the benefactor might alleviate the charge of ingratitude; but it plainly awakens the charge again, if he choose to remain in ignorance, and would shun the information that might dispel it. In reference then to this still undiscovered patron of his family, it is possible for him to evince in gratitude; to make full exhibition of a nature that is unmoved by kindness and withholds the moral responses which are due to it, that can riot with utmost selfishness and satisfaction upon the gifts while in total indifference about the giver, an indifference which might be quite as clearly and characteristically shown, by the man who seeks not after his unknown friend, as by the man who slights him after that he has found him.

9. It may thus be made to appear, that there is an ethics connected with theology, which may come into play, anterior to the clear view of any of its objects. More especially, we do not need to be sure of God, ere we ought to have certain feelings^ or at least certain aspirations towards him. For this purpose we do not need, fully and absolutely, to believe that God is. It is enough that our minds cannot fully and absolutely acquiesce in the position that God is not. To be fit subjects for our present argument, we do not need to have explored that territory of nature which is within our reach; and thence gathered, in the traces of a designer's hand, the positive conclusion that there is a God. It is enough if we have not traversed, throughout all its directions and in all its extent, the sphere of immensity; and if we have not scaled the mysterious altitudes of the eternity that is past 5 nor, after having there searched for a divinity in vain, have come at length to the positive and the peremptory conclusion, that there is not a God. In a word, it is quite enough that man is barely a finite creature, who has not yet put forth his faculties on the question whether God is; neither has yet so ranged over all space and all time, as definitely to have ascertained that God is not, but with whom, though in ignorance of all proofs, it still remains a possibility that God may be.

10. Now to this condition there attaches a most clear and incumbent morality. It is to go in quest of that unseen benefactor, who, for aught I know, has ushered me into existence, and spread so glorious a panorama around me. It is to probe the secret of my being and my birth, and, if possible, to make discovery whether it was indeed the hand of a benefactor, that brought me forth from the chambers of nonentity, and gave me place and entertainment in that glowing territory, which is lighted up with the hopes and the happiness of living men. It is thus that the very conception of a God throws a responsibility after it; and that duty, solemn and imperative duty, stands associated with the thought of a possible Deity, as well as with the sight of a present Deity, standing in full manifestation before us. Even anterior to all knowledge of God, or when that knowledge is in embryo, there is both a path of irreligion and a path of piety; and that law which denounces the one, and gives to the other an approving testimony, may find in him who is still in utter darkness about his origin and his end, a fit subject for the retributions which she deals in. He cannot be said to have borne disregard to the will of that God whom he has found. But his is the guilt of impiety, in that he has borne disregard to the knowledge of that God, whom he was bound by every tie of gratitude to seek after, a duty not founded on the proofs that may be exhibited for the being of a God, but a duty to which even the most slight and slender of presumptions should give rise. And who can deny that, antecedent to all close and careful examination of the proofs, there are at least many presumptions in behalf of a God, to meet the eye of every observer? Is there any so hardy as to deny, that the curious workmanship of his frame

may have had a designer and an architect, that the ten thousand independent circumstances which must be united ere he can have a moment's ease, and the failure of any one of which would be agony, may not have met at random, but that there may be a skilful and unseen hand to have put them together into one wondrous concurrence, and that never ceases to uphold it; that there may be a real and living artist, whose fingers did frame the economy of actual things, and who hath so marvellously suited all that is around us to our senses and our powers of gratification? Without affirming aught that is positive, surely the air that we breathe, and the beautiful light in which we expatiate, these elements of sight and sound so exquisitely fitted to the organs of the human framework, may have been provided by one who did benevolently consult in them our special accommodation. The graces innumerable that lie widely spread over the face of our world, the glorious concave of heaven that is placed over us, the grateful variety of seasons that like Nature's shifting panorama ever brings new entertainment and delight to the eye of spectators, these may, for ought we know, be the emanations of a creative mind, that originated our family, and devised such a universe for their habitation. Regarding these, not as proofs, but in the humble light of presumptions for a God, they are truly enough to convict us of foullest ingratitude,if we go not forth in quest of a yet unknown, but at least possible or likely benefactor. They may not resolve the question of a God. But they bring the heaviest reproach on our listlessness to the question; and show that, anterior to our assured belief in his existence, there lies upon us a most imperious obligation to *' stir ourselves up that we may lay hold of him."

11. Such presumptions as these, if not so many demands on the better of man, are at least so many demands upon his attention; and then, for aught he knows, the presumptions on which he ought to inquire may be more and more enhanced, till they brighten into proofs which ought to convince him. The *prima-facie* evidence for a God may not be enough to decide the question; but it should at least decide man to entertain the question. To think upon how slight a variation either in man or in external nature, the whole difference between physical enjoyment and the most acute and most appalling of physical agony may turn; to think how delicate the balance is, and yet how surely and steadfastly it is maintained, so as that the vast majority of creatures are not only upheld in comfort, but often may be seen disporting themselves in the redundance of gaiety; to think of the pleasurable sensations wherewith every hour is enlivened, and how much the most frequent and familiar occasions of life are mixed up with happiness; to think of the food, and the recreation, and the study, and the society, and the business, each having an appropriate relish of its own, so as in fact to season with enjoyment the great bulk of our existence in the world; to think that, instead of living in the midst of grievous and incessant annoyance to all our faculties, we should have awoke upon a world that so harmonised with the various senses of man, and both gave forth such music to his ear, and to his eye such manifold loveliness; to think of all these palpable and most precious adaptations, and yet to care not whether in this wide universe there exists a being who has had any hand in them; to riot and regale oneself to the uttermost in the midst of all this profusion, and yet to send not one wishful inquiry after that Benevolence which for aught we know may have laid it at our feet, this, however shaded from our view the object of the question may be, is, from its very commencement, a clear outrage against its ethical properties. If that veil of dim transparency, which hides the Deity from our immediate perceptions, were lifted up; and we should then spurn from us the manifested God, this were direct and glaring impiety. But, anterior, to the lifting of that veil, there may be impiety. It is impiety to be so immersed as we are in the busy objects and gratifications of life; and yet to care not whether there be a great and a good spirit by whose kindness it is that life is upholden. It needs not that this spirit should reveal himself in characters that force our attention to him, ere the guilt of our impiety has begun. But ours is the guilt of impiety, in not lifting our attention towards God, in not seeking after Him if haply we may find Him.

12. Man is not to blame, if an atheist, because of the want of proof. But he is to blame, if an atheist, because he has shut his eyes. He is not to blame, that the evidence for a God has not

been seen by him, if no such evidence there were within the field of his observation. But he is to blame, if the evidence has not been seen, because he turned away his attention from it. That the question of a God may lie unresolved in his mind, all he has to do is to refuse a hearing to the question. He may abide without the conviction of a God, if he so choose. But this his choice is matter of condemnation. To resist God after that He is known, is criminality towards Him; but to be satisfied that He should remain unknown, is like criminality towards Him, There is a moral perversity of spirit with him who is willing, in the midst of many objects of gratification, that there should not be one object of gratitude. It is thus that, even in the ignorance of God, there may be a responsibility towards God. The Discerner of the heart sees whether, for the blessings innumerable wherewith He has strewed the path of every man, He be treated like the unknown benefactor who was diligently sought, or like the unknown benefactor who was never cared for. In respect at least of desire after God, the same distinction of character may be observed between one man and another, whether God be wrapt in mystery, or stand forth in full development to our world. Even though a mantle of deepest obscurity lay over the question of His existence, this would not efface the distinction, between the piety on the one hand which laboured and aspired after Him, and the impiety upon the other which never missed the evidence that it did not care for, and so grovelled in the midst of its own sensuality and selfishness. The eye of a heavenly witness is upon all these varieties; and thus, whether it be darkness or whether it be dislike which hath caused a people to be ignorant of God, there is with Him a clear principle of judgment, that He can extend even to the outfields of atheism.

13. It would appear then, that even in the initial state of the human mind on the question of a God, there is an impellent force upon the conscience, which man ought to obey, and which he incurs guilt by resisting. We do not speak of that light which irradiates the termination of the inquirer's path, but of that embryo or rudimental light which glimmers ever the outset of it; which serves at least to indicate the commencement of his way; and which, for aught he knows, may brighten, as he advances onwards, to the blaze of a full and finished revelation. At no point of this progress does ** the trumpet give an uncertain sound," extending, if not to those who stand on the ground of Antitheism, (which we have already pronounced upon and we trust proved to be madly irrational), at least to those who stand on the ground of Atheism, who, though strangers to the conviction, are certainly not strangers to the conception of a Deity. It is of the utmost practical importance, that even these are not beyond the jurisdiction of an obvious principle; and that a right obligatory call can be addressed to men so far back on the domain of irreligion and ignorance. It is deeply interesting to know, by what sort of moral force, even an atheist ought to be evoked from the fastness which he occupies, what are the notices, by responding to which, he should come forth with open eyes and a willing mind to this high investigation; and by resisting which, he will incur a demerit, whereof a clear moral cognizance might be taken, and whereon a righteous moral condemnation might be passed. The ** fishers of men" should know the uttermost reach of their argument; and it is well to understand of religion, that, if she have truth and authority at all, there is a voice proceeding from her which might be universally heard, so that even the remotest families of earth, if not reclaimed by her, are laid by her under sentence of righteous reprobation.

14. On this doctrine of the moral dynamics, which operate and are in force, even in our state of profoundest ignorance respecting God, there may be grounded three important applications.

15. The first is that all men, under all the possible varieties of illumination, may nevertheless be the fit subjects for a judicial cognizance. Their theology, seen through the hazy medium of a dull and imperfect evidence, may have arisen no higher than to the passing suggestion of a God, a mere surmise or rumination about an unseen spirit, who, tending all their footsteps, was their guardian and their guide through the dangers of the pathless wilderness. Now in this thought, fugitive though it be, in these uncertain glimpses whether of a truth or of a possibility, there is that to which the elements of their moral nature might respond, so that to them, there is not the same

exemption from all responsibility, which will be granted to the man who is sunk in hopeless idiotism, or to the infant of a day old. Even with the scanty materials of a heathen creed, a pure or a perverse morality might be grounded thereupon, whether, in those longings of a vague and undefined earnestness that arise from him who feels in his bosom an affinity for God and godliness; or, in the heedlessness of him, who, careless of an unknown benefactor, would have been alike careless, although he had stood revealed to his gaze, with as much light and evidence as is to be had in Christendom. These differences attest what man is, under the dark economy of Paganism; and so give token to what he would be, under the bright economy of a full and finished revelation. It is thus that the Searcher of the heart will find out data for a reckoning, even among the rudest of nature's children, or among those whose spiritual light glimmers most feebly. Even the simple theology of the desert can supply the materials of a coming judgment, so that the Discerner of the inner man will be at no loss for a principle, on which He might clearly and righteously try all the men of all the generations that be upon the face of the earth.

16. The second important bearing of this principle is on the subject of religious education. For what is true of a savage is true of a child. Its moral may outrun its argumentative light. Long anterior to the possibility of any sound conviction as to the character or existence of a God, it may respond with sound and correct feeling to the mere conception of Him. We hold, that, on this principle, the practice of early, nay even of infantine religious education, may, in opposition to the invectives of Rousseau and others, be fully and philosophically vindicated. For the effect of this anticipative process is, that, though it do not at once enlighten the mind on the question of a God, it at least awakens to the question. It does not consummate the process; but in as far as the moral precedes the intellectual, it makes good the preliminary steps of the process, insomuch that, in every Christian land, the youth and the manhood are accountable for their belief, because accountable for their use or their neglect of that inquiry, by which the belief ought to have been determined. They have all from their infancy heard of God. Many have been trained to think of Him, amidst a thousand associations of reverence. Some, under a roof of piety, have often lisped the prayers of early childhood to this unseen Being; and, in the oft-repeated sound of morning and evening orisons, they have become familiar to His . name. Even they who have grown up at random through the years of a neglected boyhood, are greatly within the limits of that responsibility for which we plead. They are fully possessed, if not with the certainty, at least with the idea, of a great eternal Sovereign. The very imprecations of profaneness may have taught it to them. The very Sabbath they spend in riot and blasphemy at least reminds them of a God. The worship-bell of the church they never enter, conveys to them, if not the truth, at least an imagination of the truth, which, if it do not arrest them by a sense of obligation, will leave guilt upon their souls, though it be guilt against a God who is unknown.

17. But lastly, we may now perceive what that is, on which a teacher of religion finds an introduction for his topic, even in the minds of people in the lowest state both of moral and intellectual debasement. They may have not that in them, at the outset of his ministrations, which can en* able them to decide the question of God; but they have at least that in them, which should summon all their faculties to the respectful entertainment of it. They have at least such a sense of the Divinity, as their own consciences will tell, should put them on the regards and the inquiries of moral earnestness. This is a clear principle which operates at the very commencement of a religious course; and causes the first transition, from the darkness and insensibility of alienated nature, to the feelings and attentions of seriousness. The truth is, that there is a certain rudimental theology every where, on which the lessons of a higher theology may be grafted, as much as to condemn, if not to awaken the apathy of nature. What we have already said of the relation in which the father of a starving household stands to the giver of an anonymous donation, holds true of the relation in which all men stand to the unseen or anonymous God. Though in a state of absolute darkness, and without one token or clue to a discovery, there is room for the exhibition of moral differences among men, for even then, all the elements of morality might be at work, and all the tests of moral

propriety might be abundantly verified; and still more, after that certain likelihoods had arisen, or some hopeful opening had occurred for investigating the secret of a God. There is the utmost moral difference that can be imagined between the man who would gaze with intense scrutiny upon these likelihoods, and the man who, either in heedlessness or aversion, would turn his eyes from them; between the man who would seize upon such an opening, and prosecute such an investigation to the uttermost, and the man who either retires or shrinks from the opportunity of a disclosure that might burden him both with the sense and with the services of some mighty obligation.

18. And the same moral force which begins this inquiry, also continues and sustains it. If there be power in the very conception of a God to create and constitute the duty of seeking after Him, this power grows and gathers with every footstep of advancement in the high investigation. If the thought of a merely possible Deity have rightfully awakened a sense of obligation within us to entertain the question; the view of a probable Deity must enhance this feeling, and make the claim upon our attention still more urgent and imperative than at the first. Every new likelihood makes the call louder, and the challenge more incumbently binding than before. In proportion to the light we had attained, would be the criminality of resisting any further notices or manifestations of that mighty Being with whom we had so nearly and so emphatically to do. Under the impulse of a right principle, we should follow on to know God, till, after having done full justice both to our opportunities and our powers, we had made the most of all the available evidence that was within our reach, and possessed ourselves of all the knowledge that was accessible.

19. We can conceive how, under the influence of these considerations, one should begin and prosecute the study of Natural Theology, till he had exhausted it. But an interesting inquiry remains. We have already endeavoured to estimate what the proper leadings of the mind are, at the commencement and along the progress of the study. The remaining question is, What were the proper leadings of the mind at the termination of it?

20. And first it will be seen, on the principles which we have already endeavoured to establish, that no alleged defect of evidence in Natural Theology can extinguish the use of it, a use which m ht still remain, under every conceivable degree whether of dimness or of distinctness in its views. Even the faint and distant probabilities of the subject, may still lay upon us the duty of careful and strenuous inquisition; and that long anterior to our full acquaintance with the certainties of the subject. The verisimilitudes of the question are the signal-posts, by following the intimations of which, we are at length conducted to the verities of the question. Although Natural Theology, therefore, should fail to illuminate, yet, by a moral force upon the attention, it may fully retain the power to impel. Even if it should have but some evidence, however slender, this should put us at the very least into the attitude of inquirers; and the larger the evidence, the more earnest and v ilant ought the inquiry to be. Thus a great object is practically fulfilled by Natural Theology. It gives us to conceive, or to conjecture, or to know so much of God, that, if there be a professed message with the likely s natures upon it of having proceeded from Him, though not our duty all at once to surrender, it is at least our bounden duty to invest ate. It may not yet be entitled to a place in our creed; but it is at least entitled to a place in the threshold of the understanding, where it may wait the full and fair examination of its credentials. It may not be easy to measure the intensity of Nature's l ht; but enough if it be a l ht that, had we obeyed its intimations, would have guided us onwards to larger manifestations of the Deity. If Natural Theology but serve thus to fix and direct our inquiries, it may fulfil a most important part as the precursor of revelation. It may not be itself the temple; but it does much by leading the way to it. Even at the outset period of our thickest norance, there is a voice which calls upon us to go forth in quest of God. And in proportion as we advance does the voice become more urgent and audible, in calling us onward to further manifestations. It says much for Natural Theology, that it begins at the commencement, and carries us forward a part of this way; and it has indeed discharged a most important function, if, at the point where its guesses or its discoveries terminate, it leaves us with as much light as

should make us all awake to the further notices of a God, or as shall leave our heedlessness wholly inexcusable.

21. There is a confused imagination with many, that every new accession, whether of evidence or of doctrine, made to the Natural, tends in so far to reduce the claims or to depreciate the importance of the Christian Theology. The apprehension is, that, as the latter was designed to supplement the insufficiency of the former,, then, the more that the arguments of Natural Theology are strengthened, or its truths are multiplied, the more are the lessons of the Christian Theology unneeded and uncalled for. It is thus that the discoveries of reason are held as superseding, or as casting a shade of insignificence, and even of discredit, over the discoveries of revelation. There is a certain dread or jealousy, with some humble Christians, of all that incense which is offered at the shrine of the Divinity by human science, whose daring incursion on the field of theology, it is thought, will, in very proportion to the brilliancy of its success, administer both to the proud independence of the infidel, and to the pious alarm of the believer.

22. But, to mitigate this disquietude, it should be recollected, in the first place, that, if Christianity have real and independent evidence of being a message from God, it will be all the more humbly and respectfully deferred to, should a previous natural theology have assured us of His existence, and thrown the radiance of a clear and satisfying demonstration over the perfections of His character. However plausible its credentials may be, we should feel no great interest in its statements or its overtures, if we doubted the reality of that Being from whom it professes to have come; and it is precisely in as far as we are preoccupied with the conviction of a throne in heaven, and of a God sitting upon that throne, that we should receive what bore the signatures of an embassy from Him with awful reverence.

23. But there is another consideration still more decisive of the place and importance of Christianity, notwithstanding every possible achievement by the light of nature. There are many discoveries which, so far from alleviating, serve but to enhance the difficulties of the question. For example, though science has made known to us the magnitude of the universe, it has not thereby advanced one footstep towards the secret of God's moral administration; but has, in fact, receded to a greater distance, from this now more hopeless, because now more complex and unmanageable problem than before. To multiply the data of a question, is not always the way to facilitate its solution; but often the way, rather, to make it more inextricable. And this is precisely the effect of all the discoveries that can be made by natural theology, on that problem which it is the special office of Christianity to resolve. With every new argument by which philosophy enhances the goodness and greatness of the Supreme Being, does it deepen still more the guilt and ingratitude of those who have revolted against Him. The more emphatically it can demonstrate the care and benevolence of God, the more emphatically, along with this, does it demonstrate the worthlessness of man. The same light which irradiates the perfections of the divine nature, irradiates, with more fearful manifestations than ever, the moral disease and depravation into which humanity has fallen. Had natural theology been altogether extinct, and there had been no sense of a law or lawgiver among men, we should have been unconscious of any difficulty to be redressed, of any dilemma from which we needed extrication. But the theology of nature and conscience tells us of a law; and in proportion as it multiplies the claims of the Lawgiver in heaven, does it aggravate the criminality of its subjects upon earth. With the rebellious phenomenon of a depraved species before our eyes, every new discovery of God but deepens the enigma of man*s condition in time, and of his prospects in eternity; and so makes the louder call for that remedial system, which it is the very purpose of Christianity to introduce into the world.

24. We hold that the theology of nature sheds powerful light on the being of a God; and that, even from its unaided demonstrations, we can reach a considerable degree of probability, both for His moral and natural attributes. But when it undertakes the question between God and man, this is

what it finds to be impracticable. It is here where the main helplessness of nature lies. It is baffled in all its attempts to decipher the state and the prospects of man, viewed in the relation of an offending subject to an offended sovereign. In a word, its chief obscurity, and which it is wholly unable to disperse, is that which rests on the hopes and the destiny of our species. There is in it enough of manifestation to awaken the fears of guilt, but not enough again to appease them. It emits, and audibly emits, a note of terror; but in vain do we listen for one authentic word of comfort from any of its oracles. It is able to see the danger, but not the deliverance. It can excite the forebodings of the human spirit, but cannot quell them, knowing just enough to stir the perplexity, but not enough to set the perplexity at rest. It can state the difficulty, but cannot unriddle the difficulty, having just as much knowledge as to enunciate the problem, but not so much as might lead to the solution of the problem. There must be a measure of light, we do allow; but, like the lurid gleam of a volcano, it is not a light which guides, but which bewilders and terrifies. It prompts the question, but cannot frame or furnish the reply. Natural theology may see as much as shall draw forth the anxious interrogation, “What shall I do to be saved?" The answer to this comes from a higher theology.

25. These are the grounds on which we would affirm the insufficiency of that academic theism, which is sometimes set forth in such an aspect of completeness and certainty, as might seem to leave a revelation or a gospel wholly uncalled for. Many there are who would gloss over the difficulties of the question; and who, in the midst of all that undoubted outrage which has been inflicted by sinful creatures on the truth and the holiness and the justice of God, would, by merging all the attributes of the Divinity into a placid and undistinguishing tenderness, still keep their resolute hold of heaven, as at least the splendid imagination, by which to irradiate the destinies of our species. It is thus that an airy unsupported romance has been held forth as the vehicle, on which to embark all the hopes and the hazards of eternity. We would not disguise the meagreness of such a system. We would not deliver the lessons of natural theology, without telling at the same time of its limits. We abjure the cruelty of that sentimentalism, which, to hush the alarms of guilty man, would rob the Deity of his perfections, and stamp a degrading mockery upon His law. When expounding the arguments of natural theology, along with the doctrines which it dimly shadows forth, we must speak of the difficulties which itself suggests but which it cannot dispose of; we must make mention of the obscurities into which it runs, but which it is unable to dissipate, of its unresolved doubts, of the mysteries through which it vainly tries to grope its uncertain way, of its weary and fruitless efforts, of its unutterable longings. And should, on the one hand, the speculations of human ingenuity, and, on the other, the certainties of a well accredited revelation, come forth to illuminate this scene of darkness, we must not so idolize the light or the sufficiency of nature, as to turn from the firmament's meridian blaze, that we might witness and admire the tiny lustre of a glow-worm.

26. The two positions are perfectly reconcilable, first, of the insufficiency of natural religion; and secondly, the great actual importance of it. It is the wise and profound saying of D' Alembert, that "man has too little sagacity to resolve an infinity of questions, which he has yet sagacity enough to make." Now this marks the degree in which natural theology is sagacious, being able, from its own resources, to construct a number of cases, which at the same time it is not able to reduce. These must be handed up for solution to a higher calculus; and thus it is, that the theology of nature and of the schools, the theology of the ethical class, though most unsatisfactory, when treated as a terminating science, is most important, and the germ of developments at once precious and delightful, when treated as a rudimental one. It is a science, not so much of dicta as of desiderata; and, from the way in which these are met by the counterpart doctrines of the gospel, the light of a powerful and most pleasing evidence is struck out by the comparison between them. It is that species of evidence which arises from the adaptation of a mould to its counterpart form; for there is precisely this sort of fitting, in the adjustment which obtains between the questions of the natural and the responses of the supernatural theology. For the problem which natural theology

cannot resolve, the precise difficulty which it is wholly unable to meet or to overcome, is the restoration of sinners to acceptance and favour with a God of justice. All the resources and expedients of natural theology are incompetent for this solution, it being, in fact, the great desideratum which it cannot satisfy. Still it performs an important part in making us sensible of the desideratum. It makes known to us our sin; but it cannot make known to us salvation. Let us not overlook the importance of that which it does, in its utter helplessness as to that which it does not. It puts the question, though it cannot answer the question; and nowhere so much as at this turningpoint, are both the uses and the defects of natural theology so conspicuously blended.

27. Natural theology, then, however little to be trusted as an informer, yet as an inquirer, or rather as a prompter to inquiry, is of inestimable service. It is a high function that she discharges, for though not able to satisfy the search, she impels to the search. We are apt to undervalue, if not to set her aside altogether, when we compare her obscure and imperfect notices with the lustre and the fulness of revelation. But this is because we overlook the virtue that lies in the probabilities of a subject, a virtue, either, on the one hand, to fasten the attention; or, on the other hand, to condemn the want of it. This we hold to be the precise office of natural theology, and an office too, which she performs, not merely as the theology of science among those who listen to her demonstrations in the academic hall; but which she also performs with powerful and practical effect, as the theology of conscience, throughout all the classes of our general population. It is this initial work which makes her so useful, we should say so indispensable, as a preliminary to the gospel. Natural theology is quite overrated by those who would represent it as the foundation of the edifice. It is not that, but rather the taper by which we must grope our way to the edifice. The stability of a fabric is not greater than the stability of that upon which it rests; and it were ascribing a general infirmity to revelation, to set it forth, as leaning upon natural theism, in the way that a mathematical doctrine leans upon the axioms or first principles of the science. Christianity rests on its own proper evidence; and if, instead of this, she be made to rest on an antecedent natural religion, she becomes weak throughout, because weak radically. It is true that in theology, the natural goes before the revealed, even as the cry of weakness or distress goes before the relief to which it aspires, and which it is prompted to seek after. It goes before, not synthetically in the order of demonstration, but historically in the mind of the inquirer. It is not that natural religion is the premises, and Christianity the conclusion; but it is that natural religion creates an appetite which it cannot quell; and he who is urged thereby, seeks for a rest and a satisfaction which he can only obtain in the fulness of the gospel. Natural theology has been called the basis of Christianity. It would accord better with our own views of the place which it occupies, and of the high purpose which it undoubtedly serves, if it were called the basis of Christianization.

28. The most important exemplification of the way in which natural religion bears upon Christianity, is furnished by the question of a sinner's acceptance with God. Natural religion can suggest to man the apprehension of his guilt; for however dim her objective view of the Deity, there is no such dimness in her ethical notion of what is due even to an uncertain God. Without having seriously resolved the question, we may stand convicted to our own minds of a hardened and habitual carelessness to the question. If our whole lives long have been spent in the midst of created things, without any serious or sustained effort of our spirits in quest of a Creator, if, as our consciences can tell, the whole drift and practical earnestness of our thoughts are towards the gifts, with but a rare and occasional anxiety towards the Giver, if the sense of Him touch but lightly on our spirits, and we, by our perpetual lapses from the sacred to the secular, prove that our gravitation is to earth, and that in truth our best-loved element is atheism, if the notices of a God, however indistinct, wherewith we are surrounded, instead of fastening our regards on this high contemplation, do but disturb without at all influencing the general tenor of our engagements, these are things of which the light of Nature can take cognizance; and these are things because of which, and of their felt unworthiness, nature is visited by the misgivings both of remorse and of terror. She has data enough on which to found the demonstration and the sense of her own

unworthiness; and hence a general feeling of insecurity among all spirits, a secret but strong apprehension that all is not right between them and God.

29. This is not a matter of mere sensitive and popular impression; but in strict accordance with the views of a calm and intelligent jurisprudence. It enters into the very essence of our conception of a moral government, that it must have sanctions which could not have place, were there either to be no dispensation of rewards and punishments; or were the penalties, though denounced with all the parade and proclamation of law, to be never executed. It is not the lesson of conscience, that God would, under the mere impulse of a parental fondness for the creatures whom He had made, let down the high state and sovereignty which belong to him j or that He would forbear the infliction of the penalty, because of any soft or timid shrinking from the pain it would give to the objects of His displeasure. There is nothing either in history or nature, which countenances such an imagination of the Deity, as that, in the relentings of mere tenderness, he would stoop to any weak or unworthy compromise with guilt. The actual sufferings of life speak loudly and experimentally against the supposition; and when one looks to the disease and the agony of spirit, and above all the hideous and unsparing death, with its painful struggles and gloomy forebodings, which are spread universally over the face of the earth, we cannot but imagine of the God who presides over such an economy, that He is not a being who will falter from the imposition of any severity, which might serve the objects of a high administration. Else all steadfastness of purpose, and steadfastness of principle, were fallen from. God would stand forth to the eye of his own creatures, a spectacle of outraged dignity. And He of whom we image that He dwells in an inviolable sanctuary, the august Monarch of heaven and earth, with a law by subjects dishonoured, by the sovereign unavenged, would possess but the semblance and the mockery of a throne.

30. Such a conception is not only a violence to the apprehensions of nature, but is even acknowledged at times by our academic theists, as a violence to the sound philosophy of the subject. The most striking testimony to this effect is that given by Dr. Adam Smith, on the first appearance of his “Theory of Moral Sentiments,'” nor does it detract from its interest or its value, that he afterwards suppressed it, in the subsequent editions of his work:, "All our natural sentiments,*' he says, ** prompt us to believe, that as perfect virtue is supposed necessarily to appear to the Deity as it does to us, as for its own sake and without any farther view, the natural and proper object of love and reward, so must vice of hatred and punishment. That the gods neither resent nor hurt, was the general maxim of all the different sects of the ancient philosophy; and if by resenting be understood that violent and disorderly perturbation which often distracts and confounds the human heart; or if by hurting be understood the doing of mischief wantonly, and without regard to propriety or justice, such weakness is undoubtedly unworthy of the Divine perfection. But if it be meant that vice does not appear to the Deity to be for its own sake the object of abhorrence and aversion, and what, for its own sake, it is fit and reasonable should be punished, the truth of this maxim can by no means be so easily admitted. If we consult our natural sentiments, we are apt to fear lest before the holiness of God vice should appear to be more worthy of punishment, than the weakness and imperfection of human virtue can ever seem to be of reward. Man, when about to appear before a Being of infinite perfection, can feel but little confidence in his own merit, or in the imperfect propriety of his own conduct. In the presence of his fellow-creatures he may often justly elevate himself, and may often have reason to think highly of his own character and conduct, compared to the still greater imperfection of theirs. But the case is quite different, when about to appear before his infinite Creator. To such a Being, he can scarcely imagine, that his littleness and weakness should ever appear to be the proper objects either of esteem or of reward. But he can easily conceive how the numberless violations of duty of which he has been guilty, should render him the proper object of aversion and punishment; neither can he see any reason why the divine indignation should not be let loose, without any restraint, upon so vile an insect as he is sensible that he himself must appear to be. If he would still hope for happiness, he is conscious that he cannot demand it from the justice, but he must entreat it from

the mercy of God. Repentance, sorrow, humiliation, contrition at the thought of his past misconduct, are upon this account the sentiments which become him, and seem to be the only means which he has left for appeasing that wrath which he knows he has justly provoked. He even distrusts the efficacy of all these, and naturally fears lest the wisdom of God should not, like the weakness of man, be prevailed upon to spare the crime by the most importunate lamentations of the criminal. Some other intercession, some other sacrifice, some other atonement, he imagines must be made for him, beyond what he himself is capable of making, before the purity of the divine justice can be reconciled to his manifold offences. The doctrines of revelation coincide in every respect with these original anticipations of nature; and as they teach us how little we can depend upon the imperfection of our own virtue, so they show us at the same time that the most powerful intercession has been made, and that the most dreadful atonement has been paid, for our manifold transgressions and iniquities."

31. This interesting passage seems to have been written by its author, under a true apprehension of that dilemma in which the world is involved. He admits a moral government on the part of God. He admits a universal delinquency on the part of man. And his feeling is, that the government would be nullified by a mere act of indemnity, which rendered no acknowledgment to the justice which had been violated, or to the authority of that law which had been trampled on. In these circumstances, he casts about as it were for an adjustment; and puts forth a conjectural speculation; and guesses what the provision should be, which, under a new economy, might be adopted for repairing a defect, that is evidently beyond all the resources of natural theism; and proposes the very expedient of our professed revelation, for the resolving of a difficulty which had been else impracticable. We deem it a melancholy fact, that this noble testimony to the need of a gospel should have disappeared in the posterior editions of his work, revised and corrected as they were by his own hand. It is not for men to sit in the chair of judgment; and never should they feel a greater awe or tenderness upon their spirits, than when called to witness or to pronounce upon the aberrations of departed genius. Yet when one compares the passage he could at one time have written, with the Memoir, that, after an interval of many years he gave to the world, of David Hume, that ablest champion of the infidel cause, one fears lest, under the contagion of a near and withering intimacy with him, his spirit may have imbibed of the kindred poison; and he at length have become ashamed of the homage that he once had rendered to the worth and importance of Christianity.

32. This, notwithstanding, remains one of the finest examples of the way in which the Natural bears upon the Christian theology; and of the outgoings, by which the one conducts to a landing-place in the other. We hold that there are many such outgoings: that at the uttermost margin of the former there is a felt want, and that, in accurate counterpart to this, the latter has something to offer in precise and perfect adaptation thereto. Now the great error of our academic theism, as commonly treated, is, that it expresses no want; that it reposes in its own fancied sufficiency; and that all its landing-places are within itself, and along the uttermost limits of its own territory. It is no reproach against our philosophical moralists, that they have not stepped beyond the threshold of that peculium, which is strictly and appropriately theirs; or not made incursion into another department than their own. The legitimate complaint is, that, on taking leave of their disciples, they warn them not of their being only yet at the outset or in the prosecution of a journey, instead of having reached the termination of it. They in fact take leave of them in the middle of an unprotected highway, when they should have reared a finger-post of direction to the places which lie beyond. The paragraph which we have now extracted, was just such a finger-post, though taken down, we deeply regret to say, by the very hand that had erected it. Our veneration for his name must not restrain the observation, that, by this, he undid the best service which a professor of moral science can render to humanity. Along the confines of its domain, there should be raised, in every quarter, the floating signals of distress; that its scholars, instead of being lulled into the imagination that now they may repose as in so many secure and splendid dwelling places, should be taught to regard

them only as towers of observation, whence they have to look for their ulterior guidance and their ulterior supplies, to the region of a conterminous theology.

33. There is a difficulty here in the theism of nature, within the whole compass of which no solution for it can be found. It will at least afford a specimen of the way in which the one bears upon the other, if we state the method of escape from this difficulty that has been provided in the theism of Christianity. The great moral problem which under the former waits to be resolved, is to find acceptance in the mercy of God, for those who have braved His justice, and done despite to the authority, of His law; and that, without any compromise of truth or dignity. By the offered solution of the New Testament, a channel has been opened up, through a high mediatorsbip between God and man, for the descent of a grace and a mercy the most exuberant on a guilty world; and through it, the overtures of reconciliation are extended unto all; and a sceptre of forgiveness, but of forgiveness consecrated by the blood of a great atonement, has been stretched forth, even to the most polluted and worthless outcasts of the human family 5 and thus the goodness of the Divinity obtained its fullest vindication, yet not a goodness at the expense of justice, for the affront done to an outraged law, has been amply repaired by the homage to its authority of an illustrious Sufferer, who took upon himself the burden of all those penalties which we should have borne; and, in the spectacle of whose deep and mysterious sacrifice, God's hatred of moral evil stands forth in most impressive demonstration. So that, instead of a conflict or a concussion between these two essential attributes of His nature, a way has been found, by which each is enhanced to the uttermost, and a flood of most copious and convincing illustration has been poured upon them both.

34. This specimen will best illustrate of moral philosophy, even in its most finished state, that it is not what may be called a terminating science. It is at best but a science *in transitu;* and its lessons are those of a preparatory school. It contains but the rudiments of a nobler acquirement; and he discharges best the functions of a teacher, not who satiates, but who excites the appetite, and then leaves it wholly unappeased. This arises from the real state and bearing of the science, as being a science not so much of doctrines as of desiderata. At most, it leaves its scholars in a sort of twilight obscurity. And, if a just account is rendered of the subject, there will unavoidably be the feeling, that, instead of having reached a secure landing-place, we have broken off, as in the middle of an unfinished demonstration.

35. That indeed is a most interesting adjustment between Moral Philosophy and the Christian Theology, which is represented to us by the unresolved difficulties of the one science, and the reduction which is made of these difficulties in the other. We have far the most important example of this in the doctrine of the atonement, that sublime mystery, by which the attributes of the Divinity have all been harmonised; and the most liberal outlet has been provided for mercy to the offender, while still the truth and justice of the Lawgiver have been vindicated, and all the securities of His moral government are upholden. By the disloyalty of our race, the principles of Heaven's jurisprudence are brought to a test of utmost delicacy; for there seems to be no other alternative, than that man should perish in overwhelming vengeance, or that God should become a degraded sovereign. It nullifies the moral government of the world, if all force and authority be taken from its sanctions; and it is a problem which even "angels desired to look into," how the breach could be healed, which had been made by this world's rebellion, and yet the honour of heaven's high Sovereign be untarnished by the compromise. The one science lands us in the difficulty j and by the Other alone it is that we are extricated. The one presents us with the case; but, for the solution of it, we must recur to a higher calculus, to an instrument of more powerful discovery and of fuller revelation. The one starts a question which itself cannot untie; and the other furnishes the satisfactory response to it. The desideratum of the former meets with the doctrine of the latter; and it is this frequent adjustment, as of a mould to its counterpart die; it is this close and manifold adaptation between the wants of nature and the overtures of a professed

revelation; it is this fitting of the supernal application to the terrestial subject upon which it is laid; it is the way, more especially, in which the disruption between heaven and earth has been restored, and the frightful chasm that sin had made on the condition and prospects of our species is wholly repaired to all who will through the completeness of an offered Saviour; it is this mingled harmony of the greater and lesser lights, which gives evidence that both have been kindled by the same hand, and that it is He who put the candle which glimmers so feebly into my heart, it is He also who poured the noonday effulgence of Christianity around me.

36. It were foreign to our prescribed subject to attempt an exposition, in however brief and rapid a sketch, of the credentials of Christianity. We only remark, that, amid the lustre and variety of its proofs, there is one strikingly analogous, and indeed identical in principle, with our own peculiar argument. If in the system of external nature we can recognise the evidence of God being its author, in the adaptations wherewith it teems to the Moral and Intellectual Constitution of Man, there is room and opportunity for this very evidence in the book of an external revelation. What appears in the construction of a world might be made to appear as manifestly in the construction of a volume, whose objective truths may present as obvious and skilful an accommodation to our mental economy, as do the objective things of a created universe. And it is not the less favourable, for an indication of its divine original, that whereas Nature, as being the original system, abounds with those fitnesses which harmonise with the mental constitution in a state of health, Christianity, as being a restorative system, abounds in fitnesses to the same constitution in a state of disease. We are not sure but that in the latter, from its very design, we shall meet with still more delicate and decisive tests of a designer, than have yet been noticed in the former; and certain it is, that the wisdom and goodness and even power of a moral architect, may be as strikingly evinced in the reparation, as in the primary establishment of a Moral Nature.

Treatise 3 - On Astronomy and General Physics - By the Reverend William Whewell

Book III - Religious Views

The contemplation of the material universe exhibits God to us as the author of the laws of material nature; bringing before us a wonderful spectacle, in the simplicity, the comprehensiveness, the mutual adaptation of these laws, and in the vast variety of harmonious and beneficial effects produced by their mutual bearing and combined operation. But it is the consideration of the moral world, of the results of our powers of thought and action, which leads us to regard the Deity in that light in which our relation to him becomes a matter of the highest interest and importance. We perceive that man is capable of referring his actions to principles of right and wrong; that both his faculties and his virtues may be unfolded and advanced by the discipline which arises from the circumstances of human society; that good men can be discriminated from the bad, only by a course of trial, by struggles with difficulty and temptation; that the best men feel deeply the need of relying, in such conflicts, on the thought of a superintending Spiritual Power; that our views of justice, our capacity for intellectual and moral advancement, and a crowd of hopes and anticipations which rise in our bosoms unsought, and cling there with inexhaustible tenacity, will not allow us to acquiesce in the belief that this life is the end of our existence. We are thus led to see that our relation to the Superintender of our moral being, to the Depositary of the supreme law of just and right, is a relation of incalculable consequence. We find that we cannot be permitted to be merely contemplators and speculators with regard to the Governor of the moral world; we must obey His will; we must turn our affections to Him; we must advance in His favour; or we offend against the nature of our position in the scheme of which He is the author and sustainer.

It is far from our purpose to represent natural religion as of itself sufficient for our support and guidance; or to underrate the manner in which our views of the Lord of the universe have been,

much more, perhaps, than we are sometimes aware, illustrated and confirmed by lights derived from revelation. We do not here speak of the manner in which men have come to believe in God, as the Governor of the moral world; but of the fact, that by the aid of one or both of these two guides, Reason or Revelation, reflecting persons in every age have been led to such a belief. And we conceive it may be useful to point out some connexion between such a belief of a just and holy Governor, and the conviction, which we have already endeavoured to impress upon the reader, of a wise and benevolent Creator of the physical world. This we shall endeavour to do in the present book.

At the same time that men have thus learnt to look upon God as their Governor and Judge, the source of their support and reward, they have also been led, not only to ascribe to him power and skill, knowledge and goodness, but also to attribute to him these qualities in a mode and degree excluding all limit: — to consider him as almighty, all-wise, of infinite knowledge and inexhaustible goodness; everywhere present and active, but incomprehensible by our minds, both in the manner of his agency, and the degree of his perfections. And this impression concerning the Deity appears to be that which the mind receives from all objects of contemplation and all modes of advance towards truth. To this conception it leaps with alacrity and joy, and in this it acquiesces with tranquil satisfaction and growing confidence; while any other view of the nature of the Divine Power which formed and sustained the world, is incoherent and untenable, exposed to insurmountable objections and intolerable incongruities. We shall endeavour to show that the modes of employment of the thoughts to which the well conducted study of nature gives rise, do tend, in all their forms, to produce or strengthen this impression on the mind; and that such an impression, and no other, is consistent with the wisest views and most comprehensive aspects of nature and of philosophy, which our Natural Philosophy opens to us. This will he the purpose of the latter part of the present hook. In the first place we shall proceed with the object first mentioned, the connexion which may be perceived between the evidences of creative power, and of moral government, in the world.

Chapter I The Creator of the Physical World is the Governor of the Moral World.

With our views of the moral government of the world and the religious interests of man, the study of material nature is not and cannot be directly and closely connected. But it may be of some service to trace in these two lines of reasoning, seemingly so remote, a manifest convergence to the same point, a demonstrable unity of result. It may be useful to show that we are thus led, not to two rulers of the universe, but to one God;—to make it appear that the Creator and Preserver of the world is also the Governor and Judge of men; that the Author of the Laws of Nature is also the Author of the Law of Duty;—that He who regulates corporeal things by properties of attraction and affinity and assimilating power, is the same being who regulates the actions and conditions of men, by the influence of the feeling of responsibility, the perception of right and wrong, the hope of happiness, the love of good.

The conviction that the Divine attributes which we are taught by the study of the material world, and those which we learn from the contemplation of man as a responsible agent, belong to the same Divine Being, will be forced upon us, if we consider the manner in which all the parts of the universe, the corporeal and intellectual, the animal and moral, are connected with each other. In each of these provinces of creation we trace refined adaptations and arrangements which lead us to the Creator and Director of so skilful a system; but these provinces are so intermixed, these different trains of contrivance so interwoven, that we cannot, in our thoughts, separate the author of one part from the author of another. The Creator of the Heavens and of the Earth, of the inorganic and of the organic world, of animals and of man, of the affections and the conscience, appears inevitably to be one and the same God.

We will pursue this reflection a little more into detail.

1. The Atmosphere is a mere mass of fluid floating on the surface of the hall of the earth; it is one of the inert and inorganic portions of the universe, and must be conceived to have been formed by the same Power which formed the solid mass of the earth and all other parts of the solar system. But how far is the atmosphere from being inert in its effects on organic beings, and unconnected with the world of life! By what wonderful adaptations of its mechanical and chemical properties, and of the vital powers of plants, to each other, are the developement and well-being of plants and animals secured! The creator of the atmosphere must have been also the creator of plants and animals: we cannot for an instant believe the contrary. But the atmosphere is not only subservient to the life of animals, and of man among the rest; it is also the vehicle of voice; it answers the purpose of intercourse; and, in the case of man, of rational intercourse. We have seen how remarkably the air is fitted for this office; the construction of the organs of articulation, by which they are enabled to perform their part of the work, is, as is well known, a most exquisite system of contrivances. But though living in an atmosphere capable of transmitting articulate sound, and though provided with organs fitted to articulate, man would never attain to the use of language, if he were not also endowed with another set of faculties. The powers of abstraction and generalization, memory and reason, the tendencies which occasion the inflexions and combinations of words, are all necessary to the formation and use of language. Are not these parts of the same scheme of which the bodily faculties by which we are able to speak are another part? Has man his mental powers independently of the creator of his bodily frame? To what purpose then, or by what cause was the curious and complex machinery of the tongue, the glottis, the larynx produced? These are useful for speech, and full of contrivances which suggest such a use as the end for which those organs were constructed. But speech appears to have been no less contemplated in the intellectual structure of man. The processes of which we have spoken, generalization, abstraction, reasoning, have a close dependence on the use of speech. These faculties are presupposed in the formation of language, but they are developed and perfected by the use of language. The mind of man then, with all its intellectual endowments, is the work of the same artist by whose hands his bodily frame was fashioned; as his bodily faculties again are evidently constructed by the maker of those elements on which their action depends. The creator of the atmosphere and of the material universe is the creator of the human mind, and the author of those wonderful powers of thinking, judging, inferring, discovering, by which we are able to reason concerning the world in which we are placed; and which aid us in lifting our thoughts to the source of our being himself.

2. Light, or the means by which light is propagated, is another of the inorganic elements which forms a portion of the mere material world. The luminiferous ether, if we adopt that theory, or the fluid, light of the theory of emission, must indubitably pervade the remotest regions of the universe, and must be supposed to exist, as soon as we suppose the material parts of the universe to be in existence. The origin of light then must be at least as far removed from us as the origin of the solar system. Yet how closely connected are the properties of light with the structure of our own bodies! The mechanism of the organs of vision and the mechanism of light are, as we have seen, most curiously adapted to each other. We must suppose, then, that the same power and skill produced one and the other of these two sets of contrivances, which so remarkably fit into each other. The creator of light is the author of our visual powers. But how small a portion does mere visual perception constitute of the advantages which we derive from vision! We possess ulterior faculties and capacities by which sight becomes a source of happiness and good to man. The sense of beauty, the love of art, the pleasure arising from the contemplation of nature, are all dependent on the eye; and we can hardly doubt that these faculties were bestowed on man to further the best interests of his being. The sense of beauty both animates and refines his domestic tendencies; the love of art is a powerful instrument for raising him above the mere cravings and satisfactions of his animal nature; the expansion of mind which rises in us at the sight of the starry sky, the cloud-capt mountain, the boundless ocean, seems intended to direct our thoughts by an impressive though

indefinite feeling, to the Infinite Author of All. But if these faculties be thus part of the scheme of man's inner being, given him by a good and wise creator, can we suppose that this creator was any other than the creator also of those visual organs, without which the faculties could have no operation and no existence? As clearly as light and the eye are the work of the same author, so clearly also do our capacities for the most exalted visual pleasures, and the feelings flowing from them, proceed from the same Divine Hand, by which the mechanism of light was constructed.

3. The creator of the earth must be conceived to be the author also of all those qualities in the soil, chemical and whatever else, by which it supports vegetable life, under all the modifications of natural and artificial condition. Among the attributes which the earth thus possesses, there are some which seem to have an especial reference to man in a state of society. Such are the power of the earth to increase its produce under the influence of cultivation, and the necessary existence of property in land, in order that this cultivation may be advantageously applied; the rise, under such circumstances, of a surplus produce, of a quantity of subsistence exceeding the wants of the cultivators alone; and the consequent possibility of inequalities of rank and of all the arrangements of civil society. These are all parts of the constitution of the earth. But these would all remain mere idle possibilities, if the nature of man had not a corresponding direction. If man had not a social and economical tendency, a disposition to congregate and co-operate, to distribute possessions and offices among the members of the community, to make and obey and enforce laws, the earth would in vain be ready to respond to the care of the husbandman. Must we not then suppose that this attribute of the earth was bestowed upon it by Him who gave to man those corresponding attributes, through which the apparent niggardliness of the soil is the source of general comfort and security, of polity and law? Must we not suppose that He who created the soil also inspired man with those social desires and feelings which produce cities and states, laws and institutions, arts and civilization; and that thus the apparently inert mass of earth is a part of the same scheme as those faculties and powers with which man's moral and intellectual progress is most connected?

4. Again: — It will hardly be questioned that the author of the material elements is also the author of the structure of animals, which is adapted to and provided for by the constitution of the elements in such innumerable ways. But the author of the bodily structure of animals must also be the author of their instincts, for without these the structure .would not answer its purpose. And these instincts frequently assume the character of affections in a most remarkable manner. The love of offspring, of home, of companions, are often displayed by animals, in a way that strikes the most indifferent observer; and yet these affections will hardly be denied to be a part of the same scheme as the instincts by which the same animals seek food and the gratifications of sense. Who can doubt that the anxious and devoted affection of the mother-bird for her young after they are hatched, is a part of the same system of Providence as the instinct by which she is impelled to sit upon her eggs? And this, of the same by which her eggs are so organized that incubation leads to the birth of the young animal? Nor, again, can we imagine that while the structure and affections of animals belong to one system of things, the affections of man, in many respects so similar to those of animals, and connected with the bodily frame in a manner so closely analogous, can belong to a different scheme. Who, that reads the touching instances of maternal affection, related so often of the women of all nations, and of the females of all animals, can doubt that the principle of action is the same in the two cases, though enlightened in one of them by the rational faculty? And who can place in separate provinces the supporting and protecting love of the father and of the mother? or consider as entirely distinct from these, and belonging to another part of our nature, the other kinds of family affection? or disjoin man's love of his home, his clan, his tribe, his country, from the affection which he bears to his family? The love of offspring, home, friends, in man, is then part of the same system of contrivances of which bodily organization is another part. And thus the author of our corporeal frame is also the author of our capacity of kindness and resentment, of our love and of our wish to be loved, of all the emotions which bind us to individuals, to our families, and to

our kind.It is not necessary here to follow out and classify these emotions and affections; or to examine how they are combined and connected with our other motives of action, mutually giving and receiving strength and direction. The desire of esteem, of power, of knowledge, of society, the love of kindred, of friends, of our country, are manifestly among the main forces by which man is urged to act and to abstain. And as these parts of the constitution of man are clearly intended, as we conceive, to impel him in his appointed path; so we conceive that they are no less clearly the work of the same great Artificer who created the heart, the eye, the hand, the tongue, and that elemental world in which, by means of these instruments, man pursues the objects of his appetites, desires, and affections.

5. But if the Creator of the world be also the author of our intellectual powers, of our feeling for the beautiful and the sublime, of our social tendencies, and of our natural desires and affections, we shall find it impossible not to ascribe also to Him the higher directive attributes of our nature, the conscience and the religious feeling, the reference of our actions to the rule of duty and to the will of God. It would not suit the plan of the present treatise to enter into any detailed analysis of the connexion of these various portions of our moral constitution. But we may observe that the existence and universality of the conception of duty and right cannot be doubted, however men may differ as to its original or derivative nature. All men are perpetually ed to form judgments concerning actions, and emotions which lead to action, as right or wrong; as what they ought or ought not to do or feel. There is a faculty which approves and disapproves, acquits or condemns the workings of our other faculties. Now, what shall we say of such a judiciary principle, thus introduced among our motives to action? Shall we conceive that while the other springs of action are balanced against each other by our Creator, this, the most pervading and universal regulator, was no part of the original scheme? That— while the love of animal pleasures, of power, of fame, the regard for friends, the pleasure of bestowing pleasure, were infused into man as influences by which his course of life was to be carried on, and his capacities and powers developed and exercised;—this reverence for a moral law, this acknowledgment of the obligation of duty,—a feeling which is every where found, and which may become a powerful, a predominating motive of action, —was given for no purpose, and belongs not to the design? Such an opinion would be much as if we should acknowledge the skill and contrivance manifested in the other parts of a ship, but should refuse to recognize the rudder as exhibiting any evidence of a purpose. Without the reverence which the opinion of right inspires, and the scourge of general disapprobation inflicted on that which is accounted wicked, society could scarcely go on; and certainly the feelings and thoughts and characters of men could not be what they are. Those impulses of nature which involve no acknowledgment of responsibility, and the play and struggle of interfering wishes, might preserve the species in some shape of existence, as we see in the case of brutes. But a person must be strangely constituted, who, living amid the respect for law, the admiration for what is good, the order and virtues and graces of civilized nations, (all which have their origin in some degree in the feeling of responsibility) can maintain that all these are casual and extraneous circumstances, no way contemplated in the formation of man; and that a condition in which there should be no obligation in law, no merit in self-restraint, no beauty in virtue, is equally suited to the powers and the nature of man, and was equally contemplated when those powers were given him.

6. If this supposition be too extravagant to be admitted, as it appears to be, it remains then that man, intended, as we have already seen from his structure and properties, to be a discoursing, social being, acting under the influence of affections, desires, and purposes, was also intended to act under the influence of a sense of duty; and that the acknowledgment of the obligation of a moral law is as much part of his nature, as hunger or thirst, maternal love or the desire of power; that, therefore, in conceiving man as the work of a Creator, we must imagine his powers and character given him with an intention on the Creator's part that this sense of duty should occupy its place in his constitution as an active and thinking being: and that this directive and judiciary principle is a part of the work of the same Author who made the elements to minister to the

material functions, and the arrangements of the world to occupy the individual and social affections of his living creatures.

7. This principle of conscience, it may further be observed, does not stand upon the same level as the other impulses of our constitution by which we are prompted or restrained. By its very nature and essence, it possesses a supremacy over all others. Your obligation to obey this law is its being the law of your nature. That your conscience approves of and attests such a course of action is itself alone an obligation. Conscience does not only offer itself to show us the way we should walk in, but it likewise carries its own authority with it, that it is our natural guide: the guide assigned us by the author of our nature."* That we ought to do an action, is of itself a sufficient and ultimate answer to the questions, why we should do it?—how we are obliged to do it? The conviction of duty implies the soundest reason, the strongest obligation, of which our nature is susceptible.

8. We appear then to be using only language which is well capable of being justified, when we speak of this irresistible esteem for what is right, this conviction of a rule of action extending beyond the gratification of our irreflective impulses, as an impress stamped upon the human mind by the Deity himself; a trace of His nature; an indication of His will; an announcement of His purpose; a promise of His favour; and though this faculty may need to be confirmed and unfolded, instructed and assisted by other aids, it still seems to contain in itself a sufficient intimation that the highest objects of man's existence are to be attained, by means of a direct and intimate reference of his thoughts and actions to the Divine Author of his being.

9. Such then is the Deity to which the researches of Natural Theology point; and so far is the train of reflections in which we have engaged, from being merely speculative and barren. With the material world we cannot stop. If a superior Intelligence have ordered and adjusted the succession of seasons and the structure of the plants of the field, we must allow far more than this at first sight would seem to imply. We must admit still greater powers, still higher wisdom for the creation of the beasts of the forest with their faculties; and higher wisdom still and more transcendent attributes, for the creation of man. And when we reach this point, we find that it is not knowledge only, not power only, not foresight and beneficence alone, which we must attribute to the Maker of the World; but that we must consider him as the Author, in us, of a reverence for moral purity and rectitude; and, if the author of such emotions in us, how can we conceive of Him otherwise, than that these qualities are parts of his nature; and that he is not only wise and great, and good, incomparably beyond our highest conceptions, but also conformed in his purposes to the rule which he thus impresses upon us, that is, Holy in the highest degree which we can image to ourselves as possible.

Chapter II - On the Vastness of the Universe,

1. The aspect of the world, even without any of the peculiar lights which science throws upon it, is fitted to give us an idea of the greatness of the power by which it is directed and governed, far exceeding any notions of power and greatness which are suggested by any other contemplation. The number of human beings who surround us— the various conditions requisite for their life, nutrition, well-being, all fulfilled;—the way in which these conditions are modified, as we pass in thought to other countries, by climate, temperament, habit;—the vast amount of the human population of the globe thus made up:—yet man himself but one among almost endless tribes of animals; — the forest, the field, the desert, the air, the ocean, all teeming with creatures whose bodily wants are as carefully provided for as his; — the sun, the clouds, the winds, all attending, as it were, on these organized beings; — a host of beneficent energies, unwearied by time and succession, pervading every corner of the earth; — this spectacle cannot but give the contemplator a lofty and magnificent conception of the Author of so vast a work, of the Ruler of so wide and rich

an empire, of the Provider for so many and varied wants, the Director and Adjuster of such complex and jarring interests.

But when we take a more exact view of this spectacle, and aid our vision by the discoveries which have been made of the structure and extent of the universe, the impression is incalculably increased.

The number and variety of animals, the exquisite skill displayed in their structure, the comprehensive and profound relations by which they are connected, far exceed any thing which we could have beforehand imagined. But the view of the universe expands also on another side. The earth, the globular body thus covered with life, is not the only globe in the universe. There are, circling about our own sun, six others, so far as we can judge, perfectly analogous in their nature: besides our moon and other bodies analogous to it. No one can resist the temptation to conjecture, that these globes, some of them much larger than our own, are not dead and barren; that they are, like ours, occupied with organization, life, intelligence. To conjecture is all that we can do, yet even by the perception of such a possibility, our view of the domain of nature is enlarged and elevated. The outermost of the planetary globes of which we have spoken is so far from the sun, that the central luminary must appear to the inhabitants of that planet, if any there are, no larger than Venus does to us; and the length of their year will be 82 of ours.

But astronomy carries us still onwards. It teaches us that, with the exception of the planets already mentioned, the stars which we see have no immediate relation to our system. The obvious supposition is that they are of the nature and order of our sun: the minuteness of their apparent magnitude agrees, on this supposition, with the enormous and almost inconceivable distance which, from all the measurements of astronomers, we are led to attribute to them. If then these are suns, they may, like our sun, have planets revolving round them; and these may, like our planet, be the seats of vegetable and animal and rational life:—we may thus have in the universe worlds, no one knows how many, no one can guess how varied;—but however many, however varied, they are still but so many provinces in the same empire, subject to common rules, governed by a common power.

But the stars which we see with the naked eye are but a very small portion of those which the telescope unveils to us. The most imperfect telescope will discover some that are invisible without it; the very best instrument perhaps does not show us the most remote. The number of stars which crowd some parts of the heavens is truly marvellous: Dr. Herschel calculated that a portion of the milky way, about 10 degrees long and??? broad, contained 258,000. In a sky so occupied the moon would eclipse 2000 of such stars at once.

We learn too from the telescope that even in this province the variety of nature is not exhausted. Not only do the stars differ in colour and appearance, but some of them grow periodically fainter and brighter, as if they were dark on one side, and revolved on their axes. In other cases two stars appear close to each other, and in some of these cases it has been clearly established, that the two have a motion of revolution about each other; thus exhibiting an arrangement new to the astronomer, and giving rise, possibly, to new conditions of worlds. In other instances again, the telescope shows, not luminous points, but extended masses of dilute light, like bright clouds, hence called nebulee. Some have supposed (as we have noticed in the \ast book) that such nebulae by further condensation might become suns; but for such opinions we have nothing but conjecture. Some stars again have undergone permanent changes; or have absolutely disappeared, as the celebrated star of 1572, in the constellation Cassiopea.

If we take the whole range of created objects in our own system, from the sun down to the smallest animalcule, and suppose such a system, or something in some way analogous to it, to be repeated

for each of the millions of stars which the telescope reveals to us, we obtain a representation of the material universe; at least a representation which to many persons appears the most probable one. And if we contemplate this aggregate of systems as the work of a Creator, which in our own system we have found ourselves so irresistibly led to do, we obtain a sort of estimate of the extent through which his creative energy may be traced, by taking the widest view of the universe which our faculties have attained.

If we consider further the endless and admirable contrivances and adaptations which philosophers and observers have discovered in every portion of our own system; every new step of our knowledge showing us something new in this respect; and if we combine this consideration with the thought how small a portion of the universe our knowledge includes, we shall, with out being able at all to discern the extent of the skill and wisdom displayed in the creation, see something of the character of the design, and of the copiousness and ampleness of the means which the scheme of the world exhibits. And when we see that the tendency of all the arrangements which we can comprehend is to support the existence, to develope the faculties, to promote the well-being of these countless species of creatures; we shall have some impression of the beneficence and love of the Creator, as manifested in the physical government of his creation.

2. It is extremely difficult to devise any means of bringing before a common apprehension the scale on which the universe is constructed, the enormous proportion which the larger dimensions bear to the smaller, and the amazing number of steps from larger to smaller, or from small to larger, which the consideration of it offers. The following comparative representations may serve to give the reader to whom the subject is new some idea of these steps.

If we suppose the earth to be represented by a globe a foot in diameter, the distance of the sun from the earth will be about two miles; the diameter of the sun, on the same supposition, will be something above one hundred feet, and consequently his bulk such as might be made up of two hemispheres, each about the size of the dome of St. Paul's. The moon will be thirty feet from us, .and her diameter three inches, about that of a cricket ball. Thus the • sun would much more than occupy all the space within the moon's orbit. On the same scale, Jupiter would be above ten miles from the sun, and Uranus forty. We see then how thinly scattered through space are the heavenly bodies. The fixed stars would be at an unknown distance, but, probably, if all distances were thus diminished, no star would be nearer to such a one-foot earth, than the moon now is to us.

On such a terrestrial globe the highest mountains would be about l-80th of an inch high, and consequently only just distinguishable. We may imagine therefore how imperceptible would be the largest animals. The whole organized covering of such an earth would be quite undiscoverable by the eye, except perhaps by colour, like the bloom on a plum.

In order to restore the earth and its inhabitants to their true dimensions, we must magnify the length, breadth, and thickness of every part of our supposed models forty millions of times; and to preserve the proportions, we must increase equally the distances of the sun and of the stars from us. They seem thus to pass off into infinity; yet each of them thus removed, has its system of mechanical and perhaps of organic processes going on upon its surface.

But the arrangements of organic life which we can see with the naked eye are few, compared with those which the microscope detects. We know that we may magnify objects thousands of times, and still discover fresh complexities of structure; if we suppose, therefore, that we thus magnify every member of the universe and every particle of matter of which it consists; we may imagine that we make perceptible to our senses the vast multitude of organized adaptations which lie hid on every side of us; and in this manner we approach towards an estimate of the extent through

which we may trace the power and skill of the Creator, by scrutinizing his work with the utmost subtlety of our faculties.

3. The other numerical quantities which we have to consider in the phenomena of the universe are on as gigantic a scale as the distances and sizes. By the rotation of the earth on its axis, the parts of the equator move at the rate of a thousand miles an hour, and the portions of the earth's surface which are in our latitude, at about six hundred. The former velocity is nearly that with which a cannon ball is discharged from the mouth of a gun; but, large as it is, it is inconsiderable compared with the velocity of the earth in its orbit about the sun. This latter velocity is sixty-five times the former. By the rotatory motion of the earth, a point of its surface is carried sometimes forwards and sometimes backwards with regard to the annual progression; but in consequence of the great predominance of the annual motion in amount, the diurnal scarcely affects it either way in any appreciable degree. And even the velocity of the earth in her orbit is inconsiderable compared with that of light; which comparison, however, we shall not make; since, according to the theory we have considered as most probable, the motion of light is not a transfer of matter but of motion from one part of space to another.

The extent of the scale of density of different substances has already been mentioned; gold is twenty times as heavy as water; air is eight hundred and thirty times lighter, steam eight thousand times lighter than water; the luminiferous ether is incomparably rarer than steam: and this is true of the matter of light, whether we adopt the undulatory theory or any other.

4. The above estimates are vast in amount, and almost oppressive to our faculties. They belong to the measurement of the powers which are exerted in the universe, and of the spaces through which their efficacy reaches (for the most distant bodies are probably connected both by gravity and light). But these estimates cannot be said so much to give us any notion of the powers of the Deity, as to correct the errors we should fall into by supposing his powers to have any limits like those which belong to our faculties:—by supposing that numbers, and spaces, and forces, and combinations, which would overwhelm us, are any obstacle to the arrangements which his plan requires. We can easily understand that to an intelligence surpassing ours in degree only, that may be easy which is impossible to us. The child who cannot count beyond four, the savage who has no name for any number above five, cannot comprehend the possibility of dealing with thousands and millions: yet a little additional developement of the intellect makes such numbers conceivable and manageable. The difficulty which appears to reside in numbers and magnitudes and stages of subordination, is one produced by judging from ourselves—by measuring with our own sounding line; when that reaches no bottom, the ocean appears unfathomable. Yet in fact how is a hundred millions of miles a great distance? how is a hundred millions of times a great ratio? Not in itself; this greatness is no quality of the numbers which can be proved like their mathematical properties; on the contrary, all that absolutely belongs to number, space, and ratio, must, we know demonstrably, be equally true of the largest and the smallest. It is clear that the greatness of these expressions of measure has reference to our faculties only. Our astonishment and embarrassment take for granted the limits of our own nature. We have a tendency to treat a difference of degree and of addition, as if it were a difference of kind and of transformation. The existence of the attributes, design, power, goodness, is a matter depending on obvious grounds: about these qualities there can be no mistake: if we can know anything, we can know these attributes when we see them. But the extent, the limits of such attributes must be determined by their effects; our knowledge of their limits by what we see of the effects. Nor is any extent, any amount of power and goodness improbable beforehand: we know that these must be great, we cannot tell how great. We should not expect beforehand to find them bounded; and therefore when the boundless prospect opens before us, we may be bewildered, but we have no reason to be shaken in our conviction of the reality of the cause from which their effects proceed: we may feel ourselves incapable of following

the train of thought, and may stop, but we have no rational motive for quitting the point which we have thus attained in tracing the Divine Perfections.

On the contrary, those magnitudes and proportions which leave our powers of conception far behind;—that ever-expanding view which is brought before us, of the scale and mechanism, the riches and magnificence, the population and activity of the universe;—may reasonably serve, not to disturb, but to enlarge and elevate our conceptions of the Maker and Master of all; to feed an ever-growing admiration of His wonderful nature; and to excite a desire to be able to contemplate more steadily and conceive less inadequately the scheme of his government and the operation of his power.

Chapter III - On Mans Place in the Universe.

The mere aspect of the starry heavens, without taking into account the view of them to which science introduces us, tends strongly to force upon man the impression of his own insignificance. The vault of the sky arched at a vast and unknown distance over our heads; the stars, apparently infinite in number, each keeping its appointed place and course, and seeming to belong to a wide system of things which has no relation to the earth; while man is but one among many millions of the earth's inhabitants;—all this makes the contemplative spectator feel how exceedingly small a portion of the universe he is; how little he must be, in the eyes of an intelligence which can embrace the whole. Everyperson, in every age and country, will recognise as irresistibly natural the train of thought expressed by the Hebrew psalmist:

When I consider the heavens, the work of thy hands—
The moon and the stars which thou hast ordained—
Lord, what is man that thou art mindful of him,
or the son of man that thou regardest him?

If this be the feeling of the untaught person, when he contemplates the aspect of the skies, such as they offer themselves to a casual and unassisted glance, the impression must needs be incalculably augmented, when we look at the universe with the aid of astronomical discovery and theory. We then find, that a few of the shining points which we see scattered on the face of the sky in such profusion, appear to be of the same nature as the earth, and may perhaps, as analogy would suggest, be like the earth, the habitations of organized beings;—that the rest of "the host of heaven" may, by a like analogy, be conjectured to be the centres of similar systems of revolving worlds;—that the vision of man has gone travelling onwards, to an extent never anticipated, through this multitude of systems, and that while myriads of new centres start up at every advance, he appears as yet not to have received any intimation of a limit. Every person probably feels, at first, lost, confounded, overwhelmed, with the vastness of this spectacle; and seems to himself, as it were, annihilated by the magnitude and multitude of the objects which thus compose the universe. The distance between him and the Creator of the world appears to be increased beyond measure by this disclosure. It seems as if a single individual could have no chance and no claim for the regard of the Ruler of the whole.

The mode in which the belief of God's government of the physical world is important and interesting to man, is, as has already been said, through the connexion which this belief has with the conviction of God's government of the moral world; this latter government being, from its nature, one which has a personal relation to each individual, his actions and thoughts. It will, therefore, illustrate our subject to show that this impression of the difficulty of a personal superintendence and government, exercised by the Maker of the world over each of his rational and free creatures, is founded upon illusory views; and that on an attentive and philosophical

examination of the subject, such a government is in accordance with all that we can discover of the scheme and the scale of the universe.

1. We may, in the first place, repeat the observation made in the last chapter, on the confusion which sometimes arises in our minds, and makes us consider the number of the objects of the Divine care as a difficulty in the way of its exercise. If we can conceive this care employed on a million persons—on the population of a kingdom, of a city, of a street—there is no real difficulty in supposing it extended to every planet in the solar system, admitting each to be peopled as ours is; nor to every part of the universe, supposing each star the centre of such a system. Large numbers have no peculiar attributes which distinguish them from small ones; and when we disregard the common limits of our own faculties, which, though important to us, can have no application to the Divine nature, it is quite as allowable to suppose a million millions of earths, as one, to be under the moral government of God.

2. In the next place we may remark, not only that no reason can be assigned why the Divine care should not extend to a much greater number of individuals than we at first imagine, but that in fact we know that it does so extend. It has been well observed, that about the same time when the invention of the telescope showed us that there might be myriads of other worlds claiming the Creator's care; the invention of the microscope proved to us that there were in our own world myriads of creatures, before unknown, which this care was preserving. While one discovery seemed to remove the Divine Providence further from us, the other gave us most striking examples that it was far more active in our neighbourhood than we had supposed: while the first extended the boundaries of God's known kingdom, the second made its known administration more minute and careful. It appeared that in the leaf and in the bud, in solids and in fluids, animals existed hitherto unsuspected; the apparently dead masses and blank spaces of the world were found to swarm with life. And yet, of the animals thus revealed, all, though unknown to us before, had never been forgotten by providence. Their structure, their vessels and limbs, their adaptation to their situation, their food and habitations, were regulated in as beautiful and complete a manner as those of the largest and apparently most favoured animals. The smallest insects are as exactly finished, often as gaily ornamented, as the most graceful beast or the birds of brightest plumage. And when we seem to go out of the domain of the complex animal structure with which we are familiar, and come to animals of apparently more scanty faculties, and less developed powers of enjoyment and action, we still find that their faculties and their senses are in exact harmony with their situation and circumstances; that the wants which they have are provided for, and the powers which they possess called into activity. So that Muller, the patient and accurate observer of the smallest and most obscure microscopical animalcula, declares that all classes alike, those which have manifest organs, and those which have not, offer a vast quantity of new and striking views of the animal economy; every step of our discoveries leading us to admire the design and care of the Creator.* We find, therefore, that the Divine Providence is, in fact, capable of extending itself adequately to an immense succession of tribes of beings, surpassing what we can image or could previously have anticipated; and thus we may feel secure, so far as analogy can secure us, that the mere multitude of created objects cannot remove us from the government and superintendence of the Creator.

3. We may observe further, that, vast as are the parts and proportions of the universe, we still appear to be able to perceive that it is finite; the subordination of magnitudes and numbers and classes appears to have its limits. Thus, for anything which we can discover, the sun is the largest body in the universe; and at any rate, bodies of the order of the sun are the largest of which we have any evidence: we know of no substances denser than gold and platinum, and it is improbable that any denser, or at least much denser, should ever be detected: the largest animals which exist in the sea and on the earth are almost certainly known to us. We may venture also to say, that the smallest animals which possess in their structure a clear analogy with larger ones, have been

already seen. Many of the animals which the microscope detects, are as complete and complex in their organization as those of larger size: but beyond a certain point, they appear, as they become more minute, to be reduced to a homogeneity and simplicity of composition which almost excludes them from the domain of animal life. The smallest microscopical objects which can be supposed to be organic, are points,* or gelatinous globules,* or threads,! in which no distinct organs, interior, or exterior, can be discovered. These, it is clear, cannot be considered as indicating an indefinite progression of animal life in a descending scale of minuteness. We can, mathematically speaking, conceive one of these animals as perfect and complicated in its structure as an elephant or an eagle, but we do not find it so in nature. It appears, on the contrary, in these objects, as if we were, at a certain point of magnitude, reaching the boundaries of the animal world. We need not here consider the hypothesis and opinions to which these ambiguous objects have given rise; but without any theory, they tend to show that the subordination of organic life is finite on the side of the little as well as of the great.

Some persons might, perhaps, imagine that a ground for believing the smallness of organized beings to be limited, might be found in what we know of the constitution of matter. If solids and fluids consist of particles of a definite, though exceeding smallness, which cannot further be divided or diminished, it is manifest that we have, in the smallness of these particles, a limit to the possible size of the vessels and organs of animals. The fluids which are secreted, and which circulate in the body of a mite, must needs consist of a vast number of particles, or they would not be fluids; and an animal might he so much smaller than a mite, that its tubes could not contain a sufficient collection of the atoms of matter, to carry on its functions. We should, therefore, of necessity reach a limit of minuteness in organic life, if we could demonstrate that matter is composed of such indivisible atoms. We shall not, however, build anything on this argument; because, though the atomic theory is sometimes said to be proved, what is proved is, that chemical and other effects take place as if they were the aggregate of the effects of certain particles of different elements, the proportions of which particles are fixed and definite; but that any limit can be assigned to the smallness of these particles, has never yet been made out. We prefer, therefore, to rest the proof of the finite extent of animal life, as to size on the microscopical observations previously referred to.

Probably we cannot yet be said to have reached the limit of the universe with the power of our telescopes; that is, it does not appear that telescopes have yet been used, so powerful in exhibiting small stars, that we can assume that more powerful instruments would not discover new stars. Whether or no, however, this degree of perfection has been reached we have no proof that it does not exist; if it were once obtained, we should have, with some approximation, the limit of the universe as to the number of worlds, as we have already endeavoured to show we have obtained the limits with regard to the largeness and smallness of the inhabitants of our own world.

In like manner, although the discovery of new species in some of the kingdoms of nature has gone on recently with enormous rapidity, and to an immense extent;—for instance in botany, where the species known in the time of Linnaeus were about 10,000, and are now above 100,000; —there can be no doubt that the number of species and genera is really limited; and though a great extension of our knowledge is required to reach these limits, it is our ignorance merely, and not their non-existence, which removes them from us.

In the same way it would appear that the universe, so far as it is an object of our knowledge, is finite in other respects also. Now when we have once attained this conviction, all the oppressive apprehension of being overlooked in the government of the universe has no longer any rational source. For in the superintendence of a finite system of things, what is there which can appear difficult or overwhelming to a Being such as we must, from what we know, conceive the Creator to be? Difficulties arising from space, number, gradation, are such as we can conceive ourselves

capable of overcoming, merely by an extension of our present faculties. Is it not then easy to imagine that such difficulties must vanish before him who made us and our faculties? Let it be considered how enormous a proportion the largest work of man bears to the smallest;—the great pyramid to the point of a needle. This comparison does not overwhelm us, because we know that man has made both. Yet the difference between this proportion and that of the sun to the claw of a mite, does not at all correspond to the difference which we must suppose to obtain between the Creator and the creature. It appears then that, if the first flash of that view of the universe which science reveals to us, does sometimes dazzle and bewilder men, a more attentive examination of the prospect, by the light we thus obtain, shows us how unfounded is the despair of our being the objects of Divine Providence, how absurd the persuasion that we have discovered the universe to be too large for its ruler.

4. Another ground of satisfactory reflexion, having the same tendency, is to be found in the admirable order and consistency, the subordination and proportion of parts, which we find to prevail in the universe, as far as our discoveries reach. We have, it may be, a multitude almost innumerable of worlds, but no symptom of crowding, of confusion, of interference. All such defects are avoided by the manner in which these worlds are distributed into systems;—these systems, each occupying a vast space, but yet disposed at distances before which their own dimensions shrink into insignificance;—all governed by one law, yet this law so concentrating its operation on each system, that each proceeds as if there were no other, and so regulating its own effects that perpetual change produces permanent uniformity. This is the kind of harmonious relation which we perceive in that part of the' universe, the mechanical part namely, the laws of which are best known to us. In other provinces, where our knowledge is more imperfect, we can see glimpses of a similar vastness of combination, producing, by its very nature, completeness of detail. Any analogy by which we can extend such views to the moral world, must be of a very wide and indefinite kind; yet the contemplation of this admirable relation of the arrangements of the physical creation, and the perfect working of their laws, is well calculated to give us confidence in a similar beauty and perfection in the arrangements by which our moral relations are directed, our higher powers and hopes unfolded. We may readily believe that there is, in this part of the creation also, an order, a subordination of some relation to others, which may remove all difficulty arising from the vast multitude of moral agents and actions, and make it possible that the superintendence of the moral world shall be directed with as exact a tendency to moral good, as that by which the government of the physical world is directed to physical good.

We may perhaps see glimpses of such an order, in the arrangements by which our highest and most important duties depend upon our relation to a small circle of persons immediately around us: and again, in the manner in which our acting well or ill results from the operation of a few principles within us; as our conscience, our desire of moral excellence, and of the favour of God. We can hardly consider such principles otherwise than as intended to occupy their proper place in the system by which man's destination is to be determined; and thus, as among the means of the government and superintendence of God in the moral world.

That there must be an order and a system to which such regulative principles belong, the whole analogy of creation compels us to believe. It would be strange indeed, if, while the mechanical world, the system of inert matter, is so arranged that we cannot contemplate its order without an elevated intellectual pleasure;—while organized life has no faculties without their proper scope, no tendencies without their appointed object;—the rational faculties and moral tendencies of man should belong to no systematic order, should operate with no corresponding purpose: that, while the perception of sweet and bitter has its acknowledged and unquestionable uses, the universal perception of right and wrong, the unconquerable belief of the merit of certain feelings and actions, the craving alike after moral advancement and after the means of attaining it, should exist only to delude, perplex, and disappoint man. No one, with his contemplations calmed and filled

and harmonized by the view of the known constitution of the universe, its machinery "wheeling unshaken" in the farthest skies and in the darkest cavern, its vital spirit breathing alike effectively in the veins of the philosopher and the worm;—no one, under the influence of such a train of contemplations, can possibly admit into his mind a persuasion which makes the moral part of our nature a collection of inconsistent and futile impressions, of idle dreams and warring opinions, each having the same claims to our acceptance. Wide as is the distance between the material and the moral world; imperfect as all reasonings necessarily are which attempt to carry the inferences of one into the other; elevated above the region of matter as all the principles and grounds of truth must be, which belong to our responsibilities and hopes; still the astronomical and natural philosopher can hardly fail to draw from their studies an imperturbable conviction that our moral nature cannot correspond to those representations according to which it has no law, coherency, or object. The mere natural reasoner may, or must, stop far short of all that it is his highest interest to know, his first duty to pursue; but even he, if he take any elevated and comprehensive views of his own subject, must escape from the opinions, as unphilosophical as they are comfortless, which would expel from our view of the world all reference to duty and moral good, all reliance on the most universal grounds of trust and hope.

Men's belief of their duty, and of the reasons for practising it, connected as it is with the conviction of a personal relation to their Maker, and of His power of superintendence and reward, is as manifest a fact in the moral, as any that can be pointed out is in the natural world. By the mere analogy which has been intimated, therefore, we cannot but conceive that this fact belongs in some manner or other to the order of the moral world, and of its government.

When any one acknowledges a moral governor of the world; perceives that domestic and social relations are perpetually operating and seem intended to operate, to retain and direct men in the path of duty; and feels that the voice of conscience, the peace of heart which results from a course of virtue, and the consolations of devotion, are ever ready to assume their office as our guides and aids in the conduct of all our actions;—he will probably be willing to acknowledge also that the means of a moral government of each individual are not wanting; and will no longer be oppressed or disturbed by the apprehension that the superintendence of the world may be too difficult for its Ruler, and that any of His subjects and servants may be overlooked. He will no more fear that the moral than that the physical laws of God's creation should be forgotten in any particular case: and as he knows that every sparrow which falls to the ground contains in its structure innumerable marks of the Divine care and kindness, he will be persuaded that every man, however apparently humble and insignificant, will have his moral being dealt with according to the laws of God's wisdom and love; will be enlightened, supported, and raised, if he use the appointed means which God's administration of the world of moral light and good offers to his use.

Chapter IV - On the Impression produced by the Contemplation of Laws of Nature; or, on the Conviction that Law implies Mind

The various trains of thought and reasoning which lead men from a consideration of the natural world to the conviction of the existence, the power, the providence of God, do not require, for the most part, any long or laboured deduction, to give them their effect on the mind. On the contrary, they have, in every age and country, produced their impression on multitudes who have not instituted any formal reasonings upon the subject, and probably upon many who have not put their conclusions in the shape of any express propositions. The persuasion of a superior intelligence and will, which manifests itself in every part of the material world, is, as is well known, so widely diffused and deeply infixed, as to have made it a question among speculative men whether the notion of such a power is not universal and innate. It is our business to show only how plainly and how universally such a belief results from the study of the appearances about us. That in many nations, in many periods, this persuasion has been mixed up with much that was erroneous and

perverse in the opinions of the intellect or the fictions of the fancy, does not weaken the force of such consent. The belief of a supernatural and presiding power runs through all these errors: and while the perversions are manifestly the work of caprice and illusion, and vanish at the first ray of sober enquiry, the belief itself is substantial and consistent, and grows in strength upon every new examination. It was the firmness and solidity of the conviction of something Divine which gave a hold and permanence to the figments of so many false divinities. And those who have traced the progress of human thought on other subjects, will not think it strange, that while the fundamental persuasion of a Deity was thus irremoveably seated in the human mind, the developement of this conception into a consistent, pure, and steadfast belief in one Almighty and Holy Father and God, should be long missed, or never attained, by the struggle of the human faculties; should require long reflexion to mature it, and the aid of revelation to establish it in the world.

The view of the universe which we have principally had occasion to present to the reader, is that in which we consider its appearances as reducible to certain fixed and general laws. Availing ourselves of some of the lights which modern science supplies, we-have endeavoured to show that the adaptation of such laws to each other, and their fitness to promote the harmonious and beneficial course of the world, may be traced, wherever we can discover the laws themselves; and that the conceptions of the Divine Power, Goodness and Superintendence which we thus form, agree in a remarkable manner with the views of the Supreme Being, to which reason, enlightened by the divine revelation, has led.

But we conceive that the general impressions of mankind would go further than a mere assent to the argument as we have thus stated it. To most persons it appears that the mere existence of a law connecting and governing any class of phenomena, implies a presiding intelligence which has preconceived and established the law. When events are regulated by precise rules of time and space, of number and measure, men conceive these rules to be the evidence of thought and mind, even without discovering in the rules any peculiar adaptations, or without supposing their purpose to be known.

The origin and the validity of such an impression on the human mind may appear to some matters of abstruse and doubtful speculation: yet the tendency to such a belief prevails strongly and widely, both among the common class of minds whose thoughts are casually and unsystematically turned to such subjects, and among philosophers to whom laws of nature are habitual subjects of contemplation. We conceive therefore that such a tendency may deserve to be briefly illustrated; and we trust also that some attention to this point may be of service in throwing light upon the true relation of the study of nature to the belief in God.

1. A very slight attention shows us how readily order and regularity suggest to a common apprehension the operation of a calm and untroubled intelligence presiding over the course of events. Thus the materialist poet, in accounting for the belief in the Gods, though he does not share it, cannot deny the habitual effect of this manifestation.

Prseterea coeli rationes ordine certo
Et variu annorum cernebant tempora vorti;
Nee poterant quibus id fieret cognoscere caussis.
Ergo perfugium sibi habebant omnia Divis
Tradere et illorum nutu facere omnia flecti.
Lucret. v. 1182.

They saw the skies in constant order run,
The varied seasons and the circling sun,
Apparent rule, with unapparent cause,

And thus they sought in Gods the source of laws.

The same feeling may be traced in the early mythology of a large portion of the globe. We might easily, taking advantage of the labours of learned men, exemplify this in the case of the oriental nations of Greece, and of many other countries. Nor does there appear much difficulty in pointing out the error of those who have maintained that all religion had its origin in the worship of the stars and the elements; and who have insinuated that all such impressions are unfounded, inasmuch as these are certainly not right objects of human worship. The religious feeling, the conviction of a supernatural power, of an intelligence connecting and directing the phenomena of the world, had not its origin in the worship of sun, or stars, or elements; but was itself the necessary though unexpressed foundation of all worship, and all forms of false, as well as true, religion. The contemplation of the earth and heavens called into action this religious tendency in man; and to say that the worship of the material world formed or suggested this religious feeling, is to invert the order of possible things in the most unphilosophical manner. Idolatry is not the source of the belief in God, but is a compound of the persuasion of a supernatural government, with certain extravagant and baseless conceptions as to the manner in which this government is exercised.

We will quote a passage from an author who has illustrated at considerable length the hypothesis that all religious belief is derived from the worship of the elements.

Light, and darkness its perpetual contrast; the succession of days and nights, the periodical order of the seasons; the career of the brilliant luminary which regulates their course; that of the moon his sister and rival; night, and the innumerable fires which she lights in the blue vault of heaven; the revolutions of the stars, which exhibit them for a longer or a shorter period above our horizon; the constancy of this period in the fixed stars, its variety in the wandering stars, the planets; their direct and retrograde course, their momentary rest; the phases of the moon waxing, full, waning, divested of all light; the progressive motion of the sun upwards, downwards; the successive order of the rising and setting of the fixed stars which mark the different points of the course of the sun, while the various aspects which the earth itself assumes mark, here below also, the same periods of the sun's annual motion; . . .all these different pictures, displayed before the eyes of man, form the great and magnificent spectacle by which I suppose him surrounded at the moment when he is about to create his gods.

What is this (divested of its wanton levity of expression) but to say, that when man has so far traced the course of nature as to be irresistibly impressed with the existence of order, law, variety in constancy, and fixity in change; of relations of form and space, duration and succession, cause and consequence, among the objects which surround him; there springs up in his breast, unbidden and irresistibly, the thought of superintending intelligence—of a mind which comprehended from the first and completely that which he late and partially comes to know? The worship of earth and sky, of the host of heaven and the influences of nature, is not the ultimate and fundamental fact in the early history of the religious impressions of mankind. These are but derivative streams, impure and scanty, from the fountain of religious feeling which appears to be disclosed to us by the contemplation of the universe, as the seat of law and the manifestation of intellect. Time suggests to man the thought of eternity; space of infinity; law of intelligence; order of purpose; and however difficult and long a task it may be to develope these suggestions into clear convictions, these thoughts are the real parents of our natural religious belief. The only relation between true religion and the worship of the elemental world is, that the latter is the partial and gross perversion, the former the consistent and pure developement of the same original idea.

2. The connexion of the laws of the material world with an intelligence which preconceived and instituted the law, which is thus, as we perceive, so generally impressed on the common apprehension of mankind, has also struck no less those who have studied nature with a more

systematic attention, and with the peculiar views which belong to science. The laws which such persons learn and study, seem, indeed, most naturally to lead to the conviction of an intelligence which orginally gave to each law its form. What we call a general law is, in truth, a form of expression including a number of facts of like kind. The facts are separate; the unity of view by which we associate them, the character of generality and of law, resides in those relations which are the object of the intellect. The law once apprehended by us, takes in our minds the place of the facts themselves, and is said to govern or determine them, because it determines our anticipations of what they will be. But we cannot, it would seem, conceive a law, founded on such intelligible relations, to govern and determine the facts themselves, any otherwise than by supposing also an intelligence by which these relations are contemplated, and these consequences realized. We cannot then represent to ourselves the universe governed by general laws, otherwise than by conceiving an intelligent and conscious Deity, by whom these laws were originally contemplated, established, and applied.

This perhaps will appear more clear when it is considered that the laws of which we speak are often of an abstruse and complex kind, depending upon relations of space, time, number, and other properties, which we perceive by great attention and thought. These relations are often combined so variously and curiously, that the most subtle reasonings and calculations which we can form are requisite in order to trace their results. Can such laws be conceived to be instituted without any exercise of knowledge and intelligence? can material objects apply geometry and calculation to themselves? can the lenses of the eye, for instance, be formed and adjusted with an exact suitableness to their refractive powers, while there is in the agency which has framed them, no consciousness of the laws of light, of the course of rays, of the visible properties of things? This appears to be altogether inconceivable.

Every particle of matter possesses an almost endless train of properties, each acting according to its peculiar and fixed laws. For every atom of the same kind of matter these laws are invariably and perpetually the same, while for different kinds of matter the difference of these properties is equally constant. This constant and precise resemblance, this variation equally constant and equally regular, suggest irresistibly the conception of some cause, independent of the atoms themselves, by which their similarity and dissimilarity, the agreement and difference of their deportment under the same circumstances, have been determined. Such a view of the constitution of matter, as is observed by an eminent writer of our own time, effectually destroys the idea of its eternal and self-existent nature, “by giving to each of its atoms the essential characters, at once, of a manufactured article and a subordinate agent.”

That such an impression, and the consequent belief in a divine Author of the universe, by whom its laws were ordained and established, does result from the philosophical contemplation of nature, will, we trust, become still more evident by tracing the effect produced upon men's minds by the discovery of such laws and properties as those of which we have been speaking; and we shall therefore make a few observations on this subject.

Chapter V - On Inductive Habits; or, on the Impression produced on Men’s minds by discovering Laws of Nature

The object of physical science is to discover such laws and properties as those of which we have spoken in the last chapter. In this task, undoubtedly a progress has been made on which we may well look with pleasure and admiration; yet we cannot hesitate to confess that the extent of our knowledge on such subjects bears no proportion to that of our ignorance. Of the great and comprehensive laws which rule over the widest provinces of natural phenomena, few have yet been disclosed to us. And the names of the philosophers, whose high office it has been to detect such laws, are even yet far from numerous. In looking back at the path by which science has advanced to

its present position, we see the names of the great discoverers shine out like luminaries, few and scattered along the line: by far the largest portion of the space is occupied by those whose comparatively humble office it was to verify, to develope, to apply the general truths which the discoverers brought to light.

It will readily be conceived that it is no easy matter, if it be possible, to analyse the process of thought by which laws of nature have thus been discovered; a process which, as we have said, has been in so few instances successfully performed. We shall not here make any attempt at such an analysis. But without this, we conceive it may be shown that the constitution and employment of the mind on which such discoveries depend, are friendly to that belief in a wise and good Creator and Governor of the world, which it has been our object to illustrate and confirm. And if it should appear that those who see further than their fellows into the bearings and dependencies of the material things and elements by which they are surrounded, have also been, in almost every case, earnest and forward in acknowledging the relation of all things to a supreme intelligence and will; we shall be fortified in our persuasion that the true scientific perception of the general constitution of the universe, and of the mode in which events are produced and connected, is fitted to lead us to the conception and belief of God.

Let us consider for a moment what takes place in the mind of a student of nature when he attains to the perception of a law previously un. known, connecting the appearances which he has studied. A mass of facts which before seemed incoherent and unmeaning, assume, on a sudden, the aspect of connection and intelligible order. Thus, when Kepler discovered the law which connects the periodic times with the diameters of the planetary orbits; or, when Newton showed how this and all other known mathematical properties of the solar system were included in the law of universal gravitation according to the inverse square of the distance; particular circumstances which, before, were merely matter of independent record, became, from that time, indissolubly conjoined by the laws so discovered. The separate occurrences and facts, which might hitherto have seemed casual and without reason, were now seen to be all exemplifications of the same truth. The change is like that which takes place when we attempt to read a sentence written in difficult or imperfect characters. For a time the separate parts appear to be disjoined and arbitrary marks; the suggestions of possible meanings, which succeed each other in the mind, fail, as fast as they are tried, in combining or accounting for these symbols: but at last the true supposition occurs; some words are found to coincide with the meaning thus assumed; the whole line of letters appear to take definite shapes and to leap into their proper places; and the truth of the happy conjecture seems to flash upon us from every part of the inscription.

The discovery of laws of nature, truly and satisfactorily connecting and explaining phenomena, of which, before, the connexion and causes had been unknown, displays much of a similar process, of obscurity succeeded by evidence, of effort and perplexity followed by conviction and repose. The innumerable conjectures and failures, the glimpses of light perpetually opening and as often clouded over, by which Kepler was tantalized, the unwearied perseverance and inexhaustible ingenuity which he exercised, while seeking for the laws which he finally discovered, are, thanks to his communicative disposition, curiously exhibited in his works, and have been narrated by his biographers; and such efforts and alternations, modified by character and circumstances, must generally precede the detection of any of the wider laws and dependencies by which the events of the universe are regulated. We may readily conceive the satisfaction and delight with which, after this perplexity and struggle, the discoverer finds himself in light and tranquillity; able to look at the province of nature which has been the subject of his study, and to read there an intelligible connexion, a sufficing reason, which no one before him had understood or apprehended.

This step so much resembles the mode in which one intelligent being understands and apprehends the conceptions of another, that we cannot be surprised if those persons in whose minds such a

process has taken place, have been most ready to acknowledge the existence and operation of a superintending intelligence, whose ordinances it was their employment to study. When they had just read a sentence of the table of the laws of the universe, they could not doubt whether it had had a legislator. When they had decyphered there a comprehensive and substantial truth, they could not believe that the letters had been thrown together by chance. They could not but readily acknowledge that what their faculties had enabled them to read, must have been written by some higher and profounder mind. And accordingly, we conceive it will be found, on examining the works of those to whom we owe our knowledge of the laws of nature, and especially of the wider and more comprehensive laws, that such persons have been strongly and habitually impressed with the persuasion of a Divine Purpose and Power which had regulated the events which they had attended to, and ordained the laws which they had detected.

To those who have pursued science without reaching the rank of discoverers;—who have possessed a derivative knowledge of the laws of nature which others had disclosed, and have employed themselves in tracing the consequences of such laws, and systematising the body of truth thus produced, the above description does not apply;' and we have not therefore in these cases the same ground for anticipating the same frame of mind. If among men of science of this class, the persuasion of a supreme Intelligence has at some periods been less vivid and less universal, than in that higher class of which we have before spoken, the fact, so far as it has existed, may perhaps be in some degree accounted for. But whether the view which we have to give of the mental peculiarities of men whose science is of this derivative kind be well founded, and whether the account we have above offered of that which takes place in the minds of original discoverers of laws in scientific researches be true, or not, it will probably be considered a matter of some interest to point out historically that in fact, such discoverers have been peculiarly in the habit of considering the world as the work of God. This we shall now proceed to do.

As we have already said, the names of great discoverers are not very numerous. The sciences which we may look upon as having reached or at least approached their complete and finished form, are Mechanics, Hydrostatics, and Physical Astronomy. Galileo is the father of modern Mechanics; Copernicus, Kepler, and Newton are the great names which mark the progress of Astronomy. Hydrostatics shared in a great measure the fortunes of the related science of Mechanics; Boyle and Pascal were the persons mainly active in developing its more peculiar principles. The other branches of knowledge which belong to natural philosophy, as Chemistry and Meteorology, are as yet imperfect, and perhaps infant sciences; and it would be rash to presume to select in them, names of equal preeminence with those above mentioned: but it may not be difficult to show, with sufficient evidence, that the effect of science upon the authors of science is, in these subjects as in the former ones, far other than to alienate their minds from religious trains of thought, and a habit of considering the world as the work of God.

We shall not dwell much on the first of the above mentioned great names, Galileo; for his scientific merit consisted rather in adopting the sound philosophy of others, as in the case of the Copernican system, and in combating prevalent errors, as in the case of the Aristotelian doctrines concerning motion, than in any marked and prominent discovery of new principles. Moreover the mechanical laws which he had a share in bringing to light, depending as they did, rather on detached experiments and transient facts, than on observation of the general course of the universe, could not so clearly suggest any reflexion on the government of the world at that period, as they did afterwards when Newton showed their bearing on the cosmical system. Yet Galileo, as a man of philosophical and inventive mind, who produced a great effect on the progress of physical knowledge, is a person whose opinions must naturally interest us, engaged in our present course of reasoning. There is in his writings little which bears upon religious views, as there is in the nature of his works little to lead him to such subjects. Yet strong expressions of piety are not wanting, both in his letters, and in his published treatises. The persecution which he underwent, on account

of his writings in favour of the Copernican system, was grounded, not on his opposition to the general truths of natural religion, which is our main concern at present, nor even on any supposed rejection of any articles of Christian faith, but on the alleged discrepancy between his adopted astronomical views and the declarations of scripture. Some of his remarks may interest the reader.

In his third dialogue on the Copernican system he has occasion to speak of the opinion which holds all parts of the world to be framed for man's use alone: and to this he says:

I would that we should not so shorten the arm of God in the government of human affairs; but that we should rest in this, that we are certain that God and nature are so occupied in the government of human affairs, that they could not more attend to us if they were charged with the care of the human race alone.

In the same spirit, when some objected to the asserted smallness of the Medicean stars, or satellites of Jupiter, and urged this as a reason why they were unworthy the regard of philosophers, he replied that they are the works of God's power, the objects of His care, and therefore may well be considered as sublime subjects for man's study.

In the Dialogues on Mechanics, there occur those observations concerning the use of the airbladder in fishes, and concerning the adaptation of the size of animals to the strength of the materials of which they are framed, which have often since been adopted by writers on the wisdom of Providence. The last of the dialogues on the system of the world is closed by a religious reflexion, put in the mouth of the interlocutor who usually expresses Galileo's own opinions:

While it is permitted us to speculate concerning the constitution of the world, we are also taught (perhaps in order that the activity of the human mind may not pause or languish) that our powers do not enable us to comprehend the works of His hands. May success therefore attend this intellectual exercise, thus permitted and appointed for us; by which we recognise and admire the greatness of God the more, in proportion as we find ourselves the less able to penetrate the profound abysses of his wisdom.

And that this train of thought was habitual to the philosopher we have abundant evidence in many other parts of his writings. He had already said in the same dialogue:
Nature (or God, as he elsewhere speaks) employs means in an admirable and inconceivable manner; admirable, that is, and inconceivable to us, but not to her, who brings about with consummate facility and simplicity things which affect our intellect with infinite astonishment. That which is to us most difficult to understand is to her most easy to execute.

The establishment of the Copernican and Newtonian views of the motions of the solar system and their causes, were probably the occasions on which religious but unphilosophical men entertained the strongest apprehensions that the belief in the government of God may be weakened when we thus "thrust some mechanic cause into his place." It is therefore fortunate that we can show, not only that this ought not to occur, from the reason of the thing, but also that in fact the persons who are the leading characters in the progress of these opinions were men of clear and fervent piety.

In the case of Copernicus himself it does not appear that, originally, any apprehensions were entertained of any dangerous discrepancy between his doctrines and the truths of religion, either natural or revealed. The work which contains these memorable discoveries was addressed to Pope Paul III, the head, at that time, (1543) of the religious world; and was published, as the author states in the preface, at the urgent entreaty of friends, one of whom was a cardinal, and another a bishop.* "I know," he says, " that the thoughts of a philosopher are far removed from the judgment

of the vulgar; since it is his study to search out truth in all things, as far as that is permitted by God to human reason." And though the doctrines are for the most part stated as portions of a mathematical calculation, the explanation of the arrangement by which the sun is placed in the centre of the system is accompanied by a natural reflexion of a religious cast:

Who in this fair temple would place this lamp in any other or better place than there whence it may illuminate the whole? We find then under this ordination an admirable symmetry of the world, and a certain harmonious connexion of the motion and magnitude of the orbs, such as in any other way cannot be found. Thus the progressions and regressions of the planets all arise from the same cause, the motion of the earth. And that no such movements are seen in the fixed stars, argues their immense distance from us, which causes the apparent magnitude of the earth's annual course to become evanescent. So great, in short, is this divine fabric of the great and good God.

"this best and most regular artificer of the universe" as he elsewhere speaks:

Amici me cunctantem atque etiam reluctantem, retraxerunt, inter quos primus fuit Nicolaus Schonbergius, Cardinalis Capuanus, in omni genere literatum Celebris; proximus ille vir mei amantissimus Tidemannus Gisius, episcopus Culmensis, sacrarum ut est et omnium bonarum literarum studiosissimus.—De Revolutionibus. Prcef. ad Paulum III.

Kepler was the person, who by further studying "the connexion of the motions and magnitude of the orbs," to which Copernicus had thus drawn the attention of astronomers, detected the laws of this connexion, and prepared the way for the discovery, by Newton, of the mechanical laws and causes of such motions. Kepler was a man of strong and lively piety; and the exhortation which he addresses to his reader before entering on the exposition of some of his discoveries, may be quoted not only for its earnestness but its reasonableness also:

I beseech my reader, that not unmindful of the divine goodness bestowed on man, he do with me praise and celebrate the wisdom and greatness of the Creator, which I open to him from a more inward explication of the form of the world, from a searching of causes, from a detection of the errors of vision: and that thus, not only in the firmness and stability of the earth he perceive with gratitude the preservation of all things in nature as the gift of God, but also that in its motion, so recondite, so admirable, he acknowledge the wisdom of the Creator. But him who is too dull to receive this science, or too weak to believe the Copernican system without harm to his piety, him, I say, I advise that, leaving the school of astronomy, and condemning, if he please, any doctrines of the philosophers, he follow his own path, and desist from this wandering through the universe, and lifting up his natural eyes, with which alone he can see, pour himself out from his own heart in praise of God the Creator; being certain that he gives no less worship to God than the astronomer, to whom God has given to see more clearly with his inward eye, and who, for what he has himself discovered, both can and will glorify God.

The next great step in our knowledge of the universe, the discovery of the mechanical causes by which its motions are produced, and of their laws, has in modern times sometimes been supposed, both by the friends of religion and by others, to be unfavourable to the impression of an intelligent first cause. That such a supposition is founded in error we have offered what appear to us insurmountable reasons for believing. That in the mind of the great discoverer of this mechanical cause, Newton, the impression of a creating and presiding Deity was confirmed, not shaken, by all his discoveries, is so well known that it is almost superfluous to insist upon the fact. His views of the tendency of science invested it with no dangers of this kind. " The business of natural philosophy is," he says, (Optics, Qu. 28.) "to argue from phenomena without feigning hypotheses, and to deduce causes from effects, till we come to the very first cause, which certainly is not mechanical." " Though every true step made in this philosophy brings us not immediately to the

knowledge of the first cause, yet it brings us nearer to it, and is on that account highly to be valued." The Scholium, or note, which concludes his great work, the Principia, is a well known and most striking evidence on this point:

This beautiful system of sun, planets and comets, could have its origin in no other way than by the purpose and command of an intelligent and powerful Being. He governs all things, not as the soul of the world, but as the lord of the universe. He is not only God, but Lord or Governor. We know him only by his properties and attributes, by the wise and admirable structure of things around us, and by their final causes; we admire him on account of his perfections, we venerate and worship him on account of his government.

Without making any further quotations, it must be evident to the reader that the succession of great philosophers through whom mankind have been led to the knowledge of the greatest of scientific truths, the law of universal gravitation, did, for their parts, see the truths which they disclosed to men in such a light that their religious feelings, their reference of the world to an intelligent Creator and Preserver, their admiration of his attributes, were exalted rather than impaired by the insight which they obtained into the structure of the universe.

Having shown this with regard to the most perfect portion of human knowledge, our knowledge of the motions of the solar system, we shall, adduce a few other passages, illustrating the prevalence of the same fact in other departments of experimental science; although, for reasons which have already been intimated, we conceive that sciences of experiment do not conduct so obviously as sciences of observation to the impression of a Divine Legislator of the material world.

The science of Hydrostatics was constructed in a great measure by the founders of the sister science of Mechanics. Of those who were employed in experimentally establishing the principles peculiarly belonging to the doctrine of fluids, Pascal and Boyle are two of the most eminent names. That these two great philosophers were not only religious, but both of them remarkable for their fervent and pervading devotion, is too well known to be dwelt on. With regard to Pascal, however, we ought not perhaps to pass over an opinion of his, that:

The existence of God cannot be proved from the external world. I do not undertake to prove this, not only because I do not feel myself sufficiently strong to find in nature that which shall convince obstinate atheists, but because such knowledge without Jesus Christ is useless and sterile.

It is obvious that such a state of mind would prevent this writer from encouraging or dwelling upon the grounds of natural religion; while yet he himself is an example of that which we wish to illustrate, that those who have obtained the furthest insight into nature, have been in all ages firm believers in God. He says in another place:

Nature has perfections in order to show that she is the image of God, and defects in order to show that she is only his image.

Boyle was not only a most pious man as well as a great philosopher, but he exerted himself very often and earnestly in his writings to show the bearing of his natural philosophy upon his views of the divine attributes, and of the government of the world. Many of these dissertations convey trains of thought and reasoning which have never been surpast for their combination of judicious sobriety in not pressing his arguments too far, with fervent devotion in his conceptions of the Divine nature. As examples of these merits, we might adduce almost any portion of his tracts on these subjects; for instance, his "Inquiry into the Final Causes of Natural Things;" his "Free Inquiry into the Vulgar Notion of Nature;" his "Christian Virtuoso;" and his Essay entitled "The High Veneration Man's Intellect owes to God." It would be superfluous to quote at any length from these works. We may

observe, however, that he notices that general fact which we are at present employed in exemplifying, that:

In almost all ages and countries the generality of philosophers and contemplative men were persuaded of the existence of a Deity from the consideration of the phenomena of the universe; whose fabric and conduct they rationally concluded could not justly be ascribed either to chance or to any other cause than a Divine Being.

And in speaking of the religious uses of science, he says:

Though I am willing to grant that some impressions of God's wisdom are so conspicuous that even a superficial philosopher may thence infer that the author of such works must be a wise agent; yet how wise an agent he has in these works expressed himself to be, none but an experimental philosopher can well discern. And 'tis not by a slight survey, but by a diligent and skilful scrutiny, of the works of God, that a man must be, by a rational and affective conviction, engaged to acknowledge that the author of nature ' is wonderful in counsel, and excellent in working.

After the mechanical properties of fluids, the laws of the operation of the chemical and physical properties of the elements about us, offer themselves to our notice. The relations of heat and of moisture in particular, which play so important a part, as we have seen, in the economy of our world, have been the subject of various researches; and they have led to views of the operation of such agents, some of which we have endeavoured to present to the reader, and to point out the remarkable arrangements by which their beneficial operation is carried on. That the discoverers of the laws by which such operations are regulated, were not insensible to the persuasion of a Divine care and contrivance which those arrangements suggest, is what we should expect, in agreement with what we have already said, and it is what we find. Among the names of the philosophers to whom we owe our knowledge on these subjects, there are none greater than those of Black, the discoverer of the laws of latent heat, and Dalton, who first gave us a true view of the mode in which watery vapour exists and operates in the atmosphere. With regard to the former of these philosophers, we shall quote Dr. Thomson's account of the views which the laws of latent heat suggested to the discoverer.

Dr. Black quickly perceived the vast importance of this discovery, and took a pleasure in laying before his students a view of the beneficial effects of this habitude of heat in the economy of nature. During the summer season a vast magazine of heat is accumulated in the water, which by gradually emerging during congelation serves to temper the cold of winter. Were it not for this accumulation of heat in water and other bodies, the sun would no sooner go a few degrees to the south of the equator than we should feel all the horrors of winter.

In the same spirit are Mr. Dalton's reflexions, after pointing out the laws which regulate the balance of evaporation and rain, which he himself first clearly explained:

It is scarcely possible to contemplate without admiration the beautiful system of nature by which the surface of the earth is continually supplied with water, and that unceasing circulation of a fluid so essentially necessary to the very being of the animal and vegetable kingdom takes place.

Such impressions appear thus to rise irresistibly in the breasts of men, when they obtain a sight, for the first time, of the varied play and comprehensive connexions of the laws by which the business of the material world is carried on and its occurrences are brought to pass. To dwell upon or develope such reflexions is not here our business. Their general prevalence in the minds of those to whom these first views of new truths are granted, has been, we trust, sufficiently illustrated. Nor are the names adduced above, distinguished as they are, brought forward as authorities merely. We

do not claim for the greatest discoverers in the realms of science any immunity from error. In their general opinions they may, as others may, judge or reason ill. The articles of their religious belief may be as easily and as widely as those of other men, imperfect, perverted, unprofitable. But on this one point, the tendency of our advances in the scientific knowledge of the universe to lead us up to a belief in a most wise maker and master of the universe, we conceive that they who make these advances, and who feel, as an original impression, that which others feel only by receiving their teaching, must be looked to with a peculiar attention and respect. And what their impressions have commonly been, we have thus endeavoured to show.

The opinion illustrated in the last chapter, that the advances which men make in science tend to impress upon them the reality of the Divine government of the world, has often been controverted. Complaints have been made, and especially of late years, that the growth of piety has not always been commensurate with the growth of knowledge, in the minds of those who make nature their study. Views of an irreligious character have been entertained, it is sometimes said, by persons eminently well instructed in all the discoveries of modern times, no less than by the superficial and ignorant. Those who have been supposed to deny or to doubt the existence, the providence, the attributes of God, have in many cases been men of considerable eminence and celebrity for their attainments in science. The opinion that this is the case, appears to be extensively diffused, and this persuasion has probably often produced inquietude and grief in the breasts of pious and benevolent men.

This opinion, concerning the want of religious convictions among those who have made natural philosophy their leading pursuit, has probably gone far beyond the limits of the real fact. But if we allow that there are any strong cases to countenance such an opinion, it may be worth our while to consider how far they admit of any satisfactory explanation. The fact appears at first sight to be at variance with the view we have given of the impression produced by scientific discovery; and it is moreover always a matter of uneasiness and regret, to have men of eminent talents and knowledge opposed to doctrines which •we consider as important truths.

We conceive that an explanation of such cases, if they should occur, may be found in a very curious and important circumstance belonging to the process by which our physical sciences are formed. The first discovery of new general truths, and the developement of these truths when once obtained, are two operations extremely different—imply different mental habits, and may easily be associated with different views and convictions on points out of the reach of scientific demonstration. There would therefore be nothing surprising, or inconsistent with what we have maintained above, if it should appear that while original discoverers of laws of nature are peculiarly led, as we have seen, to believe the existence of a supreme intelligence and purpose; the far greater number of cultivators of science, whose employment it is to learn from others these general laws, and to trace, combine, and apply their consequences, should have no clearness of conviction or security from error on this subject, beyond what belongs to persons of any other class.

This will, perhaps, become somewhat more evident by considering a little more closely the distinction of the two operations of discovery and developement, of which we have spoken above, and the tendency which the habitual prosecution of them may be expected to produce in the thoughts and views of the student.

We have already endeavoured in some measure to describe that which takes place when a new law of nature is discovered. A number of facts in which, before, order and connexion did not appear at all, or appeared by partial and contradictory glimpses, are brought into a point of view in which order and connexion become their essential character. It is seen that each fact is but a different manifestation of the same principle; that each particular is that which it is, in virtue of the same

general truth. The inscription is decyphered; the enigma is guessed; the principle is understood; the truth is enunciated.

When this step is once made, it becomes possible to deduce from the truth thus established, a train of consequences often in no small degree long and complex. The process of making these inferences may properly be described by the word Deduction. On the other hand, the very different process by which a new principle is collected from an assemblage of facts, has been termed Induction; the truths so obtained and their consequences constitute the results of the Inductive Philosophy; which is frequently and rightly described as a science which ascends from particular facts to general principles, and then descends again from these general principles to particular applications and exemplifications.

While the great and important labours by which science is really advanced consist in the successive steps of the inductive ascent, in the discovery of new laws perpetually more and more general; by far the greater part of our books of physical science unavoidably consists in deductive reasoning, exhibiting the consequences and applications of the laws which have been discovered; and the greater part of writers upon science have their minds employed in this process of deduction and application.

This is true of many of those who are considered, and justly, as distinguished and profound philosophers. In the mechanical philosophy, that science which applies the properties of matter and the laws of motion to the explanation of the phenomena of the world, this is peculiarly the case. The laws, when once discovered, occupy little room in their statement, and when no longer contested, are not felt to need a lengthened proof. But their consequences require far more room and far more intellectual labour. If we take, for example, the laws of motion and the law of universal gravitation, we can express in a few lines, that which, when developed, represents and explains an innumerable mass of natural phenomena. But here the course of developement is necessarily so long, the reasoning contains so many steps, the considerations on which it rests are so minute and refined, the complication of cases and of consequences is so vast, and even the involution arising from the properties of space and number is so serious, that the most consummate subtlety, the most active invention, the most tenacious power of inference, the widest spirit of combination, must be tasked and tasked severely, in order to solve the problems which belong to this portion of science. And the persons who have been employed on these problems, and who have brought to them the high and admirable qualities which such an office requires, have justly excited in a very eminent degree the admiration which mankind feel for great intellectual powers. Their names occupy a distinguished place in literary history; and probably there are no scientific reputations of the last century higher, and none more merited, than those earned by the great mathematicians who have laboured with such wonderful success in unfolding the mechanism of the heavens; such for instance as D'Alembert, Clairault, Euler, Lagrange, Laplace. But it is still important to recollect, that the mental employments of men, while they are occupied in this portion of the task of the formation of science, are altogether different from that which takes place in the mind of a discoverer, who, for the first time, seizes the principle which connects phenomena before unexplained, and thus adds another original truth to our knowledge of the universe. In explaining, as the great mathematicians just mentioned have done, the phenomena of the solar system by means of the law of universal gravitation, the conclusions at which they arrived were really included in the truth of the law, whatever skill and sagacity it might require to develope and extricate them from the general principle. But when Newton conceived and established the law itself, he added to our knowledge something which was not contained in any truth previously known, nor deducible from it by any course of mere reasoning. And the same distinction, in all other cases, obtains, between these processes which establish the principles, generally few and simple, on which our sciences rest, and those reasonings and calculations,

founded on the principles thus obtained, which constitute by far the larger portion of the common treatises on the most complete of the sciences now cultivated.

X

Since the difference is so great between the process of inductive generalization of physical facts, and that of mathematical deduction of consequences, it is not surprising that the two processes should imply different mental powers and habits. However rare the mathematical talent, in its highest excellence, may be, it is far more common, if we are to judge from the history of science, than the genius which divines the general laws of nature. We have several good mathematicians in every age; we have few great discoverers in the whole history of our species.

The distinction being thus clearly established between original discovery and derivative speculation, between the ascent to principles and the descent from them, we have further to observe, that the habitual and exclusive prosecution of the latter process may sometimes exercise an unfavourable effect on the mind of the student, and may make him less fitted and ready to apprehend and accept truths different from those with which his reasonings are concerned. We conceive, for example, that a person labours under gross error, who believes the phenomena of the world to be altogether produced by mechanical causes, and who excludes from his view all reference to an intelligent First Cause and Governor. But we conceive that reasons may be shown which make it more probable that error of such a kind should find a place in the mind of a person of deductive, than of inductive habits;—of a mere mathematician or logician, than of one who studies the facts of the natural world and detects their laws.

The person whose mind is employed in reducing to law and order and intelligible cause the complex facts of the material world, is compelled to look beyond the present state of his knowledge, and to turn his thoughts to the existence of principles higher than those which he yet possesses. He has seen occasions when facts that at first seemed incoherent and anomalous, were reduced to rule and connexion; and when limited rules were discovered to be included in some rule of superior generality. He knows that all facts and appearances, all partial laws, however confused and casual they at present seem, must still, in reality, have this same kind of bearing and dependence;—must be bound together by some undiscovered principle of order; —must proceed from some cause working by most steady rules;—must be included in some wide and fruitful general truth. He cannot therefore consider any principles which he has already obtained, as the ultimate and sufficient reason of that which he sees. There must be some higher principle, some ulterior reason. The effort and struggle by which he endeavours to extend his view, makes him feel that there is a region of truth not included in his present physical knowledge; the very imperfection of the light in which he works his way, suggests to him that there must be a source of clearer illumination at a distance from him.

We must allow that it is scarcely possible to describe in a manner free from some vagueness and obscurity, the effect thus produced upon the mind by the efforts which it makes to reduce natural phenomena to general laws. But we trust it will still be allowed that there is no difficulty in seeing clearly that a different influence may result from this process, and from the process of deductive reasoning which forms the main employment of the mathematical cultivators and systematic expositors of physical science in modern times. Such persons are not led by their pursuits to any thing beyond the general principles, which form the basis of their explanations and applications. They acquiesce in these; they make these their ultimate grounds of truth; and they are entirely employed in unfolding the particular truths which are involved in such general truths. Their thoughts dwell little upon the possibility of the laws of nature being other than we find them to be, or on the reasons why they are not so; and still less on those facts and phenomena which philosophers have not yet reduced to any rule; which are lawless to us, though we know that, in

reality, they must be governed by some principle of order and harmony. On the contrary, by assuming perpetually the existing laws as the basis of their reasoning, without question or doubt, and by employing such language that these laws can be expressed in the simplest and briefest form, they are led to think and believe as if these laws were necessarily and inevitably what they are. Some mathematicians indeed have maintained that the highest laws of nature with which we are acquainted, the laws of motion and the law of universal gravitation, are not only necessarily true, but are even self-evident and certain a priori, like the truths of geometry. And though the mathematical cultivator of the science of mechanics may not adopt this as his speculative opinion, he may still be so far influenced by the tendency from which it springs, that he may rest in the mechanical laws of the universe as ultimate and all-sufficient principles, without seeing in them any evidence of their having been selected and ordained, and thus without ascending from the contemplation of the world to the thought of an Intelligent Ruler. He may thus substitute for the Deity certain axioms and first principles, as the cause of all. And the follower of Newton may run into the error with which he is sometimes charged, of thrusting some mechanic cause into the place of God, if he do not raise his views, as his master did, to some higher cause, to some source of all forces, laws, and principles.

When, therefore, we consider the mathematicians who are employed in successfully applying the mechanical philosophy, as men well deserving of honour from those who take an interest in the progress of science, we do rightly; but it is still to be recollected, that in doing this they are not carrying us to any higher point of view in the knowledge of nature than we had attained before: they are only unfolding the consequences, which were already virtually in our possession, because they were implied in principles already discovered:—they are adding to our knowledge of effects, but not to our knowledge of causes:—they are not making any advance in that progress of which Newton spoke, and in which he made so vast a stride, in which " every step made brings us nearer to the knowledge of the first cause, and is on that account highly to be valued." And as in this advance they have no peculiar privileges or advantages, their errors of opinion concerning it, if they err, are no more to be wondered at, than those of common men; and need as little disturb or distress us, as if those who committed them had confined themselves to the study of arithmetic or of geometry. If we can console and tranquillize ourselves concerning the defective or perverted views of religious truth entertained by any of our fellow men, we need find no additional difficulty in doing so when those who are mistaken are great mathematicians, who have added to the riches and elegance of the mechanical philosophy. And if we are seeking for extraneous grounds of trust and comfort on this subject, we may find them in the reflexion; —that, whatever may be the opinions of those who assume the causes and laws of that philosophy and reason from them, the views of those admirable and ever-honoured men who first caught sight of these laws and causes, impressed them with the belief that this is " the fabric of a great and good God;" that " it is man's duty to pour out his soul in praise of the Creator;" and that all this beautiful system must be referred to " a first cause, which is certainly not mechanical."

2. We may thus, with the greatest propriety, deny to the mechanical philosophers and mathematicians of recent times any authority with regard to their views of the administration of the universe; we have no reason whatever to expect from their speculations any help, when we attempt to ascend to the first cause and supreme ruler of the universe. But we might perhaps go further, and assert that they are in some respects less likely than men employed in other pursuits, to make any clear advance towards such a subject of speculation. Persons whose thoughts are thus entirely occupied in deduction are apt to forget that this is, after all, only one employment of the reason among more; only one mode of arriving at truth, needing to have its deficiencies completed by another. Deductive reasoners, those who cultivate, science of whatever kind, by means of mathematical and logical processes alone, may acquire an exaggerated feeling of the amount and value of their labours. Such employments, from the clearness of the notions involved in them, the irresistible concatenation of truths which they unfold, the subtlety which they require, and their

entire success in that which they attempt, possess a peculiar fascination for the intellect. Those who pursue such studies have generally a contempt and impatience of the pretensions of all those other portions of our knowledge, where from the nature of the case, or the small progress hitherto made in their cultivation, a more vague and loose kind of reasoning seems to be adopted. Now if this feeling be carried so far as to make the reasoner suppose that these mathematical and logical processes can lead him to all the knowledge and all the certainty which we need, it is clearly a delusive feeling. For it is confessed on all hands, that all which mathematics or which logic can do, is to develope and extract those truths, as conclusions, which were in reality involved in the principles on which our reasonings proceeded.* And this being allowed, we cannot but ask how we obtain these principles? from what other source of knowledge we derive the original truths which we thus pursue into detail? since it is manifest that such principles cannot be derived from the proper stores of mathematics or logic. These methods can generate no new truth; and all the grounds and elements of the knowledge which, through them, we can acquire, must necessarily come from some extraneous source. It is certain, therefore, that the mathematician and the logician must derive from some process different from their own, the substance and material of all our knowledge, whether physical or metaphysical, physiological or moral. This process, by which we acquire our first principles, (without pretending here to analyse it,) is obviously the general course of human experience, and the natural exercise of the understanding; our intercourse with matter and with men, and the consequent growth in our minds of convictions and conceptions such as our reason can deal with, either by her systematic or unsystematic methods of procedure. Supplies from this vast and inexhaustible source of original truths are requisite, to give any value whatever to the results of our deductive processes, whether mathematical or logical; while, on the other hand, there are many branched of our knowledge, in which we possess a large share of original and derivative convictions and truths, but where it is nevertheless at present quite impossible to erect our knowledge into a complete system;—to state our primary and independent truths, and to show how on these all the rest depend by the rules of art. If the mathematician is repelled from speculations on morals or politics, on the beautiful or the right, because the reasonings which they involve have not mathematical precision and conclusiveness, he will remain destitute of much of the most valuable knowledge which man can acquire. And if he attempts to mend the matter by giving to treatises on morals, or politics, or criticism, a form and a phraseology borrowed from the very few tolerably complete physical sciences which exist, it will be found that he is compelled to distort and damage the most important truths, so as to deprive them of their true shape and import, in order to force them into their places in his artificial system.

If therefore, as we have said, the mathematical philosopher dwells in his own bright and pleasant land of deductive reasoning, till he turns with disgust from all the speculations, necessarily less clear and conclusive, in which his imagination, his practical faculties, his moral sense, his capacity of religious hope and belief, are to be called into action, he becomes, more than common men, liable to miss the roads to truths of extreme consequence.

This is so obvious, that charges are frequently brought against the study of mathematics, as unfitting men for those occupations which depend upon our common instinctive convictions and feelings, upon the unsystematic exercise of the understanding with regard to common relations and common occurrences. Bonaparte observed of Laplace when he was placed in a public office of considerable importance, that he did not discharge it in so judicious and clear-sighted a manner as his high intellectual fame might lead most persons to expect.* " He sought," that great judge of character said, " subtleties in every subject, and carried into his official employments the spirit of the method of infinitely small quantities," by which the mathematician solves his most abstruse problems. And the complaint that mathematical studies make men insensible to moral evidence and to poetical beauties, is so often repeated as to show that some opposition of tendency is commonly perceived between that exercise of the intellect which mathematics requires and those processes

which go on in our minds when moral character or imaginative beauty is the subject of our contemplation.

Thus, while we acknowledge all the beauty and all the value of the mathematical reasonings by which the consequences of our general laws are deduced, we may yet consider it possible that a philosopher, whose mind has been mainly employed, and his intellectual habits determined, by this process of deduction, may possess, in a feeble and imperfect degree only, some of those faculties by which truth is attained, and especially truths such as regard our relation to that mind, which is the origin of all law, the source of first principles, and which must be immeasurably elevated above all derivative truths. It would, therefore, be far from surprising, if there should be found, among the great authors of the developements of the mechanical philosophy, some who had refused to refer the phenomena of the universe to a supreme mind, purpose, and will. And though this would be, to a believer in the Being and government of God, a matter of sorrow and pain, it need not excite more surprise than if the same were true of a person of the most ordinary endowments, when it is recollected in what a disproportionate manner the various faculties of such a philosopher may have been cultivated. And our apprehensions of injury to mankind from the influence of such examples will diminish, when we consider, that those mathematicians whose minds have been less partially exercised, the great discoverers of the truths which others apply, the philosophers who have looked upwards as well as downwards, to the unknown as well as to the known, to ulterior as well as proximate principles, have never rested in this narrow and barren doctrine; but have perpetually extended their view forwards, beyond mere material laws and causes, to a First Cause of the moral and material world, to which each advance in philosophy might bring them nearer, though its highest attributes must probably ever remain indefinitely beyond their reach.

It scarcely needs, perhaps, to be noticed, that what we here represent as the possible source of error is, not the perfection of the mathematical habits of the mind, but the deficiency of the habit of apprehending truth of other kinds;—not a clear insight into the mathematical consequences of principles, but a want of a clear view of the nature and foundation of principles;—not the talent for generalizing geometrical or mechanical relations, but the tendency to erect such relations into ultimate truths and efficient causes. The most consummate mathematical skill may accompany and be auxiliary to the most earnest piety, as it often has been. And an entire command of the conceptions and processes of mathematics is not only consistent with, but is the necessary condition and principal instrument of every important step in the discovery of physical principles. Newton was eminent above the philosophers of his time, in no one talent so much as in the power of mathematical deduction. When he had caught sight of the law of universal gravitation, he traced it to its consequences with a rapidity, a dexterity, a beauty of mathematical reasoning which no other person could approach; so that on this account, if there had been no other, the establishment of the general law was possible to him alone. He still stands at the head of mathematicians as well as of philosophical discoverers. But it never appeared to him, as it may have appeared to some mathematicians who have employed themselves on his discoveries, that the general law was an ultimate and sufficient principle; that the point to which he had hung his chain of deduction was the highest point in the universe. Lagrange, a modern mathematician of transcendent genius, was in the habit of saying, in his aspirations after future fame, that Newton was fortunate in having had the system of the world for his problem, since its theory could be discovered once only. But Newton himself appears to have had no such persuasion that the problem he had solved was unique and final; he laboured to reduce gravity to some higher law, and the forces of other physical operations to an analogy with those of gravity, and declared that all these were but steps in our advance towards a first cause. Between us and this first cause, the source of the universe and of its laws, we cannot doubt that there intervene many successive steps of possible discovery and generalization, not less wide and striking than the discovery of universal gravitation: but it is still more certain that no extent or success of physical investigation can carry us to any point which is not at an immeasurable distance from an adequate knowledge of Him.

Chapter VII - On Final Causes

We have pointed out a great number of instances where the mode in which the arrangements of nature produce their effect, suggests, as we conceive, the belief that this effect is to be considered as the end and purpose of these arrangements. The impression which thus arises, of design and intention exercised in the formation of the world, or of the reality of Final Causes, operates on men's minds so generally, and increases so constantly on every additional examination of the phenomena of the universe, that we cannot but suppose such a belief to have a deep and stable foundation. And we conceive that in several of the comparatively few cases in which such a belief has been rejected, the averseness to it has arisen from the influence of some of the causes mentioned in the last chapter; the exclusive pursuit, namely, of particular trains and modes of reasoning, till the mind becomes less capable of forming the conceptions and making the exertions which are requisite for the apprehension of truths not included among its usual subjects of thought.

1. This seems to be the case with those who maintain that purpose and design cannot be inferred or deduced from the arrangements which we see around us, by any process of reasoning. We can reason from effects to causes, say such writers, only in cases where we know something of the nature of the cause. We can infer from the works of men, the existence of design and purpose, because we know, from past observation, what kind of works human design and purpose can produce. But the universe, considered as the work of God, cannot be compared with any corresponding work, or judged of by any "analogy with known examples. How then can we, in this case, they ask, infer design and purpose in the artist of the universe? On what principles, on what axioms, can we proceed, which shall include this necessarily singular instance, and thus give legitimacy and validity to our reasonings?

What has already been said on the subject of the two different processes by which we obtain principles, and by which we reason from them, will suggest the reply to these questions. When we collect design and purpose from the arrangements of the universe, we do not arrive at our conclusion by a train of deductive reasoning, but by the conviction which such combinations as we perceive, immediately and directly impress upon the mind. " Design must have had a designer." But such a principle can be of no avail to one whom the contemplation or the description of the world does not impress with the perception of design. It is not therefore at the end, but at the beginning of our syllogisms, not among remote conclusions, but among original principles, that we must place the truth, that such arrangements, manifestations, and proceedings as we behold about us imply a Being endowed with consciousness, design, and will, from whom they proceed.

This is inevitably the mode in which such a conviction is acquired; and that it is so, we may the more readily believe, when we consider that it is the case with the design and will which we ascribe to man, no less than in that which we believe to exist in God, At first sight we might perhaps be tempted to say, that we infer design and purpose from the works of man in one case, because we have known these attributes in other cases produce effects in some measure similar. But to this we must reply, by asking how we come to know the existence of human design and purpose at first, and at all? What we see around us are certain appearances, things, successions of events; how come we ever to ascribe to other men the thought and will of which we are conscious ourselves? How do we come to believe that there are other men? How are we led to elevate, in our conceptions, some of the objects which we perceive into persons? Undoubtedly their actions, their words induce us to do this: we see that the manifestations which we observe must be so understood, and no otherwise: we feel that such actions, such events must be connected by consciousness and personality; that the actions are not the actions of things, but of persons; not necessary and without significance, like the falling of a stone, but voluntary and with purpose like what we do ourselves. But this is not a result of reasoning: we do not infer this from any similar

case which we have known; since we are now speaking of the first conception of a will and purpose different from our own. In arriving at such knowledge, we are aided only by our own consciousness of what thought, purpose, will, are: and possessing this regulative principle, we so decypher and interpret the complex appearances which surround us, that we receive irresistibly the persuasion of the existence of other men, with thought and will and purpose like our own. And just in the same manner, when we examine attentively the adjustment of the parts of the human frame to each other and to the elements, the relation of the properties of the earth to those of its inhabitants, or of the physical to the moral nature of man, the thought must arise and cling to our perceptions, however little it be encouraged, that this system, everywhere so full of wonderful combinations, suited to the preservation, and well-being of living creatures, is also the expression of the intention, wisdom, and goodness of a personal creator and governor.

We conceive then that it is so far from being an unsatisfactory or unphilosophical process by which we collect the existence of a Deity from the works of creation, that the process corresponds most closely with that on which rests the most steadfast of our convictions, next to that of our own existence, the belief of the existence of other human beings. If any one ever went so far in scepticism as to doubt the existence of any other person than himself, he might, so far as the argument from final causes is concerned, reject the being of God as well as that of man; but without dwelling on the possibility of such fantasies, when we consider how impossible it is for men in general not to attribute personality, purpose, thought, will to each other, in virtue of certain combinations of appearances and actions, we must deem them most consistent and reasonable in attributing also personality and purpose to God, in virtue of the whole assemblage of appearances and actions which constitute the universe, full as it is of combinations from which such a suggestion springs. The vividness, the constancy of the belief of a wise and good Being, thus governing the world, may be different in different men, according to their habit of directing their thoughts to the subject; but such a belief is undoubtedly capable of becoming lively and steadfast in the highest degree. It has been entertained and cherished by enlightened and well-regulated minds in all ages; and has been, at least since the rise of Christianity, not only the belief, but a pervading and ruling principle of action of many men, and of whole communities. The idea may be rendered more faint by turning the mind away from it, and, perhaps by indulging too exclusively in abstract and general speculations. It grows stronger by an actual study of the details of the creation; and, as regards the practical consequences of such a belief, by a habit of referring our actions and hopes to such a Governor. In this way it is capable of becoming as real and fixed an impression as that of a human friend and master; and all that we can learn, by observing the course of men's feelings and actions, tends to convince us, that this belief of the being and presence and government of God, leads to the most elevated and beneficial frame of mind of which man is capable.

2. How natural and almost inevitable is this persuasion of the reality of Final Causes and consequent belief in the personality of the Deity, we may gather by observing how constantly it recurs to the thoughts, even of those who, in consequence of such peculiarities of mental discipline as have been described, have repelled and resisted the impression.

Thus, Laplace, of whom we have already spoken, as one of the greatest mathematicians of modern times, expresses his conviction that the supposed evidence of final causes will disappear as our knowledge advances, and that they only seem to exist in those cases where our ignorance leaves room for such a mistake. " Let us run over," he says, " the history of the progress of the human mind and its errors: we shall perpetually see final causes pushed away to the bounds of its knowledge. These causes, which Newton removed to the limits of the solar system, were not long ago conceived to obtain in the atmosphere, and employed in explaining meteors: they are, therefore, in the eyes of the philosopher nothing more than the expression of the ignorance in which we are of the real causes."

We may observe that we have endeavoured to give a very different, and, as we believe, a far truer view of the effect which philosophy has produced on our knowledge of final causes. We have shown, we trust, that the notion of design and end is transferred by the researches of science, not from the domain of our knowledge to that of our ignorance, but merely from the region of facts to that of laws. We hold that, in this form, final causes in the atmosphere are still to be conceived to obtain, no less than in an earlier state of meteorological knowledge; and that Newton was right, when he believed that he had established their reality in the solar system, not expelled them from it.

But our more peculiar business at present is to observe that Laplace himself, in describing the arrangements by which the stability of the solar system is secured, uses language which shows how irresistibly these arrangements suggest an adaptation to its preservation as an end. If in his expressions we were to substitute the Deity for the abstraction " nature" which he employs, his reflexion would coincide with that which the most religious philosopher would entertain. " It seems that ' God' has ordered everything in the heavens to ensure the duration of the planetary system, by views similar to those which He appears to us so admirably to follow upon the earth, for the preservation of animals and the perpetuity of species. * This consideration alone would explain the disposition of the system, if it were not the business of the geometer to go further." It may be possible for the geometer to go further; but he must be strangely blinded by his peculiar pursuits, if, when he has discovered the mode in which these views are answered, he supposes himself to have obtained a proof that there are no views at all. It would be as if the savage, who had marvelled at the steady working of the steam-engine, should cease to consider it a work of art, as soon as the self-regulating part of the mechanism had been explained to him.

The unsuccessful struggle in which those persons engage, who attempt to throw off the impression of design in the creation, appears in an amusing manner through the simplicity of the ancient Roman poet of this school. Lucretius maintains that the eye was not made for seeing, nor the ear for hearing. But the terms in which he recommends this doctrine show how hard he knew it to be for men to entertain such an opinion. His advice is—

II semble que la nature ait tout dispos6 dans le ciel, pour assurer la duree du systeme planetaire, par des vues semblables a celles qu'elle nous parait suivre si admirablement sur la terre, pour la conservation des individus et la perpetuite des especes. —Syst. du Monde, p. 442.

Illud in his rebus vitium vehementer et istum
Effugere errorem, vitareque prcemeditator,
Lumina ne facias oculorutn clara creata,
Prospicere ut possimus. iv. 823.

'Gainst their preposterous error guard thy mind
Who say each organ was for use design *d;
Think not the visual orbs, so clear, so bright,
Were furnish'd for the purposes of sight.

Undoubtedly the poet is so far right, that a most " vehement" caution and vigilant " premeditation" are necessary to avoid the " vice and error" of such a persuasion. The study of the adaptations of the human frame is so convincing, that it carries the mind with it, in spite of the resistance suggested by speculative systems. Cabanis, a modern French physiological writer of great eminence, may be selected as a proof of this. Both by the general character of his own speculations, and by the tone of thinking prevalent around him, the consideration of design in the works of nature was abhorrent from his plan. Accordingly, he joins in repeating Bacon's unfavourable mention of final causes. Yet when he conies to speak of the laws of reproduction of

the human race, he appears to feel himself compelled to admit the irresistible manner in which such views force themselves on the mind. "I regard," he says, "with the great Bacon, the philosophy of final causes as barren; but I have elsewhere acknowledged that it was very difficult for the most cautious man (l'homme le plus reserve) never to have recourse to them in his explanations."*

3. It may be worth our while to consider for a moment the opinion here referred to by Cabanis, of the propriety of excluding the consideration of final causes from our natural philosophy. The great authority of Bacon is usually adduced on this subject. " The handling of final causes," says he, " mixed with the rest in physical enquiries, hath intercepted the severe and diligent enquiry of all real and physical causes, and given men the occasion to stay upon these satisfactory and specious causes, to the great arrest and prejudice of further discovery:

A moment's attention will show how well this representation agrees with that which we have urged, and how far it is from dissuading the reference to final causes in reasonings like those on which we are employed. Final causes are to be excluded from physical enquiry; that is, we are not to assume that we know the objects of the Creator's design, and put this assumed purpose in the place of a physical cause. We are not to think it a sufficient account of the clouds that they are for watering the earth, (to take Bacon's examples,) or " that the solidness of the earth is for the station and mansion of living creatures." The physical philosopher has it for his business to trace clouds to the laws of evaporation and condensation; to determine the magnitude and mode of action of the forces of cohesion and crystallization by which the materials of the earth are made solid and firm. This he does, making no use of the notion of final causes: and it is precisely because he has thus established his theories independently of any assumption of an end, that the end, when, after all, it returns upon him and cannot be evaded, becomes an irresistible evidence of an intelligent legislator. He finds that the effects, of which the use is obvious, are produced by most simple and comprehensive laws; and when he has obtained this view, he is struck by the beauty of the means, by the refined and skilful manner in which the useful effects are brought about;— points different from those to which his researches were directed. We have already seen, in the very case of which we have been speaking, namely, the laws by which the clouds are formed and distribute their showers over the earth, how strongly those who have most closely and extensively examined the arrangements there employed (as Howard, Dalton, and Black) have been impressed with the harmony and beauty which these contrivances manifest. w.T A A

We may find a further assertion of this view of the proper use of final causes in philosophy, by referring to the works of one of the greatest of our philosophers, and one of the most pious of our writers, Boyle, who has an Essay on this subject:

I am by all means, for encouraging the contemplation of the celestial part of the world, and the shining globes that adorn it, and especially the sun and moon, in order to raise our admiration of the stupendous power and wisdom of him who was able to frame such immense bodies; and notwithstanding their vast bulk and scarce conceivable rapidity, keep them for so many ages constant both to the lines and degrees of their motion, without interfering with one another. And doubtless we ought to return thanks and praises to the divine goodness for having so placed the sun and moon, and determined the former, or else the earth, to move in particular lines for the good of men and other animals; and how disadvantageous it would have been to the inhabitants of the earth if the luminaries had moved after a different manner. I dare not, however, affirm that the sun, moon, and other celestial bodies were made solely for the use of man: much less presume to prove one system of the world to be true and another false; because the former is better fitted to the convenience of mankind, or the other less suited, or perhaps altogether useless to that end.

This passage exhibits, we conceive, that combination of feelings which ought to mark the character of the religious natural philosopher; an earnest piety ready to draw nutriment from the

contemplation of established physical truths; joined with a philosophical caution, which is not seduced by the anticipation of such contemplations, to pervert the strict course of physical enquiry.

It is precisely through this philosophical care and scrupulousness that our views of final causes acquire their force and value as aids to religion. The object of such views is not to lead us to physical truth, but to connect such truth, obtained by its proper processes and methods, with our views of God, the master of the universe, through those laws and relations which are thus placed beyond dispute.

Bacon's comparison of final causes to the vestal virgins is one of those poignant sayings, so frequent in his writings, which it is not easy to forget. " Like them," he says, " they are dedicated to God, and are barren." But to any one who reads his work it will appear in what spirit this was meant. " Not because those final causes are not true and worthy to be inquired, being kept within their own province." (Of the Advancement of Learning, b. ii. p. 142.) If he had had occasion to develope his simile, full of latent meaning as his similes so often are, he would probably have said, that to these final causes barrenness was no reproach, seeing they ought to be, not the mothers but the daughters of our natural sciences; and that they were barren, not by imperfection of their nature, but in order that they might be kept pure and undefiled, and so fit ministers in the temple of God.

Chapter VIII - On the Physical Agency of the Deity

1. We are not to expect that physical investigation can enable us to conceive the manner in which God acts upon the members of the universe. The question, "Canst thou by searching find out God? " must silence the boastings of science as well as the repinings of adversity. Indeed, science shows us, far more clearly than the conceptions of every day reason, at what an immeasurable distance we are from any faculty of conceiving how the universe, material and moral, is the work of the Deity. But with regard to the material world, we can at least go so far as this;—we can perceive that events are brought about, not by insulated interpositions of divine • power exerted in each particular case, but by the establishment of general laws. This, which is the view of the universe proper to science, whose office it is to search out these laws, is also the view which, throughout this work, we have endeavoured to keep present to the mind of the reader. We have attempted to show that it combines itself most readily and harmoniously with the doctrines of Natural Theology; that the arguments for those doctrines are strengthened, the difficulties which affect them removed, by keeping it steadily before us. We conceive, therefore, that the religious philosopher will do well to bear this conception in his mind. God is the author and governor of the universe through the laws which he has given to its parts, the properties which he has impressed upon its constituent elements: these laws and properties are, as we have already said, the instruments with which he works: the institution of such laws, the selection of the quantities which they involve, their combination and application, are the modes in which he exerts and manifests his power, his wisdom, his goodness: through these attributes, thus exercised, the Creator of all, shapes, moves, sustains and guides the visible creation.

This has been the view of the relation of the Deity to the universe entertained by the most sagacious and comprehensive minds ever since the true object of natural philosophy has been clearly and steadily apprehended. The great writer who was the first to give philosophers a distinct and commanding view of this object, thus expresses himself in his " Confession of Faith:"

I believe—that notwithstanding God hath rested and ceased from creating since the first Sabbath, yet, nevertheless, he doth accomplish and fulfil his divine will in all things, great and small, singular and general, as fully and exactly by providence, as he could by miracle and new creation,

though his working be not immediate and direct, but by compass; not violating Nature, which is his own law upon the creature.

And one of our own time, whom we can no longer hesitate to place among the worthiest disciples of the school of Bacon, conveys the same thought in the following passage:

The Divine Author of the universe cannot be supposed to have laid down particular laws, enumerating all individual contingencies, which his materials have understood and obey—this would be to attribute to him the imperfections of human legislation;—but rather, by creating them endued with certain fixed qualities and powers, he has impressed them in their origin with the spirit, not the letter of his law, and made all their subsequent combinations and relations inevitable consequences of this first impression.

2. This, which thus appears to be the mode of the Deity's operation in the material world, requires some attention on our part in order to understand it with proper clearness. One reason of this is, that it is a mode of operation altogether different from that in which we are able to make matter fulfil our designs. Man can construct exquisite machines, can call in vast powers, can form extensive combinations, in order to bring about results which he has in view. But in all this he is only taking advantage of laws of nature which already exist; he is applying to his use qualities which matter already possesses. Nor can he by any effort do more. He can establish no new law of nature which is not a result of the existing ones. He can invest matter with no new properties which are not modifications of its present attributes. His greatest advances in skill and power are made when he calls to his aid forces which before existed unemployed, or when he discovers so much of the habits of some of the elements as to be able to bend them to his purpose. He navigates the ocean by the assistance of the winds which he cannot raise or still: and even if we suppose him able to control the course of these, his yet unsubjugated ministers, this could only be done by studying their characters, by learning more thoroughly the laws of air and heat and moisture. He cannot give the minutest portion of the atmosphere new relations, a new course of expansion, new laws of motion. But the Divine operations, on the other hand, include something much higher. They take in the establishment of the laws of the elements, as well as the combination of these laws and the determination of the distribution and quantity of the materials on which they shall produce their effect. We must conceive that the Supreme Power has ordained that air shall be rarefied, and water turned into vapour, by heat; no less than that he has combined air and water so as to sprinkle the earth with showers, and determined the quantity of heat and air and water, so that the showers shall be as beneficial as they are.

We may and must, therefore, in our conceptions of the Divine purpose and agency, go beyond the analogy of human contrivances. We must conceive the Deity, not only as constructing the most refined and vast machinery, with which, as we have already seen, the universe is filled; but we must also imagine him as establishing those properties by which such machinery is possible: as giving to the materials of his structure the qualities by which the material is fitted to its use. There is much to be found, in natural objects, of the same kind of contrivance which is common to these and to human inventions; there are mechanical devices, operations of the atmospheric elements, chemical processes;—many such have been pointed out, many more exist. But besides these cases of the combination of means, which we seem able to understand without much difficulty, we are led to consider the Divine Being as the author of the laws of chemical, of physical, and of mechanical action, and of such other laws as make matter what it is;—and this is a view which no analogy of human inventions, no knowledge of human powers, at all assist us to embody or understand. Science, therefore, as we have said, while it discloses to us the mode of instrumentality employed by the Deity, convinces us, more effectually than ever, of the impossibility of conceiving God's actions by assimilating them to our own.

3. The laws of material nature, such as we have described them, operate at all times, and in all places; affect every province of the universe, and involve every relation of its parts. Wherever these laws appear, we have a manifestation of the intelligence by which they were established. But a law supposes an agent, and a power; for it is the mode according to which the agent proceeds, the order according to which the power acts. Without the presence of such an agent, of such a power, conscious of the relations on which the law depends, producing the effects which the law prescribes, the law can have no efficacy, no existence. Hence we infer that the intelligence by which the law is ordained, the power by which it is put in action, must be present at all times and in all places where the effects of the law occur; that thus the knowledge and the agency of the Divine Being pervade every portion of the universe, producing all action and passion, all permanence and change. The laws of nature are the laws which he, in his wisdom, prescribes to his own acts; his universal presence is the necessary condition of any course of events, his universal agency the only origin of any efficient force.

This view of the relation of the universe to God has been entertained by many of the most eminent of those who have combined the consideration of the material world with the contemplation of God himself. It may therefore be of use to illustrate it by a few quotations, and the more so, as we find this idea remarkably dwelt upon in the works of that writer whose religious views must always have a peculiar interest for the cultivators of physical science, the great Newton.

Thus, in the observations on the nature of the Deity with which he closes the " Opticks," he declares:

The various portions of the world, organic and inorganic, can be the effect of nothing else than the wisdom and skill of a powerful everliving Agent, who being in all places, is more able by his will to move the bodies within his boundless uniform sensorium, and thereby to form and reform the parts of the universe, than we are by our will to move the parts of our own bodies.

And in the Scholium at the end of the " Principia," he says:

God is one and the same God always and everywhere. He is omnipresent, not by means of his virtue alone, but also by his substance, for virtue cannot subsist without substance. In him all things are contained, and move, but without mutual passion: God is not acted upon by the motions of bodies; and they suffer no resistance from the omnipresence of God.

And he refers to several passages confirmatory of this view, not only in the Scriptures, but also in writers who hand down to us the opinions of some of the most philosophical thinkers of the pagan world. He does not disdain to quote the poets, and among the rest, the verses of Virgil;

Principio coelum ac terras camposque liquentes
Lucentemque globum lunse, Titaniaque astra,
Spiritus intus alit, totamque infusa per artus
Mens agitat molem et magno se corpore miscet:

warning his reader however against the doctrine which such expressions as these are sometimes understood to express:

All these things he rules, not as the soul of the world, but as the Lord of all.

Clarke, the friend and disciple of Newton, is one of those who has most strenuously put forwards the opinion of which we are speaking,

All things which we commonly say are the effects of the natural powers of matter and laws of motion, are indeed (if we will speak strictly and properly,) the effects of God's acting upon matter continually and at every moment, either immediately by himself, or mediately by some created intelligent being. Consequently there is no such thing as the cause of nature, or the power of nature, independent of the effects produced by the will of God.

Dugald Stewart has adopted and illustrated the same opinion, and quotes with admiration the well-known passage of Pope, concerning the Divine Agency, which

Lives though all life, extends through all extent,
Spreads undivided, operates unspent.

Mr. Stewart, with no less reasonableness than charity, asserts the propriety of interpreting such passages according to the scope and spirit of the reasonings with which they are connected; since, though by a captious reader they might be associated with erroneous views of the Deity, they may be susceptible of a more favourable construction; and we may often see in them only the results of the necessary imperfection of our language, when we dwell upon the omnipresence and universal activity of God.

Finally, we may add that the same opinions still obtain the assent of the best philosophers and divines of our time. Sir John Herschel says, (Discourse on the Study of Natural Philosophy, p. 37.)

We would no way be understood to deny the constant exercise of His direct power in maintaining the system of nature; or the ultimate emanation of every energy which material agents exert, from his immediate will, acting in conformity with his own laws.

And the Bishop of London, in a note to his " Sermon on the duty of combining religious instruction with intellectual culture," observes:

The student in natural philosophy will find rest from all those perplexities which are occasioned by the obscurity of causation, in the supposition, which although it was discredited by the patronage of Malebranche and the Cartesians, has been adopted by Clarke and Dugald Stewart, and which is by far the most simple and sublime account of the matter; that all the events which are continually taking place in the different parts of the material universe, are the immediate effects of the divine agency.

Chapter IX - On the Impression produced by considering the Nature and Prospects of Science; or, on the Impossibility of the Progress of our Knowledge ever enabling us to comprehend the Nature of the Deity

If we were to stop at the view presented in the last chapter, it might be supposed that—by considering God as eternal and omnipresent, conscious of all the relations, and of all the objects of the universe, instituting laws founded on the contemplation of these relations, and carrying these laws into effect by his immediate energy, —we had attained to a conception, in some degree definite, of the Deity, such as natural philosophy leads us to conceive him. But by resting in this mode of conception, we should overlook, or at least should disconnect from our philosophical doctrines, all that most interests and affects us in the character of the Creator and Preserver of the world;—namely, that he is the lawgiver and judge of our actions; the proper object of our prayer and adoration; the source from which we may hope for moral strength here, and for the reward of our obedience and the elevation of our nature in another state of existence.

We are very far from believing that our philosophy alone can give us such assurance of these important truths as is requisite for our guidance and support; but we think that even our physical philosophy will point out to us the necessity of proceeding far beyond that conception of God, which represents him merely as the mind in which reside all the contrivance, law, and energy of the material world. We believe that the view of the universe which modern science has already opened to us, compared with the prospect of what she has still to do in pursuing the path on which she has just entered, will show us how immeasurably inadequate such a mode of conception would be: and that if we take into our account, as we must in reason do, all that of which we have knowledge and consciousness, and of which we have as yet no systematic science, we shall be led to a conviction that the Creator and Preserver of the material world must also contain in him such properties and attributes as imply his moral character, and as fall in most consistently with all that we learn in any other way of his providence and holiness, his justice and mercy.

1. The sciences which have at present acquired any considerable degree of completeness, are those in which an extensive and varied collection of phenomena, and their proximate causes, have been reduced to a few simple general laws. Such are Astronomy and Mechanics, and perhaps, so far as its physical conditions are concerned, Optics. Other portions of human knowledge can be considered as perfect sciences, in any strict sense of the term, only when they have assumed this form; when the various appearances which they involve are reduced to a few principles, such as the laws of motion and the mechanical properties of the luminiferous ether. If we could trace the endless varieties of the forms of crystals, and the complicated results of chemical composition, to some one comprehensive law necessarily pointing out the crystalline form of any given chemical compound, Mineralogy would become an exact science. As yet, however, we can scarcely boast of the existence of any other such sciences than those which we at first mentioned: and so far therefore as we attempt to give definiteness to our conception of the Deity, by considering him as the intelligent depositary and executor of laws of nature, we can subordinate to such a mode of conception no portion of the creation, save the mechanical movements of the universe, and the propagation and properties of light.

2. And if we attempt to argue concerning the nature of the laws and relations which govern those provinces of creation whither our science has not yet reached, by applying some analogy borrowed from cases where it has been successful, we have no chance of obtaining any except the most erroneous and worthless guesses. The history of human speculations, as well as the nature of the objects of them, shows how certainly this must happen. The great generalizations which have been established in one department of our knowledge, have been applied in vain to the purpose of throwing light on the other portions which still continue in obscurity. When the Newtonian philosophy had explained so many mechanical facts, by the two great steps,—of resolving the action of a whole mass into the actions of its minutest particles, and considering these particles as centres of force,—attempts were naturally soon made to apply the same mode of explanation to facts of other different kinds. It was conceived that the whole of natural philosophy must consist in investigating the laws of force by which particles of different substances attracted and repelled, and thus produced motions, or vibrations to and from the particles. Yet what were the next great discoveries in physics? The action of a galvanic wire upon a magnet; which is not to attract or repel it, but to turn it to the right and left; to produce motion, not to or from, but transverse to the line drawn to the acting particles; and again, the undulatory theory of light, in which it appeared that the undulations must not be longitudinal, as all philosophers, following the w/ B B analogy of all cases previously conceived, had, at first, supposed them to be, but transverse to the path of the ray. Here, though the step from the known to the unknown was comparatively small, when made conjecturally it was made in a direction very wide of the truth. How impossible then must it be to attain in this manner to any conception of a law which shall help us to understand the whole government of the universe!

3. Still, however, in the laws of the luminiferous ether, and of the other fluid, (if it be another fluid) by which galvanism and magnetism are connected, we have something approaching nearly to mechanical action, and, possibly, hereafter to be identified with it. But we cannot turn to any other part of our physical knowledge, without perceiving that the gulf which separates it from the exact sciences is yet wider and more obscure. Who shall enunciate for us, and in terms of what notions, the general law of chemical composition and decomposition? sometimes indeed we give the name of attraction to the affinity by which we suppose the particles of the various ingredients of bodies to be aggregated; but no one can point out any common feature between this and the attractions of which alone we know the exact effects. He who shall discover the true general law of the forces by which elements form compounds, will probably advance as far beyond the discoveries of Newton, as Newton went beyond Aristotle. But who shall say in what direction this vast flight shall be, and what new views it shall open to us of the manner in which matter obeys the laws of the Creator?

4. But suppose this flight performed;—we are yet but at the outset of the progress which must carry us towards Him: we have yet to begin to learn all that we are to know concerning the ultimate laws of organized bodies. What is the principle of life? What is the rule of that action of which assimilation, secretion, developement, are manifestations? and which appears to be farther removed from mere chemistry than chemistry is from mechanics. And what again is the new principle, as it seems to be, which is exhibited in the irritability of an animal nerve? the existence of a sense? How different is this from all the preceding notions! No efforts can avoid or conceal the vast but inscrutable chasm. Those theorists, who have maintained most strenuously the possibility of tracing the phenomena of animal life to the influence of physical agents, have constantly been obliged to suppose a mode of agency altogether different from any yet known in physics. Thus Lamarck, one of the most noted of such speculators, in describing the course of his researches, says, "I was soon persuaded that the internal sentiment constituted a power which it was necessary to take into account." And Bichat, another writer on the same subject, while he declares his dissent from Stahl, and the earlier speculators, who had referred everything in the economy of life to a single principle, which they call the anima, the vital principle, and so forth, himself introduces several principles, or laws, all utterly foreign to the region of physics: namely, organic sensibility, organic contractility, animal sensibility, animal contractility, and the like. Supposing such principles really to exist, how far enlarged and changed must our views be before we can conceive these properties, including the faculty of perception, which they imply, to be produced by the will and power of one supreme Being, acting by fixed laws. Yet without conceiving this, we cannot conceive the agency of that Deity who is incessantly thus acting, in countless millions of forms and modes.

How strongly then does science represent God to us as incomprehensible! his attributes as unfathomable! His power, his wisdom, his goodness, appear in each of the provinces of nature which are thus brought before us; and in each, the more we study them, the more impressive, the more admirable do they appear. When then we find these qualities manifested in each of so many successive ways, and each manifestation rising above the preceding by unknown degrees, and through a progression of unknown extent, what other language can we use concerning such attributes than that they are infinite? What mode of expression can the most cautious philosophy suggest, other than that He, to whom we thus endeavour to approach, is infinitely wise, powerful, and good?

5. But with sense and consciousness the history of living things only begins. They have instincts, affections, passions, will. How entirely lost and bewildered do we find ourselves when we endeavour to conceive these faculties communicated by means of general laws! Yet they are so communicated from God, and of such laws he is the lawgiver. At what an immeasurable interval is he thus placed above every thing which the creation of the inanimate world alone would imply; and how far must he transcend all ideas founded on such laws as we find there!

6. But we have still to go further and far higher. The world of reason and of morality is a part of the same creation as the world of matter and of sense. The will of man is swayed by rational motives; its workings are inevitably compared with a rule of action; he has a conscience which speaks of right and wrong. These are laws of man's nature no less than the laws of his material existence, or his animal impulses. Yet what entirely new conceptions do they involve? How incapable of being resolved into, or assimilated to, the results of mere matter, or mere sense! Moral good and evil, merit and demerit, virtue and depravity, if ever they are the subjects of strict science, must belong to a science which views these things, not with reference to time or space, or mechanical causation, not with reference to fluid or ether, nervous irritability or corporeal feeling, but to their own proper modes of conception; with reference to the relations with which it is possible that these notions may be connected, and not to relations suggested by other subjects of a completely extraneous and heterogeneous nature. And according to such relations must the laws of the moral world be apprehended, by any intelligence which contemplates them at all.

There can be no wider interval in philosophy than the separation which must exist between the laws of mechanical force and motion, and the laws of free moral action. Yet the tendency of men 'to assume, in the portions of human knowledge which are out of their reach, a similarity of type to those with which they are familiar, can leap over even this interval. Laplace has asserted that " an intelligence which, at a given instant, should know all the forces by which nature is urged, and the respective situation of the beings of which nature is composed, if, moreover, it were sufficiently comprehensive to subject these data to calculation, would include in the same formula, the movements of the largest bodies of the universe and those of the slightest atom. Nothing would be uncertain to such an intelligence, and the future, no less than the past, would be present to its eyes." If we speak merely of mechanical actions, this may, perhaps, be assumed to be an admissible representation of the nature of their connexion in the sight of the supreme intelligence. But to the rest of what passes in the world, such language is altogether inapplicable. A formula is a brief mode of denoting a rule of calculating in which numbers are to be used: and numerical measures are applicable only to things of which the relations depend on time and space. By such elements, in such a mode, how are we to estimate happiness and virtue, thought and will? To speak of a formula with regard to such things, would be to assume that their laws must needs take the shape of those laws of the material world which our intellect most fully comprehends. A more absurd and unphilosophical assumption we can hardly imagine.

We conceive, therefore, that the laws by which God governs his moral creatures, reside in his mind, invested with that kind of generality, whatever it be, of which such laws are capable; but of the character of such general laws, we know nothing more certainly than this, that it must be altogether different from the character of those laws which regulate the material world. The inevitable necessity of such a total difference is suggested by the analogy of all the knowledge which we possess and all the conceptions which we can form. And, accordingly, no persons, except those whose minds have been biassed by some peculiar habit or course of thought, are likely to run into the confusion and perplexity which are produced by assimilating too closely the government and direction of voluntary agents to the production of trains of mechanical and physical phenomena. In whatever manner voluntary and moral agency depend upon the Supreme Being, it must be in some such way that they still continue to bear the character of will, action, and morality. And, though too exclusive an attention to material phenomena may sometimes have made physical philosophers blind to this manifest difference, it has been clearly seen and plainly asserted by those who have taken the most comprehensive views of the nature and tendency of science. " I believe," says Bacon, in his Confession of Faith, "that, at the first the soul of man was not produced by heaven or earth, but was breathed immediately from God: so that the ways and proceedings of God with spirits are not included in nature; that is in the laws of heaven and earth; but are reserved to the law of his secret will and grace; wherein God worketh still, and resteth not from

the work of redemption, as he resteth from the work of creation; but continueth working to the end of the world." We may be permitted to observe here, that, when Bacon has thus to speak of God's dealings with his moral creatures, he does not take his phraseology from those sciences which can offer none but false and delusive analogies; but helps out the inevitable scantiness of our human knowledge, by words borrowed from a source more fitted to supply our imperfections. Our natural speculations cannot carry us to the ideas of ' grace' and ' redemption;' but in the wide blank which they leave, of all that concerns our hopes of the Divine support and favour, the inestimable knowledge which revelation, as we conceive, gives us, finds ample room and appropriate place.

7. Yet even in the view of our moral constitution which natural reason gives, we may trace laws that imply a personal relation to our Creator. How can we avoid considering that as a true view of man's being and place, without which his best faculties are never fully developed, his noblest energies never called out, his highest point of perfection never reached? Without the thought of a God over all, superintending our actions, approving our virtues, transcending our highest conceptions of good, man would never rise to those higher regions of moral excellence which we know him to be capable of attaining. Again says the great philosopher:

To deny a God destroys magnanimity and the raising of human nature; for take an example of a dog, and mark what a generosity and courage he will put on, when he finds himself maintained by a man; who, to him, is instead of a God, or *melior natura*: which courage is manifestly such, as that creature, without that confidence of a better nature than his own, could never attain. So man, when he resteth and assureth himself upon divine protection and favour, gathereth a force and faith, which human nature could not obtain. Therefore, as atheism is in all respects hateful, so in this, that it depriveth human nature of the means to exalt itself above human frailty.

Such a law, then, of reference to a Supremely Good Being, is impressed upon our nature, as the condition and means of its highest moral advancement. And strange indeed it would be if we should suppose, that in a system where all besides indicates purpose and design, this law should proceed from no such origin; and no less inconceivable, that such a law, purposely impressed upon man to purify and elevate his nature, should delude and deceive him.

8. Nothing remains, therefore, but that the Creator, who, for purposes that even we can see to be wise and good, has impressed upon man this disposition to look to him for support, for advancement, for such happiness as is reconcileable with holiness;—this tendency to believe him to be the union of all perfection, the highest point of all intellectual and moral excellence;—is in reality such a guardian and judge, such a good, and wise, and perfect Being, as we thus irresistibly conceive him. It would indeed be extravagant to assert that the imagination of the creature, itself the work of God, can invent a higher point of goodness, of justice, of holiness, than the Creator himself possesses: that the Eternal Mind, from whom our notions of good and right are derived, is not himself directed by the rules which these notions imply.

It is difficult to dwell steadily on such thoughts; but they will at least serve to confirm the reflexion which it was our object to illustrate; namely, how incomparably the nature of God must be elevated above any conceptions which our natural reason enables us to form: and we have been led to these views, it will be recollected, by following the clue of which science gave us the beginning. The Divine Mind must be conceived by us as the seat of those laws of nature which we have discovered. It must be no less the seat of those laws which we have not yet discovered, though these may and must be of a character far different from any thing we can guess. The Supreme Intelligence must therefore contain the laws, each according to their true dependence, of organic life, of sense of animal impulse, and must contain also the purpose and intent for which these powers were put in play. But the Governing Mind must comprehend also the laws of the responsible creatures which the world contains, and must entertain the purposes for which their responsible

agency was given them. It must include these laws and purposes, connected by means of the notions, which responsibility implies, of desert and reward, of moral excellence in various degrees, and of well-being as associated with right doing. All the laws which govern the moral world are expressions of the thought and intentions of our Supreme Ruler. All the contrivances for moral no less than for physical good, for the peace of mind, and other rewards of virtue, for the elevation and purification of individual character, for the civilization and refinement of states, their advancement in intellect and virtue, for the diffusion of good, and the repression of evil; all the blessings that wait on perseverance and energy in a good cause; on unquenchable love of mankind, and unconquerable devotedness to truth; on purity and self-denial; on faith, hope, and charity;—all these things are indications of the character, will, and future intentions of that God, of whom we have endeavoured to track the footsteps upon earth, and to show his handiwork in the heavens. "This God is our God, for ever and ever." And if, endeavouring to trace the plan of the vast labyrinth of laws, by which the universe is governed, we are sometimes lost and bewildered, and can scarcely, or not at all, discern the lines by which pain, and sorrow, and vice fall in with a scheme directed to the strictest right and greatest good, we yet find no room to faint or falter; knowing that these are the darkest and most tangled recesses of our knowledge; that into them science has as yet cast no ray of light; that in them reason has as yet caught sight of no general law by which we may securely hold: while, in those regions where we can see clearly, where science has thrown her strongest illumination upon the scheme of creation; where we have had displayed to us the general laws which give rise to all the multifarious variety of particular facts;—we find all full of wisdom, and harmony, and beauty: and all this wise selection of means, this harmonious combination of laws, this beautiful symmetry of relations, directed, with no exception which human investigation has yet discovered, to the preservation, the diffusion, the well-being of those living things, which, though of their nature we know so little, we cannot doubt to be the worthiest objects of the Creator's care.

1853
Brigham Young
We see the spangled vault of the starry heavens
Journal of Discourses vol.2 p.122

If people would contemplate the stupendous works of God, and be honest and candid in their investigations, there is much to be learned that would show them how comparatively worthless are earthly things. We see the spangled vault of the starry heavens stretched over us; but little is known of the wonders of the firmament. Astronomers have, by their researches, discovered some general facts that have proved useful and instructing to the scientific portion of mankind. The phenomena of the motions of the heavenly bodies, and their times and seasons are understood pretty accurately. But who knows what those distant planets are? Who can tell the part they play in the grand theatre of worlds? Who inhabits them, and who rules over them? Do they contain intelligent beings, who are capable of the happiness, light, glory, power, and enjoyments that would satisfy the mind of an angel of God? Who can tell these things? Can they be discovered by the light of science? They cannot. Let every intelligent person seriously contemplate this subject, and let the true light of reason illuminate the understanding, and a sound judgment inspired by the Spirit of Christ be your guide, and what will be your conclusions? They will be what mine are-that the Lord Almighty reigns there; that His people are there; and that they are, or have been, earths to fulfil a similar destiny to the one we inhabit; and there is eternity; and as Enoch of old said-"Thy curtains are stretched out still."

Can any of the astronomers in the world point out the kingdom or the world where God is not? where He does not reign? Can a kingdom be found, by worldly wisdom, study, or by any means that can be employed, over which He does not sway His sceptre? If such a kingdom exists, I will

acknowledge that the doctrine I taught you the other day is incorrect; and besides that, you will have to blot out some of the writings of the ancient Scriptures.

1857
Jules Simon, French Catholic Philosopher
Natural Religion
Book published by Richard Bentley

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Part The First - The Nature Of God

Chapter I - Reflections On The Proofs Of The Existence Of God

Every thing which is born must necessarily proceed from something else; but it is difficult to find the author and father of the universe, and impossible, when he is found, to render him intelligible to all the world.—Plato's Timeaus, translated by V. Cousin, t. xii. p. 117.

There are beyond doubt, in the present lamentably unsettled state of society, men who live without thinking of God. They neither deny nor question that he exists; they simply forget him. Exclusively devoted to their own worldly interests and passions, they are occupied in the enjoyment of life, and in banishing the idea of death. To whatever length the tragedy may be prolonged, the catastrophe always comes upon them by surprise; and the last hour finds them filled with the thoughts and love of those sterile possessions which are about to be snatched away for ever. These indifferent sensualists do not comprise the majority; a great proportion of mankind believe firmly in the existence of God. Too often their faith is neither active nor fortified by reflection; they do not examine themselves on their tenets, and could scarcely explain them if called upon; in the practice of life they proceed as if they were void of faith, but they recover themselves, if we may so express it, under solemn circumstances. They may be seen to pray upon a tomb or over a cradle. Although they do not, with the philosophers, explore and inhabit the invisible world, they know and feel that such a world awaits them, and is their true inheritance. The name of God rises naturally to their lips in necessity and suffering. They have a confused perception that God is the originating principle of all morality and knowledge, and that to give up this fundamental truth is to plunge into scepticism and deliver the soul over to annihilation.

In seeking for the causes which give predominance to this salutary belief, we may assuredly enumerate the influence of religion, education, and philosophy; but we must at the same time admit that there are implanted in the mind and heart of man a secret instinct, and a natural impulse which draw him towards God. The spectacle of the world instructs us; the afflictions of life, while they demonstrate our helplessness, compel us to look for a comforter; and enjoyment itself, in a generous, noble nature, gives rise to sentiments of gratitude and piety. The longer we live, the more deeply are we impressed with the impossibility of admitting annihilation; and with the necessity of believing that there is a God above who regulates everything,

Fortified, without our own consciousness, by the events which have left their traces upon our souls, this belief in the existence of God becomes at last an imperceptible portion of our nature. We feel it to be so essential and irresistible, that without reflecting or comprehending, we repose upon it with confidence and security, as a child relies on the love and protection of a father.

It is satisfactory to reflect that this conviction and confidence are to be met with, in equal force, through every class of society; that all nations, divided as they may be upon other points, are in

accordance upon this; that religious faith precedes civilisation, and is assuredly its original institutor; that travellers never discover a new tribe without finding amongst them at least the elements of some rude worship; and that history, ascending to the earliest periods, always presents to us God associated with the first thoughts and feelings of man. The inherent faith which we acknowledge within ourselves, and which develops and increases with the intercourse of life, encounters an analogous faith on every side, in the external world. This community of belief and sentiment renders human nature a single family.

Since the age of Plato, who has reasoned on the existence of God in his Timaus and Laws,* and that of Aristotle, who has demonstrated the divine essence in the twelfth book of his Metaphysics, the schools have handed down a certain number of formal arguments, which have been successively amended, and which, renewed, as we may say, by Descartes and Leibnitz, comprise, at this, day, the basis of instruction. These arguments are full of force, if we consider above all other points the principle on which they chiefly rest, and which embraces incontestable truth; but in arrangement they are neither solid nor efficacious. The propositions are sound, but the reasonings are feeble. They will never convert the soul of an atheist, and are insufficient to fix hesitating and unsettled minds. Let us pass them summarily in review, on account of their historical importance, without deceiving ourselves as to any advantageous result. Their inutility will console us for their weakness. We know that certain dispositions feel the necessity of reasoning on their faith, of verifying it by argument, of sifting its tenor, of examining its consequences, of separating it from all that appears obscure, incomplete or paradoxical; but to arrive thus at the power of transforming an instinctive and impulsive belief in the existence of God into a philosophical dogma, requires a long series of study and persevering meditation. The habit of finding God everywhere, as the inseparable foundation of all truth and reality, renders our faith equally specific and animated. Such an effect cannot be expected from two or three syllogisms. Arguments rapidly run over to arrive at a logical conclusion, are insufficient to reassure and convince. We strive in vain to admit their solidity; the mind is startled and checked by the greatness of the result. We require a longer road, and more time to collect our powers of reflection, until we become accustomed to the splendour of divine majesty. We believe, by an invincible instinct, in the existence of God; but to establish our faith upon fixed rules, demands the fullest extent of human science.*

When Descartes undertook to demonstrate the existence of God through a regular formula, he was driven to the task by the predicament in which he had voluntarily plunged. In order to divest himself of all contradictory prejudices derived from education, and to abandon every opinion of which he could not distinctly estimate the origin and value, he made a plain tablet of his mind, and swept from it every point of faith which he had previously adopted. This extended scepticism, the object of which was not to cease to believe, but to recommence belief upon superior reason and authority, is what has been denominated " Doubting according to method." Descartes escaped from it by this remark,—that he could doubt of everything, except only of his doubt, and consequently of his thought and being. Saint Augustine, before him, had uttered precisely the same opinion. " I am certain of my existence," says he, in his treatise De Civitate Dei;" in this I cannot be accused of deceiving myself, for even to deceive myself, I must exist."* Being convinced of his existence, Descartes demands of himself what he is, and answers, that he is a living being endowed with thought. This reflection leads him to examine the different ideas which present themselves to his mind, and the first that arrests his attention is that of perfection. What is this idea? Is it a pure chimera? Or does it apply to some object actually existing? It is thus that Descartes finds himself led on from the first step of his philosophy to demonstrate the existence of God.

" I conceive," says he, " the idea of a perfect being: now, I am not myself a perfect being, because I doubt. I possess many other ideas, such as those of heaven, earth, and animals;but I may have formed these myself, for there is nothing in them which I cannot draw from my own nature by means of analysis or composition. But perfection is something so far beyond myself that I am unable

to form any notion of it from the imperfections with which I am acquainted. God, therefore, exists."

We may develop, or, to speak with more exactness, we may detail this demonstration, as follows: —

I possess within myself the idea of God; that is to say, the idea of the infinite: how is this?

It can only be from one of these two reasons:—

Either because infinity exists, and it thus becomes perfectly natural that I should possess the idea: or that infinity does not exist, and I have myself formed the idea I conceive.

Now, is it possible that I could myself have originated the idea of infinity which I feel within me?

I have only two ways of forming an idea of an object which does not exist; either by attenuation, in suppressing through power of thought some of the qualities of an actual object; or by amplification, in uniting under the same idea the qualities of many objects.

The infinite cannot be an attenuation of the finite; neither can it be an accumulation of finite qualities; for a great number of finite things can make no more than a great number of finite things; they cannot expand into a single infinite. The difficulty i3 not removed by supposing that if I conceive a finite being, setting aside all that limits it, I ascend thus to the notion of infinity. This is to fall back into the hypothesis we have just rejected; for if we cannot produce infinity by combining together an indeterminate number of finites, neither can we do so by multiplying for an indeterminate number of times any given thing which is finite in itself.

It follows, therefore, that I cannot conceive the idea of infinity except upon the sole condition that infinity exists.

This demonstration is equally solid and simple. But, unfortunately, it only addresses itself to those minds who are convinced that the idea of infinity is inherent in their nature, and has not been produced by a combination of several other' ideas. Now, it necessarily follows, that all those who reason from the senses must agree on the first point, and that their theory consists precisely in denying the second. Thus, the proof of Descartes has no value except for philosophers, who least of all require that the existence of God should be proved.

After the foregoing demonstration, he laid down another much more complicated, which we may sum up in the following manner:—

I exist, and I possess within me the notion of a God;* I am, therefore, not the author of my own being; for if I were, I should have given myself all the perfections of which I have any idea, having already assumed the most difficult of all acquired things— substance. But if I conclude that I have always been what I am now, still that does not enable me to dispense with an originating cause; for the duration of defined substance is only the uninterrupted repetition of the act by which it has been produced. To have recourse to my parents, or to any other cause less perfect than God, explains nothing, as I must define such a cause as I define myself, I cannot imagine an infinite series of successive causes, for I must find not only a cause which produces, but one which preserves,—consequently, an actual, identical cause. Several distinct causes, therefore, have not contributed to my formation, each adding a specific perfection to the idea I entertain of the general perfection of God; for unity and simplicity form the leading characteristics which I

attribute to him. Thus, by my existence and the idea of God implanted within me, the existence of God can alone be proved.

We recognise in this demonstration the intellectual vigour with which Descartes preserves the chain of a proposition, and the exact enumeration of every point of an hypothesis. Nevertheless it does not entirely satisfy the mind, and all who read it will be arrested by some assertions which at least are open to contest.

Thus, for example, when Descartes says, " If I had been my own creator, I should have given myself all the perfections of which I can conceive the idea, because it is less difficult to have given these perfections than to have given substance," this mode of expression is, to say the least of it, inconsistent, since the mind cannot implicitly adopt the conclusion that it is more difficult to give substance than perfection. As we are unable to comprehend clearly what it is to bestow on ourselves substance, or to give perfection, we can scarcely decide between these two incomprehensible difficulties, which is the most incomprehensible. Descartes might have said in a more simple form, that the being who exists by his own will, if such a being does exist, must of necessity be perfect. The proposition thus laid down, would seem to be beyond dispute.

The same result applies to the conclusion that the duration of substance is merely continued creation; whence Descartes decides that, being imperfect, we not only require a cause which has made, but also a cause which preserves us, and, consequently, a perpetually acting cause. After all, it is most true, that having no other reason to be, beyond the will of the Creator, we require no other reason for continued being; but, on the one hand, Descartes has awkwardly complicated this simple idea of a theory of continued creation; and, on the other, if we admit the necessity of a preserving cause to continue our being, such an admission includes an acknowledgment of the existence of God, and the demonstration becomes superfluous.

Finally, the last assertion of Descartes, that unity and simplicity form the leading characteristics which the human mind attributes to perfection, will undoubtedly be admitted by the rationalists, but warmly contested by other philosophers. Whence it follows, that the greater part of the propositions, of which this argument consists, possess the fault of rendering the rest of the demonstration useless, if once they are admitted; and the still greater fault of being only admissible by philosophers of the rationalist school.

We find again, in the " Discourse upon Method," and the " Meditations," a third demonstration of the existence of God, which is no other than the celebrated proof known under the name of The argument of Saint Anselm, and which consists in concluding directly the existence of God from the idea of God.* This argument may be thus laid down, according to Saint Anselm, Descartes, and Leibnitz:—

I have within myself the idea of God, that is to say, of a perfect being, of a being endowed with all perfections.! Now, existence being a perfection, I cannot without absurdity suppose that a perfect being does not exist.

It requires a great effort to understand this argument in its extreme brevity. We shall give in succession the formula of Saint Anselm, that of Descartes, and the improved one of Leibnitz.

"It is impossible," says Saint Anselm, "to think that God does not exist; for God is, when defined, such a being that we cannot conceive one superior. Now, I can conceive a being whose existence it is impossible to disbelieve, and this being is evidently superior to one whose non-existence I am capable of imagining. Therefore, if we admit the possibility of supposing that God does not exist,

there must be a being superior to God; that is to say, a being superior to one, than which we cannot conceive a greater—which is absurd."

While examining this proof in the fifth "Meditation," Descartes has explained and strengthened it. " I cannot," says he, " conceive a mountain without a valley, nor a right-angled triangle of which the sum of the three angles is not equal to two right angles; in like- manner, I am unable to imagine God without existence, for existence is a perfection, and God is the sum of all perfections." " It might be objected," he continues, " that if I cannot conceive a mountain without a valley, this does not prove that there is either a mountain or a valley, but simply that one cannot exist without the other; and, in like manner, if I cannot conceive God without existence, because God is perfect, this does not prove that God exists, but merely that he could not be perfect without existence. Now, this objection is specious, not solid, since it is existence itself, and not any other specific quality, which is inseparable from our idea of God. I am as incapable of conceiving a God without existence, that is to say, a being supremely perfect, yet wanting a supreme perfection, as I am free to imagine a horse with or without wings."* Enlightened minds have judged that this reasoning cannot be attacked. Leibnitz endeavoured to improve it by anticipating a possible objection.-)According to him it is thus peremptorily demonstrated that if God is possible, he is necessary. Everything consists in establishing that the simple definition of God implies the existence of God; above all, that it is indispensable that God should be defined, that he should be proved to be possible, or, in plainer terms, that the idea of a perfect being should not embrace a contradiction. Leibnitz, therefore, imagined he had given to the argument of Saint Anselm the utmost degree of severe perspicuity, when he expressed it under the following formula:—" The being whose essence implies existence, exists, if it is possible; that is to say, if it has an essence. (This is an axiom of identity, which requires no demonstration.)

" Now, God is a being whose essence implies existence. (Through definition.) Therefore, if God is possible, he exists. (By the sole force of the idea we conceive of him.) "

Must it be confessed? This argument appears more subtle than sound; and without the respect inspired by such names as those of Descartes, Bossuet, Fenelon, and Leibnitz, we should venture to say that it resembles a sophism. This last word naturally suggested itself to the pen of Descartes while he was writing.* The improvements added by Leibnitz are not very encouraging. He is undoubtedly right in declaring that if by some contradiction or impossibility, the idea of perfection should prove to be in itself a chimera, we could not conclude from the presence of such an idea in our own minds, that the object of it actually existed; but, on the other hand, it seems difficult not to admit that if the presence in our own minds of the idea of perfection does not prevent us from supposing the impossibility of perfection, still less does it prevent us from conceiving its nonexistence. The error of this argument lies in its having a reality for conclusion, and an abstraction for principle. It is true that we conceive God to be perfect; it is true that existence is a perfection; it is, therefore, equally true that we conceive God to be existing at the same time and in the same manner that we conceive him to be perfect. Now, in what manner do we conceive God as perfect? When I say, " I conceive a perfect being," that means, " I conceive that there is, or that there may be, a perfect being." In like manner, when I say, " I conceive that a perfect being exists," I mean to imply, " I conceive that there is or may be a perfect being, and that such a being could not be perfect without the condition of existence."

Descartes, who foresaw this objection, maintains that we do not conceive the existence of God as simply possible, but as absolutely necessary, "considering that God exists through himself alone, and that that which exists by its own power must exist for ever." This conclusion may be classed with nearly all the preceding arguments. It is true, but the reasoning applies to the conclusion alone; which means, that here again there is no reasoning, and Descartes has only once more affirmed the philosophy of the rationalists.

"If we carefully enquire whether existence accords with an omnipotent being, and what sort of existence, we shall be able clearly and distinctly to ascertain, in the first place, that, at least, possible existence may be one of his suitable attributes; and secondly, because we cannot think that his existence is possible without at the same time knowing that, 33 his power is infinite, he exists through his own will, we must therefore conclude from thence that he actually does exist." See Answer to the first objections, Answer to the second objections, and, above all, at the end of these Answers, The Demands of Descartes, (Fifth Demand.)

If now, including in a single glance all the different arguments we have gone through, and disengaging them from their syllogistic form, we endeavour to explain what gives them, in spite of their logical weakness, a real value which the most sceptical mind is compelled to how to and acknowledge, we shall find it is the constant presence of the following affirmation so incessantly repeated under every possible form. " It is evident that the infinite exists; it is absurd to suppose its non-existence; nothing opposes the existence of the infinite; if the infinite is not, nothing is possible; while, on the contrary, everything is possible on the condition that the infinite exists." This is not an argument; it is a principle, an intuitive conviction, if so it may be called, a self-evident truth. Remove this from our perception and we shall be no longer capable of thought. It is precisely because this principle is the foundation of thought, that it cannot be reduced to a logical demonstration. To demonstrate is to rest a truth upon an antecedent principle: therefore, all principles may be demonstrated with the exception of those first principles which serve for the demonstration of others. What we have to deal with here, is not to introduce into our minds a belief in the existence of the infinite, but simply to establish that the belief is already there. The authors of the arguments we have recapitulated have only erred upon a question of method.

If instead of having had recourse to the scholastic form, which seems more in its place in the Proslogium than in the " Meditations," Descartes had confined himself to saying that the human mind in considering perfection, comprehends that it must exist by the necessity of its nature, while, on the contrary, it acknowledges that an imperfect being can only exist upon the condition of having been produced by some extraneous cause, this principle, which forms the whole point of the argument, must have been received with conviction. Bossuet has adopted it in his " Elevations." " Why," says he, " should imperfection exist, and not perfection? Or rather, why should that be which contains the elements of nonentity, and that not be which has no particle of annihilation? . . . My soul, who art endowed with the faculty of reason, but whose reason is so limited, why dost thou desire to endure, and how canst thou believe that God does not? Alas! art thou superior to God? Weak, ignorant, and misguided soul, full of doubt and error in thine intelligence, overflowing with ignorance, wandering, corruption, and evil desires, in thine own will, can it be that thou shouldst exist, and that certainty, comprehension, the boundless knowledge of truth, and the immutable law of justice and rectitude should not exist?* . . . Tell me, my soul, how dost thou understand nothingness, except by being? How dost thou feel privation except by the distinct something which is taken away? How dost thou conceive imperfection, except by the idea of the perfection from which it has fallen? . . . There must be perfection before there can be a fault; before irregularity there must be something essentially regular, and which being inseparable from its own nature, can neither fail nor err."

Spinoza reasons after the same manner: " Nothing," he says, " either in God or out of God can establish any obstacle to the existence of God. There cannot be a square circle, because the nature of such a figure is contradictory, and a circle cannot exist without a cause, because its nature is not essentially necessary; but God, on the contrary, cannot be without existence, because he is self-sufficient, and there is nothing in his nature which can render him impossible. "

In speaking thus, Bossuet and Spinoza merely repeat the argument of Descartes, of which they neglect, or, as we may almost venture to say, of which they disdain the form.

Descartes, whose genius was essentially metaphysical, has intentionally omitted the demonstration drawn from the visible universe, and from the necessity of a perfect cause which explains its existence and harmony.

"We ought to be able to assign a cause or reason for everything, to explain why it does or does not exist. For instance, if there is a triangle, there must be a reason or cause why it is there. If the triangle does not exist, still it is necessary to show a reason or cause which either opposes or destroys its existence. Now this cause or reason must be found either in or out of the nature of any given thing. For instance, the reason why there cannot be a square circle is comprised in the very nature of the thing, which implies a contradiction. ... On the other hand, the reason why there should be either a triangle or a circle does not lie in the nature of these figures, but in the order of bodily nature taken entirely; for it must result from this order, either that the triangle already existed of necessity, or that it is impossible that it should continue to exist. These principles are self-evident, and from these we conclude, that a given thing necessarily exists when there is no cause or reason which prevents its existence. But we cannot find, out of the divine nature, any cause or reason which prevents its existence, and it is therefore absurd to imagine a contradiction in a being absolutely infinite and endowed with sovereign perfection. Let us conclude, therefore, that neither in God nor out of God is there any cause or reason which destroys his existence, and consequently that God necessarily exists."—Spinoza's Ethics, part i., second proposition. Translation of M. Emile Saisset, vol. i. pp. 13 and 14.

This demonstration includes three parts, or rather divides itself into three distinct demonstrations.

First,—It establishes that the matter of the world requires a cause; for how could it subsist of itself, seeing that it is the most imperfect, and in some respects the least real of all existences? Therefore, the existence of matter proves the existence of a Creator.

Secondly,—It proves that matter left to itself is inert. It undergoes, receives, and transmits motion, but cannot produce it. Therefore, everything in matter that has power and organisation comes from an exterior cause; consequently there must be an originating mover of matter.

Finally,—An argument is drawn from the universal harmony of motion and being. Not only is it impossible for matter to exist or move of itself, but its movements, if they were, as has been supposed, the consequences of a blind necessity, would be capricious and disorderly, instead of being replete with beauty, proportion, and regulated force. There must, therefore, be a controlling intelligence which has conceived and carried into execution the plan of the universe. There is a Providence.

This triple, or, if the phrase is preferred, this single demonstration (for the whole question lies in tracing back the existence of the world to a cause), is the most popular argument on the subject, the most frequently employed, and the most readily admitted. It embraces all the resources of oratorical art, and addresses itself, perhaps, quite as powerfully to the imagination and feelings, as to the reasoning faculties. It has the merit of accustoming us to seek especially, in the study of phenomena, the law by which they are governed, and to look upon all laws as the different formulae of a single and undivided principle.

But the misfortune of this argument is, that if it proves invincibly what it undertakes to prove, it does not establish all that is necessary. The God who has made the world is unquestionably powerful and intelligent, but does he possess infinity of power and intelligence? Between a God

simply capable of making the world, and a perfect God, there is still an infinite abyss. We perceive, here below, beauties and perfections in -vast number, but we find also abundance of disorder. The induction which concludes the perfection of the Creator from the greatness of his work, does not supply any explanation of the evil that exists in the world. One point alone of the argument could give us a glimpse of the divine perfection—that which touches upon creation. But the world is a bad road through which to arrive at creation, for creation has no analogue.

This proof, or one exactly similar, has been elaborately discussed by Samuel Clarke, in his " Treatise on the Existence of God," which excited the somewhat excessive admiration of Voltaire. Clarke handles the same materials, and writes with the abrupt inelegance of Spinoza, but without his genius. He arranges an interminable series of axioms and syllogisms, sometimes to prove that the world is contingent; at others, to establish that it exists necessarily as an infinite and eternal essence. The whole winds up with a conclusion that perfection cannot be produced by a combination of all imperfections; so that, by a different path, Clarke falls into the error of Descartes, and merely repeats over and over again, under a syllogistic form, the fundamental proposition of the rationalist schools.

We merely mention, for the sake of record, another argument peculiarly belonging to Samuel Clarke, and which Leibnitz has considered worthy of a reputation. This is it; " Infinite time and infinite space are not substances; they are therefore attributes; consequently there must exist an infinite cause and subject to which infinite time and space belong."

This conclusion is not only denied by the sensualists, but by the rationalists, who equally agree in rejecting these two chimeras of time and space, which Clarke endeavours to establish as the attributes of God.

Finally, a very beautiful and simple proof of the existence of God (beautiful on account of its simplicity), has been drawn from the existence of axioms, or self-evident truths. The reasoning may be thus conveyed: Since there are certain self-evident and eternal truths, and that the distinctive mark and object of any truth is to be understood, it follows that there must be an eternal intelligence, by which these truths are eternally comprehended. Consequently, God exists.

We shall not inquire whether it is possible to suppose an indefinite series of finite intelligences, by means of which, axioms could be understood throughout interminable ages. The argument which concludes from the existence of eternal ideas, the existence of an eternal intelligence, and consequently of an eternal being, seems perfectly solid and convincing for all who, with us, admit the necessity and eternity of axioms. As a general question, it appears extremely easy to demonstrate the existence of God to the rationalists, because they cannot set him aside for a single moment; or rather, it is unnecessary to enter into the demonstration with them, for his existence is implicitly contained in all their doctrines. The rationalists never go beyond the major of these propositions, because that suffices to convince them; and the other philosophers stop there equally, because they reject it.

Such are the formal proofs of the existence of God, which are of sufficient importance to be pointed out, and which, under various forms, fill the treatises of philosophy wherein it has been endeavoured to reduce to the authority of a syllogism this fundamental truth, without which nothing can be true. Fenelon has summed them all up with much force and eloquence, in his Essay on the Existence of God. Thus collected together, in a body of doctrine, they impress the mind as something serious and weighty. We readily discover certain objections; we hesitate a little on particular details; but we comprehend, on the whole, that any thesis contrary to that of the author must be inadmissible. The priest and preacher are visible behind the philosopher. Fenelon is one of the first writers in our language, who possesses the rare gift of passing from a familiar simplicity of

style to the most florid oratory, and from the scholastic severity of logic to the most touching effusions of tenderness. His book, which is exclusively a reflection of his heart, is a grand and beautiful work, where ignorance may find method and perspicuity, and whence the whole world, learned and unlettered, may extract noble emotions. Such a lecture, considered with attention, is equivalent to a prayer. Our conclusion may be easily foreseen. Fenelon will be read with delight; but we shall derive from his volume edification rather than incentives to faith.

We admire in Descartes, in Leibnitz, and, in a lesser degree, in Clarke, a strong and solid train of thought; but their proofs are insufficient for unbelievers, as they all rest on the impossibility under which we find ourselves of conceiving the idea of God, without an inspiration from God; an impossibility, which the rationalists alone confess: * and for the rationalists they are useless, because if the idea of God is in us, as they believe, without our having formed it ourselves, it is clear, before all demonstration, that God exists.

We incline to think, that instead of adopting any particular formula, which must be ever open to discussion; and which, argued as it may, will never appear a sufficient base for such an important point of faith, it would be wiser to " approach philosophy with this salutary reflection, that we are entering into the temple of truth, which only manifests itself to sincere inquirers; " and to examine successively every section of which science is composed, without dwelling too much on first results, and without expecting to arrive, all at once, at the solution of the most important and intricate problems. When we seek God thus, we may be sure to find traces of him at every step. We comprehend, from the outset, that he exists, without forming a distinct conception of his attributes: but, in proportion as during the gradual development of science, we find him always as a necessary conclusion to every new theory, we gather from this study unexpected light upon the nature of him who is the cause of all substance and all law. We accustom ourselves to contemplate God while first studying him in his works; like children, who being unable to look on the sun, seek for its reflection in a stream.

Do you desire to know if there is a God? Study the world; or, if the world is too extended, study man. Every thing within us bears testimony to the existence and omnipotence of the Deity.

Human form is single in principle, but triple in its manifestations. To live, is to think, to feel, and to desire.

What is to feel? Is it merely to experience sensations of pleasure and of pain? We have here but the first indications of sensibility. To these ephemeral phenomena something is attached more grand and enduring—our affections. In what do they originate? Does the external world bring them, or do they spring from the heart, as from a burning centre, to expand themselves upon all that surrounds us? If love came from without, why is not the same cause equally attractive to every one? Whence could proceed the varieties of feeling between cold and impassioned temperaments? How could we then comprehend so many lofty sentiments excited by unworthy objects? Or that magic of affection which creates in the subject of its worship the beauties it admires? Or those souls born for love, who, finding nothing on which to concentrate an exclusive attachment, perish of an unknown disease, victims of their own richness and of the poverty of the world? The same hand which, in the seed of a plant, has disposed the mysterious power which draws the roots towards the earth, and elevates the stem above the soil, to expand itself in fruits and flowers, has fixed in the depths of the human heart a love of eternal beauty, which inclines us to all that is good and perfect, by a secret and controlling analogy. What is this sentiment, this innate perception of the beautiful and the good, without which we should be incapable of love? What is this beauty towards which the entire heart springs, and which we adore, by reflection, in the glorious creatures in whom it is manifested? Is it not infinite, eternal, and perfect beauty? And this boundless love, is it not one of the ties that connect us with God?

The faculty of intelligence soars, perhaps, even above that of feeling. To think, with ordinary minds, is to distinguish the form, the size, and the weight of bodies; to calculate the degree of muscular force required to displace a mass; to foresee that a necessity will arise at a particular part of the globe for conveying thither, at a precise moment, the merchandise which has been called for; to buy and sell with relative convenience; to balance expense and profit; in a word, to concentrate human understanding upon this one point—the preservation and nourishment of the body. We have no occasion to* go further or ascend higher; for even to accomplish such a restricted end, how great is the mechanism of human understanding? Must it not conceive laws and necessary affinities between different things? Does it discover those affinities in the things themselves, the inevitable in the contingent, the right in the act, the law in that which submits to the law? If it be true that the visible world does not contain the law, here is in itself the first intuition of the invisible world. But let us approach the latter by another road. Let us examine the objects which surround us, this narrow horizon, by which we are compressed. We only touch what is close to us, or literally within reach; we only see distinctly for a few paces: at a given distance everything disappears and escapes. Let us fly from this prison, since we can remove ourselves, painfully and slowly, by natural means, but with extreme rapidity by the aid of mechanism. To enjoy expansion, let us travel one thousand or two thousand leagues, or make a tour of the globe. We shall thus introduce into our minds the idea of extended spaces, which we can only look upon in sue cession, but which we are able to conceive by a single notion. In fact, we do not even require movement to comprehend space; imagination suffices; and, by its aid, we can figure to ourselves, as in a dream, the dimensions of the entire world. But the world comprises little, although it would take a man's life to visit it all: we know that it is merely an atom in the immensity of the universe. Let us travel in thought from star to star; let us figure to ourselves those vast bodies, more extensive than the earth, separated by boundless intervals, and more numerous than the sands of the sea. When we have accumulated together all these wonderful and multiplied existences; and when, to describe them, we have exhausted the resources of language, and the powers of calculation, we still feel within us a propelling force which urges us onward, beyond the real, the possible, and the imaginary. What must we conclude from this? That we cannot conceive a space which is not contained within another. And whence arises this impossibility? Is it the limited extent we are capable of conceiving which impresses it on our minds? Is it this bounded atom which brings with itself immensity? Is there not in the idea something originating in ourselves, which, instead of resulting from the senses, is directly opposed to them? If we quit space for durability, we find at the end of our double analysis an identical conclusion. If from time and space we pass to motion, or multiplication, we still recognise the same progress towards the infinite, the same necessity of conceiving something which goes beyond what we can derive from the senses and the power of imagination. We call this indescribable something by different names, according to the path by which we have been led towards it—immensity, if we were following space; eternity, if we were on the track of time; immutability, if we were pursuing motion; and unity, if we recurred to multiplication. But this immensity, eternity, or immutability, is merely one identical idea under various names—the idea of the infinite. If we examine this idea in itself, and demand what it includes, we shall find it always necessary, entire, and indivisible, while the world is ever contingent, changing, moveable, and shut up on every side within narrow limits. We are forced to acknowledge the perpetual opposition of these two ideas. We are compelled to conclude that we have within us an idea which neither the world, nor the faculties with which we analyse it, can explain, and that this idea is the idea of infinity, which the Infinite can alone produce.*

Human liberty studied in its true depth, carries us directly to a conception of the infinite, What is liberty? The power of making or of not making. By this endowment, instead of being subjugated, like the rest of creation, we become masters, and are responsible for our own destinies: a mighty privilege, which gives us the present, and assures us of the future. But can this liberty subsist without rule'? Liberty without restraint would fail to elevate, but must degrade the possessor. If we

were alone in the world, without law, we should be vain and futile beings, indifferent to the order and system of the universe. Liberty is not bestowed to raise us above the law, but that we may obey the law in full knowledge of the cause. In this consists the power of human freedom and the strength we derive from it. Given up to itself, it would destroy us; subjected to an immutable law, it becomes the instrument and distinctive mark of our superiority. What is this law? Whence does it proceed? From the world,,which has no liberty, and is in itself changeable, and controlled by necessary regulations? No—the law of moral government comes neither from man, nor society, nor the world. It existed before man and will endure after him. Man may outrage but cannot abrogate it. Human society may forget, deny, despise this law; if the present world were destroyed, the next creation would still obey it. Liberty is changeable, but justice is absolute. Our sentiments, our actions, our thoughts are transitory, but beauty, goodness, and truth are eternal.

Thus, psychology, logic, and morals combine in producing a conviction of infinity. They tend towards it incessantly by every analysis and by all theories. They assist each other in this common work, which produces their unity by a unity of object and end. We may almost define philosophy in all its branches, a method of arriving at the infinite by the study of the finite.

All philosophy is full of God, and all the sciences are full of philosophy. Are you studying mathematics? What is size? Reflect a little deeply on this question; size will lead you by contrast to the idea of simple, single substance. Everything in the world is commensurable; but measure is nothing. You must seek the being, the reality, the truth, and consequently the cause, in that which cannot be measured—in the immoveable. Are you engaged in writing history? Why are certain nations alternately raised and subdued, and wherefore are these revolutions and catastrophes? Do we find in any given series of events, merely an empty spectacle, or the progressive realisation of a thought? Perhaps you are deeply immersed in jurisprudence. Law, on the surface, appears nothing more than a compilation proceeding from human will; but pause a little before you adopt this conclusion; behind these forms of man's invention, strange and ephemeral as they often are, you will perceive the image of a necessary and inevitable law. You will see and feel that if the written law is subject to change, there exists beyond it an immutable, independent, and eternal law, constituting at the same time the condition and sanction of human liberty. Are you a physician? Search for the first voluntary movement in your body, and tell us whence it comes. It is in vain that you are encompassed by matter: your bones, your fibres, your anatomical texture are inert: they are subject, in common with all bodies, to physical laws, and equally so, with all living bodies, to physiological conditions. Where then is the spring which gives them spontaneous motion? It escapes from all your efforts and instruments; yet, nevertheless, there it is in positive existence, the impenetrable mystery of life, the final secret which laughs at science, the initial force which attests the presence of creative Deity. Physician, when you study the law of motion,—chemists, while you are decomposing bodies, explain to us, if you can, what are causes, movement, extension, and particles—the primary and irreducible qualities of matter. You hesitate between a dynamical and a mechanical theory; but whether it be force or law, whence comes the originating impulse? from what does the first regulated plan emanate? The study of nature throughout every department of her extended kingdom brings us back to God by the infinitely little and the infinitely great. He stands forth as a cause at the beginning of all, and as a foundation of universal harmony at the end of all. Human life itself, with its joys and sorrows, is one prolonged demonstration of the existence of God. We recognise him at every instant in our thoughts and feelings. What we comprehend of ourselves teaches us to know him, and what we cannot understand still enhances that knowledge.

We have thus given a brief indication of the manner in which philosophical enquiry should be conducted, so that collective science may concur in rendering irrefragable the dogma of the divine being. Assuredly, there is here no new demonstration; who could dream of producing a new demonstration of the existence of God? Still less is there any attempt at a new form of

demonstration: on the contrary, we have gone back to the most ancient, the simplest, the most familiar, and (for that reason) the best of all forms—meditation in place of reasoning. A syllogism is good as a summary, or in an argument, when it becomes necessary to cut short an opponent; but let us not undertake to prove the existence of God by such a rapid process. Let us take time to think over and penetrate his nature; and for this express purpose, let us select the most circuitous roads. After all, we cannot conclude that he exists from any one specific evidence, but we perceive him in the evidence of all things. We have only to learn how to look about us. Well regulated reflection will give us so much light, that the presence of God will shine forth in all our actions, thoughts, and sentiments.

We must, therefore, take up knowledge at its source, and from the first word, without intermission, in every principle, and in every observation, we must show the infinite as he develops himself; sometimes in producing the love of that love with which ho has inspired us; at others, in supplying a rule for our judgments, an ideal for our thoughts, and a star for our desires. God is the corner-stone which cannot be shaken without overthrowing the entire building, and of which, by a necessary consequence, the firmness of the edifice establishes and proves the immutable and eternal solidity. Let us not complain that we have to travel on a lengthened path, for we shall not lose our time, even though it should be necessary to consume life in the journey. This is our appointed course; the rest is merely an episode. Happy is he who believes in God, through natural grace, without so many subtle disquisitions, and who only seeks in science a confirmation of his faith! But for the sceptic, it will not suffice to refer him to two or three syllogisms.

It is related of Diderot, that bearing, on a particular occasion, the ordinary scholastic proofs of the existence of God expounded, he became a sudden believer; and, in the warmth of his enthusiasm, ran to seek a philosopher, one of his intimate friends, that he might induce him to participate in his own recent conversion. He met him in a printing-office; opened the subject, detailed his arguments with the intemperate fervour by which he was ever characterised, but encountered a mind utterly closed against conviction. Diderot persevered, appealed to the heart of his listener, and urged him with the most impassioned expostulations; be considered his friend lost by his atheism, depicted bis miserable condition in glowing colours, and implored him with tears to become a convert. The other remained unshaken, replied to all the arguments, refuted and turned them into ridicule, restored the equanimity of the zealot, and concluded by extinguishing his fire and new-born faith. The apostleship of Diderot lasted only for an hour. His belief was destroyed as rapidly as it had been conceived, and he came out of the enquiry a more obstinate unbeliever than ever. If this anecdote be true, it does not prove that the demonstrations of the schools are bad in themselves, but it teaches us not to attach much value to such sudden revolutions of opinion, and to judge how little can be expected from an isolated faith which has only a few logical arguments to oppose to the obscurities and deficiencies of thought, the thousand objections of the incredulous, the difficulties of life, and the fears of death. He alone has a true faith who accustoms himself to live with God in heart and meditation, to find him at the end of all his researches, to include him in all his hopes. Let us accept no demonstration of the eternal existence of a supreme being, except one so overpowering, and so completely interwoven with our convictions, that it cannot disappear from the mind without leaving behind it solitude and despair.

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Rev. James McComb, LL.D. and George Dickie, A.M., M.D.
Typical Forms and Special Ends in Creation

Book First

Chapter I - Nature Op The Order Prevailing In The Material World

Section I - Principles Which Seem To Run Through The Structure Of The Cosmos

In taking an enlarged view of the constitution of the material universe, so far as it falls under our notice, it may be discovered that attention, at once extensive and minute, is paid to two great principles or methods of procedure. The one is the Principle Of Order, or a General Plan, Pattern, or Type, to which every given object is made to conform with more or less precision. The other is the Principle Of Special Adaptation, or Particular End, by which each object, while constructed after a general model, is, at the same time, accommodated to the situation which it has to occupy, and a purpose which it is intended to serve. These two principles are exhibited in not a few inorganic objects, and they meet in the structure of every plant and every animal.

These two principles are characteristic of intelligence; they must proceed from intelligence, and they are addressed to intelligence. They may both be discovered, though necessarily to a limited extent, in human workmanship. When circumstances admit, man delights to construct the instruments or utensils which are designed to serve a common purpose after a common plan, even when this is by no means essential to the immediate purpose to he served. Each particular piece of dress or article of furniture in a country is commonly fashioned after some general model, so that we are able to guess its use as soon as we cast our eyes upon it. That there is so much of this figure no way fitted to accomplish a special end, is evident from the circumstance that articles serving the same purpose take—in different ages and nations, and according to the fashion of the place or time —somewhat different forms, all of which are equally convenient. The farmer builds up his grain in stacks, which have all a like contour, and the merchant packs his goods in vessels of equal size and similar shape, or disposes of them in bales of equal weight. It is only when his possessions are so arranged that man can be said to have the command of them. Were his property not so disposed, were his grain gathered into heaps of all sizes and shapes, were his merchandise scattered in every corner of the apartment, the possessor would become bewildered in proportion to the profusion and variety of his wealth. When things are formed or arranged on some plan tacitly agreed on, man can recognize every object at a distance by its physiognomy, and determine its nature and its end without seeing it in use or operation.

There are still more frequent and obvious examples in the works of man of the principle of special adaptation. While there is a general regard, so far as it can be done without immediate inconvenience to the principle of order, there is a far more constant attention to the other principle. In some cases, indeed, little respect tan be had to the general model; the sole end aimed at is the fitting of the instrument to the purpose which it is meant to serve. In nations low in the scale of civilization, and among persons who have to engage in a hard struggle to procure the necessaries of life, the general order is apt to be neglected in the exclusive regard which must be had to immediate utility. In such circumstances, individuals care little how an article be constructed, provided it serves its practical purpose. But as man's industrial treasures increase, and the number of separate works intended to accomplish similar ends are multiplied, he finds it becoming to institute some systematic arrangement among them, or devise some pattern after which to fashion them.

When hard necessity does not forbid, man feels a pleasure in constructing his works upon a general plan. Human intelligence delights to employ itself in forming such models. They seem to have a beauty to the eye, or rather to the mind, 'which contemplates them. If it is a basket that is to be woven, there will commonly be a regularity in the succession of the plaits, and an aiming after some ideal form in the shape of the whole. If it is a water-jug that is to be fashioned, there will be a general attention paid to symmetry; not infrequently there will be graceful and waving lines in the figure which strikes the eye. The dwelling which the individual erects for his own special accommodation, will commonly be found to have a door, or some other prominent object, in the

center, with a balancing of pillars, windows, or something else that fixes the attention, on the one side and the other. As man advances in the scale of civilization, and comes to have superfluous wealth and leisure, he pays an increasing attention to symmetry and ornament. In the urns which he makes to receive the ashes of the dead, in the temples erected by him in honor of the God whom he worships, there is a scrupulous regard had to proportion and outline. As wealth accumulates and taste is cultivated, the law of order and ornament comes to be valued for its own sake, and is followed in the construction of every house, and of every article of furniture in that house, in the setting of every jewel, and in the location of every ornament.

In most articles of human workmanship we may discover a greater or less attention to both of the principles to which we have referred. The farmer's stacks are all formed after a general mould, but we may observe a departure from it on either side to suit the quantity or quality of the grain. The merchant's shop seems to be regulated by forms or weights, but there is special form or average weight for every separate article. In some objects we see a greater regard to general plan, and in others to special purposes, and this according as persons wish to give a greater prominence at the time to ornament or to utility.

Now, if this world proceeds from intelligence, and it is intended to be contemplated by intelligence, it is surely not unreasonable to suppose that there may be traces in it of the same two modes of procedure. In this treatise we hope to be able to show that there are abundant illustrations of both, by an induction reaching over all the kingdoms of nature, and extending even into the kingdoms of grace. Both will be found in the theology of nature to point to the same conclusion; each furnishes its appropriate proof of the existence and wisdom of a Being who hath constructed every thing on a plan, and made it, at the same time, to serve a purpose. The one, as well as the other, will be found in the dispensations of God, in the kingdom of his Son, and point to a most interesting analogy between nature and revelation. It will be expedient to treat of them as so far different, which they really are, but it will be necessary, at the same time, to show, what is equally true, that the two principles are made to correspond the one to the other, that they meet in a higher unity, and that, after all, they are but two aspects—in many respects different indeed—of one Great Truth. In order to remove misapprehension, it may be necessary here to estimate how much troth there is In a statement of Professor Owen, who has done so much to illustrate the subject of general order. "By whatever means or Instruments man aids or supersedes his natural locomotive organs, such Instruments are adapted expressly and immediately to the end proposed. He does not fetter himself by the trammels of any common typo of locomotive instrument, and increase his pains by having to adjust the parts and compensate their proportions so as hest to perform the end required without deviating from the pattern previously laid down for all. There is no community of plan or structure between the boat and the balloon, between Stephenson's engine and Brunci's tunnelling machinery; a very remote analogy, if any, can he traced between the instruments devised by man to travel In the air and on the sea, through the earth or along its surface." (Owen on the Nature of Limbs, p. 9.) There is truth in the remark here made, but it seems to ns to he overstated, and without the necessary corrections. Man dues, in many cases, construct the works which are to serve a common end upon a common plan. There is a model structure for the boat, for the steam-engine, for our houses, and our temples, in which elegance is more or less attended to. But still it is to he admitted that the harmonies, the correspondences, the compensations, are far more numerous and beautiful, both In kind and degree, in the works of God than in the works of man. It is certain that the union of the two principles is not so frequently attended to In human as in Divine workmanship. Man is often obliged to sacrifice the one to the other, the same try to the convenience, or the utility to the ornament It is only In the works of Deity that we find the two at all times in harmonious operation.

In certain sections of this treatise it is proposed to unfold some of the more striking examples of General Plan. In respect of this order of facts, natural theology can now take a step in advance, in consequence of what has been done of late years in the discovery of homologies by the sciences of comparative anatomy and morphological botany. But the recent discoveries in regard to the homology of parts can never set aside the old doctrine of the teleology of parts, which affirms that every organ is adapted to a special end. Every organic object is constructed after a type, and is, at the same time, made to accomplish a final cause. Throughout the next Book we purpose to exhibit the traces of General Order in one series of sections, and the traces of Special Adaptation in another series of sections, the two being made to run alongside of each other. While both will be illustrated, it will be seen, by our adopting this method, that the two are not contradictory, but coincident; that they do not cross, but run parallel to each other. The general conformity to a pattern will be seen to be all the more curious when contemplated in connection with certain singular deviations; while the special modifications will appear all the more wonderful when exhibited as a departure, and evidently an intentional departure, to effect a particular end, from a model usually attended to, nay, to some extent attended to, it may be, in the very structure which is thus modified. The designed irregularities will thus, by a legitimate reaction, show that the regularities are also designed; the exceptions in this case emphatically prove the rule. The nature of the eccentricities demonstrate that, after all, there is a center round which the revolution is performed; the deviations point to a disturbing influence also under the influence of law—in much the same way as the deviations of an old planet were shown by living astronomers to point to a previously undiscovered planetary body. The nature, the value, and the relation of the two principles, will thus come out to view more strikingly by comparison and contrast when they are placed in juxtaposition.

The arguments and illustrations adduced by British writers for the last age or two in behalf of the Divine existence, have been taken almost exclusively from the indications in nature of special adaptation of parts. Hence, when traces were discovered within the last age of a general pattern, which had no reference to the comfort of the animal or the functions of the particular plant, the discovery was represented by some as overturning the whole doctrine of final cause; not a few viewed the new doctrine with suspicion or alarm, as seemingly adverse to religion, while the great body of scientific men did not know what to make of its religious import. The question is thus started, Have not the writers on the theology of nature been of late most unnecessarily narrowing and restricting the argument? We have found it most interesting to notice that the philosophers of ancient Greece and Rome, and not a few of the earlier writers on the subject in our own country, gave it a much wider range, and reckoned that they had found evidence of the existence of God whenever they detected traces of order and ornament. Let us inquire what instruction we can gather on this subject from some of those great luminaries of the ancient world, which, like stars, send their light down to us through the wide space which intervenes, and serve, like them, to enlarge and rectify our ideas of magnitude, and to keep us from being unduly impressed with the greatness of the near and the present.

Plato, in the Fourth Book of the Laws, makes Clinias of Crete, in proving the existence of God from his works, appeal at once to the order and beauty of the universe, and does not regard it as at all necessary to dwell on minute instances of adaptation. He refers to the earth, the sun, and all the stars, and to the beautiful arrangement of the seasons, divided into months and years, as evidencing that there is a Divine Being.* In the review of the argument in the Twelfth Book, he repeats, that the orderly movements of the stars, and other objects, prove that all things were arranged and adorned, not by matter or necessity, but according to a Divine forethought and will.* According to the sublime philosophy of Plato, all things are formed according to unalterable laws or types, which remain unchanged amidst the flux of individual objects, and that because they proceed from eternal ideas, which had been in or before the Divine mind from all eternity.

A similar style of argument is adopted in Cicero's. Treatise on the Nature of the Gods, the most systematic work on natural theology which has been handed down to us from ancient times. The evidence adduced by Balbus the Stoic, the representative of theism in the dialogue by which the argument is conducted, is derived from four sources: first, from the presages of futurity by gifted men and oracles; secondly, from the number of things fit and useful; thirdly, from prodigies; fourthly, and highest of all, from the equable motions of the heavenly bodies, and from the beauty and order of the sun, moon, and stars, of which the very sight is sufficient to convince us that they are not fortuitous. Throughout his defence, he dwells on the consenting and conspiring motions of the heavenly bodies, on their progressions and other movements, all constant and according to law; he points to the planets, which are regular in their very wanderings; and shews how, in all this, there is an order and a certain likeness to art. When one observes, he says, their defined and equable motions, and all things proceeding in an appointed order, and by a regulated and unchangeable constancy, he is led to understand not only that there is an inhabitant in this celestial and divine dwelling, but a ruler or regulator, and, if we may so speak, architect of so great a work and gift. He speaks of the harmony arising from dissimilar motions; and after quoting largely from the hymn of Aratus, he says, such order and ornament could not have proceeded from bodies running together hither and thither, and by accident.

Plutarch derives men's general agreement as to the existence of God, from their observation of the constant order and motion of the stars. In modern times, we have the same line of argument seized by the profound mind of Newton. Referring to the uniformity in the bodies of animals, he says, " It must necessarily be confessed that it has been effected by intelligence and counsel." Dr. Samuel Clarke quotes this language, and asks—" In all the greater species of animals, where was the necessity for 'the conformity we observe in the Number and Likeness of all their principal members.

It is very evident that, down to a comparatively late date, writers on natural theism did not confine their proof to a mere adaptation of parts, but that along with this they introduced other considerations, and in particular, the prevalence of general order. It will not be difficult to defend the legitimacy of the conviction which the order and beauty of the universe have produced in unsophisticated minds in all ages. In this, as in many other instances, the philosopher will find it to be his delightful office, not to set aside the spontaneous beliefs of mankind, but rather to vindicate and illustrate them by the new discoveries which advancing science is ever opening.

Section II — Analysis Of The Order In Nature—Laws Of Nature

The most careless observer is led to notice, that there is a beautiful regularity running through nature as a whole, and through every individual part of it. This was discovered in very early ages of the world's history, by persons who had no very precise ideas as to its nature, or the means by which it was produced. The Greeks, from the time of Pythagoras, embodied their impressions in the word by which they denoted the visible world, which they called Cosmos, to denote at once its order and its beauty, while the Latins styled the world Mundus, to express their sense of its surpassing loveliness. Ever since the time when the philosophic spirit was first awakened, reflecting minds have been speculating as to the sources of this order, and caught, at a very early age, glimpses of the truth. The philosophers of the Ionian School, which arose between 600 B.C. and 500 B.C., referred it to the power and the varied transformations of certain elements, which they did their best to classify, as air, water, earth, and fire, representing the dry, the moist, the solid, the ethereal. In the speculations of this school, we have vague anticipations of modern chemistry, and in particular, of the doctrine of polar forces, in the balanced strife and friendships of Empedocles, and of that of definite proportions, in the " homoiomera" or equal parts of Anaxagoras. A rival school arose at a little later date, among the Greeks in Italy, and ascribed the order of nature, in a more profound spirit, to the power of Numbers. We have no authentic or connected account of the

system of the Pythagoreans, but it is evident, from the scattered notices which have been handed down to us, that they represented numbers, the significance of which is so clearly seen in music, as in some mysterious sense the principia of the universe. Aristotle tells us, that they considered existing things to he a copy of numbers,* and we have extracts preserved from the writings of some of the disciples of the school, describing numbers as being in the Divine Mind prior to the existence of things, as being used as a model in the formation of objects, and as that by which all things were brought together and linked in order. Among the disciples of the same school, and others who arose at a subsequent date, there was supposed to be a deep meaning in forms; and the properties of certain figures, such as the triangle, the square, the parallelogram, the circle,. the ellipse, were investigated with great care, giving us the science of geometry as the result. A very special interest gathered round certain numbers, such as seven and ten, and certain figures, such as the circle and triangle, which came in consequence to be regarded as perfect, or as sacred. From a still earlier date, and as a manifestation of the same intellectual propensity, peculiar feelings became associated with certain recurring times and periodical seasons, such as the revolutions of the moon, the signs of the zodiac, and other cycles, which seemed to have a deep significance in the economy of nature. Democritus, who lived 400 B.C., and the Epicureans, who flourished at a later date, sought for the origin of this order in the formation of all things out of atoms possessed of definite forms. The sublime genius of Plato ascribed it to certain patterns after which all things were fashioned, which patterns he traced back to the eternal ideas of the Divine Mind. Aristotle, while correcting some of the extravagances of his great master, clung resolutely to the doctrine, that forms were as necessary as matter to the construction of the universe. The Platonists of the Alexandrian School literally revelled among numbers and forms, till they lost themselves among their intricacies and windings. The Platonizing Jew who wrote the Book of Wisdom, caught for a moment a very clear glimpse of the full truth, when he speaks of God "having arranged all things in measure, number, and weight."*

Early science, like youth, is ardent, is eager, and not having as yet determined either its strength or its weakness, it would attempt every work, and works far beyond its capacity. Like the giants of the early world, it is ambitious, and would heap Ossa on Pelion, and mount to heaven, not by gradual and numerous steps, but by one old bold and presumptuous effort. In following this method of speculation, the sage—as he meditates on the banks of the Euphrates or Nile, along which an early civilisation had sprung up, or in the cities of Miletus, Elea, or Athens, in which the human spirit was sharpened by discussion and the love of enterprise —makes many a shrewd guess; he anticipates not a few truths which later discovery confirms; he awakens a spirit of inquiry which craves for a more accurate mode of procedure; and if he does not settle, he at least starts questions which must sooner or later be settled. But his attempt, though characterized by enlargement of vision and power of vaccination, is, in respect of scientific strictness and certainty of result, a failure, and the favourite dogma of one school is ever disputed by the disciples of another school. It turns out that the work which one man or one school has attempted, needs, in order to its completion, the combined industry of many investigators continued through long successive ages.

For just as when society makes progress there is a necessity for the division of manual labour, (as Adam Smith has shewn in the opening chapter of the Wealth of Nations,) so, in order to the advance of science, there is need of a division of intellectual labour. Most important of all, there arises, in the midst of the jealousies of rival schools and the noise of fruitless disputations, a demand for a surer, even though it should be a slower, method of investigation,—a method which will give results, be they many or be they few, which are not of the nature of ingenious speculations, to be set aside by other ingenious speculations, but ascertained truths, fixed for ever, and which all inquirers who come after may use, to help them to add to the accumulating stores of knowledge. It is late in the history of the world before such a plan comes to be systematically unfolded; and it is to the glory of our country, a glory not exceeded even by that of the land which produced Plato and Aristotle, that the first exposition of it was by Lord Bacon. Since his days,

scientific inquirers, according to their tastes, talents, and position, have betaken them each to his own field of investigation, with the view of thoroughly exploring it; and as the grand result, we have a settled body of truth, to which additions will be made from age to ago.

But as the deeply-underlying and prompting cause of all this intellectual activity, there is still the same craving desire to find out the means by which unity and order are given to the great Cosmos. In these days we speak of all things being governed by laws; we lay it down as a maxim, that the end of all science is the discovery of law. The language may be more correct than that employed by the ancients, but it is far from being definite or incapable of misinterpretation. For the question occurs, What is meant by laws in this application of the term? Every one sees that, as thus used, it does not mean the same thing as when we speak of the laws of a country, of the moral law, or of the law of God. It is a term with which we cannot dispense, but it is far from being unambiguous; it is often used in an unlawful sense, and at times it is turned to the worst of purposes, as when it is supposed, that in referring an event to a law of nature, we have placed it beyond the dominion of God. When we speak of things being arranged in a law, or falling out according to a law, we signify, if we know what we mean, that all phenomena take place in a regular manner, that is, according to a rule.* It is the special office of each science to discover what the nature of the law is in its own department. This is the grand aim, so far as it has a grand aim, of all modern physical investigation,—to determine the ride to which the particular classes of objects under contemplation accommodate themselves. But in very proportion as the sciences have become subdivided and narrowed to particular facts, is there a desire waxing stronger, among minds of larger view, to have the light which they have scattered collected into a focus. As the special sciences advance, the old question, which has been from the beginning, will anew and anew be started,—What is the general meaning of the laws which reign throughout the visible world? A correct and adequate answer to this wide question can be given only by a wide induction, and a combination of the results gained by a vast number of separate sciences, each conducted on its own principles. We live in the expectation of the approach of a time when science—the division of labour having fulfilled its ends—shall seek to combine its individual truths, and to realize the dream of its youth, and, as it were, carry us to a mountain top, whence we may obtain not only a scattered view of the separate parts, but a connected view of the whole, and of the relative bearing and direction of every part. It appears to us that we are approaching the time when an answer may be given to the old question, and that this must be something like the following: —All things in this world are subordinated to law, and this law is just the order established in nature by Him who made nature, and is an order in respect of such qualities as Number, Time, Colour, and Form. We use the vague languages of such qualities, because science has not arrived at such a stage as to enable it to determine what these qualities are with anything like perfect certainty and precision.*

Every law of nature which can be said to be correctly ascertained is certainly of this description. We shall furnish abundant illustrations in the next Book of this treatise; in this section we are merely to collect a few striking examples of the attention paid to each of the qualities named, and thus prepare the way for entering upon the separate sciences, when more systematic proof will be offered.

First., There Is An Order In Nature In Respect Of Number.—This important truth, long believed in before it could plead any scientific evidence in its favour, was established and brought into prominence when Kepler unfolded the three laws which have formed, historically, the foundation of modern astronomy. It was the confident expectation that there would be found* some such principle of order which led that ingenious and persevering sage to make calculation upon calculation, and devise one hypothesis after another, till, after nineteen unsuccessful attempts, his fine genius and his industry were rewarded by the discovery of the true laws of the planetary movements. These laws are,— that the planets move in orbits, which are elliptical in shape; that if you draw a line from the planet to the sun, the areas described by that line in its motion round the

sun are proportional to the times employed in the motion; and that the squares of the periodic times are as the cubes of the distances. The first of these is a law of forms, the other two are laws of numbers. The discoveries of Kepler prepared the way for the still more important ones of Sir Isaac Newton. When the immortal work of this greatest of inductive philosophers was published, it was seen that the laws of Kepler were not original but derivative; but the original law now unfolded belonged to the same class; for the law of gravitation, the best established and the most universally operative law yet determined, is a law of numbers. Turning to chemistry, we find that ever since it emerged as a science there has been a constantly renewed attempt to reduce its laws to a numerical expression. The only laws which can be reckoned as certainly determined in this science possess this character. The great law which lies at the basis of all the compositions and decompositions of substances, is that of definite proportions for equivalents, as expounded by Dalton. In the same science Gay Lussac discovered an arithmetical law, regulating the combination of gaseous substances, which unite in very simple proportions, according to volumes. Lest it should be thought that we are making a fanciful reduction of the operations of nature, we are happy to he able to bring to our aid the name of Sir John Herschel. " Chemistry/' says he, " is, in a most pre-eminent degree, a science of quantity, and to enumerate the discoveries which have risen from it from the mere determination of weights and measures, would be nearly to give a synopsis of this branch of knowledge. We need only mention the law of definite proportions which fixes the composition of every body in nature in determinate proportional weights of its ingredients. Indeed, it is a character of all the higher laws of nature to assume the form of a precise quantitative statement. Thus the law of gravitation, the most universal truth at which the human reason has yet arrived, expresses not merely the general fact of the mutual attraction of all matter, not merely the vague statement that its influence decreases as the distance increases, but the exact numerical rate at which that increase takes place, so that when the amount is known at any one distance it may be calculated exactly for any other."* Similar language is used by Humboldt:—" The progress of modern physical science is especially characterized by the attainment and the rectification of the mean values of certain quantities by means of the processes of weighing and measuring. And it may be said that the only remaining and widely diffused hieroglyphic characters still in our writing—numbers, appear to us again as powers of the cosmos, although in a wider sense than that applied to them by the Italian school."

In looking at other departments of nature, we find similar examples of numerical order. Thus, ten is the typical number of the fingers and toes of man, and, indeed, of the digits of all vertebrate animals. It is also a curious, though perhaps not very significant circumstance, that in mammalia seven is the number of vertebrae in the neck,* and this whether it be long as in the giraffe, or short as in the elephant, whether it be flexible as in the camel, or firm as in the whale. In the vegetable kingdom we find that two is the prevailing number in the lowest division of plants, the acrogenous or flowerless; thus, 2, 4, 8, 16, 32, 64, &c., are the number of teeth in the mouth of the capsule in mosses. Three, or multiples of three, is the typical number of the next class of plants, the monocotyledonous or endogenous; and five, with its multiples, is the prevailing number in the highest class, the dicotyledonous or exogenous plants. We shall shew, as we advance, that a curious series, 1, 2, 3, 5, 8, 13, 21, 34, &c., in which any two numbers added together give the succeeding one, regulates the arrangement of the leaf appendages of plants generally, and in particular of the leaves and the scales on the cones of firs and pines. In the inflorescence of the plant we find that the outer organs, or sepals, always alternate with the petals which are next them, and that the whorl of organs further in, namely, the stamens, is generally either the same in number as the petals, or some multiple of them. When there is an exception to this rule there is reason to believe that there has been some abortion of the stamens; and the traces of this abortion are not infrequently visible in the rudiments of the organs undeveloped.

Secondly, There Is An Order In Nature In Respect Of Time.—It is obvious that all such laws can be expressed in proportional numbers, taking some fixed time as a unit. But we are here introduced to

a new fundamental power, deserving of being put under a separate head. For the laws of which we are now to speak imply a peculiar arrangement in reference to time. We see the principle most strikingly exhibited in those movements of natural objects which are periodical. No doubt, there is some disposition of physical forces necessary to produce this periodicity; but this just shews all the more clearly that an arrangement has been made to produce the regularity. The ancients were much struck with the order in respect of time of the celestial motions. The stars, the planets, and even the comets, were seen to perform their revolutions in certain fixed times. Some of them seem to depart from this rule only to exemplify it the more strikingly, for their irregularities, which are periodical, are as methodical as their more uniform movements. There have been regular epochs, to all appearance, in the changes on the earth's surface, and in the succession of plants and animals, as disclosed by geological science. The variations of magnetism on the earth's surface seem to be periodical, and attempts have been made of late to connect this cycle with that which the spots of the sun arc known to follow. There is a beautiful progression, as shewn by the science of embryology in the growth of the young animal in the womb, and the whole life of every living creature is for an allotted period. The plants of the earth have their seasons for springing up, for coming to maturity, and bearing flowers and seeds; and if this order is seriously interfered with, the plant will sooner or later be incapable of fulfilling its function. Thus the hyacinth may be prematurely hastened into flower for one season, but the next year it will be found impossible to make it flower or produce seed. In this way great natural events, and especially the life of animals and plants, the movements of the heavenly bodies, and the eras of geology, become to us the measurers of time, rearing up prominent landmarks to guide us as we would make excursions into the past or future, and dividing it for our benefit into days and months, and seasons, and years, and epochs.

Thirdly, There Is An Order In Respect Of Colour Running Through Nature.—Colour is not without its significance among the works of man. Every nation, every regiment has its distinctive colours upon its flags, which are its visible symbols and representatives. Colour appears as a peculiar mark on the stamps impressed by the post-office, and on many of our public conveyances. It is used as a signal by sea and by land, in our ships and on our railways; it announces danger and proclaims safety. It has also, we are convinced, a meaning in nature. It has been far too generally supposed that colour obeys no laws in natural objects. It has been a very common impression, that it is spread indiscriminately over the surface of earth and sky, animal and plant. We are sure that further research will shew that mistake. It is true that colour has not so much value as form and structure in the classification of plants and animals. Still, we find that some tribes of algee are arranged by Harvey according to their colours, and that some fungi were classified by Berkeley according to the colours of their minute seeds* We arc convinced that, amidst all the apparent irregularities, there will be found to be some fixed principles in the distribution of colours in the animal and vegetable kingdoms, and, indeed, over the whole suitable to certain modifications, which are limited, it is probable that there is a fixed distribution of colour for many families of animals and plants, and that this distribution is fixed within still narrower limits for the species. It is certain, whether we are or are not able to seize it, and turn it to any scientific or practical purpose, that there are plan and system in the arrangement of colours throughout both the animal and vegetable worlds. Every dot in the flower comes in at the proper place, every tint and shade and hue is in accordance with all that is contiguous to it. We shall shew at considerable length as we proceed, that the distribution of colours in the vegetable kingdom is in beautiful accordance with the now established laws of harmonious, and especially of complementary colours. We shall likewise point out some very curious and interesting relations between the forms and colours of plants. The eye testifies, too, that there is an order in respect of colour in the decorations of insects, in the spots and stripes of wild beasts, and in the plumage of birds. " He who," says Field, " can regard nature with the intelligent eye of the colourist, has a boundless source of never-ceasing gratification arising from harmonies and accordance which are lost to the untutored eye."

Fourthly, There Is An Order In Nature In Respect Of Form.—We use the word form in a large sense, and as including not only figure, in the narrow sense of the term, but structure, which is the relation or connexion of forms. Great attention is evidently paid to this quality in the construction of natural objects. It appears before us as a significant element in every department of nature. The planets, with their satellites, have a definite spheroidal shape, and they move in orbits which have a certain outline in space, namely, the elliptic. It is because strict regard is paid to this principle in the structure of the universe, that the science which treats of forms, that is, geometry, admits of an application to so many of the objects and arrangements of nature. And here it is worthy of being noted that the ancient geometers, from a general idea of the importance of forms, had carefully investigated the properties of those figures called the Conic Sections, (because capable of being produced by sections of the cone,) at a time when no very important application could be made of the propositions established by them. When Kepler discovered that the planets moved in elliptic orbits, the properties of the ellipse, unfolded so many centuries before by Apollonius and others, were ready to be applied to the solution of a host of important questions connected with the movements of the celestial bodies. It is instructive to notice that the clusters of stars revealed by telescopes of great power, shew regular forms, some of them being round, and a number of them having apparently a spiral tendency.

In the mineral kingdom, we find forms playing-an important part. In circumstances admitting of the operation, most (if not all) minerals crystallize—that is, assume regular forms. These forms are mathematically exact in a variety of ways. Every perfect crystal is bounded by plane surfaces, its sides are parallel to each other, and the angles made by its sides are invariable. Each mineral assumes certain crystalline forms, and no others. These forms have now an important place allotted to them in the classification of minerals. They have been expressively designated the geometry of nature.

But it is among organized objects that we find form assuming the highest significance. Every living object composed though it be of a number, commonly a vast number and complication of parts, takes, as a whole, a definite shape, and there is likewise a normal shape for each of its organs. The general or normal form which any particular tribe of plants or animals assumes, is called its type. Animals and vegetables, it is well known, are classified according to type; and they can be so arranged, because types are really found in nature, and are not the mere creation of human reason or fancy. It is because attention is paid to type, and because it is so fixed and universal, that it is possible to arrange into groups the innumerable natural objects by which we are surrounded. Without some such principles of unity to guide him, man would have felt himself lost, as in a forest, among the works of God, and this because of their very multiplicity and variety. In some cases the forms assumed by organic objects are mathematically regular. A series of beautiful rhomboidal figures, with definite angles, may be observed on the surface of the cones of pines and firs. It may be noticed, too, how the leaves and branches of the plant are placed round the axis in sets of spirals. The spiral structure is also very evident both in the turbinated and discoid shells of mollusks. Mr. Mosely has shewn that the size of the whorls, and the distance between contiguous whorls, in these shells, follow a geometrical progression; and the spiral formed is the logarithmic, of which it is a property, that it has everywhere the same geometrical curvature, and is the only curve, except the circle, which possesses this property. Following this law, the animal winds its dwelling in a uniform direction through the space round its axis. " There is traced," says Mr. Mosely, " in the shell, the application of properties of a geometric curve to a mechanical purpose, by Him who metes the dimensions of space, and stretches out the forms of matter according to the rules of a perfect geometry."* We are reminded of the ancient Platonic maxim, that Deity proceeds by geometry.

The lower tribes of animals and plants often assume mathematically regular forms, such as the triangular, polygonal, cylindrical, spherical, and elliptical. It is seldom, however, that we meet

with such rigid mathematical figures in the outline of the higher orders of organic beings. Those who have any sense of beauty will be grateful that trees are not triangular, that animals are not circular in their outline; in short, that they have not taken any such painfully exact shape. Still, the forms of organic objects—such as the sweep of the veins of leaves and the outline of trees—though more flowing and waving, are evidently regular curves. There is truth, we suspect, in a favourite maxim of Oersted, "that inorganic beings constitute the elementary, and organic the higher geometry of nature."

Besides the typical resemblances which enable us to classify plants and animals, and the beautiful curves which do so gratify the contemplative intellect, there are certain correspondences in the structure of organs which seem to us to be especially illustrative of a plan intelligently devised and systematically pursued. At an early date, these struck the attention of persons addicted to deep reflection, but it is only within these few years that they have been scientifically investigated and expounded. Aristotle noticed the correspondence between the hands of man, the fore-limbs of mammals, and the wings of birds, and between the limbs of these animals and the fins of fishes, and spoke of it as an interesting species of analogy. The profound mind of Newton used to muse upon the symmetry of the animal frame: " Similiter posita omnia in omnibus lore animalibus.'" These correspondences, so far as vertebrate and curtain portions of invertebrate animals are concerned, have now been examined with great care, and we have a set of well-defined phrases to explain them.

A homologue is defined as the same organ in different animals, under every variety of form and function. Thus the arms and feet of man, the fore and hind feet of quadrupeds, the wings and feet of birds, and the fins of fishes, are said to be all homologous.

The corresponding or serially repeated parts in the same animal are called homo types. Thus the fingers and toes of man, indeed the fore and hind limbs of vertebrate animals generally, are said to be homotypal.

The phrase analogue has been reserved for another curious correspondence, found both in the animal and vegetable kingdoms. By an analogue is meant an organ in one animal having the same function as a different organ in a different animal. The difference between homologue and analogue may be illustrated by the wing of a bird and that of a butterfly; as the two totally differ in anatomical structure, they cannot be said to be homologous, but they are analogous in function, since they both serve for flight.

These phrases, and the ideas on which they are founded, have taken their rise from the animal kingdom. But similar, though by no means identical, correspondences have been detected in the vegetable kingdom. The branch of botanical science which treats of the forms of plants is called morphology, and is now regarded as the fundamental department of botany. We shall shew, as we proceed, that comparative anatomy and vegetable morphology supply illustrations, at once copious and striking, of an all-prevailing order in nature in respect of form or structure. J As this order of facts comes before us, we shall see that science, in its latest advances, is fulfilling some of the anticipations of large-minded observers and deep thinkers, who, in earlier and unsophisticated times, looked upon nature with a fresh eye, and believed in the existence of - a profound plan in it, when they were not able to give —- a scientific reason for their conviction. Systematic research is only coming up in these later years to the native beliefs and expectations which sages entertained from the beginning. But there are these important differences between the early glimpses and the later discoveries:—that what was at first guess and fascination, has become demonstration; that what was at first a mixture of fact and speculation has become, by the inductive methods of weighing and measuring every phenomenon, unadulterated truth; and we may add, that the

realities disclosed by science far transcend in grandeur and true dignity the loftiest musings of the profoundest sages or the most brilliant speculators.

It is to be regretted that the recent discoveries as to a harmony of structure running through the whole organic kingdoms have been turned by some to improper purposes. The famous German poet, Goethe, who did so much by his doctrine that all the appendages of the plant are leaves, or transformed leaves, (he should have said, formed after the same model as the leaf,) to found a scientific botany, has not defined his religious creed (we rather think he could not define it); but it is evident that he was by no means inclined to look upon nature as the work of a personal God. The celebrated French comparative anatomist, Geoffrey St. Hilaire, who laboured so effectually to prove that there is a unity of composition in the animal structure, unfortunately (though no atheist) speaks in a contemptuous manner of final cause.* Lorenz Oken, who propounded the idea that the skull is a vertebrate column, (he should have said that the skull is formed after the same model as the back-bone,) was a pantheist, and sought, in a mystical rhapsodical manner, to find the beginnings of existence and of life without calling in a living or a personal God. Yet the ideas which these men expounded, after being first denied and then modified and improved, have received the all but universal consent of scientific inquirers. Admitted, as they now are, among the established generalizations of science, and constituting, as they do, the most brilliant discoveries in natural history of the past age, they cannot be overlooked in a natural theology suited to the middle of the nineteenth century. If they are hostile—as we believe they are not—to the cause of religion, then let their exact force and bearing be measured; and if they are favourable to theology, natural and revealed,—as we hope to be able to shew that they are, when properly interpreted,—then they require from their number and value, to have a very prominent place allotted to them. We have here a class of phenomena to which Paley has never once alluded in his Natural Theology, and which are referred to only in an incidental manner, and without their meaning being apprehended, in one or two passages of the Bridgewater Treatises.^ The authors of these works are not to be blamed for this omission, for in their day the facts had not been discovered, or, at least, admitted into acknowledged science. But now that they have taken their place, and that a very high place, among settled doctrines, it is time to examine their religious import and tendency. They will be found not to be isolated or exceptional in their character, but to belong to a large and wide-spread class, possessing a deep theological signification.

It is not pretended that these facts do of themselves prove that there is a living and personal God, clothed with every perfection. But they are fitted to deliver us from several painful and degrading notions, which may be suggested by the human heart in times of unbelief, or by persons who have been lost in a labyrinth built by themselves, and who are not unwilling that others should become as bewildered as they are. They prevent us from feeling that we, and all things else, are the mere sport of chance, ever changing its procedure, without reason and without notice, or, what is still more dreadful, that we may be crushed beneath the chariot wheels of a stern and relentless fate, moving on without design and without end. They shew us what certainly looks very like a method pursued diligently and systematically— very like a plan designed for some grand end, so very like it that it behooves the sceptic to take upon himself the burden of demonstrating that it can be anything else. Taken along with their proper complement, the special adaptation of parts, they exhibit to us an enlarged wisdom, which prosecutes its plans methodically, combined with a minute care, which provides for every object and every part of that object. Conjoined with higher considerations, and, in particular, with certain internal principles, which have the sanction of the very constitution of our minds,* they disclose to our faith a God who sees the end from the beginning, and who"""? hath from the first instituted the plan to which all individual things and events have ever since been conformed. These objects so regularly constructed, and modes of procedure so systematic, fill the mind, and prepare us, if they do no more, to wait for the disclosure of a loving being who may fill the heart. For the intellect is not satisfied with contemplating, unless the heart be at the same time satisfied with loving. It is the grand mistake"^

of not a few gifted men, in these latter ages when physical nature is so much studied, to imagine that the order and loveliness of the universe, its forces, its mechanism, its laws, its well-fitted proportions, will of themselves satisfy the soul. It will be found that all these, however fondly dwelt on, must, in the end, leave the same melancholy and disappointed feeling as the sight of a noble mansion doomed to remain for ever tenantless—unless they lead on to love, and such love as can only be felt towards &^ living and loving God.

Chapter II - Nature Of The Special Adjustments

Section I - Need Of Special Adjustments Ix Order To The Beneficent Operation Of The Forces Of Nature

"Order is Heaven's first law," and the second is like unto it, that everything serves an end. This is the sum of all science. These are the two mites, even all that she hath, which she throws into the treasury of the Lord; and as she does so in faith, Eternal Wisdom looks on and commends the deed. As the separate physical sciences advance, they will necessitate the rise of combining sciences to collect their separate truths; and this they may best be able to do under the two heads of order and special end. The science which treats of a certain important department of the first of these has already a suitable name allotted to it, and is called Homology. But we need a word to embrace the whole, and we propose that this be Cosmology—that is, the Science of the Order in the Universe. We are aware that this term has been unfortunately devoted to an unattainable inquiry, which would penetrate into the origin of worlds; but this makes us the more anxious to rescue so excellent a phrase from so degraded a use, and give it a profitable application. The other general science has already an admirable name appropriated to it in Teleology, or the Science of Special Ends.

Physical science, at its present advanced stage, seems to be at one with the Word of God, in repressing all nature as in a state of constant change, but with principles of order instituted in order to secure its stability. "one Generation Passeth Away, And Another Generation COMETH: but the earth abidetii for ever.

The Sun Also Ariseth, And The Sun Goeth Down, And Hasteth To His Place Where He Arose. the Wind Goeth Toward The South, And Turneth About Unto The North J It Whirleth About Continually, And The Wind Returneth Again According To His Circuits. All The Rivers Run Into The Sea: Yet The Sea Is Not Full; Unto The Place From Whence The Rivers Come, Thither They Return Again. All Things Are Full Of Labour. Man Cannot Utter It: The Eye Is Not Satisfied With Seeing, Nor The Ear Filled With Hearing." There seems to be no such thing as absolute rest in nature. We are impressed with the fickleness of the winds and the restlessness of the waves; but the truth is, every o(her object is infected with the same love of change. There is probably no one body in precisely the same state in every respect for two successive instants. We think that we are stationary, but, in fact, we are being swept through space at a rate which it dizzies the imagination to contemplate. Every object in nature seems to have a work to do, and it lingers not, as it moves on, in the execution of its office. It exists in one state and in one place this instant, but it is changing meanwhile, and next instant it is found in another state or in another place. But there is an equilibrium established among these ever moving forces, and the processes of nature are made like the wind, to return according to their circuits.

So far as inductive science has been able to penetrate, it would appear that the active physical powers of the universe consist of a number of forces, or rather, we should say, properties, each with its own tendency or rule of action, and yet all intimately connected the one with the other, that is, correlated. I wave my hand in the air, and in doing so, I set mechanical power a-working. " The motion," says Mr. Grove, " which has apparently ceased, is taken up by the air, from the air by

the walls of the room, &c., and so, by direct and reacting waves, continually comminuted but never destroyed."* The production of mechanical power may be more distinctly seen if the hand is employed to move a machine. Mechanical power, it is well known, generates heat, and this heat, according to Mr. Joule, is in proportion to the mechanical power exercised. Heat may lead to chemical action, as when bodies are decomposed by a rise in the temperature. Chemical action is always accompanied by electricity, and electricity may produce light or galvanism or magnetism. Galvanism, again, may have an effect on nervous or muscular action, and muscular action may produce mechanical power. Thus we have the various known (or rather, perhaps we should say, unknown) forces producing or exciting each other, according to laws which have not yet been fully determined. Nay, if we turn in upon the organism itself we shall find traces of a similar circuit. For whence the muscular action that originated the actions which we have mentioned? Tracing it inwards, we find it conducting us to the nerves and the brain. But the brain is not an inexhaustible, nor is it a self-filled fountain of physical power; on the contrary, if exercised in excess it becomes deranged in all its functions, or exhausted. In order to restoration of power, it needs, as every one knows, nightly rest, and also sustenance; and, on inquiring into the source of this sustenance, we find that it is derived from without, from animals and plants. Again, animals are fed by other animals and by plants, and plants by unorganized matter. The circuits are thus made to include all physical powers, organic and inorganic. All these forces, distinct from - each other, (so far as we know,) but intimately correlated, are made to balance each other, and to run in circles. It is to be specially noticed, however, that there has been a power here exorcised which is not thus dependent on the others. We refer to the mental power which willed the bodily action. The oldest definition of mind represents it as essentially a self-moving power. We must ever set ourselves against the Idea maintained by some, that mental power is correlated to the physical and vital forces, as these are correlated to each other. We never can believe that the devotedness of the patriot, the self-sacrificing spirit of the martyr, or the heroism which resists bribe and temptation, are capable of being excited by heat, light, and magnetism, in the same way as these can he excited by each other. But still it is true that mind, we mean the human mind, can merely direct physical force: it cannot create or originate it, it can merely turn it this way or that; but the power exists prior to any mental effort being directed towards it, and when it is set a-working, by the needful conditions being supplied, it follows it own laws.

We have introduced these generalized facts, which are independent of all speculations as to the nature of the physical forces, for the purpose of shewing that these natural powers are all blind in themselves, and require an arrangement to be made—and this arrangement must proceed from intelligence—in order to their beneficial action. Heat, light, electric action, chemical composition and decomposition, organic affection—these are among the most powerful instruments of good in our world, but they become the most potent means of inflicting evil. In their bearings towards animate objects capable of pleasure and pain, they may all be benignant, but they also spread misery and destruction. There is obvious need of a disposing mind to cause these various forces to act in harmony, and to issue in wise and benevolent results. "Elements," says Faraday, "the most seemingly unmanageable and discordant, are made to watch like ministering angels around us—each performing tranquilly its destined function, moving through all the varying phases of decomposition, decay, and death— then springing into new life, assuming new forms, resting in passive inactivity, or assuming the extreme of violence, according as cither may he suited to accomplish the appointed end.

It will be necessary at this place to state an important distinction which Dr. Chalmers had the merit of introducing into natural theology in a formal manner. He calls on us to notice how, the laws of matter being as they are, the results might have been different if a different set of collocations had been made of the bodies obeying these laws. Thus the law of gravitation still being as it is, the planetary bodies would have been moving in a very different manner from what they do, had they been differently situated in reference to the sun and to one another. Had they not, for example,

revolved in nearly one plane, they might in their revolutions have come into violent and destructive collision with each other. This is prevented by their being so disposed that their spheres can never intersect each other, that is, by their skilful collocation. Dr. Chalmers thinks that the argument in favour of the existence of God should be founded on the collocations of matter rather than the laws of matter.

The distinction is undoubtedly a sound one. In all discussions as to the material universe, we must set out with assuming the existence of body occupying space and exercising force, or rather active property. Now, it may be admitted that it is doubtful, to say the least of it, 'whether we are entitled to argue that the mere extension of matter, that is, the circumstance that it occupies space, implies that it has been created. It might be further allowed, without any prejudice to the argument in behalf of the Divine existence, that the mere possession of active properties does not prove, in a manner convincing to every one, that matter has been formed by an intelligent being. The opponent, whether inclined to materialism or pantheism, might urge that in contemplating the material world merely as exercising force and capable of motion, we are not imperatively called to suppose anything else than that power, be it a material thing, or be it a spiritual thing (as the pantheist maintains), resides in the bodily substance itself. The argument of the pantheist, as against the materialist, would no doubt be overwhelming in such a case. The pantheist would be able to shew without difficulty that in the exercise of chemical, electric, luminiferous, calorific, and vital force, there is vastly more than mere extension or dead matter, and this he would call spiritual power. But all this does not tend to prove that this spiritual power (so called) is of the nature of Intelligence, compassing an end by means employed for the purpose. When we have established on other grounds, the existence of a Divine or even of a spiritual being, it might then be reasonably maintained that these physical powers, which have been shewn of late years to be more wonderful than men ever supposed them to be before, are not independent of the Divine Power, but are rather one of the expressions of it. But when we are proving the being of a God, it might not be prudent to peril the whole argument on the principle that the exercise of active power implies an intelligent and a personal God. It might be safer, to say the least of it, to argue the existence of Intelligence, not from matter considered simply as extended or as possessed of force, but from the material universe as it actually presents itself, with its graceful forms, its lovely colours, its skilful adjustments, and harmonious laws. There are questions agitated in the present day in regard to the precise nature of the physical forces which strict inductive science is not yet prepared to settle, and there have been questions started as to the potency of matter in itself, which, in our opinion, the human intellect cannot very satisfactorily answer, and which may at least be answered in more than one way by different parties, with views and principles all equally favourable to religion.

It seems more than probable that the very original properties of matter, whatever they be, have a rule, a law, so constituted as to suit them admirably to the purposes to be served by them in the universe. But this cannot be conclusively demonstrated till we have reached the ultimate properties of matter; and we are not certain that we have found any one of the original forces of nature. The law of universal gravitation and the law of chemical affinity might seem to approach the nearest to simple and unresolvable powers; but the illustrious discoverer of gravitation did not look upon it as an essential or ultimate property of matter, and Dalton represented chemical proportions as resulting from the size of the elementary atoms, and in the present day an eminent scientific man has proposed to resolve gravitation into a simpler property with a collocation suited to it; while chemists generally are by no means inclined to affirm dogmatically that we know the original power from which the phenomena of the combination of bodies proceed. Were we at liberty to assume that these are ultimate properties, it might not be difficult to shew that there is a beautiful correspondence between the law of gravitation and the mundane system through which it operates, and between the relations of the various chemical equivalents. But as we are not sure that we have gone down to the fundamental properties of matter, all that we can argue is, that if

the adaptations do not consist in the adjustment of the original law to the objects, they must consist in the adjustment of the objects to that law. The truth seems to be, that they consist in the adjustment of the one to the other by Him who instituted both.

But by no process can we get rid of these original adjustments. There is need, as Mr. J. S. Mill says, not only of a law of causation, but of a collocation of causes, and this collocation he shews " cannot be reduced to any law," that is, any natural law. With him, therefore, it is an ultimate fact of which he can make nothing. " We not only," he says,* " do not know of any reason why the sun's attraction and the tangential force co-exist in the exact proportion they do, but we can trace no coincidence between it and the proportions in which any other elementary powers in the universe are intermingled." But this we can clearly perceive, that if these proportions and coincidences had been different, there would have been confusion throughout the universe; that if the centripetal force had been proportionally greater, the earth and all the planets would have been drawn into the body of the sun; and that if the centrifugal force had been much increased, the earth would have wandered into regions so far from the sun that all living beings must have perished. The beauty and fitness of these coincidences and proportions compel us to see, that though they do not proceed from natural law, they must proceed from an Intelligence planning all things, and the relations of things, from the beginning.

Taking these principles along with us, we are entitled to say that mutual adjustments are necessary in order not only to individual effects of a beneficent character, but also to those general results of an orderly description, which are very commonly and very properly called laws of nature. We call the general facts observed by Kepler laws, but they are evidently the result of the relation of the planets to the sun, and of their centripetal to their centrifugal tendency. We talk of the law of the plant according to which it springs up, assumes certain forms, bears leaves and seed; but every one sees that we have here a complex effect proceeding from a vast number of arrangements, in which the laws of vitality, whatever they be, with the laws of moisture, heat, light, and electricity, are all made to act in unison. It seems to be a law of the appendages of the plant, of branches, leaves, and scales, that they are arranged in a spiral manner round the axis; but no one looks on this as a simple law; it is obviously the result of certain methodical dispositions. We suspect that most of what we call laws of nature, that most of the principles of order observable in nature, are of this compound or derivative character. They are the harmonious result of adjustments many and varied among a vast number of bodies and of forces, which, in our present state of knowledge, we must regard as different from each other, and which at least require adaptations to be constituted in order to their operation in a beneficent manner.

If these remarks be just, we are entitled to argue, that there has been adaptation not only in two or more bodies being so arranged as to produce an isolated effect of a benign character, but also in their being so disposed as to produce general laws or general results, these being wide-spread and continuous, stretching through extensive regions of space, and prolonged through many successive ages, such as the seasons, and the regular forms and periods of plants and animals. These—indeed all the principles of order in respect of number, time, colour, and form—are entitled to be called laws. But they are not original, they are derivative laws, not simple but composite, and the result of arrangements. We are thus ^ enabled to connect the principle of order with the principle of special adaptation; for it is required in order to the existence of general order, that there should be adaptation upon adaptation, and these necessarily of a most ingenious and far-reaching character.* We shall have occasion to return, as we proceed, to this subject, as serving to combine general law and special use in a higher unity.

Section II - The Adjustments Are Designed, And Not Casual

Nature Of Chance

The argument from design in behalf of the Divine existence, has sometimes been so stated as to make its main premises a mere truism, and the whole argument a begging of the question. It sets out with the maxim, that whatever exhibits marks of design must have proceeded from a designing mind; but by exhibiting marks of design, is meant proceeding from a designing mind, and thus the whole ratiocination is nothing but the pompous repetition of the same proposition. When put in this way, the argument is easily repelled and turned against him who urges it. But it is not thus that it has been propounded by any skilful defender of religion.

The argument from final cause, properly understood, is derived from those concurrences and correspondences of agents to produce a given end, which everywhere fall under our notice. These mutual adaptations of different and independent powers are so numerous, so curious, and so beneficent, that they clearly shew that there has been an Intelligent Being arranging them beforehand. They cannot proceed from chance, and we therefore conclude that they must proceed from design.

And this leads us to inquire what is meant by the word Chance, what is usually meant by it, and what is the proper meaning of the phrase. A thousand errors have been lurking in the confused ideas afloat on this subject, and we must be allowed to say that we have seldom found the nature of chance thoroughly expounded, or the various meanings of the word distinctly stated. The ancient atheists argued that there was such a thing as chance, and ascribed to it the formation of the universe. Modern materialists and pantheists maintain that there is no such thing as chance, that there can be no such thing, and thence argue that there can be no traces of design, since all things proceed from a chain of physical or metaphysical causes. "We are convinced that C. the one as well as the other of these parties is mistaken. We mean to shew, in opposition to the modern, that there is such a thing as chance, and, in opposition to the ancient, that there are adjustments in nature which cannot proceed from chance.

In maintaining, however, that there is really such a thing as chance, it is proper to announce that there cannot be chance in this sense, that there is an event without a cause. It is not necessary in the present clay to institute any proof of this; there is no principle more firmly established or more universally admitted. There may be a difference of opinion as to the nature of cause and effect, and a still greater diversity of view as to the nature of the belief in causation, whether it is derived from internal or external sources, but there is none as to the law or the fact itself. It is admitted that in our world no event happens without a cause. In this sense chance does not exist. " There is no such thing as chance," says Hume. Some would say that it cannot so much as be conceived to exist.

But still there are senses, and these most important senses, in which there may be said to be chance in our world. The word chance, and the corresponding words accident, casualty, fortuity, may be used, and have an intelligible meaning when used in two different senses.

First, To use the language of Professor De Morgan, " the word chance, in the acceptation of probability, refers to events of which the law or purpose is not visible and elsewhere, " events do happen by chance, for they certainly do happen so that we can see no reason why they should not have been otherwise."* In this sense, whether looking forward to the future, ever dimly seen, or to the present or the past as so far unknown, we may speak of chance, that is, of events of which we do not see the cause or purpose. As thus used, however, the word is significant merely of our ignorance, or rather of the necessary limits set to our knowledge. In this sense it can have no application to the Divine mind, which is ever cognizant, of the antecedents and consequents, of the intention and the issue, of all that has occurred, or that is occurring, or that will occur. As thus employed, the word can have no place for or against us in the argument which we are now

advancing. The limit of our knowledge cannot settle the question as to whether the adjustments in nature are or are not designed.

Secondly, Things may he said to he casually related to each other when the relation between them is not that of cause and effect, nor designed by the person producing them. Every event has a cause, but every event is not causally connected with every other which may happen about the same time or place, or have some relation to it of property or number. This part of the truth is expressed by Mr. J. S. Mill,—" Facts causally conjoined are separately the effects of causes, and therefore of laws, but of different causes, and causes not connected by any law. It is incorrect, then, to say, that any phenomenon is produced by chance; but we may say that two or more phenomena are conjoined by chance, meaning that they are in no way related through causation, that they are neither cause and effect, nor effects of the same cause, nor effects of causes between which there subsists any law of co-existence, nor even effects of the same original law of collocation."* The meaning of the phrase, " law of collocation," and the use to which it may he turned in the theistic argument, as pointing to a designed adjustment in the original constitution of things, have already been noticed.

So much, then, for casual as distinguished from causal connexion. But casual connexion may also be opposed to contrived connexion. It is needful to illustrate this, for it is a position of great importance in our argument. An agriculturist, let us suppose, is using the means necessary to secure a crop from his ground. Every step which he takes must have a causal connexion with something going before and something coming after; to this there can be no exceptions whatsoever. But among the many agencies he sets a-moving there will be some which have no discoverable mutual relation, while there will be others which very visibly have such a relation, which, we would have it observed, may cither be casual or designed. Thus it may be by accident that he began to plough the land on the same day as he did the previous year; by chance that the two horses in a particular plough are of the same age; that his harrows, constructed by different makers, are painted the same colour; that the workmen employed by him have the same Christian name; and that he has precisely the same extent of land in crop as in the previous year. There may be many such relations and correspondences which persons of a particular turn of mind find pleasure in noticing, and this because they are purely casual. But there are other connexions which are not of this fortuitous character. It is not by accident that he begins his work about the same season as he did the previous year; that he has put two horses into his plough; that the ploughing has been followed by sowing and harrowing; that he has workmen engaged in tilling his ground, and a certain portion of his whole ground under cultivation. There is here an evident distinction between two sets of events, and this distinction does not arise from the one class having causes, whereas the others have not, nor from the two proceeding from altogether unconnected laws of collocation, but from the one being designed as a mean toward an end, and the other not being so designed, as having no reference to that end. This distinction between the concurrence of independent means intended to produce an end, and mere coincidences which promote no special end, is an all-important one in the argument from design or final cause.

According to these views we cannot speak of an event being produced by chance. Such language has either no meaning, or a meaning opposed to the universally acknowledged principles of all science and all philosophy. In respect of causal connexion, chance has and can have no place; it is absolutely excluded. But in respect of other connexions of co-existence or succession, of number and property, there is room for chance, and, as opposed to chance, of designed coincidences and correspondences, and a co-operation of associated means for the production of a given end. In respect of production there can be no such thing as chance, but in respect of disposition there may. There are mutual relations which are not designed, even as there are relations which are designed. We cannot speak of accidental occurrences, but we may speak of accidental concurrences. We are

to shew that in the place where there is room for chance, there we have the most striking examples of design.

It may be difficult at times to determine whether certain events or phenomena are conjoined by chance, or whether an arrangement has been made to produce the conjunction. It is no proof of an intended connexion that they have been conjoined once or twice, or a few times. Nor can any absolute rule be laid down as to frequency of co-existence, which shall decide every supposable case that may arise. But there are cases of designed concurrence so clear that they do not admit of a moment's hesitation. When we see independent agents all moving towards one end—when we see stone, lime, wood, glass, slate, and lead, all combined in a house—when we find various kinds of metals, and wheels, pulleys, cylinders, of various shapes and sizes, conjoined to produce a machine, we at once say the connexion cannot be accidental, but is the result of arrangements made to secure a contemplated end.

Let us suppose that, on entering a room, we discover on a table before us five or six balls formed into a ring like figure, we do not allow ourselves for one instant to imagine that the balls came hither of their own accord, and without any one placing them there; but it may be a question whether the mutual arrangements involved in the figure are accidental or designed. This question would at once be settled if we saw other five balls on the same table formed into a similar figure. We would then acknowledge at once that there can be as little of accident in the mutual arrangement of the balls as in their being brought to this particular place.

These distinctions and explanations enable us to bring out very distinctly the nature of the argument derived from adaptation of parts in favour of the existence of God.

In physical nature we have the universal reign of causation, or every event connected with at least one other event as its cause, and yet another event as its consequence. In regard to this point there is no difference . of opinion. But in perfect consistency with this doc- -» trine we may find a number of events occurring at the same time or place, or nearly at the same time or place, or having some sort of bearing towards each other of a purely accidental character. In this sense there is no doubt much of chance in this world, that is, many events have some sort of discoverable relation, which may yet have no intended connexion. The year in which a' comet blazes in the heavens may be a year of famine or of fearful wars and intestine feuds, but this does not go to prove that the one was meant to forebode the other. We are quite willing to admit that all these phenomena can be traced up to God—we are sure that God foreordained both the comet and the famine; but it is quite a different thing to affirm that the two have a designed connexion with each other. Every scar upon the rocks of our earth may have been produced by causes set in operation by God, but this will not convince us that there is deep design on the part of God in presenting to us, here and there, on these rocks, a figure, which men discover to bear a rude resemblance to the face of George III., of L Nelson, or Napoleon Bonaparte. The fact that there are accidental concurrences, in the sense now explained, will not he urged, by any one who seriously reflects upon the subject, as proving this world is not the product of design, and that there is not design in every department of it. In the works of man which exhibit the clearest signs of contrivance, it is not found that ever}7 one part of the work has an intended relation to every other. In the construction of the walls of a church there may be the most careful attention implied in the way in which the stones are made to fit into each other, but it may all the while be purely accidental that two stones of much the same size, weight, or colour, are placed exactly opposing each other.

But wherever there may be chance, there may surely be design likewise. If there may be coincidences which are casual, there may also be concurrences which are contemplated. It is in the very place where there might be accident that we discover the clearest and most convincing evidences of design. Upon observing a number of separate forces acting in union and harmony, we

must believe that there has been a designing mind bringing them together and causing them to co-operate. When we see these agencies working in happiest association to produce innumerable effects of a beneficent character— when we find them consenting and consorting throughout thousands or myriads of years or geological ages, the evidence is felt to be overwhelming beyond the power of human calculation. Yet this is the sort of conjunctions and co-operations which is constantly presenting itself to our view. We observe everywhere a host of separate bodies and powers, all tending towards a particular end;—say a number of material substances with the vital agency, the heat agency, the light agency, the electric agency, all conspiring to the production of a living plant or animal; or bone, nerves, and muscles, meeting to give an easy motion to a limb. " How often," J asks Tillotson, " might a man, after he had jumbled a set of letters in a bag, fling them out upon the ground before they would fall into an exact poem, yea, or so much as make a good discourse in prose? And may not a little book be as easily made by chance as this great volume of the world? How long might a man be sprinkling colours upon canvas, with a careless hand, before they would happen to make the exact picture of a man? And is a man easier made by chance than this picture? How long might twenty thousand blind men, which should be sent out from the several remote parts of England, wander up and down before they would all meet upon Salisbury Plains, and fall into rank and file in the exact order of an army? And yet this is much more easy to be imagined than that the innumerable blind parts of matter should rendezvous themselves into a world."

We have the mathematical theory on this subject, with a most important application, laid down by an eminent living mathematician. After stating that when we have a question of pure numbers we can absolutely try the question with chance in precisely the same manner in natural theology as we try it in the common affairs of life, Professor De Morgan thus proceeds: "Let us assume, as we must, that a number produced by chance alone, (in the anti-deistical sense of the word,) might as well have been any other as what it is. And further, let us require, before we grant intelligence and contrivance, not merely the presence of an adaptation, which would have been unlikely from chance alone, but two such phenomena perfectly distinct from each other considered as phenomena, each of which might have existed without the other, and both tending to the same object, which would have been defeated by the absence of either. Let it be also granted, to fix our ideas, that we admit as proved a proposition which has a hundred million to one in its favour. This being premised, and laying it down as our object to shew that the necessary result of the theory of probabilities lead to the conclusion that the existence of contrivance is made at least as certain, by means of it, as any other result which can come from it, we proceed to state a consequence. The action of the planets upon each other, and that of the sun upon all, (the most certain law of the universe,) would not produce a permanent system, unless certain other conditions were fulfilled which do not necessarily follow from the law of attraction. The latter might have existed without the former, or the former without the latter, for anything we know to the contrary.* Two of these conditions are, that the orbital motions must be all in the same direction, and also that the inclinations of the planes of these orbits must not be considerable. Granting a planetary system, which is what ours is in every respect, except either of these two, and it is mathematically shewn that such a system must go to ruin; its planets would not preserve their distances from the sun. Neither of these phenomena can he shewn to depend necessarily on the other, or on any law which regulates the system in general. For anything we know to the contrary, then, they are distinct and independent circumstances of the organization of the whole. Now, let us see what are the phenomena in question.

1. All the eleven planets yet discovered" [that is, when the work was written] " move in one direction round the sun. 2. Taking one of them (the earth) as a standard, the sum of all the angles made by the planes of the orbits of the remaining ten, with the plane of the earth's orbit, is less than a right angle, whereas it might by possibility have been ten right angles.

Now, it will hereafter be shewn that causes are likely or unlikely, just in the same proportion that it is likely or unlikely that observed events should follow from them. The most probable cause is that from which the observed event could most easily have arisen. Taking it, then, as certain that the preceding phenomena would have followed from design, if such had existed, seeing that they are absolutely necessary, ceteris manentibus, to the maintenance of a system which that design, if it exist, actually has organized, we proceed to inquire what prospect there would have been of such a concurrence of circumstances if a state of chance had been the only antecedent. With regard to the sameness of the directions, either of which might have been from west to east, or from east to west, the case is precisely similar to the following:—There is a lottery containing black and white balls, from each drawing of which it is as likely a black ball shall arise as a white one, what is the chance of drawing eleven balls all white?—Answer, 2047 to one against it. With regard to the other question, our position is this:—There is a lottery containing an infinite number of counters, marked with all possible different angles less than a right angle, in such a manner that any angle is as likely to be drawn as another, so that in 10 drawings the sum of the angles drawn may be anything under 10 right angles. Now, what is the chance of ten drawings giving collectively less than one right angle?—Answer, 10,000,000 to one against it. Now, what is the chance of both these events coming together? —Answer, more than 20,000,000,000 to one against it. It is consequently of the same degree of probability that there has been something at work which is not chance in the formation of the solar system. And the preceding does not involve a line of argument addressed to our perception of beauty or utility, but one which is applied every day, numerically or not, to the common business of life.

We have quoted this passage mainly for the mathematical principles which it unfolds. Since the treatise was written a great number of small planets have been discovered. These all run in the same direction as the planets previously discovered, and so add enormously to the weight of the argument. It is true that the inclination of some of them is considerable, but their mass is so diminutive that this circumstance is not fitted to produce any permanent disturbance.*

This is the argument from "Final Cause," as it is commonly called. At the same time we are inclined to look upon the phrase as rather an unhappy one. The word, according to the all but invariable usage of our tongue, points to that which has efficiency; and there is nothing of the nature of power implied in the great class of facts which we are now advancing. In this branch of investigation we are contemplating not so much a cause, as an end aimed at, by a combination of means, by a concurrence of causes. The science which treats of 1 the relation of means and ends has an unexceptionable name applied to it, and is called teleology. It would J serve several important ends to have an equally good ' phrase to denote the class of facts which it is the business of that science to explore. As "typos" and "cosmos" have been naturalized into our language, we wish that some high authority would introduce " telos" likewise. In the absence of any such authorized phrase we shall be obliged to employ final cause, or, in lieu of it, such terms as aim and purpose, end and special end. We; are to shew that throughout the whole of nature there is a union and co-operation of means for the production of what are evidently ends, and such special ends as argue a living being arranging the means in order to their accomplishment.

It is not necessary, in order to the conclusiveness of such an argument, that we should be able to say that we have discovered the ultimate end aimed at in all these concurrences of means to produce anterior or intermediate ends. There are persons who seek to cloak the hideousness of their atheism under the guise of an affected humility, urging it is not for them to be so presumptuous as to pretend to detect the purposes of Deity. And there might have been some plausibility in this pretext, provided it had been necessary, in order to the validity of the argument, to determine the grand ultimate design of creation. But it is by no means requisite in order to prove the existence of design that we should be able to fathom all the depths of the Divine counsels, and settle what is the last end of the Creator's work. On seeing Napoleon Bonaparte

gathering his army to a given point—on finding one battalion coming from one province and other battalions collecting from other provinces, distant from the first and from each other, persons would have been entitled to conclude that these were means, and well-devised means, to an end, and this though entirely ignorant of the ultimate purpose to be effected by the subordinate ends; it would be enough for them that they discovered the immediate end and the means employed to accomplish it. On precisely the same grounds are we justified in maintaining that we observe in nature a singular combination of means towards the production of an end. This end may not be the final end of creation, but still it is an end— a subordinate end, aimed at by a combination of means arranged by intelligence. Nor can this inference be at all affected by the circumstance that these ends are commonly found to be means towards some other and a higher end. In God's works all the means are ends, and all the ends are means, and all means and subordinate ends are obviously concurring towards a final consummation, which man can not fully compass, but which he has abundant reason—from the tendency of the inferior ends—to regard as at once grand and beneficent.

The argument advanced under this head seems a complete one in itself. It does not require in order to its conclusiveness that it should be proven that this world has had a beginning, nor to look to any physical facts except those adduced in the premises. The adjustment of the bodies and forces of nature so as to produce harmonious and useful results, is in itself a proof of an arrangement not casual but planned by intelligence. We require not, in order to its conclusiveness, to specify the time when the adjustments were constituted, nor to shew that God has created matter as well as arranged it, nor even so much as that matter has had a beginning. These other truths may be established more satisfactorily after it has been demonstrated, from the design manifested in the universe, that there is a God the author of the design.

The force of the argument now adduced is not to be turned aside by going back in the chain of causation, and shewing how each of the combined circumstances, which form this means towards an end, has proceeded from a cause. We are not to discard final causes, as Laplace used to do so summarily, as soon as the physical cause of the individual circumstance is pointed out. Nor are we, with Kant, to lay down the principle that we are at liberty to call in final cause only when mechanical cause fails to account for each particular fact. The argument which we adduce in favour of final cause is derived from the wonderful combination of physical causes. It is freely admitted, that in the material universe every phenomenon has had a cause, but this does not weaken the argument founded on the correspondence between a number of associated phenomena, proceeding from different and independent causes. No doubt it forces us to acknowledge that there has been a correspondence in the causes producing such concordant results, but in carrying us back thus far it only opens up larger views of the wisdom and foresight involved in a plan which contemplated such far-reaching consequences. In Divine workmanship, as also in the higher kinds of human workmanship, order and utility are commonly produced by a long previously arranged consortment of means or causes. For example, the crop which the cultivated ground yields is the result of a vast number of preparations, human and Divine too, made long before. It is the peculiarity of the Divine workmanship that we can see in it a set of causes so ordered that they can produce a series or succession of orderly and benign results going on from age to age. The plants and animals now on the earth have all proceeded from progenitors created many thousand years ago, and which were so constituted as to produce an offspring after their kind. To argue from the succession of such effects that they are not designed, is to make the very beauty and perfection of the work a proof that it has not proceeded from an intelligent being.

Nor is the force of the argument to be weakened by the attempt to discover an alleged contradiction; if everything, it is said, comes from God, there can be nothing casual, there is no room for chance, and therefore no room for design as distinguished from chance. Now, it is at once admitted that every physical occurrence may be regarded as proceeding from God; at this point,

that is, in regard to the production of the event, there is no room for accident. But while every event comes from God, this does not prove that the coincidences between I every two events were designed by Him to produce a specific end. God has no doubt appointed both the eclipse and plague which may have happened the same year, but this does not prove that He designed the one [j_ dark event to foreshadow the other. As there may be casual relations in nature, so there may be, so there are, in nature designed concurrences, as distinguished from accidental coincidences. All that is now occurring is doubtless the result of collocations previously made, and in tracing it back we must come to certain original collocations. At this point physical research stops, but all inquiry is not arrested. The mind asks, whence this / systematic collocation of agents and forces which has produced such good and useful results for thousands, or I it may be, millions of years? The present so full of order / carries us back to the past as also full of order, and shews that the system now in operation had been planned from the beginning.

Still less is the force of the argument to be evaded by the miserable subterfuge of certain French materialists, who tell us that this consorting of means and end is the mere condition of existence. When it is found, for example, that certain independent members of carnivorous animals are in admirable harmony, the limbs for running after the prey, the claws for seizing it, the muscles for keeping hold of it, the teeth for tearing it, and the stomach for digesting it, an attempt is made to avoid the force of the appeal by urging that these are the conditions of the existence of the animal. True, we reply, but the argument is derived from the circumstance that these independent conditions should meet so as to enable the animal to exist and to enjoy existence. He who brings in the principle of the conditions of existence will find it, if legitimately followed out, landing him in a designing intelligence no less certainly than the principle of final cause does. The argument, whether for or against theism, is not to be made to depend on a word or the shifting of a word. It is not to be established on the one side by a verbal sophism about design implying a designer, but neither is its overwhelming force to be turned aside by changing the word final cause for conditions of existence. It seems that conditions are necessary to certain existences, and it is the concurrence of these conditions, proceeding from various and independent quarters, which proves so irresistibly that there must have been design in their arrangement and collocation.

Section III - The Obviousness And Completeness Op The Special Adaptations

The argument from adaptation to a particular end is one which addresses itself to every human being. It is suited to every intellect, and comes home to every man's experience.

1. Every manual labourer may see something analogous to the art by which he earns his livelihood operating among the natural objects by which he is surrounded.

The sailor may discover the peculiarities of his craft among marine animals. Thus, among the lower tribes, he has observed a jelly-fish—called by him the Portuguese man-of-war—setting up a sail which consists of a crest surmounting the bladder. He may notice, too, how the mussel and pinna anchor themselves by means of threads of a horny material. The tail of the fish, it is well known, acts as a scuttle, enabling its possessor to plough its way through the deep. The web-foot of the swimmers is an example of what is called "feathering the oar;" when advanced forward the web and toes collapse; the leg (usually so called) of the guillemot and divers is compressed laterally, presenting a knife edge before and behind, and thus gives resistance in the fore and back stroke. It is also worthy of being mentioned, as illustrating the same point, that the whale's tail collapses in the upward but expands in the downward stroke.

The fisher, as he prepares the bladder to make the edges of his net float on the water, may observe that the sea-weed is buoyed on the surface of the deep by a contrivance more ingenious than his own, that is, by vesicles which act as floats. Most fishes have one or more bladders filled with air,

the amount of which is regulated by the will of the animal, so that it can vary its depth, sink or rise to the surface, as may suit its purposes. The fisher, too, may see that if he has nets to catch the food needful for his sustenance, so also have spiders and other species of animals.

The shepherd knows how much care and watchfulness are necessary in order to protect his flocks from the wild beasts which attack them, and is thus led to admire the instincts of those animals, such as the deer, which set a watch to give a signal of danger. The hunter knows how much cunning he must exercise in order to come within reach of the wild animals pursued by him, and should not withhold a feeling of wonder when he observes how their instincts lead the brutes to shew such dexterity in avoiding their natural enemies. The weapons with which he and the fisher attack the animals which they wish to seize or kill, do not point more clearly to a purpose, than the instruments, whether claws or teeth, with which they defend themselves. The Aphrodite hispida, for example, is furnished with very curious weapons of defence; they are harpoons with a double series of barbs, these are retractile, and the animal can draw them into the body by a muscular apparatus, and in order to prevent them, when drawn in, from injuring the animal itself, each barbed spine is furnished with a two-bladed horny sheath, which closes on the barbs in the act of retraction. Some of these provisions have a reference to the native instincts of the animals, others have rather a regard to the position of the species. Thus we find that those liable to be chased as prey often take the colour of the ground on which they habitually feed. The riflemen of our army are dressed in the hue which is deemed least conspicuous, and which is hest fitted for concealment; and is there not an equally clear proof of design furnished by the circumstance that fishes are often of the colour of the ground over which they swim, and that wild animals are not unfrequently of the colour of the covert in which they hide themselves? Thus the back of the young turbot may be seen of the same colour as the sand on which it lies. The red grouse and red deer are of the colour of the heath on which they feed, whereas the lapwing and curlew, themselves and their eggs, take the grey hue of the pasture among which they are usually% found.

The horticulturist and agriculturist regulate their plans in accordance with the seasons, and in doing so they should observe that the plants of the ground suit themselves in regard to the time of budding, bearing leaves and fruit, to the same seasons, which are all determined by the movements of the celestial bodies. The builder may easily perceive that the woody structure of plants and the bones of animals are constructed on architectural principles, being strengthened where weight has to be supported and pressure resisted, and becoming more slender where lightness is required. The form of the bole of a tree, and the manner in which it fixes itself into the ground, so as to be able to face the storms of a hundred winters, is said to have yielded some suggestions to the celebrated engineer, Smeaton, in the construction of the Eddystone Lighthouse. The architect of the Crystal Palace confesses that he derived some of the ideas embodied in that structure from observing the wonderful provision made for bearing up the very broad leaf of the beautiful lily which has been brought within these few years from the marshes of Guiana to adorn our conservatories. The weaver cannot but notice that there are certain tribes of insects which fashion a web of finer texture than his own. The cloth maker obtains not a little of the material of the fabrics with which he clothes the human frame, from the covering provided for the lower animals, and he derives it all from natural products.

When man wishes to protect his body from severe cold, he steals their covering from the lower animals, and by no means of his own devising can he furnish clothing so
warm as that which has been provided for the brutes in the Arctic regions. The dyer and calico-printer, with all the aids of modern chemistry, cannot produce such rich and agreeable colours as are made to appear for our gratification in the flowers of plants and the plumage of birds; no doubt through the influence of principles which have not been detected by the very deepest scientific research. Rising higher in the arts we find the painter taking credit to himself for the beauty of his

figures and colours; but he cannot, with all his skill and genius, match those lovely ideal forms and exquisite tints which everywhere fall under our eye in nature.

Who can paint Like nature?
Can imagination boast,
Amid her gay creation, hues like these?
What hand can mix them with that matchless skill,
And lay them on so delicately fine,
And lose them in each other, as appears
In every bud that blows?

2. Every kind of contrivance, every principle of mechanism used by man, is visibly employed in the operations of nature. The lamp placed in a window to direct the benighted traveller, the lighthouse erected on the harbour to guide the mariner to a place of safety, are not clearer and more decided illustrations of purpose than the phosphorescent spark by which the glowworm allures its mate in the darkness of night. What contrivances does man resort to in order to keep his dwelling warm and comfortable, but the physiologist will tell him that there are still more wonderful schemes devised for keeping up the heat of the bodily frame.

Every mechanical power employed by man is at work in nature. There is as much skilful leverage in the human frame as in the most ingenious human machine. The pulleys by which heavy bodies are lifted from the ground do not give such clear indications of means and end, as the tendons and muscles by which the bones are moved. The mechanician has often a large cylinder running across or through his works, .and to this he attaches the lesser parts of his machinery. Have we not a similar contrivance in the backbone of the higher animals, and the axis of the plant, constituting the support of all the appendages? Every one who has seen the cord of plaited iron by which a carriage is dragged up an inclined plane, and has noticed how in it strength and flexibility are combined, should be prepared to admire the different means by which the same end is effected in the backbone of all animals, but especially in that of such animals as the eel and the serpent. The mechanician who wishes to combine the saving of materials and lightness with strength, makes his cylinder a hollow tube: it is on this principle that Messrs. Stephenson and Fairbairn have spanned the Mersey by a tubular bridge; but the principle was in operation before man adopted it, or was created to observe it, in many of the bones of animals which are hollow. Found in the bones of all grades of living creatures, it is carried out to the greatest extent where most needed in the bones of birds, so as to allow them to float in the air. In the case of birds, too, the air from the lungs permeates the larger bones as well as the smaller parts, the higher temperature of the body (108°-112° F.) rarefies it, and imparts an increased buoyancy to the whole frame.

Every joint in the animal frame can be shewn to be exactly suited to-the function which it has to perform. Where motion backward and forward in one direction is all that is required, we have a common joint; where motion all round is necessary, we Lave, as at the shoulder and hip, the ball and socket-joint admitting of a rotatory motion round a ball. We have a beautiful example of ball and socket-joint in the sea-urchin, the spines of which have a cuplike cavity at the base, which is fitted to a converse tubercle in the shell, fixed by ligaments, and combining strength and great freedom of motion. In some parts of the animal frame, a single bone is all that is required, and more would injure the strength; in other parts, as in the fore-arm, a kind of rotatory motion is furnished by two bones, a radius and an ulna, so adjusted as to move to some extent round each other.

Almost every sort of instrument employed by man has something resembling it in the operations of nature. The parts of the mouth of insects are made according to the instincts and habits of the animal, to act now as saws, now as knives, and, in the case of the leaf-cutting bees, the mandibles

become scissors. The hyena is led by its instincts to crush the bones of carcases and feed on them; and when certain teeth of that animal were shewn by Professor Owen to an engineer, they were declared by him to be admirable models of hammers to break stones for roads. The tongue of many shell-fish, that of the common limpet for instance, has numerous siliceous spines, and the organ is used as a rasp or drill. One end of the shell of Pholas resembles a file, and, by varied motions, the animal makes for itself tunnels in clay and in other substances. The foot of the mole is an admirable tunnelling instrument, and enables it to construct for itself those subterranean passages through which it is led, by its instincts, to wend its way in search of food.

Instruments of a more peculiar nature, and instruments invented by man only at a late date in the history of the race, have all along had their analogues in nature. Millstones are selected because they have gritty materials in the midst of softer substances; and we find that, on a like principle, soft and hard matters are mixed in the grinding-teeth of mammals. The cupping instruments of surgery were anticipated in the animal kingdom; the mouth of the leech combines in itself the offices of cupping-glass and scarificator; hence the importance of the animal, as a remedial agent. It is also worthy of notice in regard to this animal, that the capacious stomach, with its lateral appendages or reservoirs, enables it to extract a very considerable quantity of blood before being detached. Some of the feet of argulus foliaceus, a parasite on various fresh-water fishes, are so modified that they act as real suckers or cupping-glasses; by a certain arrangement of muscles the animal can exhaust the cavity of its disc-like feet, and produce a vacuum, and is thus enabled to stick closely to the body of the fish.

The tubes and pipes which conduct water and gas through all the streets and dwellings of a great city, are not such ingenious contrivances as the veins and arteries which convey the blood to every extremity of the frame. The means by which water is forced to rise in a pump are not so wonderful as those by which, proceeding on a different principle, fluid is made to mount in the plant to the most distant twig and leaf. We construct valves to allow fluids to pass in one direction, but to prevent them from flowing back in the opposite direction; but before man devised such agency they were already in his own veins; and it was upon noticing them that Harvey, proceeding, as he tells us, on the principle that they were there to serve a purpose, was led to the discover}' of the circulation of the blood. In the back of the mouth of the crocodile are two cartilaginous plates or valves, one above, the other below; these, acting as floodgates, cut off communication between the mouth and throat, so that the animal can hold its prey underneath the water till dead, and itself continue all the while to breathe by its nostrils.

3. Among the most curious special modifications are those in which there is a provision made beforehand for the support of living creatures not yet in existence. Every one sees that there is foresight implied in parents laying up wealth to promote the future comfort of their children; but there are equally clear evidences of forethought in the anticipations found among natural objects. In expectation of the birth of her child the mother makes preparation for its clothing and comfort; but there has been a preparation by another Designing Mind, so as to cause the milk to flow at the very time at which it is required for the sustenance of the infant. In the case of animals developed from the egg, we find a store of nourishment laid up beforehand in the yolk, part of which is absorbed as food by the young chick or reptile. In the egg-cases of the common white whelk of our coasts there is a farther provision made for the sustenance of the young animal, in the form of a supplemental yolk, as it might be called. Each case, or capsule, contains several hundred bodies having the appearance of embryo, but only a small number in each capsule becomes living creatures. There can be no doubt, from Dr. Carpenter's observations, that these few are developed by the metamorphosis of the contents of their own yolks, but their growth or increase in the size depends on the fact that they swallow and feed upon the additional or supplemental yolk.

4. Not only are the different parts of the animal and plant suited to each other, but there is a perfectibility about them—they are better adapted than anything else to the accomplishment of their end. There are examples of this which have now become commonplace by the eloquent expositions of them by Lord Brougham and others. Every principle followed by the skilful optician in the construction of artificial glasses has been attended to in the formation of the eye, and difficulties which long impeded the formation of perfect glasses were obviated all along in the structure of the natural organ. Every one interested in such investigations knows that bees economize, on mathematical principles, the space which they occupy and the wax which they employ, by building their honeycombs of double layers of hexagonal cells, and by having the floor of their cells made of three square planes meeting at a point and at a particular angle. It is now said that this is produced by the compound eye of the bee being divided by hexagonal marks; " and as the motions of the muscles of animals are directed very much by the mode of admission of light, the shape of the cells may be in accordance with that of the surface of the eyes." f Be it so, it is only a new illustration of the adjustment of natural instinct and the structure of an organ to produce an end which must have been contemplated, not by the intelligence of the bee, but of Him who gave to the bee its endowments. It has been shewn by mathematical investigation, that the shape of fishes is that which is best fitted to enable them to cleave their way through their native element. At the time when it was disputed whether Newton or Leibnitz was the inventor of that calculus which has opened the way to such splendid results in various branches of science, John Bernouilli addressed a letter to the most distinguished mathematicians of Europe, challenging them to solve two difficult problems, one of which was to determine the line through which a falling body would descend most swiftly. Both of the distinguished men referred to, (and also M. de L'Hopital,) were able to solve the problem, and declared the line of swiftest descent to be not a straight line but a particular curve called the cycloid. Now, it is believed that it is by this very swoop that the eagle descends upon its prey. The question presses itself upon us, Who taught the birds of the air the line of swiftest descent, the discovery of which was believed to test the highest mathematical skill?

We have already referred to the univalve shells of molluscs as illustrative of the principle of order.* There is another circumstance in connection with these shells worthy of being mentioned here, as connecting the principle of general order with that of special adaptation. In aquatic molluscs, the shell must not only be a habitation for the animal, but a float, which it becomes, by the portion of the narrower extremity of its chamber left unoccupied. But in order to preserve its buoyancy, and enable the animal to ascend and descend the water at will, it is necessary that the increment of the capacity of its float should bear a constant ratio to the corresponding increment of its body—a ratio which always assigns a greater amount to the increment of the shell than to the corresponding increment of the animal bulk. Now, it is in accordance with the geometrical character of the form assumed, that the capacity of the shell and the dimensions of the animal do increase in a constant ratio, causing the whole bulk of the animal to bear a relation of constantly increasing inequality to the whole capacity of the shell. " God," says Mr. Mosely, " hath bestowed upon this humble architect the practical skill of a learned mathematician."

5. It is a circumstance of great significance, that parts of animals which, to superficial observers, might seem useless, or even cumbersome and inconvenient, have been found, in the progress of discovery, to serve most important ends in the economy of life. The hump of the camel might readily be regarded as a very unseemly encumbrance, and we find even the distinguished naturalist, Buffon, speaking of these humps, and of the callous pads on the legs of that animal, as mere marks of degradation and servitude. A little patient investigation, however, suffices to shew that these parts of their frame, like every other, fit these useful creatures for the purposes served by them in the regions which they inhabit. It has often been remarked that the abundant supply of fluid laid up in the cells of one of the stomachs, is a beautiful provision for enabling the animal to endure a long continuance of thirst; and it can be shewn that the enlargement of their feet, with

their convex soles, allows them to tread easily on the loose, yielding sand of the desert; that the callosities or pads on their legs permit them to lie down and repose on scorching surfaces; and that their humps are supplies of superabundant nourishment provided for their long journeys, so that, when deprived of other food, their frames feed on this nutriment; and it has been observed that, at the close of a long journey, their humps have been much diminished in size.

We are not surprised to find a man so proverbially vain as Buffon failing to discover marks of design in the hump of the camel, but it is rather wonderful to find J Cuvier, whose heart was so filled with admiration of the Divine wisdom, speaking somewhat doubtfully of the sloth. Its peculiar structure would, to use his language, have been inconvenient if it had been intended that it should support itself on its limbs, like most vertebrated animals. But however incapable of walking, its frame is admirably constructed for enabling it to hang by its limbs on the branches of trees. Amid the great intertangled forests of South America, stretching for hundreds of miles, it is by no means so slow in its movements; at least its motion is sufficiently quick to admit of its gathering its sustenance. It has long, coarse, shaggy hairs to protect it from insects; it clings to the bough of the tree by its two hinder claws, and commonly also by one of the fore-limbs, and it employs its other arm in hooking in the foliage on which it browses. It can fling itself from one branch of a tree to another; and in the more open parts of the forest, it can take advantage of windy weather to throw itself from the tree which it has stript to another covered with rich and tempting foliage. Such facts as these go to prove that it is our own ignorance and presumption which lead us to complain of the inconveniences of nature, and that a little more knowledge, and, better still, a little more humility and patience, would lead us to discover and acknowledge, that there are admirable wisdom and benevolence even in those parts of God's works which may seem to be useless, or even injurious.

The problem which we are seeking to help to solve, is stated so aptly and felicitously in the opening address of the President at the last meeting of the British Association for the Promotion of Science,* that we cannot refrain from quoting the language. " In physiology, what is the meaning of that great law of adherence to type and pattern, standing behind, as it were, and in reserve, of that other law by which organic structures are specially adapted to special modes of life? What is the relation between these two laws; and can any light be cast upon it derived from the history of extinct forms, or from the conditions to which we find that existing forms are subjected? In vegetable physiology do the same or similar laws prevail; or can we trace others, such as these on the relations between structure, form, and colour, of which clear indications have already been established?" These questions may best be answered by going round the various kingdoms of nature, and placing examples of the two governing laws alongside of each other.

July 1869
Brigham Young
The infidel looks abroad and sees works of nature, in all their diversity, all giving most irrefutable evidence of Designer and Creator of infinite wisdom, skill and power, and yet says there is no Deity
Brigham Young, Discourses of Brigham Young, selected and arranged by John A. Widtsoe, p.154

The first principle of the Gospel is faith in God-faith in a Supreme Being. This is a point that meets the infidel, and is one upon which I have reflected and talked a great deal, and I have come to this conclusion-that good, solid, sound sense teaches me never to judge a matter until I understand it, and infidels should never pass their opinion with regard to the character of a Supreme Being until they know whether there is one or not. If this principle were an article in the creed of the infidel world, I think they would not be quite so skeptical as they are; I think we should not meet with any person who would deny the existence of a Deity. The infidel looks abroad and sees the works of

nature, in all their diversity-the mountain piercing the clouds with its snowy peaks, the mighty river, fertilizing, in its course to the sea, the valleys and plains in every direction, the sun in his glory at mid-day, the moon in her silvery splendor, and the myriad organizations from man to the minutest form of insect life, all giving the most irrefutable evidence of a Designer and Creator of infinite wisdom, skill and power, and yet he says there is no Deity, no Supreme Ruler, but all is the result of blind chance. How preposterous! Now, here is a book called the Bible. It is enclosed in what we call the cover, consisting of boards, paper and leather. Within the covers we see a vast amount of writing-syllables, words and sentences; now if we say there never was a person to compose, write, print or bind this book, but that it is here wholly as the result of chance, we shall only give expression to the faith, if faith it can be called, of those who are termed infidels; in fact this is infidelity. I do not want to say much about it, it is too vain! 13:142.

1872
Duke of Argyll
The Reign of Law
Book

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Chapter II - Law - Its Definitions

THE Reign of Law—is this, then, the reign under which we live? Yes, in a sense it is. There is no denying it. The whole world around us, and the whole world within us, are ruled by Law. Our very spirits are subject to it—those spirits which yet seem so spiritual, so subtle, so free. How often in the darkness do they feel the restraining walls—bounds within which they move—conditions out of which they cannot think! The perception of this is growing in the consciousness of men. It grows with the growth of knowledge; it is the delight, the reward, the goal of Science. From Science it passes into every domain of thought, and invades, amongst others, the Theology of the Church. And so we see the men of Theology coming out to parley with the men of Science,—a white flag in their hands, and saying, " If you will let us alone we will do the same by you. Keep to your own province, do not enter ours. The Reign of Law which you proclaim, we admit—outside these walls, but not within them:—let there be peace between us." But this will never do. There can be no such treaty dividing the domain of Truth. Every one Truth is connected with every other Truth in this great Universe of God. The connexion may be one of infinite subtlety, and apparent distance—running, as it were, underground for a long way, but always asserting itself at last, somewhere, and at some time. No bargaining, no fencing off the ground—no form of process, will avail to bar this right of way. Blessed right, enforced by blessed power! Every truth, which is truth indeed, is charged with its own consequences, its own analogies, its own suggestions. These will not be kept outside any artificial boundary; they will range over the whole Field of Thought, nor is there any corner of it from which they can be warned away.

And therefore we must cast a sharp eye indeed on every form of words which professes to represent a scientific truth. If it be really true in one department of thought, the chances are that it will have its bearing on every other. And if it be not true, but erroneous, its effect will be of a corresponding character; for there is a brotherhood of Error as close as the brotherhood of Truth. Therefore, to accept as a truth that which is not a truth, or to fail in distinguishing the sense in which a proposition may be true, from other senses in which it is not true, is an evil having consequences which are indeed incalculable. There are subjects on which one mistake of this kind will poison all the wells of truth, and affect with fatal error the whole circle of our thoughts.

It is against this danger that some men would erect a feeble barrier by defending the position, that Science and Religion may be, and ought to be, kept entirely separate;—that they belong to wholly different spheres of thought, and that the ideas which prevail in the one province have no relation to those which prevail in the other. This is a doctrine offering many temptations to many minds. It is grateful to scientific men who are afraid of being thought hostile to Religion. It is grateful to religious men who are afraid of being thought to be afraid of Science. To these, and to all who are troubled to reconcile what they have been taught to believe with what they have come to know, this doctrine affords a natural and convenient escape. There is but one objection to it—but that is the fatal objection—that it is not true. The spiritual world and the intellectual world are not separated after this fashion: and the notion that they are so separated does but encourage men to accept in each, ideas which will at last be found to be false in both. The truth is, that there is no branch of human inquiry, however purely physical, which is more than the word " branch" implies;—none which is not connected through endless ramifications with every other,—and especially that which is the root and centre of them all If He who formed the mind be one with Him .who is the Orderer of all things concerning which that mind is occupied, there can be no end to the points of contact between our different conceptions of them, of Him, and of ourselves.

The instinct which impels us to seek for harmony in the truths of Science and the truths of Religion, is a higher instinct and a truer one than the disposition which leads us to evade the difficulty by pretending that there is no relation between them. For, after all, it is a pretence and nothing more. No man who thoroughly accepts a principle in the philosophy of Nature which he feels to be inconsistent with a doctrine of Religion, can help having his belief in that doctrine shaken and undermined. We may believe, and we must believe, both in Nature and Religion, many things which we cannot understand; but we cannot really believe two propositions which are felt to be contradictory. It helps us nothing in such a difficulty, to say that the one proposition belongs to Reason and the other proposition belongs to Faith. The endeavour to reconcile them is a necessity of the mind. We are right in thinking that, if they are both indeed true, they can be reconciled, and if they really are fundamentally opposed, they cannot both be true. That is to say, there must be some error in our manner of conception in one or in the other, or in both. At the very best, each can represent only some partial and imperfect aspect of the truth. The error may lie in our Theology, or it may lie in what we are pleased to call our Science. It may be that some dogma, derived by tradition from our fathers, is having its hollowness betrayed by that light which sometimes shines upon the ways of God out of a better knowledge of His works. It may be that some proud and rash generalisation of the schools is having its falsehood proved by the violence it does to the deepest instincts of our spiritual nature,—to:

" Truths which wake to perish never!
'Which neither man nor boy,
Nor all that is at enmity with joy,
Can utterly abolish or destroy."
" Ode to Immortality, from the Recollections of early Childhood. "—Wordsworth.

Such, for example, is the conclusion to which the language of some scientific men is evidently pointing, that great general Laws inexorable in their operation, and Causes in endless chain of invariable sequence, are the governing powers in Nature, and that they leave no room for any special direction or providential ordering of events. If this be true, it is vain to deny its bearing on Religion. What then can be the use of prayer? Can Laws hear us? Can they change, or can they suspend themselves? These questions cannot but arise, and they require an answer. It is said of a late eminent Professor and clergyman of the English Church, who was deeply imbued with these opinions on the place occupied by Law in the economy of Nature, that he went on, nevertheless, preaching high doctrinal sermons from the pulpit until his death. He did so on the ground that propositions which were contrary to his reason were not necessarily beyond his faith. The

inconsistencies of the human mind are indeed unfathomable; and there are men so constituted as honestly to suppose that they can divide themselves into two spiritual beings, one of whom is sceptical, and the other is believing. But such men are rare—happily for Religion, and not less happily for Science. No healthy intellect, no earnest spirit, can rest in such self-betrayal. Accordingly we find many men now facing the, consequences to which they have given their intellectual assent, and taking their stand upon the ground that prayer to God has no other value or effect than so far as it may be a good way of preaching to ourselves. It is a useful and helpful exercise for our own spirits, but it is nothing more. But how can they pray who have come to this? Can it ever be useful or helpful to believe a lie? That which has been threatened as the worst of all spiritual evils, would then become the conscious attitude of our " religion," the habitual condition of our worship. This must be as bad science, as it is bad religion. It is in violation of a Law the highest known to Man — the Law which inseparably connects earnest conviction of the truth in what we do or say, with the very fountains of all intellectual and moral strength. No accession of force can come to us from doing anything in which we disbelieve. Such a doctrine will be indeed

" The little rift within the lute
That by and by will make the music mute,
And ever widening slowly silence all. "
i "Idylls of the King — Vivien." — Tennyson.

If there is any helpfulness in Prayer even to the Mind itself, that helpfulness can only be preserved by showing that the belief on which this virtue depends is a rational belief. The very essence of that belief is this — that the Divine Mind is accessible to supplication, and that the Divine Will is capable of being moved thereby. No question is, or indeed can be, raised as to the powerful effect exerted by this belief on Man's nature. That effect is recognised as a fact. Its value is admitted; and in order that it may not be lost, the compromise now offered by some philosophers is this— that although the course of external nature is unalterable, yet possibly the phenomena of Mind and character may be changed by the Divine Agency. But will this reasoning bear analysis? Can the distinction it assumes be maintained? Whatever difficulties there may be in reconciling the ideas of Law and of Volition, they are difficulties which apply equally to the Worlds of Matter and of Mind. The Mind is as much subject to Law as the Body is. The Reign of Law is over all; and if its dominion be really incompatible with the agency of Volition, Human or Divine, then the Mind is as inaccessible to that agency as material things. It would indeed be absurd to affirm that all Prayers are equally rational or equally legitimate. Most true it is that "we know not what we should pray for as we ought." Prayer does not require us to believe that anything can be done without the use of means; neither does it require us to believe ^that anything will be done in violation of the Universal Order. " If it be possible," was the qualification used in the most solemn Prayer ever uttered upon Earth. What are and what are not legitimate objects of supplication, is a question which may well be open. But the question now raised is a wider one than this—even the question whether the very idea of Prayer be not in itself absurd—whether the- Reign of Law does not preclude the possibility of Will affecting the successive phenomena either of Matter or of Mind. This is a question lying at the root of our whole conceptions of the Universe, and of all our own powers, both of thinking and of acting. The freedom which is denied to God is not likely to be left to Man. We shall see, accordingly, that precisely the same denials are applied to both.

The conception of Natural Laws—of their place, of their nature, and of their office—which involves us in such questions, and which points to such conclusions, demands surely a very careful examination at our hands.

What, then, is this Reign of Law? What is Law, and in what sense can it be said to reign?

Words, which should be the servants of Thought, are too often its masters; and there are very few words which are used more ambiguously, and therefore more injuriously, than the word "Law." It may indeed be legitimately used in several different senses, because in all cases as applied in Science it is a metaphor, and one which has relation to many different kinds and degrees of likeness in the ideas which are compared. It matters little in which of these senses it is used, provided the distinctions between them are kept clearly in view, and provided we watch against the fallacies which must arise when we pass insensibly from one meaning to another. And here it may be observed, in passing, that the metaphors which are employed in Language are generally founded on analogies instinctively, and often unconsciously, perceived, and which would not be so perceived if they were not both deep and true. In this case the idea which lies at the root of Law in all its applications is evident enough. In its primary signification, a " law " is the authoritative expression of human Will enforced by Power. The instincts of mankind finding utterance in their language, have not failed to see that the phenomena of Nature are only really conceivable to us as in like manner the expressions of a Will enforcing itself with Power. But, as in many other cases, the secondary or derivative senses of the word have supplanted the primary signification; and Law is now habitually used by men who deny the analogy on which that use is founded, and to the truth of which it is an abiding witness. It becomes therefore all the more necessary to define the secondary senses with precision. There are at least Five different senses in which Law is habitually used, and these must be carefully distinguished:—

First, We have Law as applied simply to an observed Order of facts.

Secondly, To that Order as involving the action of some Force or Forces of which nothing more may be known.

Thirdly, As applied to individual Forces the measure of whose operation has been more or less denned or ascertained.

Fourthly, As applied to those combinations of Force which have reference to the fulfilment of Purpose, or the discharge of Function.

Fifthly, As applied to Abstract Conceptions of the mind—not corresponding with any actual phenomena, but deduced there-from as axioms of thought necessary to our understanding of them. Law, in this sense, is a reduction of the phenomena, not merely to an Order of facts, but to an Order of Thought.

These great leading significations of the word Law all circle round the three great questions which Science asks of Nature, the What, the How, and the Why:—

(1) What are the facts in their established Order?

(2) How—that is, from what physical causes,—does that Order come to be?

(3) Why have these causes been so combined? What relation do they bear to Purpose, to the fulfilment of intention, to the discharge of Function?

It is so important that these different senses of the word Law should be clearly distinguished, that each of them must be more fully considered by itself.

The First and, so to speak, the lowest sense in which Law is applied to natural phenomena is that in which it is used to express simply " an observed Order of facts "— that is to say, facts which under the same conditions always follow each other in the same order. In this sense the laws of Nature

are simply those facts of Nature which recur according to a rule. It is not necessary to the legitimate application of Law in this sense, that the cause of any observed Order of facts should be at all known, or even guessed at. The Force or Forces to which that Order is due may be hid in total darkness. It is sufficient that the Order or sequence of phenomena be uniform and constant. The neatest and simplest illustration of this, as well as of the other senses in which Law is used, is to be found in the exact sciences, and especially in the history of Astronomy. It is nearly 250 years since Kepler discovered, in respect to the distances, velocities, and orbits of the Planets, three facts, or rather three series of facts, which, during many years1 of intense application to physical inquiry, remained the highest truths known to Man on the phenomena of the Solar System. They were known as the Three Laws of Kepler. It is not necessary to describe in detail here what these laws were. Suffice it to say, that the most remarkable among them were facts of constant numerical relation between the distances of the different Planets from the Sun, and the length of their periodic times; and again, between the velocity of their motion and the space enclosed within certain corresponding sections of their orbit. These Laws were simply and purely an " Order of facts" established by observation, and not connected with any known cause. The Force of which that Order is a necessary result had not then been ascertained. A very large proportion of the laws of every science are laws of this kind and in this sense. For example, in Chemistry the behaviour of different substances towards each other, in respect to combination and affinity, is reduced to system under laws of this kind, and of this kind only. Because, although there is a probability that Electric or Galvanic Force is the cause, or one of the causes, of the series of facts exhibited in chemical phenomena, this is as yet no better than a probability, and the laws of Chemistry stand no higher than facts which by observation and experiment are found to follow certain rules.

i The "Third Law" of Kepler was made known to the world In 1619. Newton's "Principia" appeared in 1687.

But the ascertainment of a law in this First and lower sense leads immediately and instinctively to the research after Law in another sense which is higher. An observed Order of facts, to be entitled to the rank of a Law, must be an Order so constant and uniform as to indicate necessity, and necessity can only arise out of the action of some compelling Force. Law, therefore, comes to indicate not merely an observed Order of facts, but that Order as involving the action of some Force or Forces, of which nothing more may be known than these visible effects. Every observed Order in physical phenomena suggests irresistibly to the mind the operation of some physical cause. We say of an observed Order of facts that it must be due to some " law," meaning simply that all Order involves the idea of some arranging cause, the working of some Force or Forces (whether they be such as we can further trace and define or not) of which that Order is the index and the result. This is the Second of the five senses specified above.

And so we pass on, by an easy and natural transition, to the Third sense in which the word Law is used. This is the most exact and definite of all The mere general idea that some Force is at the bottom of all phenomena, which are invariably consecutive, is a very different thing from knowing what that Force is in respect to the rule or measure of its operation. Of Law in this sense the one great example, before and above all others, is the Law of Gravitation, for this is a Law in the sense not merely of a rule, but of a cause—that is, of a Force accurately defined and ascertained according to the measure of its operation, from which Force other phenomena arise by way of necessary consequence. Force is the root-idea of Law in its scientific sense. And so the Law of Gravitation is not merely the " observed order" in which the heavenly bodies move; neither is it only the abstract idea of some Force to which such movements must be due, but it is that Force the exact measure of whose operation was numerically ascertained or defined by Newton — the Force which compels those-movements and (in a sense) explains them. Now the difference between Law in the narrower and Law in the larger sense cannot be better illustrated than in the difference between the Three special Laws discovered by Kepler, and the One universal Law discovered by

Newton. The Three Laws of Kepler were, as we have seen, simply and purely an observed Order of facts. They stood by themselves —disconnected,—their cause unknown. The higher Law, discovered by Newton, revealed their connexion and their cause. The " observed Order " which Kepler had discovered, was simply a necessary consequence of the Force of Gravitation. In the light of this great Law the "Three Laws of Kepler" have been merged and lost.

When the operations of any material Force can be reduced to rules so definite as those which have been discovered in respect to the Force of Gravitation, and when these rules are capable of mathematical expression and of mathematical proof, they are, so far as they go, in the nature of pure truth. Mr. Lewes, in his very curious and interesting work on the " Philosophy of Aristotle," has maintained that the knowledge of Measure —or what he calls the "verifiable element" in our knowledge—is the element which determines whether any theory belongs to Science, strictly so called, or to Metaphysics; and that any theory may be transferred from Metaphysics to Science, or from Science to Metaphysics, simply by the addition or withdrawal of its " verifiable element." In illustration of this, he says that if we withdraw, from the Law of Universal Attraction, the formula, " inversely as the square of the distance, and directly as the mass," it becomes pure Metaphysics. If this means that, apart from ascertained numerical relations, our conception of Law, or our knowledge of natural phenomena, loses all reality and distinctness, I do not agree in the position. The idea of natural Forces is quite separate from any ascertained measure of their energy. The knowledge, for example, that all the particles of matter exert an attractive force upon each other, is, so far as it goes, true physical knowledge, even though we did not know the further truth, that this force acts according to the numerical rule ascertained by Newton. To banish from physical Science, properly so called, and to relegate to Metaphysics, all knowledge which cannot be reduced to numerical expression, is a dangerous abuse of language.

Force, ascertained according to some measure of its operation—this is indeed one of the definitions, but only one, of a scientific Law. The discovery of laws in this sense is the great quest of Science, and the finding of them is one of her great rewards. Such laws yield to the human mind a peculiar delight, from the satisfaction they afford to those special faculties whose function it is to recognise the beauty of numerical relations. This satisfaction is so great, and in its own measure is so complete, that the mind reposes on an ascertained law of this kind as on an ultimate truth. And ultimate it is as regards the particular faculties which are concerned in this kind of search. When we have observed our facts, and when we have summed up our figures, when we have recognised the constant numbers,—then our eyes, our ears, and our calculating faculties have done their work. But other faculties are called into simultaneous operation, and these have other work to do. For let it be observed that laws, in the first three senses we have now examined, cannot be said to explain anything except the Order of subordinate phenomena. They set forth that order as due to Force. They do nothing more. Least of all do laws, in any of these three senses, explain themselves. They suggest a thousand questions much more curious than the questions which they solve. The very beauty and simplicity of some laws is their deepest mystery. What can their source be? How is their uniformity maintained? Every law implies a Force, and all that we ever know is some numerical rule or measure according to which some unknown Forces operate. But whence come those measures—those exact relations to number, which never vary? Or, if there are variations, how comes it that these are always found to follow some other rules as exact and as invariable as the first?

And as there can be no better example of what Law is, so also there can be no better example of what it is not—than the Law of Gravitation. The discovery of it was probably the highest exercise of pure intellect through which the human mind has found its way. It is the most universal physical law which is known to us, for it prevails, apparently, through all Space. Yet of the Force of Gravitation all we know is, that it is a force of attraction operating between all the particles of matter in the exact measure which was ascertained by Newton,—that is—" directly as the mass, and inversely as the square of the distance." This is the Law. But it affords no sort of explanation of

itself. What is the cause of this Force—what is its source—what are the media of its operation—how is the exact uniformity of its proportions maintained?—these are questions which it is impossible not to ask, but which it is quite as impossible to answer. Sir John Herschel, in speaking of this Force, has indicated in a passing sentence a few questions out of the many which arise:—" No matter," he says, " from what ultimate causes the power called gravitation originates—be it a virtue lodged in the sun as its receptacle, or be it pressure from without, or the resultant of many pressures, or solicitations of unknown kinds, magnetic or electric, ethers or impulses," &c. &c. How little we have ascertained in this Law, after all! Yet there is an immense and an instinctive pleasure in the contemplation of it. To analyse this pleasure is as difficult as to analyse the pleasure which the eye takes in beauty of form, or the pleasure which the ear takes in the harmonies of sound. And this pleasure is inexhaustible, for these laws of number and proportion pervade all Nature, and the intellectual organs which have been fitted to the knowledge of them have eyes which are never satisfied with seeing, and ears which are never full of hearing. The agitation which overpowered Sir Isaac Newton as the Law of Gravitation was rising to his view in the light of rigorous demonstration, was the homage rendered by the great same pleasure in its own degree is felt by every man of science who, in any branch of physical inquiry, traces and detects any lesser law. And it is perfectly true that such laws are being detected everywhere. Forces which are in their essence and their source utterly mysterious, are always being found to operate under rules which have strict reference to measures of number,—to relations of Space and Time. The Forces which determine chemical combination all work under rules as sharp and definite as the Force of Gravitation. So do the Forces which operate in Light, and Heat, and Sound. So do those which exert their energies in Magnetism and Electricity. All the operations of Nature—the smallest and the greatest—are performed under similar measures and restraints. Not even a drop of water can be formed except under rules which determine its weight, its volume, and its shape, with exact reference to the density of the fluid, to the structure of the surface on which it may be formed, and to the pressure of the surrounding atmosphere. Then that pressure is itself exercised under rigorous rules again. Not one of the countless varieties of form which prevail in clouds, and which give to the face of heaven such infinite expression, not one of them but is ruled by Law,—woven, or braided, or torn, or scattered, or gathered up again and folded,—by Forces which are free only " within the bounds of Law."

And equally in those subjects of inquiry in which rules of number and of proportion are not applicable, rules are discernible which belong to another class, but which are as certain and as prevailing. All events, however casual or disconnected they may at first appear to be, are found in the course of time to arrange themselves in some certain Order, the index and exponent of Forces, of which we know nothing except their existence as evidenced in these effects. It is indeed wonderful to find that in such a matter, for example, as the development of our Human Speech, the unconscious changes which arise from time to time among the rudest utterances of the rudest tribes and races of Mankind, are all found to follow rules of progress as regular as those which preside over any of the material growths of Nature. Yet so it is; and it is upon this fact alone that the science of Language rests—a science in which all the facts are not yet observed, and many of those which have been in which enough has been ascertained to show that languages grow, and change from generation to generation, according to rules of which the men who speak them are wholly unconscious. It is the same with all other things. And as it is now, so apparently has it been in all past time of which we have any record. Even the work of Creation has been and is being carried on under rules of adherence to Typical Forms, and under limits of variation from them, which can be dimly seen and traced, although they cannot be denned or understood. The universal prevalence of laws of this kind cannot therefore be denied. The discovery of them is one of the first results of all physical inquiry. In this sense it is true that we, and the world around us, are under the Reign of Law.

It is true, but only a bit and fragment of the truth. For there is another fact quite as prominent as the universal presence and prevalence of laws—and that is, the number of them which are concerned in each single operation in Nature. No one Law—that is to say, no one Force—determines anything that we see happening ' or done around us. It is always the result of different and opposing Forces nicely balanced against each other. The least disturbance of the proportion in which any one of them is allowed to tell, produces a total change in the effect. The more we know of Nature, the more intricate do such combinations appear to be. They can be traced very near to the fountains of Life itself, even close up to the confines of the last secret of all—how the Will acts upon its organs in the Body. Recent investigations in Physiology seem to favour the hypothesis that our muscles are the seat of two opposing Forces, each so adjusted as to counteract the other; and that this antagonism is itself so arranged as to enable us by acting on one of these Forces, to. regulate the action of the other. One Force—an elastic or contractile Force—is supposed to be inherent in the muscular fibre: another Force—that of Animal Electricity in statical condition—holds the contractile Force in check; and the relaxed, or rather the restful, condition of the muscle when not in use, is due to the balance so maintained. When, through the motor nerves the Will orders the muscles into action, that order is enforced by a discharge of the Electrical Force, and upon this discharge the contractile Force is set free to act, and does accordingly produce the contraction which is desired.1

NOTE: This theory of muscular and nervous action is set forth with much ingenuity and force of illustration in " Lectures on Epilepsy," &c., by Charles Bland Radcliffe. M.D.

Such is, at least, one suggestion as to the means employed to place human action under the control of human Will, in that material frame which is so wonderfully and fearfully made. And whether this hypothesis be accurate or not, it is certain that some such adjustment of Force to Mechanism is involved in every bodily movement which is subject to the Will. Even in this high region, therefore, we see that the existence of individual laws is not the end of our physical knowledge. What we always reach at last in the course of every physical inquiry, is the recognition, not of individual laws, but of some definite relation to each other, in which different laws are placed, so as to bring about a particular result. But this is, in other words, the principle of Adjustment, and adjustment has no meaning except as the instrument and the result of Purpose. Force so combined with Force as to produce certain definite and orderly results,—this is the ultimate fact of all discovery.

And so we come upon another sense—the Fourth sense, in which Law is habitually used in Science, and this is perhaps the commonest and most important of all. It is used to designate not merely an observed Order of facts—not merely the bare abstract idea of Force—not merely individual Forces according to ascertained measures of operation—but a number of Forces in the condition of mutual adjustment, that is to say, as combined with each other, and fitted to each other for the attainment of special ends. The whole science of Animal Mechanics, for example, deals with Law in this sense— with natural Forces as related to Purpose and subservient to the discharge of Function. And this is the highest sense of all—Law in this sense being more perfectly intelligible to us than in any other; because, although we know nothing of the real nature of Force, even of that Force which is resident in ourselves, we do know for what ends we exert it, and the principle that governs our devices for its use. That principle is, Combination for the accomplishment of Purpose.

Accordingly it is, when natural phenomena can be reduced to Law, in this last sense, that we reach something which alone is really in the nature of an explanation. For what do we mean by an explanation? It is an unfolding or a " making plain." But as the human mind has many faculties, so each of these seeks a satisfaction of its own. That which is made plain to one faculty is not necessarily made plain to another. That which is a complete answer to the question What, or to the question How, is no answer at all to the question Why. There are some philosophers who tell us that this last is a question which had better never be asked, because it is one to which Nature gives no reply. If this be so, it is strange that Nature should have given us the faculties which impel us to

ask this question—ay. and to ask it more eagerly than any other. It is, indeed, true that there is a point beyond which we need not ask it, because the answer is inaccessible. But this is equally true of the questions What, and How. We cannot reach Final Causes any more than Final Purposes. For every cause which we can detect, there is another cause which lies behind; and for every purpose which we can see, there are other purposes which lie beyond.

And so it is true that all things in Nature may either be regarded as means or as ends—for they are always both—only that Final Ends we can never see. For, as Bishop Butler truly says in his " Analogy," 1 " We know what we ourselves aim at as final ends, and what courses we take merely as means conducing to these ends. But we are greatly ignorant how far things are considered by the Author of Nature under the simple notion of means and ends,—so as that it may be said this is merely an end, and that merely means, in His regard. And whether there be not some peculiar absurdity in our very manner of conception concerning this matter, somewhat contradictory, arising from an extremely imperfect view of things, it is impossible to say." This is indeed a wise caution, and one which has been much needed to check the abuse of that method of reasoning which has been called the doctrine of Final Causes. When Man makes an implement, he knows the purpose for which he makes it—he knows the function assigned to it in his own intention. But as in making it there are a thousand chips and fragments of material which he casts aside, so in its final use it often produces consequences and results which he did not contemplate or foresee. But in Nature all this is different. Nature has no chips or fragments which she does not put to use; and as on the way to her apparent ends there are no incidents which she did not foresee, so beyond those ends there are no ulterior results which do not open out into new firmaments of Design. Of nothing, therefore, can we say with even the probability of truth that we see its Final Cause; that is to say, its ultimate purpose. All that we can ever see are the facts of Adjustment and of Function, and these constitute not Final, but Immediate Purpose. But a purpose is not less a purpose, because other purposes may lie beyond it. And not only can we detect Purpose in natural phenomena, but, as we have already seen, it is very often the only thing about them which is intelligible to us. The How is very often incomprehensible, where the Why is apparent at a glance. And be this observed, that when Purpose is perceived, it is a " making plain " to a higher faculty of the mind than the mere sense of Order. It is a making plain to Reason. It is the reduction of phenomena to that Order of Thought which is the basis of all other Order in the works of Man, and which, he instinctively concludes, is the basis also of all Order in the works of Nature.

And here it is important to observe, that although this general conclusion, like all other general conclusions, belongs to the category of mental inferences, and not to the category of physical facts, yet each particular instance of Purpose on which the general inference is founded, is not an inference merely, but a fact. The function of an organ, for example, is a matter of purely physical investigation. But the function of an organ is not merely that which it does, but it is that which some special construction enables it to do. It is, not merely its work, but it is the work assigned to it as an Apparatus, and as fitted to other organs having other functions related to its own. The nature of that Apparatus, as being in itself an adjustment for a particular purpose, is not an inference from the facts, but it is part of the facts themselves. The very idea of Function is inseparable from the idea of Purpose. The Function of an organ is its Purpose; and the relation of its parts, and of the whole to that Purpose, is as much and as definitely a scientific fact as the relation of any other phenomenon to Space, or Time, or Number.

This distinction between Purpose as a general inference and Purpose as a particular fact, has not been sufficiently observed. The just condemnation pronounced by Bacon on the pursuit of Final Causes as distorting the true Method of Physical Investigation, has been applied without discrimination to two very different conceptions. Even Philosophers who believe in the Supremacy of Purpose in Nature have been willing to banish this conception from the Domain of Science, and to classify it as belonging altogether to Metaphysics or Theology. Thus in the very able Harveian

Oration for 1865 by Dr. H. W. Acland, he says, —"Whether there be any Purpose, is the object of Theological and Metaphysical, but not of Physical inquiry."1 And again, "The evidence of intention is metaphysical, and depends on probabilities. It"is not positive. It is inferential from many considerations."2 I venture to dissent from these conclusions. They involve, I think, a confounding of two separate questions. The nature and character of the intending Mind—this is indeed a question of Theology; but not the existence of intention. Neither in any restrictive sense of the word can it be called Metaphysical. Even as a general doctrine, the doctrine of Contrivance and Adjustment is not so metaphysical as the Doctrine of Homologies; and when we come to particular cases there can be no question whatever that the relation of a given Structure to its Purpose and Function comes more unequivocally under the class of physical facts than the relation of that same Structure to some corresponding part in another animal. It is less ideal, for example,— less theoretical—less metaphysical—to assert of the little hooked claw which is attached to the (apparent) elbow of a Bat's wing, that it was placed there to enable the Bat to climb and crawl, than to affirm of that same claw that it is the " homologue" of the human thumb. Yet who can deny that this doctrine of Homologies has been established as a strictly scientific truth? There is a sense, of course, in which all Knowledge and all Science belongs to Metaphysics. Mere classification, which is the basis of all Science, what is it but the marshalling of physical facts in an Ideal Order—an arrangement of them according to the relation which they bear to the laws of Thought? But this does not constitute as a branch of Metaphysics, the division of animals into Genera, and Families, and Orders. And what relation can physical facts ever have to Thought so directly cognisable or so susceptible of Demonstration as the relation of an animal organ to its purpose and function in the animal economy? Whether Purpose be the basis of all natural Order or not is a separate question. It is at least one of the facts of that Order. Combination for the accomplishment of Purpose therefore in particular cases, such as the relation between the structure of an Organ and its function, is not merely a safe conclusion of Philosophy, but an ascertained fact of Science.1

This question has acquired additional importance since the revival in our own day, and with new resources, of that old philosophy which assumes to banish from the domain of Knowledge no small part of the richest and surest acquisitions of Reason. That Philosophy must' be tested by a rigid analysis of thought and language. This is the weapon with which the assault is made, and it is by the same weapon better handled that it can alone be met. An arbitrary limitation of the word " knowledge," to a particular kind of knowledge, can only be tolerated on condition that the arbitrary nature of the limitation be constantly kept in view. In like manner the word "verification" may be confined to a particular kind of proof applicable only to a particular class of truths. So again, in regard to " Metaphysics," it may be considered with reference to its subject-matter as denoting a particular branch of inquiry—such as Psychology—or as a method of investigation which may be applied equally to all subjects which furnish the mind with the materials of thought. But we must watch against the substitution of one of these meanings for another; and against the jugglery by which men first use Metaphysical Analysis to pull down conceptions which they dislike, and then denounce Metaphysics as incapable of establishing any conclusions on which we can rely. The fact to which I have previously referred,1 is a fact of immense significance, that one of the most able supporters of the Positive Philosophy in England relegates to Metaphysics the great scientific fact of Physical Attraction, when it is considered apart from its numerical relations. But if this be considered Metaphysics, then let it be remembered that many of the most certain truths we know belong to the same category. From a similar point of view, it might be argued, and it has actually been argued, that Number and all numerical relations are purely abstract conceptions of the mind, having no other reality than as there conceived.2 The same reasoning may be applied to all our most fundamental conceptions—without which Science could not even begin her work. The existence of Force under any form, of which the existence of Matter is only a special case, may be regarded as a purely metaphysical conception. It is surely a comfort to find that, if all ideas of Plan and of Design in the Adjustments of Organic Life are to be condemned as Metaphysical, they stand at least in goodly company among the necessities of Thought. Mr. Lewes, indeed, himself confesses

that " Science finds it indispensable to co-ordinate all the facts in a general concept, such as a Plan." But he pronounces it one of the " Infirmities of Thought" to "realize the concept." But no accurate thinker ever " realized" such an idea as a "Plan"—that is to say, no one ever conceived it as existing by itself, separate from an intending Mind. Mr. Lewes complains that " Matter and Force are mysterious enough" without a " new mystery of Architectural Plan, shaping Matter and directing Force." But, substituting here " Mind" for Plan, it may surely be argued that, if Science finds it " indispensable" t7 co-ordinate all the facts in some such general concept, this is of itself a proof that the element so introduced does not add to the mystery, but helps to remove it. Even if it be an "artifice of thought," it can only be resorted to as rendering the facts not less but more conceivable. And this it plainly does by appealing to an agency having known power in the production of analogous phenomena. The instinctive wisdom which lies in this "infirmity" of the mind becomes more apparent when we turn to the efforts of an acute intellect to cast such infirmities away. The most abstract metaphysical conceptions are substituted for those which are denounced: the only difference being that, whilst the old conceptions are intelligible as connecting the Phenomena by a link of thought which the mind can feel and follow, the new conceptions are unintelligible because they try to describe facts without any reference to the ideas they involve. No new light—nothing but denser darkness—is cast on the phenomena of Organic Life by calling " Life the connexus of the organic activities."1 Yet meaningless words are heaped on each other in the desperate effort to dispense with those conceptions which can alone render the order of Nature intelligible to us. Thus we are told again, that " The Organism is the synthesis of diverse parts, and Life is the synthesis of their properties;"2—and again, that " Vitality is the abstract designation of certain special properties manifested by Matter under certain special conditions."3 Surely there is more light in the old reading:—" Finding," says Mr. Lewes, " in an organism a certain adjustment of parts, which may be reduced to a plan, we are easily led to conceive that this plan was made before the parts, and that the adjustment was determined by the plan." No doubt! This is the easiest conception, and it is the easiest because it is most conformable to the laws of Thought; and that which is the most conformable to the laws of Thought is that which makes the nearest approach to absolute Truth attainable by the Mind.

The universal prevalence of this idea of Purpose in Nature is indicated by the irresistible tendency which we observe in the language of Science to personify the Forces, and the combinations of Force by which all natural phenomena are produced. It is a great injustice to scientific men—too often committed—to suspect them of unwillingness to accept the idea of a Personal Creator merely because they try to keep separate the language of Science from the language of Theology.1 But it is curious to observe how this endeavour constantly breaks down—how impossible it is in describing physical phenomena to avoid the phraseology which identifies them with the phenomena of Mind, and is moulded on our own conscious Personality and Will. It is impossible to avoid this language simply because no Other language conveys the impression which innumerable structures leave upon the mind. Take, for example, the word " contrivance." How could Science do without it? How could the great subject of Animal Mechanics be dealt with scientifically without continual reference to Law as that by which, and through which, special organs are formed for the doing of special work? What is the very definition of a machine? Machines do not increase Force, they only adjust it. The very idea and essence of a machine is that it is a contrivance for the distribution of Force with a view

1 A remarkable instance of this injustice has been lately brought to light. Professor Huxley, in an article in the Fortnightly Review, had used one of those vague phrases, so common with scientific men, about the "unknown and the unknowable" being the goal of all scientific thought, which not unnaturally suggest the notion that all idea of a God is unattainable. A writer in the Spectator accordingly dealt with Professor Huxley as avowing Atheism, and was rebuked by the Professor in a letter published in the Spectator of Feb. 10, 1866. Professor Huxley says: "I do not know that I care very much about popular odium, so that there is no great merit in saying that if I really saw fit to

deny the existence of a God, I should certainly do so, for the sake of my own intellectual freedom, and be the honest Atheist you are pleased to say I am. As it happens, however, I cannot take this position with honesty, inasmuch as it is, and always has been, a favourite tenet of mine, that Atheism is as absurd, logically speaking, as Polytheism." On the subject of miracles, in the same letter, Professor Huxley says, that " denying the possibility of miracles seems to me quite as unjustifiable as speculative Atheism." The question of miracles seems now to be admitted on all hands to be simply a question of evidence.

to its bearing on special purposes. A man's arm is a machine in which the law of leverage is supplied to the vital force for the purposes of prehension. We shall see presently that a bird's wing is a machine in which the same law is applied, under the most complicated conditions, for the purpose of flight. Anatomy supplies an infinite number of similar examples. It is impossible to describe or explain the facts we meet with in this or in any other branch of Science without investing the " laws " of Nature with something of that Personality which they do actually reflect, or without conceiving of them as partaking of those attributes of Mind which we everywhere recognise in their .working and results.

We may, again, take the Forces which determine the Planetary motions as the grandest and the simplest illustrations of this truth of Science. Gravitation, as already said, is a Force which prevails apparently through all Space. But it does not prevail alone. It is a Force whose function it is to balance other Forces, of which we know nothing, except this,—that these, again, are needed to balance the Force of Gravitation. Each Force, if left to itself, would be destructive of the Universe. Were it not for the Force of Gravitation, the centrifugal Forces which impel the Planets would fling them off into Space. Were it not for these centrifugal Forces, the Force of Gravitation would dash them against the Sun. The orbits, therefore, of the Planets, with all that depends upon them, are determined by the nice and perfect balance which is maintained between these two Forces; and the ultimate fact of astronomical science is not the Law of Gravitation, but the Adjustment between this law and others which are less known, so as to produce and maintain the existing Solar System. This is one example of the principle of Adjustment; but no one example, however grand the scale may be on which it is exhibited, can give any idea of the extent to which the principle of Adjustment is required, and is adopted in the works of Nature. The revolution of the seasons, for example—seed-time and harvest—depend on the Law of Gravitation in this sense, that if that law were disturbed, or if it were inconstant, they would be disturbed and inconstant also. But the seasons equally depend on a multitude of other laws,—laws of heat, laws of light, laws relating to fluids, and to solids, and to gases, and to magnetic attractions and repulsions, each one of which laws is invariable in itself, but each of which would produce utter confusion if it were allowed to operate alone, or if it were not balanced against others in the right proportion. It is very difficult to form any adequate idea of the vast number of laws which are concerned in producing the most ordinary operations of Nature. Looking only at the combinations with which Astronomy is concerned, the adjustments are almost infinite. Each minutest circumstance in the position, or size, or shape of the Earth, the direction of its axis, the velocity of its motion and of its rotation, has its own definite effect, and the slightest change in any one of these relations would wholly alter the world we live in. And then it is to be remembered that the seasons, as they are now fitted to us, and as we are fitted to them, do not depend only on the facts or the laws which Astronomy reveals. They depend quite as much on other sets of facts, and other sets of laws, revealed by other sciences, —such, for example, as Chemistry, Electricity, and Geology. The motion of the Earth might be exactly what it is, every fact in respect to our Planetary position might remain unchanged, yet the seasons would return in vain if our own atmosphere were altered in any one of the elements of its composition, or if any one of the laws regulating the action were other than it is. Under a thinner air even the torrid zone might be wrapped in eternal snow. Under a denser air, and one with different refracting powers, the Earth and all that is therein might be burnt up. And so it is through the whole of Nature: laws everywhere—laws in themselves invariable, but so worked

as to produce effects of inexhaustible variety by being pitched against each other, and made to hold each other in restraint.

I have already referred to Chemistry as a science full of illustrations of Law in the First and simplest sense— that is, of facts in observed orders of recurrence. But Chemistry is a science not less rich in illustration of Law in the Fourth sense—that is, of Forces in mutual adjustment. Indeed, in Chemistry, this system of adjustment among the different properties of matter is especially intricate and observable. Some of the laws which regulate Chemical Combination were discovered in our own time, and are amongst the most wonderful and the most beautiful which have been revealed by any science. They are laws of great exactness, having invariable relations to number and proportion. Each elementary substance has its own combining proportions with other elements, so that, except in these proportions, no chemical union can take place at all. And when chemical union does take place, the compounds which result have different and even opposite powers, according to the different proportions employed. Then, the relations in which those inorganic compounds stand to the chemistry of Life, constitute another vast series in which the principle of adjustment has applications, infinite in number, and as infinite in beauty. How delicate these relations are, and how tremendous are the issues depending on their management, may be conceived from this single fact,—that the same elements combined in one proportion are sometimes a nutritious food or a grateful stimulant, soothing and sustaining the powers of life; whilst, combined in another proportion, they may be a deadly poison, paralysing the heart and carrying agony along every nerve and fibre of the animal frame. This is no mere theoretical possibility. It is actually the relation, for example, in which two well-known substances stand to each other—Tea and Strychnia. The active principles of these two substances, " Theine" and " Strychnine," are identical so far as their elements are concerned, and differ from each other only in the proportions in which they are combined. Such is the power of numbers in the Laboratory of Nature! What havoc in this world, so full of Life, would be made by blind chance gambling with such powers as these! What confusion, unless they were governed by laws whose certainty makes them capable of fine adjustment, and therefore subject to accurate control! How fine these adjustments are, and how absolute is that control, is indicated in another fact—and that is the few elements out of which all things are made. The number of substances deemed elementary has varied with the advance of Science; but as compared with the variety of their products, that number may be considered as infinitesimally small; whilst the progress of analysis, with glimpses of laws as yet unknown, renders it almost certain that this number will be found to be smaller still. Yet out of that small number of elementary substances, having fixed rules, too, limiting their combination, all the infinite varieties of organic and inorganic matter are built up by means of nice adjustment. As all the faculties of a powerful mind can utter their voice in language whose elements are reducible to twenty-four letters, so all the forms of Nature, with all the ideas they express, are worked out from a few simple elements having a few simple properties.

Simple! can we call them so? Yes, simple by comparison with the exceeding complication of the uses they are made to serve: simple also, in this sense, that they follow some simple rule of numbers. But in themselves these laws, these forces are incomprehensible. That which is most remarkable about them is their unchangeableness. The whole mind and imagination of scientific men is often so impressed with this character of material laws, that no room is left for the perception of other aspects of their nature and of their work. We hear of rigid and universal sequence—necessary—invariable;— of unbroken chains of cause and effect, no link of which can, in the nature of things, be ever broken. And this idea grows upon the mind, until in some confused manner it is held as casting out the idea of Purpose in creation, and inconsistent with the element of Will. If it be so, the difficulty cannot be evaded by denying the uniformity, any more than the universality, of Law. It is perfectly true that every law is, in its own nature, invariable, producing always precisely and necessarily the same effects,—that is, provided it is worked under the same conditions. But then, if the conditions are not the same, the invariableness of effect gives place to

capacities of change which are almost infinite. It is by altering the conditions under which any given law is brought to bear, and by bringing other laws to operate upon the same subject, that our own Wills exercise a large and increasing power over the material world. And be it observed—to this end the uniformity of laws is no impediment, but, on the contrary, it is an indispensable condition. Laws are in themselves—if not unchangeable—at least unchanging, and if they were not unchanging, they could not be used as the instruments of Will. If they were less rigorous they would be less certain, and the least uncertainty would render them incapable of any service. No adjustment, however nice, could secure its purpose if the implements employed were of uncertain temper.

The notion therefore that the uniformity or invariableness of the Laws of Nature cannot be reconciled with their subordination to the exercise of Will, is a notion contrary to our own experience. It is a confusion of thought arising very much out of the ambiguity of language. For let it be observed that, of all the senses in which the word Law is used, there is only one in which it is true that laws are immutable or invariable; and that is the sense in which Law is used to designate an individual Force. Gravitation, for example, is immutable in this respect—that (so far as we know) it never operates according to any other measure than " directly as the mass, and inversely as the square of the distance." But in all the other senses in which the word Law is used, laws are not immutable; but, on the contrary, they are the great instruments, the unceasing agencies, of change. When, therefore, scientific men speak, as they often do, of all phenomena being governed by invariable laws, they use language which is ambiguous, and in most cases they use it in a sense which covers an erroneous idea of the facts. There are no phenomena visible to Man of which it is true to say that they are governed by any invariable Force. That which does govern them is always some variable combinations of invariable forces. But this, makes all the difference in reasoning on the relation of Will to Law,—this is the one essential distinction to be admitted and observed. There is no observed Order of facts which is not due to a combination of Forces; and there is no combination of Forces which is invariable—none which are not capable of change in infinite degrees. In these senses—and these are the common senses in which Law is used to express the phenomena of Nature—Law is not rigid, it is not immutable, it is not invariable, but it is, on the contrary, pliable, subtle, various. In the only sense in which laws are immutable, this immutability is the very characteristic which makes them subject to guidance through endless cycles of design. We know this in our own case. It is the very certainty and in variableness of the laws of Nature which alone enables us to use them, and to yoke them to our service.

Now, the laws of Nature appear to be employed in the system of Nature in a manner precisely analogous to that in which we ourselves employ them. The difficulties and obstructions which are presented by one law in the way of accomplishing a given purpose, are met and overcome exactly on the same principle on which they are met and overcome by Man—viz., by knowledge of other laws, and by resource in applying them,—that is, by ingenuity in mechanical contrivance. It cannot be too much insisted on, that this is a conclusion of pure Science. The relation which an organic structure bears to its purpose in Nature can be recognised as certainly as the same relation between a machine and its purpose in human art. It is absurd to maintain, for example, that the purpose of the cellular arrangement of material in combining lightness with strength, is a purpose legitimately cognisable by Science in the Menai Bridge, but is not as legitimately cognisable when it is seen in Nature, actually serving the same use. The little Barnacles which crust the rocks at low tide, and which to live there at all must be able to resist the surf, have the building of their shells constructed strictly with reference to this necessity. It is a structure all hollowed and chambered on the plan which engineers have so lately discovered as an arrangement of material by which the power of resisting strain or pressure is multiplied in an extraordinary degree. That shell is as pure a bit of mechanics as the bridge, both being structures in which the same arrangement is adapted to the same end.

" Small, but a work divine;

Frail, but of force to withstand,
Year upon year, the shock
Of cataract seas that snap
The three-decker's oaken spine."l
Owen's "Lectures on Comp. Anat" vol. ii. (Fishes).

This is but one instance out of a number which no man can count. So far as we know, no Law—that is, no elementary Force—of Nature is liable to change. But every Law of Nature is liable to counteraction; and the rule is, that laws are habitually made to counteract each other in precisely the manner and degree which some definite result requires.

Nor is it less remarkable that the converse of this is true: no Purpose is ever attained in Nature, except by the enlistment of Laws as the means and instruments of attainment. When an extraordinary result is aimed at, it often happens that some common law is yoked to extraordinary conditions, and its action is intensified by some special machinery. For example, the Forces of Electricity are in action, probably, in all living Organisms, but certainly in the muscular and nervous system of the higher animals. In a very few (so far as yet known, in only a very few animals among the millions which exist, and these all belonging to the Class of Fishes), the electrical action has been so stored and concentrated as to render it serviceable as a weapon of offence. Creatures which grovel at the bottom of the sea, or in the slime of rivers, have been gifted with the astonishing faculty of wielding at their will the most subtle of all the powers of Nature. They have the faculty of" shooting out lightning" against their enemies or their prey. But this gift has not been given without an exact fulfilment of all the laws which govern Electricity, and which especially govern its concentration and destructive force. The Electric Ray, or Torpedo, has been provided with a Battery closely resembling, but greatly exceeding in the beauty and compactness of its structure, the Batteries whereby Man has now learned to make the laws of Electricity subservient to his will. There are no less than 940 hexagonal columns in this Battery like those of a bees' comb, and each of these is subdivided by a series of horizontal plates, which appear to be analogous to the plates of the Voltaic Pile. The whole is supplied with an enormous amount of nervous matter, four great branches of which are as large as the animal's spinal cord, and these spread out in a multitude of thread-like filaments round the prismatic columns, and finally pass into all the cells.1 This, again, seems to suggest an analogy with the arrangement by which an electric current, passing through a coil and round a magnet, is used to intensify the magnetic force. A complete knowledge of all the mysteries which have been gradually unfolded from the days of Galvani to those of Faraday, and of many others which are still inscrutable to us, is exhibited in this structure. The laws which are appealed to in the accomplishment of this purpose are many and very complicated; because the conditions to be satisfied refer not merely to the generation of Electric force in the animal to which it is given, but to its effect on the nervous system of the animals against which it is to be employed, and to the conducting medium in which both are moving.

When we contemplate such a structure as this, the idea is borne in with force upon the mind, that the need of conforming to definite conditions seems as absolute a necessity in, making an Electric Fish as in making an Electric Telegraph. But the fact of these conditions existing, and requiring to be satisfied,—or, in other words, the fact of so many natural laws demanding a first obedience,—is not the ultimate fact, it is not even the main fact, which Science apprehends in such phenomena as these. On the contrary, that which is most observable and most certain, is the manner in which these conditions are met, complied with, and, by being complied with, are overcome. But this is, in other words, the subordination of many laws to a difficult and curious Purpose,—a subordination which is effected through the instrumentality of a purely mechanical contrivance.

It is no objection to this universal truth, that the machines thus employed in Nature are themselves constructed through the agency of Law. They grow—or, in modem phraseology, they are developed.

But this makes no difference in the case—or, rather, it only carries us farther back to other and yet other illustrations of the same truth. This is precisely one of those cases already referred to, in which Causes are unknown, whilst Purposes are clear and certain. The Battery of an Electric Fish is both a means and an end. As respects the electric laws which it puts in motion—that is, as respects the Force which it concentrates—it must be regarded as a means. As respects the organic laws by which it is itself developed, it is an end.

What we do know in this case is why the apparatus was made; that is to say, what we do know is the Purpose. What we do not know, and have no idea of, is how it was made; that is to say, what we do not know is the Law, the Force or Forces, which have been used as the instrument of that Purpose. When Man makes a voltaic Battery, he selects materials which have properties and relations with each other previously ascertained—metals worked out of natural ores, acids distilled out of other natural substances; and he puts these together in such fashion as he knows will generate the mysterious Force which he desires to evoke and to employ. But how can such a machine be made out of the tissues of a fish? Well may Mr. Darwin say, " It is impossible to conceive by what steps these wondrous organs have been produced." J We see the Purpose—that a special apparatus should be prepared, and we see that it is effected by the production of the machine required; but we have not the remotest notion of the means employed. Yet we can see so much as this, that here again other laws, belonging altogether to another department of Nature— laws of organic growth—are made subservient to a very definite and very peculiar Purpose. The paramount facts disclosed by Science, however, in this case, are these:— first, the adaptation of the animal tissues to form a battery; and, secondly, the Purpose or function of the apparatus, when made, to discharge electric shocks.

NOTE: "Origin of Species," p. 192, 1st edition.

There is indeed one objection to this method of conception, which would be a fatal objection if it could be consistently maintained. But all the strength of this objection lies in the obscure terrors which a very long word is sometimes capable of inspiring. This word is "Anthropomorphism." Purpose and Design, it is said, is a human conception. Unquestionably it is, and so is all knowledge in every form. We can never stand outside ourselves. We can never get behind or above our own methods of conception. The human mind can know nothing, and can think of nothing except in terms of its own capacities of thought. But if this be fatal to our knowledge of any of the meanings in creation, it must be equally fatal to our having any knowledge of the very existence of a Creator. Once, grant it to be true, " that if we are to apply our human standard to the Creator in one direction, we must apply it in all,"—then it will follow that we cannot conceive any Creator unless it be one as weak, and as corrupt, and as ignorant as ourselves. If this be not bad logic, as on the face of it it clearly is, then it is not " Theology" alone which goes by the board. The purest and most naked Theism is equally destroyed. If it can be said with truth that " the Universal Mind is essentially other than the Human Mind," l so that no recognisable relations can exist between them, then that Universal Mind is to us as if it were not. But those who take objection to Anthropomorphism, are not generally prepared to follow it to this extreme conclusion. Mr. Lewes speaks of the sceptical philosophy he supports as "rejecting Atheism"—of Atheism being "an error which it has not maintained,"—of Atheism being not only rash, but "contradictory."2 But every conception of a " Mind," even though it be described as " Universal," must be in some degree Anthropomorphic. Our minds can think of another mind only as having some powers and properties which in kind are common with our own. Nor is this objection avoided by any of the other methods of conception which are devised to eliminate from the Order of Nature one of the most patent of its facts. The idea of natural forces working "by themselves " is pre-eminently Anthropomorphic. This is undoubtedly the way in which they seem to us to work when we employ them. The idea of those forces having been so co-ordinated at the first as to produce " necessarily " and " by themselves " all the phenomena of Nature— this is an idea essentially formed on those higher

efforts of human ingenuity in virtue of which "self-acting" machines are made. It is quite true, no doubt, that this is one aspect in which the adjustments and contrivances in Nature present themselves to us. But it does not render this idea more Anthropomorphic, but rather less when we add to it other conceptions—such as the idea of a Mind which is the source of all power, and a Will which is present in all effects. There may be other difficulties in the way of this conception, but not the difficulty of Anthropomorphism. From neither of these conceptions, however, can we eliminate the idea of Purpose and Design.

It is very difficult to divest ourselves of the notion, that whatever happens by way of natural consequence is thereby removed, at least by one degree, from being the expression of Will and the effect of Purpose. We forget that all our own works, not less than the works of Nature, are works done through the means and instrumentality of Law. All that we can effect is brought about by way of natural consequence. All our machines are simply contrivances for bringing natural Forces into operation; and these machines themselves we are able to construct only out of the materials and by application of the laws of Nature. The Steam-engine works by way of natural consequence; so does Mr. Babbage's Calculating Machine; so does the Electric Telegraph; so does the Solar System. It is true, indeed, that in all human machinery we know by the evidence of sight the ultimate agency to which the machinery is due, whereas in the machinery of Nature the ultimate agency is concealed from sight. But it is the very business and work of Science to rise from the Visible to the Invisible—from what we observe by Sense to what we know by Reason.

And this brings us to the Fifth meaning in which the word Law is habitually used in Science,—a meaning which is indeed well deserving of attention. In this sense, Law is used to designate, not any observed Order of facts,—not any Force to which such Order may be due,—neither yet any combination of Force adjusted to the discharge of function, but—some purely Abstract Idea, which carries up to a higher point our conception of what the phenomena are and of what they do. There may be no phenomena actually corresponding to such Idea, and yet a clear conception of it may be essential to a right understanding of all the phenomena around us. A good example of Law in this sense is to be found in the law which, in the Science of Mechanics, is called the First Law of Motion. The law is, that all Motion is in itself (that is to say, except as affected by extraneous Forces) uniform in velocity, and rectilinear in direction. Thus according to this law a body moving, and not subject to any extraneous Force, would go on moving for ever at the same rate of velocity, and in an exactly straight line.

Now, there is no such motion as this existing on the earth or in the heavens. It is an Abstract Idea of Motion which no man has ever, or can ever, see exemplified. Yet a clear apprehension of this Abstract Idea was necessary to a right understanding and to the true explanation of all the motions which are actually seen. It was long before this idea was arrived at; and for want of it, the efforts of Science to explain the visible phenomena of Motion were always taking a wrong direction. There was a real difficulty in conceiving it, because not only is there no such motion in Nature, but there is no possibility by artificial means of producing it. It is impossible to release any moving body from the impulses of extraneous Force. The First Law of Motion is therefore a purely Abstract Idea. It represents a Rule which never operates as we conceive it, by itself, but is always complicated with other Rules which produce a corresponding complication in result. Like many other laws of the same class, it was discovered, not by looking outwards, but by looking inwards; not by observing, but by thinking. The human mind, in the exercise of its own faculties and powers, sometimes by careful reasoning, sometimes by the intuitions of genius unconscious of any process, is able, from time to time, to reach now one, now another, of those purely Intellectual Conceptions which are the basis of all that is intelligible to us in the Order of the Material World. We look for an ideal order or simplicity in material Law; and the very possibility of exact Science depends upon the fact that such ideal order does actually prevail, and is related to the abstract conceptions of our own intellectual nature. It is in this way that many of the greatest discoveries of Science have been

made. Especially have the great pioneers in new paths of discovery been led to the opening of those paths by that fine sense for abstract truths which is the noblest gift of genius. Copernicus, Kepler, and Galileo were all guided in their profound interpretations of visible phenomena by those intuitions which arise in minds finely organised, brought into close relations with the mind of Nature, and highly trained in the exercise of speculative thought. They guessed the truth before they proved it to be true; and those guesses had their origin in Abstract Ideas of the mind which turned out to be ideas really embodied in the Order of the Universe. So constantly has this recurred in the history of Science, that, as Dr. Whewell says, it is not to be considered as an exception, but as the rule.

NOTE: Whewell's " History of the Inductive Sciences," 2nd edition, vol i. p. 434. Speaking of Copernicus, Dr. Whewell says, in another place: "It is manifest that in this, as in other cases of discovery, a clear and steady possession of abstract Ideas, and an aptitude in comprehending real Facts under these general conceptions, must have been leading characters in the Discoverer's mind." —Vol. i. p. 389.

Here again it is very instructive to observe how "Law" in this last sense is dealt with by the Positive Philosophy. Scientific men are accustomed to reckon such Laws as the First Law of Motion among the surest possessions of pure Intellect, and the faculty by which they are conceived among the noblest proofs of its energy and power. Positivism, on the contrary, regards such laws as mere " artifices " of thought, and the Power by which they are conceived not as a Strength, but as an " Infirmity" of Mind.

NOTE: " Science is distinguished from common knowledge by its conscious employment of artifices which our infirmity renders indispensable." Again, " Abstraction is one of the necessary (from infirmity) artifices of research."—Lewes' " Prologue," p. lxxxix.

I do not deny that the process by which these Abstractions are attained is a metaphysical process,—that is to say, they are purely mental conceptions. But the process which denies " reality" to these conceptions is also purely a metaphysical process, with this only difference, that it is bad metaphysics instead of good. The analysis which evolves these abstract Laws out of the phenomena of Nature is an analysis which truly coordinates the order of those phenomena with an Order of Thought. The counter Analysis which pronounces them to be mere artifices of Thought, and " preliminary falsifications of fact," is an attempt to make Reason disbelieve herself, and immerses us at once in the worst kind of Metaphysics—that which has made the name almost opprobrious—even the old Scholastic subtleties of the Nominalistic and the Realistic controversy.

And now having traced the various senses in which Law is used, we can form some estimate on the value of those conclusions of which some men are so boastful and of which other men are so much afraid. We can see how much and how little is really meant when it is said that Law can be traced in all things, and all things can be traced to Law. It is a great mistake to suppose that, in establishing this conclusion, the progress of modern investigation is in a direction tending to Materialism. This may be and always has been the tendency of individual minds. There are men who would stare into the very Burning Bush without a thought that the ground on which they stand must be Holy Ground. It is not now of wood or stone that men make their Idols, but of their own abstract conceptions. Before these, borrowing for them the attributes of Personality, they bow down and worship. Nothing is more common than to find men who may be trusted thoroughly on the facts of their own Science, who cannot be trusted for a moment on the place which those facts assume in the general system of truth. Philosophy must include Science; but Science does not necessarily include Philosophy. There are, and there always have been, some special misconceptions connected with the prosecution of physical research. It is, however, or; the surface of things, rather than below it, that the suggestions of Materialism lie thickest to the eye. They abound among the

commonest facts which obtrude themselves .on our attention in Nature and in human life. When the bursting of some small duct of blood upon the Brain is seen to destroy in a moment the Mind of Man, and to break down all the powers of his Intellect and his Will,' we are in presence of a fact whose significance cannot be increased by a million of other facts analogous in kind.

Yet on every fresh discovery of a few more such facts, there is generally some fresh outbreak of old delusions respecting the forms and the Laws of Matter as the supreme realities of the world. But when the new facts have been looked at a little longer, it is always seen that they take their place with others which have been long familiar, and the eternal problems which lie behind all natural phenomena are seen to be unaffected and unchanged. Like the most distant of the Fixed Stars, they have no parallax. The whole orbit of human knowledge shows in them no apparent change of place. No amount of knowledge of the kind which alone physical Science can impart can do more than widen the foundation of intelligent spiritual beliefs. We think that Astronomy and Geology have given to us in these latter days ideas wholly new in respect to Space and Time. Yet, after all, can we express those ideas, or can we indicate the questions they suggest, in any language which approaches in power to the majestic utterances of David and of Job? We know more tharj they knew of the magnitude of the Heavenly Bodies; but what more can we say than they said of the wonder of them,—of Orion, of Arcturus, and the Pleiades P1 We know that the earth moves, which they did not know; and we know that the rapid rotation of a globe on its own axis is a means of maintaining the steadiness of that axis in its course through Space. But what effect, except that of increasing its significance, has this knowledge upon the praise which David ascribes to that ultimate Agency which has made the round world so sure " that it cannot be moved?"2

And so of other departments of Science. Even the modern idea of Law, of the constancy and therefore the trustworthiness of Natural Forces, has been known, not indeed scientifically but instinctively, to Man since first he made a Tool, and used it as the instrument of Purpose. What has Science added to this idea, except that the same rule prevails as widely as the Universe, and is made subservient in a like manner to Knowledge and to Will? In the enthusiasm awakened by the discovery of some new facts, or of some new forces, and in the freshness with which they impress the idea of such agencies on our minds, we sometimes very naturally exaggerate the length of way along which they carry us towards the great ultimate objects of intellectual desire. We forget altogether that the knowledge they convey is in quality and in kind identical with knowledge already long in our possession, and places us in no new relation whatever to the vast background of the Eternal and the Unseen. Thus it is that the notions of Materialism are perpetually reviving, and are again being perpetually swept away—swept away partly before the Intuitions of the Mind, partly before the Conclusions of the Reason. For there are two great enemies to Materialism,—one rooted in the Affections, the other in the Intellect. One is the power of Things Hoped For—a power which never dies: the other is the evidence of Things Not Seen—and this evidence abounds in all we see. In reinforcing this evidence, and in adding to it, Science Is doing boundless work in the present day. It is not the extent of our knowledge, but rather the limits of it, that physical research teaches us to see and feel the most. Of course, in so far as its discoveries are really true, its influence must be for good. To doubt this were to doubt that all truth is true, and that all truth is God's.

There are eddies in every stream—eddies where rubbish will collect, and circle for a time. But the ultimate bearing of scientific truth cannot be mistaken. Nothing is more remarkable in the present state of physical research than what may be called the transcendental character of its results. And what is transcendentalism but the tendency to trace up all things to the relation in which they stand to abstract Ideas? And what is this but to bring all physical phenomena nearer and nearer into relation with the phenomena of Mind? The old speculations of Philosophy which cut the ground from Materialism by showing how little we know of Matter, are now being daily reinforced by the subtle analysis of the Physiologist, the Chemist, and the Electrician. Under that analysis Matter dissolves

and disappears, surviving only as the phenomena of Force; which again is seen converging along all its lines to some common centre—"sloping through darkness up to God."1

Even the writers who have incurred most reasonable suspicion as to the drift of their teaching, give nevertheless constant witness to what may be called the purely mental quality of the ultimate results of physical inquiry. It has been said with perfect truth that " the fundamental ideas of modern Science are as transcendental as any of the axioms in ancient philosophy.1 We have seen that one of the senses in which Law is habitually used is to designate abstract ideas and doctrines of this kind. So far from these doctrines and ideas having a tendency to Materialism, they serve rather to bring inside the strict domain of Science ideas which in the earlier stages of human knowledge lay wholly within the region of Faith or of Belief. For example, the writer of the Epistle to the Hebrews specially declares that it is by Faith that we understand " that the things which are seen were not made of the things which do appear." Yet this is now one of the most assured doctrines of Science,—that invisible Forces are behind and above all visible phenomena, moulding them in forms of infinite variety, of all which forms the only real knowledge we possess lies in our perception of the Ideas they express—of their beauty, or of their fitness,—in short, of their being all the work of " Toil co-operant to an End."

Every natural Force which we call a law is itself invisible—the idea of it in the mind arising by way of necessary inference out of an observed Order of facts. And very often, if not always, in our conception of these Forces, we are investing them with the attributes of Intelligence and of Will at the very moment, perhaps, r/hen we are stumbling over the difficulty of seeing in them the exponents of a Mind which is intelligent and of a Will which is Supreme. The deeper we go in Science, the more certain it becomes that all the realities of Nature are in the region of the Invisible, so that the saying is literally, and not merely figuratively true, that the things which are seen are temporal, and it is only the things which are not seen that are eternal. For example, we never see the phenomena of Life dissociated from Organisation. Yet the profoundest physiologists have come to the conclusion that Organisation is not the cause of Life, but, on the contrary, that Life is the cause of Organisation,—Life being something—a Force of some kind, by whatever name we may call it—which precedes Organisation, and fashions it, and builds it up. This was the conclusion come to by the great anatomist Hunter, and it is the conclusion endorsed in our own day by such men as Dr. Carpenter and Professor Huxley,—men neither of whom have exhibited in their philosophy any undue bias towards either theological or metaphysical explanations. One illustration referred to by these writers is derived from the shells—the beautiful shells—of the animals called the " Foraminifera." No Forms in Nature are more exquisite. Yet they are the work and the abode of animals which are mere blobs of jelly—without parts, without organs—absolutely without visible structure of any kind. In this jelly, nevertheless, there works a "vital Force" capable of building up an Organism of most complicated and perfect symmetry.

But what is a vital Force? It is something which we cannot see, but of whose existence we are as certain as we are of its visible effects—nay, which our reason* tells us precedes and is superior to these. We often speak of Material Forces as if we could identify any kind of Force with Matter. But this is only one of the many ambiguities of language. All that we mean ' by a Material Force is a force which acts upon Mattel, and produces in Matter its own appropriate effects. We must go a step further therefore and ask ourselves, What is Force? What is our conception of it? What idea can we form, for example, of the real nature of that Force, the measure of whose operation has been so exactly ascertained—the Force of Gravitation? It is invisible—imponderable—all our words for it are but circumlocutions to express its phenomena or effects.

There are many kinds of force in Nature—which we distinguish after the same fashion—according to their effects or according to the forms of Matter in which they become cognisable to us. But if we trace all our conceptions on the nature of Force to their fountain-head, we shall find that they are

formed on our own consciousness of Living Effort—of that force which has its seat in our own vitality, and especially on that kind of it which can be called forth at the bidding of the Will. In saying this I do not mean to borrow from that false philosophy which pretends by the exercise of reason to get behind all the intuitive convictions on which reason rests. It is in this way that men have come to argue on what they call the " reality of an external world." Even if there were no process of reasoning capable of defending that reality, this would not lend a reasonable character to doubts regarding it. Reason must start from some postulate—some primary truths which cannot be denied. But we need not assume the reality of an external world to be one of these. Yet if it be not a first step, it is a second step hardly distinguishable from the first. Self-existence is of course the truth which may be regarded as the first of all, but in the very idea of Self the existence of that which is Not-Self is necessarily involved. In connecting, however, our conceptions of Force with the consciousness of Living Effort in ourselves, we must guard against mistaking analogy for identity, and against confounding together two items of knowledge which are quite distinct . Correlative with the consciousness of Living Effort in ourselves, and inseparable from it, there is the consciousness of Force acting on us, as well as acting in us. And this argument applies equally whether Self be regarded as a perceiving Mind, or as a physical Organism through which Mind perceives. Thus the knowledge of an external world—that is to say, the knowledge of external Force—stands side by side with the knowledge of Self. Nothing can be known except as distinguished from other things; and all things which are distinguishable from each other, are, in a sense, and in the measure of that distinction, known. And so we know the existence both of internal and of external Force. But if we come to ask ourselves farther questions, as to the nature and seat of Material Force, we can only think of it in the terms of the Vital Force exerted by ourselves. If we can ever know anything of the nature of any Force, it ought to be of this one. And yet the fact is that we know nothing. If, then, we know nothing of that kind of Force which is so near to us, and with which our own Intelligence is in such close alliance, much less can we know the ultimate nature of Force in its other forms.

It is important to dwell on this, because both the aversion with which some men regard the idea of the Reign of Law, and the triumph with which some others hail it, are founded on a notion that, when we have traced any given phenomena to what are called Natural Forces, we have traced them farther than we really have. We know nothing of the ultimate nature, or of the ultimate seat of Force. Science, in the modern doctrine of the Conservation of Energy, and the Convertibility of Forces, is already getting something like a firm hold of the idea that all kinds of Force are but forms or manifestations of some one Central Force issuing from some one Fountain-head of Power. Sir John Herschel has not hesitated to say, that " it is but reasonable to regard the Force of Gravitation as the direct or indirect result of a Consciousness or a Will existing somewhere." And even if we cannot certainly identify Force in all its forms with the direct energies of One Omnipresent and all pervading Will, it is at least in the highest degree unphilosophical to assume the contrary—to speak or to think as if the Forces of Nature were either independent of, or even separate from, the Creator's Power.

It follows, then, from these considerations, that whatever difficulty there may be in conceiving of a Will not exercised by a visible Person, it is a difficulty which cannot be evaded by arresting our conceptions at the point at which they have arrived in forming the idea of Laws or Forces. That idea is itself made up out of elements derived from our own consciousness of Personality. This fact is seen by men who do not see the interpretation of it. They denounce as a superstition the idea of any Personal Will separable from the Forces which work in Nature. They say that this idea is a mere projection of our own Personality into the world beyond—the shadow of our own Form cast upon the ground on which we look. And indeed this, in a sense, is true. It is perfectly true that the Mind does recognise in Nature a reflection of itself. But if this be a deception, it is a deception which is not avoided by transferring the idea of Personality to the abstract Idea of Force, or by investing combinations of Force with the attributes of Mind.

We need not be jealous, then, when new domains are claimed as under the Reign of Law—an agency through which we see working everywhere some Purpose of the Everlasting Will. There are many things in Nature of which we do not see the reason; and many other things of which we cannot find out the cause; but there are none from which we exclude the idea of Purpose by success in discovering the cause. It has been said, with perfect truth, by a living naturalist who is of all others most opposed to what he calls Theological explanations in Science, that we may just as well speak of a watch as the abode of a " watch-force," as speak of the organisation of an animal as the abode of a " vital Force." l The analogy is precise and accurate. The Forces by which a watch moves are natural Forces. It is the relation of interdependence in which those Forces are placed to each other, or, in other words, the adjustment of them to a particular Purpose, which constitutes the " watch-force;" and the seat of this Force—which is in fact no one Force, but a combination of many Forces—is in the Intelligence which conceived that combination, and in the Will which gave it effect. The mechanisms devised by Man are in this respect only an image of the more perfect mechanism of Nature, in which the same principle of Adjustment is always the highest result which Science can ascertain or recognise. There is this difference, indeed,—that in regard to our works we see that our knowledge of natural laws is very imperfect, and our control over them is very feeble; whereas in the machinery of Nature there is evidence of complete knowledge and of absolute control. The universal rule is, that everything is brought about by way of Natural Consequence. But another rule is, that all natural consequences meet and fit into each other in endless circles of Harmony and of Purpose. And this can only be explained by the fact that what we call Natural Consequence is always the conjoint effect of an infinite number of elementary Forces, whose action and reaction are under direction of the Will which we see obeyed, and of the Purposes which we see actually attained.

It is, indeed, the completeness of the analogy between our own works on a small scale, and the works of the Creator on an infinitely large scale, which is the greatest mystery of all. Man is under constraint to adopt the principle of Adjustment, because the Forces of Nature are external to and independent of his Will. They may be managed, but they cannot be disobeyed. It is impossible to suppose that they stand in the same relation to the Will of the Supreme; yet it seems as if He took the same method of dealing with them —never violating them, never breaking them, but always ruling them by that which we call Adjustment or Contrivance. Nothing gives us such an idea of. the immutability of Laws as this! nor does anything give us such an idea of their pliability to use. How imperious they are, yet how submissive I How they reign, yet how they serve!

Chapter III - Contrivance A Necessity Arising Out Of The Reign Of Law—Example In The Machinery Of Flight

THE necessity of Contrivance for the accomplishment of Purpose arises out of the immutability of Natural Forces. They must be conformed to, and obeyed. Therefore, where they do not serve our purpose directly, they can only be made to serve it by ingenuity and contrivance. This necessity, then, may be said .to be the index and the measure of the power of Law. And so, on the other hand, the certainty with which Purpose can be accomplished by Contrivance, is the index and the measure of mental knowledge and resource. It is by wisdom and knowledge that the Forces of Nature—even those which may seem most adverse— are yoked to service. This idea of the relation in which Law stands to Will, and in which Will stands to Law, is familiar to us in the works of Man: but it is less familiar to us as equally holding good in the works of Nature. We feel, sometimes, as if it were an unworthy notion of the Will which works in Nature, to suppose that it should never act except through the use of means. But our notions of unworthiness are themselves often the unworthiest of all. They must be ruled and disciplined by observation of that which is,—not founded on ct priori conceptions of what ought to be. Nothing is more certain than that the whole Order of Nature is one vast system of Contrivance. And what is Contrivance but that kind of arrangement by

which the unchangeable demands of Law are met and satisfied? It may be that all natural Forces are resolvable into some One Force; and indeed in'the modern doctrine of the Correlation of Forces, an idea which is a near approach to this, has already entered the domain of Science. It may also be that this One Force, into which all others return again, is itself but a mode of action of the Divine Will. But we have no instruments whereby to reach this last analysis. Whatever the ultimate relation may be between mental and material Force, we can at least see clearly this,—that in Nature there is the most elaborate machinery to accomplish Purpose through the instrumentality ofi, means. It seems as if all that is done in Nature as well as all that is done in art, were done by knowing how to do it. It is curious how the language of the great Seers of the Old Testament corresponds with this idea. They uniformly ascribe all the operations of Nature—the greatest and the smallest—to the working of Divine Power. But they never revolt—as so many do in these weaker days—from the idea of this Power working by wisdom and knowledge in the use of means; nor, in this point of view, do they ever separate between the work of first Creation, and the work which is going on daily in the existing world. Exactly the same language is applied to the rarest exertions of power, and to the gentlest and most constant of all natural operations. Thus the saying that " The Lord by wisdom hath founded the Earth; by understanding hath He established the Heavens,"—is coupled in the same breath with this other saying, " By His knowledge the depths are broken up, and the clouds drop down the dew." (1 Prov. iii. 19, 20)

Every instance of Contrivance which we can thoroughly follow and understand, has an intense interest—as casting light upon this method of the Divine government, and upon the analogy between the operations of our own minds and the operations of the Creator. Some instances will strike us more than others—and those will strike us most which stand in some near comparison with our own human efforts of ingenuity and contrivance. There is one such instance which I propose to consider in this chapter—the machinery by which a great purpose has been accomplished in Nature—a purpose which Man has never been able to accomplish in art, and that is the Navigation of the Air. No more beautiful example can be found, even in the wide and rich domain of Animal Mechanics—none in which we can trace more clearly, too, the mode and method in which laws the most rigorous and exact are used as the supple instruments of Purpose.

"The way of an Eagle in the air" was one of the things of which Solomon said, that "he knew it not." No wonder that the Wise King reckoned it among the great mysteries of Nature! The Force of Gravitation, though its exact measure was not ascertained till the days of Newton, has been the most familiar of all Forces in all ages of Mankind. How, then, in violation of its known effects, could heavy bodies be supported upon the thin air—and be gifted with the power of sustaining and directing movements more easy, more rapid, and more certain than the movements of other animals upon the firm and solid earth? No animal motion in Nature is so striking or so beautiful as the

Scythe-like sweep of wings, that dare
The headlong plunge through eddying gulfs of air.

Longfellow's "Wayside Inn—Ser Federigo."

Nor will the wonder cease when, so far as the mechanical problem is concerned, the mystery of flight is solved. If we wish to see how material laws can be bent to purpose, we shall study this problem.

In the first place, it is remarkable that the Force which seems so adverse—the Force of Gravitation drawing down all bodies to the earth—is the very Force which is the principal one concerned in flight, and without which flight would be impossible. It is curious how completely this has been

forgotten in almost all human attempts to navigate the air. Birds are not lighter than the air, but immensely heavier. If they were lighter than the air they might float, but they could not fly. This is the difference between a Bird and a Balloon. A Balloon rises because it is lighter than the air, and floats upon it. Consequently, it is incapable of being directed, because it possesses in itself no active Force enabling it to resist the currents of the air in which it is immersed, and because, if it had such a force, it would have no fulcrum, or resisting medium against which to exert it. It becomes, as it were, part of the atmosphere, and must go with it where it goes. No Bird is ever for an instant of time lighter than the air in which it flies; but being, on the contrary, always greatly heavier, it keeps possession of a Force capable of supplying momentum, and therefore capable of overcoming any lesser Force, such as the ordinary resistance of the atmosphere, and even of heavy gales of wind. The Law of Gravitation, therefore, is used in the flight of Birds as one of the most essential of the Forces which are available for the accomplishment of the end in view.

The next law appealed to, and pressed into the service, is again a law which would seem an impediment in the way. This is the resisting force of the atmosphere in opposing any body moving through it. In this force an agent is sought and found for supplying the requisite balance to the Force of Gravity. But in order that the resisting force of air should be effectual for this purpose, it must be used under very peculiar conditions. The resisting force of fluids, and of airs or gases, is a force acting equally in all directions, unless special means are taken to give it predominant action in some special direction. If it is a force strong enough to prevent a body from falling, it is also a force strong enough to prevent it from advancing. In order, therefore, to solve the problem of flight, the resisting power of the air must be called into action as strongly as possible in the direction opposite to the Force of Gravity, and as little as possible in any other. Consequently a body capable of flight must present its maximum of surface to the resistance of the air in the perpendicular direction, and its minimum of surface in the horizontal direction. Now, both these conditions ate satisfied (i) by the great breadth or length of surface presented to the air perpendicularly in a Bird's expanded wings, and by (2) the narrow lines presented in its shape horizontally, when in the act of forward motion through the air. But something more yet is required for flight. Great as the resisting force of air is, it is not strong enough to balance the Force of Gravity by its mere pressure on an expanded wing — unless that pressure is increased by an appeal to yet other laws — and other properties of its nature. Every sportsman must have seen cases in which a flying Bird has been so wounded as to produce a rigid expansion of the wings. This does not prevent the Bird from falling, although it breaks the fall, and makes it come more or less gently to the ground.

Yet further, therefore, to accomplish flight, another law must be appealed to, and that is the immense elasticity of the air, and the reacting force it exerts against compression. To enable an animal heavier than the air to support itself against the Force of Gravity, it must be enabled to strike the air downwards with such force as to occasion a rebound upwards of corresponding power. The wing of a flying animal must, therefore, do something more than barely balance Gravity. It must be able to strike the air with such violence as to call forth a reaction equally violent, and in the opposite direction. This is the function assigned to the powerful muscles by which the wings of Birds are flapped with such velocity and strength. We need not follow this part of the problem further, because it does not differ in kind from the muscular action of other animals. The connexion, indeed, between the Wills of animals and the mechanism of their frame, is the last and highest problem of all in the mechanics of Nature; but it is merged and hid for ever in the one great mystery of Life. But so far as this difficulty is concerned, the action of an Eagle's wing is not more mysterious than the action of a Man's arm. There is a greater concentration of muscular power in the organism of Birds than in most other animal frames; because it is an essential part of the problem to be solved in flight, that the engine which works the wings should be very strong, very compact, of a special form, and that, though heavier than the air, it should not have an excessive weight. These conditions are all met in the power, in the outline, and in the bulk of the pectoral

muscles which move the wings of Birds. Few persons have any idea of the force expended in the action of ordinary flight. The pulsations of the wing in most Birds are so rapid that they cannot be counted. Even the Heron seldom flaps its wings at a rate of less than from 120 to 150 strokes in a minute. This is counting only the downward strokes, preparatory to each one of which there must be an upward stroke also; so that there are from 240 to 300 separate movements per minute. Yet the Heron is remarkable for its slow and heavy flight, and it is difficult to believe, until one has timed the pulsations with a watch, that they have a rapidity approaching to two in a second. But this difficulty is an index to the enormous comparative rapidity of the faster-flying Birds. Let any one try to count the pulsations of the wing in ordinary flight of a Pigeon, or of a Blackcock, or of a Partridge, or, still more, of any of the diving seafowl. He will find that though, in the case of most of these Birds, the quickness of sight enables him to see the strokes separate from each other, it is utterly impossible to count them; whilst in some Birds, especially in the Divers, as well as in the Pheasant and Partridge tribe, the velocity is so great that the eye cannot follow it at all, and the vibration of the wings leaves only a blurred impression on the eye.

Our subject here, however, is not so much the amount of vital force bestowed on Birds, as the mechanical laws which, are appealed to in order to make that force effective in the accomplishment of flight. The elasticity of the air is the law which offers itself for the counteraction of gravity. But, in order to make it available for this purpose, there must be some great force of downward blow in order to evoke a corresponding rebound in the opposite, or upward direction. Now, what is the nature of the implement required for striking this downward blow? There are many conditions it must fulfil. First, it must be large enough in area to compress an adequate volume of air; next, it must be light enough in substance not to add an excess of weight to the already heavy body of the Bird; next, it must be strong enough in frame to withstand the pressure which its own action on the air creates. The first of these conditions is met by an exact adjustment of the size or area of the wing to the size and weight of the Bird which it is to lift. The second and the third conditions are both met by the provision of a peculiar substance, feathers, which are very light and very strong; whilst the only heavy parts of the framework, namely, the bones in which the feathers are inserted, are limited to a very small part of the area required.

But there is another difficulty to be overcome—a difficulty opposed by natural laws, and which can only be met by another adjustment, if possible more ingenious and beautiful than the rest. It is obvious that if a Bird is to support itself by the downward blow of its wings upon the air, it must at the end of each downward stroke lift the wing upwards again, so as to be ready for the next. But each upward stroke is in danger of neutralising the effect of the downward stroke. It must be made with equal velocity, and if it required equal force, it must produce equal resistance,—an equal rebound from the elasticity of the air. If this difficulty were not evaded somehow, flight would be impossible. But it is evaded by two mechanical contrivances, which, as it were, triumph over the laws of aerial resistance by conforming to them. One of these contrivances is, that the upper surface of the wing is made convex, whilst the under surface, is concave. The enormous difference which this makes in atmospheric resistance is familiarly known to us by the difference between the effect of the wind on an umbrella which is exposed to it on the under or the upper side. The air which is struck by a concave or hollow surface is gathered up, and prevented from escaping; whereas the air struck by a convex or bulging surface escapes readily on all sides, and comparatively little pressure or resistance is produced. And so, from the convexity of the upper surface of a Bird's wing, the upward stroke may be made with comparatively trifling injury to the force gained in the downward blow.

But this is only half of the provision made against a consequence which would be so fatal to the end in view. The other half consists in this—that the feathers of a Bird's wing are made to underlap each other, so that in the downward stroke the pressure of the air closes them upwards against each other, and converts the whole series of them into one connected membrane, through which there is

no escape; whilst in the upward stroke the same pressure has precisely the reverse effect —it opens the feathers, separates them from each other, and converts each pair of feathers into a self-acting valve, through which the air rushes at every point. Thus the same implement is changed in the fraction of a second from a close and continuous membrane which is impervious to the air, into a series of disconnected joints through which the air passes without the least resistance—the machine being so adjusted that when pressure is required the maximum of pressure is produced, and, when pressure is to be avoided, it is avoided in spite of rapid and violent action.

This, however, exhausts but a small part of the means by which Law is made to do the work of Will in the machinery of flight. It might easily be that violent and rapid blows, struck downwards against the elastic air, might enable animals possessed of such power to lift themselves from the ground and nothing more. There is a common toy which lifts itself in this manner from the force exerted by the air in resisting, and reacting upon little vanes which are set spinning by the hand. But the toy mounts straight up, and is incapable of horizontal motion. So, there are many structures of wing which might enable animals to mount into the air, but which would not enable them to advance or to direct their flight. How, then, is this essential purpose gained? Again we find an appeal made to natural laws, and advantage taken of their certainty and unchangeableness.

The power of forward motion is given to Birds, first by the direction in which the whole wing feathers are set, and next by the structure given to each feather in itself. The wing feathers are all set backwards,—that is, in the direction opposite to that in which the Bird moves; whilst each feather is at the same time so constructed as to be strong and rigid toward its base, and extremely flexible and elastic towards its end. On the other hand, the front of the wing, along the greater part of its length, is a stiff hard edge, wholly unelastic and unyielding to the air. The anterior and posterior webs of each feather are adjusted on the same principle. The consequence of this disposition of the parts as a whole, and of this construction of each of the parts, is, that the air which is struck and compressed in the hollow of the wing, being unable to escape through the wing, owing to the closing upwards of the feathers against each other, and being also unable to escape forwards owing to the rigidity of the bones and of the quills in that direction, finds its easiest escape backwards. In passing backwards it lifts by its force the elastic ends of the feathers; and thus whilst effecting this escape, in obedience to the 'law of action and reaction, it communicates, in its passage along the whole line of both wings, a corresponding push forwards to the body of the Bird. By this elaborate mechanical contrivance the same volume of air is made to perform the double duty of yielding pressure enough to sustain the Bird's weight against the Force of Gravity, and also of communicating to it a forward impulse. The Bird, therefore, has nothing to do but to repeat with the requisite velocity and strength its perpendicular blows upon the air, and by virtue of the structure of its wings the same blow both sustains and propels it. The upward stroke has no sustaining power, but has considerable propelling power; because some air, failing to escape between the feathers, must always pass along the convex surface of the wing, and, escaping backwards, must exert upon the ends of the quills a similar reactive force to that which is exerted in the downward stroke.

The truth of this explanation of the mechanical theory of flight may be tested in various ways. In the first place it is quite visible to the eye. In many birds flying straight to us, or straight from us, the effect of aerial resistance in bending upwards the ends of the quill feathers is very conspicuous. The flight of the common Rook affords an excellent example—where the Bird is seen foreshortened. In Eagles the same effect is very marked—the wing tips forming a. sharp upward curve. I have seen it equally obvious in that splendid Bird the Gannet, or Solan Goose; and when we recollect the great weight which those few quill feathers are thus seen sustaining, we begin to appreciate the degree in which lightness, strength, and imperviousness to the passage of air are combined in this wonderful implement of flight.

But perhaps the simplest test of the action and reaction of the air and the wing feathers in producing forward motion is an actual experiment. If we take in the hand the stretched wing of a Heron, which has been dried in that position, and strike it quickly downwards in the air, we shall find that it is very difficult indeed to maintain the perpendicular direction of the Stroke, requiring, in fact, much force to do so; and that if we do not apply this force, the hand is carried irresistibly forward, from the impetus in that direction which the air communicates to the wing in its escape, backwards from the blow.

Another test is one of reasoning and observation. If the explanation now given be correct, it must follow that since no Bird can flap its wings in any other direction than the vertical—i.e. perpendicular to its own axis (which is ordinarily horizontal)—and as this motion has been shown to produce necessarily a forward motion, no Bird can erer fly backwards. Accordingly no Bird ever does so—no man ever saw a Bird, even for an instant, fly tail foremost. A Bird can, of course, allow itself to fall backwards by merely slowing the action of its wings so as to allow its weight to overcome their sustaining power; and this motion may sometimes give the appearance of flying backwards,—as when a Swift drops backwards from the eaves of a house, or when a Humming Bird allows itself to drop in like manner from out of the large tubular petals of a flower. But this backward motion is due to the action of gravity, and not to the action of the Bird's wing. In short, it is falling downwards, not flying backwards. Nay, more, if the theory of flight here given be correct, it must equally follow that even standing still, which is the easiest of all things to other animals, must be very difficult, if not altogether impossible, to a Bird when flying. This also is true in fact. To stand still in the air is not indeed impossible to a flying Bird, for reasons to be presently explained, but it is one of the most difficult feats of wingmanship,—a feat which many Birds, not otherwise clumsy, can never perform at all, and which is performed only by special exertion, and generally for a very short time, by those Birds whose structure enables them to be adepts in their glorious art.

It cannot be too often repeated—because misconception on this point has been the cardinal error in human attempts to navigate the air—that in all the beautiful evolutions of birds upon the wing, it is weight, and not buoyancy, which makes those evolutions possible. It supplies them, so to speak, with a store of Force which is constant, inexhaustible, inherent in the very substance of themselves, and entirely independent of any muscular exertion. All they have to do is to give direction to that internal Force, by acting on the external Force of aerial currents, through the contraction and expansion of the implements which have been given them for that purpose. Those who have watched the flight of Birds with any care, must have observed that when once they have attained a certain initial velocity and a certain elevation, by rapid and repeated strokes upon the air, they are then able to fly with comparatively little exertion, and very often to pursue their course for long distances without any flapping whatever of the wings. The contrast between the violent efforts required for the first acquisition of the initial velocity, and the perfect ease with which flight is performed after it has been acquired, is a contrast described by Virgil in lines of incomparable beauty:—

Qualis spelunca subito commota columba,
Cui domus et dulces latebroso in pumice nidi,
Fertur in arva volans, plausumque exterrita pennis
Dat tecto ingentem; mox, aere lapsa quieto,
Radit iter liquidum, celeres neque commovet alas.

Mn. lib. v. 213-17.

Still more remarkable, as showing, the power and the value of weight in flight, is the fact that Birds are able to resume rapid and easy motion not only as the result of a previously-acquired

momentum, but after " soaring" in an almost perfectly stationary position. Nothing, for example, is more common than to see Sea Gulls, and some large species of Hawks, " soaring " one moment (that is, all the forces bearing on the Bird brought to an equilibrium, and all motion brought consequently to nearly a perfect standstill), and the next moment sailing onwards in rapid and apparently effortless progression. Now, how is this effect produced? If we only think of it, the question ought rather to be, How is it ever prevented? The soaring is a much more difficult thing to do than the going onwards. It cannot be done at all in a perfectly still atmosphere. It can only be done when there is a breeze of sufficient Strength. Gravity is ceaselessly acting on the Bird to pull it downwards: and downwards it must go, unless there is a countervailing Force to keep it up. This force is the force of the breeze striking against the vanes of the wings. But in order to bring these two forces to nearly a perfect balance, and so to "soar,"

the Bird must expand or contract its wings exactly to the right size, and hold them exactly at the right angle. The slightest alteration in either of these adjustments produces instantly an upsetting of the balance, and of course a resulting motion. The exact direction of that motion will depend on the degree in which the wing is contracted, and the degree in which its angle to the wind is changed. If the wing is very much contracted, and at the same time held off from the wind, that motion will be steeply downwards. Accordingly this is the action of a Hawk when it swoops upon its prey from a great height above it. I have seen a Merlin dash down from a great distance with its wings so closed as to seem almost wholly folded. The Gannet in diving for fish does not close its wings at all, but turning them and the whole axis of its body into the perpendicular, and thus allowing its great weight to act without any counteraction, dashes itself into the sea with foam. But every variety of forward motion is attained by different degrees of contraction and exposure, according to the strength of the breeze with which the Bird has to deal. The limit of its velocity is the limit of its momentum, and the limit of its momentum is the limit of its weight. The lightness of a Bird is therefore a limit to its velocity. The heavier a Bird is, the greater is its possible velocity of flight—because the greater is the store of Force—or to use the language of modern physics, the greater is the quantity of " potential energy " which, with proper implements to act upon aerial resistance, it can always convert into upward, or horizontal, or downward motion, according to its own management and desires.

It will be at once seen from this view of the forces concerned in flight, that the common explanation of Birds being assisted by air-cells for the inhalation and storage of heated air, must not only be erroneous, but founded on wholly false conceptions of the fundamental mechanical principles on which flight depends. If a Bird could inhale enough warm air to make it buoyant, its power of flight would be effectually destroyed. It would become as light as a Balloon, and consequently as helpless. If, on the other hand, it were merely to inflate itself with a small quantity of hot air insufficient to produce buoyancy, but sufficient to increase its bulk, the only effect would be to expose it to increased resistance in cleaving the air. It is true, indeed, that the bones of Birds are made more hollow and lighter than the bones of Mammals, because Birds, though requiring weight, must not have too much of it. It is true, also, that the air must have access to these hollows, else they would be unable to resist atmospheric pressure. But it is no part whatever of the plan or intention of the structure of Birds, or of any part of that structure, to afford balloon space for heated air with a view to buoyancy.

And here, indeed, we open up a new branch of the same inquiry, showing, in new aspects, how the universality and unchangeableness of all natural laws are essential to the use of them as the instruments of Will; and how by being played off against each other they are made to express every shade of thought, and the nicest change of purpose. The movement of all flying animals in the air is governed and determined by Forces of muscular power, and of aerial resistance and elasticity, being brought to bear upon the Force of Gravity, whereby, according to the universal laws of motion, a direction is given to the animal which is the resultant, or compromise, between all the

Forces so employed. Weight, as we have seen, is one of these Forces—absolutely essential to that result, and no flying animal can ever for a moment of time be buoyant, or lighter than the air in which it is designed to move. But it is obvious that, within certain limits, the proportion in which these different Forces are balanced against each other admits of immense variety. The limits of variation can easily be specified. Every flying animal must have muscular power great enough to work its own size of wing: that size of wing must be large enough to act upon a volume of air sufficient to lift the animal's whole weight: lastly, and consequently, the weight must not be too great, or dispersed over too large a bulk. But within these limits there is room for great varieties of adjustments, having reference to corresponding varieties of purpose. To some Birds the air is almost their perpetual home—the only region in which they find their food—a region which they never leave, whether in storm or sunshine, except during the hours of darkness, and the yearly days which are devoted to their nests. Other Birds are mainly terrestrial, and never betake themselves to flight except to escape an enemy, or to follow the seasons and the sun. Between these extremes there is every possible variety of habit. And all these have corresponding varieties of structure. The Birds which seek their food in the air have long and powerful wings, and so nice an adjustment of their weight to that power and to that length, that the faculty of self-command in them is perfect, and their power of direction so accurate that they can pick up a flying gnat whilst they are passing through the air at the rate of more than a hundred miles an hour. Such especially are the powers of some species of the Swallow tribe, one of which, the common Swift, is a creature whose wonderful and unceasing evolutions seem part of the happiness of summer and of serene and lofty skies.1

There are other Birds in which the wing has to be adapted to the double purpose of swimming, or rather of diving, and of flight. In this case, a large area of wing must be dispensed with, because it would be incapable of being worked under water. Consequently in all diving Birds the wings are reduced to the smallest possible size which is consistent with retaining the power of flight at all; and in a few extreme Forms, the power of flight is sacrificed altogether, and the wing is reduced to the size, and adapted to the function, of a powerful fin. This is the condition of the Penguins. But in most genera of swimming Birds, both purposes are combined, and the wing is just so far reduced in size and stiffened in texture as to make it workable as a fin under water, whilst it is still just large enough to sustain the weight of the Bird in flight. And here again we have a wonderful example of the skill with which inexorable mechanical laws are subordinated to special purpose. It is a necessary consequence of the area of the wing being so reduced, in proportion to the size of the Bird, that great muscular power must be used in working it, otherwise the Force of Gravity could not be overcome at all. It is a farther consequence of this proportion of weight to working power, that there must be great momentum and therefore great velocity of flight. Accordingly this is the fact with all the oceanic diving Birds. They have vast distances to go, following shoals of fish, and moving from their summer to their winter haunts. They all fly with immense velocity, and the wing-strokes are extremely rapid. But there is one quality which their flight does not possess—because it is incompatible with their structure, and because it is not required by their habits—they have no facility in evolutions, no delicate power of steering; they cannot stop with ease, nor can they resume their onward motion in a moment. They do not want it: the trackless fields of ocean over which they roam are broad, and there are no obstructions in the way. They fly in straight lines, changing their direction only in long curves, and lighting in the sea almost with a tumble and a splash. Their rising again is a work of great effort, and generally they have to eke out the resisting power of their small wings, not only by the most violent exertion, but by rising against the wind, so as to collect its force as a help and addition to their own.

And now, again, we may see all these conditions changed where there is a change in the purpose to be served. There is another large class of oceanic Birds whose feeding ground is not under water, but on the surface of the sea. In this class all those powers of flight which would be useless to the Divers are absolutely required, and are given in the highest perfection, by the enlistment of the same mechanical laws under different conditions. In the Gulls, the Terns, the Petrels, and in the

Fulmars, with the Albatross. as their typical Form, the mechanism of flight is carried through an ascending scale, to the highest degrees of power, both as respects endurance and facility of evolution.

The mechanical laws which are appealed to in all these modifications of structure require adjustment of the finest kind; and some of them are so curious and so beautiful that it is well worth following them a little further in detail.

There are two facts observable in all Birds of great and long-sustained powers of flight:—the first is, that they are always provided with wings which are rather long than broad, sometimes extremely narrow in proportion to their length; the second is, that the wings are always sharply pointed at the ends. Let us look at the mechanical laws which absolutely require this structure for the purpose of powerful flight, and to meet which it has accordingly been devised and provided.

One law appealed to in making wings rather long than broad is simply the law of leverage. But this law has to be applied under conditions of difficulty and complexity, which are not apparent at first sight The body to be lifted is the very body that must exert the lifting power. The Force of Gravity, which has to be resisted, may be said to be sitting side by side, occupying the same particles of matter, with the Vital Force which is to give it battle. Nay, more, the one is connected with the other in some mysterious manner which we cannot trace or understand. A dead Bird weighs as much as a living one. Nothing which our scales can measure is lost when the Vital Force is gone. It is The Great Imponderable. Nevertheless, vital forces of unusual power are always coupled with unusual mass and volume in the matter through which they work. And so it is that a powerful Bird must always also be comparatively a heavy Bird. And then it is to be remembered that the action of gravity is constant and untiring. The Vital Force, on the contrary, however intense it may be, is intermitting and capable of exhaustion. If, then, this Force is to be set against the Force of Gravity, it has much need of some implement through which it may exert itself with mechanical advantage as regards the particular purpose to be attained. Such an implement is the lever—and a long wing is nothing but a long lever. The mechanical principle, or law, as is well known, is this,—that a very small amount of motion, or motion through a very small space, at the short end of a lever, produces a great amount of motion, or motion through a long space, at the opposite or longer end. This action requires indeed a very intense force to be applied at the shorter end, but it applies that force with immense advantage for the purpose in view: because the motion which is transmitted to the end of a long wing is a motion acting at that point through a long space, and is therefore equivalent to a very heavy weight lifted through a short space at the end which is attached to the body of the Bird. Now this is precisely what is required for the purpose of flight. The body of a Bird does not require to be much lifted by each stroke of the wing. It only requires to be sustained; and when more than this is needed—as when a Bird first rises from the ground, or from the sea, or when it ascends rapidly in the air—greatly increased exertion—in many cases, very violent exertion—is required.1 And then it is to be remembered that long wings economise the vital force in another way. When a strong current of air strikes against the wings of a Bird, the same sustaining effect is produced as when the wing strikes against the air. Consequently Birds with very long wings have this great advantage, that with pre-acquired momentum, they can often for a long time fly without flapping their wings at all. Under these circumstances, a Bird is sustained very much as a boy's kite is sustained in the air. The string which the boy holds, and by which he pulls the kite downwards with a certain force, performs for the kite the same offices which its own weight and balance and momentum perform for the Bird. The great long-winged oceanic Birds often appear to float rather than to fly. The stronger is the gale, their flight, though less rapid, is all the more easy—so easy indeed as to appear buoyant; because the blasts which strike against their wings are enough to sustain the bird with comparatively little exertion of its own, except that of holding the wing vanes stretched and exposed at proper angles to the wind. And whenever the onward force previously acquired by flapping becomes at length exhausted, and the ceaseless inexorable Force of Gravity is

beginning to overcome it, the Bird again rises by a few easy and gentle half-strokes of the wing. Very often the same effect is produced by allowing the Force of Gravity to act, and when the downward momentum has brought the Bird close to the ground or to the sea, that force is again converted into an ascending impetus by a change in the angle at which the wing is exposed to the wind. This is a constant, action with all the oceanic Birds. Those who have seen the Albatross have described themselves as never tired of watching its glorious and triumphant motion:—

Tranquil its spirit seemed, and floated slow;
Even in its very motion there was rest.

Rest—where there is nothing else at rest in the tremendous turmoil of its own stormy seas! Sometimes for a whole hour together this splendid Bird will sail or wheel round a ship in every possible variety of direction without requiring to give a single stroke to its pinions. Now, the Albatross has the extreme form of this kind of wing. Its wings are immensely long—about fourteen or fifteen feet from tip to tip—and almost as narrow in proportion as a riband.2 Our common Gannet is an excel lent, though a more modified, example pf the same kind of structure. On the other hand, Birds of short wings, though their flight is sometimes very fast, are never able to sustain it very long. The muscular exertion they require is greater, because it does not work to the same advantage. Most of the Gallinaceous Birds (such as the common Fowl, Pheasants, Partridges, &c.) have wings of this kind; and some of them never fly except to escape an enemy, or to change their feeding-ground.

The second fact observable in reference to Birds of easy and powerful flight—namely, that their wings are all sharply«pointed at the end—will lead^ us still further into the niceties of adjustment which are so signally displayed in the machinery of flight.

The feathers of a Bird's wing have a natural threefold division, according to the different wing-bones to which they are attached. The quills which form the end of the wing are called the Primaries; those which form the middle of the vane are called the Secondaries; and those which are next the body of the Bird are called the Tertiaries. The motion of a Bird's wing increases from its minimum at the shoulder-joint to its maximum at the tip. The primary quills which form the termination of the wing are those on which the chief burden of flight is cast. Each feather has less and less weight to bear, and less and less force to exert, in proportion as it lies nearer the body of the Bird; and there is nothing more beautiful in the structure of a wing than the perfect gradation in strength and stiffness, as well as in modification of form, which marks the series from the first of the Primary quills to the last and feeblest of the Tertiaries.1 Now, the sharpness or roundness of a wing at the tip depends on the position which is given to the longest Primary quill. If the first, or even the second, primary is the longest, and all that follow are considerably shorter, the wing is necessarily a pointed wing, because the tip of a single quill forms the end; but if the third or fourth Primary quills are the longest, and the next again on.both sides are only a little shorter, the wing becomes a round-ended wing. Round-ended wings are also almost always openended—that is to say, the tips of the quills do not touch each other, but leave interspaces at the end of the wing, through which, of course, a good deal of air escapes. Since each single quill is formed on the same principle as the whole wing—that is, with the anterior margin stiff and the posterior margin yielding—this escape is not useless for progression; but the air acts less favourably for this purpose than when struck by a more compact set of feathers. The common Rook and all the Crows are examples of this. The Peregrine Falcon, the common Swallow, and all Birds of very powerful flight, have been provided with the sharp-pointed structure.1

The object of this structure, and the mechanical laws to which it appeals, will be apparent when we recollect what it is on which the propelling power, as distinct from the sustaining power, of a Bird's wing depends. It depends on the reaction of the air escaping backwards— that is, in the

direction exactly opposite to that of the intended motion of the Bird. Any air which escapes from under the wing, in any other direction, will of course react with less advantage upon that motion. But from under a round wing a good deal of air must necessarily escape along the rounded end—that is, in a direction at right angles to the line of intended flight. All the reaction produced by this escape is a reaction which is useless for propulsion. Accordingly, in all Birds to which great velocity of flight is essential, this structure, which is common in other Birds, is carefully avoided.

The Hawks have been classified as " noble" or " ignoble," according to the length and sharpness of their wings: those which catch their prey by velocity of flight having been uniformly provided with the long-pointed structure. The Sparrow-Hawk and the Merlin are excellent examples of the difference. The SparrowHawk, with its comparatively short and blunt wings, steals along the hedgerows and pounces on its prey by surprise; seldom chasing it, except for a short distance, and when the victim is at a disadvantage. And well do the smaller Birds know this habit, and the limit of his powers. Many of them chase and "chaff" the SparrowHawk, when he is seen flying in the open, perfectly aware that he cannot catch them by fast flying. But they never play these tricks with the Merlin. This beautiful little Falcon hunts the open ground, giving fair chase to its quarry by power and speed of flight. The Merlin delights in flying at some of the fastest Birds, such as the Snipe. The longest and most beautiful trial of wingmanship I have ever seen was the chase of a Merlin after a Snipe in one of the Hebrides. It lasted as far as the eye could reach, and seemed to continue far out to sea. In the Merlin, as in all the fastest Falcons, the second quill feather is the longest in the wing; the others rapidly diminish; and the point of the wing looks as sharp as a needle in the air.

There is yet one other power which it is absolutely necessary to some Birds that their wings should enable them to exert: and that is, the power of standing still, or remaining suspended in the air without any forward motion. One familiar example of this is the common Kestrel, which, from the frequent exercise of this power, is called in some counties the "Windhover." The mechanical principles on which the machinery of flight is adapted to this purpose, are very simple. No Bird can exercise this power which is not provided with wings large enough, long enough, and powerful enough to sustain its weight with ease, and without violent exertion. Large wings can always be diminished at the pleasure of the Bird, by being partially folded inwards; and this contraction of the area is constantly resorted to. But a Bird which has wings so small and scanty as to compel it to strike them always at full stretch, and with great velocity in order to fly at all, is incapable of standing still in the air. No man ever saw a Diver or a Duck performing the evolution which the Kestrel may be seen performing every hour over so many English fields. The cause of this is obvious, if we refer to the principles which have already been explained. We have seen that the perpendicular stroke of a Bird's wing has the double effect of both propelling and sustaining. The reaction from such a stroke brings two different forces to bear upon the Bird—one whose direction is upwards, and another whose direction is forwards. How can these two effects be separated from each other? How can the wing be so moved as to keep up just enough of the sustaining force without allowing the propelling force to come into play? The answer to this, although it involves some very complicated laws connected with what mechanicians call the "parallelogram of forces," is practically a simple one. It can only be done by shortening the stroke, and altering the perpendicularity of its direction. Of course, if a Bird, by altering the axis of its own body, can direct its wing-stroke in some degree forwards, it will have the effect of stopping instead of promoting progression. But in order to do this, it must have a superabundance of sustaining force, because some of this force is sacrificed when the stroke is off the perpendicular. Hence it follows that Birds so heavy as to require the whole action of their wings to sustain them at all, can never afford this sacrifice of the sustaining force, and, except for the purpose of arresting their flight, can never strike except directly downwards,—that is, directly against the opposing force of gravity. But Birds with superabundant sustaining power, and long sharp wings, have nothing to do but to diminish the length of stroke, and direct it off the perpendicular at such an angle as will bring all

the forces bearing upon their body to an exact balance, and they will then remain stationary at a fixed point in the air.1

They are greatly assisted in this beautiful evolution by an adverse current of air; and it will always be observed that the Kestrel, when hovering, turns his head to wind, and hangs his whole body at a greater or less angle to the plane of the horizon. When there is no wind, or very little, the sustaining force is kept up by a short rapid action of the pinions, and the long tail is spread out like a fan to assist in stopping any tendency to onward motion. When there is a strong breeze, no flapping is required at all—the force of the wind supplying the whole force necessary to counteract the force of gravity; and in proportion to the increasing strength of the wind, the amount of vane which must be exposed to it becomes less and less. I have seen a Kestrel stand suspended in a half gale with the wings folded close to the body, and with no visible muscular motion whatever. And so nice is the adjustment of position which is requisite to produce this exact balance of all the forces bearing on the Bird, that the change in that position which again instantly results in a forward motion is very often almost insensible to the eye. It is generally a slight expansion of the wings, and a very slight change in the axis of the body.

And here it may be observed that the tails of Birds have not, as is often supposed, any function analogous to the rudder of a ship. Birds which have lost the tail are not thereby rendered incapable of turning. If the steering function had been assigned to Birds' tails, the vane of the tail must have been set, not, as it is, horizontally, but perpendicularly to the line of flight. But a Bird's tail has in flight no lateral motion whatever. It does, indeed, materially assist the Bird in turning, because it serves to stop the way of a Bird when it rises or turns in the air to take a new direction. The feathers of the tail are also capable of being depressed unequally,—that is, more at one side than at the other; and when the whole are spread out like the leaves of a fan, this depression at one side is a means whereby the Bird can exert against the air which is passing under it greater muscular pressure upon one side than upon the Other, and can thus help the turning action of the wings, With a telescope I have seen this action of the tail very marked in the soaring flight of the Buzzard, when the Bird is wheeling round in spiral circles. The tail contributes also largely to the general balance of the body, which in itself is an important element in the facility of flight. Accordingly, almost all Birds which depend on great ease of evolution in flight—or on the power of stopping suddenly, have largely developed tails. This is the case with all the Birds of prey—with the Kestrel in a conspicuous degree. But there are some exceptions which show that great powers of flight are not always dependent on the possession of a large tail —as, for example, the Swift.

Another explanation has been given of the means by which Birds are able to turn in flight, which is a curious example how preconceived theories founded on false analogies will vitiate our observation of the commonest facts in nature. I do not know of any modern work that gives any account of the theory of flight, which is even tolerably correct. But in most points an admirable account is to be found in the celebrated work of Borelli, " De Motu Animalium.'^ On the question, however, of steerage in flight, he gives a solution which the most ordinary observation is sufficient to contradict. Borelli is quite aware that the tail in Birds has no such function as that which is usually assigned to it, and he points out the true theoretical objection to the possibility of its having any guiding power—viz., its horizontal position, and its immobility in the lateral direction. But the theory which he himself propounds is equally erroneous. It is this,—that Birds deflect their course to the right or to the left, as rowers turn a rowboat—by striking more quickly and more strongly with one wing than with the other.1 To this theory there are two objections—first, that as matter of fact Birds can turn, and do turn, even to the (extent of describing complete circles in the air, without any flapping either of one wing or the other: and secondly, that when Birds do flap and turn at the same time, not the slightest difference in time between the two wingstrokes can ever be detected. The beats of a Bird's two wings are always exactly synchronous. But the first of these two objections is of itself quite sufficient to disprove the theory. No man can have watched even

for a moment the flight of the common Swallow, and especially the flight of the Swift, without seeing it perform complete gyrations in the air without any strokes of either wing. The only change which can ever be detected by the eye is a slight elevation on one side of the whole body, and a slight depression of the other. The depression is always on that side towards which the bird is turning. On the opposite side, that from which the Bird is turning, there is of course a corresponding elevation. Sometimes this is very obvious; but in general it is so slight as to require close observation to detect it. In the Albatross, when sweeping round, the wings are often pointed in a direction nearly perpendicular to the sea.1 The effect of this, of course, is to expose the two vanes at different angles to the aerial currents— and it must be remembered that in flight the balance of all the forces employed is so extremely fine that the most minute alteration in the degree in which they bear upon each other will produce an immense change in the result. It is not surprising, therefore, that the muscular movements which serve to turn the axis of a flying Bird from one direction to another, are very often so extremely minute as generally altogether to elude the sight. But in general terms, it may be said that a Bird turns in flying essentially on the same principle as that on which a Man turns in walking. It is done in both cases by change in the direction of muscular pressure upon a resisting medium. By an exquisite combination of different laws, and by mechanical contrivance in the adjustment of them, it has been given to a Bird to find in the thin and yielding air a medium of resistance against which its own muscular force may act, as firm and as effective as that which Man finds in the solid earth.

The Humming Birds are perhaps the most remarkable examples in the world of the machinery of flight. The power of poising themselves in the air,—remaining absolutely stationary whilst they search the blossoms for insects,—is a power essential to their life. It is a power accordingly which is enjoyed by them in the highest perfection. When they intend progressive flight, it is effected with such velocity as to elude the eye. The action of the wing in all these cases is far too rapid to enable the observer to detect the exact difference between that kind of motion which keeps the Bird at absolute rest in the air, and that which carries it along with such immense velocity. But there can be no doubt that the change is one from a short quick stroke delivered obliquely forward, to a full stroke, more slow, but delivered perpendicularly. This corresponds with the account given by that most accurate ornithological observer, Mr. Gould. He says: " When poised before any object, this action of the wing is SO rapidly performed that it is impossible for the eye to follow each stroke, and a hazy semicircle of indistinctness on each side of the Bird is all that is perceptible." There is another fact mentioned by those who have watched their movements most closely which corresponds with the explanation already given—viz., the fact that the axis of the Humming Bird's body when hovering is always highly inclined, so much so as to appear almost perpendicular in the air. In other words the wing-stroke, instead of being delivered perpendicularly downwards, which would infallibly carry the body onwards, is delivered at such an angle forwards as to bring to an exact balance the upward, the downward, and the forward forces which bear upon the body of the Bird. Mr. Darwin says, " When hovering by a flower, the tail is constantly shut and expanded like a fan, the body being kept in a nearly vertical position" Mr. Wallace, another accurate observer, describes the Humming Birds as " balancing themselves vertically in the air."

These are a few, and a few only, of the adjustments required in order to the giving of the power of flight;— adjustments of organic growth to intensity of vital force —of external structure to external work—of shape in ••€ach separate feather to definite shape in the series as a whole—of material to resistance—of mass and form to required velocities; adjustments, in short, of law to law, of force to force, and of all to Purpose. So many are these contrivances, so various, so fine, so intricate, that a volume might be written without exhausting the beauty of the method in which this one mechanical problem has been solved. It is by knowledge of unchanging laws that these victories over them seem to be achieved: yet not by knowledge only, except as the guide of Power. For here as everywhere else in Nature, we see the same mysterious need of conforming to imperative conditions, side by side with absolute control over the forces through which this conformity is

secured. When any given purpose cannot be attained without the violation of some law, unless by some new power, and some new machinery—the requisite power and mechanism are evolved generally out of old materials, and by modifications of pre-existing forms. There can be no better example of this than a wing-feather. It is a production wholly unlike any other animal growth—an implement specially formed to combine strength with lightness, elasticity, and imperviousness to air. Again, the bones of a Bird's wing are the bones of the Mammalian arm and hand, specially modified to support the feathers. The same purpose is effected by other means in connexion with precisely the same bones in the flying Mammalia—the Bats. In these animals the finger-bones instead of being compressed or soldered together to support feathers, are separated, attenuated, and greatly lengthened to afford attachment to a web or flying membrane which is stretched between them. In other ages of the world there were also flying Lizards. But in all these cases the mechanical principle is the same, and there has been the same ingenious adaptation of material and of force to the universal laws of motion.

On the earth and on the sea Man has attained to powers of locomotion with which, in strength, endurance, and in velocity, no animal movement can compare. But the air is an element on which he cannot travel—an ocean which he cannot navigate. The Birds of heaven are still his envy, and on the paths they tread he cannot follow. As yet! for it is not certain that this exclusion is to be perpetual. His failure has resulted quite as much from his ignorance of natural laws, as from his inability to meet the conditions which they demand. All attempts to guide bodies buoyant in the air must be fruitless. Balloons are mere toys. No flying animal has ever been formed on the principle of buoyancy. Birds and Bats, and Dragons, have been all immensely heavier than the air, and their weight is one of' the forces most essential to their flight. Yet there is a real impediment .in the way of Man navigating the air—and that is the excessive weight of the only great mechanical moving powers hitherto placed at his disposal. When Science shall have discovered some moving power greatly lighter than any we yet know, in all probability the problem will be solved.1 But of one thing we may be sure—that if Man is ever destined to navigate the air, it will be in machines formed in strict obedience to the mechanical laws which have been employed by the Creator for the same purpose in flying animals.2

of Glasgow, and the late Mr. Robert Bryson, of Edinburgh. The result of his investigations led him to the opinion that until a lighter moving power than steam is discovered, it will be impossible to Construct successfully machines for the navigation of the air. I shall only add, that having made ornithology a favourite pursuit, I have been led during many years to test this theory by close observation of the flight of Birds; and that from the manner in which it fits into, and explains all the facts, I have been always more and more satisfied of its truth.

Chapter IV - Apparent Exceptions To The Supremacy Of Purpose

YET, as we look at Nature, the fact will force itself upon us that there are structures in which we cannot recognise any use; that there are contrivances which often fail of their effect; and that there are others which appear to be separated from the conditions they were intended to meet, and under which alone their usefulness could arise. Such instances occur in many branches of inquiry; and although in the great mass of natural phenomena the supremacy of Purpose is evident enough, such cases do frequently come across our path as cases of exception—cases in which Law does not seem to be subservient to Will, but to be asserting a power and an endurance of its own.

The degree of importance which may be attached to such cases as a source of real difficulty, will vary with the character of the individual mind, and its capacity of holding by the great lines of evidence which run through the whole Order of Nature. It is with these cases as with the local currents which sometimes obscure the rising and falling of the tides. When watched from hour to hour, the greater law is clearly discernible by well-marked effects: but when watched from minute

to minute, that law is not distinct, and there are waves which seem like a rebellion of the sea against the force which is dragging it from the land. The Order of Nature is very complicated, and very partially understood. It is to be expected therefore that there should be a vast variety of subordinate facts, whose relation to each other and to the whole must be a matter of perplexity to us. It is so with the relation in which different known laws of Nature stand to each other; much more must it be so with the far deeper subject of the relation which these laws bear to the Will and the intentions of the Supreme. But as cases of intention frustrated, of structure without apparent purpose, of organs dissociated from function and from the opportunities of use, are sometimes sources of difficulty, it may be well to consider this subject a little nearer. Let us look at it both in the light of abstract reasoning, and also in the light of particular illustration.

In the first place, then, we must remember that results which may appear as exceptions to the attainment of one Purpose may be nothing more than fulfilments of another. This follows from the truth which has been dealt with in a former page,1 that we are " greatly ignorant," as Bishop Butler says, how far anything in Nature is to be regarded as a means or as an end, and that ultimate or final purposes we can never see. The difficulty hence arising has often been represented as a fundamental objection to the whole doctrine of Intention. But this view is founded on a very great, although a very natural confusion of thought. The perception of Purpose and Intention is inseparable from the perception of Adjustment and Function as these are exhibited in Nature. As such it belongs to Knowledge. It is the perception of a relation between those phenomena and certain well known phenomena of Mind. But to perceive a relation is not necessarily to perceive all that this relation involves. To perceive intention is a very different thing from perceiving all that is intended. Our own human experience should make this distinction familiar to us. Many things we do and many things we contrive are done and contrived with more than one intention. In the light of this experience it is altogether irrational to regard as an exception to the attainment of Purpose in Nature the fact, for example, " that of fifty seeds she often brings but one to bear." It throws no doubt or difficulty in the way of our conviction, for example, that one purpose of seed-bearing in Plants is the reproduction of their kind, because it appears that another purpose to which that seed-bearing is applied is the support of animal life. The intention with which a grain of wheat is so constituted as to be capable of producing another wheat plant, is not the less in the nature of Purpose because it co-exists with another intention, that the same grain should be capable of sustaining the powers and the enjoyments of Life in the Body and in the Mind of Man. On the contrary, the power possessed by most plants, and by this plant especially, of producing seed in a ratio far beyond that which would be required for one purpose, is the sure indication and the proof that another purpose larger and wider was in view. Yet the seeds of corn which, as seeds, are destroyed when they are converted into bread, may in that aspect be represented and regarded as " failures." In reference to this kind of failure, it has been actually argued that in Nature "the prodigality of waste is far more conspicuous than the wise economy of which so much is said." When applied to the case of the wheat plant the fallacy is apparent, and would probably be admitted. But this is only one example of a class to which an infinite number of other examples in Nature may be referred. There may be, indeed, and there are, innumerable examples where the meaning of like " failures " is not equally evident to us—some which may be involved in utter and hopeless darkness—some which may run up into the great master difficulty—that which we are accustomed to call the " Origin of Evil." But the same argument applies to all. It is not that Purpose and Intention solve all difficulties. But it is that no difficulty in perceiving what may be the purpose and intention of a particular fact can affect the reality and truth of that perception in other cases where no such difficulty exists. Let us now look at the same subject in the light of particular examples.

There is one explanation which, it cannot be doubted, applies to many cases; and this is, the simple explanation that we often mistake the purpose of particular structures in Nature, and connect them with intentions which are not, and never were, the intentions really in view. The best naturalists

are liable to such mistakes. A very curious illustration is afforded by an observation of Mr. Darwin, in his " Origin of Species." He says that " if green Woodpeckers alone had existed, and we did not know that there were any black and pied kinds; I daresay we should have thought that the green colour was a beautiful adaptation to hide this tree-frequenting bird from its enemies." Now, this introduces us to a very curious subject, and one as well adapted as any other to illustrate the relation in which Law stands to Purpose in the economy of Nature.

There can be no doubt that the principle of adapted colouring with the effect and for the purpose of concealment, prevails extensively in various branches of the Animal Kingdom. It arises, probably, like all other phenomena, by way of Natural Consequence, out of some combination of forces which are the instruments employed. We have no knowledge what these forces are; but we can imagine them to be worked into a law of assimilation, founded on some such principle as that which photography has revealed. It is true that Man has not yet discovered any process by which the tints of Nature can be transferred, as the most delicate shades of light can be transferred, to surfaces artificially prepared to receive them. Such a process is, however, very probably within the reach even of human chemistry, and it is one which is certainly known in the laboratory of Nature. The Chameleon is the extreme case in which the effect of such a process is proverbially known. Many Fish exhibit it in a remarkable degree, changing colour rapidly in harmony with the colour of the water in which they swim, or of the bottom on which they lie. The law on which such changes depend is very obscure: but it appears to be a natural process, as constant as all other laws are—that is, constant whenever given conditions are brought together. It is possible that the effect may be due to a cause which is well known to be capable of producing somewhat analogous results. Even before the days of Jacob and of Laban, it seems to have been known that through the eyes of the female parent colour can be determined in her young; and although this is certainly not the law which commonly determines colour —operating as it does, so far as we know, seldom, and only in a small degree—it is quite conceivable that, under special conditions, it is capable of being worked as a great power in Nature. But, then, these conditions are not brought together except with a view to purpose. For now let us see how this law, whatever it may be, is regulated and applied.

One thing is certain: assimilated colouring is not applied universally; on the contrary, it is applied very partially. Is it, therefore, applied arbitrarily—at haphazard, or without reference to conditions in which we can trace a reason and a rule? Far from it. The rule appears to be this:—adaptive colouring, as a means of concealment, is never applied (i) to any animal whose habits do not expose it to special danger, or (2) to any animal which is sufficiently endowed with other more effective means of escape.

This is the higher Law of Purpose which governs the lesser law, whatever it may be, by which assimilative colouring is produced. Now, no man who had observed this higher law could ever fall into the error of supposing that the colour of the Green Woodpecker was given to it as a means of concealment. Few Birds are so invisible as Woodpeckers, because their structure and habits give them other methods of escaping observation, which are most curious and effective. They have few natural enemies but Man; and when in danger of being seen by him, they slip and glide round the bole of a tree or bough on which they may be climbing, with a swift, silent, and cunning motion, and from behind that shelter, with nothing visible but their head, they keep a close watch upon the movements of the enemy. With such sleight of feet, there is no need of lazier methods of concealment.

Accordingly, in this family of Birds, the law of assimilation is withheld from application, and the most violent and strongly contrasted colouring prevails. Jet black, side by side with pure white, and the most brilliant crimsons, are common in the plumage of the Woodpeckers. No birds are more conspicuous in colouring, yet none are more seldom seen. The Green Woodpecker itself, with its yellow tints and crimson hood, contrasts strongly with the bark on which it climbs. The purpose of

concealment being effected by other means, gives way to the purpose of beauty or of adornment in the disposition of colours. And in general the same rule applies to all Birds whose life is led among woods and forests. Comparatively inaccessible to Birds of prey, they exhibit every variety of tint, and the principle of invisibility from assimilated colouring is almost unknown.

It must always be remembered, that animals of prey are as much intended to capture their food, as their victims are intended to have some chances and facilities of escape. The purpose here is a double purpose—a purpose not in all cases to preserve life, but to maintain its balance and due proportion. In order to effect this purpose, the means of aggression, and of defence, or of escape, must bear a definite relation to each other both in kind and in degree. When arboreal Birds leave their sheltering trees, they are exposed to the attacks of Hawks, but they have fair opportunities of retreating to their coverts again; and the upward spring of the disappointed Falcon in the air, when his quarry reaches the shelter of trees, tells how effective such a retreat is, and how completely it ends the chase. On the other hand, there is a great variety of Birds whose habitat is the open plain—the desert—the unprotected shore— the treeless moor—the stony mountain-top. These are the favourite hunting-grounds of the Eagles, and the Falcons, and the Hawks. There they have free scope for their great powers of wing, and uninterrupted range for their piercing powers of sight. And it must be remembered, that even the slowest of the Hawks can on such ground capture with ease Birds which, when once on the wing, could distance their pursuer by superior speed, because the Hawk, sweeping over the ground, takes the prey at a disadvantage, pouncing on it before it can get fairly into the air. Birds whose habitat is thus exposed could not maintain their existence at all without special means of concealment or escape. Accordingly it is among such Birds almost exclusively that the law of assimilative colouring prevails. And among them it is carried to a perfection which is wonderful indeed. Every ornithologist will recognise the truth of the observation, that this law prevails chiefly among the Grouse, the Partridges, the Plovers, the Snipes, Woodcocks, Sandpipers, and other kindred families, all of which inhabit open ground. There can be no better examples than the Grouse and the Ptarmigan of our Scottish mountains. The close imitation in the plumage of these Birds of the general tinting and mottling of the ground on which they lie and feed is apparent at a glance, and is best known to those who have tried to see Grouse or Ptarmigan when sitting, and when their position is indicated within a few feet or a few inches by the trembling nostrils and dilated eyeballs of a steady Pointer-Dog. In the case of the common Grouse, as the ground is nearly uniform in colour throughout the year, the colouring of the Bird is constant also. But in the case of the Ptarmigan, it changes with the changing seasons. The pearly grays which in summer match so exactly with the lichens of the mountain peaks, give place in winter to the pure white which matches not less perfectly with the wreaths of snow.

This is indeed a change which requires for its production the agency of other laws than those merely of reflected light, because the substitution of one entire set of feathers for another of a different colour, twice in every year, implies arrangements which lie deep in the organic chemistry of the Bird. The various genera of Sand-Grouse and Sand-Partridges which frequent the deserts and naked plains of the Asiatic continent, are coloured in exquisite harmony with the ground. Our common Woodcock is another excellent example, and is all the more remarkable as there is one very peculiar colour introduced into the plumage of this Bird which exactly corresponds with a particular stage in the decay of fallen leaves—I mean that in which the browns and yellows of the Autumn rot away into the pale ashy skeletons which lie in thousands under every wood in winter. This colour is exactly reproduced in the feathers of the Woodcock, and so mingled with the dark browns and warm yellows of fresher leaves, that the general imitation of effect is perfect. And so curiously is the purpose of concealment worked out in the plumage of the Woodcock, that one conspicuous ornament of' the bird is covered by a special provision from the too curious gaze of those for whose admiration it was not intended. The tail-feathers of the Woodcock can be erected and spread out at pleasure like a fan, and, being tipped on their under surface with white of a brilliant and silvery lustre, set off by contrast with an adjacent patch of velvety black, they then

produce a most conspicuous effect. But the same web which on its under surface bears this beautiful but dangerous ornament, is on its upper surface dulled down to a sombre ashy-gray, and becomes as invisible as the rest of the plumage. These are all provisions of Nature, which; stand in clear and intelligible relation to the habits of the Bird. It rests all day upon the ground, under trees;. and were it not for its ingeniously adapted colouring, it would be peculiarly exposed to destruction. Man is an enemy whose cunning inventions overcome all such methods of protection, and the Woodcock, when in his most rapid flight, is now an easier prey than in older times when sitting on the ground. But before fire-arms had reached the perfection which has enabled us to shoot flying Birds, the colouring of the Woodcock served it in good stead, even against the Lords of the Creation. In old times it required special skill and practice to see Woodcocks on the ground, and the large lustrous black eye which is adapted for night vision was the one spot of colour which enabled the fowler of a century and a half years ago to detect the bird. Thus Hudibras has it:—

For fools are known by looking wise,
As men find woodcocks by their eyes.

In Snipes, again, there is a remarkable series of strawcoloured feathers introduced along the back and shoulders, which perfectly imitate the general effect of the bleached vegetable stalks common on the ground which the Bird frequents.

There are other animals in which the principle of imitation with a view to concealment is carried very much farther than the mere imitation of colour, and extends also to form and structure. There are some examples of this in the Class of Insects, so remarkable that it is impossible to look at them without ever fresh astonishment. I refer to some families of the Orthopterous order, and especially to some genera of the Mantidce and Phasmidte. Many species of the genus Mantis are wholly modelled in the form of vegetable growths. The legs are made to imitate leaf-stalks, the body is elongated and notched so as to simulate a twig; the segment of the shoulders is spread out and flattened in the likeness of a seed-vessel; and the large wings are exact imitations of a full-blown leaf, with all its veins and skeleton complete, and all its colour and apparent texture. There is something startling and almost horrible in the completeness of the deception—very horrible it must be to its hapless victims. For in this case the purpose of the imitation is a purpose of destruction, the Mantis being a predacious insect, armed with the most terrible weapons, hid under the peaceful forms of the vegetable world. It is the habit of these creatures to sit upon the leaves which they so closely resemble, apparently motionless, but really advancing on their prey with a slow and insensible approach. Their structure disarms suspicion. Wonderful as this structure is, it would be none the less, but all the more wonderful, if. it should arise by way of Natural Consequence from some law of development or of growth. It must be a law of which at present we have no knowledge, and can hardly form any conception. But certain it is that here, as in all other cases, the purpose which is actually attained, is attained by a special adaptation of ordinary structure to a special and extraordinary purpose. No new members are given to the Mantis; there is no departure from the plan on which all other Insects of the same Order are designed. The body has the same number of segments, the legs are the same in number, and are composed of the same joints; every part of this strange creature which seems like a bit of foliage animated with insect life, can be referred to its corresponding part in the ordinary anatomy of its Class. The whole effect is produced by a little elongation here, a little swelling there, a little dwarfing of one part, a little development of another. The most striking part of the whole imitation—that of the " nervation " of the leaf— is produced by a modification, not very violent, of a structure which belongs to all flying Insects. Their wings are constructed of a thin filmy material stretched upon a framework of stronger substance, as the sails of a windmill are stretched upon a trellis-work of spars. This framework is designed in a great variety of patterns —more elaborate and more beautiful than the tracery of Gothic windows. In the Mantis this tracery, instead of being drawn in a mere pattern, is

drawn in imitation of the nervature of a leaf. And imitative colouring is added to imitative structure—so that nothing should be wanting to its completeness and success.

It must always be remembered, however, that Contrivance in Nature can never be reduced to a single purpose, and to that alone. Almost every example of it is connected with a number of effects which fit into each other in endless ramifications of adjustment. For example, this imitative structure of the Mantidce serves as well for their own protection from insectivorous birds as for the procuring of their food in the capture of other Insects. And this, which is perhaps the subordinate purpose in the case of the Mantidce, emerges as the main purpose in another family of imitative Insects, the Phasmida. These last are vegetable feeders, and their imitative structure is, if possible, even more wonderful, as it certainly is more beautiful. In some species 1he wings are not only made like leaves in form, in structure, and in general colour, but they are tinted at different seasons of the year with the varying colours of spring, of summer, or of autumn. The fundamental green is shaded off into browns, and reds, and yellows, with a few of those crimson touches which are so common in the " Pageant of the year." There is one specimen in the British Museum where the imitative effect is pursied, as it were, into a region of still more minute and curious observation. The general aspect of summer vegetation is much affected by the ravages of insect life. Minute larvae eat into the cuticle of leaves, and mark them with various spots of bleached or faded colour. Now the specimen of Phasma I refer to has its wing covered with spots which exactly imitate this appearance of a larva-eaten leaf. Can it be that this effect is itself produced by a really similar cause—the eating of some larval parasite into the tissue of the wing? If so, the combination of means to the production of so wonderful an effect becomes only the more bewildering in the endless vistas of adjustment which are opened out. And there is another fact connected with these Insects which is as astonishing as any other. It is this—that the idea and purpose of imitation is carried into effect consistently and perseveringly through all the stages of the creature's metamorphoses. The eggs are as perfect imitations of vegetable seeds as the adult insect is of the expanded leaf. In the larval form they are like bits of stalk, or chips or cuttings of leaves.

But although the laws which determine both form and colouring are here seen to be subservient to use, we shall never understand the phenomena of Nature unless we admit that mere ornament or beauty is in itself a purpose, an object, and an end. Mr. Darwin denies this; but he denies it under the strange impression, that to admit it would be absolutely fatal to his own theory on the Origin of Species. So much the worse for his theory, if this incompatibility be true. There is indeed a difference, at least in words, between the doctrine now asserted and the doctrine which Mr. Darwin denies. What he denies as a purpose in nature is beauty " in the eyes of Man." But this evades the real point at issue. The relation in which natural beauty stands to Man's appreciation of it, is quite a separate question. It is certain enough that the gift of ornament in natural things has not been lavished, as it is lavished, for the mere admiration of mankind. Ornament was as universal—applied upon a scale at once as grand and as minute as now—during the long ages before Man was born. Some of the most beautiful forms in Nature are the shells of the marine Mollusca, and many of them are the richest, too, in surface ornament. But, prodigal of beauty as the Ocean now is in the creatures which it holds, its wealth was even greater and more abounding in times when there was no man to gather them. The shells and corals of the old Silurian Sea were as elaborate and as richly carved as those which we now admire: and the noble Ammonites of the Secondary ages must have been glorious things indeed. Even now there is abundant evidence that although Man was intended to admire beauty, beauty was not intended only for Man's admiration. Nowhere is ornament more richly given, nowhere is it seen more separate from use, than in those organisms of whose countless millions the microscope alone enables a few men for a few moments to see a few examples There is no better illustration of this than a class of forms belonging to the border-land of animal and vegetable life called the Diatomacetz, which, though invisible to the naked eye, play an important part in the economy of Nature. They exist almost everywhere, and of

their remains whole strata, and even mountains, are in great part composed. They have shells of pure silex, and these, each after its own kind, are all covered with the most elaborate ornament—striated, or fluted, or punctured, or dotted in patterns which are mere patterns, but patterns of perfect, and sometimes of most complex, beauty. No graving done with the graver's tool can equal that work in gracefulness of design, or in delicacy and strength of touch. Yet it is impossible to look at these forms—in all the variety which is often crowded under a single lens—without recognising instinctively that the work of the graver is work strictly analogous, —addressed to the same perceptions,—founded on the same idea,—having for its object the same end and aim.' And as the work of the graver varies for the mere sake of varying, so does the work on these microscopic shells. In the same drop of moisture there may be some dozen or twenty forms, each with its own distinctive pattern, all as constant as they are distinctive, yet having all apparently the same habits, and without any perceptible difference of function.

It would be to doubt the evidence of our senses and of our reason, or else to assume hypotheses of. which there is no proof whatever, if we were to doubt that mere ornament, mere variety, are as much an end and aim in the workshop of Nature as they are known to be in the workshop of the goldsmith and the jeweller. Why should they not? The love and desire of these is universal in the mind of Man. It is seen not more distinctly in the highest forms of civilized art than in the habits of the rudest savage, who covers with elaborate carving the handle of his war-club, or the prow of his canoe. Is it likely that this universal aim and purpose of the mind of Man should be wholly without relation to the aims and purposes of his Creator? He that formed the eye to see beauty, shall He not see it? He that gave the human hand its cunning to work for beauty, shall His hand never work for it? How, then, shall we account for all the beauty of the world — for the careful provision made for it where it is only the secondary object, not the first? Even in those cases, for example, where concealment is the main object in view, ornament is never forgotten, but lies as it were underneath, carried into effect under the conditions and limitations imposed by the higher law and the more special purpose. Thus the feathers of the Ptarmigan, though confined by the law of assimilative colouring to a mixture of black and white or gray, have those simple colours disposed in crescent bars and mottlings of beautiful form, even as the lichens which they imitate spread in radiating lines and semicircular ripples over the weather-beaten stones. It is the same with all other Birds whose colour is the colour of their home. For the purpose of concealment, their colouring would be equally effective if it were laid on without order or regularity of form. But this is never done. The required tints are always disposed in patterns, each varying with the genus and the species; varying for the mere sake of variation, and for the beauty which belongs to ornament. And where this purpose is not under the restraint of any other purpose controlling it and keeping it down as it were within comparatively narrow limits, how gorgeous are the results attained! What shall we say of flowers—those banners of the vegetable world, which march in such various and splendid triumph before the coming of its fruits? What shall we say of trie Humming Birds—whose feathers are made to return the light which falls upon them, as if rekindled from intenser fires, and coloured with more than all the colours of all the gems?

There is one instance in Nature (and, as far as I know, only one) in which ornament takes the form of pictorial representation. The secondary feathers in the wing of the Argus Pheasant are developed into long plumes, which the bird can erect and spread out like a fan, as a Peacock spreads his train. These feathers are decorated with a series of conspicuous spots or " eyes," which are so coloured as to imitate the effect of balls. The shadows and the "high light" are placed exactly where an artist would place them in order to represent a sphere.1 The " eyes" of the Peacock's train are wonderful examples of ornament; but they do not represent anything except their own harmonies of colour. The " eyes " of the Argus Pheasant are like the "ball and socket" ornament which is common in the decorations of human art. It is no answer to this argument in respect to beauty, that we are constantly discovering the use of beautiful structures in which the beauty only, and not the usefulness, had been hitherto perceived. The harmonies on which all beauty probably depends are

so minutely connected in Nature that "use" and ornament may often both arise out of the same conditions. Thus, some of the most beautiful lines on the surface of shells are simply the lines of their annual growth, which growth has followed definite curves, and it is the "law" of these curves that is beautiful in our eyes. Again, the forms of many Fish which are so beautiful, are also forms founded on the lines of least resistance. The same observation applies to the form of the bodies and of the wings of Birds. Throughout Nature, ornament is perpetually the result of conditions and arrangements fitted to use and contrived for the discharge of function. But the same principle applies to human art, and few persons are probably aware how many of the mere ornaments of architecture are the traditional representation of parts which had their origin in essential structure. Yet who would argue from this fact that ornament is not a special aim in the works of Man? When the savage carves the handle of his war-club, the immediate purpose of his carving is to give his own hand a firmer hold. But any shapeless scratches would be enough for this. When he carves it in an elaborate pattern, he does so for the love of ornament, and to satisfy the sense of beauty.

There is, however, another department of natural phenomena which, much more than the one we have been now considering, does at first sight suggest to the mind the subordination of Purpose and the supremacy of Law. It is the department of Comparative Anatomy. It is a fact now well known and universally accepted, that in many animal structures, perhaps in all except one, there are parts the presence of which cannot be explained, from their serving any immediate use, or discharging any actual function. For example, the limbs of all the Mammalia, and even of all the Lizards, terminate in five jointed bones or fingers. But in many animals the whole five are not needed, but only some one, or two, or three. In such cases the remainder are indeed dwarfed, sometimes almost extinguished; but the curious fact is that rudimentally the whole number are always to be traced. Even in the Horse, where one only of the five is directly used, and where this one is enlarged and developed into a hoof, parts corresponding to the remaining four fingers can be detected in the anatomy of the limb. Other examples of the same principle might be given without number. Thus there are Monkeys which have no thumbs for use, but only thumb-bones hid beneath the skin: the wingless Bird of New Zealand, the " Apteryx," has useless wing-bones similarly placed: snakes destined always to creep "upon their belly" have nevertheless rudiments of legs, and the common " Slowworm " has even the " blade bone " and " collar bone " of rudimentary or aborted limbs: the Narwhal has only one tusk, on the left side, developed for use, like the horn of an heraldic Unicorn, but the other tusk, on the right side, is present as a useless germ: the female Narwhal has both tusks reduced to the same unserviceable condition: young whalebone Whales are born with which never cut the gum, and which are afterwards absorbed as entirely useless to the creature's life.

At first sight it may appear as if these were facts not to be reconciled with the supremacy of Purpose:—at first sight, but at first sight only. For as we look at them and wonder at them, and set ourselves to discover how many of a like nature can be found, our eye catches light of an Order which had not been at first perceived. Exceptions to one narrow rule such as we might have laid down and followed for ourselves, they are now seen to be in strict subordination to a larger rule which it would never have entered into our imagination to conceive. These useless members, these rudimentary or aborted limbs which puzzled us so much, are parts of an universal Plan. On this plan the bony skeletons of all living animals have been put together. The forces which have been combined for the moulding of Organic Forms have been so combined as to mould them after certain types or patterns. And when Comparative Anatomy has revealed this fact as affecting all the animals of the existing world, another branch of the same science comes in to conform the generalisation, and extend it over the innumerable creatures which have existed and have passed away. This one Plan of Organic Life has never been departed from since Time began.

When we have grasped this great fact, all the lesser facts which are subordinate to it assume a new significance. In the first place a Plan of this kind is in itself a Purpose. An Order so vast as this,

including within itself such variety of detail, and maintained through such periods of Time, implies combination and adjustment founded upon, and carrying into effect, one vast conception. It is only as an Order of Thought that the doctrine of Animal Homologies is intelligible at all. It is a Mental Order, and can only be mentally perceived. For what do we mean when we say that this bone in one kind of animal corresponds to such another bone in another kind of animal? Corresponds —in what sense? Not in the method of using it—for very often limbs which are homologically the same are put to the most diverse and opposite uses. To what standard, then, are we referring when we say that such and such two limbs are homologically the same? It is to the standard of an Ideal Order—a Plan—a Type—a Pattern mentally conceived. This sounds very recondite and metaphysical; and yet the habit of referring physical facts to some ideal standard and order of thought is a universal instinct in the human mind. It is one of the earliest of our efforts in endeavouring to understand the phenomena around us. The science of Homologies, as developed by Cuvier and Hunter and Owen and Huxley, is indeed an intricate, almost a transcendental science. Yet Dr. Livingstone found the natives of Africa debating a question which belongs essentially to that science and involves the whole principle of the mental process by which it is pursued. The debate was on the question " whether the two toes of the Ostrich represent the thumb and forefinger in. Man, or the little and ring-finger." This is purely a question of Comparative Anatomy. It is founded on the instinctive perception that even between two frames so widely separated as those of an Ostrich and a Man, there is a common Plan of structure, with reference to which plan, parts wholly dissimilar in appearance and in use, can nevertheless be identified as "representative" of each other:—that is, as holding the same relative place in one Ideal Order of arrangement.

The recognition of this idea in minds so rude is not the less remarkable from the fact that both sides in this African debate were wrong in their practical application of the idea to the particular case before them. Unity of design amidst variety of form is so conspicuous and ' universal in the works of Nature that the perception of it could not possibly escape recognition even by the rudest human mind, formed as that Mind is to see Order, and to work for it, and to admire it. But though instinct is enough to give us the general idea, and to trace it in a thousand instances where it can hardly be overlooked, yet it needs close and laborious study, and high powers of analysis and of thought, to trace correctly the true Order and Plan through the fine 'and subtle passages of Nature. It would have astonished those poor natives of Africa to be told, as is the truth, that if they wished to find in the Ostrich the parts corresponding to their own middle finger, or ring-finger, or any other finger, they must look, not to the toes of the Ostrich, but to her little aborted wings, which, though useless for the purposes of flight, are still retained as representing the wings of other Birds, and the forearms of all the Mammals.

For here we come upon the interchange and crossing as it were of two distinct ideas, which seem to stand the one as the warp and the other as the woof in the fabrics of Organic Life. There is the idea of Homology in Structure and the idea of Analogy in Use. The one represents the Unity of Design, the other represents Variety of Function. It might have been supposed that these could not easily be reconciled—that where great differences in use and application are essential, rigid adherence to one pattern of structure would be an impediment in the way. But it is not so. The same bones in different animals are made subservient to the widest possible diversity of function. The same limbs are converted into paddles, and wings, and legs, and arms. And so it is with every other part of the skeleton and every other organ of the body. Indeed it is difficult to say whether the law of unity if. design, or the law of variety in adaptation, is pushed to the greatest length. There are some cases in which the adaptation of form to special function is carried so far that all appearance of common structure is entirely lost. It is very difficult, for example, to persuade persons ignorant of the - principles of anatomy that the Whale and the Porpoise are not Fish, that they breathe with lungs as Man breathes, that they would be drowned if kept long under water, and that, as they suckle their young, they belong to the same great Class, Mammalia. Living in the same element as Fish, and feeding very much as fishes feed, a similar outward form has been given to them, because that

form is the best adapted for progression through the water. But that form has been, so to speak, put on round the Mammalian skeleton, and covers all the organs proper to the Mammalian Class. Whales and Porpoises, notwithstanding their form, and their habitat, and their food, are as separate from Fishes as the Elephant, or the Hippopotamus, or the Giraffe.

And when we remember that the immense variety of Organic Forms in the existing world does not exhaust the adaptability of their Plan, but that the still vaster varieties of all the extinct creations have circled round the same central Types, it becomes evident that these Types have had from the first a Purpose which has been well and wonderfully fulfilled. As a matter of fact, we see that the original conception of the framework of Organic Life has included in itself provisions for applying the principle of adaptation in infinite degrees. Its last development is in Man. In his frame there is no aborted member. Every part is put to its highest use:— highest, that is, in reference to the supremacy of Mind.1 There are stronger arms, there are swifter limbs, there are more powerful teeth, there are finer ears, there are sharper eyes. There are creatures which go where he cannot go, and can live where he would die. But all his members are co-ordinated with one power—the power of Thought. Through this he has the dominion over all other created things—whilst yet as regards the type and pattern of his frame he has not a single bone or joint or organ which he does not share with some one or other of the Beasts that perish. It is not in any of the parts of his structure, but in their combination and adjustment, that he stands alone.

All these facts must convince us that we must enlarge our ideas as to what is meant by Use in the Economy of Nature. In the first place, it must be so interpreted as to include ornament; and in the second place, it must include also not merely Actual Use, but Potential Use, or the capacity of being turned to use in new. creations. Of course this is one of the ideas which Philosophers of the Positive School denounce as "Metaphysical." But here again their opposition is itself based upon metaphysics, only upon metaphysics which are bad. " Potential existence," says Mr Lewes,1 " is ideal not real." " A fact is not a fact until it is accomplished. Nothing exists before it exists. This truism is disregarded by those who talk of potential existence." So it is, and it ought to be disregarded, because it has no bearing on the question. May not the formation of a plan or conspiracy to murder be " a fact" although the murder is not " accomplished?" Is not the capacity in the different pieces of a puzzle of being fitted together, a fact—even when the pieces are all huddled confusedly in a box? Is there no potential use in the udder of a cow-calf before it can have had any calves of its own? Is the idea of Potential use in all these cases an idea which has no " reality? " Are they mere "artifices of thought," or "preliminary falsifications of fact? " If the metaphysics of Positivism are available to establish this conclusion, they must be equally available to condemn knowledge in all its forms as "Ideal" and not "real." Bad metaphysics of this kind are indeed, what Dr. Newman dreads the human mind may be, a " universal solvent," casting doubt on the most certain of its own conclusions, and landing itself in universal scepticism.

We have not far to go to find the same kind of reasoning, and the same methods of analysis, employed to establish the converse proposition, that so far from Potentiality having no existence, it is the only form under which the existence of anything beyond ourselves can be known to us. No less eminent a thinker than Mr. J. S. Mill reduces Matter itself, and the very idea of the existence of an external world, to a " Permanent Possibility of Sensation." Nay, he is not sure—he only sees some " intrinsic difficulties " in the way—whether our knowledge of Self-existence may not be brought under the same " Potential" category—as a mere " Possibility of Sensation."2 In regard to Matter, Mr. Mill distinctly says that so far from a mere Possibility having no real existence, it is the only reality—the one thing which is constant and abiding behind the flux and uncertainty of actual sensations. My own opinion is that the metaphysical process by which these opposite paradoxes are arrived at is nearly as worthless in the one case as in the other. Of the two I prefer the paradox of Mr. Mill to the paradox of Mr. Lewes—so far at least*as the reality of Potential Existences is concerned. But I prefer it only in the very case to which Mr. Mill shrinks from applying it. I can think

of my own mind or existence as a " Possibility of Sensation " (whether " permanent" or not). It is a method of conception indeed which casts no light on anything, and it is highly artificial; but at least it is not false. It involves no confounding of two different elements of thought. But I cannot transfer the word or the idea of sensation from myself to the external things which cause sensation in me. This transfer involves a fundamental confusion of thought and of language as the instrument of thought.1 But such paradoxes are the natural result of one great error —the endeavour to get rid of, or to explain away, or to dissolve by analysis, such simple and elementary conceptions of the Mind as the idea of External Force and of Causation, or the idea of Purpose and Intention.

Matter may very well be conceived as " That which produces, or has a Possibility of producing, Sensation in Sentient beings." But this is a definition which involves the idea of Causation. And if this be rejected as an elementary conception, (or as a distinct conception, whether elementary or not,) then the paradox of Mr. Mill is the natural result. In like manner, if the idea of Purpose and Intention be repudiated, as representing no " reality" in Nature, then the opposite paradox of Mr. Lewes is reached along the same slippery and deceptive ways. We know at least, as a matter of experience, that we are capable of forming plans which exist as such before they are carried into effect. We know too that one plan may be large enough to include another, and that even within the fractional limits of our foresight we can provide for contingent as well as for actual use. We can therefore easily conceive the existence of the same kind of prevision in the Mind which works in Nature, and we can easily understand how the. apparent difference between actual and contingent use should be greater in proportion as the Plan is larger, and is designed to operate during vaster periods of Time.

In this point of view rudimentary or aborted organs need no longer puzzle us, for in respect to Purpose they may be read either in the light of History, or in the light of Prophecy. They may be regarded as indicating always either what had already been, or what was yet to be. Why new creations should never have been made wholly new;—why they should have been always moulded on some pre-existing Forms;—why one fundamental ground-plan should have been adhered to for all Vertebrate Animals, we cannot understand. But as a matter of fact it is so. For it appears that Creative Purpose has been effected through the instrumentality of Forces so combined as to arrange the particles of organic matter in definite forms: which forms include many separate parts having a constant relation to each other and to the whole, but capable of arrestment or development according as special organs are required for the discharge of special functions. Each new creation seems to have been a new application of these old materials. Each new House of Life has been built on these old foundations. Among the many wonders of Nature there is nothing more wonderful than this—the adaptability of the one Vertebrate Type to the infinite variety of Life to which it serves as an organ and a home. Its basement has been so laid that every possible change or addition of superstructure could be built upon it. Creatures destined to live on the earth or in the earth, on the sea or in the sea, under every variety of condition of existence, have all been made after that one pattern; and each of them with as close an adaptation to special function as if the pattern had been designed for itself alone. It is true that there are particular parts of it which are of no use to particular animals. But there is no part of it which is not of indispensable use to some member of the group; and there is one Supreme Form in which all its elements receive their highest interpretation and fulfilment. It is indeed wonderful to think that the feeble and sprawling paddles of a Newt, the ungainly flippers of a Seal, and the long leathery wings of a Bat, have all the same elements, bone for bone, with that human hand which is the supple instrument of Man's contrivance, and is alive, even to the finger-tips, with the power of expressing his Intellect and his Will. Here again the Laws of Nature are seen to be nothing but combinations of Force with a view to Purpose: combinations which indicate complete knowledge, not only of what is, but of what is to be, and which foresees the End from the Beginning.

Chapter V - Creation By Law

WE see, then, how the existence of Organs separated from Function, and of structures without immediate use, find their natural place among all the other phenomena of the world. They do not show that "Law" is ever superior to Will, or can ever assert, even for a moment, an independence of its own. On the contrary, they show, as nothing else can show, the patient movements, and the incalculable years, through which material laws have been made to follow the steps of Purpose.

But, then, let us remember this: these discoveries in Physiology, though they are helpless to prove that Law has ever been present as a Master, are eminently suggestive of the idea that Law has never been absent as a Servant;—that as, in governing the world, so in forming it, Material Forces have been always used as the instruments of Will.

It is no mere theory, but a fact as certain as any other fact of Science, that Creation has had a History. It has not been a single act, done and finished once for all, but a long series of acts—a work continuously pursued through an inconceivable lapse of time. It is another fact, equally certain, respecting this work, that as it has been pursued in Time, so also it has been pursued by Method. There is an " observed Order of facts" in the history of Creation, both in the organic and in the inorganic world. I speak here, however, of the organic world alone, and chiefly of those higher Forms which are the seat of Animal Life. In these, there is an observed Order in the most rigid scientific sense— that is, phenomena in uniform connexion, and mutual relations which can be made, and are made, the basis of systematic classification. These classifications are imperfect, not because they are founded on ideal connexions where none exist, but only because they fail in representing adequately the subtle and pervading Order which binds together all living things. But the Order which prevails in the existing world is not the only Order which has been recognised by science. A like Order has prevailed through all the past history of Creation. Nay, more; it has, I think, been clearly ascertained, not only that relations similar to those which now exist have existed always among all the animals of each contemporary Creation, but that Order of a like kind has connected with each other all the different Creations which were successively introduced. In almost all the leading Types of Life which have existed in the different geological ages, there is an orderly gradation connecting the Forms which were becoming extinct with the Forms which were for the first time appearing in the world. It is still disputed by some geologists, whether we have certain evidence that this gradation has been the gradation of a rising scale—of progressive Creations from lower to higher Types. But this dispute is maintained only on the ground that we cannot safely trust to negative evidence. It is an unquestionable fact, that so far as this kind of evidence can go, it does testify to the successive introduction of higher and higher Forms of Life. Very recently a discovery has been made, to which Mr. Darwin only a few years ago referred as "a discovery of which the chance is very small"—viz. of fossil Organisms in beds far beneath the lowest Silurian strata. This discovery has been made in Canada—in beds far down, near the bottom even, of the rocks hitherto termed " Azoic." But what sre the Forms of Life which have been found here? They belong to the very lowest of living types—to the " Rhizopods." So far as this discovery, goes, therefore, it is in strict accordance with all the facts previously known—that, as we go back in time, we lose, one after another, the higher and more complex organisms': first, the Mammalia; then the Vertebrata; and now, lastly, even the Mollusca. It is in accordance, too, with another fact which has been observed before, viz. that particular Forms of Life have attained, at particular epochs, a maximum development, both in respect to size and distribution—the favourites, as it were, of Creation for a time. These earliest Rhizopods seem to have been of enormous size, and developed on an enormous scale; since there is good reason to believe that beds of immense thickness are composed of their remains.. All that is new in this discovery is the vast extension which it gives in Time to the same rules which had been already traced through ages which we cannot number.

Then, there is another observed Order. For each Class of animal some definite Type or pattern has been adhered to; and the modifications of that Type have been gradual and successive. In many cases the science of fossil remains enables us to trace the intermediate Forms through which existing animals can be connected with animals long since extinct. It must be remembered that the fact of this connexion is quite a separate thing from any theory as to its physical cause. Professor Owen pointed out some years before the publication of Mr. Darwin's theory, the existence of fossil animals which showed an increasing approximation to the forms of the Horse and of the Ox: and he showed that this approximation was related in Time, as it seemed to be in Purpose, with the coming need of them for the service and use of Man. These are the facts on which the idea of " Creation by Law " is founded. Let us look a little nearer what this idea is, and what it involves. It is an idea much vaunted by some men, much feared by others. Perhaps it may be found, on closer investigation, that they are fearing or worshipping, as the case may be, an idol of the imagination.

It being certain that Creation exhibits an Order of facts which can be so clearly denned and traced, it follows, that at least in this first sense of the word, Creation has been by Law. We are, therefore, led on to the farther question, whether Law in any other sense can be traced or detected in the work of Creation? Is the observed Order which prevails in the organic world an Order of which we can even guess the physical cause? Is it an Order which contains within itself any indications of the Force or combination of Forces which have been concerned in producing it?

In considering this question, there is one thing to be observed at the outset. It is certain that nothing is known, or has been even guessed at, in respect to the history and Origin of Life, which corresponds with Law in its strictest and most definite sense. We have no knowledge of any one or more Forces—such as the Force of Gravitation, or of magnetic attraction and repulsion—to which any one of the phenomena of Life can be traced. Far less have we any knowledge of any laws of the like kind which can be connected with the successive creation or development of new Organisms. Professor Huxley, in a recent work,1 has indeed spoken of " that combination of natural forces which we term Life." But this language is purely rhetorical. I do not mean to say that Life may not be denned to be a kind of Force, or a combination of Forces. All I mean is, that we know nothing of any of these Forces in the same sense in which we do know something of the Force of Gravity, or of Magnetism, or of Electricity, or of Chemical Affinity. These are all more or less known, not, indeed, in respect to their ultimate nature, but in respect to certain methods and measures of their operation. No such knowledge exists in respect to any of the Forces which have been concerned in the development of Life. No man has ever pretended to get such a view of any of these as to enable him to apply to them the instruments of his analysis, or to trace in their working any definite relations to Space, or Time, or Number.

Since, then, laws, in this most definite sense of the word, have not been discovered in the existing phenomena, or an the past history of Organic Life, let us look a little closer at the ideas which these phenomena have suggested to the mind of those who have speculated on the Origin and Development of Species.

There is one idea which has been common to all theories of Development, and that is, the idea that ordinary generation has somehow been producing, from time to time, extraordinary effects, and that a new Species is, in fact, simply an unusual birth. It is worthy of observation, that the earlier forms in which the theory of Development appeared, did suggest something more nearly approaching to a Law of Creation than is contained in the later form which that theory has assumed in the hands of Mr. Darwin. The essential idea of the theory of Development, in its earlier forms, was, that modifications of structure arose somehow by way of natural consequence from the outward circumstances or physical conditions which required them, and from the living effort of Organism sensible in some degree of that requirement. Now, inadequate and even grotesque though this idea may be as explaining the Origin of new ' Species, it cannot be denied, that it makes

its appeal to a process which, at least to a limited extent, does operate in producing modification's of organic structure. For example, the same species of Mollusc has often a shell comparatively weak and thin, or a shell comparatively robust and strong, according as it lies in tranquil or in stormy water. The shell which is much exposed needs to be stronger than the shell which is less exposed. But it is obvious that the mere fact of the need cannot supply the thing needed, unless by the adjustment of some machinery for the purpose. How the vital forces of the Mollusc can thus be made to work to order, under a change of external conditions, we do not know. But we do know, as a matter of fact, that the shell is thickened and strengthened, according as it needs resisting power. This result does not appear to arise from any difference in the amount of lime held in solution in the water, but from some power in the secreting organs of the animal to appropriate more or less of it, according to its own need. The effects of this power are seen where there is no difference of condition except difference of exposure. It is said that they are observable, for example, in the shells which lie on the different sides of Plymouth Breakwater,—the sheltered side and the exposed side. The same power of adaptation is seen in many other forms. Trees which are most exposed to the blast are the most strongly anchored in the soil. Limbs which are the most used are the most developed. Organs which are in constant use, are strengthened, whilst organs in habitual disuse have a tendency to become weaker.

All these results arise by way of natural consequence. How shall we describe them? Shall we say that they are the result of Law? We may safely do so, remembering only that by Law, in this sense, we mean nothing but the co-operation of different natural Forces, which, under certain conditions, work together for the fulfilment of an obvious intention. Of the nature of those Forces we know nothing; nor is it easy to conceive how they have been so co-ordinated as to produce effects fitting with such exactness into the conditions requisite for the preservation of Organic Life. If there were any evidence that by the same means new Forms of Life could be developed from the old, I cannot see why there should be any reluctance to admit the fact. It would be different from anything that we see; but I do not know that it would be at all less wonderful, or that it would bring us much nearer than we now stand to the great mystery of Creation. The adaptation and arrangement of natural forces, which can compass these modifications of animal structure, in exact proportion to the need of them, is an adaptation and arrangement which is in the nature of Creation. It can only be due to the working of a power which is in the nature of Creative power.

We are so accustomed to these and other similar phenomena, and so act to hide our own ignorance of their cause, by describing them as the result of " Law," that we forget what a multitude of natural Forces must be concerned in their production, and what complicated adjustments of these amongst each other for the accomplishment of Purpose. It is purely, therefore, in my view, a question of evidence, whether this particular law of adaptation has or has not been the means of introducing new Forms of Life. There is no evidence that it has. So far as we know, this power of self-adaptation, wonderful as it is, has a comparatively limited application; when that limit is outrun by changes in outward conditions, which are too great or too rapid, whole Species die and disappear. Nevertheless, the introduction of new Species to take the place of those which have passed away, is a work which has been not only so often, but so continuously repeated, that it does suggest the idea of having been brought about through the instrumentality of some natural process. But we may say with confidence, that it must have been a process different from any that we yet know—a process not the same as that (obscure as that is) which produces the lesser modifications of Organic Forms.

It has not, I think, been sufficiently observed, that the theory of Mr. Darwin does not address itself to the same question, and does not even profess to trace the Origin of new Forms to any definite law. His theory gives an explanation, not of the processes by which new Forms first appear, but only of the processes by which, when they have appeared, they acquire a preference ^over others, and thus become established in the world. A new Species is, indeed, according to his theory, as

well as with the older theories of Development, simply an unusual birth. The bond of connexion between allied specific and generic Forms, is in his view simply the bond of Inheritance. But Mr. Darwin does not pretend to have discovered any law or rule according to which new Forms have been born from old Forms. He does not hold that outward conditions, however changed, are sufficient to account for them. Still less does he connect them with the effort or aspirations of any Organism after new faculties and powers. He frankly confesses that " our ignorance of the laws of variation is profound;" and says, that in speaking of them as due to chance, he means only " to acknowledge plainly our ignorance of the cause of each particular variatioji." J Again he says—" I believe in no law of necessary development." 2

This distinction between Mr. Darwin's theory and other theories of Development, has not, I think, been sufficiently observed. His theory seems to be far bette' than a mere theory—to be an established scientific truth—in so far as it accounts, in part at least, for the success and establishment and spread of new Forms when they have arisen. But it does not even suggest the law under which, or by which, or according to which, such new Forms are introduced. Natural Selection can do nothing except with the materials presented to its hands. It cannot select except among the things open to selection. Natural Selection can originate nothing; it can only pick out and choose among the things which are originated by some other law. Strictly speaking, therefore, Mr. Darwin's theory is not a theory on the Origin of Species at all, but only a theory on the causes which lead to the relative success or failure of such new Forms as may be born into the world. It is the more important to remember this distinction, because it seems to me that Mr. Darwin himself frequently forgets it. Not only does he speak of Natural Selection "producing" this and that modification of structure, but he undertakes to affirm of one class of changes that they can be produced, and of another class of changes that they cannot be produced by this process.1

Now, what are the changes for the preservation of which Natural Selection does, in some sense, account? They are such changes, and these only, as are of some direct use to the Organism in the "struggle for existence." Any change which has not this direct value, is not provided for in the theory. All structures, therefore, are unaccounted for—not only as respects their origin, but even as respects their preservation—in which the variations have no other value than mere beauty or variety. Accordingly, Mr. Darwin is tempted, as I have already had occasion to observe, to deny that any such structures exist in Nature. Any theory of which this denial is really a necessary part, is self-condemned. Yet a theory may be good as accounting for the preservation of some structures, although it fails to account for the preservation of others. And so the fact that Natural Selection cannot have operated on structures of mere beauty and variety is no proof that the theory of Natural Selection is false, but only that it is incomplete. It does not account for the origin of any structure; and it accounts for the preservation of only a certain number. Surely, then, Mr. Darwin assigns to his "law" of Natural Selection a range far wider than really belongs to it, when, on the strength of it, he denies that beauty for its own sake can be an end or object in Organic Forijis. He says—" This doctrine, if true, would be absolutely fatal to my 'theory." Why should this be fatal to his theory, except on the supposition that Natural Selection gives a complete account both of the Origin of new Forms, (of which, in reality, it gives no account at all,) and of their preservation, of which it does give some account, but one which is only partial? I dwell on this, because it lies at the very root of the question, how far Mr. Darwin's theory can be said to suggest anything in the nature of a Creative Law of a kind to explain the Method which ha? been followed in the introduction of new Forms.

We may test this question by bringing to bear upon it some particular example of specific variation. I select for this purpose one example, which will illustrate tie subject better than any abstract discussion. It is the case of the Humming Birds.

This group of Birds seems to exhibit, in the most striking form, not a few of those mysteries of Creation which at once tempt us to speculate on the Origin of Species, and at the same time confound every endeavour to bring it into relation with any process which we knew or can conceive. In the first place, they are sharply defined from all other forms in that Class of the animal kingdom to which they belong. It is most difficult to say what is their nearest affinity, and the nearest, when it is found, is very distant. Secondly, they are absolutely confined to one Continent of the Globe. In the third place, the various Species as amongst themselves are very closely united, ranging, indeed, over a great variety of forms, but for the most part connected with each other by very nice gradations. In the fourth place, there are, so to speak, some gaps in the scale, which suggest that some Species have either been lost, or have not yet been discovered. In the fifth place, each of these Species, however nearly allied to some other, appears to be absolutely fixed and constant, there being not the slightest indication of any mixture—of any hybrid forms. In the sixth place, there is the most wonderful adaptation of special organs for the performance of special functions, and for the relation of these organs to particular structures in the vegetable kingdom. In the seventh place, there is a development, for which, in extent and variety, there is no parallel in the world, of structures designed apparently for mere ornament, and entirely separate from any other known or conceivable use.

A few words on some of these characters will show their separate and joint bearing on the idea of Creation by Law.

In the first place, then, the absolute distinctiveness from all others of this Family of Birds, coupled with its immense extent, gives the idea of some common bond, some physical cause, to which such an identity in physical characters must be due. This identity prevails not only in such essential matters as the structure of the bill and tongue, in the form of the feet and of the wings, in the habits of flight, and in the nature of the food, but runs also into some very curious details, as, for example, in the number of feathers in the tail and in the wings, which are constant numbers—adhered to even when some of the feathers, not being used even for ornament, are reduced almost to rudiments. But under degrees of development which are very variable, the number is invariable. This identity of structure is the more remarkable from the immense extent of the group which it characterises. There are now known to science no less than about 430 different species of Humming Bird; and it cannot be doubted that many more remain to be discovered among the immense forests and mountain ranges of Central America.

Now, what is the bond that unites so closely, in a common structure, all the forms of this great Family of birds? We think it a sufficient explanation sometimes of the likeness of things, that they are made for a common purpose. And so it is an explanation in one sense, but not in another. It gives the reason why likeness should be aimed at, but not the cause or the means through which it has been brought about. Sameness in the purpose for which things are intend

a reason why those things should be made alike; but it is no explanation of the process to which the common aspect is due. It is an explanation of the "why;" but it is no explanation of the "how." Purpose is attained in Nature through the instrumentality of means; and community of aspect in created things suggests the idea of some common process in the creative work. Thus, the likeness which is due to common parentage serve:-; the most important purposes; but it is not the less the result of a physical cause, out of which it arises by way of natural consequence. The likeness of the Humming Birds to each other suggests this kind of cause. It is true that the organs which it principally affects are specially adapted for a special habit of life. They are fitted to enable the Bird to feed on the nectar, and the insects which frequent the nectar of flowers, or the leaves or bark of trees. But there are flowers and insects in abundance in other quarters of the globe where there are no Humming Birds.

And here we come on the curious facts of geographical distribution,—a class of facts which, as much as any other, suggest some specific methods as having been followed in the work of Creation. Humming Birds are absolutely confined to the great Continent of America with its adjacent islands. Within those limits there is every range of climate, and there are particular species of Humming Bird adapted to every region where a flowering vegetation can subsist. It is therefore neither climate nor food which confines the Humming Birds to the New World. What is it, then? The idea of " centres of Creation" is at once suggested to the mind. It seems as if the Humming Birds were introduced at one spot, and as if they had spread over the whole Continent which was accessible to them from that spot. They are absent elsewhere, simply because from that spot the other Continents of the world were inaccessible to them. But if these ideas are suggested to the mind by the general aspect of this family as a whole, they are strengthened by some of the facts which we discover when we examine and compare with each other the genera and species of which it is composed. There is a beautiful gradation between the different genera and the different species,—so much so, that it has been found impossible to divide the Humming Birds into more than two sub-families, from the absence of sufficiently well-marked divisions. And yet on the other hand, they cannot be arranged in anything like a continuous series, because some links appear to be missing in the chain.

But these general facts terminate in nothing more definite than a vague surmise. When we enter farther into details, we feel at once how little they agree with any physical law which is known or even conceivable iby us. If the likeness which prevails in the whole group reminds us of the likeness which is due to community of blood, it is equally true that the differences between the species are totally distinct, both in kind and degree, from the variation which we ever see arising among the offspring of the same parents. Let us look at what these differences are. The generic and specific distinctions between the Humming Birds are mainly of two kinds,—ist, Differences in the form of essential organs, such as the bill and the wings; and, Differences in those parts of the plumage which are purely ornamental. Now, of these two kinds of variation, the only one on which the law of Natural Selection has any bearing at all is the first. And on that kind of variation, the only bearing which Natural Selection has is this—that if any Humming Bird were born with a new form of bill, or a new form of wing, which enabled it to feed better and to range farther, then that improved bill and wing would naturally tend to be perpetuated by ordinary generation. This is unquestionably true; but it really does not touch the facts of the case. The bills and wings of the .different genera do not differ from each other in respect of any comparative advantage of this kind, but simply in respect to variety corresponding with the variety of certain vegetable Forms. One form of bill is as good as another, but some forms are adapted to some special class of flower. Some bills, for example, are formed of enormous length, specially adapted to obtain access to the nectar chambers of long tubular flowers, such as the Brugmansia. Some, on the other hand, as if to show that the same end may be attained by different means, obtain access to the same flowers by a shorter process, and pierce the bases of the corolla instead of seeking access by the mouth. Some have bills bent downwards like a sickle, adapted to searching the bark of Palm-trees for the insects hid under the scaly covering; others have bills curved in the opposite direction, fitted, apparently, to the curious construction of some of the great family of Orchids so immensely developed in the forests of Central America. Some have bills equally well adapted for searching a vast variety of flowers and blossoms, and these, accordingly, migrate with the flowering season, and, issuing from the great stronghold of the family in tropical America, spread like our own summer Birds of passage, northwards to Canada, and southwards to Cape Horn, in the corresponding seasons of the year. In contrast with these species of extended range, there are many species whose habitat is confined, perhaps to a single mountain, and there are a few which never have been seen 'beyond the edges of some extinct volcano, whose crater is now filled with a special flora. Many of the great mountains of the Andes have each of them species peculiar to themselves. On Chimborazo and Cotopaxi, and other summits, special forms of Humming Birds are found in special zones of vegetation even close up to the limits of perpetual snow. Again, many of the Islands have species

peculiar to themselves. The little island of Juan Fernandez, 300 miles from the mainland, has three species peculiar to itself, of which two are so distinct from all others known, that they cannot for a moment be confounded with any of them.1 It is impossible not to see, in such complicated facts as these, that the creation of new Species has followed some plan in which mere variety has been in itself an object and an aim. The divergence of form is not a divergence which can have arisen by way of natural consequence, merely from comparative advantage and disadvantage in the struggle for existence. Bills highly specialised in form are certainly not those which would give the greatest advantage to birds which have equal' access to the abundant Flora of an immense Continent. Some form of bill adapted to the probing or piercing of all flowers with almost equal ease, would seem to be the form most favourable to the multiplication and spread of Humming Birds. Continued approximation to some of common type would seem to be quite as natural a change, and a much more advantageous kind of change as regards advantage in the struggle for existence, than endless divergence and special adaptation to limited spheres of enjoyment . At all events, we may safely say that mere advantage, in Mr. Darwin's sense, is not the rule which has chiefly guided Creative Power in the Origin of these new Species. It seems rather to have been a rule having for its object the mere multiplying of Life, and the fitting of new Forms for new spheres of enjoyment, according as these might arise out of corresponding changes in other departments of the organic world.

If, now, we turn to the other kind of specific distinction between Humming Birds, viz., that which consists in differences in the mere colouring and disposition of the plumage, we shall find the same phenomena still more remarkable. In the first place, it is to be observed of the whole group that there is no connexion which can be traced or conceived between the splendour of the Humming Birds and any function essential to their life. If there were any such connexion, that splendour could not be confined, as it almost exclusively is, to one sex. The female Birds are of course not placed at any disadvantage in the struggle for existence by their more sombre colouring. Mere utility in this sense, therefore, can have had no share in determining one of the most remarkable of all the characteristics of this family of Birds. It is obviously beside the question to account, as Mr. Wallace and Mr. Darwin do, for the beauty of the Humming Birds upon the ground that the males are thus rendered more attractive to the females. This attractiveness can only operate as between different individuals of the same species, since no one ever heard of the females of a dull-coloured species wandering in their affection from their rightful lords to the more brilliant males of some other species. Every animal, however little beautiful it may be in our eyes, has sufficient attractiveness as between the sexes to secure the great object of the continuation of its race. Utility, indeed, in a different sense, can be quoted with probability, as accounting for the comparative plain colouring of females in this and in almost all other genera of Birds. But then it is Utility conceived as operating by way of motive in a Creative Mind, and not operating as a physical cause in the production of a mechanical result. And here we find Mr. Wallace instinctively testifying to this great distinction, and employing language which indicates the passage from one order of ideas to another. He says, "The Reason Why female birds are not adorned with equally brilliant plumes is sufficiently clear; they would be injurious by rendering their possessors too conspicuous during incubation."1 This is, no doubt, the true explanation of the purpose which the plain colouring of female Birds is intended to serve; but it is no explanation at all of the physical causes by which this special protection is secured.

Those who, by special study, have laid their minds alongside the Mind of Nature in any of her Provinces, have generally imparted to them a true sense, so far as it goes, in the interpretation of her mysteries. Let us then hear what Mr. Gould says on the beauty of the Humming Birds:—" The members of most of the genera have certain parts of their plumage fantastically decorated; and in many instances most resplendent in colour. My own opinion is, that this gorgeous colouring of the Humming Birds has been given for the mere purpose of ornament, and for no other purpose of special adaptation in their mode of life; in other words, that ornament and beauty, merely as such, was the end proposed." 2 Different parts of the plumage have been selected in different genera as

the principal subject of ornament. In some, it is the feathers of the crown worked into different forms of crest; in some, it is the feathers of the throat, forming gorgets and beards of many shapes and hives; in some, it is a special development of neck plumes, elongated into frills and tippets of extraordinary form and beauty. In a great number of genera the feathers of the tail are the special subjects of decoration, and this on every variety of plan and principle of ornament. In some, the two central feathers are most elongated, the others decreasing in length on either side, so as to give the whole the wedge form. In others, the converse plan is pursued, the two lateral feathers being most developed, so that the whole is forked after the manner of the common Swallow. In others, again, they are radiated or pointed and sharpened like thorns. In some genera there is an extraordinary development of one or two feathers into plumes of enormous length, with flat or spatulose terminations. Mere ornament and variety of form, and these for their own sake, is the only principle or rule with reference to which Creative Power seems to have worked in these wonderful and beautiful Birds. And if we cannot account for the differences in the general style and plan of ornament followed in the whole group, by referring them to any sort of use in the struggle for existence, still less is it possible to account, on this principle, for the kind of difference which separates from each other the different species in each of the genera. These differences are often little more than a mere difference of colour. The radiance of the ruby or topaz in one species, is replaced perhaps by the radiance of the emerald or the sapphire in another.

In all other respects the different species are sometimes almost exact counterparts of each other. As an example, let me refer to the two species figured by Mr. Gould as the Blue-tailed and the Green-tailed Sylphs; and also to two species of the " Comets," in which two different kinds of luminous reds or crimsons are nearly all that serve to distinguish the species.

A similar principle of variation applies in other genera, where the amount of difference is greater. For example, one of the most singular and beautiful of all the tribe is comprised within the genus Lophornis, or the "Coquettes." The principle of ornament in this genus is, that the different species are all provided both with brilliant crests, and with frills or tippets on the neck. The feathers of these' parts are generally of one colour, ending in spots or spangles of another; the spangles being generally of metallic lustre. There seems to be a rule of inverse proportion between the two kinds of ornament. The species which have the neck plumes longest have the shortest crests, and vice versa. In the shape and structure of all essential organs there is hardly any difference between the species.

One very curious example of variety for the sake of ornament may be mentioned in connexion with this wonderful family of Birds. It is a law—in the sense of an observed order of facts—regulating the ornament of Humming Birds, that where white is introduced into the colouring of the tail feathers, it is not applied to the central feathers, but is confined to the marginal feathers on either side. There is, however, one species (Urosticte Bengamint), recently discovered, which affords the only example yet known of a departure from this rule. It is a species in which white is one of the principal ornaments of the Bird, and is used in places where it can be placed in conspicuous contrast with the darkest tints. Tufts and lines of purest white shine among the greens and violets of the neck and head; whilst, in exquisite harmony with this, the four central feathers of the tail are alone dipped, as it were, in a solid glaze of the same white, and the marginal feathers on either side are kept wholly dark. Then, as if to mark with emphasis the meaning of this departure from the ordinary rule, it is a departure confined to the ornamented sex; and the Female Form of the same species follows the ordinary law—white being introduced in the marginal feathers, and in these alone.

Now, what explanation does the law of Natural Selection give—I will not say of the origin, but even of the continuance and preservation — of such specific varieties as these? None whatever. A crest of topaz is no better in the struggle for existence than a crest of sapphire. A frill ending in spangles of

the emerald is no better in the battle of life than a frill ending in 'he spangles of the ruby. A tail is not affected for the purposes of flight, whether its marginal or its central feathers are decorated with white. It is impossible to bring such varieties into relation with any physical law known to us. It has relation, however, to a Purpose, which stands in close analogy with our own knowledge of Purpose in the works of Man. Mere beauty and mere variety, for their own sake, are objects which we ourselves seek when we can make the Forces of Nature subordinate to the attainment of them. There seems to be no conceivable reason why we should doubt or question, that these are ends and aims also in the Forms given to living Organisms, when the facts correspond with this view, and with no other. In this sense, we can trace a creative law,—that is, we can see that these Forms of Life do fulfil a purpose and intention, which we can appreciate and understand.

But then it may be asked, has this purpose and intention been attained without the use of means? Have no physical laws been used, whereby these new forms of beauty have been evolved, the one from the other, in a series so wonderful for its variety in unity, and its unity in variety? I am not now seeking to answer this question in the negative. All I say is, that the physical laws which are made subservient to this purpose are entirely unknown to us. That particular combination of a great many natural laws, which Mr. Darwin groups under the name of Natural Selection, does not in the least answer the conditions which we seek in a law to account for either the origin or the spread of such creatures as the various kinds of Humming Birds. On the other hand, if I am asked whether I believe that every separate Species has been a separate creation—not born, but separately made—I must answer, that I do not believe it. I think the facts do suggest to the mind the idea of the working of some creative Law, almost as certainly as they convince us that ww know nothing of its nature, or of the conditions under which it does its glorious work. Our experience of the existing Order of Nature is, that the young of each species repeat the form and the colours of their parent, and that even where variations occur, they are inconstant, and tend to disappear. We have no knowledge, for example, that from the eggs of the Bluetailed Sylph a pair of Green-tailed Sylphs can ever be produced. We have no reason to believe that a species of Lophornis with a tippet of emerald spangles, can ever hatch out a pair of young adorned with spangles of some other gem. And yet we cannot assert that such phenomena are impossible, nor can it be denied that, as a matter of speculation, this process is natural and easy of conception, as compared with the idea of each Species being separately called into existence, out of the inorganic elements of which its body is composed.

Such new births—if they do take place—would perfectly fulfil, I think, the only idea we can ever form of new creations. For example, it would appear that every variety which is to take its place as a new Species must be born male and female; because it is one of the facts of specific variation in the Humming Birds, that although the male and female plumage is generally entirely different, yet the female of each Species is as distinct from the female of every other, as the male is from the male of every other. If, therefore, each new variety were not born in couples, and if the divergence of Form were not thus secured in the organisation of both the sexes, it would fail to be established, or would exhibit for a time the phenomena of mixture, and terminate in reversion to the original type. Now here again we have the emphatic declaration of Mr. Gould, that among the thousands of specimens which have passed through his hands, from all the genera of this great family, he has never seen one case of mixture or hybridism between any two Species, however nearly allied. But this passage is so important, that I quote it entire. " It might be thought by some persons that four hundred species of birds so diminutive in size, and of one family, could scarcely be distinguished from each other - but any one who studies the subject, will soon perceive that such is not the case. Even the females, which assimilate more closely to each other than the males, can be separated with perfect certainty; nay, even a tail-feather will be sufficient for a person well versed in the subject to say to what genus and species the Bird from which it has been taken belongs. I mention this fact to show that what we designate a Species has really distinctive and constant characters; and in the whole of my experience, with many thousands of Humming Birds

passing through my hands, I have never observed an instance of any variation which would lead me to suppose that it was the result of a union of two species. I write this without bias, one way or the other, as to the question of the Origin of Species. I am desirous of representing Nature in her wonderful ways as she presents herself to my attention at the close of my work, after a period of twelve years of incessant labour, and not less than twenty years of interesting study."1

If, therefore, new Species are born from the old, it is not by accidental mixture; it is not by the mere nursing of changes advantageous in the battle of life; it must be from the birth of some one couple, male and female, whose organisation is subjected to new conditions corresponding with each other, and having such force of self-continuance as to secure it against reversion. It matters not how small the difference may be from the parent Form; if that difference be constant, and if it be associated with some difference equally constant in the female Form, it becomes at once a new Species. There are some cases mentioned by Mr. Gould which may possibly be examples of the first founding of a new Species. In the beautiful genus Cynanthus, he tells us that there are some local varieties near Bogota, in which the ornament is partially changing from blue to green; and it is a curious fact that this variation appears to be taking effect under the direction of some definite rule or " law,"—inasmuch as it is only the eight central feathers of the tail which are tipped with the new colour. Mr. Gould expressly says of one such variety from Ecuador, that it possesses characters so distinctive as to entitle it, in his opinion, to the rank of a separate Species. The very discussion of such a question shows the possibility of new births being the means of introducing new Species. But my object here is simply to point out that Mr. Darwin's theory offers no explanation of such births, either as respects their origin or their preservation, neither does it even approach to tracing these births to any physical law whatever. It fails also to recognise, even if it does not exclude, the relation which the birth of new Species has to the mental purpose of- producing mere beauty and mere variety. Nevertheless it may be true that ordinary generation has been the instrument employed; but if so, it must be employed under extraordinary conditions, and directed to extraordinary results.

It will be seen, then, that the principle of Natural Selection has no bearing whatever on the Origin of Species, but only on the preservation and distribution of Species when they have arisen. I have already pointed out that Mr. Darwin does not always keep this distinction clearly in view, because he speaks of Natural Selection "producing" organs, or "adapting" them. It cannot be too often repeated that Natural Selection can produce nothing whatever, except the conservation or preservation of some variation otherwise originated. The true Origin of Species does not consist in the adjustments which help varieties to live and to prevail, but in those previous adjustments which cause those varieties to be born at all. Now what are these? Can they be traced or even guessed at? Mr. Darwin has a whole chapter on the Laws of Variation; and it is here, if anywhere, that we look for any suggestion as to the physical causes which account for the Origin as distinguished from the mere Preservation if Species. He candidly admits that his doctrine of Natural Selection takes cognisance of variations only after they have arisen, and that it regards those variations as purely accidental in their origin, or, in other words, as due to chance. This, of course, he adds, is a supposition wholly incorrect, and only serves " to indicate plainly our ignorance of the cause of each particular variation." Accordingly, the Laws of Variation which he proceeds to indicate are merely, for the most part, certain observed facts in respect to Variation, and do not at all come under the category of Laws, in that higher sense in which the word Law indicates a discovered method under which Natural Forces are made to work. There is, however, in this chapter, one Law which approaches to a Law in the higher sense. Mr. Darwin, whilst candidly confessing our profound ignorance of the cause or origin of varieties, yet groups together a great class of facts as connected by a tie which he calls the " Correlation of Growth." Now what is this law—this observed Order of facts? It is, that variation in one part of an organism is, as a rule, accompanied with corresponding variations in other parts, and especially in those parts which are " homologous," that is to say, which occupy the same relative place in the general Plan.

This, however, is but a very imperfect definition of the vast Order of mysterious facts which are covered by the words, "Correlation of Growth." The fundamental idea which these words express is an Idea of wider and deeper significance in Nature, than Mr. Darwin seems to have perceived. There is a correlation between all natural organic growths; that is to say, that any variation of form in a single part has a constant relation to 'other variations of form in some other part or parts of the same organism. But "relation " is a vague word. There are many kinds of " relation"—there are indeed an infinite variety of kinds. What is the kind of relation that we detect in Correlated Growths? It is not until we ask ourselves this question that we discover what a deep question it is—how endless are the avenues of thought and of inquiry which it opens up.

First, one relation which we detect in all variations of organic growth, is simply the relation of symmetry. This kind and degree of Correlation of Growth prevails even in the world which we call Inorganic. The corresponding sides and angles of a crystal, for example, may be said to be correlated together. The nature of this relation is geometrical and numerical. It is a relation having reference to invariable rules of number. As regards its physical cause, all we can say is, that it is the result of forces whose property it is 'to aggregate the particles of matter in definite forms, which forms are symmetrical— that is to say, they are forms having an axis with equal developments on either side. Correlation of Growth, therefore, in this sense points to the work of Forces, one of whose essential properties is Polarity—-that is, equal and similar action in opposite directions. Now, this kind of Correlation of Growth may be traced upwards from simple Minerals through all the infinite complications of the organic world. It is unquestionably the basis of many of the Correlations of Growth prevailing in Plants and Animals. It is seen in the symmetrical arrangement of all vegetable and of all animal Forms. A central axis is traceable in them all; and the Bilateral or Radiated arrangement of their subordinate parts is one of the most fundamental and universal of all the Correlations of Growth.

This is one, but it is one only, of the Correlations of Growth which are constantly observed. It would lead us to expect that any change of form on one side of an animal would be accompanied by an exactly corresponding change on the other side: so that limbs on one side of the central axis, if changed at all, would change in exact and symmetrical accordance with the limbs on the opposite and corresponding side. This, accordingly, is one of the Correlations of Growth most constantly observed.

Now, it will be seen that Correlation of Growth, in this first and simplest sense, runs alongside, as it were, of Correlation in another and higher sense. The relation between two equal and opposite growths, which is a relation, in the first place, of simple symmetry as between themselves, is always accompanied by another relation, in the second place, of correspondence or fitness as between these growths and external conditions. An organism which is developed unsymmetrically, unequally, would be not only ugly in its form, but it would be maimed and imperfect in its functions. Here, then, we see one kind and one idea of Correlation rising above another. Two growths might be correlated as regards each other, and might yet be wanting in any corresponding correlation of fitness and of function towards outward things. But the first of these two kinds of correlation would be useless without the last. And this last is obviously the higher and more complex Correlation of the two. It is higher, not only in the sense of being more complex, but as involving an idea which lifts us at once from a lower to a higher region of thought. Growths correlated as between each other according to mere symmetry of arrangement suggest nothing, except the work of Forces with inherent Polarity of action. But growths correlated with things outside the organism in which those growths occur,—and which can exert no physical effect upon it,—suggest at once the operation of Forces working under Adjustment with a view *o Purpose.

When we see a Mineral salt crystallising under the power of a Voltaic Current, we see Correlation of Growth in its simplest form, and in visible connexion with its immediate cause. The particles of salt are marshalled in a constant Order—an Order, the principle of which is some central axis, with branches and branchlets grouped around it in equal and exquisite arrangement. Wonderful as this arrangement is, it suggests no other question to the mind than that which may be asked in respect to the ultimate nature and source of Polarity in Magnetic Force. But when we see two growths in an organism which not only are correlated to each other with reference to a centre, but are correlated also to external things with reference to Function, we see something which raises questions altogether different in kind. We have passed at once from the region of the What, and the How, into the region of the Why. The one kind of Correlation has reference to Physical Causes, the other kind of correlation has reference to those Mental Purposes which Physical Causes are made to serve. These two kinds of Correlation are perfectly distinct. They are as distinct as the correlation of equal pressures which a given volume of steam exerts upon the opposite sides of a boiler is distinct from the correlation between that pressure and its conversion into the driving-force of cranks and wheels, with all their adaptations for running on the rails, or for paddling in the sea. They are as distinct as the correlations of force developed in a Voltaic Battery are distinct from the adjustments which convert those forces into the means of communicating Thought.

Mr. Darwin has not pointed out this distinction clearly. Indeed, he does not seem to have had it in his view. He groups under one name,—the Correlation of Growth,—two classes of Phenomena, which are indeed always combined in fact, but which are entirely separate in idea. Correlation of Growth, in one sense, is that law of vital force which secures that any change in the shape of one limb in an animal shall be accompanied by a corresponding change in all the other limbs. Correlation of Growth in the other sense, is that adjustment of vital forces to the contingencies of external circumstance, which secures that all the changes which do take place shall be changes adapted to the discharge of new functions—to the fulfilment of new conditions of life—to command over new sources of enjoyment.

Keeping, then, clearly in our view the distinction between these two different kinds of Correlation of Growth, let us look at the phenomena actually presented in the aspect and history of Organic Forms, as respective of both these kinds of Correlation.

As regards the first kind of Correlation, I have referred to the law of Bilateral Symmetry as the simplest and most obvious illustration. It is a law which at once connects itself with the idea of Polarity of Force. But though this be one kind of Correlation, almost universal, and may very probably be the foundation of every other, there are many Correlations of Growth between which and mere Polarity there is no visible connexion. The truth is that all the parts of an organism are bound together as one whole by a pervading system of correlations as intricate as they are obscure. When the organism is in health, and all its parts are working in harmony, the wonder of these correlations is not perceived. But they are brought out in a marked degree by the phenomena of disease, and also by the phenomena of monstrosity or malformation. The " sympathy " which the most distant and apparently unconnected parts of an organism show with each other, when one of them is affected by disease, is the index of correlations whose nature is utterly beyond the reach of our anatomy. It is the same with malformations. Mr. Darwin mentions one case of curious unintelligible correlation—viz., that a blue iris is associated in Cats with deafness; and, again, that the tortoise-shell colour of the fur is associated, with the female sex in the same animal. In like manner the bright colours, and the more conspicuous ornaments of plumage in Birds, are correlated with the male sex. So likewise are vocal organs with the wonderful gift of song. In many insects the differences of form which are correlated with the differences of sex, are far greater than the differences which separate species and even genera. There are insects of which the male is a fly, whilst the female is a worm. There are many other cases of correlation between different growths in respect to which the nature and source of the connexion is equally unknown. For example, the

complex stomachs of the Ruminant Order are uniformly associated with a particular form of hoof. Sometimes correlations the most constant and invariable are at the same time the most subtle and the most secret, because they are hid under other growths which are not so correlated, and which produce total diversities of outward aspect. One very curious class of correlations is the correlation between the internal structure of the teeth in animals, and the structure of other very distant portions of their frame. There lately was, for example, in the Zoological Gardens, a little animal, the Hyrax, not unlike a Rabbit in general appearance, and very like it in habit. It is the " Cony" of Scripture. Now this little animal will be found on examination to have limbs which do not terminate in a foot like a Rabbit, but in a divided hoof of peculiar form.

This hoof is in miniature like the hoof a Rhinoceros. If next we examine the teeth of the Hyrax we shall find that the materials of these teeth are also combined in the same manner, and after the same pattern as the teeth of the Rhinoceros. So it is with other parts of the same two animals. Along with the teeth and the hoofs there are certain other shapes of bones which seem to be under the same bond of likeness. Now these are Correlations of Growth between different parts of the same animal, and between the corresponding parts in two different species.

The conception, then, which we are led to form by this kind of Correlation between organic growths, is more complex than we had at first supposed. Mere Polarity of Force, leading to equal and opposite arrangement of subordinate parts, is not enough to satisfy the facts. This, indeed, may continue to be the type to which our thoughts refer, and by which we are helped to some more adequate idea of the facts. But the general impression left on the mind is this—that some One Force directs the form and structure of every organism, so that any change in one part of it is but the index of changes which run visibly or invisibly throughout the whole. The growths between which we detect a correlation, are not really separate things connected only by the few correspondences which we may be able to detect, but are part and parcel of one operation, the result of one Force, exerting its energies through channels which we cannot see, and according to laws of which we can form but a distant and faint conception. The truth is that Correlation in this sense is involved in the very word " Growth." Each part of every structure which is the result of growth must be correlated to every other part. This is essential to the very idea of growth, and to the very idea of an organism due to growth. When, therefore, Mr. Darwin says that one of the laws on which variation of form depends is Correlation of Growth, he simply says that variations of Growth depend on growth —for all growths must be correlated.

But Correlation in this sense helps but a little way indeed in conceiving the origin of a new Species/ There might be the most minute and perfect harmony between the changes effected in an animal newly born without those changes tending even in the most remote degree towards the establishment of a new Form of Life. In order to that establishment there must be another correlation, and a correlation of a higher kind.' There must be a correlation between those changes and all the outward conditions amidst which the new Form is to be placed and live. If this correlation fails the new Form will die. Yet, so far as we can see, this kind of correlation is without any physical cause. It is not necessarily involved, as the other kind of correlation is, in the very idea of Growth. On the contrary, it is not only entirely separable in thought, but, as we see in monstrosities, it is sometimes separated in fact. We have no conception of any Force emanating from external things which shall mould the structure of an organism in harmony with themselves. Mr. Darwin freely confesses this, and says that many considerations " incline him to lay very little weight on the direct action of the conditions of life" in producing variety of Form. We can conceive, dimly indeed, but still we can conceive, how in the Humming Birds a special form of Wing shall be correlated with a special form of Bill. But we have no conception whatever how a special form of Bill should be correlated with a special form of Flower from which the Bill is to extract its food. Mr. Darwin has shown how an improved Bill, when once produced, will be preserved by finding external

conditions to which it is adapted. But he has not shown, and he frankly confesses he has no idea, how the adapted variation of Bill conies to be born at all.

Yet it is this higher and more complex Correlation which is the most constant and the most obvious of all the facts of Nature. In these facts we see that the forces of Organic Growth are worked under rules of close adjustment to external conditions; and that particular shapes which might seem inseparably associated, if we looked at one Genus or one Family alone, are at once disjoined where different adaptations to Function are required. Let us take another example from the great Class of Birds. If we were to look only to the family of the Atiatida (Ducks and Geese), we might suppose that there is a constant Correlation of Growth between webbed feet and spoon-shaped bills. But the real and efficient Correlation of Growth in this case is not between the spoon-bill and the web-foot, but between both of these and certain external conditions of life. The web-foot is correlated to an aquatic habitat: and the spoon-bill is correlated to spoon-food. And accordingly this association of form in foot and bill is at once dissolved where different external functions require a separation. In the Gulls, the Fulmars, and the Petrels, the web-foot is retained, because action upon the element of water is still required; but the correlated form of bill vanishes, and shapes altogether different are given,— shapes adapted, that is correlated, to different kinds of food, and to different methods of capture.

Again, there is another great family of Birds where some of the same forms are correlated with other forms entirely different, because of the different external Cor relations which are required by Function. In the Divers the web-foot is mounted upon a flattened leg-bone, with the sharp edge set " fore and aft." Now what is this Correlation of Growth? It is, first, the Internal Correlation of those parts to each other, but secondly and principally, it is the External Correlation of both to their function of propelling under water. The form of the foot is correlated to the function of opposing the largest possible area of resistance to that medium, exactly where, for the purpose of swimming, the maximum of resistance is required; the knife-shaped leg-bone is correlated to the function of opposing the least possible resistance, precisely where, for the same purpose, the minimum of resistance is required. In Australia we have, in the Ornithorynchus paradoxus, the webbed feet correlated with the Duck-shaped Bill in an animal which does not belong to the Class of Birds at all.

There is another case of what may be called Correlated Correlations, which brings out very clearly the distinction which is so important in the philosophy of this great subject. Feathers are a kind of covering peculiar to the Class of Birds. Under every variety of modification they have one fundamental plan—a central shaft or quill to which lateral filaments are attached. Now there is a vast range of correlations between the different kinds of feather and the different Families or Species, and between different parts of the body in the same Species. But there are two Correlations of Growth in respect to feathers which are constant. In all cases, (excepting, of course, the Wingless Birds,) the feathers which grow from the fore-arm and finger-bones, constituting the Wings, are comparatively long, strong, tapering, elastic, and with thin lateral filaments, which filaments are closely hooked together by means of minute teeth fitting into each other, so that the whole shall form one continuous surface or web. This is a Correlation of Growth between one particular kind of feather, and one particular member of the body, which, in all Birds capable of flight, is constant, and amounts to a universal Law. Now let us contrast this with another Correlation of Growth which is equally constant. On the side of the head of all Birds, there is a patch of feathers of peculiar structure, with fine and slender shafts, and with the lateral filaments not hooked together as in the other case, but, on the contrary, always separated from each other— the whole series forming a fine and open network spread over the surface which they cover and protect. These feathers cover the orifice of the ear, and are called the auriculars. They are correlated with the curious passages, the finely hung clapper-bones, and all the elaborate mechanism of that organ. Such are the Internal Correlations. But they are intelligible only when

considered in the light shed by other correlations which are external. The wing feathers with close continuous webs are correlated to the laws by which the passage of air may be prevented—the auricular feathers, with open unconnected webs, are correlated to the laws by which the passage of sound may be rendered easy. The one set of feathers are adapted to the active function of evoking and resisting atmospheric pressure by striking strong, yet light and elastic blows, upon the air—the other set of feathers are adapted to the passive function of allowing the free access of the waves of sound into the passages, of the ear. These are but a few examples Out of millions. Throughout the whole range of Nature the system of Internal Correlation is entirely subordinate to the system of External Correlation. Forms or growths which are inseparably joined with each other in one group of animals, are wholly divorced from each other in another group; whereas Forms which have correlations adapted to external conditions, are repeated over and over again across the widest gaps in. the scale of Natural affinity.

If, then, it be true that New Species are created out of small variations in the form of Old Species, and this by way of Natural Generation, there must be some bond of connexion which determines those variations in a definite direction, and keeps up the External Correlations pari passu with the Internal Correlations. Natural Selection can have no part in this. Natural Selection seizes on these External Correlations when they have come to be. But Natural Selection cannot enter the secret chambers of the womb, and there shape the new Form in harmony with modified conditions of external life. How, then, are these external correlations provided for beforehand? There can be but one reply. It is by Utility, not acting as a Physical Cause upon organs already in existence, but acting through Motive as a Mental Purpose in contriving organs before they have begun to be. And where obvious utility does result, the only connecting Bond which can be conceived as capable of maintaining the Internal Correlations in harmony with the External Correlations, is the Bond of Creative Will giving to Organic Forces a foreseen direction. It is, in short, precisely the same bond which in all mechanism produces Structure in harmony with intended Function.

Hence it is that scientific men, ip seeking expression for the ultimate ideas arrived at in the course of Physical research, find themselves compelled to borrow the language of Mechanical Invention. There is no other language which conveys an impression of the facts, or of the tie by which the facts are connected with each other. In the first chapter of this work I have had occasion to point out how true this is of Mr. Darwin's description of the Orchids, and of the curious functions of their structure. The correlations there are all external. But the same result appears in every other department of Science. In a remarkable paper on the " Constitution of the Universe," Professor Tyndall has occasion to speak of the non-luminous rays of heat emitted by all incandescent bodies,—rays which, though intensely hot, are altogether insensible to the eye. Now the Retina of the eye is a piece of mechanism whose Correlations are essentially External. It is the expansion of a special nerve whose function it is to be sensitive to certain particular vibrations, and to no other vibrations whatever. Light itself, therefore, is discovered to be merely a relative term—a word, in short, denoting nothing but an external Correlation between the Retina and vibrations of a certain kind and quality. Now what is the language which Professor Tyndall is constrained to use in explanation of facts so difficult of conception? It is the language of Mechanism, of mental Purpose and Design. " It is not," he says, " the size of a wave which determines its power of producing light; it is, broadly speaking, the fitness of the wave to the Retina. The ethereal pulses must follow each other with a certain .rapidity of succession before they can produce light, and if their rapidity exceed a certain limit, they also fail to produce light. The Retina is attuned, if I may use the term, to a certain range of vibrations, beyond which, in both directions, it ceases to be of use." These are indeed wonderful Correlations which reveal to us fittings and adjustments of which we had no previous conception: but they give us no glimmering even, of knowledge as to the physical causes which have "attuned " a material organ so as to catch certain ethereal pulsations in the external world, and to make these the means of conveying to Man's Intelligence the enjoyment and the power of sight.

It will be seen, then, that when Mr. Darwin speaks of the Law of Correlation of Growth as a Law which determines variation in organic growths, he is really presenting to us under one phase two separate ideas which are radically distinct. One is the idea of different growths in the same organism, corresponding with each other in respect to arrangement,—or in respect to texture, or in respect to form,—or to some other point of comparison. The other idea is that these growths (each and all) correspond with the conditions of external nature in such a way as to fit them for the discharge of Function with some new adaptation, and consequently with some new advantage. In one aspect the Law of Correlation of Growth is (or at least may probably be) a Law in the strictest sense of the word; that is to say, the result of a Force acting according to its own definite modes and measures of operation. But the Law of Correlation of Growth in the other aspect, is a law only in the sense (i) of an observed order of facts; and (2) of that Order depending on Adjustment with a view to Purpose.

Many naturalists have spoken of the facts of organic likeness as sufficiently accounted for by referring them to Adherence to Type. Mr. Darwin complains that this phrase, as an explanation of organic likeness, is no explanation at all, but amounts only to a re-statement of the facts in another form of language. This is true; but it is equally true of his own phrase of Correlation of Growth.

NOTE: 1 Mr. Wallace traces the whole Darwinian theory to six "general laws of the simplest kind—laws which," he emphatically adds, "are in most cases mere statements of admitted facts," Again he says, "This series of facts or laws are mere statements of what is the condition of nature."

"Adherence to Type" is not in the nature of a Physical Cause, but in the nature of a Mental Purpose. It is no explanation, therefore, to those faculties of the mind which seek for Methods of operation. In like manner " Correlation of Growth," in the only sense in which it is possible to connect it with the Origin of Species, is not a Physical Cause, but a Mental Purpose. ' The physical means by which that purpose is secured remain as dark as ever; and such of them as are conceivable by us, are seen, like all other physical forces, working to order, subject to direction, and having that direction determined by foresight, forethought, and contrivance.

Correlation of Growth, in the sense of external adaptations, may be said to be the most universal of all the Laws of Nature. But it accounts for the Origin of Organic Forms only in the same sense in which it accounts for the origin of all other phenomena, which in their result exhibit adaptations, or fittings into use and service. Let us take, as an example, the origin, nature, and capacities of Coal. That substance is correlated in a truly wonderful manner with the needs, the powers, and the capacities of Man. It contains within itself, in a form condensed and portable, a store of physical Force of incredible amount. The particles of one pound weight of it are held together by a Force which, when liberated and applied in the form of heat, is capable of lifting one million times its own weight to the height of one foot.1 No other substance known to Man is to be compared with this as a furnisher of Force. This is its function in the world. It is a function relating to Man's mechanical and inventive powers; and coal has been rendered capable of discharging this function by processes of preparation which began millions of ages before Man was born. But these External Correlations are a result arising by way of natural consequence out of certain physical causes working to order, that is to say, out of Internal Correlations of Growth between Solar Heat and Vegetable Structure, and again between these and the causes which occasion interchange between sea and land. No explanation so definite as this can be given of the method in which Vital Forces are made to evolve a new Form of Life. But even if such explanation could be given, it would render no account at all of the fittings of that Form into the outward requirements of its life. These are Correlations which in their very nature belong to Mind, are the work of Mind, and are intelligible only in the light of Mind.

I do not represent this conclusion as one necessarily adverse to Mr. Darwin's Theory on the Origin of Species. It is a conclusion which he would probably be willing to accept. I only desire to point out in how very limited a sense that Theory can be said to trace Creation to a " Law " at all, and how entirely inadequate that Theory is to account by any physical cause for the Origin of Species.

The only senses, therefore, in which we get any glimpse of Creation by Law are these—1st, That the close physical connexion between different Specific Forms is probably due to the operation of some Force or Forces common to them all; 2nd, That these Forces have been employed and worked, with others equally unknown, for the attainment of such ends as the multiplication of Life, in Forms fitted for new spheres of enjoyment, and for the display of new kinds of beauty.

Is there anything in this conclusion to conflict with such knowledge as we have from other sources of the nature and working of Creative Power? I do not know on what authority it is that we so often speak as if Creation were not Creation unless it work from nothing as its material, and by nothing as its means. We know that out of the " dust of the ground "—that is, out of the ordinary elements of Nature—are our own bodies formed, and the bodies of all living things. Nor is there anything which should shock us in the idea that the creation of new Forms, any more than their propagation, has been brought about by the use and instrumentality of means. In a theological point of view it matters nothing what those means have been. I agree with M. Guizot, when he says that " Those only would be serious adversaries of the doctrine of Creation who could affirm that the universe—the earth, and Man upon it—have been from all eternity, and in all respects, just what they are now."1 But this cannot be affirmed except in the teeth of facts which Science has clearly ascertained. There has been a continual coming-to-be of new Forms of Life.2 This is Creation, no matter what have been the laws or forces employed by Creative Power.

The truth is, that the theory which fixes upon Inheritance as the cause of organic likeness, startles us only when it is applied to Forms in which unlikeness is more prominent than resemblance. The idea, for example, that the different kinds of Pigeon, or of Humming Birds, have all descended through successive variation from some one ancestral pair, whether it be true or not, would not startle any one. Yet, if this be true, we must be prepared for the same surmise extending farther. The advocates of Development urge that Time is a powerful factor. They say that if changes small, but constant enough, and definite enough, to constitute new Species, can and do arise out of born varieties, it is impossible to fix the limits of divergence which may be reached in the course of ages. It does not follow, on the other hand, that there is no such limit because we cannot fix it. It does not necessarily follow that because we admit the idea of the Rock-dove, and the Turtle-dove, and the Ring-dove being all descended from one ancestral Pigeon, we are bound to accept the idea of the Whale, and the Antelope, and the Monkey being all descended from some one primeval Mammal. Mr. Darwin says, truly enough, that Inheritance " is that cause which alone, as far as we positively know, produces organisms quite like, or nearly like, each Other." But this is no reason why we should conclude that Inheritance is the only cause which can produce Organisms quite unlike, or only very partially like each other. We are surely not entitled to assume that all degrees and kinds of likeness can arise only from this single cause. Yet until this extreme proposition be proved, or rendered probable, we have a sound scientific basis for doubting the application of the theory, precisely in proportion to the unlikeness of the animals to which it is applied.

And this is the ground of reasoning, besides the ground of feeling, on which we revolt from the doctrine as applied to Man. We do so because we are conscious of an amount and of a kind of difference between ourselves and the lower animals, which is, in sober truth, immeasurable, in spite of the close affinities of bodily structure. Yet the closeness of these affinities is a fact; and it may with truth be said that in contrast with the gulf of separation in all resulting characters, these affinities are among the profoundest mysteries of Nature. Professor Huxley, in his work on " Man's Place in Nature," has endeavoured to prove that, so far as mere physical structure is concerned,

"the differences which separate him from the Gorilla and the Chimpanzee are not so great as those which separate the Gorilla from the lower Apes." On the frontispiece of this work he exhibits in series the skeletons of the Anthropoid Apes and of Man. It is a grim and grotesque procession. The Form which leads it, however like the others in general structural plan, is wonderfully different in those lines and shapes of Matter which have such mysterious power of expressing the characters of Mind. And significant as those differences are in the skeleton, they are as nothing to the differences which emerge in the living creatures. Huxley himself admits that these differences amount to " an enormous gulf,"—to a " divergence immeasurable —practically infinite." What more striking proof could we have than this, that Organic Forms are but as clay in the hands of the Potter, and that the " Law" of Structure is entirely subordinate to the " Law " of Purpose and Intention under which the various parts of that structure are combined for use?

But Science will continue to ask, even if she never gets an answer, What is the community of physical cause which produces this community of resulting structure? The fact which it is most difficult to disengage from the theory of Development, or, in other words, from the theory of Creation by Birth, is the existence of rudimentary or aborted organs; the existence of teeth, for example, in the jaws of the Whale—teeth which never cut the gum, and which are entirely useless to the animal. We have an inherent conviction that this must have some use in the future,—that is, in some organism to be born from this one,—or else it must have had some use in the past,—that is, in some organism from which this one has descended. In either case the power of Inheritance is suggested to the mind. We think instinctively of the existence of some Derivative Form in which these teeth have been, or are to be turned to use. It is only fair towards the Theory of Creation by Birth, to admit that it does explain the existence of useless organs in a sense in which no other Theory explains them. It would be almost a necessary consequence of Creation by Birth, that there must be stages in which the ultimate use of new Forms could not be yet apparent. And if mere beauty or variety were in themselves objects which Creative Power sets before itself, then, also, we might expect to meet with modifications of structure having no other apparent use. Both these explanations, however, exclude Mr. Darwin's idea of Natural Selection; because this is a process which can never operate, except through the agency of actual use and disuse, upon organs already existing and capable of discharging function. The only theory of Creation by Birth which really does afford some explanation of the facts, is a theory which assumes modifications of structure to be entirely independent of the effect of actual use or disuse. Mr. Darwin himself candidly admits that in flowers, at least, the forces of Correlated Growth do " modify important structures independent of Utility, and therefore of Natural Selection." This admission must be extended to all organic growths. There must have been a time with all of them when they began to be; and, therefore, a time before Natural Selection had room to play. These considerations, however, only serve to put a higher interpretation on the Theory of Creation by Birth. They do not condemn it.

One suggestion, indeed, has been made on this subject which I think it is impossible to accept. When men were yet unwilling to admit the existence of life and death upon the globe so long before the creation of Man, it used to be said that fossils were only " sports of nature." So in our own day, I have heard it said that rudimentary organs are merely intended to satisfy that condition of our finite minds in virtue of which we are unable to conceive Creation, except in connexion with some History and Method of growth. And so, as a condescension to this weakness, aborted members are given to suggest a History which was never true, and a Method which was never followed! Now of one thing we may be sure, that there are no fictions of this kind in Nature, and no bad jokes. Whatever natural things really point to, they point to faithfully; and the conclusions really indicated are never false. Abortive organs mean something, and they mean it truly.

Still, there is no proof that Inheritance is the only cause from which such structures can arise. In the inorganic world we know that not mere similarity, but absolute identity of form, as in crystals, is the result of laws which have nothing to do with Inheritance, but of forces whose nature it is to

aggregate the particles of matter in identical shapes. It is impossible to say how far a similar unity of effect may have been impressed on the forces through which vital Organisms are first started, ^a their way. There are some essential resemblances en a11 Forms of Life which it is impossible even in ima§Pati°n to connect with community of blood by descent, ^'or example, the Bilateral arrangement is common to >U Organisms, dow» at least to the Radiata, and in this great class we have the same principle of Polarity developed in a circle. Again, the general mechanism of the digestive organs by which food is in part assimilated and part rejected, is also common through a range of equal extent. Indeed, it may be said with truth, that never in all the changes of Time has there been any alteration throughout the whole scale of Organic Life, in the fundamental principles of chemical and mechanical adjustment, on which the great animal functions of Respiration, Circulation, and Reproduction, have been provided for.1 These are fundamental similarities of plan, depending probably on the very nature of Forces which necessitate these adjustments in order to the production of the phenomena of Life—Forces of which we know nothing, but which we have not the slightest reason to suppose to be due to Inheritance. Other similarities of plan may depend on the same laws, equally unconnected with Inheritance by descent.

Inheritance, indeed, has been suggested as the cause of organic likeness, mainly because there is a difficulty in conceiving any other. But there is at least an equal difficulty in conceiving the applicability of this cause to Man. We have already seen2 that M. Guizot lays it down as a physical impossibility that Man—the human pair—can have been introduced into the world except in complete stature—in the full possession of all his faculties and powers. He holds it as certain that on no other condition could Man, on his first appearance, have been able to survive and to found the human family. Even those who question whether this argument is entitled to the rank of a self-evident physical truth, must admit that it is at least quite as good as the opposite assertion, that any origin except the origin of natural birth is inconceivable. Where our ignorance is so profound, no reasoning of this kind is of much value. There is undoubtedly much to be said in support of M. Guizot's position. Certainly, Man as a mere animal is the most helpless of all animals. His whole frame has relation to his mind, and apart from that relation, it is feebler than the frame of any of the brutes. All its members are Correlated amongst each Other with the functions of his Brain, so that action may follow upon Knowledge—so that embodiment may be possible to Thought. Yet in its plan and structure his frame is homologically, that is ideally, the same as the frame of the brutes—organ answering to organ, and bone to bone.

The words "Adherence to Type" are words expressive of an Idea, of a Purpose, which we see fulfilled in Organic Forms. But this purpose must have sought its own accomplishment by the use of means, and the question of Science always is, what were these means? Love of beauty is equally a Purpose which we see fulfilled in Nature, but in the case of the Humming Birds this has been accomplished by giving to their plumes the structure of "Thin Plates,"—a structure which decomposes light and flings back its prismatic colours to the eyes. Fitness and special adaptation is another of the purposes of Creation, but this also is attained through the careful arrangement, and pliability to use, of physical laws. In like manner, "Adherence to Type" is the expression of a fact, or the statement of a Purpose, which, like all the other purposes fulfilled in Nature, invites to an investigation of the instrumentality employed. We see the Purpose, but we do not see the Method. We see the purpose, for example, in the wonderful adaptability of the Vertebrate Type to the infinite varieties of Life to which it serves as an organ and a home. Science should be allowed without suspicion or remonstrance to pursue her proper object, which is to detect, if she can, what the method of this work has been. There is no point, short of the last and highest, at which Science can be satisfied. Her curiosity is insatiable. It is a curiosity representing man's desire of knowledge. But that desire extends into regions where the means of investigation cease, and in which the processes of Verification are of no avail. Above and behind every Detected Method in Nature there lies the same ultimate question as before—What is it by which this is done?

It is the great mystery of our Being that we have powers impelling us to ask such questions on the history of Creation, when we have no powers enabling us to solve them. Ideas and faint suggestions of reply are ever passing across the outer limits of the Mind, as meteors pass across the margin of the atmosphere, but we endeavour in vain to grasp or understand them. The faculties both of reason and of imagination fall back with a sense of impotence upon some favourite phrase— some form of words built up out of the materials of analogy, and out of the experience of a Mind, which, being finite, is not creative. We beat against the bars in vain. The only real rest is in the confession of ignorance, and the confession, too, that all ultimate physical Truth is beyond the reach of Science.

I have slightly altered this passage as it stood in the earlier editions, because, although the context clearly indicates its reference to Physical truth, it has been quoted by Mr. Lewes as granting all that the Positive Philosophy demands. There is a sense, of course, in which it may be said that no Truth knowable by man can be "ultimate." That is to say, there is no Truth even conceivable, respecting which we might not ask, or desire to ask, farther questions. But there is no use in appearing to agree with those probable that even the nearest methods of Creation, though far short of ultimate truths, lie behind a veil too thick for us to penetrate. It is here surely, if it is anywhere in the sphere of natural investigation, that the Man of Science may lay down the weapons of his analysis, and say, " I do not exercise myself in great matters, or in things which are too high for me." *

There is at least one conclusion which is certain, namely, this—that no theory m respect to the means and method employed in the work of Creation—provided such theory takes in all the facts—can have the slightest effect in removing that work from the relation in which it stands to the attributes of Will. All such theories are, and can only be " simply questions of how the Creator has worked." This is the confession made in respect to Mr. Darwin's theory by one of the most competent of its supporters.2 Creation by Law—Evolution by Law—Development by Law, or, as including all those kindred ideas, the Reign of Law, is nothing but the reign of Creative Force directed by Creative Knowledge, worked under the control of Creative Power, and in fulfilment of Creative Purpose.

November 1873
Orson Pratt, Quorum of the Twelve Apostles
The Creation
Discourse Delivered in the Sixteenth Ward Meeting Rooms

Journal of Discourses, 26 vols., 16:, p.312-318, Nov. 22, 1873.
Now these two states of being in which our earth existed are called first, the evening, and second, the morning-and the evening and the morning were the first day. Whether the day here mentioned was a period such as the one to which we now apply that term, we are not informed in the Bible, but from what has been revealed to the Latter-day Saints we have great reason to believe that it was a very long period of time, and that this darkness existed over the face of the great deep for a long time. It might have been for many centuries, we have no definite information on this point.

We find that, after the dry land appeared by the gathering together of the waters in one place, God created a firmament, dividing the waters from the waters-the waters that were above the firmament from the waters that were beneath. We do not exactly understand the meaning of this. If we had the process of creation unfolded to us, we should probably find that many of the materials of our globe once existed in a dispersed or scattered form, in a state of chaos, and that the Lord, in collecting them together, brought them from a distance in the solar system, and that

in so doing, he took his own time and way, and wrought according to his own laws, for, as far as we are acquainted, the Lord works by law, and why not create by law?

T to take these self-existent materials and organize them into a world. This is called creation. There is, however, a declaration made by many religious people, that "God created all things out of nothing." They even teach it in their Sunday schools; but they have never been able to prove any such thing. It is one of those ideas which have got into the minds of people through the teachings of uninspired men. The ancients-those who lived many centuries before Christ, did not believe this doctrine; but since the days of Christ, and since the days of the great apostasy, they have got up the idea that God made all things out of nothing, and they have incorporated it into their disciplines, catechisms, Sunday school books, and various works which they have published. The Scriptures say-"In the beginning God created the heavens and the earth." The word "create" does not mean make out of nothing. For instance, when he says-"I created darkness and I created light," what does he do? Does he absolutely form light out of nothing? No, he causes the light that existed from all eternity to shine where darkness existed, and it is light creating light, the same as you, when you attend meeting, lock up your house and blow out the lights. When you return, supposing you say in your own hearts, or to your wife, daughter, or son, "Let there be light." Do you create it out of nothing? No, you look for a match, or for some means by which you can start the light and cause it to be exhibited, where darkness was before. So when God creates light he calls forth and makes to shine that light which has existed from all eternity. We read that God is light. Was there ever a time that God did not exist? No, and if he is light there never was a time when light did not exist, one being as eternal as the other.

In order to prove that light did exist long before this world was called forth from the womb of the great waters, long before God said, "Let there be light," so far as this earth was concerned, I will refer you to some discoveries that have been made by philosophers and astronomers of the present day. They have invented telescopes that are of such penetrating power that they have discovered systems of worlds at such an immense distance in space, that they calculate their light would take six hundred thousand years to reach our system. Very well then, how long must it have been on the journey when the Lord said-"Let there be light," so far as this creation is concerned? I answer, that light was traveling five hundred and ninety-four thousand years before that time; consequently light must have existed, at least, half a million years before the Lord said-"Let there be light," so far as this globe was concerned.

In gathering together the materials that were scattered in space, the firmament that I was speaking of seems to have been one of the parts of creation, necessary in the grand process of collecting and condensing the constituents of our globe; and in doing this I do not know but what some portions of the atmospheric materials collected together helped to form some other worlds. At any rate the firmament was placed in such a manner as to divide the waters beneath it from those which were above it. According to the theory which is accepted by some as being true, the planets of our system are supposed to have been originally formed by a rotation on its axis of a nebulous fluid, that was expanded far beyond the bounds of our present solar system; that by rotation and condensation nebulous masses were thrown off or detached from the great parent body, and that the orbits assumed by the parent mass and its detached masses, are the necessary results of their respective directions and velocities at the instant of detachment, combined with the laws of gravitation, and the relative positions of their respective centres of gravity. That in like manner, a still further operation of similar laws finally formed secondary planets or moons. This nebulous fluid, extending for millions of miles, might indeed be called a firmament, containing the constituents of water, both above and beneath, as recorded in Genesis.

But what I wish to more fully explain, on this occasion, is the length of the days of creation-the days mentioned in which God performed certain portions of his work. It is said, that in six days he

formed this world of ours, and that on the fourth day he formed the sun and the moon and the stars. What I understand by the formation of these celestial luminaries, is that he then caused them to shed forth their light. I can not suppose that it would take the Lord six days to form such a little speck of a world as ours, and then for him on the fourth day to form a globe fourteen hundred thousand times larger than the earth. This does not look consistent to me. If it took six days to form a small work like ours, we might certainly suppose that it would require more than one day to form the sun, which contains a quantity of matter sufficient to make some three hundred and fifty-four thousand worlds like this, and whose actual size or magnitude is fourteen hundred thousand times larger than our globe; consequently I understand by the formation of the sun and of the moon and stars, and setting them in the firmament of the heavens, that he merely suffered their light to shine on the fourth day, to regulate the evenings and mornings that were produced prior to that time, probably by some other cause. The Lord wanted, by these luminaries, to divide the day from the night, and he set them for times and for seasons in the firmament of the heavens.

These six days in which the Lord performed this work, I do not believe, were each limited to twenty-four hours, as are the periods which we now call day; indeed, when we come to new revelation, we find some light on this subject. In the Book of Abraham, as well as in the inspired translation of the Scriptures, given through Joseph Smith, the Lord says, in speaking of the work of creating this earth, that he was governed by celestial time. According to this new revelation, there is a certain great world, called Kolob, placed near one of the celestial kingdoms, whose diurnal rotation takes place once in a thousand of our years; and that celestial time was measured by those celestial beings, by the rotations of Kolob, hence one day with the Lord was a thousand of our years. If this was the case, the six days of the creation of our earth, the six days during which it was being prepared as a habitation for man, must have been six thousand of our years. When the Lord spoke to Adam, after having placed him in the Garden of Eden, concerning the forbidden fruit, saying-"In the day that thou eatest thereof thou shalt surely die!" we can not suppose that the day there referred to meant a day of twenty-four hours. It could not have meant that, for history informs us that Adam lived almost one thousand years from the time of the Fall; but before the day of a thousand years had wholly passed away his death did take place.

The book of Abraham, translated by the Prophet Joseph Smith, also contains an account of the creation and the fall of man; but the word translated "day" in Genesis is translated in the Book of Abraham "time"-"in the time that thou eatest thereof thou shalt surely die." In the next sentence the same book says, speaking of time-"The reckoning of time was not yet given to man," that is, the Lord had reckoned previous to that period by the diurnal rotations of Kolob, and that, without doubt, was the day referred to in which our first parents should die, if they ate of the forbidden fruit.

We will now come to the seventh period of creation,-the seventh thousand years; that is called in Scripture a day of rest, that is supposing that what were called days in the beginning were a thousand years. The Lord rested from his labors the seventh day. What particular period of time within that day Adam fell I do not know; but one thing is certain, that in the morning of the seventh day the Garden of Eden was planted and he was placed therein, and during that morning a great many things transpired pertaining to this temporal creation. In the preceding six days was completed the formation or creation of the earth, after the spiritual order that man was formed or born in the heavens. All men, male and female, that ever have lived, or that ever will live on this earth, had a pre-existence before the formation of the earth commenced; and during our pre-existence in the heavens, the earth was undergoing this formation.

November 1876
Orson Pratt, Quorum of the Twelve Apostles

Creation and Organization
Conference Address

Journal of Discourses, 26 vols., 18:, p.294-296
How many transformations this earth had before it received its present form of creation, I do not know. Geologists pretend to say that this earth must have existed many millions of years, and this assertion is generally made by men who do not believe in God or the Bible, to disprove the history of the creation of the world, as given by the Prophet Moses. We will go further than geologists dare to go, and say that the materials of which the earth is composed are eternal, they will never have an end.

What is meant by creation? Merely organization. In six days, we are told, God created this world, also every living thing that then existed. Did he create any of these things out of nothing? Did the materials then originate? No, there is no Scripture to be found within the lids of the Old and New Testament, or Book of Mormon, or Doctrine and Covenants, or in any of the revelations of God, ancient or modern, that even intimates such a thing, for such was not the case; but go to the creeds of men and you will find these things taught. I was taught them in my youth; they were instilled into my young mind, and of course I believed them. But as I matured in years and thought, especially after I began to study the Hebrew language, I learned that the material of which this earth was made, always did exist, and that it was only an organization or formation which took place, during the time spoken of by Moses.

How many transformations this earth passed through before the one spoken of by Moses, I do not know, neither do I particularly care. If it had gone through millions on millions of transformations, it is nothing to us. We are willing, for the sake of argument, to admit that the materials themselves are as old as geologists dare to say they are; but then, that does not destroy the idea of a God, that does not destroy the idea of a great Creator, who, according to certain fixed and unalterable laws, brought these materials, from time to time, in a certain organization, and then by his power completed the worlds that were thus made, by placing thereon intelligent and animated beings, capable of thinking and having an existence; and then again, for various reasons, he destroys their earthly existence, until finally he exalts them from their former condition, and makes them celestial in their nature.

1876
Charles Darwin (1809-1882)
Autobiography
Religious Belief (Mentions Original Agreement with William Paley as a Student)

During these two years (i.e. October 1836 to January 1839) I was led to think much about religion. Whilst on board the Beagle I was quite orthodox, and I remember being heartily laughed at by several of the officers (though themselves orthodox) for quoting the Bible as an unanswerable authority on some point of morality. I suppose it was the novelty of the argument that amused them. But I had gradually come, by this time, to see that the Old Testament from its manifestly false history of the world, with the Tower of Babel, the rainbow as a sign, etc., etc., and from its attributing to God the feelings of a revengeful tyrant, was no more to be trusted than the sacred books of the Hindoos, or the beliefs of any barbarian. The question then continually rose before my mind and would not be banished,—is it credible that if God were now to make a revelation to the Hindoos, would he permit it to be connected with the belief in Vishnu, Siva, &c., as Christianity is connected with the Old Testament. This appeared to me utterly incredible.

By further reflecting that the clearest evidence would be requisite to make any sane man believe in the miracles by which Christianity is supported,—that the more we know of the fixed laws of nature the more incredible do miracles become,—that the men at that time were ignorant and credulous to a degree almost incomprehensible by us,—that the Gospels cannot be proved to have been written simultaneously with the events,—that they differ in many important details, far too important as it seemed to me to be admitted as the usual inaccuracies of eye-witnesses;—by such reflections as these, which I give not as having the least novelty or value, but as they influenced me, I gradually came to disbelieve in Christianity as a divine revelation. The fact that many false religions have spread over large portions of the earth like wild-fire had some weight with me. Beautiful as is the morality of the New Testament, it can hardly be denied that its perfection depends in part on the interpretation which we now put on metaphors and allegories.

But I was very unwilling to give up my belief;—I feel sure of this for I can well remember often and often inventing day-dreams of old letters between distinguished Romans and manuscripts being discovered at Pompeii or elsewhere which confirmed in the most striking manner all that was written in the Gospels. But I found it more and more difficult, with free scope given to my imagination, to invent evidence which would suffice to convince me. Thus disbelief crept over me at a very slow rate, but was at last complete. The rate was so slow that I felt no distress, and have never since doubted even for a single second that my conclusion was correct. I can indeed hardly see how anyone ought to wish Christianity to be true; for if so the plain language of the text seems to show that the men who do not believe, and this would include my Father, Brother and almost all my best friends, will be everlastingly punished.

And this is a damnable doctrine.

Although I did not think much about the existence of a personal God until a considerably later period of my life, I will here give the vague conclusions to which I have been driven. The old argument of design in nature, as given by Paley, which formerly seemed to me so conclusive, fails, now that the law of natural selection has been discovered. We can no longer argue that, for instance, the beautiful hinge of a bivalve shell must have been made by an intelligent being, like the hinge of a door by man. There seems to be no more design in the variability of organic beings and in the action of natural selection, than in the course which the wind blows. Everything in nature is the result of fixed laws.

But I have discussed this subject at the end of my book on the Variation of Domestic Animals and Plants, and the argument there given has never, as far as I can see, been answered.

But passing over the endless beautiful adaptations which we everywhere meet with, it may be asked how can the generally beneficent arrangement of the world be accounted for? Some writers indeed are so much impressed with the amount of suffering in the world, that they doubt if we look to all sentient beings, whether there is more of misery or of happiness;—whether the world as a whole is a good or a bad one. According to my judgment happiness decidedly prevails, though this would be very difficult to prove. If the truth of this conclusion be granted, it harmonises well with the effects which we might expect from natural selection. If all the individuals of any species were habitually to suffer to an extreme degree they would neglect to propagate their kind; but we have no reason to believe that this has ever or at least often occurred. Some other considerations, moreover, lead to the belief that all sentient beings have been formed so as to enjoy, as a general rule, happiness.

Every one who believes, as I do, that all the corporeal and mental organs (excepting those which are neither advantageous or disadvantageous to the possessor) of all beings have been developed through natural selection, or the survival of the fittest, together with use or habit, will admit that

these organs have been formed so that their possessors may compete successfully with other beings, and thus increase in number. Now an animal may be led to pursue that course of action which is the most beneficial to the species by suffering, such as pain, hunger, thirst, and fear,—or by pleasure, as in eating and drinking and in the propagation of the species, &c. or by both means combined, as in the search for food. But pain or suffering of any kind, if long continued, causes depression and lessens the power of action; yet is well adapted to make a creature guard itself against any great or sudden evil. Pleasurable sensations, on the other hand, may be long continued without any depressing effect; on the contrary they stimulate the whole system to increased action. Hence it has come to pass that most or all sentient beings have been developed in such a manner through natural selection, that pleasurable sensations serve as their habitual guides. We see this in the pleasure from exertion, even occasionally from great exertion of the body or mind,—in the pleasure of our daily meals, and especially in the pleasure derived from sociability and from loving our families. The sum of such pleasures as these, which are habitual or frequently recurrent, give, as I can hardly doubt, to most sentient beings an excess of happiness over misery, although many occasionally suffer much. Such suffering, is quite compatible with the belief in Natural Selection, which is not perfect in its action, but tends only to render each species as successful as possible in the battle for life with other species, in wonderfully complex and changing circumstances.

That there is much suffering in the world no one disputes. Some have attempted to explain this in reference to man by imagining that it serves for his moral improvement. But the number of men in the world is as nothing compared with that of all other sentient beings, and these often suffer greatly without any moral improvement. A being so powerful and so full of knowledge as a God who could create the universe, is to our finite minds omnipotent and omniscient, and it revolts our understanding to suppose that his benevolence is not unbounded, for what advantage can there be in the sufferings of millions of the lower animals throughout almost endless time? This very old argument from the existence of suffering against the existence of an intelligent first cause seems to me a strong one; whereas, as just remarked, the presence of much suffering agrees well with the view that all organic beings have been developed through variation and natural selection.

At the present day the most usual argument for the existence of an intelligent God is drawn from the deep inward conviction and feelings which are experienced by most persons. But it cannot be doubted that Hindoos, Mahomadans and others might argue in the same manner and with equal force in favour of the existence of one God, or of many Gods, or as with the Buddists of no God. There are also many barbarian tribes who cannot be said with any truth to believe in what we call God: they believe indeed in spirits or ghosts, and it can be explained, as Tyler and Herbert Spencer have shown, how such a belief would be likely to arise.

Formerly I was led by feelings such as those just referred to, (although I do not think that the religious sentiment was ever strongly developed in me), to the firm conviction of the existence of God, and of the immortality of the soul. In my Journal I wrote that whilst standing in the midst of the grandeur of a Brazilian forest, 'it is not possible to give an adequate idea of the higher feelings of wonder, admiration, and devotion which fill and elevate the mind.' I well remember my conviction that there is more in man than the mere breath of his body. But now the grandest scenes would not cause any such convictions and feelings to rise in my mind. It may be truly said that I am like a man who has become colour-blind, and the universal belief by men of the existence of redness makes my present loss of perception of not the least value as evidence. This argument would be a valid one if all men of all races had the same inward conviction of the existence of one God; but we know that this is very far from being the case. Therefore I cannot see that such inward convictions and feelings are of any weight as evidence of what really exists. The state of mind which grand scenes formerly excited in me, and which was intimately connected with a belief in God, did not essentially differ from that which is often called the sense of sublimity; and however

difficult it may be to explain the genesis of this sense, it can hardly be advanced as an argument for the existence of God, any more than the powerful though vague and similar feelings excited by music.

With respect to immortality, nothing shows me how strong and almost instinctive a belief it is, as the consideration of the view now held by most physicists, namely that the sun with all the planets will in time grow too cold for life, unless indeed some great body dashes into the sun and thus gives it fresh life.—Believing as I do that man in the distant future will be a far more perfect creature than he now is, it is an intolerable thought that he and all other sentient beings are doomed to complete annihilation after such long-continued slow progress. To those who fully admit the immortality of the human soul, the destruction of our world will not appear so dreadful.

Another source of conviction in the existence of God, connected with the reason and not with the feelings, impresses me as having much more weight. This follows from the extreme difficulty or rather impossibility of conceiving this immense and wonderful universe, including man with his capacity of looking far backwards and far into futurity, as the result of blind chance or necessity. When thus reflecting I feel compelled to look to a First Cause having an intelligent mind in some degree analogous to that of man; and I deserve to be called a Theist.

This conclusion was strong in my mind about the time, as far as I can remember, when I wrote the Origin of Species; and it is since that time that it has very gradually with many fluctuations become weaker. But then arises the doubt—can the mind of man, which has, as I fully believe, been developed from a mind as low as that possessed by the lowest animal, be trusted when it draws such grand conclusions? May not these be the result of the connection between cause and effect which strikes us as a necessary one, but probably depends merely on inherited experience? Nor must we overlook the probability of the constant inculcation in a belief in God on the minds of children producing so strong and perhaps an inherited effect on their brains not yet fully developed, that it would be as difficult for them to throw off their belief in God, as for a monkey to throw off its instinctive fear and hatred of a snake.

I cannot pretend to throw the least light on such abstruse problems. The mystery of the beginning of all things is insoluble by us; and I for one must be content to remain an Agnostic.

A man who has no assured and ever present belief in the existence of a personal God or of a future existence with retribution and reward, can have for his rule of life, as far as I can see, only to follow those impulses and instincts which are the strongest or which seem to him the best ones. A dog acts in this manner, but he does so blindly. A man, on the other hand, looks forwards and backwards, and compares his various feelings, desires and recollections. He then finds, in accordance with the verdict of all the wisest men that the highest satisfaction is derived from following certain impulses, namely the social instincts. If he acts for the good of others, he will receive the approbation of his fellow men and gain the love of those with whom he lives; and this latter gain undoubtedly is the highest pleasure on this earth. By degrees it will become intolerable to him to obey his sensuous passions rather than his higher impulses, which when rendered habitual may be almost called instincts. His reason may occasionally tell him to act in opposition to the opinion of others, whose approbation he will then not receive; but he will still have the solid satisfaction of knowing that he has followed his innermost guide or conscience.—As for myself I believe that I have acted rightly in steadily following and devoting my life to science. I feel no remorse from having committed any great sin, but have often and often regretted that I have not done more direct good to my fellow creatures. My sole and poor excuse is much ill-health and my mental constitution, which makes it extremely difficult for me to turn from one subject or occupation to another. I can imagine with high satisfaction giving up my whole time to philanthropy, but not a portion of it; though this would have been a far better line of conduct.

Nothing is more remarkable than the spread of scepticism or rationalism during the latter half of my life. Before I was engaged to be married, my father advised me to conceal carefully my doubts, for he said that he had known extreme misery thus caused with married persons. Things went on pretty well until the wife or husband became out of health, and then some women suffered miserably by doubting about the salvation of their husbands, thus making them likewise to suffer. My father added that he had known during his whole long life only three women who were sceptics; and it should be remembered that he knew well a multitude of persons and possessed extraordinary power of winning confidence. When I asked him who the three women were, he had to own with respect to one of them, his sister-in-law Kitty Wedgwood, that he had no good evidence, only the vaguest hints, aided by the conviction that so clear-sighted a woman could not be a believer. At the present time, with my small acquaintance, I know (or have known) several married ladies, who believe very little more than their husbands. My father used to quote an unanswerable argument, by which an old lady, a Mrs Barlow, who suspected him of unorthodoxy, hoped to convert him:—" Doctor, I know that sugar is sweet in my mouth, and I know that my Redeemer liveth."

May 1879
Brigham Young
I believe I shall be endorsed by the highest scientific authorities when I say that they acknowledge the existence of a master intelligence that organizes, sustains and controls the universe
Jounal of Discourses, 26 vols., 20:, p.211

It is customary with the Lord and his angelic messengers to generally give some reason for the requirements made by them; God is ever willing to show his children why we should obey his commands, we find his doctrines reasonable; his requirements reasonable, and his revelations reasonable; hence the angel added by way of reasonable argument, "and worship him that made heaven and earth, and the sea and the fountains of waters." But why did he not call attention to some of the great things in the unseen world; why not refer to the hosts of heaven or the majestic glory of God, as he sat upon his throne; or any others of the numerous existences that create joy or wonder "behind the vail?" No doubt, because the angel could see prophetically that when the time should arrive for him to deliver his heavenly message, at the hour of God's judgment, the whole world would have reached what may be called a scientific age, an epoch of "materialism" a time when the universal scientific thought would be centered on that which was material in its character; and that people would be more devoted to searching out the matters of the visible world, than the hidden mysteries that lay beyond the vail. Hence he called attention to the things which were most engrossing their thoughts. He saw that men would reach as they have done, some conclusions concerning the planetary bodies, and establish some theories, the correctness of which has in certain instances been proved, as particularly shown in the precision with which eclipses are predicted, that frequently occur within a minute, and even a few seconds of the time designated. Although men have discovered comparatively little with regard to such matters, and even in our own solar system are at a loss in some things, still enough has been discovered to create wonderment and inquiry as to the origin of the worlds that "roll upon their wings" in the firmament, and I believe I shall be endorsed by the highest scientific authorities when I say that they acknowledge the existence of a master intelligence that organizes, sustains and controls the universe. But who or what that power and intelligence is, they do not comprehend, neither can they without he should reveal himself unto them. But when the inquiry arises as to who is this organizer? the voice of the angels comes ringing down the cycle of time, "Worship God, who made the heavens," for, as the Psalmist gives it, "The heavens declare the glory of God, and the firmament showeth his handiwork." How charming it is to contemplate the beauty of the heavens, and then think of the discoveries that have been made; concerning light, for instance. How

wonderful it is! To think that light, traveling, as scientists assert, from the sun to the earth in eleven minutes, a distance that would occupy a cannon ball twenty-five years in transit; and yet, notwithstanding its velocity, it is so composed as not to harm in the least degree the tenderest of animal or vegetable substances; the minutest plant-the most delicate flower is blessed by its influence, and not in the least injured by the rapidity of its motion. How is this accomplished? By the particles of which it is composed being so minute as not to offer any resistance to the slightest substance. And yet a single sunbeam, which no one can paint or define, looking so innocent and colorless, is found to consist of seven colors, and will penetrate the deepest darkness and reveal all existing objects in their proper and actual form and color. The beneficial effects of the sun's light cannot be too highly appreciated, and, in contemplating its blessings we are constrained to "worship God who made the heavens." Let us now consider the earth; take for instance the atmosphere which we breathe and by which we are sustained. We find it in a pure condition originally, but we ascertain that it is rendered impure by being breathed. Through passing through the lungs it becomes so highly carbonized that it is unfit for our use; the large infusion of carbonic dioxide it receives through the process of respiration, renders it poisonous to men and animals; but strange to say it is then in the most proper condition to nourish the life of the vegetable kingdom. Plants thrive on it, and vegetation generally, receives its chief nutriment from that impurity which animals could not endure. Scientific experiment has proved that a sprig of mint placed in a bottle of air rendered impure by respiration or putrefaction, will so absorb the impurity, and nourish itself on the unwholesome carbonic acid gas, as to again render the air sufficiently pure to sustain human and animal life. Thus we find that the atmosphere which would otherwise become unfit to sustain our lives, is purified, and at the same time is enriching us through the medium of the vegetable creation, from which we derive much of our support and sustenance.

Discourse By Elder C. W. Stayner
Fates of the Ancient Apostles-Worship of the True God-His Creations and Handiwork-Prophecy
Journal of Discourses, 26 vols., 20:, p.206 - 208
Delivered in the Tabernacle, Salt Lake City, Sunday Afternoon May 25th, 1879.

Then think of the richness of our fields, of the mineral wealth in these huge mountains, of the beauties to be seen and studied in the floral creation, of the grandeur of earth's scenery, and the capacity of the soil to support its wonderful population, think of what is on the earth's surface, and consider what is discovered in its deepest recesses; and when the inquiry arises as to the originator of these blessings, and men of science and reflection ask who and what is the controlling power that bestows and regulates all these things, the loud voice of the angel comes down through the ages, "Worship God who made the earth!" Then there is the mighty ocean that covers such a large portion of our globe. Now, some people have thought that there was too great a proportion of our earth covered by water; but scientific men, who have thought deeply on this subject, declare that if there were any less, there would not be sufficient to furnish moisture for the fertilization of the land. Here, then, is an element prepared, from which, through the action of the atmosphere, the moisture is drawn up into the clouds, and, what is very wonderful, it is not emptied out in torrents, to ravage and destroy by its furious impetuosity, our fields and gardens, but is carried in the clouds as they are gently wafted by the wind, and beautifully distributed in grateful showers, to refresh and nourish the crops of the husbandman. Then, again, see the provision for preserving those large bodies of water, called seas, so that they may not become putrid and malarious; they are strongly supplied with salt, and thus turned into brine, which preserves the water in a wholesome state. Upon the surface of the seas are the vessels of the commercial world, laden with treasure, and down in those almost unfathomable depths are found endless varieties of the finny tribes, that delight to dwell there, and are so useful to man. The sea is their home, from the smallest specimen that floats near the surface, to the huge leviathan that lashes the ocean in his fury. They are

perfectly adapted to live there, and the element is specially fitted to supply their necessities. Then, too, beneath its surface we discover beauteous and precious gems for the adornment of the person; providing even for the pleasures and fashionable tastes of "them that dwell on the earth." And when we ask what intelligence and beneficent power has provided for our happiness, we still hear the voice of the angel as he cries, "worship God who made the sea!" There is still another branch of the subject to which we must briefly refer, and that is the "fountains of waters" What can be more delightful than a fountain, or spring of pure water? Up in these glorious mountains which have inspired the Saints with a love of liberty, we can see and hear the rippling brook as it escapes from a bright, cold, pure spring in the nook of a canon or the crevice of a rock! How is it formed and sustained? We find that through the process of evaporation before alluded to, moisture is drawn from the oceans and lakes up into the clouds; some of these clouds pass over the mountains, and deposit sheets of snow, and showers of rain in the canons and on the mountain sides. These sink into the crevices between the rocks, and here and there burst forth in bubbling springs of fresh water which feed the rivulets and streams, and form the creeks that descend to the land in the valleys, then pass into rivers and finally return to the bosom of the oceans and lakes from whence they came, there to be again preserved till again evaporated. But one peculiarity we should notice here, and that is, the water in these springs is fresh and sweet, although the bodies of water from whence it is evaporated are salt. Here we live on the borders of the Great Salt Lake, yet did you ever notice any saline flavor to the springs and streams sustained by the evaporations from the lake? No, and yet this is a body of water having the strongest saline character in the world! What a glorious provision to have pure fresh water in constant supply! And how beautiful to contemplate, is the present fertility of these valleys! When we look back to the time when those grand old pioneers set their feet on this soil, and realize its past barren, arid condition, we are led to thank God, "who made the fountains of waters;" and we can see the literal fulfillment of his word through the ancient prophets, that he would "turn the dry ground into water springs," and "make pools in the desert;" we see that "fountains of water" have sprung up in unexpected places, to enable this dry and unpromising soil to yield and equitable return for the toil of the laborer; and we can now say that indeed the "Desert has been made to blossom as the rose." In short it seems that "the heavens and the earth and the sea and the fountains of waters" have formed a grand combination to introduce their united evidences of the Divine existence,-and the rich Divine dealings with mankind. Through the ages that are past every method consistent with the perfection of omnipotence, has been adopted to impress man with reverence for the Deity; angels from the heavens declare the glory of God, and the music of the spheres as they perform their wonderful course in the firmament, invite our attention to his glorious handiwork; God has written his being on the imperishable rocks, has recorded the existence of Deity in the granite mountains and among "the everlasting hills;" if we "go down into the depths of the sea, he is there;" and at his bidding, "fountains of water" burst forth in fertilizing streams, to nourish the barren soil that it may bring forth its rich fruit for the sustenance of the Saints. Thus the heavens in their glory, the earth with its rich blessings, the seas upon which we ride, and the "fountains of waters" that supply us with an element without which we could not live, furnish us with a chain of material evidences, of the existence and goodness of the Deity, that cannot be successfully denied. But I would still fail in the performance of my duty this afternoon, if I should close without touching upon the subject of spiritual evidences that are furnished in such rich abundance from the very commencement of the world's history to the time when God revealed himself to Joseph Smith, a young boy of fourteen or fifteen years of age, unskilled in the sciences, and unlettered in the learning of the world. God revealed to him not only the fact of Divine existence, but even how he became God; that it was through living up to correct principles, and by developing within himself every sublime sentiment that had its origin in truth. He taught him how the people "who dwelt on the earth" might also be thus exalted to be angels of God, and finally Gods themselves; how they could scale the ladder of intelligence step by step, till they finally overcame all evil, and sat down at the right hand of the "majesty on high." Read and consider the beautiful prophecies in the Book of Daniel! Read his florid account of the wonderful visions given to him, of the method he was commanded to adopt in order

that he might be worthy to receive them. How he was required to fast, "to eat no pleasant food;" to subsist on flowers and other innocent kinds of vegetation; and then ponder over his prophecies, and the prophecies of angels recorded by him, especially concerning the four beasts, which represented the four great kingdoms of the world, Babylon, the kingdom of the Medes and Persians, the Macedonian Empire, and the Roman power. Read his prophecies concerning the last days; and compare them with the writings of Gibbon and other historians whom while they denounced God and religion, and declared the prophets were impostors, actually recorded the most literal fulfillment of their glorious predictions; and it will be found by those prophecies and their recorded fulfillment, that Daniel and his colleagues were not simply writers of poetry for the amusement of themselves and their neighbors, but that they were ministers of God, chosen to warn mankind of the great things that should come to pass on the earth, long centuries after those prophets should be called behind the vail. God has painted the history of the world in the rich colors of prophecy, and mankind, under Divine Providence has sculptured its fulfillment in the marble of history. The two records are before us, and I am ashamed of the intelligence of the nineteenth century when I think that scientific men, and learned people can be induced to impute to those holy servants of God other motives than the advancement of God's purposes in the earth. But I do not condemn the caviller by any means, or consign him to endless torments; no, I regard him as being of great use and of infinite importance to society; he, acting like the tempestuous elements, promotes a healthy condition of the atmosphere, and stirs up the great ocean of thought; this leads us to reflect and consider, and while investigating more closely the works of God, we are apt to come to right conclusions and be more firmly established in the principles of truth.

1883

Louis Ezra Hicks, Professor Of Geologv At Denison University, Granville, Ohio

A Critique Of Design-Arguments - Historical Review And Free Examination Of The Methods Of Reasoning In Natural Theology

Book

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Introduction

Classification Of Design-Arguments

Most of the reasoning in natural theology falls under the head of what has been called design. If we inquire into the meaning of this word "design," we shall find that our ordinary conception of it grows out of its constant association with teleology. We think of design-arguments as teleological arguments. Not only do we so think of them in those moments when we are not making any studied effort to analyze them, or to think profoundly about them, but all writers on systematic theology have so classified them in those careful and elaborate treatises in which they have given us their best and deepest thoughts. They make all design arguments teleological. I hope to be able to show that there are good grounds for a radical change in this classification. A teleological argument always has reference to the accomplishment of an end or purpose. There are numerous appearances in nature, which, upon any ordinary principle of judging from appearances, are strongly indicative of an intention upon the part of the Creator to accomplish this or that result. Mankind have in all ages accepted these marks of design in good faith, and drawn certain conclusions from them. But the extent to which these indications of a purpose in nature have been suffered to guide the mind to an inference of the existence and attributes of a Supreme Ruler, has varied extremely in different periods of human history; as has also the extent of that field, or sphere of action, in nature wherein the play of special purposes and divine interpositions was supposed to be customary and legitimate.

In the youth of the world men looked upon all phenomena as direct products of a divine activity, specially directed to serve and bless, or to punish and destroy, mankind. Every natural event was an end foreseen, chosen, and brought to pass by suitable means. But with the birth of science many such teleological notions perished; and, as science has advanced, the phenomena of nature have been brought more and more under the reign of law, while the field of special interventions of a divinity for the purpose of achieving this or that result as an end has been constantly narrowed. At length the province of biology, the last stronghold of the old teleology, has been invaded by the theory of evolution, and, if not absolutely conquered, at least so far occupied, that teleology must either ally itself with evolution, or retire from the field. But, just as fast and as far as the field of teleology has been restricted by the advances of science, the range of another argument for the existence of God has been correspondingly enlarged. The reign of law is but another name for the order of nature. Physical law is merely a formula for the orderly movement of physical force. But order, and method, and the harmonious action and interaction of physical forces, are marks of intelligence, and prove the divine authorship of the cosmos just as conclusively as the use of means to accomplish an end proves it. As the reign of law has been extended over one after another of those provinces which were thought to be the special preserve of teleology, the argument from the order of nature has been progressively drawn into greater and greater prominence. This is also a deai^rn-argument, as well as the teleological argument. So that while teleology has been, as La Place remarked, pushed back more and more as science advanced, the order-argument having been at the same time brought to the front, the province of design-arguments has not suffered any restriction. On the contrary, it has been constantly enlarged, because the advances of science have created new fields for it, without infringing at all upon the sphere it formerly occupied.

It is not indeed historically true, that the order-argument has advanced pari passu with the retreat of teleology. All that can be said is, that it ought to have done so, and would have done so if natural theologians had been awake to their mission, and made good use of their opportunities. But it is only quite recently that reasoning from the order of nature, without regard to ends, has been recognized as an argument distinct from teleology, and quite as valid as that. In fact, it can hardly be said yet to be so recognized, only a few writers having employed it in such manner as to show that they clearly apprehended it as a distinct and independent line of reasoning. If the present treatise shall serve to set out the order-argument more clearly and prominently, an important object will be accomplished.

Dr. McCosh regards the order-argument in the light of a revival rather than a new invention. He says that natural theology has been chiefly occupied in this country for a century or two in displaying the external facts of nature instead of its internal principles of order, which the ancients attended to as well as the facts. Now "this branch of proof must come once more into prominence."

Professor Baden Powell also maintains, that design-arguments need a radical re-adjustment, such as to bring order to the front instead of utility, or useful ends accomplished.2

A clear proof that this is a very new argument, or else a very old one newly revived, is that it has not yet been named. As a distinct argument it deserves a name. Dr. McCosh has, indeed, suggested one: —

Two great principles run through every part of the works of God. The one is the principle of order, or general plan, to which every given object U conformed with amazing skill. The other is the principle of special adaptation, by which each object, while formed after an ideal pattern, is at the same time, and by an equally wonderful skill, accommodated to the situation which it occupies, and the purpose which it has to serve. . . . The science which treats of the one might be called — were it not that the word has been so abused — cosmology; the science which treats of the other has an admirable phrase allotted to it in teleology.' (* Meth. of Div. Gov., p. 158. The passage does

not occur in the earlier editions: hence the more confident proposal of the name cosmology is probably earlier than the more cautious one, though it appears in a work published six years later)

This suggestion is very cautiously advanced here, but repeated with greater confidence in his " Typical Forms and Special Ends in Creation," published six years later (1856). The doctor has not, however, followed his own suggestion. In his frequent references to the principle of order in subsequent portions of these books, and in later publications, he describes it in other terms, avoiding the word "cosmology." Wolff, the famous German mathematician and philosopher, divided metaphysics into ontology, psychology, cosmology, and theology. Lewes adopts his division, except that he drops ontology. " There are three grand divisions of metaphysics; namely, psychology, cosmology, and theology." 1 This is a natural and convenient division. The terms might be briefly interpreted thus: psychology, the doctrine of the soul; theology, the doctrine of God; and cosmology, the doctrine of the cosmos, or the general metaphysical considerations respecting the universe. The meaning of the term seems to be too well fixed in this sense to admit of its being applied in the sense suggested by Dr. McCosh.

It is true it has been used in several other senses; and in order to judge fairly, and with all the evidence before us, whether it can be brought into physico-theology as a companion word to teleology, it may be worth while to notice some other examples of its use.

A quarter of a century before the publication of Wolff's " Transcendental Cosmology," which appeared in 1731, Nehemiah Grew, M.D., published in London his " Cosmologia Sacra." The greater part of this is in the ordinary style of apologetics, or a treatise upon the evidences of Christianity; and, so far as this part is concerned, the title, Sacred Cosmology, has no pertinence. But it also contains design-arguments, and a singular theory of a "vital principle" in matter generally, aside from vegetative and animal life,—a sort of hylozoism, or world-soul theory. So far it is cosmological, or treats of the cosmos.

Twenty years after Wolff's book appeared in Germany, — that is, in 1751, — another cosmology was published in France1 by Moreau de Maupertuis. His " Essai de Cosmologie" is an attempt to prove the existence of God by a novel method. Starting with a definition of the Supreme Being, he deduces from this, by rigid mathematical processes and formulas, the laws of the universe. Then comparing the laws so deduced with those actually found in nature, and finding them to be identical, he infers that the being from whom they were deduced must truly exist, and must be the author of the actual cosmos.

Still another cosmology appeared in 1861 in New York. This was the " Rational Cosmology " of Laurens P. Hickok, D.D. He attempts to reduce all phenomena under two forces, "antagonist and diremptive." "The principle of the generation of the material universe involved the agency of these two forces, and needed none other."2 He seems to be trying to get at the modus operandi of creation ex nihilo, — a truly hazardous attempt.

Thus we have the transcendental cosmology of Wolff, the metaphysical cosmology of Lewes, the sacred cosmology of Grew, the mathematical cosmology of Maupertuis, and the rational cosmology of Hickok. Germany, France, England, and America have all had their tilt at the word. With good reason the canny Scotchman felt shy of attempting to appropriate it in a new and special sense after it had been thus bandied about. Besides, if life were not too short to be wasted in such an investigation, we might probably find still other varieties of cosmology. It is one of those handy Greek compounds, general in signification and convenient in form, so that it is sure to be taken up and used in different senses by authors in different lines of research. Another' objection to its use in theology is, that the adjective form of it, cosmological, is already appropriated for the argument for a First Cause.

The order-argument is therefore still unnamed. I propose to call it eutaxiological, from eutaxy, established order. Eutaxiology will then be the sum of the reasonings from the order of nature respecting the existence of God.

In the following treatise I propose to deal with these two design-arguments, the eutaxiological and the teleological. But their relations to other arguments for the existence of God are so numerous and intricate, that it will be impossible to treat these fully without giving some attention to the others. And, in order that I may be clearly understood, it is desirable here in the beginning to set forth all these arguments in their mutual relations, and with their mutual limitations and boundaries, as I understand them.

First, there is the argument from intuitive conceptions of the necessary existence of a perfect Being, — the Ontological Argument.

Secondly, the argument which proceeds upon the principle of cause and effect, and seeks for an adequate First Cause, — the Causal Argument.

Thirdly, the argument from the mental and moral attributes of man, as implying the existence of God as a necessary complement to human faculties, — the Anthropological Argument.

The fourth and fifth are the two Design-Arguments.

The Ontological and Causal Arguments together constitute Rational, or, as Kant calls it, Transcendental Theology. The two Design-Arguments constitute Physico-Theology; and the same, with the addition of the Anthropological Argument, constitute Natural Theology.

What I have called the causal argument is often called the cosmological argument, in accordance with Kant's scheme, I suppose. But Kant is not consistent with himself. In one place he applies the term " cosmological " to the causal argument alone; but in another place he includes under it the design-arguments of physico-theology, as well as the causal argument. A moment's consideration will suffice to enable us to see that the latter usage of the term is the more correct. The design-arguments are unquestionably cosmological. They draw their data from the cosmos just as much, or even more, than the causal argument; since the last may be based upon the existence of any single being, while design-arguments involve a wide survey of the universe. Indeed, they all draw their facts from nature; but each views its facts from its own peculiar standpoint. Teleology views them always in the relation of means and ends; eutaxiology, with reference to the principle of order; while the argument for a First Cause views them always in the relation of cause and effect. They are all cosmological; but as one is named teleologieal from its special ground-notion of an end, another eutaxiological from its special ground-notion of order, so ought the third to be named causal from its special ground-notion of cause and effect.

This would remove one objection to the use of the term " cosmology" as proposed by Dr. McCosh; namely, that the adjective " cosmological" was already appropriated to the argument for a First Cause. But it brings another objection into view at the same time that it removes the one. It would be as inappropriate to restrict the term to one of the design-arguments as to restrict it to the causal argument. Besides, the other objections to the doctor's suggestion are numerous enough without that.

The extent which I have given to the term " natural theology," making it include the argument drawn from the human intellect and conscience, has not been uniformly observed by writers upon this subject. The greater number, perhaps, have written about natural theology just as if it had to

do only with design-arguments; and, as these were all included under teleology, the latter term was practically a synonyme of natural theology. The truth is, most of them did not stop either to analyze or define their terms and arguments; but, of those who did systematize their thoughts, the greater number include the anthropological argument under natural theology. Lord Brougham notably does so, and he further distinguishes between natural theology and natural religion. The first appeals to reason, endeavoring to convince men that there is a God; the second appeals to the moral sentiments, to the hopes and fears and reverence natural to man, as he contemplates his relation to the Deity so far as it is manifested to him by the light of nature.

Analysis Of The Teleological Argument

There is a degree of simplicity about teleologies! reasoning which in part accounts for its great strength as a popular argument. It has the advantage, that it can be gathered up into a single proposition, and hurled like a solid shot at an adversary. Don't you believe that feet were made for the purpose of walking? It is difficult to make a blank denial, but the anti-teleologist must deny it. If he admits a purpose in this case, he must do the same in a multitude of similar cases; and, if he admits the existence of a purpose, he admits the existence and dominance of mind in nature. There is no such thing as a blind purpose. Purposes belong to the realm of mind. Every conceivable sort of purpose is an act of intelligence, though it may not display wisdom. The most foolish aims of men presuppose an intellect to conceive and a will to execute them. There are no foolish aims in nature; but, since even a foolish purpose can only be entertained by a being endowed with mind, how much more evident is it that nature's purposes, provident and admirable as they are, could not have been conceived and executed by any other than an intelligent being!

This, I say, must be the conclusion if purpose is admitted at all. The anti-tcleologist must bolt on a steel-plate armor of hard scepticism thick enough to turn that first solid shot, or else make up his mind to lower his flag sooner or later. He must speak out fair and plain, without any mouthing or mincing, and say that feet were somehow formed without any intention that they should be used for walking.

In view of this fact, .the reason of the popular strength of teleology is not far to seek. Imagine two men debating in public, one affirming and the other denying that eyes were intended to see with! In the average, intelligent, lecture-going audience, the man who would plant himself squarely in the negative of that question would be set down for a fool by half of his hearers the moment he did so. Much more would he be set down for a fool by the common crowd. This popular strength may be delusive, but it is a fact. Whatever fate this argument may meet at the hands of metaphysicians, the common sense of mankind will always gravitate mightily towards the belief that bodily organs were intended to perform the functions which they do perform.

It is implied in what has been said of the popular strength of teleology, that this strength is due to the simplicity of the reasoning. It is apparently very simple; and, as compared with what Herbert Spencer calls "compound quantitative reasoning," it is really very simple. Still the analysis of it discloses a greater number of elements, and a greater complexity of relations, than would be suspected without analysis. Take a familiar example: The ear being well fitted for hearing, we infer that it was created, or evolved, for the purpose of hearing. In this the elements are, (1) the ear, a material object; (2) hearing, a physiological function, but just as real a thing as the material object; (3) a relation of fitness between the organ and its function; (4) a mental conception of hearing as an end to be attained by means of the ear, — that is, a conception which includes all .J\e first three elements, and forms a sort of duplicate of them; (5) a volition or determination of the will to bring about hearing by means of the ear. The consideration that the end attained is a useful one is usually involved in the reasoning, and constitutes an additional element, making six in all. And these are simply the conceptions involved in teleological reasoning, without any reference to the logical processes involved in it. These will be carefully investigated in a subsequent chapter.

Thus the argument which looked so simple in its concentrated form, looks much less simple when spread out by analysis into its elements. These are numerous enough; and their relations of dependence and likeness and unlikeness are intricate enough to furnish ground for two notable consequences. In the first place, there is a splendid chance for the advocates of teleology to get themselves tangled up, and involved in dangerous if not hopeless confusion, through the failure to keep each of these elements in its place> clear of entanglements with its neighbors or relatives to whom it bears a striking family resemblance. The sequel will show that they have made the most of this opportunity. Especially has there been a general failure to recognize the duplication of the elements of this argument. Hearing, for example, is one thing when regarded as the function of the ear, but quite another thing when it is regarded as an end. The one is a fact, the other a supposed mental conception of the Creator. The most cursory examination of physico-theological writings will reveal instances of the fallacy of an ambiguous middle term, arising from the fact that the author glided unconsciously from the function to the mental conception of it as an end.

In the second place, there is a splendid chance here for the enemies of teleology to throw these numerous elements into false relations and utter confusion; and they have not been slow to do it. They had this advantage, too, that they often gained their purpose through ignorance as well as through knowledge. They did not need to attain and hold fast to clear distinctions. All they wanted was to spoil the argument; and for that a small outfit of dialectic ingenuity was just as effective as, if not more so than, a thoroughly philosophical comprehension. And, in addition to their original capital of dialectic skill, their stock was always re-enforced by the blunders of the other side to an extent which enabled them to do a very respectable business in the argumentative line. The debaters on the affirmative side must comprehend their propositions through and through; but for those on the negative side a superficial treatment has certain advantages, especially if the affirmative position is inherently sound and strong.

But what if the affirmative is weak? Or, suppose it is apparently stronger than it is really, is it then the policy of its advocates to blink distinctions, and confuse relations, so as to conceal their weakness? That depends, of course, upon the question whether you love truth and righteousness. Now, in respect to the popular strength of teleology, I am constrained to make a remark which may be painful to my readers, because it is disparaging to that argument. But, besides being tolerably fond of truth and righteousness, I think I am doing a real service to any cause by ridding it of factitious and unreal elements of strength.

Now, the thing I am getting at is not so dreadful, after all, as you might suppose from such a solemn and formal introduction of it. It is simply this: the popular strength of teleology is partly due to a blinking of distinctions. Ask almost any ordinary person whether the eye was made for the purpose of seeing with it. He will say, " Yes, of course it was. Why should you ask such a foolish question?" But nine out of ten—nay, more likely, ninety-nine in a hundred — of such persons make that answer, and regard the question as a silly one, simply because they don't know, or, if they know, don't think of, the difference between function and purpose, — between seeing as a fact, and the mental, creative conception of vision as an end. The function of the biceps muscle is to bend the arm at the elbow, is one proposition; the purpose of the biceps muscle is to bend the arm at the elbow, is a very different proposition. The first is a plain truth of physiology, to which all who know the meaning of the terms will yield a prompt and willing assent. The second is a teleological statement, to which no one who knows the full import of the terms will subscribe, unless he is ready to go the whole length of the teleological road, and accept its uttermost conclusion. If the biceps muscle was created, or evolved, for the purpose of bending the arm, that was an act of intelligence, and the presence and supremacy of mind in nature is established.

To the man who does not know or think of the distinction between use and end, between function and purpose, between vision as a fact and the primitive conception of it in creative thought, not only does the affirmative answer seem a matter of course, but so much a matter of course, that he adds to his "yes " the mental if not audible comment, " What a silly question I" To deny that ears were made for the purpose of hearing is, to him, precisely equivalent to saying that they are not used for hearing, and consequently are of no use at all. That is why the anti-teleological debater would be set down for a fool by the crowd, if he made a point-blank denial that organs were intended for the functions appropriate to them.

The popular strength of teleology is delusive to this extent at least, that it depends in part upon this obliviousness to an actual distinction, —a distinction, too, so fundamental that no teleological argument can be valid which does not take it into account. The service rendered to the cause by pointing out this fallacy of confusion is therefore a real one, since it lays the foundation for correct reasoning, and at the same time explains, or does something towards explaining, the fact that teleology has been so much stronger with the thoughtless masses than with the thoughtful few. If it stands on such props alone, away with them, and let it fall! but if, as I believe, it has other and better supports, still away with these! Popular strength may be a source of real weakness. It enables the other side to say with a sneer, and a wag of the head, " Your argument will do for the multitude." Or it may lead the defenders of a cause to repose in a false security while enemies sap its foundations. But, worst of all, it fosters the feeling, that an argument which is naturally so strong can be easily and effectively handled by almost any one whose fancy it is to make the trial. Teleology has suffered untold mischief from this source. Not only have incompetent bunglers taken it up because it seemed so easy, but very able men writing upon it have confided too much in its popular strength, and failed to subject teleology in general, and their own presentation of it in particular, to that severe analysis and criticism which would have stripped off some of its fallacies.

Another remark of the same kind as the last, I have to make, — like it, disparaging to teleology, but having the same sort of defence. False pretensions are as damaging to a cause as apparent but unreal elements of strength. Now, it is a fact that a certain claim advanced by teleologists is a false one; and it has been entered in behalf of their doctrine, and persistently insisted upon, because of this very same blinking of distinctions mentioned in the previous remark. That is to say, it has been asserted that teleology is a useful, and even an indispensable, guide in physical, or still more in biological, research. The case of Harvey's discovery of the circulation of the blood is cited; and, so far as he is individually concerned, there is some justice in the claim. He said to himself, " These valves all opening in the same direction are not here without a wise purpose;" and, thus reasoning teleologically, he was led on to his great discovery. But just make the reasoning non-teleological by substituting function for " wise purpose," and it works out the conclusion quite as well. Any rejecter of teleology, any Huxley or Haeckel with mere function as a guide, might have made the discovery just as well as Harvey did with " wise purpose " as a guide.

But not any better! The teleologist is not disqualified for scientific investigation by his belief, — only he has no private latch-key to the riddles of nature. He treads no royal road to discovery. Still, as he trudges along the common highway of science side by side with his unbelieving brother, is there not possibly some difference? As scientists they are on precisely the same level; but as men, as beings endowed with immortality, having a few other problems to solve besides those which can be attacked with scalpel, crucible, and balance, there may be just the difference that exists between a friendless orphan and a beloved child in his father's house.

Analysis Of The Eutaxiological Argument

At first view the teleological argument seems simple; but we find that it possesses a considerable degree of complexity. At first view the eutaxiological argument looks rather complex, but it is really very simple. The order of nature seems like a broad theme. To treat it exhaustively one

would be obliged to survey the whole field of the physical sciences, and draw from each one of them its fundamental principles as illustrations of eutaxiology. Physical science is a classified knowledge of external nature; but the possibility of classification, and therefore of science, lies in the fact that there is first a natural, external order, whence arises the logical, internal order in the arrangement of facts and principles, which constitutes true science. The external order existed before the science which is based upon it. There was celestial harmony before the science of astronomy was constructed by formulating the laws and principles gathered from observation of the heavens. What, then, is this impressive fact of celestial harmony, — this majestic and orderly movement of vast bodies through boundless space, — what is it but a divine thought impressed upon the cosmos? Chemical combinations obey the law of definite and multiple proportions: can nature count then? Crystals present, some simple and complete, others modified and complex, geometrical forms: is nature a geometrician? Plants and inferior animals are built upon the radiate plan, the higher animals having, on the contrary, distinct right and left sides, dorsal and ventral aspects: is there any thought of symmetry in this? or any thought of symmetry and number both in the parts of flowers, and the fractional series in phyllotaxy? Then there are the " types of structure " in zoology, — a definite pattern or fashion running through whole classes and sub-kingdoms; a flan it would seem, and so the comparative anatomists call it.

Thus we might go on through all the sciences, and see, ever and anon, some new principle of order standing out like a creative thought. This eutaxiological argument, then, seems to have no end to it; for order is universal in nature. True, it is universal; and there is no end to the examples of it, but they are all essentially alike. Order in the heavens is the same principle as order in the setting of leaves on a tiny plant, or of the sparkling facets of a minute crystal. The illustrations of the principle of order are countless, but the argument based upon them is one.

The fundamental proposition of eutaxiology is, that order and harmony are marks of intelligence. They imply that there has been a preconceived plan, to which the phenomena in question have been made to conform. Let us take an illustration from the animal kingdom. Here eutaxiology takes the special form of morphology, or the doctrine of typical forms; that is, morphology is one of its phases, though not the only one. The orderly series of animals grouped into classes, orders, and genera, is another phase of eutaxiology; but we will draw upon morphology at present for an illustration.

In the sub-kingdom vertebrata the morphological type of a limb is, that there shall be first a single bone (humerus or femur), then two bones side by side (radius and ulna or tibia and fibula), then a number of small bones (wrist or ankle), then five bones side by side (metacarpus or metatarsus), and finally five digits (fingers or toes). This type, though not universal among vertebrated animals, prevails so widely, and is so often realized in different animals which are otherwise extremely unlike, that naturalists have no hesitation in accepting it as a type, and describing its elements with all the minuteness and confidence which belong to the description of real things. Is it not then a real thing? Not in the sense of being material: it is simply an idea, nothing more and nothing less. But an idea which has moulded the form of the hand with which you hold this book, and the wing of a bat, and the paw of a lion, and a thousand other animal forms, all on the same pentamerous pattern, is considerable of an idea. It is quite a real fact if it is not a material object. Call it a creation-idea or an evolution-idea, whichever you like best. An idea it is at all events, —a veritable plan which only an intelligent being could have conceived and executed.

The key-note of eutaxiology is plan, as that of teleology is purpose. " Plans and Purposes in Nature" would be a comprehensive title for a treatise on physico-theology.

The elements of the eutaxiological proof, or the fundamental conceptions involved in it, are, (1) the fact of order in nature; (2) the plan, or the mental conception of that disposition of objects and that movement of forces which constitute order and harmony.

This analysis shows that the eutaxiological is much simpler than the teleological argument. There is no such reduplication of the elements, and they are clearly distinct and different; so that there is not the same danger of confounding similar elements as in teleology. Eutaxiology is certainly simpler, but is it as forcible? I shall not at present attempt to answer this question in full. The critical estimation of both these arguments will be undertaken after I have given a historical review of natural theology, and after that estimate will be the time to institute the comparison.

But, without such careful examination, judging simply by what lies upon the surface, it would seem that this argument is at least equal to the other in effectiveness. Moreover, it is probable that a considerable part of the energy supposed to belong to teleology has really come from eutaxiology, seeing that they have always been lumped together under the head of design. When Napoleon, in reply to the fine-spun theories of the French atheists, pointed to the heavens and said, " But who made all these things? " his argument was eutaxiological, and there is no question but that it was forcible. It was a shot quite as solid as any which teleology can forge. The order, harmony, and beauty of the heavens speak a clear and universal language. " Their line is gone out through all the earth, and their words to the end of the world." The burden of their nightly song is the existence of a creative Intelligence. There is no thought of their utility, of an end for which they exist, — no complex relations of means and ends to be reasoned out before we can receive their sublime message. The lesson they teach is as simple as it is grand; and the argument based upon it is so plain, that neither bungling advocates nor captious critics can easily throw it into confusion.

If it should turn out that eutaxiology is as strong as teleology, the addition of an independent and valid proof of God's existence to those already in use would be a reason for separating this argument from teleology. But it may be that the latter is weakened by the separation. There ought to be solid reasons for it, aside from the mere increase in the number of arguments. There is a natural conservatism in human thought which will resent the change. Men who have become accustomed to associate the word " design " with teleology alone, will possibly feel reluctant to entertain the proposed division of design-arguments into two distinct species. Is there not a purpose in the order of nature? Why not leave that argument where it was before, under teleology? Are not all arguments from the order of nature really teleological, no matter how they are named?

Far be it from me to deny that there is a purpose in the admirable harmony of the universe. But the whole force of teleological reasoning consists in the fact, that not merely some purpose may be plausibly supposed to exist, but that the purpose is unmistakable, if it is a purpose at all. The purpose of the eye is vision* and no possibility of mistake about it, if it has any purpose whatever. Now, while the fact of order is plain enough, and the supposition of an underlying purpose is plausible enough, it is not so easy to say just what the purpose is. And teleology is certainly in a bad way, if, having set out to prove God's existence from the fact that special ends appear to have been chosen and wrought out in nature, its advocate is unable to specify what the end is, from the selection and accomplishment of which, as a premise, he hopes to reach his desired conclusion by legitimate reasoning.

But suppose we say that order is an end in itself? Very well: how, then, was it brought to pass? What are the means? Can you specify them minutely? Is not order too broad, and, so to speak, diffuse a thing to be of any teleological value? That argument is forcible only when structures and forces are, as it were, focused upon a definite result. But order is produced in a thousand different ways and places. Turn it about as you will, call it a means or call it an end, the notion of order sturdily refuses to shape itself as a valid teleological argument. But why grieve over that? Order is

in itself a mark of intelligence just as clearly as the adaptation of means to an end. If by main force you thrust it under the relation of means and ends, it will give you but a halling and unwilling service. Why not leave it where it belongs? why so eager to spoil a good eutaxiological argument to make a bad teleological one?

But suppose that the advocate of the old teleology returns to the charge once more with the suggestion that law is the means by which order is maintained. That notion might be sound enough in political science, but not in physics or in physico-theology. Human laws are a means of preserving order, but nature's laws are a different affair altogether. Natural law, instead of being the cause of order, is merely one form of order: it is order itself under another name. Law is merely an expression of constancy in the operation of forces. It signifies that forces move in a regular, that is, an orderly, manner. Now, not only is it a difficult matter to point out the means by which other forms of order are brought about, and particularly so in the case of the orderly movement of forces, — who can tell why or by what means gravitation acts according to the law of inverse squares?—but whan order appears under the form of law it is positively repugnant and hostile to the radical notion of teleology. Law is unbending and universal; teleology asserts that there has been a bending, a modification of structures directed to the evolution of a special result. Fixedness and universality are quite the opposites of adaptation and specialty.

We have already alluded to the constant encroachment of the province of eutaxiology upon that of teleology, — a diminution of the latter which has progressed just in proportion as men learned the lesson that God rules by fixed laws rather than by special interventions. The question whether there is any thing left of teleology, or, granting that it has some standing-room now, whether there will be any thing left of it after science has done its best or worst to reduce every thing under fixed laws, — that question is held in abeyance for the present. But, assuming that it may possibly receive an affirmative answer, that there is flexibility as well as fixedness in nature, that there are such numerous convergences of things and forces to a particular issue that any philosophical view of the whole system must take these into the account as well as the inflexible1 order of the cosmos, — then it is obvious, that, if there is such a thing as teleology, it is not only a thing quite distinct from eutaxiology, but the very opposite of it. Flexibility and specialty characterize the one, but fixedness and universality are the marks of the other. These opposite characteristics furnish ample ground for refusing to leave both together under the same name and in the same province of argument, — ample ground for the erection of eutaxiology into a distinct argument with a distinct name.

But, in thus emphasizing the sharp contrast between these two arguments for the purpose of justifying my classification and nomenclature, it may seem that I have so far overdone my task as to make them appear, not only distinct, but repugnant, hostile, irreconcilable, and mutually destructive the one to the other. It is therefore now in order to set forth their relations of harmony and likeness if they have any. Such relations do exist, and require but a moment's reflection to discover them. Radically different and even opposite in character as they are, still they are not opposed and hostile, but harmonious. Eutaxiology furnishes the general ground upon which teleology builds up definite results. If the scene which nature unfolds always presents certain hard and inflexible lines of order, and at the same time certain flexible lines which shape themselves into definite and graceful forms, the whole picture is none the less harmonious for that. There is unity of composition, notwithstanding the several elements are in sharp contrast.

Not only are these elements harmonious whenever they are found together, they are almost always together, almost inseparable in nature. Wherever the one is present, the other is more or less involved. In the analysis of teleology the divine element appears as a purpose; in eutaxiology it appears as a plan. The conception of a plan, type, or pattern realized in material forms is, indeed, quite distinct from the conception of an end accomplished by suitable means; but, though clearly

distinct, it is entirely harmonious, and thus capable of co-existence in the same object, or in the same series of operations. General plans and special purposes are alike products of mind: they both alike and equally involve the notion of a foreseeing intelligence and a determining will. This brings them into a very close likeness, and the more when we observe that the presence of the one frequently involves the other in a greater or less degree. For instance, the conception of a given function as an end involves the conception of the plan of an organ as a means. Respiration involves the conception of lungs constructed upon some general pattern. Every clear case of teleology involves eutaxiological elements.

Is the converse equally true? Is there a purpose in every example of order? We have already seen that if there is, — and no one. who admits any purposes at all in nature would feel competent to deny that there may be, — still it cannot, in many cases, be so specified as to base a teleological argument upon it. The typical vertebrate limb terminating in five digits is a plan realized in thousands of material forms; and it is probable there is a purpose in all this persistent exhibition of a morphological type, though it is not obvious what the purpose is, — at least not so obvious as in the case of organs in relation to their functions. Hence it appears that the converse is not true in the same sense and to the same extent.

In another sense, however, the teleological element is clearly present in all these cases. All the limbs built upon this general plan have some function, either walking or grasping or swimming or flying. But, the moment you turn your thought into this channel, it is the contrast and opposition of teleology and eutaxiology— or morphology, the biological phase of eutaxiology — that forces itself upon your notice. Teleology seizes the general pentamerous type which morphology presents, and plays all sorts of tricks with it; spreads it out into a paddle for swimming, or a wing for flying; swings round one or two of the digits to oppose the others for grasping; lops off one here, another there, or all but one of them for the sake of concentration and solidarity, as in the foot of the horse; in short, takes the greatest liberties with the general type, treating it as a sort of convenient platform, or stage, upon which to produce her ever-changing play of special ends.

The Use And Abuse Of The Word "Design"

What is meant by design in natural theology? From the fact that it has been constantly associated with teleology, we might infer that it means contrivance for a purpose, or adaptation of means to an end.1 That has undoubtedly been the thought of authors in the majority of places where they have written the word. But it is an ambiguous word: it has a number of other meanings. It may mean preliminary sketch, outline, plan, or delineation, as in drawing and architecture; or it may mean scheme, plot, device, aim, intent, or purpose. Any one who will examine the writings of design-advocates will easily find examples of gliding insensibly from the meaning usual with them, contrivance for a purpose, to some other of these numerous meanings. It is a pity that this ambiguous term should have so long held a foremost place in physico-theology; and, if this branch of theology is ever to have any pretensions to exactness and scientific method, the word "design" must either be wholly banished from its vocabulary, or at least remanded to a subordinate place, and used with extreme caution, in order not to mislead and confuse both author and reader.

Whewell'a definition of design. " We direct our thoughts to an action we are about to perform: we intend to do it; we make it our aim; wo place it before us, and act with purpose (propositum); we design it, or mark it beforehand (designo)." Elements of Morality, I., i. 7. This would be a better definition of designate than design. He has been too much influenced by the force of the Latin original. Besides, the range of meaning of the noun is considerably different from that of the verb, and it is the nouu with which we have to deal in teleology.

Although it would not be difficult to do so, it is not necessary to present an extended list of examples to show what abuses have arisen in the use of this word. The bare fact that teleology and

eutaxiology have been lumped together as a single design-argument is enough to condemn it. How so? Are they not both concerned with the question of design in nature? Certainly they are; and that is just what I complain of, — that is to say, that design is so versatile in meaning that it can be applied to both of these arguments in spite of their radical distinctness and sharp contrasts. It has even caused a persistent ignoring of the fact that they were distinct. Were they not both design-arguments, and therefore one and the same argument?

Two considerable infelicities are involved in the use of the word " design." The first is rhetorical. Shall I say argument from design, argument for design, argument of design, argument respecting design? or shall I dodge the delicate question of preference among pretty little prepositions, and (as some men have died bachelors rather than grieve the other fair charmers by choosing one) bluntly say design-argument? What is the trouble about those prepositions? None whatever: the mischief lies in the word "design." There is some real difficulty or ambiguity about that, which has been at the bottom of all these variations in the phrase-form used as a synonyme of teleology. All the variations given above have been actually employed by different authors.

The reason of it is this: if your argument is teleological, then " design " means " adaptation of means to an end," and it is an argument from design; that is, from the fact of adaptation, as a premise, to an intelligent author of that adaptation as a conclusion. But, if your argument is eutaxiological, then "design " means "plan," and it is an argument for design; that is, the fact of order in nature is your premise, from which you infer a preconceived plan, or design, as a conclusion. So that it is indeed true that both kinds of reasoning have to do with design, but in very different senses of that word.

It turns out that none of those phrase-forms are correct. If we say argument from desigri, that might answer as a synonyme for teleology, were it not for a couple of serious objections. One of these will appear presently; the other is, that, since eutaxiology has to do with design as well as teleology, it is inexpedient to incorporate the word "design " in the name of the latter. The same objection lies against the phrase, "argument for design," as a synonyme of eutaxiology. And if we should attempt to deal out an even-handed justice to both arguments by calling one the argument from design, and the other the argument for design, that would involve the awkwardness of using design in opposite senses in two closely related phrases in the same science.

It is also inadmissible to speak of the design-argument, or the argument of design, or the argument respecting design; for in each case it is implied that there is but one design-argument. These phrase-forms all involve and imply a failure to perceive the distinction between eutaxiology and teleology, and are indeed largely responsible for that failure. It is, however, convenient sometimes, and always quite admissible, to use these phrase-forms in the plural, — to speak of eutaxiology and teleology collectively as design-arguments. Or we may speak of either one of them as a design-argument, but not properly as the design-argument. Design, with all its shortcomings, is too good a word, and too firmly fixed by usage, to be wholly banished from natural theology. And, if used at all, it may be conveniently employed in the general way indicated by the phrase design-arguments, or arguments respecting design; these phrases being understood as equivalent expressions for the sum of eutaxiological and teleological arguments. In this way, whatever convenience and utility there is in the word will be preserved, and at the same time its power to work mischief through ambiguity will be neutralized.

The second unhappy consequence involved in the old loose and indiscriminate employment of the word " design " was a logical one, and so disastrous that it would be an abuse of terms to call it a mere infelicity. Design is a cloak for numerous fallacies. Some of these have been pointed out by various writers; but it does not seem to be sufficient merely to designate "design" as a dangerous word, and to show that this or that fallacy has resulted from its use. The most effectual remedy

would seem to be that of drawing hard and fast lines between eutaxiology and teleology, and showing in what sense design is used in each of these arguments. This I have done already; and a further safeguard against the ambiguities of design will be furnished by keeping each argument in its proper place, and applying it to its proper use, as I shall show in the sequel.

One of these fallacies which has been frequently criticised is that involved in the proposition, " Design implies a designer." Irons, McCosh, Powell, and several others have noticed this fallacy, some of these criticisms being nearly half a century old; and yet we find that Dr. Hodge opens his discussion of teleology with this syllogism: " Design supposes a designer. The world everywhere exhibits marks of design. Therefore the world owes its existence to an intelligent author."1 He goes on to explain design as including, " (1) The selection of an end to be attained. (2) The choice of suitable means for its attainment. (3) The actual application of those means for the accomplishment of the proposed end. Such being the nature of design, it is a self-evident truth, or even an identical proposition, that design is indicative of intelligence, will, and power."

Exactly so: the major premise is, as he says, an identical proposition. But, that being the case, the syllogism reduces to this form: A is A; B is A; therefore B is A. No valid syllogism can be constructed with only two terms. The truism contained in the major premise contributes nothing to legitimate reasoning, but serves only to cloak a fallacy.

The Doctrine Of Final Causes

Another phrase which has been used as a synonyme of teleology is the "doctrine of final causes." To show that this is still more objectionable than any of the names containing the word " design," is the object of the following discussion.

Aristotle stands sponsor for final causes; also for the dictum that nature does nothing in vain, — two things which have done infinite mischief in physico-theology. Respecting any object in nature, the question may be asked, What is it good for? The answer to this question designates the Aristotelian so-called final cause of that object. What is a house good for? To dwell in: habitableness is therefore the final cause of a house.

Aristotle's statement of his fourth principle is,1 That on account of which a thing was to be and the good of it, for this is the END of all becoming and change. It might easily be shown that modern teleologists have understood final cause somewhat differently from Aristotle's own interpretation of it. But that would be a waste of words, because the doctrine is vicious in any form, whether it be the primitive Aristotelian, or the perverted scholastic phase of it.

Ueberweg says, —

Of the four principles, matter, form, moving cause, and end, or final cause, the three latter are often one and the same in fact; for essence (form) and end are in themselves identical, since the proximate end of every object consists in the full development of its proper form (i.e., the immanent end of every object, by the recognition of which the Aristotelian doctrine of finality is radically distinguished from the superficial utilitarian teleology of later philosophers), and the cause of motion is at least identical in kind with the essence and the end.

From which it would seem that Aristotle's fourth principle was not the ultimate but the proximate end. But with teleologists the notion of final cause seems to be ultimate and exclusive cause, or end.

The schoolmen in the Middle Ages took up the phrase, and manipulated it in their peculiar fashion. From their commentatorial mills it sifted down into modern philosophy and theology. What sort of a grist it has become may be gathered from Whewell's statement of it: —

Thus we necessarily include in our idea of organization the notion of an End, a Purpose, a Design; or, to use another phrase which has been peculiarly appropriated in this case, a Final Cause. This idea of a Final Cause is an essential condition in order to the pursuing our researches respecting organized bodies. This idea of Final Cause is not deduced from the phenomena by reasoning, but is assumed as the only condition under which we can reason on such subjects at all.

He refers to his "History of Physiology," where, says he,—

I have shown that those who studied the structure of animals were irresistibly led to the conviction that the parts of this structure have each its end or purpose; that each member and organ not merely produces a certain effect or answers a certain use, but is so framed as to impress us with the persuasion that it was constructed for that use; that it was intended to produce the effect. It was there seen that this persuasion was repeatedly expressed in the most emphatic manner by Galen; that it directed the researches and led to the discoveries of Harvey; that it has always been dwelt upon as a favorite contemplation, and followed as a certain guide, by the best anatomists; and that it is inculcated by the physiologists of the profoundest views and most extensive knowledge of our own times. All these persons have deemed it a most certain and important principle of physiology, that in every organized structure, plant, or animal, each intelligible part has its allotted office; each organ is designed for its appropriate function; that nature, in these cases, produces nothing in vain; that, in short, each portion of the whole arangement has its final cause, —an end to which it is adapted, and in this end the reason that it is where and what it is.

The use of every organ has been discovered by starting from the assumption that it must have some use. The doctrine of the circulation of the blood was, as we have seen, clearly and professedly due to the persuasion of a purpose in the circulatory apparatus.

These statements involve all the principal vices of the doctrine of final causes, — the exaggerated pretension that, in " pursuing our researches respecting organized bodies," the idea of final cause " is assumed as the only condition under which we can reason on such subjects at all;" the ignoring of the distinction between use and purpose, which plainly appears in the unconsciousness with which he glides from the one to the other in the last quotation, and upon which fallacy of confusion his whole claim rests; the maxim that nature does nothing in vain; the notion of final cause as ultimate and exclusive,— "the reason why it (any organ) is where and what it is;" and the confounding of the two distinct notions of cause and effect, and means and ends. Let us examine some of these weak points in this doctrine, beginning with the last.

The trouble with final causes is, that while they are not causes at all, but ends or purposes, they take on the semblance of causes by reason of this name which is applied to them. Thus we have an inexcusable jumbling-up of two entirely distinct notions. Entirely distinct, I say, and so they are in close analysis; and yet they are sufficiently alike (here is where the trouble comes in) to lend themselves with great facility as instruments of confusion and mischief and mistaken identity, — in short, a whole " Comedy of Errors " when they are set jigging and masquerading in each other's clothes as they are in the doctrine of final causes.

Dr. Whewell distinctly admits this objection, but does not regard it as fatal:

The idea of final cause, of end, purpose, design, intention, is altogether different from the idea of cause as efficient cause. . . . But, if the idea be clearly entertained and steadily applied, the word

is a question of subordinate importance. The term final cause has been long familiarly used, and appears not likely to lead to confusion.

In order to judge for ourselves of the extent of the danger, which he admits does exist, that this term may lead to confusion, let us look into it a little more closely. The doctrine of final causes is clearly a teleological affair: hence we must recall the analysis of teleology already given, in order to see whether any of the elements of that argument can properly be called a cause. We have in the example previously given, that of hearing, (1) the ear, (2) hearing as a function, (3) the relation of the first to the second, (4) the reduplication of all these three elements in creative thought, (5) the determination of creative will.

If any one of these is a cause, it is certainly the last. But in the doctrine of final causes the formula would be, Hearing is the final cause of the ear. That is what it is good for, in Aristotelian phraseology; that is " the end to which it is adapted," "the reason that it is where and what it is," in the phraseology of Whewell. Let us see what consequences are likely to follow from the proposition that hearing is the cause of the ear. No one but a veteran teleologist ever thinks of cause in any other sense than as efficient cause; and even for the teleologist it requires a special effort to think of it simply as an end or purpose. It looks very much as if Whewell himself mixed a little efficient cause into his notion of final cause when he spoke of it as the reason for any organ being such as it is and placed where it is. Whether he did or not, the ordinary reader would be sure to do it; and we will endeavor to see where it will lead him.

Hearing is the final cause of the ear; but is it hearing as a function, or hearing as an end? The latter of course, because end and final cause are synonymous. I say the latter of course; because, in the light of a clear analysis of teleology, there can be no possible doubt about it. But would it be a matter of course in the absence of that analysis? The old teleologists failed entirely to distinguish between function and purpose. This is notoriously true of Whewell: he glides from use to purpose, and skips back again to function, with a serene and guileless unconsciousness of any difference between them. If he had seen the distinction, it must instantly have opened his eyes to the monstrous fallacy of his pretension, that an apprehension of the idea of final cause was the only condition under which we can reason at all about organized beings. Turn back to the last quotation but one, and observe, that, if he had stuck to the word use all the way through, it would have given no support to his claim of the value of final causes; but in the very crisis of the statement he slips in the word purpose instead of use, just as if it were synonymous with it. If he used these words and the notions they represent so indiscriminately, it would be surprising if his readers were not still more confused about them. So that, when it is said that hearing is the cause of the ear, it is just as likely to be understood of the function as of the purpose. Suppose it is the latter, however: what follows? The statement will be, that the conception in creative thought of hearing as a desirable end was the cause of the ear. How would such a statement be commonly understood? If it conveyed any meaning at all, which is somewhat doubtful, it must be either, that, if God had not happily thought of hearing, the ear would never have existed; or that the conception acting as a motive was the cause of that volition which set in motion the whole train of agencies resulting in the production of the ear. The first alternative makes it a condition rather than a cause; and the second is almost blasphemous, because it implies a denial of the freedom of the will of the Almighty himself.

Suppose, then, it is hearing as a function that is the cause of the ear. Will the veteran teleologist subscribe to that opinion? If so, he surrenders his whole case. That is precisely what those evolutionists who deny all teleology assert. The utility of hearing, they say, even in the rudest beginnings of the ear, was so great, that, in the struggle for life, natural selection and inheritance carried the organ right up to perfection, without any purpose about it. The assertion that the

physiological function of the ear was the cause of its present perfection at least, if not of its origin, would be received with applause; but the plaudits would come from the wrong quarter.

See where the devout teleologist is liable to be landed if he starts with the assertion that hearing is the cause of the ear. lie is brought to face a dilemma of which one horn pushes him to the verge of blasphemy, and the other into the enemy's camp. That is what may come of playing fast and loose with words, and mixing up two distinct notions in one phrase. The safe course will be not to say that hearing is the cause of the ear at all: it is sure to be misunderstood, and there is no need of it. When we have good plain words to express the only legitimate meaning, — viz., that hearing is the purpose of the ear, — why should we resort to an obsolete scholastic phrase, and say that hearing is the final cause of the ear?

When you say cause you are supposed to mean it. There is but one kind of cause known to mankind in general, and that is efficient cause, — a cause that causes something. But the schoolmen were so much better off than mankind in general, that they had four kinds of causes, — the formal, the material, the efficient, and the final cause. They supposed that they got all these from Aristotle; but he probably regarded the first two, matter and form (17 vA.77 and To as principles, or categories of existence rather than causes; and, whether he would agree to it or not, it is the real fact, that the fourth is not a cause any more than the first two. At all events, the notion of cause as efficient holds the common mind so firmly and exclusively, that confusion is sure to be the result of attempting to use the word " cause " in any other sense. There is no conceivable advantage in it which cannot be gained as well or better in some other way; and the dangers, difficulties, and objections involved in it are real, radical, and fatal.

It would be an interesting piece of knowledge, if it were attainable, to find out exactly what was the ordinary state of mind of a believer in final causes in respect to them and their relation to efficient cause; and whether they always succeeded in keeping them distinct, or sometimes themselves shared in the confusion which their use of terms was liable to produce in the minds of their readers. Just what was the "idea " of which Whewell speaks when he says, that, if it " be clearly entertained and steadily applied, the word in question is of subordinate importance"? Of course the answer to that is quite attainable: it was end, or purpose, though he called it came. But his language implies some difficulty in holding on to this notion in its strictness, and yet calling it a cause. It is difficult. It requires a special and constant effort. The teleologist can manage it so long as his mental machinery is, so to speak, screwed up to it. But, as we often get a very different notion of a man by seeing him in church on Sunday from that obtained by a business transaction with him on Monday, the interesting point would be to get at the every-day conceptions of these men who believed in final causes.

In the first place, what did they ordinarily mean when they used the word cause f That, too, is a question easily answered. They meant efficient cause, just as mankind in general do, who know nothing about any other kind of cause but that. In his discussion of "The Idea of Cause," Dr. Whewell thus defines it: " By cause we mean some quality, power, or efficacy, by which a state of things produces a succeeding state."1 He gives this simply as a general definition of cause, without specifying it as efficient cause. But he plainly meant that, though he left off the adjunct "efficient;" and he goes on through three chapters talking about cause just as if there were only one kind of cause in the world. He does not call it efficient cause in all those chapters, but simply cause. Subsequently, in the discussion of final cause, he brings in the term " efficient."

It was a matter of course with himself as well as his readers, that, when he said cause, he meant efficient cause.

The same is true of Dr. McCosh. In a long discussion of "cause-and effect," he seems utterly oblivious of any other than efficient causes. Nevertheless, he uses elsewhere the term " final cause." It might be shown, that the advocates of the doctrine of final causes generally thought of cause as efficient. So far our attempt to get at their every-day thoughts of this matter have been reasonably successful. But in the further attempt to round out and complete this interesting piece of knowledge by inquiring whether they ever tripped, nodded, or got confused in respect to the two kinds of causes, and what was their notion of the relation of final to efficient cause, the path of this investigation is not so plain and easy.

It is not certain that Whewell always kept up a clear distinction in his own mind between final and efficient causes. As already hinted, his language about the reason of a thing being " where and what it is," smacks somewhat of efficient cause. If his thought was at all tinged with that notion, then he himself was weltering in the " confusion " to which he hoped the term " final cause " " was not likely to lead." However that may be, it is certain that another advocate of final causes was thoroughly confused. I mean Cudworth. His general notion seems to be, that all mental causes are final causes; and yet he speaks of the "wisdom and contrivance of the divine Architect" as "the true efficient cause."

Upon the last point — that is, the relation of final to efficient cause — Kant's definition of end may give us some light: "An end is the object of a conception, provided that this (the conception) is considered as the cause of that (the object), the real ground of its possibility."1

Here is a definition within a definition, and the incidental one is better than the principal one. An end need not be a material object, as seems to be implied here; but the incidental definition of cause is " the real ground of its (the object's) possibility." All the associations of this definition, as well as the definition itself, which would not well apply to efficient cause, show that Kant was speaking of final cause. The ground of possibility of a thing is of the nature of a condition: hence it appears that final cause was a conditional notion in the mind of the German philosopher. But each condition is a part of the efficient cause: it is one of the circumstances,' all of which must be taken into the account in an exhaustive statement of the efficient cause; so that here again we have a blending and mingling of the two notions, instead of a clean separation.

Not that Kant was to blame, however, for not making a clean separation of the two notions. It cannot be done, at least not without doing violence to nature and truth. He undoubtedly hit upon the correct statement of the relation when he made it conditional. We have previously encountered the same notion in this discussion. In speaking of the interpretations which might be placed upon the scholastic formula, — Hearing is the cause of the ear, — one alternative (and the only admissible one) was, that the conception of hearing as an end was a condition of the existence of the ear. Kant was right in making the final cause a condition, because, in a true teleology emancipated from scholastic "finality," the conception of an end is of the nature of a condition.

But the vital consideration here again emerges, that the notion of an end is, though distinct, very closely related to the notion of efficient cause; that it is, in fact, a part of the cause. Hence the "Comedy of Errors." The twin brothers in the same dress — that is, both ideas clothed in the same word " cause " — make it a tough problem even for the veteran teleologist to distinguish them, and entirely too much for the "lay brethren " to manage.

Upon the whole, it appears that the advocates of final causes ordinarily thought of cause just as other people do. When they said cause they meant efficient cause. And so deep and strong was this current of their thought, that it was hard rowing for them to bring their minds up to the conception of final cause as simply purpose, — so hard that we find some of them in precarious shallows, and others actually aground upon the mudbanks of error and confusion. Hence it seems highly

inexpedient, as it is wholly unnecessary, to use the word " cause " in any other than the commonly accepted sense of efficient cause.

But we have as yet dealt with only one-half of the phrase "final cause." The word "final" is no less objectionable than "cause." Its proper function in the phrase is to direct the mind to an end (finis); and, if it stopped there, all would be well, — at least, not so bad as it is. It would, indeed, be a self-stultifying phrase even then; for one end of it is a plain " end," and the other a fine, wire-drawn, metaphysical " cause." The two opposite notions might, however, neutralize each other, and less harm be done. But "final" does not stop short and conclude its meaning when it has designated an end — or cause (?) (I am really in doubt which word would give the orthodox finish to that sentence. In this " Comedy of Errors," where " causes" and "ends." — Dromios and Antipholuses — are cantering indistinguishable about the stage, one is very liable to salute the wrong person as his dear friend who owes him money.) It goes on to describe it as the ultimate and exclusive end, or cause. When you have given the final cause of a thing, there is no more to be said. That's the end of it. You have given the reason for its being " where and what it is."

Now nothing could be more aside from the true aim and intent of teleology than such a notion as that. The purpose of any organ is always proximate and subordinate, not ultimate, not final. Lungs exist for the purpose of respiration: but that is subordinate to the existence and well-being of the animal; that possibly is subordinate to the utility of the animal to man, to plough his fields for example; that to the raising of grain; and so on through a long series of proximate ends, all subordinate to some ultimate divine purpose. This word final throws a tremendous load upon the teleologist, and a wholly needless one. It places him in the attitude of attempting to demonstrate, not merely a purpose, but the purpose, the only, the ultimate, the exclusive, the final intention of the Creator in respect to each structure. It has been objected to teleological reasoning, that it is presumptuous in man to ascribe any intention whatever to the Deity.1 How much more presumptuous to assume that we have entered so far into the divine counsels as to discern the one purpose which is exhaustive of his whole thought!

It may be said, that the advocates of this doctrine never meant any such thing by " final," whatever force that adjective may have acquired in popular use. With them it meant only what the etymology indicates. It is derived from finis, end; and its whole force and function is to describe cause as that peculiar sort of cause which is not a cause, but an end (finis).

I am quite desirous to put the case as favorably as possible for this " consecrated "1 doctrine of final causes. But really it is hard for me to defend it in any of its phases without seeming to make fun of it, as witness that last sentence of the preceding paragraph. Let it be granted that the trained advocates of this doctrine never tripped on the precise teleological force of " final: " it would not follow that the rank and file of their readers did not. The English force of the word would be very likely to get the better of the Latin force of it in the common mind; and that would be a valid objection to it, no matter how rigidly teleologists might keep to the technical meaning.

A third element of difficulty in the doctrine of final causes is the Aristotelian maxim, that nature does nothing in vain. On this point I might content myself with saying, that, in the first place, the maxim is not true; and, in the second place, that, while it has stubbornly held its place as an inseparable element of the doctrine of final causes, it is no part of a true teleology. But such brevity might be misunderstood. To be more explicit, then, the maxim is true in one sense, though false in the sense intended by Whewell and the teleologists of the last century. It is not true, that " in every organized structure, plant, or animal, each intelligible part has its allotted office." There are abortive and rudimentary organs. These are " in vain " as regards their utility to the plant or animal to which they belong, though not in vain as tokens of morphological symmetry. The general plan, or type, of structure is often adhered to, even at the cost of making the creature carry about

rudiments of organs which are of no manner of use to it. Such facts thrust themselves very disagreeably in the face of an advocate of the doctrine of final causes, but give no concern whatever to the true teleologist. He can assert, that the stomach was intended to digest food without being at all shaken in this conclusion by the consideration that farther down the alimentary tract there is a worm-like appendage to the CEecum which has no function at all. Instead of these rudiments disturbing him in the least, he seizes upon them as materials for eutaxiology, — an argument wholly distinct from teleology, but none the less valid for that. Those ideas of a plan in nature so forcibly brought home to the mind by the occurrence of abortive organs are very conclusive tokens of intelligence, although they have no relation whatever to the adapting of means to an end.

There are ample reasons why the term final cause ought to be summarily thrust out, and forever excluded, not only from physics, in which province Bacon regarded it as an intruder,1 but also from metaphysics and theology.

Notwithstanding these ample reasons, the term "final cause" will cut an important figure in the following pages; but that is only because teleology has generally assumed the form of a doctrine of final causes, and in the historical review this term cannot be avoided. In the subsequent chapters it will not appear, unless it steals in as the ghost of a defunct fallacy.

1884
Paul Janet, French Philosopher
Final Causes
Book

Book Second - The First Cause Of Finality

If the series of inductions which we have developed in the previous book be admitted, we shall be brought to this conclusion, that there are ends in nature. But between this proposition, and this other that is generally deduced from it —Namely, that a divine understanding has co-ordinated all towards these ends, — between these two propositions, I say, there is still a long enough interval.

What have we, in fact, seen? That human intelligence acts for ends; that, by analogy, it must be admitted that the animals act for ends, not only in their so-called intelligent, but also in their instinctive actions; that, in fine, by extension of the same reasoning, living nature must be considered as also acting for ends. Thus our argument would signify that living nature expresses, in its rudimentary form, the same property that is manifested under its most salient form in human intelligence — namely, the property of acting for ends, or finality. Finality, then, is one of the properties of nature; such is the result of the preceding analysis. But how should this analysis enable us to emerge from nature? how enable us to pass from facts to the cause? The force of our argument lies precisely in this, that we do not change the genus, but that in one and the same genus — namely, nature—we pursue the same met or the same property under different forms. But if, on the other hand, in place of following the same order whether ascending or descending, we suddenly pass from nature to its cause, and say there is in nature such w being (itself a member and part of the whole) which acts in a certain manner, therefore the first cause of this thing must have acted in the same manner, — if, I say, we reason thus, and this is what is generally called the proof of God from final causes, it cannot be doubted that we very boldly and rashly draw a conclusion which is certainly not contained in the premises.

The legitimate and natural impatience of believing souls, who would have philosophy to guarantee to them an evidence from reason equal to the evidence of feeling, by which they are convinced,

can hardly bear the application to such problems of the methods of trial, approximation, and cross-questioning, which are the peculiar features of the scientific method. It is hard to see the noblest beliefs of humanity weighed in the balance of a subtle dialectic. Of what use is philosophy, we are asked, but to obscure what is clear, and to shake what it defends? It has been thought by some a sufficient praise of such spiritualist philosophy to say: It does not hinder us from believing in God. In this order of ideas, in effect, it seems that demonstration weakens rather than proves, affords more doubt than light, and teaches us to dispute rather than to decide.

We are as sensible as any of this anxiety and trouble; and the fact mentioned, which is nothing but the truth, is one of the proofs of the feebleness of the human mind. But it is also precisely part of the greatness of the human mind to learn to consider vigorously and calmly its natural condition, and courageously to seek to remedy it. We distinguish, for our part, even in the order of nature, two things, faith and science, the object of the one being to supplement the other. There is a natural, practical, and moral faith in the existence of a Deity, which no demonstration can equal, to which no reasoning is adequate.1 But if the soul needs to believe, it also needs to know; it will try to unfold the causes of things by the laws of reason; and it is one of the strongest temptations of the human mind to equalize its knowledge with its faith, fides qiicerena intellectum. Hence the necessity of applying the abstract and discursive methods of science to what it would seem ought only to be an object of love and hope; even this, as it seems, has something disrespectful in it. The demonstration, even were it as affirmative as possible, is itself a failure of respect, for it calls in question what it is sought to demonstrate. An Deus sit? says St. Thomas Aquinas at the beginning of the Summa; and, faithful to the scholastic method, he first replies, Dico quod non. But who guarantees this holy theologian that he will retrieve at the «end of his argument what he has denied at the beginning? If he is sure of it beforehand, why does he make a show of seeking it? Does he only reason, then, for form's sake? Let him be silent, then; let him pray, let him preach, but let him quit this two-edged weapon, which must not be played with. But this is an impossibility. No believer will renounce the temptation to demonstrate what he believes; and though he wished to do so, he would soon be forced to it by attack. Hence the application of the cold methods of science becomes necessary, and with science there appears all the difficulties inherent in the employment of these methods. Hence he who employs them has the perfect right to proportion affirmations to evidence, according to the rule of Descartes. As a philosopher, I am bound to but one thing: to admit as true what appears to me evident, nothing more. That there should be a very great difference between the demonstrations of science and the instincts of faith, is self-evident; for an adequate demonstration of the Deity, of His existence and essence, would imply a reason adequate thereto. The absolute reason can alone know the absolute Being as He is. If, then, faith, anticipating this impossible knowledge, gives us moral certainty, science can only give a relative approximate knowledge, subject to revision in another state of knowledge, tout which for us is the mode of representation the most adequate to which we could attain. When Bacon said that we only know God by a refracted ray (radio refracto), this expression, admired by all, just means that the idea we have of Him is inadequate, without, however, being untrue, — as the projection of a circle is not a circle, although it faithfully reproduces all its parts.

NOTE: A single sigh towards the future and the better,' it is admirably said by Hemstorlmys,' is a more than geometrical demonstration of the Deity ' (Arist.(— d'Oeuvres d'emsterhuys,' ed. 1719, vol. ii. p. 87. — See, on the curious philosophy of Hemsterhuys, the work of M. Em. Cracker, Paris 1866).

Let us return to the question stated at the opening of this chapter: Is the existence of ends in nature equivalent to the existence of a supreme cause, external to nature, and pursuing these ends consciously and with reflection? The demonstration of such a cause is what is called in the schools the physico-theological proof of the existence of God.

This proof, as is known, has been reduced to a syllogism, whose major is, that all order, or, strictly speaking, all adaptation of means to ends, supposes an intelligence, and whose minor is, that nature presents order, and an adaptation of means to ends.

We have hitherto confined ourselves to the analysis and discussion of the minor.

There still remains the major proposition of the argument. Finality being a law of nature, what is the first cause of that law? That cause, says the traditional voice of the schools, from Socrates to Kant, is intelligence; therefore there is a supreme intelligent cause. Is this conclusion legitimate" Such will be the object of the second part of this treatise.

Chapter I - The Physico-Theological Proof

In one of his most profound comedies, Moliere makes a simple and pious valet give a lesson of theodicy to a sceptical and railing master. He makes the good Sganarelle speak thus to the unbelieving Don Juan: '

I have not studied like you, thank God, and no one could boast of having ever taught me anything; but with my small sense, my small judgment, I see things better than books, and understand very well that this world that we see is not a mushroom that has come of itself in a night. I would ask you, Who has made these trees, these rocks, this earth, and yonder sky above? and whether all that has made itself? . . . Can you see all the inventions of which the human machine is composed, without admiring the way in which it is arranged, one part within another? these nerves, bones, veins, arteries, these . . . these lungs, this heart, this liver, and all these other ingredients that are there, and that . . . My reasoning is that there is something wonderful in man, whatever you may say, and which all the savants cannot explain.

Under this comic and simple form, Moliere sets forth the most striking and oldest proof of the existence of God, that which persuades most men, and which philosophers have called the proof from final causes. It is this argument that Fenelon develops so amply and eloquently in his treatise on the Existence of God; that Cicero before him had set forth, almost in the same words, in his De Natura Deorum; and that Socrates appears to have first employed; and which Kant himself, even while criticising it, never mentions without respectful sympathy.

NOTE: Ltfesttn de Piem, act ill. tc. 1.

This classical and traditional proof has been set forth a thousand times under the most varied and sometimes the most piquant forms. Let us give some examples of them.

The illustrious Kepler, whose soul was as religious as his genius was powerful, found everywhere material for philosophic or scientific reflections. One day, when he had long meditated on atoms and their combinations, he was, as he himself relates, called to dinner by his wife Barbara, who laid a salad on the table. 'Dost think,' said I to her, 'that if from the creation plates of tin, leaves of lettuce, grains of salt, drops of oil and vinegar, and fragments of hard-boiled eggs were floating in space in all directions and without order, chance could assemble them to-day to form a salad?' ' Certainly not so good a one,' replied my fair spouse, ' nor so well seasoned as this.'1

A Scottish philosopher, the wise Beattie, formed the ingenious idea of putting in operation the proof of final causes, to inspire his young child with faith in Providence. This child was five or six years old, and was beginning to read; but his father had not yet sought to speak to him of God, thinking that he was not of an age to understand such lessons. To find entrance into his mind for this great idea in a manner suitable to his age, he thought of the following expedient. In a corner of

a little garden, without telling any one of the circumstance, he drew with his finger on the earth the three initial letters of his child's name, and, sowing garden cresses in the furrows, covered the seed and smoothed the earth. ' Ten days after,' he tells us, ' the child came running to me all amazed, and told me that his name had grown in the garden. I smiled at these words, and appeared not to attach much importance to what he had said. But he insisted on taking me to see what had happened. "Yes," said I, on coming to the place, " I see well enough that it is so; but there is nothing wonderful in this, — it is a mere accident," and went away. But he followed me, and, walking beside me, said very seriously: " That cannot be an accident. Some one must have prepared the seeds, to produce this result." Perhaps these were not his very words, but this was the substance of his thought. " You think, then," said I to him, " that what here appears as regular as the letters of your name, cannot be the product of chance? " " Yes," said he firmly, " I think so." " Well, then, look at yourself, consider your hands and fingers, your legs and feet, and all your members, and do not they seem to you regular in their appearance, and useful in their service? Doubtless they do. Can they, then, be the result of chance? " " No," replied he, " that cannot be; some one must have made me them." "And who is that some one? " I asked him. He replied that he did not know. I then made known to him the name of the great Being who made all the world, and regarding His nature I gave him all the instruction that could be adapted to his age. The lesson struck him profoundly, and he has never forgotten either it or the circumstance that was the occasion of it.'

Let us now pass to Baron d'Holbach's drawing-room, to a company where each one out-vied the atheism of his neighbour so as to scandalize Duclos himself; let us hear Abbe" Galiani, the witty improvisatore, so fond of paradox that he did not fear to defend God against his friends the Encyclopedists. Here is the scene, as reported by Abbe Morellet: 1 After dinner and coffee the abb6 sits down in an arm chair, his legs crossed like a tailor, as was his custom, and, it being warm, he takes his wig in one hand, and, gesticulating with the other, commences nearly as follows: "I will suppose, gentlemen, that he among you who is most fully convinced that the world is the effect of chance, playing with three dice, I do not say in a gambling-house, but in the best house in Paris, his antagonist throws sixes once, twice, thrice, four times — in a word, constantly. However short the duration of the game, my friend Diderot, thus losing his money, will unhesitatingly say, without a moment's doubt, ' The dice are loaded; I am in a bad house.' What then, philosopher? Because ten or a dozen throws of the dice have emerged from the box so as to make you lose six francs, you believe firmly that this is in consequence of an adroit manoeuvre, an artificial combination, a well-planned roguery; and, seeing in this universe so prodigious a number of combinations, thousands of times more difficult and complicated, more sustained and useful, etc., you do not suspect that the dice of nature are also loaded, and that there is above a great rogue, who takes pleasure in catching you.'"

NOTE: Al. Bertland, Les fondateurs de l'astronomie moderne, p. 104.

It were useless to multiply the different examples whereby it has been sought to bring home the force of this proof, and which are all of the same mould.1 The most ancient known form is that of throwing the twenty-four letters of the alphabet, which, according to Cicero, Fenelon, and so many others, could not produce a single verse of the Iliad.2 In a word, the stress of the proof is that chance will never produce a regulated work.

This last form of the proof,—namely, the throwing of letters of the alphabet, — while it gives it the most striking appearance, is yet at the same time the very thing that supplies the objection. We know, in effect, that chance is not impossibility. A thing may only happen by chance, and yet happen. For this it suffices that it implies no contradiction. There is no reason why the figures composing the date of the accession of Louis XIV. (1643), that of his personal government (1661), and that of his death (1715), should always form the same number (14), and that this number

should be precisely that of his rank among those of his name (Louis xiv.); and yet, however improbable these coincidences, they have occurred, and no one will seriously suppose that Providence amused itself with this kind of game, like a philosopher who should bethink himself of playing the juggler for recreation. The improbable may happen, then, — only it happens very seldom; and, for instance, the like coincidences would not be found in the history of all kings. But we know that, to reach a given combination, the more frequent the throws the more probable becomes the event. We know that mathematical calculation can determine the degree of probability 01 each event, and that it is equal to a fraction whose denominator expresses the totality of the chances, and the numerator the number of these chances, a number which augments with the number of the throws. Starting from this datum, one can calculate what chance there would be, by drawing the letters of the alphabet one after the other, of producing the verse of the Iliad. If, then, we threw the letters the given number of times, the production of the verse of the Iliad would not only be possible, but certain. This is evidently a concession that must be made to the opponents of the argument.1 They will not, however, have gained much by this; for to make these throws a hand and an intelligence were necessary. The types will not of themselves quit their cases to play at this game; once fallen, they will not rise to begin again. It follows, then, that the event in question is so improbable as to be practically equivalent to an impossibility. But is it the same if we pass from this particular case to the most general case possible —namely, to that of atoms endued with motion, and which have moved in empty space from infinitude? If the time is infinite, the number of throws may be infinite. In order, then, that a combination be produced, it is enough that it be possible. But the combination of which the actual world consists is possible, since it is; it must, therefore, infallibly be produced one day or other. This difficulty is very old: the Epicureans knew and made use of it There was scarcely need to know the calculus of probabilities to discover it; it is an objection suggested by mere common sense. Fenelon sets it forth in these terms: ' The atoms, we are told, have an eternal motion; their fortuitous concourse must already have exhausted, during this eternity, infinite combinations. By infinite is meant something that comprehends all without exception. Among those infinite combinations of atoms which have already successively happened, there must necessarily occur all those that are possible. The combination of atoms that forms the present system of the world must, therefore, be one of the combinations the atoms have successively had. This principle being stated, need we wonder that the world is as it is? It must have taken this precise form a little sooner or a little later. We find ourselves in this system now.'

NOTE: One may quote, however, the instance given by Tillotson in one of his sermons: ' If twenty thousand blind men were to set out from different places in England remote from each other, what chance would there be that they would end by meeting, all arranged in a row, in Salisbury Plain?'

NOTE: It is not known who first employed this argument. Perhaps the germ of It may be found in a passage of Aristotle, Ds Gen. el Corrupt, i. 2.

M. Charpentier clearly proves this in his ingenious treatise on the logic of probability, already quoted (p. 186). But he himself essays to prevail over the Epicurean argument by one of his own. That a fortuitous combination should take place once, he says, is not astonishing, and might even happen very certainly in the immensity of time; but that that combination should be reproduced a second and third time in succession, and even an infinite number of times, is what the calculation of probabilities does not allow us to admit. But the world exists from a time, if not infinite, at least indefinite; therefore the combination from which it results must have been reproduced continually, and is so still daily, •which is inadmissible. Thus what opposes the Epicurean objection would not be the existence of the world, but its duration. — Despite the ingenuity of this objection, we do not regard it as decisive. The world, in fact, a not the repetition of a combination which recurs several times by different throws; it is one single combination, whose peculiar character is that, once found, it lasts just because it has in itself conditions of duration and stability. Given in effect a

certain coincidence of distances and masses among the atoms, there will follow, for instance, a circular motion (that of the stars), which, in virtue of the law of inertia, will last eternally, so long as a new cause does not come to interrupt it; and so with the other conditions of regularity which we verify in the world. True, we may ask whether chance is capable of producing a world absolutely stable. But is the world, such as it is, absolutely stable? We do not know; and there may be such an unknown cause as will one day bring about its dissolution (for instance, the law of entropy of M. Clausius; see above, p. 196). If it were so, the world would have an end; it would then be, like all other combinations, unstable, only it would have lasted longer But what are a thousand millions of years to infinitude?

Fenelon replies to this objection of the Epicureans by denying that the number of combinations could be infinite, for, as he says, 'no number is infinite.' Given a number alleged to be infinite, I can always subtract a unit from it; then it will become finite. But if it is finite minus a unit, it cannot be infinite plus a unit, otherwise it would be this very unit that made it infinite. But a unit is itself something finite. Now the finite added to the finite cannot make the infinite. So to any number whatever I can add a unit; therefore it was not infinite before the addition of that unit. From this reasoning it follows that no number actually realized can be infinite, and that, consequently, the number of combinations of atoms cannot be infinite. The principle being overthrown, the conclusion falls along with it.

I do not know that this argument of Fenelon, even granting its principle, — namely, that no number could be infinite, — I do not know that this argument hits the mark, and am inclined to believe that it would rather strengthen the Epicurean objection. In fact, the strength of this objection is not in the hypothesis of an infinite number of combinations, but in the hypothesis of an infinite time permitting the atoms to take all possible combinations. But this combination is possible, since it is. It matters little, therefore, whether the possible number of combinations be infinite or not; rather, if the number be finite, there is more chance that this in which we are should happen during infinite time. Suppose, in short, that there were only a thousand combinations possible (that in which we are being one of the thousand, which is proved by the fact that it exists), there will be a greater chance that this combination should occur than if there were a million, a thousand millions, an infinitude of possible combinations. The more you multiply the number of possible combinations, the more surprising do you render the realization of the actual one, — so much so, that even with infinite time we question whether such a combination must necessarily happen, which Fenelon too easily grants. To suppose the world to pass successively through all possible combinations, and that it passes through them all in turn, is to suppose a certain order, a certain plan in the course of the combinations, which contradicts the idea of chance. It is clear that it might pass very often through similar combinations, that those recurring most frequently will be the easiest that those in which there is a very complicated combination (were they strictly possible) will only occur with great difficulty, and, despite infinite time, have an infinite chance against their realization. One can bet, then, in a manner, the infinite to one that the present combination will not be realized, however considerable may be the series of ages.

But let us lay aside the calculation of probabilities, and let us touch the Epicurean argument at the really sensitive part. The strength of this argument consists in supposing that the actual combination forms part of the series of possible combinations of atoms. It is possible, we are told, because it is. I say that this is to beg the question. The question, in short, is whether the world is possible without an intelligent cause. Those who deny it maintain that one of the elements of the combination is just intelligence, so that if this intellectual element be suppressed, the world ceases to be possible. Is it not as if it were said: This picture is possible, because it is; it has, therefore, had no painter? I deny it; for without a painter the picture is not possible. Logical possibility and real possibility are here confounded. What implies no contradiction is possible logically. But a given combination of colours (for instance, a given picture) implies no contradiction, since it is; it is,

then, logically possible. But to pass from this logical to the real possibility, do we not need a precise cause, a determinate agent? This is at least what we allege; and it is to resolve the question by the question, to deny the condition that is the object of the debate, by affirming d priori a possibility which we only grant upon this same condition.

Besides, it is still a question whether the actual world would have been possible, if the elements of which it is composed had not been chosen and prepared precisely that the world might exist; so that if we suppose, on the contrary, any unprepared elements, the actual combination would become impossible. In fact, in order that a composed and combined work may be effected, indeterminate materials, indifferent to any form, do not suffice; there are needed particular materials, form, and arrangement. To make a table, for instance, pieces of wood of any form — spheres, cubes, pyramids, or any other solids, more or less regular — do not suffice; wood cut into planks is needed. So to compose a line of print, little pieces of copper or lead do not suffice; characters — that is, letters — are required. If the materials are not appropriate to the thing to be realized, in vain will they have moved during infinite time. They will not produce that work; for them it is outside of possible combinations; it is incompatible with their essence. Grains of gold moving without end during infinite time will never make a blade of grass.

I say, then, that to render the present world possible, the first elements of which it is composed must have such a determinate essence that precisely this may be in the number of possible combinations of these elements. I even add, that to speak of other possible combinations than this is a bad expression, for all that results, or can result, from the essence of the elements, forms part of the actual combination. By universe, in fact, I mean the whole of the phenomena, past, present, and future, which have followed from the first throw of the elements. There has never, then, been more than one combination; and from the first cast the present world was found without groping and without throw of dice. There has only been one cast, and that is the harmonious and regular world of which we see but one moment and one face, but which embraces in its unity all the faces and moments the imagination can conceive. To imagine another world, other combinations, we must suppose, if possible, other elements, but which have never been realized and never existed, otherwise the present world would itself never have existed, since it is only compatible with some elements and not with others.

This assertion in no way contradicts the doctrine of free will; for free will to not exercised at the expense of the laws of nature, and cannot change the essential conditions of the actual combination: it only shows itself in the very sphere of these conditions.

Hence it follows that the alleged infinitude of combinations, from which all at once the present world resulted, implies a contradiction, and that from the first moment it was already the present world (not the phase in which we form part, but an interior phase bound to this). The present world exists, then, from all eternity (if it exists of itself), and there never have been others. There is room for the inquiry how such a world, so regular and wise, has alone succeeded in existing among so many other worlds that might have been; and if it be said that no other than this could exist (which, for the rest, we do not know), the question will still remain, how the only possible world is precisely that in which order, harmony, and reason reign.

Let it not, meanwhile, be supposed that the question can be resolved by applying to the formation of worlds the Darwinian principle of the struggle for existence, and natural selection. It is the same with worlds, it might be said, as with living species; the best organized is the most durable, and, among all possible, that alone has endured which hat been found possessed of conditions of stability. The comparison is quite false. A species, in order to last and live, needs to be adapted to a medium. That will be the most durable in which most adaptation shall occur; that in which none at all is found will only last a moment, or even will never exist. But the world has not to be adapted

to a medium, since it is itself the whole. What need has it to be organized, harmonious, and regular? And why should it not subsist in the state of chaos? For the totality of things, the absence of order and regularity is not, as in the case of living species, a principle of destruction. The materials being eternal and necessary, what matters it whether they be in one order or in another, or even though they have no order at all? They will exist none the less. Thus a chaos has not less chance of existing than a cosmos. In the competition of the possibilities of being, the one is equal to the other. No doubt Leibnitz has justly said that in this competition of possibles, perfection is the cause of choice; but this is precisely because he occupies the point of view of the final, and not of the material cause. From a purely material point of view all the possibles are equal, and selection can do nothing in it. Hence my question recurs: How is the only world that has managed to exist precisely the world of order and harmony?

Besides, the Epicurean objection, if it were accepted, would go much farther than is imagined. If all is the product of chance, it must be admitted that not only the intentional order of nature, but even physical and mathematical order, is purely fortuitous and contingent; for, once upon this path, why should it not be supposed that it is chance that produces an apparent constancy in the laws of nature, like, for example, the constancy of chance in the case of a lucky gambler? There are no laws, it will be said, but simple coincidences which hitherto have been more frequent than others. The order of things would then have no more value than their goodness, and science would be as arbitrary as esthetics. But no one goes so far. On the contrary, it is in the name of science and of the laws of nature that finality is opposed; but if it is not believed that chance can produce laws that have full mathematical rigour, why should it be admitted that it can produce the appearance of order and wisdom?

But let us not insist on an argument now antiquated, and which no one really any longer maintains, which, besides, taken strictly, would carry us much farther than any one wants to go. From the point where the discussion was in the days of Fenelon, let us come to the point where it is at present, — that is, the point to which it has been brought by the criticism of David Hume, Kant, and Hegel.

Kant reduces the physico-theological proof to the different points that follow: — 1st, There are everywhere in the world manifest signs of an order regulated by design; 2d, This harmonious order is not inherent in the things of the world, it only belongs to them contingently; 8d, There exists, therefore, one sublime wise cause (or more), which must have produced the world not only as an omnipotent nature acting blindly by its fecundity, but as an intelligence by its liberty; 4th, The unity of this cause is deducible from that of the mutual relations of the parts of the world viewed as the different pieces of a work of art.

Kant begins by mentioning and setting aside one of the chief difficulties, which he himself, however, seems to consider a cavil here, but which, in the Critique of the Judgment^ and in the later German philosophy, becomes the point of departure of an entire revolution in the conception of finality. ' We will not here cavil with natural reason,' he says, ' on this argument, in which, founding on the analogy of some productions of nature with the products of human art, it concludes that nature must have as its principle a causality of the same kind.' This analogical reasoning is what we have hitherto made use of to prove natural finality; but to defend ourselves against the very objection of Kant, we have taken care only to make use of it to prove the existence of this finality, and not to explain its cause. Analogy can serve as a clue while only nature is concerned; whether it can also enable us to pass beyond nature is quite another question. However, since Kant himself here sets aside this difficulty as a cavil, this is not the time to raise it, and we will revert to it at the fit time and place.1

This difficulty being adjourned, there remain two objections urged by Kant against the proof of final causes. The first is that that proof, if it were considered as valid in itself, would only demonstrate that there is an architect but not a creator of the world, — that it is the form of the world, not its matter, that is contingent. To prove the contingency of the matter of the world would need an entirely different argument than this.

Note: This will be the object of the two following chapters

Thus, according to this first objection, the argument would indeed prove, according to Kant, that the form of the world is contingent, — that is, supposes a cause, — but it does not prove this of the matter. The distribution of the elements, and their co-ordination according to a plan, would suppose a cause; but as to the elements, the very atoms composing the material of the world, nothing proves them to have a cause, and that they do not pre-exist necessarily and eternally.

The second objection is, that the argument, resting only upon experience, — that is, upon imperfect, contingent, and limited things, — can only infer a proportionate cause; in other words, a cause which is itself relative and imperfect. One can only rise to a very wise, very skilful, very powerful cause; and it is only by imperceptibly changing the argument that we infer an entirely wise, entirely skilful, and all powerful cause. ' The physico-theological proof, then, finds itself arrested in the midst of its undertaking; in its difficulty it leaps of a sudden to the cosmological proof, which is itself only a disguised ontological proof. . . . After having gone a good way on the ground of nature and experience, the partisans of this proof suddenly abandon this domain, and rush into the region of pure possibilities.' The conclusion is that the proof of final causes only gives us a relative and indeterminate cause, and leaves us in complete ignorance as to its nature; for ' there is no determinate concept but that which comprehends all possible perfection, and it is only the whole (omnitudo') of reality that is completely determinate.'

It has been generally agreed, even in the modern spiritualist school, to accept the two preceding objections. It has been acknowledged that Kant has clearly limited the range of the proof of final causes, and that we must have recourse to other proofs to complete the demonstration.

NOTE: Philosophic de Kant, 6« le<;oii, p. 217.

The masters of eclectic spiritualism, M. V. Cousin and M. Emile Saisset, express themselves on this question as follows: — ' We are not afraid of criticism for the principle of final causes,' says M. Cousin,1' but we believe, with Kant, that its range must not be exaggerated. In fact, the harmony of the phenomena of nature only proves an architect of the •world. One may admit a supreme architect, and deny that he can be the creator. These are two entirely different things. In the second place, if we do not pass beyond the argument of final causes, that greatness of the worker which we conceive proportionate to his works is quite indeterminate, and experience will never give us the idea of the omnipotence, perfect wisdom, and absolute unity of the supreme author.' ' These objections are valid,' says M. Emile Saisset;1 ' this dialectic is irrefutable; but what does it prove? Not that the argument from final causes is false, but that it is insufficient; not that it must be despised or rejected, but that it should be confined to its just range. It does not prove the existence of the creator; it does not even prove the existence of an infinite intelligence; but it serves powerfully to confirm it.'

Perhaps it is a little presumptuous to try to gain back from Kant, if not all, at least a part of what such wise philosophers have thought it their duty to yield to him. Still let us try. I shall not insist on noticing how inexact it is to blame an argument for not proving what it is in no way meant to prove. The proof of final causes does not aim to prove the creation of the world; it might as well be criticised because it does not prove the immortality of the soul. There is a time for everything, and

in good logic we ought to ask of every proof only what it promises. The existence of God is one thing; creation is another. One may admit a God without admitting creation ex nihilo. Plato, Aristotle, and the Stoics admitted the existence of God, without knowing anything of the dogma of creation. Does the physico-theological argument prove, or does it not, an intelligent cause of the world? That is the whole. If it does, the argument is good, even if it did not prove a creating God, nor even a God absolutely perfect. That will be matter for another discussion. The two objections of Kant, then, as it seems to us, fall into the sophism of the ignoratio elenchi.

NOTE: Phtlomphit reltgieuse, 2d ed. t. ii. Appendix.

But we will try to go farther, and to prove that Kant's two objections cannot subsist together: the first destroys the second, and of the two difficulties raised at once, the first can alone subsist.1

If, in fact, it be maintained that God is only the architect of the world, and that only the form of things is contingent, that means that matter is not so. If matter is not contingent, —that means that it is necessary, — it exists of itself, it has in itself the reason of its existence; this is the datum of the objection. But if we suppose matter to be necessary, for the same reason we must suppose the cause that gives the form to be necessary, on the same ground as the matter itself, and that it is self-existent. How, in short, can it be admitted that a non-necessary cause would have the power to act on a necessary matter, and to give it orders? If matter has not the principle of order and harmony in itself, how should that principle be found in an external and contingent cause? If that organizing cause were contingent, whence would it have derived the reason of its existence? This could only be in the self-existent matter; but how can it be supposed that a cause, deriving its existence from matter, should be capable of modifying and transforming it, and imprinting order and harmony upon it? Would not this be as if it were said that matter had given these to itself, which the objection ought not to assume? This cause does not, then, proceed from matter; it is, therefore, self-existent, or is derived from a self-existent cause. Notice, besides, that the processes in infinitum would here avail nothing, for by hypothesis the matter supposed necessary is also a last term; therefore, on the other hand, the cause must likewise have a last term.

NOTE: We had admitted in the first edition that the two objections of Kant destroyed each other, and that if the second were granted (namely, the imperfection of the world), one thereby destroyed the idea of an architect God. We withdraw this assertion, and limit ourselves to affirming that the first objection destroys the second. In other words, we grant that the proof of final causes only infers an architect God; but it seems to us that that suffices to infer a perfect wisdom. As to the reason that has made us abandon the second argument, it will be seen in the Appendix X.

From this it follows that the organizing cause of the world is a cause by itself, — that is to say, that it is an absolute cause; for absolute means nothing else than what is self-sufficient, what has need of nothing else to exist. It is what Kant calls the unconditioned, what does not presuppose any condition; the (Greek word) of Plato. The hypothesis of necessary matter, contained in the objection, puts us in possession of the idea of the absolute; and once in possession of this idea, we are entitled and even constrained to suppose it in the cause as well as in matter.

But then it is evident that the first objection destroys the second. What was the latter? This, that from a contingent world we cannot rise to an absolute cause; that there is not in the world material enough to make a primary being sufficient for all. But the first objection, by the hypothesis of a pre-existent — that is, necessary — matter, furnishes the material of the absolute idea of which I have need. If the first cause is absolute, it will be so in all its attributes: being by hypothesis intelligent, it will be omniscient; being powerful, it will be omnipotent; being good, it will be perfectly good, and so on. Will it be said that this cause is not absolute because it only organizes, not creates, and that it is limited by the matter on which it acts? But if there were some

contradiction here, it would rather belong to the objection than to the argument itself, and we would very soon be brought to conclude that a cause cannot be absolute without existing alone, which would destroy the hypothesis of a preexisting matter. We may affirm, then, that the Divine Architect would very speedily and inevitably lead to the Divine Creator. But without pressing this conclusion, suffice it to remark, that matter does not limit the first cause in its essence, but only in its action; that God could still be, for instance, the Good in itself of Plato, the pure Act of Aristotle, while yet as regards the world only organizer, and rot creator, which would amply suffice.

The truth is that, according to Kant, the organizing cause is not only contingent, relative, and imperfect —- it is indeterminate to the extent that it cannot even be said whether it is one or several; and the heathen did not reason so badly in admitting the plurality of gods. Seeing, in short, means and ends, but ends that did not mutually agree, they supposed as many causes as they saw categories of ends. Hence polytheism, which appears a legitimate product of the hypothesis of final causes. It is the same with Mechanism. The world consisting of good and evil, order and disorder, in strict reason it seems quite as legitimate to infer an evil cause as a good one, or else an indeterminate cause, neither good nor bad, and of which nothing is known but that it is.

We are far from saying that there is no share of truth in these objections, but we need not admit more than is necessary. And here again this part of the objection may be circumscribed.

First, should it be said, strictly speaking, that we have still the right at the present day to infer Manichaeism or polytheism, I will ask, then, why humanity has ceased to be polytheistic and Manichaean in proportion as it has become more enlightened. No doubt polytheism might be historically a plausible and relatively legitimate hypothesis. It is infinitely superior to fetishism and to coarse mechanism. Doubtless it is a first glance at nature, a first interpretation of the phenomena— an interpretation sufficiently acceptable in relation *o the knowledge of the epoch. But in proportion as nature has been studied, all these apparently divergent effects have been seen to converge towards one centre, all these ends to coordinate themselves to form one whole, and show themselves .with admirable harmony. The stars and the earth have been seen to be connected by bonds and common motions, to show even a common substance, for we find in the sun the elements of our mineral world. We see by the progress of the sciences all the classifications of causes being gradually simplified. Thus, in the scientific world, polytheism disappears, — that is, the hypothesis of several causes is constantly giving place to unity. Hence we need not wonder that humanity at last came to understand that it was to take imaginary beings for realities, to create as many gods as phenomena, and that we must not multiply beings needlessly. If, then, there is an intelligent cause of the world, it must be one. The same holds as to Mechanism. Here experience is less advanced than for the multiplicity of causes. No doubt, we are far from having explained all in the world that is called evil. There remains a certain latitude allowed the hypothesis of something bad or impotent in the first principle, if, that is, one occupy the point of view of experience alone. And yet, even from this point of view, it may be said that the hypothesis of an evil or impotent principle has been, at the very least, driven back. Have not a great many phenomena considered pernicious been reduced to phenomena conformable to the order of things? Did not the idea of a wicked and cruel God arise at the first from the contemplation of volcanoes, comets, and all that, being unexpected, strikes the senses or threatens the life of men? Yet we now know that many of these phenomena are innocent, and that they only differ by intensity from the most simple that continually surround us and that have nothing pernicious in them. The eruption of a volcano is no more extraordinary than the boiling over of water in a kettle. The lightning that throws down buildings, splits and plucks up trees, is like the electric spark with which we play. In fine, apart from pain, no phenomenon can strictly be called a disorder of nature; consequently there is in it nothing to indicate a pernicious and unreasonable power. Coming to pain, the explanation presents more difficulty; yet it cannot be denied that the studies of philosophers and moralists have at least

singularly diminished the force of the argument. It is known to be often a salutary warning, a necessary stimulus to human activity, an incitement to the progress of the human race. Pain can thus be explained to a certain extent from the point of view of final causes. As to moral evil, it is a phenomenon of an order so different, and so entirely beyond what we have hitherto been studying, that we are warranted to set aside this aspect of the question. We only remark that, when we see evil restrained in society as the result of the progress of manners and ideas, we find here again, if not a solution, at least a diminution of the difficulty. Thus apart from objections a priori, which are decisive against Mechanism, and even from the point of view of experience, from which this doctrine might still derive some support, we see that a certain number of phenomena, which at first appeared most favourable to the idea of a pernicious power, have admitted of explanation. We are, therefore, entitled to suppose that the others will be explained in the same way, or would be explained if the order of things were better known.

Kant further objects to the proof from final causes as powerless to give us a God apart from the world, or at least to rise to this, except by illegitimately going beyond itself, and surreptitiously borrowing the aid of the ontological or cosmological proof. But here again, as we think, there is a confusion of ideas.

What is meant by these words, apart from the world f Is it simply, not forming part of the chain of finite and contingent beings that we seek to explain? In this sense it is evident, in fact, that the cause of the world is apart from the world. The world comprising all the things of experience, none of these things is qualified to be, more than another, the universal cause; the cause of the world, behoving to be adequate to the entire series of the phenomena, cannot be confounded with any of them in particular. In this sense the distinction of the world and its cause is incontestable, and rests simply on the principle of causality, in virtue of which the cause is distinct from its effect. But if now by this expression, apart from the world, there is meant a more profound distinction and separation, — for instance, a distinction of substance, — such a distinction, in fact, transcends the data of the physico-theological proof, but no more is it required by the question. The existence of an intelligent cause of the universe is one thing, the transcendence or immanence of that cause is another. Even if we admitted, with the Stoics, a soul of the world, an active principle of which nature would only be the passive side, God would be none the less an intelligent cause of the universe; and if the proof goes no farther, it goes at least this length, and that is the only thing in question at present.

Metaphysicians are too often in the wrong in setting up the deadly maxim of radical politicians — all or nothing. They do not sufficiently admit what may be called the current coin of truth. A half, third, or quarter of the truth has no value in their eyes, if all they ask be not granted them. However, there is a medium between knowing all and knowing nothing; and in every question, between the extreme terms there are many degrees. Between the hypothesis of a nature produced by chance, and that of a supreme cause absolutely perfect, there may be many shades of opinion, of which none is to be despised. That nature supposes an ordering principle is a truth of first rank, whatever else may be the more or less extended meaning that may be given to this principle. The criticism of Kant, despite the two objections set forth, allows this proposition, in its essence, to stand; and on this ground it could not^ prevent our discussion from advancing a step. From finality, considered as a natural law, we have passed to its cause, and to an intelligent cause. What are the degree and nature of this intelligence? Is it interior or exterior to nature? This is what remains in suspense; but that which has been gained would be none the less of great value.

Kant, however, believes that there results from the discussion instituted by him a critical conclusion much graver than what we have just indicated — namely, that the proof in question only supplies us with a regulative, not a constitutive, principle, — that is, that this proof suggests to us, indeed, a hypothesis useful, in the course of scientific researches, for conceiving a certain

systematic unity in nature, but not a real principle, corresponding to an effective and essential law of the nature of things.1 But it happens that it is precisely in quality of a hypothesis regulative of scientific researches that the theory of final causes is useless or injurious. As a rule, then, it can be dispensed with. It is, on the other hand, in quality of truth that it is imposed upon us; but what is true is essentially constitutive. Besides, one does not see how this critical conclusion should result from the previous discussion. Because the cause of the world was only organizing, and not creative, —a relative, not an absolute cause, — how should it follow that finality is only an idea, a rule, and has no relation to objective reality? However limited may be the field of finality, while the very basis of the argument is conceded, the extent of the conclusions may be limited; but one cannot change their nature, nor conclude from the real to the ideal. It is on the real that the physico-theological argument takes its stand. This basis not being disputed, the degree of the presumed cause matters little; uncertainty regarding the degree of the cause does not suffice to transfer it from one order to another — from reality to ideality. Now, in the previous criticism, Kant did not make the discussion bear on the reality of the data (except in a parenthesis scarcely indicated), and only insisted on the disproportion between the latter and an absolute cause. But because that cause was not absolute, it would not follow that it was ideal.

It seems that there is a kind of contradiction in Kant's thought between what he at first grants to the physico-theological argument and the meaning he attributes to it is the end. 'It would be,' he says, 'not only to deprive ourselves of a consolation, but even to attempt the impossible, to pretend to take away something from the authority of the proof.' He here, then, accords to this proof at least a practical and instinctive value, which cannot be diminished ' by the uncertainties of a subtle and abstract speculation.' However, if this proof is limited finally to furnishing us with a rule for the interpretation of nature,—if it is only a ' convenient and useful hypothesis, which, in any case, can do no harm,' — the authority of the argument as a proof of the existence of God absolutely disappears.

It must not be lost sight of that our whole controversy at present only bears upon Kant's argumentation in the Critique of Pure Reason, and that we leave aside the doctrine of finality as it is set forth In the Critique of the Judgment, which will be the object of the following chapter. The only question debated here is whether, from the two objections above set forth, and which are all that Kant handles ex-professo in the Pure Reason, it results that finality has only a regulative and not a constitutive value, as he affirms.

Kant tells us that if the principle of final causes were constitutive (that is, objective), and not simply regulative (that is, hypothetical), the consequence of it would be inactive reason (ignava ratio). The investigation of nature would then be regarded as completely achieved, and reason would give itself to repose, as if it had accomplished its work; the ends of nature would free us from investigating its causes, and we would be led to recur too easily to the unfathomable decrees of the divine wisdom. But it seems to us that this difficulty rather bears against Kant himself than against the opposite doctrine. If finality is nothing else than a principle regulative of the scientific use of the reason, and the anticipated expression of the unity of nature, we will then be tempted everywhere to assume unity and ends, and will be so much the less inclined to refrain from this, that we will always be able to say to ourselves that it only regards provisional and conventional hypotheses. If, on the other hand, the theory of final causes has only a theological, and not a scientific value — if it regards not the immediate explanation of the phenomena, but their last reason, wherein can the doctrine of a creative or ordering intelligence injure the sciences and the study of nature? On the contrary, as we have often said, the assumption of ends can in no way oppose the investigation of causes, since there can only be ends if there are causes. How could a means be fit for an end, if it were not at the same time a cause capable of producing that effect? In an experimental and scientific point of view, then, it will always be possible to place the end out of account in investigating nature, and the doctrine of a supreme cause will no more encourage

inactive reason than any other. Whatever hypothesis may be formed as to the principle of things, inactive or adventurous minds will always be able to dispense with the study of particular laws and immediate causes by a recourse to the first cause. It will be said, for instance, of a given phenomenon, that it is a mode of motion, and thus one will avoid determining what mode of motion it may be, and according to what law it is governed. 'The laws of nature' will be appealed to as immoderately as is the divine wisdom in another camp. Reciprocally, a partisan of the divine wisdom is as well entitled as any other to place that conception out of account in the study of the particular laws of nature. Thus the fault in question may be common to both sides, and both sides also can escape it.

It results from the preceding discussion that the objections raised by Kant in the Critique of Pure Reason, against the proof of final causes, only touch, after all, the accessory part of the argument, and leave intact the essence — namely, that order implies intelligence. But this is only the first assault of modern criticism; the argument has still to undergo many trials before emerging intact from the fire of debate, as will be seen in the following chapters.

NOTE: See Appendix X., two notes relative to the physico-theological argument.

Chapter II - Subjective And Immanent Finality

The knot of the argument of final causes so called, or physico-theological argument, is in this major proposition of Bossuet: All order, that is, all proportion between means and ends, supposes an intelligent cause. But here also lies the radical difficulty of the argument. That the order of nature, the finality of the world, supposes a specific, appropriate principle may be allowed; but is that principle necessarily an intention, a will, a free reflection, capable of choice? This is another question, and a new object of dispute.

That is not all. Does the finality assumed in nature really belong to nature, — is it real, objective, or might it not be a form of our mind, a tendency of our feeling, — in a word, a hypothesis more or less useful and convenient for forming our ideas of things, but not an essential, real law, true in itself, as the veritable laws of nature behove to be?

Finally, for a third difficulty. Granting that finality must have a cause, still is that cause necessarily anterior and exterior to nature? May it not be precisely nature itself? Why should it not be of the essence of nature spontaneously to seek finality.

To these three questions correspond three solutions or hypotheses, which it is necessary to examine: the hypothesis of subjective finality in Kant; the hypothesis of immanent, and that of unconscious finality in Schelling, Hegel, and the whole German pantheism. Is finality subjective? Is it immanent? Is it unconscious? The first two of these questions will be the subject of this chapter, the third that of the two chapters following.

1. Subjective Finality.

In his Critique of Pure Reason, Kant had striven to limit and circumscribe the range of the physico-theological argument; but finally he seemed to admit the foundation of it, and, save a reservation of great importance, but hardly indicated,1 he acknowledged that we are warranted to infer from the order of the universe an intelligent cause — in a word, the essence of the proof remained safe and sound. But it remained to examine the value of the principle itself, in virtue of which we thus reason. This new question he has examined in his Critique of the Judgment, and has resolved it in a much more problematic sense than he appeared to do in the Critique of Pure Reason.

How was Kant led to examine the principle of finality? He himself tells us. Because the principle of liberty, demonstrated in the Critique of Practical Reason, implied that liberty must realize in the sensible world the end set by its laws. In fact, the ideal conception of morality, according to Kant, consists in conceiving the maxim of each action as capable of becoming ' a universal law of nature.' This, again, was to suppose ' that nature does not exclude the possibility of ends that must be attained according to the laws of liberty. If nature were not, in fact, susceptible of ends, how could it contribute to the ends of liberty? Consequently there must be a principle, rendering possible the agreement of the supra-sensible, that serves as a foundation to nature, with the conception of liberty, and which permits the mind to pass from the one world to the other.'2 In a word, the pure reason furnishes us with concepts sufficient to constitute nature, to render it possible. These concepts, which are the categories, and of which the principal is the concept of causality, teach us that there is a nature subject to laws; and that would suffice for the knowledge of this nature, and to give it a certain unity. But such a nature would still be possible, provided there were laws, even though these particular laws had no mutual relation, and should form separate systems. Only, on this hypothesis, how could we study it? We must, then, have something more. We need, in order to comprehend nature, and to study it with ease, to believe that it forms a system. an order, that the different parts are bound together. Hence these principles: ' Nature makes nothing in vain; nature acts in the simplest ways; nature takes no leaps. (The law of continuity, the law of parsimony, and the law of the least action. But all these maxims may be reduced to a fundamental rule—namely,' that the particular laws of nature must be considered according to a unity such as a mind would have established, which, in giving these laws, would have had regard to our faculty of knowledge, and have sought to render possible a system of experience founded on the particular laws of nature.'1

NOTE: We will not here cavil with natural reason etc.' (Critique of Pun Beaton, Book it. chap. ill. § 3). See above, p. 302, and below, p. 329. * Critique of the Judgment, Introd. § ii.

This passage from causality to finality, or from the Critique of Pure Reason to the Critique of the Judgment, will appear obscure to the reader; but it is because it is obscure in Kant himself. The principle of causality serves to constitute a nature in general, but without determining anything as to particular laws. The principles of pure physics might still be found applicable, even if one did not grasp any determinate law.2 These laws are thus contingent, and are only discovered by observation. We, however, need a clue to study and comprehend them, and to give them a certain unity. This clue is the principle of finality — a principle necessary, as is evident, but essentially subjective.

Here we must guard against a misconception. In a sense it is correct to say that, in Kant's view, all the concepts of the reason and the understanding, save those of the practical reason, are subjective. It is known, in fact, that the forms of perception (space and time), and the laws of the understanding (cause and substance), are only the conditions proper to the mind in the study of phenomena. Thus they are subjective laws, since they are only the laws of our mind. But it is to be noticed that Kant never employs the word ' subjective' to express this meaning. He considers them, on the contrary, objective in this sense: that being laws absolutely necessary and universal, and from which no mind can free itself, they determine those phenomena to affect us as objects. What is universally and necessarily true is objective. Besides, these laws are constitutive in this sense, that the object is really constituted by them, that without them it would not be possible, nor would intuition, experience, or science itself.

NOTE: Critique of the Judgment, Introd. § iv.

NOTE: For instance, the principle of the conservation of the same quantity of force and matter, the principle that external phenomena have an extensive quant it y, etc., would remain true, even though the universe formed a sort of chaos without determinate laws.

It is not the same with the principle of finality. This latter is subjective in the proper sense of the word, and it is so even with reference to the preceding laws. These, in fact, being once regarded as objective, the human mind may besides have tendencies, dispositions, needs, which, without being necessary to constitute an object of experience or of science, are not only useful but indispensable to guide the mind in its researches. It is, then, if we may say so, a subjectivity in the second degree. These kinds of principles are natural hypotheses, ways of conceiving things, frames, clues for investigations; they are not constitutive, but regulative principles.

Kant never tires of repeating that the principle of finality has only a value of this kind. It belongs not to the determining, but to the reflecting judgment. The first, which is the scientific judgment properly so called, applies the law to particular facts, without any kind of liberty. The second, on the other hand, given a particular fact, seeks to bring it under a law, to reduce it to some general notion. This is about the difference that exists between science and philosophy. In the reflections we make on things, we need not see laws, but only thoughts. Of this kind is the transcendental principle of finality: ' The judgment finds it in itself. ... It does not prescribe it to nature, because it is true that our reflection accommodates itself to nature.' The converse is not true, and nature, for its part, is not ruled on the conditions according to which we seek to form a conception of it.' Thus, in judging, ' the faculty of judging thereby gives a law for itself, and not for nature.' In fact, ' we cannot attribute to nature itself something like a relation of finality, but only make use of this conception to reflect on nature.': And further: 'This transcendental conception of a finality of nature is neither a conception of nature nor a conception of liberty, for it attributes nothing to the object; it does nothing but represent the only way in which we must proceed in reflecting on the objects of nature to arrive at a perfectly connected experience. It is thus a subjective principle (a maxim) of the judgment.' 'The judgment contains a principle d priori of the possibility of nature, but only in a subjective point of view, by which it prescribes, not to nature but to itself, a law . . . which it does not find d priori in nature, but which it admits, in order to render palpable the ordinance of nature.'2 He adds ' that observation teaches us nothing of this law, although it may confirm it.' In fine, it is the very liberty of our mind in the application of this law that is the source of the pleasure we find in it.

Kant attributes this character of subjectivity to the two kinds of finality he has distinguished— esthetical and teleological finality, which he also calls subjective and objective finality respectively.8 Speaking of the first, — that is, of the beautiful, — he distinguishes the realism and the idealism of finality. According to the first of these conceptions, the beautiful would be ' like a real end that nature proposes to itself;' according to the second, it would be ' only an agreement established without an end, of itself and in an accidental way, between the faculty of judging and the forms of nature.' He adds that 'nature everywhere, in its free formations, reveals a mechanical tendency to the production of forma which seem to have been expressly made for the esthetic use of our judgment; and we do not find in it the least reason to suspect that anything more is needed for this than the simple mechanism of nature as nature, so that the agreement of these forms with our judgment may quite well be derived from that mechanism without any idea serving as a principle to nature.' If it is so in the formation of crystals, for instance, why should it not be the same for the production of the most beautiful forms? In fine, what proves that our judgments on the beautiful are eminently subjective is ' that, in general, when we judge of beauty, we seek in ourselves a priori the measure of our judgment. ... It is we who receive nature with favour, not it that does us one.'1

NOTE: Critique of the Judgment, Introd. § iv. * Ibid. Introd. § v.

There are so many degrees of subjective and objective in Kant that one at lost gets lost in them. Here the two species of finality are subjective in the sense we have just stated; but the one (the beautiful) is only the agreement of the object with our esthetic faculties. The other (finality properly so called — that of organized beings, for instance) is the agreement of the object with its concept. It bas thus some foundation in the object itself.

Ought we now, according to Kant, to attribute more reality to the finality he calls objective (that is, what constitutes, properly speaking, the relation of means and end) than he attributes, as we have just seen, to subjective or esthetic finality? No; and it even seems that Kant attributes still less to it, for he says subjective finality still rests on some principle a priori, while objective finality (final causes properly so called) only rests on analogy. It is a ' problematic' principle, which one will do well to admit in the investigation of nature, but on condition that it shall only be made a principle of observation and investigation by analogy with the causality determined by ends, and ' that one shall not pretend to explain anything thereby.'2 Kant, however, acknowledges3 that the objective ideological principle has also ' some foundation a priori^ not in so far as one considers 'nature in general as a collection of objects of sense,'1 but so far as one considers ' an organized production of nature;' only, yet once more, it is ' a regulative principle,' ' a maxim.' This concept, which has a foundation d priori in the mind, and a determining notion in the life of organized beings, extends at once to the whole of nature, and is legitimately generalized under this form: ' Nature makes nothing in vain;' but it is always 'subjectively,' as a 'maxim,' as 'a regulative, not a constitutive principle,' as a ' clue' in our researches, that we are allowed to admit it.2 Even thus restricted, the principle of finality can only be warranted in the study of nature on condition of being again circumscribed within its own limits, and not complicated with another concept — that of God. Teleology must remain distinct from theology.8 ' If we introduce into the science of nature the concept of God to explain finality in nature, and then make use of this finality to prove that there is a God, each of these two sciences loses its consistency.' Consequently, one must limit oneself to the modest expression, ' ends of nature,' before inquiring ' of the cause of nature.' If physics would confine itself within its own limits, ' it must set entirely aside the question whether the ends of nature are intentional or not. ... It is enough that there are objects which can only be explained by taking the idea of end for a principle.' One can employ metaphysically, and for the convenience of use, the expressions, wisdom, economy, foresight of nature, 'without therefore making of it an intelligent being, which would be absurd, but also without venturing to place outside of it, as nature's workman, another intelligent being, which would be rash."

NOTE: Critique of the Judgment, t. i. § Ivii. " Ibid. t. U. $ Ix. * Ibid. § bcv.

In fine, the doctrine of Kant is summed up, as it seems, most clearly in the following passage: —' It is impossible for us to explain organized beings, and their internal possibility, by purely mechanical principles of nature; and it may be boldly maintained with equal certainty that it is absurd for men to try any such thing, and to hope that some new Newton will one day be able to explain the production of a blade of grass by natural laws over which no design has presided, for that is a view which must be absolutely denied to man. But then, on the other hand, there would be great presumption in thinking that, if we could penetrate to the principle of nature in the specification of natural laws, we could not find a principle of the possibility of organized beings which would dispense with our referring their production to design; for how can we know that?'

NOTE: Critique of the Judgment, § Ix.

NOTE: All these expressions are contained in the same passage, § Izv.

NOTE: Critique of the Judgment, § Ixvii. * Ibid.

In a word, finality is a hypothesis, and even a necessary hypothesis, given the conformation of the human mind; but nothing warrants us to suppose that this hypothesis has an objective foundation in reality, and that an understanding that should penetrate to the very principle of nature would be still obliged to conform to it.

We do not entirely reject this doctrine of Kant. We even partly accept it, but on condition of interpreting it, and giving it a different meaning.

We distinguish two sorts of hypotheses, — one which may be called objective and real; the other subjective and figurative. In both cases, the hypothesis is never more than a supposition — that is, a conception not absolutely demonstrated; but in the first case it is regarded as corresponding with the true nature of things, in the second it is only a convenient means for the mind to conceive them. The difference would be nearly that existing between natural and artificial classifications. For instance, the hypothesis of the ether is still only a hypothesis, since that substance does not come immediately under experience; but for scientists this hypothesis, in proportion as it is warranted by the facts, veritably represents nature. Its objectivity is in proportion to its probability. Because a thing is not absolutely certain, it does not follow that it is subjective, but merely that it is only probable.

NOTE: Critique of the Judgment, § lxxiv.

It is the probable, not the subjective, that is opposed to the certain. In the second case, on the other hand, the hypothesis is only a means fashioned by the imagination to represent the phenomenon to be explained. I can employ the hypothesis of attraction without attributing to it any objective value, but simply because it is convenient for the mind. I may imagine, for instance, a straight cord attached to the. moon, and which should be drawn by some one placed in the centre of the earth. Here is a figure, a metaphor, which serves to fix my ideas, as diagrams drawn on the board fix the ideas of the geometrician.

It is evident from these distinctions that a principle may not impose itself on the mind with the same necessity as the principle of causality, and yet not be, therefore, an exclusively subjective conception. An opinion is not necessarily a fiction. Even if finality and its cause in a divine intelligence should only be admitted in quality of opinions, it would not follow that they are only conventional rules for the use of the reason. The degree of their probability would have to be determined by comparison with the facts, but one would not thereby be warranted to transform them into figurative symbols having no relation to reality.

What we grant to Kant, as we have proved it in our first part, is that finality is not a constitutive principle, like the principle of causality. It is not a principle inherent in the human mind, and applicable in a necessary and universal manner, like the principle of causality itself. It is an induction resulting from analogy. No more has it the certainty that experiment and calculation can give; it is a hypothesis, a doctrine, an opinion; it is neither a theorem, an axiom, nor a fact. On this account it may be granted that there is something subjective in this doctrine — namely, the part that is insusceptible of demonstration and verification, and also the unknown part that goes on always increasing in proportion as we approach the very source of the creative activity. But then, again, the same doctrine is objective where it represents facts; it is real on the same ground as all induction that rises from what is seen to what is not seen. Such is the induction that makes us believe in the intelligence of our fellows. No one will maintain, doubtless, that this belief is a constitutive principle of the human reason, and still it will not be concluded that it is only a regulative principle and a symbolic fiction. There is here, then, a medium that Kant has not sufficiently distinguished.

Besides, we must not forget the fundamental distinction made at the beginning of this book between the finality of nature and the first cause of that finality. It is one thing to say that nature 1ms ends; it is another to say that the cause of this nature is a mind that has co-ordinated it according to ends. The hypothesis of subjectivity can be applied either to the first or the second of these two propositions. It may be maintained either that the ends of nature are only appearances, or that, these ends being admitted as real, it is only the hypothesis of an intelligent cause that is a mere symbol, a mere regulative maxim of the mind. But Kant has never clearly explained himself regarding this difficulty. Sometimes he distinguishes the two questions, and only applies his subjectivism to the second hypothesis; sometimes, on the other hand, he seems to involve them both in it, — in a word, what he calls subjective is sometimes finality in general, sometimes intentionality. Reserving this second question for discussion afterwards, let it suffice us to say with Trendelenburg,1 that if finality were a purely subjective hypothesis, it would answer no purpose, and it would be quite as well to dispense with it.

The Kantian hypothesis of the subjectivity of final causes has been discussed by the learned logician Trendelenburg (Logische Untertuchungen, t. ii. p. 47 et seq.) with great force, and we think we ought here to sum up his argument.

1st, Kant reasons as if nothing that was subjective could be objective, and vice versa: he has no thought of discussing the hypothesis according to which something might be at once subjective and objective. It is not enough that a principle is not derived from experience for it not to have an objective reality.

2d, If finality is a principle only regulative, but not constitutive, it signifies nothing; this principle is no more even a rule. A rule of arithmetic or grammar is constitutive, conformable to the thing itself; otherwise what would it signify? But, it will be said, there are rules — as in grammar the rules of the genders — which unite what perhaps has no relation, in order to aid the memory. Might not the principle of final causes have as low a value 1 Even in this case, the rules of the genders say something on the nature of the object itself. If the principle of finality has no objective value, it is only a fortuitous association of ideas.

The doctrine of the subjectivity of final causes could have no solidity if it were not attached to the general principle of subjectivism, — that is, the hypothesis that makes of all the laws of nature principles of the human mind; but it would be passing beyond our subject to enter on the question of the objective value of our knowledge. It is enough for us to have proved that it is not more subjective than the others. It is true or false, certain or doubtful, probable or improbable, like all that is discussed; but in proportion as it is established and demonstrated, it is as objective as any other truth. Is it the same when, passing from finality to its cause, and from nature to God, we infer an intentional cause? We shall see this farther on.

3d, Why does Kant admit that finality is a principle more which we have need of to subject the phenomena to rules, when mechanism no longer suffices to explain them? This principle more is a singular acquisition. A principle ought to simplify; that of finality only brings confusion, since it employs an interpretation of the phenomena absolutely contrary to the principle of the efficient cause. If this contradiction has no serious inconveniences because the principle of finality is purely subjective, then that principle has no more value than the alphabetical order followed in dictionaries, or any other artificial classification.

4th, Kant is wrong to compare the employment of the principle of finality to that of the principle of the absolute, which also is to him only regulative without being constitutive. The principle of the absolute (dos Uribedingte) prevents us from stopping at the particular and the relative; it pushes us

always forward, and excites the inactivity of the reason, but it leaves it in the same domain, in that of the efficient cause. The principle of finality, on the contrary, does not push us in the direction of the efficient cause; it leads us entirely to reverse the order of the facts. This reversal can only be called a rule so far as it leads to the truth. If finality is not in things, it only leads our mind astray and distorts reality.

5th, In fine, what is the relation of the principle of finality to the other subjective elements of Kant's philosophy? It finality were a necessary form of our knowledge, as space and time are the necessary forms of sense-intuition, all things would appear to us in the relation of means and end. But no; according to Kant, the help of finality is called in when the explanation by the efficient cause no longer suffices; it is the object itself that forces the mind to quit the rood it was following. It is, then, the object that determines when we must apply the purely subjective principle of finality. — This last objection is borrowed from Herbart. ' How is it,' says the latter,' that the convenience of the arrangements of nature is only made entirely evident in certain cases; that very often this convenience appears doubtful to us; in fine, that nature often offers us a certain mechanical regularity, or even simple facts, of which it is impossible for us to give an account? If the idea of convenience were • necessary form of the mind, it ought to admit of being applied to all things, like the form of time and space (or even the principle of the absolute)' (hiking in die Philosophic, § 132).

There is yet a kind of subjectivist finalism which we find in one of the most distinguished of contemporary philosophers* whose name we have already several times met with in these studies, M. Lachelier. He has thought proper to found the law of final causes not on mind, but on feeling. According to him, the law of efficient causes, which, he says,' is reducible to the connection of motions,' is essential to the mind; thought cannot deny it without destroying itself. But feeling has its exigencies as well as the mind. ' A world in which motion, without ceasing to obey its own laws, should no longer form any synthesis, or should only form discordant syntheses that would destroy each other, such a world would not, perhaps, be less conformable than ours to the exigencies of thought,1 but it would be far from satisfying those of our feeling, for in the former case it would leave it absolutely void, and in the latter would only cause it painful modifications.'2 However, the author acknowledges that this is a very insufficient proof; for why should nature be obliged to satisfy our faculties? Would not affirming it d priori be to assume precisely what is in question — namely, that nature has an end? How, then, could feeling impose on things a law not essential to them?

The way the author employs to explain his theory is as follows: It is not only the interest of sensation, but of thought itself, that requires the law of final causes. ' Because this law especially concerns feeling, it by no means follows that it is foreign to the essence of thought; and we do not abandon the proof that thought itself supposes the existence of this law.'1 Thus after having introduced feeling, the author abandons it and speaks of it no more, and reverts from it to the necessities of thought. Since feeling goes for nothing, what need was there to speak of it? Will it be said that it is not the bare mind by itself that needs final causes, but the mind combined with feeling? This is merely saying that it finds its pleasure in it; but the preceding objection reappears as strongly: Why should things correspond to the necessities of our feeling? If it were only a question of some very rare cases of wonderful adaptation, it might be maintained that it is, in fact, a lively fancy of our mind, against which we do not attempt to strive, to consider these phenomena as the work of an artist; and the most decided anti-finalists in the theoretic order do not refuse themselves this pleasure in the joy of admiration and enthusiasm. One can see that a man might say in such cases: I don't care whether it is really so; I can only enjoy on condition that it is so; do not take away my dream—you would take away my happiness. But the author sees finality not only in such cases, but everywhere in all that is ordered, in all that presents a certain unity — that is, in the whole universe; nay, more, it is still finality, according to him, that constitutes ' the existence'

and ' reality' of phenomena.2 Then how can we conceive that our feeling could thus command the order of things? and how should the laws of motion, in order to please our mind, constrain themselves to form composite and harmonious wholes?

NOTE: This is a very great concession. Plato, in the Theatetus, seems to believe the contrary. In fact, If a thing is destroyed as soon as formed, how can w* think it?

NOTE: Fondement de l'induction, p. 83.

The author proves that the law of thought is unity. But he says there are two sorts of unity; the one a unity of necessity, the other a unity of convenience and harmony. But if the mechanism of the universe strictly satisfies the first of these two unities, it is further necessary, to satisfy the second, that the universe be an organism. Thus, regarded as pure thought, the mind imposes on phenomena the law of mechanism; while, as mingled with feeling, it imposes on them the law of finality. We cannot comprehend this theory. We would admit it were we told: The phenomena are what they are, and we can effect no change in them; perhaps they are exclusively mechanical. But as we see in them order which we cannot explain, we are pleased to suppose a final cause. We abandon ourselves to this hypothesis, be it true or false, because it is agreeable and convenient to us. But this is not what the author means. He seems to believe that motion alone has no reason to form any regular compositions, or even any compositions at all; and we quoted from him above a beautiful passage, in which he expresses himself very strongly to this effect.1 The laws of motion do not, then, suffice to explain the harmony of the universe; there is another principle. But, then, what now becomes of your feeling? What does it signify whether that pleases you or not? It is, because it is, and not because it is agreeable to you that it should be. It may be maintained, if you will, in an exaggerated final-causality, that God has only made the world to please us; that He has illumined the suns and the stars that we might contemplate them. But to give as a proof of final causes what is only an excessive and exclusive consequence of them, is to invert the order of ideas. Will it be said that by feeling must be understood not human feeling, but feeling in general, and by thought not human thought, but thought in general? In this sense, it might be maintained that thought in the pure state is manifested in the universe by mechanism, and that, connected with feeling, it is manifested in it by finality. But then the question would no longer be regarding the faculty that should give us the principle of ends, but regarding the cause of the ends themselves, so far as previously granted as object of experience; from critical teleology one would pass without notice to dogmatic teleology.

NOTE: Fondement de l"induction, p. 85. > Ibid. p. 85 et seq.

NOTE: See above, Book i. chap. vi. p. 207: 'The world of Epicurus before the oonooune of the atoms . . .'

One would thus assume what is in question—namely, the objective validity of the principle of finality. In fine, is it meant that human feeling and feeling in general are but one, and that nature being only the play of our mind, identical with mind in general, we are warranted to conclude from the one to the other? If, then, it is a necessity of our thought and our feeling to conceive things as ordered, that is true of all thought and all feeling, and nature, having no objective existence apart from the mind that thinks and the feeling that enjoys it, is forced, in order to be something, to conform itself to the exigencies of both. If this be so, we only perceive in it a very complicated and entangled way of expressing what we here maintain, that finality is objective and not subjective; for it will always be permissible to distinguish the subjective mind as circumscribed within the limits of the individual consciousness or the human consciousness, and the objective mind that animates all other men apart from me, before me, after me, and that equally animates all other beings. That nature exists in virtue of the laws of this objective mind is denied by none of those

who recognise finality in nature; but as it derives its laws from this objective mind, it is it that is imposed on our thought and feeling (that is, on the only thought and feeling we directly know); it is not we that impose it on nature.

In a word, it is either admitted that mechanism absolutely cannot, despite the theory of fortunate chances, produce an ordered whole, — hence, as the world in reality has hitherto always presented to us a whole of this kind, it must be acknowledged that there is effectively and objectively a principle of finality in the universe, and thought, united or not to feeling, can only recognise it, and not constitute it, — or else, on the other hand, it is maintained that it is thought joined to feeling that carries with it the principle of finality. Then how can and ought nature to agree with thought, so as to produce for its pleasure the innumerable prodigies of adaptation of which the universe is composed? And to say that nature is ourselves, is to pass perpetually from the subjective to the objective sense, according to the need of the moment, by a perpetual succession of equivocations, in which all direct thought is swallowed up.

2. Immanent Finality.

If, on the one hand, led by the general tendencies of his critical philosophy, Kant seems to conclude for the doctrine of the subjectivity of final causes, on the other, by certain aspects of his theory, he opens the way again to a very different and more profound doctrine, which, while objectivizing the final cause, like the earlier philosophy, gives it a new form and an entirely different signification. Here it is proper to revert to a reservation made by Kant in the Pure Season, and already indicated above,1 but too important ins its consequences not to be expressly mentioned.

'We will not here dispute with natural reason on this. argument, in which, founding on the analogy of Souls productions of nature with the products of human art (our machines, vessels, watches), it concludes that nature must have as its principle a causality of the same kind. . . . Perhaps this reasoning would not bear strict examination by the transcendental criticism.'2

The celebrated Dr. Strauss, in his Christian Dogmatic, reproduces this difficulty. ' This proof,' he says,' is founded on> the analogy of certain products of nature with the work* of art; the organism resembles a clock, the eye a telescope, the body of a fish a vessel, etc. But a clock, a telescope, etc. are the works of a wisdom that has adapted the means. to the end; therefore the products of all nature are the. work of an intelligence which is apart from it. — But first, why should this intelligence be apart from nature? What constrains us to go out of nature? Therefore the analogy is only superficial. The pieces of a machine, of a work of human industry, remain strangers to each other; motion and unity are impressed on them from without. On the other hand, in the organism each part is in intimate, continual communication with the others; they all serve each other as end and means. There is just this difference between the works of human industry and those of nature, that the artist is outside the former, and forms the matter from without inwards; while he is within the latter, and forms the matter from within outwards. Life is the end that realizes itself.'

NOTE: See the previous chapter, p. 302.

'NOTE: ‘Critique of Pun Reason,' Tnmsc. dialect.' Book II. chap. iiI. { UL

The knot of the difficulty, as is evident from this objection, is in the comparison of the works of art and those of nature. While it is only a question of finality, analogy can go so far; but when it concerns the first cause of finality, analogy becomes inexact and insufficient, for this reason, that human industry supposes a pre-existing matter, which it turns from its ends to appropriate to its own, while nature works in nothing but itself, and has no need to pass beyond itself to realize its ends. In other words, the industry of man is external, that of nature is internal.

Aristotle had already noticed this difference between nature and art — nature acting from within, and art from without.3 Kant has made the distinction deeper.

' In a watch,' he says, ' one part is an instrument that serves to move others; but no wheel is the efficient cause of the production of the others. One part exists for the sake of another, and not by the latter. Therefore, also, the productive cause of these parts and of their forms does not reside in the nature (of this matter), but apart from it, in a being capable of acting according to the idea of a whole possible by its causality. And as in the machine one wheel does not produce another, for a stronger reason one machine does not produce others, by employing for this other matter (which it should organize). Besides, it does not replace of itself the lost parts; it does not repair the faults of the original construction by the aid of the other parts; it does not restore itself when disorder has entered it, — all which things, on the other hand, we may meet with in an organized being. An organized being is not, then, a mere machine, having only the motive force; it possesses in it a formative virtue, and communicates it to materials that have it not, by organizing them; and this formative virtue, which propagates itself, cannot be explained by the motive force alone (by mechanism).'

NOTE: Strauss, Die ChrMliche Glaubenslehr,, 1840, t. i. p. 385. Hegel says likewise: 'No doubt there is a wonderful agreement between the functions of different organs; but does this harmony require another being outride t.V organitmt'— Lessons on the Proofs of the Existence of Ood, p. 4fi8.

NOTE: Aristotle, Phys. lib. ii. 8 (Berlin ed., 199, b. 28): .; yif .v», i, Tv oMOicK &r tfn-tfii crout.

In a word, the works of nature are distinguished from the works of art by the three following differences: — 1st, The organized being has a formative virtue: the germ successively assimilates all the particles it borrows from the external world; 2d, It has a reparative virtue: when it is injured it repairs itself (in this sense it is said that nature is the best physician; it is even known that after wounds and even mutilations the different parts are often spontaneously reproduced); 3d, In fine, it has a reproductive virtue, for the species perpetuate themselves by the law of generation.

These differences are so visible that they have never escaped the observers of nature and the defenders of final causes. 'Let us confine ourselves,' says Fenelon, 'to the animal machine. There are three things in it that cannot be too much admired: 1st, It has in itself wherewith to defend itself against those that would attack and destroy it; 2d, It has wherewith to renew itself by food; 3d, It has wherewith to perpetuate its species by generation. What would be thought of a machine that should flee to purpose, that should recoil, defend itself, and escape in order to preserve itself, when it was sought to break it? What is more beautiful than a machine that repairs and renews itself incessantly?

NOTE: Critique of the Judgment, § Ixiv.

What would be said of a watchmaker who could make watches spontaneously producing others without end, so that the two first watches should be sufficient to multiply and perpetuate the species on the earth? ' 1

It is evident that Fenelon mentions nearly the same characteristic differences as Kant; only, in place of seeing therein a difficulty, he makes use of them as an a fortiori. From these differences between nature and art he concludes not that the cause of nature is not an art, but rather that it is an art very superior to ours. According to Kant, the organization of nature has nothing analogous with any of the causalities we know, and it cannot be conceived and explained exactly by analogy with human art. Fenelon is right in saying that the art of nature is superior to human art. But are

we at liberty to conclude from the one to the other? Is not nature rather an analogue of life than an analogue of art? Far from being like human intelligence, it would be the very principle from which human intelligence is itself derived, and the industry of man would only be a particular and entirely relative case of this universal art.

This distinction of Kant between nature and art attaches to another profound theory of the same thinker, which has had the greatest influence on the further development of German philosophy. I mean the theory of internal finality, which we have often mentioned, but to which it is necessary to revert.

According to Kant, there are two species of finality — internal and external or relative.

' Finality purely external — that is, the utility of one thing for another — is never more than relative,' and ' only exists accidentally in the thing to which it is attributed.' 2 In fact, this finality always supposes something else than itself, and is always hypothetical. If the sand of the sea is fittest for the growth of pines, this property can only be considered as an end of nature by supposing that pines themselves are ends of nature, — that is, that it has resolved beforehand that there shall be pines. In this sort of finality things are never considered but as means, but these means can only be such if there are beings that are considered immediately and in themselves as ends. But these beings are precisely those that show an internal finality. The first, then, are only ends relatively to the second, and the latter alone can afford room for an absolute teleological judgment.

NOTE: Trail de l'existrnc.r, tie Dieu, Book I. chap. 11 * Critique of the Judgment, f 1xII.

This profound distinction of Kant has some analogy with that which he sets up in his ethics between subjective and objective ends, whence arise two sorts of imperatives — the hypothetical and the categorical. Subjective ends are those that are always subordinated to other ends, and which consequently are only means, and only afford room for conditional rules: If you wish to be rich, be economical. Objective ends are absolute, and afford room for absolute precepts: Be sincere, whether it please you or not. So here external finality is hypothetical. Reindeer in northern lands are food destined for a man, if it be supposed that there must be men in those countries. But why should that be necessary? On the other hand, in order that an object of nature may be considered immediately as an end, and afford room for an absolute teleological judgment, we must, without leaving that object, and without needing to subordinate it to another, remark in is that ' the possibility of the form could not be derived from the simple laws of nature,' that ' this form is contingent on the eyes of reason,' and ' does not seem possible but by it' — in a word, that it is such that ' the whole contains the possibility of the parts.'1

Such, in the first place, is the character common to every end, the works of art as well as those of nature. But for a work of nature something more is necessary — namely, ' that it be at once its own cause and effect;2 that is, as we have seen, that it be able to organize, repair, and reproduce itself. ' The leaves of the tree are the products of the tree, but they also, in their turn, preserve it.' Consequently, an end of nature is a production in which ' all the parts are reciprocally ends and means.'1 Such is the character of internal finality.

NOTE: Critique of the Judgment, § Ixiii. » Md.

We see here one of the sources of all the later German philosophy. The internal finality of this philosopher became the immanent finality of the Hegelian school.2 Instead of conceiving a supreme cause, supra-mundane, constructing works of art, as man makes houses and tools (which would

seem to suppose a pre-existing matter), the entire German pantheism has conceived an intra-mundane cause, realizing its end in itself. The physical theology of the 18th century, according to the Hegelians, was exclusively founded on external finality, — that is, on utility, — and conceived all the objects of nature as fabricated for an external end. The idea that was formed of nature did not much differ from that of the Epicureans — namely, that therein all was mechanical, and that there was nothing internal in the universe. In place of chance, an external motive cause was brought in, a deus ex machine. But this cause only produced inert works, none of which was in itself a source of action, and whose only end was to serve for something else than themselves. However, Leibnitz had already, by his notion of force, restored the principle of an internal activity of things; the internal finality of Kant completed the same idea. But then, if things are no longer inert blocks, moved from without, but all living, animated within, the world itself ought no longer to be conceived as an inert and dead mass, but as a veritable whole, as an organism.

Hegel's doctrine on final causes may be reduced to these three fundamental points: —

1st, There are final causes in nature, and even all is final cause. The domain of efficient causes is that of blind necessity. The final cause is the sole veritable cause, for it alone has in itself the reason of its determinations.1

NOTE: Critique of the Judgment, § lxv.

NOTE: 'Kant,' says Hegel, ' in bringing to light the internal conformity of infinities to their end, has called attention to the intimate nature of the idea, and, above all, to the Idea of life.' — Logic, § 204.

2d, It is not necessary to conceive the final cause in the form that it has in consciousness, — that is, as an anticipated representation of the end. The ends that are in nature are not like the ends we realize, which are the result of choice, foresight, and voluntary activity. There are two ways of attaining an end, — the one, of which we find an example in human industry; the other, which is rational, without being conscious and reflective, and which is the activity of nature.2

3d, The finality of nature is an immanent, internal finality. It is not, as in the works of human industry, an external cause that produces certain means to attain an end that is foreign to them, — the cause, the means, and the end constituting three terms separated from each other. In nature all is united in the same principle — the end realizes itself. The cause attains its end by self-development. The image of this development is in the seed that contains the whole being that it has to realize. It attains its end without going outside itself. It may be said of entire nature what Kant said of the organized being, that in it everything is reciprocally end and means. Internal finality thus becomes immanent finality.8

1 ' The distinction between the final and the efficient cause is of the utmost importance. The efficient cause belongs to the sphere of blind necessity, and of what is not yet developed; it appears as passing to a foreign terminus, and as losing, in being realized, its primitive nature. The efficient cause is only a cause virtually and for us. The final cause, on the other hand, is stated as containing in itself its determination, or its effect, which, in the efficient cause, appears as a foreign term; wherefore, in acting, the final cause does not go beyond itself, but develops within itself, and is at the end what it was at the beginning, and in its primitive state. This is the true first cause.' — Hegel, logic, Ft. Tr. t. ii. p. 321. ' Because the mechanical world and finality both are, it does not follow that they both have the same reality; and as they are opposed, the first question is, Which of the two contains the truth? But as they both are, a more precise and higher question is, whether there be not a third principle that forms the truth of both, or else whether one of them

does not form the truth of the other. But finality has been here set forth as the truth of mechanism and chemistry.' — Ibid. ii. p. 334.

NOTE: On this second point see the following chapter.

NOTE: " Finality is not external to nature, it is immanent in it. The seed virtually contains all the constituent parts of the plant that have to be produced, and its development is only directed towards preservation. True teleology consist in considering nature as independent in its proper quality . . . ' of Nature, § 245.

We have no difficulty in admitting, for our part, that internal finality is likewise immanent finality, but on condition that the second term shall have exactly the same sense as the first, and shall add nothing more to it; but from this immanent finality to infer an immanent cause of finality, is to put into the conclusion what is not in the premises, for it is saying that every cause that pursues ends spontaneously and internally is, therefore, a first cause.

Let us remark, besides, that the opposition of transcendence and immanence is very far from being so absolute in reality as it appears in the eyes of the German philosophers. There is no doctrine of transcendence but implies at the same time some presence of God in the world, and, consequently, some immanence. There is no doctrine of immanence but implies some distinction between God and the world, and, consequently, some transcendence. Absolute transcendence would be such a separation of God and the world that they would no longer have anything in common — that God could not know the world, nor the world know God. Absolute immanence would be such an identity of God and the world that the cause would be but one with the effect, the substance with its phenomena, the absolute with the relative. But there is no example in philosophy of either the one or the other of these conceptions. Even in the scholastic theism, or in that of Descartes and Leibnitz, whoever will fathom the theory of the divinus concursus, or of the continued creation, will see profound traces of the doctrine of immanence. Conversely, in the pantheism of Spinoza or Hegel, whoever will reflect on the distinction of Natura naturans and Natura naturata, of the Idea and Nature, will clearly recognise a doctrine of transcendence.

Thus when it is asked, as by the Hegelians, whether the supreme cause is within or outside nature, the question is badly stated, for in every solution the cause will always be at once within and outside nature. It is a question of degree. But it is true that the physico-theological proof by itself does not furnish sufficient data to fix with precision the degree of distinction between the cause of nature and nature itself. If, for instance, it is required to proceed to a substantial distinction, whoever comprehends the terms of a philosophical question will allow that such a distinction is not contained in the premises of the argument of final causes; but no more i* it necessary to demand it, for it is not that that is in question. No one pretends to resolve with a single argument all the difficulties of philosophy, and, conversely, one ought not to require it. The problem of transcendence in the strict sense of the word—that is to say, the conflict between theism and pantheism — cannot be decided by the proof of final causes.1 A God the soul of the world, as was the God of the Stoics, is, indeed, in no way excluded by the proof of final causes; but, •even on this hypothesis, God would still be distinct from the world, as the cause from its effect, and this distinction suffices here.

Even in the philosophy of Hegel there is a profound difference between things and their cause or reason. If we consider an individual organized being, Hegel will not say that the cause of this being is in the individual itself as such. Certainly not; it is in the idea of the species. This idea, so far as it is absolute and immanent, is very distinct from the individual that manifests it, for the latter passes away, while it remains. What is true of the individual is true of the species. No species is its own cause, nor suffices for itself. The cause of humanity as a species ought to be sought in the

universal type that constitutes the animal kingdom, and the cause of the animal, as well as of the vegetable kingdom, ought to be sought in the idea of life in general. In fine,

vitality in its turn is still only a form of the universal principle which manifests itself first by mechanism, then by chemistry, then by organism, and finally by mind. We shall thus distinguish, even in the philosophy of Hegel, the particular beings given by experience from the internal causes that produce them; we shall distinguish nature and idea. Since nature is externalized idea,1 it clearly follows that the one of these terms is not the other. For it may always be asked, Why did not the idea remain quiet? Why did it come out from itself? It is clear that that is a new mode of existence for it, and, consequently, even in the philosophy of Hegel, the supreme cause is apart from nature. It is at once apart and within; and all profound theology has always taught this.

NOTE: The true point of debate between theism and pantheism Is the exploitation of consciousness and the ego.

Is it true, meanwhile, that the theory of internal finality, such as Kant constituted it, excludes all transcendence in the first cause, and absolutely contradicts what Hegel calls finite theology2 — that is to say, theism? and, conversely, is theism condemned, as he maintains, and limited to external finality?

These are very arbitrary views, forced consequences, drawn from premises that do not contain them. External finality is a relative and subordinate finality, but it is inseparably connected with internal finality, as has been seen above;] it is the converse of it. Hegel himself regards it as we do; for he owns that finite theology rests on a just idea, which is, ' that nature has not its end in itself.'2 But the theist says no more. Finite theology is by no means bound to affirm that all has been created since the beginning of the world for the use of man. Descartes and Leibnitz long ago repudiated that doctrine. But transcendental theology, as well as immanent, is entitled to say that the different degrees of nature are steps of a ladder that the divine thought successively mounts in order to realize itself, and that the lower are steps to the higher. As far as Aristotle and Hegel admit that final causes have need of efficient, to the same extent finite theology will admit that efficient causes are made for final causes. As to the more or less popular forms which may have been employed to express this doctrine, it is hardly philosophical to make use of them against the doctrine itself, for it is in its highest expression, and not in its most superficial meaning, that it must be taken.8

NOTE: 'The absolute liberty of the idea consists in this, that it resolves to produce itself outside as nature.' — Philosophy of Nature, § 244. ' The absolute liberty of the idea consists in this, that it decides to derive freely from itself in the moment of its particular existence, to separate from itself, — in a word, to place itself as nature.' — Logic, § cliv.

' If God is self-sufficient, how comes He to produce something absolutely dissimilar? The divine idea just consists in producing Itself outside, in sending forth the other from itself, and in then resuming K, in order to be subjectivity and mind.' — Phil, of Nature, § 247.

' Nature being the idea under the form of the other, It Is not only external in relation to the idea and to the subjective existence of the idea under form of mind, it is, besides, external to itself; externality constitutes its essential character, its nature.' — Ibid.

This term, finite theology, Is one of those cleverly-chosen expressions by which a philosophical school finds means to throw back on an adverse school the suspicion and reproach by which it is itself threatened. If there is a finite theology, it would seem to be that which identifies God with the world, and that confounds the Absolute Mind with human philosophy. On the other hand, a

doctrine which, wrongly or rightly, conceives a complete and perfect Absolute apart from the world, and only sees in the world an Image, reflection, a feeble expression of God, is as badly as possible represented by the expression finite theology.

If internal finality is impossible without external, conversely external finality is only a relative point of view, which, taken higher, may return to internal finality. In effect, instead of considering each organism by itself, let us consider them all in their totality. We shall see that they are all reciprocality means and ends, like the internal parts of an organism. It is thus, for instance, that the vegetables serve the animals and the animals the vegetables, whether in taking from or in restoring to the air the elements that are useful to them respectively, — these oxygen, those carbon; or, again, in serving as nutriment for each other, — on the one hand as food, on the other as manure. It is also evident that all living beings nourish each other, in so far as the superior animals, and even man, afford food to the infinitely small ones, whose function seems to be to preserve life in the universe by destroying putrefied matter, which would poison the air and deprive it of every vital property. In fine, living beings in general are in a perpetual commerce with matter in general: and the circulation of the elements constitutes in some sort an internal life of the earth, analogous to that of the individual organism. Such analogies cannot be rejected by Hegel, for no philosopher has pushed them farther.

NOTE: See above, Book i. chap. vi. p. 267, and Appendix, p. 501.

NOTE: ' Man,' he Says, ' considers himself, and with good reason, as an end in regard to natural agents. The consideration of nature, in this point of view, is that of finite theology. This theology rests on a just idea, that nature does not contain in itself the absolute end — the last end.' — Encyclopaedia of Philosophic Sciences, Philosophy of Nature, § 245.

It is not even true historically that the physical theology of the 18th century is exclusively dominated by the utilitarian point of view, or that of external finality. Paley's book, for instance, hardly appeals to this point of view, and rests mainly on the Internal finality of organized beings. The existence of a supreme cause of nature is deduced quite as well, and even much better from internal finality than from external utility, or from pure mechanism. For a cause powerful enough to make a work having in itself the principle and end of its action, is superior to that which would be obliged incessantly to put its hand to the work. The same is true of the frivolities with which Hegel, after Voltaire, and with less wit than he, reproaches the final causalists, but which may more belong to the doctrine of transcendence than to that of Immanence.

Thus we have here a sort of internal finality; but it is not absolute, since things are not founded in a unique being, and all ' natural beings are external to each other, exist outside and independently of each other.'1 Hence it follows that, in considering them separately, they seem only to be means, and this is what is called external finality. It will, therefore, be allowable, if they are taken thus, and not in their totality, to give prominence to their external utility — a point of view that does not exclude the other, and is closely united to it.

If, on the one hand, the transcendental theology is no way bound to the idea of an external finality, and especially to the abuse that may be made of that finality, on the other hand it is no way contradicted by the idea of an internal finality, such as Kant explained it. That a supra-mundane cause has produced a work manifesting an internal finality, and evec i PMosophy of Nature, § 249.

Realizing that finality by its own powers, presents nothing contradictory; for there is still a distinction to be made here, and every internal finality is not accompanied by an internal motor, nor conversely. In a statue, for instance, the finality is internal, for a statue is not like a machine, an instrument for making something: it is its own end, and yet it does not realize itself; the motive

cause is outside of it. A transcendent cause may therefore produce a work that has an internal end. Conversely, a workman who employs his arms to move a wheel is the internal and immanent cause of the motion of his arms, and yet the end is external; for the arms do not work for themselves, nor for the rest of the body, but for an external machine: they are machines of machines. In fine, one may conceive a transcendent cause that should produce a work animated by an internal principle, and acting for an internal end. Thus the father is in relation to his son what the Scholastics called a transitive cause; and yet the son has an internal principle of action, and that principle moves according to an internal finality. According to this, one does not see why the supreme cause of nature should not have produced works (no doubt derived from it), but not purely mechanical, and having in themselves the cause and end of their evolution.

The doctrine of a supra-mundane cause not only does not exclude the idea of an internal principle of action in nature, but it may almost be said to require it; and it may be maintained very forcibly, with Leibnitz, that it is only on this condition that pantheism — that is, absolute immanence — will be overcome. For it is not for maintaining a certain degree of immanence that a philosophy can be characterised as pantheism; at that rate there would be none that had not that character. But the proper character of pantheism (if it knows what it means) is to refuse to finite beings all proper activity, in order to restore it to the absolute cause and substance. If, then, this absolute cause or substance is believed to be distinct from the world, supra-mundane, transcendental, that can only be by attributing to the finite a proper reality, and that proper reality can only be an internal activity or an internal finality, or both together. If, on the other hand, the doctrine of absolute immanence be maintained, it must be recognised that the finite, considered as such, has nothing that is internal and proper to it. Hence nature, as phenomenon, — that is, perceptible nature, that which alone we know by experience, — will only be composed of appearances and shadows, having in themselves neither their principle of action nor their end, and having no more title than the artificial works of man to a soi-disant internal activity.

Another objection of the Hegelians1 is that in the hypothesis of finite theology, or of transcendency, things form an indefinite series of means and ends, of which the limit is not to be seen. The true final cause, on the other hand, ought to form a circle, and, being the realization of itself, to return to itself,—that is, to be found at the end what it is at the beginning. Be it, for instance, the immanent principle of nature that the Hegelians call the idea, this principle, issuing from itself, will become physical nature, dead nature. It at first shows itself as foreign as possible to itself in mechanism or pure motion; then, in chemistry, it begins to make a certain effort to return to itself, to arrive at an end; but it is an impotent effort. This chemical labour, perpetuated and becoming durable, is the organism. Here there turn movement is still more visible; the effort to attain unity is more efficacious; there is not merely combination, but concentration. Finally, above the organism rises the mind, in which the return of nature to the idea is completely manifested, first in the individual or subjective consciousness; then in the consciousness of peoples and races, the objective; and finally in the absolute consciousness — that is to say, in art, religion, and philosophy. At this last terminus the idea has realized itself, it has found itself again after having lost itself.

NOTE: Kuno Fischer, Logik und tfetaphysik, 2 Anflage, Heidelberg, 1865, p. 602 etseq.

It believed itself distinct from itself, and it was still itself; and it is still it that arrives at self-consciousness in philosophy.1 Here, then, is a true end—the world forms a circle; while in the other theology there is no end, and the world incessantly seeks one, but does not attain it. Such would be the advantage of the doctrine of immanence over that of transcendence. It is, in our opinion, a pure illusion. I own that, in the conception of a world distinct from God, each being, always being imperfect, cannot be considered as an absolute end; man himself is not the absolute end of nature. If we suppose above man other creatures superior to him, we no more conceive that

any of them could be an absolute end. The world is thus an indefinite line of which we cannot see the limit. But is it otherwise in the doctrine of immanence? In the one as in the other one does not see a terminus; and as to saying that, in the latter, the development of the world is represented under the figure of a curved line, and in the former of a straight line (except that these are geometrical metaphors of mediocre clearness), there is no reason to make such a distinction; for, on the hypothesis of transcendence, God being at once the end and the cause of creation, the latter tends to return to Him after having removed from Him, exactly in the same way as in the opposite doctrine. Yet once more, the curve will never be finished; but it will no more be so according to Hegel than to Leibnitz. The finite will never arrive at an adequate consciousness of the absolute, the mind will never realize the idea in its totality, which would be necessary to complete the circle. In fact, so long as the idea has not an absolute consciousness equal to itself, a perfect representation of itself, so long as the divine knowledge is not equal to the divine being, the intelligence to the intelligible, the circle n will not be completed. There will always be an immense abyss between the last degree and the absolute. Thus, on both hypotheses, there is an incessant labour of nature to attain an end it will never reach; but this impossibility lit much more irrational on the hypothesis of immanence than on that of transcendence. That a relative world, distinct from God, never attains the absolute, one can comprehend. But that an absolute world can never return to the principle from which it emanates is contradictory. But who can have seriously maintained, except in a first moment of intoxication now passed, that philosophy, and in particular the philosophy of Hegel, is adequate to the absolute itself? Cannot another philosophy be conceived superior to it, and another higher still, ad infinitum? So long as it is only a question of a human philosophy, there can be no question of a philosophy without error, obscurity, and ignorance. What! you are the absolute; and to know the cause of the smallest phenomenon, you are obliged to wait till a scientist has made experiment — has weighed, measured, calculated! An absolute that incessantly seeks and never finds itself is nothing else than a relative. Hence it must either be acknowledged that there is no absolute, that the idea is a pure chimera, that only nature is, and is self-sufficient, which is the negation of Hegelian idealism; or it must be maintained that the idea, while manifesting itself in nature, is yet entirely itself only in itself, and before being externalized, which is the essence of the doctrine of transcendence.

NOTE: ' In itself nature is a living whole. . . . The tendency of its movement is that the idea place itself as what it is in itself, or what comes to the same thing, that the idea issue from that externality, which is death, to reduplicate on itself, and become first organism and then mind (Geist), which is the last end of nature, and the absolute reality of the idea.' — Philosophy of Nature, §251.

To sum up: the idea of a nature, endued with internal activity, and working to an internal, although relative and subordinate finality, — this idea, which is nothing else than the thought of Leibnitz well understood, contains nothing that excludes a supra-mundane cause. This cause is distinguished from nature in that it is beforehand, entirely and in itself an absolute; while nature can only express and manifest this absolute through time and space, without ever completely realizing it. It is this very impotence of nature analogous to the conscious mind; but one should not, therefore, conceive the final activity of nature as a mind that is self-conscious. As artistic instinct, the notion is only the internal virtuality of the animal (das Innere an sich, the internal in itself), an unconscious worker. It is only in thought, in the human artist, that the notion exists for itself.'

Thus, according to Hegel, instinct presents us with the type of an unconscious finality, and shows us the possibility of it, and this is the true notion of nature. Consciousness is only one of the forms of finality; it is not its adequate and absolute form. It need not be supposed, however, that, in Hegel's view, instinct itself should be the last word in finality. Before all, in his thought, finality is notion, concept, or at least an element of the notion, and instinct is only a form of it. It is only in the Hegelian Left that finality has been more and more confounded with the blind activity of nature.

But the school that has most decidedly adopted and defended the doctrine of instinctive finality is that of Schopenhauer. This school has insisted much on the principle of finality; but, like the Hegelian school, it asserts an unconscious finality, and finds in instinct the type of it.

' There is no contradiction whatever,' says Frauenstadt,' in admitting that a force, a plastic instinct, by a blind tendency creates works which then are revealed to the analytic understanding as conformed to an end. An unconscious finality is not, then, a contradiction in adjecto; and from the denial of a personal creator of the world, aiming at conscious ends, there no more follows denial of the harmony of the world than the denial of the harmony of the organs follows from the affirmation that a plastic organic virtue acts unconsciously in plants and animals. The Aristotelian opposition between the efficient and the final cause is in no way identical with the opposition between the unconscious and the intelligent cause. For the final cause itself may be unconscious.'

NOTE: Fraueiutadt, Sriefe Sber die Schopenhauerscte Philotophie (Leipzig, 1864), Letter 21, [. 442.

Schopenhauer expresses himself in the same way: ' The admiration and astonishment which are wont to seize us in view of the infinite finality manifested in the construction of the organized being, rests at bottom on the natural but false supposition that this agreement of the parts with each other and with the whole of the organism, as well as with its external ends, is realized by the same principle that enables us to conceive and judge it, and, consequently, by means of representation; that, in a word, as it exists for the understanding, so it only exists by the understanding. No doubt, we can realize nothing regular or conformed to an end, except under the condition of the conception of that end; but we are not warranted to transfer these conditions to nature, which is itself a plus of all intellect, and whose action is absolutely distinct from ours. It brings to pass what appears to us so wonderfully teleological, without reflection and without concept of the end, for it is without representation, a phenomenon of secondary origin.'1

' It seems,' says the same author again,2 ' that nature has meant to give us a brilliant comment of its productive activity in the artistic instinct of the animals; for these show us most evidently that beings may work to an end with the greatest surety and precision, without knowing it, and without having the least conception of it. ... The artistic instincts of insects throw much light on the action of the will without knowledge, which is manifested in the internal springs of the organism and in its formation. . . . The insects will the end in general, without knowing it, precisely like nature when it acts according to final causes. They have not even the choice of means in general; it is only the detail that in particular cases is left to their knowledge.'

Such are the reasons of the adherents of unconscious finality. But this doctrine, we have said, may assume two forms: finality may be considered as an instinct, which is the doctrine of Schopenhauer, or as an idea, which is the that should force us to conclude that it is not itself the absolute, for an absolute that incessantly seeks without finding itself is a contradictory notion. If, then, something of this kind be admitted, it ought, if we know what we mean, to be distinguished from nature, at least so far that nature may develop and move without the first principle being involved in its movement. But this is precisely what we call transcendentalism well understood.

NOTE: Die Welt als Wille, t.ii. chap, x.tvi. f Md.

But if it were sought to press still farther the terms of the distinction, and to derive from them either a distinction of substances, or the creation ex nihilo, or some other more explicitly dualistic doctrine, we would say yet once more that this is to pass beyond the sphere of our subject, that nothing obliges us to consider these problems, and that finality does not contain in this point of view any particular element of solution.

In concluding this chapter, we shall recapitulate by saying — 1st, That finality, not being a subjective view of our mind, but a real law of nature, demands a real cause; 2d, That the finality of nature is indeed, as Kant has said, an internal finality, and in that sense immanent, this second term signifying nothing more than the first. But this relative immanence of natural finality does not imply an absolute immanence, and, on the contrary, can only be comprehended by its relation to a transcendent terminus.

These two difficulties overcome, we are now face to face with the true problem: Is the supreme cause of finality an intelligent cause, a mind? This will be the object of our last inquiries.

Chapter III - Instinctive And Intentional Finality

'We ought not to conceive the end,' says Hegel, 'under " the form it assumes in consciousness, — that is to say, under the form of a representation.'1 According to this principle, the end is not an effect realized according to a preconceived idea: it is the eternal conformity of things to their idea or essence. Finality is thus not merely immanent, it is unconscious.

We find a striking instance of unconscious finality in the instinct of animals.

' The obscurity in which instinct is enveloped,' says Hegel, 'and the difficulty of laying hold of it, arise entirely from this, that the end can only be understood as an internal notion (innere Begriff), whence it follows that all explanations and relations that are only founded on the understanding are inadequate to instinct. What chiefly causes the difficulty is that the relation of finality is usually conceived as an external relation, and that it is thought that finality only exists where there is consciousness. But instinct is the activity that acts without consciousness in order to an end (die auf bewusstlose Weise wirkende Zweckthdtigkeif). The animal does not know its ends as ends; but this activity that unconsciously acts in pursuit of ends is what Aristotle calls <£uer«.'2

' This artistic instinct,' says he elsewhere,8 ' appears as an intentional and wise act of nature (ate zweckmdssiges Thun, ate Weisheit der Natur), and it has always been regarded as a surprising faculty, because it has been the habit only to see reason in an external finality. Plastic instinct is, in fact, impossible, and that all the others are excluded by the very nature of the cause? In this case the final cause is set aside in order to revert to the efficient cause, which is Spinozism. What, in fact, does the idea of end do here, and wherein is it end, if each of the effects is contained in that which precedes, and if all together are only the unfolding of the nature of each being? On this hypothesis, there is no more final cause in physiology than in geometry.

NOTE: Logic, % 10*. * Philosophy of Nature, § 360. • Ibid. | 366, ^ P?" 'X*^

To say, with Schopenhauer, ' Because finality exists for' intelligence, it does not follow that it exists by intelligence,' is at bottom to suppress finality. We must choose between subjective and instinctive finality. If finality only exists for intelligence, it does not in reality exist at all; it is an illusory phenomenon. ' It is our understanding,' says Schopenhauer, since, seizing the object by means of its own forms, time, space, causality, first produces the plurality and divisibility of parts and of their functions, and then falls into amazement at the perfect harmony and co-operation of these parts resulting from the original unity, in which, consequently, it admires its own work.'1 If this be so, finality is only a subjective conception. But then the objection of Herbart, quoted above,1 recurs: If we carry with us the concept of finality, why not apply it everywhere, and to all things, like causality? If we only do so in regard to certain objects, it is because these objects present certain special characters. These characters do not come from us; they must, therefore, have an objective cause. But instinct is not a cause — it is a non-cause; for, •between the

indetermination of the instinctive faculty and the strict determination of the end, there is the disproportion of the infinite to the finite.

For the rest, the inadequacy of Schopenhauer's theory is confirmed even by the acknowledgment and reform of his disciple .and successor Hartmann, who, without himself advancing to the conception of intelligent finality, yet make a way of return towards that conception. In fact, Schopenhauer had completely separated the will and representation (der Wille und die Vorstellung). Representation, which is the foundation of the intellectual act, was, in his view, a merely secondary thing (ganz secunddnn Ursprungs). Hartmann, on the other hand, restores the bond between these two things, and says very justly: ' Tendency is only the empty form of the will, . . . and as every empty form is only an abstraction, volition is existential or actual only in its relation to the representation of a present or future state. No one can really will purely and simply, without willing this or that. A will that does not will something is nothing. It is only by the determination of its content that the will acquires the possibility of existence, and this content is representation. Thus, then, there is no will without representation, as Aristotle had said before: o/><«Tu<oV 8« Ovk ovtv i^an.air«is (De An. iii. 30).'J

NOTE: i Die Welt als Wille, chap. xxvi. ' « See p. 324.

Herein lies, Hartmann adds, the cause of the error and 'insufficiency (die Halbheit) of Schopenhauer's philosophy, who only recognised the will as a metaphysical principle, and made representation or the intellect originate materially.'

Hartmann admits, then, that the will is impossible without representation, only with him this representation is at first unconscious. Finality would thus still remain unconscious. And yet a great step would be taken. There would be conceded to the first cause the reality of intelligence, save in considering consciousness as only an accessory phenomenon, which remains for discussion. The question would no longer be as to an intelligent cause, but as to an unconscious intelligence, which is different. The question changes ground. Can there be representations without consciousness? Such is now the point of the debate. Hartmann quotes the opinion of Kant and Leibnitz; but these two authors rather speak of obscure, indistinct perceptions, of an extremely feeble consciousness, than of absolutely unconscious perceptions in strict terms. It is not for us further to engage in the doctrine of Hegel. Let us first consider the former. The latter will be the subject of the following chapter.

NOTE: Philos. des Unbewuuten, A. iv.

To attribute to nature an instinctive activity, is to say that nature acts like bees and the ant, in place of acting like man; it is zoomorphism substituted for anthropomorphism. We see no advantage in it.

In fact, the true difficulty, the profound difficulty in this question, is that we can only explain the creative activity of nature by comparing it to something that is in nature itself, — that is to say, which is precisely one of the effects of that activity. Kant expresses this in these words: ' Can the internal possibility of nature, acting spontaneously (which first renders possible all art, and perhaps even reason), be derived from another art still, but superhuman?' This, the true, the only difficulty, evidently applies to the hypothesis of a primitive instinct quite as well as to that of a primitive intelligence. Instinct is not less a fact of nature than intelligence itself; and in the one case, as in the other, the effect •will be transformed into the cause.

But if one is content to say, like Schopenhauer, that instinct is only a commentary of the creative activity,—that is to say, a symbol, an example that may give some idea of it,—it may be asked

wherein this commentary is more luminous than that which we find in intelligence, or in mechanism properly so called. There are, in fact, three modes of action in nature, — mechanism, instinct, and thought. Of these three modes, two only are distinctly known to us, mechanism and intelligence. Instinct is the most obscure, most unexplained. Why, of the three modes of action of nature, should the most luminous commentary of the creative activity be precisely that of which nothing is understood? All science since Descartes tends to suppress occult qualities. Instinct is essentially an occult quality. To choose it to explain finality, when it is itself the most incomprehensible instance of finality, is not this to explain obseurum per obscurius? In fine, of three modes of action of nature, one inferior, another superior, the other intermediate, why choose as type precisely that which is only a middle term? Mechanism is inferior, but it has the advantage of being the simplest of all. Intelligence is the most complicated, but it has the advantage of being the most elevated term. Instinct presents neither the one nor the other of these advantages. A middle phenomenon, it seems, indeed, to be only a passage from the one to the other, from mechanism to intelligence — to be only a more particular and complex case of the first, or the rudimentary state of the last. In any case, it seems in no way to have the character of a principle.

In another point of view, instinct is again subject to the same difficulties as intelligence. That is to say, the latter is objected to as only known to us under the condition of organization. Are we warranted, it is said, to suppress this condition, and to conceive in the pure state, and as anterior to nature, a faculty which is only given to us as a result? Whatever be the weight of this objection, it is as applicable to instinct as to intelligence; for instinct, like intelligence, is bound to organization: there is no more instinct than intelligence in inorganic beings.

But if the hypothesis of instinctive finality presents no advantage over that of intelligent finality, it presents, on the other hand, much greater difficulties. The question still remains, how a cause attains an end by appropriate means, without having either known that end or chosen the means? The question must be well answered. Is the idea of end admitted or not? If admitted, this idea necessarily implies, whether we will or not, that, a given result being predetermined (for instance, seeing or hearing), the efficient cause, which, as such, was capable of taking millions of different directions, has limited the choice of these directions to those that could bring about the required result. But to say that a hidden cause produces this limitation and determination we know not why, is simply to revert to the hypothesis of chance.

Will it be said that only one of these directions was possible to the end by the most simple means? Simply because here we do not attach any value to the end attained. Whether the triangle always has the sum of its angles equal to two right angles, whether the peripheric angles subtended by the same chord are equal or not, is of no importance in our eyes, because we do not see the use of it. We do not value a wisdom even acting for an end, if that end is of no use to us. That the triangle has its three angles equal to two right angles does not appear to us an end, but an inevitable consequence of the re-encounter of primitive mathematical relations. If, on the other hand, the question is of something that has reference to the preservation of man, or of some being affecting him, it seems we cannot then too much appreciate the ingenious means created and brought into play, with intelligence and zeal, for such an end, although in this case, as in that of the triangle, it might quite as well be supposed that the end is only the inevitable result of the conflict of certain given primitive relations. If the preservation of man, of the animals or plants, were bound up with the persistence of 180 degrees in the triangle, then we would wonder at the high excellence of this adaptation to the end, which we now find quite simple and natural; and if, conversely, we had no more interest in the preservation of man, the animal, and the plant, than in the persistence of 180 degrees in the triangle, then, like entirely disinterested spectators, we would lose sight of the co-ordination of ends and means, and would at once ask whether all these ends, attained by nature, are not the consequences of the conflict of certain primitive laws, as is the case with ends in mathematics.

' III. Besides, it must be remembered that the teleological argument does not derive its decisive force from the existence of a universal finality, extending everywhere, but from a sort of dissemination of final causes, accidentally dispersed over the vast empire of nature, such that the striking examples shine as exceptions so brilliantly that they seem to be something surpassing the powers of nature itself. If the law of finality were as universal in nature as the law of causality, if there were even no phenomenon in which it was not manifested, then we would cease to find this law miraculous as a law of nature, and would not be tempted to infer from it any supernatural intervention. For instance, because in a certain country, certain species of plants happen to grow which exactly serve for food or medicine to the animals of that country, or, again, because in a given country such animals are found as deliver the country from other animals that would be hurtful, this appears to us wonderful and surprising, because all natural events do not exhibit to us so immediately, in their reciprocal relation, so intentional and organic a connection. The poverty that nature presents, in the point of view of finality, inspires us with a certain distrust of the powers of that nature, — a distrust that goes so far, that when an accomplished finality is really displayed in it, we usually prefer to have recourse to a miracle, rather than suppose any such thing accomplished by the powers of nature itself.

' This distrust of nature is very analogous to the distrust of misanthropes, as it is shown in the moral world. As the misanthrope is tormented by the morbid prejudice that human nature is too feeble to oppose evil, and that, consequently, there is no virtuous man in the world, so the physico-theologian lives with the prejudice that nature is too feeble and too impotent for a closer connection of its creatures than the connection of efficient causality; and in his illusion, where the true law of causality ceases, he draws the bolt, and beyond he prefers to believe in the miracle and in ghost stories rather than consent to the idea of a teleological process in nature itself.

'IV. Besides, on the teleological hypothesis the creator cannot be cleared of a certain feebleness, or a certain inclination to useless play, when he is seen to attain, by a grand apparatus of ingenious inventions, very small ends, which an Almighty Creator, such as He who is in question, should have which would remove us too far from the present discussion. In fact, to reintroduce representation, even unconscious, into activity, is partly to return to the Hegelian conception, which reduces finality to notion, concept, idea, and not merely to pure instinct. But this point of view will occupy us in the following chapter.

This last transformation of hylozoism (for Schopenhauer's philosophy hardly deserves any other name) suffices to show the nullity of the explanation of finality by instinct. But if instinctive finality seems to us inadmissible, we still admit that intentional finality has its difficulties, which must be examined more closely.

The profoundest discussion that we know against intentionalism is that of a Hegelian philosopher, Fortlage, in his History of the Proofs of the Existence of God.1

This discussion sums up and completes all the difficulties previously enumerated. We reproduce it here.

'I. According to the argument of Paley, wherever there is finality, there must be present and in action the conception of an end to be attained, and, consequently, an intelligence in •which this concept resides. If, then, a single case can be produced where an end is attained without the concept of an end necessarily intervening, the argument is invalidated. Consequently, to maintain this argument, I am forced, wherever nature by a blind impulse, or by a secret force of preservation, attains its end of itself, I am forced, I say, to recur •without necessity to the creator. For instance, if the end (^Zweck} of self-preservation is manifested in the animal, and attains its

object (JZiel) by the taking of food, if the end (^Zweck) of hardness is manifested in the stone, as the force of cohesion of its atoms, and attains its goal (Ziel) by their reciprocal attraction, I can no longer see the end in the natural forces themselves (for instance, in cohesion hardness, in hunger the instinct of preservation), but I must violently separate the one from the other.

NOTE: Darstdlunrj und Kritik der Beweise furs Daseyn Gotten, Heidelberg 1810, p. 237 et seq. — Bedenken gegen die Paleysche Schluss/orm: Difficulties regarding Paley a argument.

' We soon see ourselves drawn to other still more extreme consequences. In the artistic activity of the human race, for instance, ends are manifested that are attained by a feeling acting blindly, and not by a calculation of the mind. How often has criticism been able to discover in a man of genius, ends attained by his action of which he did not think! Could any calculation of the understanding have presented to the mind of Mozart, for depicting certain emotions of the mind, so appropriate means as those which his genius found under the influence of inspiration? But if Paley's proof is considered valid, we cannot admit any case where a determinate end is attained by determinate means, without the conception of the end being found as such in a certain understanding, and without the means having been chosen for the end by an intentional arrangement. We must thus believe that, while Mozart composed, the divine understanding assisted him like an arithmetic master, and that for the end of expressing pinion he threw into his heart, in proportion as he had need, the means, carefully chosen and appropriate. If, on the other hand, it is granted us for a moment that Mozart may have attained a single end in his music by an instinct of feeling, without mental calculation, the received argument is invalidated; it may still serve to persuade, but not to convince.

' II. Mathematics give us a great number of instances of finality attained without any end proposed beforehand, or, to speak more exactly, of finality, which we do not habitually consider as such, because the end attained does not appear more important than the means applied. Kant speaks of this mathematical teleology in the Critique of the Judgment.1

' Whence comes it that, in this case, we are not astonished, as in other cases, at intentional arrangements? Why do we not infer a wise author who had ordained all that conformably the machine cannot go. He admits that God has placed in the thing at the first a certain force of spontaneity and energy, which is displayed conformably to an internal law without the necessity of the action of God being added to it, which force will be called, according to occasion, tendency, instinct, inspiration, etc. Such facts do not in the least prove that an activity can be conceived aiming at an end, without any notion of that end; for these forces, more or less blind and ignorant of their end, may be derived from some being that knows that end for them. Nay, this is the only means we have of comprehending this hidden and unconscious tendency towards an end. There is nothing in this that touches the principle, or is irreconcilable with it.

NOTE: Critique of the Judgment, t. II. § Iri.

But is it possible, it will be said, to conceive that, even if created, blind forces can attain a certain end? And if this be granted, why should not an uncreated force equally attain it? We have here the true difficulty which Bayle, in a similar discussion on plastic natures, had already excellently perceived: ' But if a faculty without consciousness and reason,' he says, ' merely because it is created by an intelligent being, becomes fit to accomplish works that require intelligence, is it not as if it were said that, of two men equally blind, the one does not know his way, the other knows it because he has been created by a father with eyes? If you are blind, it matters little whether you were born of a blind or seeing father, for in both cases you always need to be guided by the advice and the hand of another. So, to regulate matter, it matters little whether plastic nature be born of an intelligent cause, if it is blind and knows not in what way to proceed to compose, separate,

distribute, or reunite the elements of matter. Of what use is the power of acting without the faculty of comprehending? Of what use are legs to a blind man' . . . Consequently, if plastic causes are entirely destitute of intelligence, they must be continually directed by God as physical instruments.' Consequently, according to Bayle, the hypothesis of plastic natures, little different at bottom from the Leibnitzian forces, either reverts to pure mechanism and occasionalism, or leads to the negation of a supreme cause; for it a blind force, tending towards an end and attaining it, implies no contradiction, we cannot see why such forces should any more imply a contradiction because existing of themselves.

To this we reply, with J. Leclerc, the defender of plastic natures: What implies contradiction is not the fact of a blind force tending towards an end, since experience shows us such, but is just the hypothesis of such a force existing of itself: for in that case we do not see whence it can derive the determination towards the end, and the exact choice of means leading to it. If, on the other hand, such a force is only derived, the reason of its determinations is in the intelligence of the cause from which they emanate. What, says Bayle, does it matter, if the force is blind, whether it have as author an intelligent being? What matters it whether a blind man be born of a seeing father? To solve this difficulty, let us borrow, like Bayle himself, our examples from experience. Every day we see intelligent beings communicate to other beings dispositions and impulsions that direct them unconsciously towards a determinate end. This takes place, for instance, in education. Parents insinuate by example, by a certain tact, by caresses, etc., a thousand dispositions and inclinations into the soul of their children, of which the latter are unconscious, and which direct them, without their knowing it, towards an end they know not of,—for instance, virtue, wisdom, happiness. Such dispositions, however, are really incorporated in the soul of children, are blended with their natural qualities, become proper to them, and are later truly. spontaneous principles of action to them. In this case, then, we clearly enough see how an intelligent cause might originally place in created beings certain dispositions, potencies, or natural habitudes, which should be inherent, immanent, and essential to them, and which should conduct them to their destination without their knowledge, and without the Creator needing to act for them and guide them, as the husbandman been able to attain by simpler means, and much more briefly, without creating for Himself useless obstacles in His way Even Paley, the great admirer of the divine wisdom in the organization of animals, expresses his astonishment on this point, and sees no other refuge than in the incomprehensibility of God's ways: "Why," he asks himself, "has not the inventor of this marvellous machine (the eye) given the animals the faculty of sight without employing this complication of means?"

' Again, the human eye is at once the most finished and the simplest of organs. Much less perfect, more insufficient, and a thousand times more complicated, are the thousand lit tie tubes of the combined eyes of insects. Why has the wisest of creators had recourse in the creation of animals to so imperfect apparatus, when later He was to show by the fact, that the material of nature was capable of producing one much more perfect? Did He, then, find pleasure in realizing, only to vary, by imperfect and difficult means, what He could obtain much more quickly by more perfect means? Is such child's play, that creates obstacles for its own amusement, and indulges its humour in oddities and marvels, worthy of a wise Creator? He has shown in the stomach of man, the birds, and the ruminants, how many means were at His disposal to realize a process of digestion that should take place without effort: why have those means failed Him for serpents? and why has He permitted in this case the function of nutrition to be fulfilled by a disagreeable process, as fatiguing for the animal as repulsive to the spectator? These instances, and others like them, are fitted to awaken the desire for a less forced explanation of nature, in case such an explanation were possible.

'V. In fine, there is at the foundation of the physico-teleological proof a sentiment of the soul of quite another nature than that which results from the teleological calculation with concept of the

understanding—that is, an edifice added later, awkwardly to prop and magnify this instinctive sentiment. Nature, when we contemplate its works, fills us with wonder, and we feel ourselves spiritually, and as if sacredly, inspired. There breathes in us, as it were, a communion with the thousand creatures that burst forth in spring, and joyfully rush into life. We keenly feel the breath of a spiritual and vivifying power. Such a feeling is scarcely compatible with the point of view of a machine, so wisely ordained by an external mechanician that there is nothing more ingenious and better ordered than the fitting of its wheels.'

NOTE: Paley, Natural Theology, chap. IL

Such is the learned and curious reclamation of the Hegelian philosophy against the doctrine of intention. Let us briefly resume, while submitting them to a severe discussion, the preceding objections.

I. The first difficulty is this: There are numerous cases in nature where the tendency towards an end is not accompanied by the clear conception of that end. For instance, the tendency of bodies towards a centre, the instinct of animals, the inspiration of great men, are facts of this kind. If, then, these different forces are not to be recognised as immanent in nature, recourse must incessantly be had to the first cause without need, and we fall into occasionalism. In a word, immanent and unconscious finality, or deus ex machine — such are the two horns of the dilemma.

We reply that this dilemma sins against the fundamental rule of this kind of reasoning, which requires that there be only two possible alternatives, without intermediaries, whence the rule of the exclusio tertii. But here there is between the two opposite hypotheses a mean hypothesis, which the author omits, and which consists in supposing that there are, indeed, immanent forces in things, and forces unconsciously tending towards an end, but that this immanent finality is derived and not primitive, relative and not absolute. Between Hegel's hypothesis and Paley's there is room for that of Leibnitz, who by no means admits that we must incessantly have recourse to God as to a mechanician, without whom the plough. A thousand instances, derived from physiological and moral experience, might be quoted of this premeditated infusion of certain principles of action into souls that are unconscious of them, and that then obey them spontaneously and blindly. And men make use of this power as well for evil as for good. A skilled seducer, for instance, will know how to determine in an innocent mind certain unconscious impulses that will lead it unwittingly to the end fixed by him — namely, towards its ruin or misfortune. An orator or a politician will call forth in crowds commotions which, once excited, will lead to this or that consequence, foreseen by him and not by them. Thus the Creator might determine in bodies or in souls certain impulsions or tendencies leading them inevitably to the end fixed, reserving to man alone, and still within a limited circle, the faculty of acting like Himself, conformably to a premeditated end.1

In truth, it will always be possible to oppose hidden qualities, which, being neither mechanisms nor systems of thought, present nothing clear to the mind, and to say, with Descartes, that we only comprehend two things clearly and distinctly, thought and motion (or any other mediation of space); and this objection is at bottom that of Bayle, who opposes the dynamism of Cudworth from the point of view of Cartesian occasionalism. But this point of view cannot be that of the German philosopher we are discussing, for he shows himself opposed to every species of mechanism, whether the mechanism of Epicurus (that without God) or the Cartesian mechanism (that with God). He thus necessarily admits something like hidden qualities, under the names of tendencies, instincts, inclinations, inspiration, enthusiasm. He has, consequently, nothing to object to those who will admit the same hidden faculties, on condition of supposing them to be derived and not primitive; and from the point of view of the explanation of these notions there is no advantage in conceiving these sorts of qualities as existing by themselves in place of being communicated properties.

One may conceive this creation of impulsions in things either as a supererogatory act of God, adding to beings, when once formed, the instincts or powers they have need of, or else (which would be more philosophical) one may admit that God has at once created beings and their instincts, the nature of things being but the sum of the powers or Instincts of which It is composed.

There are, besides, in the facts quoted by the author, many differences to be noticed. One might even dispute regarding the approximation of mechanical tendency and instinct; but what cannot be in any way assimilated is the fact of instinct and that of inspiration.

Instinct is a phenomenon entirely blind, routine, machinelike, always like itself. It may vary more or less under the influence of circumstances; but as these modifications are slow, rare, and infinitely little, the dominant character of instinct is no less monotony, servile obedience to a blind mechanism. Inspiration is of quite another order; its proper character is invention, creation. Wherever there is imitation, or mechanical reproduction of a phenomenon already produced, we refuse to recognise the character of inspiration. The property of instinct is precisely to resemble a work calculated and arranged beforehand. Thus the bee, in choosing the hexagonal form for depositing its honey, acts precisely as an architect would do, who should be asked to construct the most pieces possible in a given space. On the other hand, the property of inspiration is in nothing to resemble calculation, and to be incapable of being in any way represented by calculation. For instance, when a poet wishes to paint a great sentiment, it would be impossible for him to find laws of combination permitting him to attain his end; he could not say: By combining words in such a way I shall be sublime. For the words must still be given him; and by what means could he find such words rather than others? In artificial works (and what renders instinct so marvellous is just that it produces such works), it is by the combination of parts that we succeed in producing the whole. In works of art, on the other hand, it is the whole that commands the arrangement of the parts. For instance, although a musical theme is necessarily successive, in virtue of the laws of time, yet even the first notes are dominated by the entire air; and one cannot imagine a musician adding note to note in order to reach an end, for that end is the entire air, and the air is in the first notes as well as in the last. No doubt, there is even in inspiration a part to be done by reflection, calculation, and science, as we shall show immediately; but the essence of inspiration is something entirely different, and cannot be conceived as a calculated combination.

These observations may appear at first sight more favourable than otherwise to the objection of the German philosopher; but our aim is first clearly to distinguish inspiration from blind instinct, two things that this philosopher puts almost on the same line as proving the same thing, wherein he deceives himself. No doubt the fact of artistic inspiration can quite prove that there is a sort of finality superior to the finality of foresight and calculation, that the soul attains its end spontaneously, while the mind laboriously seeks and combines the means of attaining its end. Where the versifier employs with consummate ability all the resources of the art of versification, to leave the reader cold while amusing him, — where the rhetorician calls to his aid all figures made to order, to persuade, please, and move according to rule, —a Corneille and a Demosthenes find in their heart unexpected words, sublime turns, whose origin they themselves cannot explain, and which astonish and elevate the soul of the spectators and auditors, and soul speaks to soul. Where shall one discover the like of Qu'il mourait? or, Je ne te hais point?* By what process? by what recipes? And how superior is emotion here to calculation! But if one may conclude from those facts that the highest finality is not perhaps that which results from a deliberate combination, still how can we confound this inspiration, in which the ancients saw the seal of the divine, To 6iiov, with a blind instinct, with the mechanical and routine course of a watch that goes alone, which is what the instinct of animals resembles? Inspiration may be superior to calculating intelligence, but intelligence remains very superior to instinct. The soul inspired by sentiment is not a blind activity. It is conscious of itself; it has a vivid and profound intuition of its end; it is quite full of it; and it is

precisely this vivid sentiment of the end that evokes in it its own realization. In this case, as Hegel says, 'the end realizes itself.' Instinct, on the other hand, not only is ignorant of the means, but of the end. Far from creating anything, it does nothing but repeat and imitate, without even knowing that it imitates what has always been done. The first animal of each species could alone be truly called an inventor. But there is no reason to attribute to it in preference to its posterity such a superiority of genius. For if it had been capable of such an innovation, why should its successors be reduced to a sterile and routine imitation? Doubtless the creation of instinct supposes genius; but instinct is not genius, and is even the opposite of it.

NOTE: Corneille, llnra •«, act iii. scene 6. - Corneillo, Le Cid, act ill. scene 4.

Moreover, we have hitherto reasoned on the hypothesis whereby inspiration would only be a purely spontaneous act, in which intelligence should have no part. But nothing is more contrary to the truth. Every one knows the old disputes between art and genius. No doubt art is not genius. .Rules do not suffice to make masterpieces; but who does not know that genius is only complete when accompanied by art? How many parts of the beautiful are derived from intelligence and science I The wise arrangement of a subject, the division and gradation of the parts, the elimination of useless parts, the choice of times, places, circumstances, the adaptation of the style to the manners and sentiments of the personages — these for the dramatic art. The investigation of proofs, their distribution, their clever gradation, the skilful interweaving of dialectic with the pathetic, the accommodation of the sentiments and motives to the habits and dispositions of the auditory — these for the art of oratory. The combination of harmonies or colours, rhythm, the contrasts of light and shade, the laws of harmony or of perspective — these for music and painting. In architecture, the part of science is greater still; and even industry comes into play. Thus even in the labour of inspiration, science and art — that is, calculation, foresight, and premeditation — play a considerable part; nay, it is almost impossible rigidly to distinguish what is of art and what is of inspiration itself. No doubt the original conception of a character like that of the Misanthrope, or, in another class, the Olympian Jupiter, can only be referred to a first stroke of the creative imagination. What means, in effect, can be employed to conceive a primary idea? At the very most, the artist may place himself in circumstances favourable for invention. But the primary idea once given, what is it that fertilizes, animates, colours, and realizes it but art, always, it is true, accompanied by inspiration? Is there not here a part to be played by calculation and thoughtful combination? Will not reflection, for instance, suggest to the author of the Misanthrope: To attain the comic, I must put my principal personage in contradiction with himself. I must then give him a weakness, and what weakness more natural than that of love? And to render the contrast more striking, and the drama more comical, I will make him love a coquette without soul, who will play with him. I will bring them together, and the man of heart shall humble himself before the selfish and frivolous fine lady. Besides, this coquette must be a perfect woman of the world; and to depict her as such I will have a conversation scene, where I will paint the salons in all their charming frivolity. That Moliere made these calculations, or others like them, cannot be doubted, although at every step he needed genius — that is, inspiration — to realize his conceptions; for it is not enough to say, I will have talent, — the great thing is to have it. But talent can no more be found by means of reflection than genius. Every one knows, on the contrary, that to seek talent is the best way not to find it. In music, inspiration properly so called plays a greater part; but even here there are skilful combinations that may be the result of reflection, and produced intentionally. For instance, it may very well be the case that it was after reflection, and voluntarily, that Mozart resolved to accompany the amorous serenade of Don Juan, that air so melancholy and touching, with the playful refrain that inspired some well-known, charming verses of Musset. Donizetti may also very well have calculated beforehand the profound effect produced on the heart by the singing of Lucia's obsequies, interrupted by Edgar's marvellous final air. At every moment one may find in the arts examples of great beauties gained by calculation and reflection. In Athalie, for instance, the introduction of choruses, the prophecy of Jehoiada, the bringing together a divine child and an

impious queen; in Horace, the idea of cutting in two the narrative to produce a sudden dramatic change; in the Descent from the Cross at Antwerp, the skilful and difficult combination that makes all the personages in some measure bear or touch the body of Christ, — are striking examples of beauties desired, premeditated, and prepared by esthetic science, on condition, no doubt, of finding a powerful imagination for their realization. These striking examples of an intelligence at the service of inspiration might incline us in favour of Schopenhauer's theory, that makes intelligence the servant of the will, if we agreed to attribute inspiration to what this philosopher calls the will; — as if inspiration itself were not already a sort of intelligence; as if the first conception, the immediate work of the creative imagination, were not also an act of intelligence; as if, in fine, love itself, which impels to create, to engender, as Plato says, were possible without a certain view of the object loved. All that can be said—and it in no way contradicts the doctrine of final causes —is that above the combining and calculating intelligence, there is a primary form of superior intelligence, which is the condition of the second, and which may be called creative.

If, then, we seek in experience some type or model that may give us an analogical idea of the primary activity, we will not refuse to admit that inspiration is that which, per haps, in fact, comes nearest to it. At this elevation intention becomes lost in finality, — that is, the means confound themselves with the end; but far from such a conception confining us within the circle of nature, it is only, on the contrary, by leaving nature that we can conceive such an identity of means and ends. It is the property of nature, on the other hand, to pass by the one to the attainment of the other, which is impossible to a blind force, not directed. Foresight, as it is manifested in the secondary substances, is not, perhaps, the highest expression of finality; but blind instinct is a still less faithful expression of it, and pure mechanism is its absolute negation.

If, moreover, we analyze the idea of intention, we shall find in it two elements: — 1st, The art of willing the end, with the consciousness that we will it; 2d, The choice of means to attain it. But in the phenomenon called inspiration, intention exists in the first sense, although not always in the second. The artist will express what he has in his soul, and he is conscious of this volition; but how is he to express what he has in his soul? He does not know. Does it follow that a higher intelligence would know no more? Is what is unconscious in artistic creation a necessary element of creative genius? On what ground could such an hypothesis be maintained? It appears that the highest degree of genius is just that which has the completest consciousness of its power. As there is more consciousness in genius than in mere instinct, so what may be called absolute genius should be accompanied by absolute consciousness.

Supposing, then, that there is a supreme act, of which artistic inspiration can give us some idea, this absolute act should be not the act of a blind force, or of a fortuitous mechanism, but of a creative intelligence, inventing at once means and end by a single act, and in which, consequently, foresight should be identical with immediate conception. It is in this sense that it may be allowed that intention is not necessary to finality; not that it is absent, as in ignorant instinct and in the blind forces of nature, but rather that it has become useless, because, being in no way separated from its end, conception and execution are for it but one. But we will return to these ideas; this is not yet the place to give them all their development.

This first objection being much the most important, we have had to dwell the longer upon it; we will pass more rapidly over those that follow.

II. The German author appeals against the intentionalist doctrine to what he calls mathematical finality, without explaining very clearly what he means by it. No doubt he means to say that, to render any regular figure possible in geometry, its lines must be arranged in a certain way; but this pre-arrangement of the lines in relation to the general figure is something analogous, not to say similar, to the arrangement of the members in the organism; it is an adaptation to an end. Yet in

this case, he says, no one supposes an intentional arrangement, no one infers a wise author, who has ordained all that, conformably to the end, by the most simple means. Why, according to this author? Because mathematical figures have no relation to our convenience, and their fundamental relations are absolutely indifferent to us.

There is here, as it seems to us, much confusion of ideas. But to come at once to the main point, we may say that Kant, from whom the principles of the objection are borrowed, has himself, with his usual profundity, furnished the solution of them. It is, that in mathematics we have to do not with the existence of things, but their possibility, and, consequently, there can be here no question of cause 'and effect.'1 This is why Kant gives to this finality the name of ' finality without an end,' which equally applies to esthetic finality. Kant's explanation amounts to that of Aristotle, according to whom mathematical entities are fixed, — that is, are not subject to generation. But where there is no generation, there is no cause and effect (except by metonymy); and where there is no cause and effect, there can be no means and end, for means are nothing but a cause fit to produce a certain effect, which, therefore, is called an end.

NOTE: t'ritiquc of the Judgment, § Ixii. note

If, however, instead of conceiving geometrical figures as pure abstract possibilities, they be taken as concrete forms, which matter really assumes under determinate conditions, — for instance, in crystallization, — there will, in fact, be room to inquire how certain blind materials come to be arranged conformably to a determinate order; and a definite reason will evidently be needed to explain why they take this arrangement rather than another, since particles left to chance would assume a thousand combinations before hitting on those simple figures that geometry designs and studies. In this case, we will be entitled to suppose that these molecules move as if they aimed to produce a determinate geometrical order; and to affirm that in this case there is a finality without intention, is to assume precisely what is in question; for it does not follow as of course that any cause can spontaneously, and without knowing anything of what it does, direct its motion according to a regular law and conformably to a determinate type.

Thus it is not because geometrical proportions and relations have no reference to our use, as Fortlage supposes, but because they are pure ideas, that we do not assume intentional arrangements in geometrical figures. But as soon as these figures are objectively realized in the real world, we raise exactly the same question as regarding the most elaborate arrangements. Besides, it is not true that human utility is the sole criterion of finality and intentionality. We admire the structure of animals and plants, even in the case of creatures that are of no use to us; and if bees' honey were of no more use to us than their wax, it would be enough that these two products are useful to themselves to make us admire the industry that yields them. Still more, we recognise finality even in beings hurtful to us, and, as Voltaire says, the very fly should own that the spider weaves its web with wondrous skill.

Thus it is the internal agreement of the object, and not its relation to us, that determines our judgment of finality; and if, in place of conceiving geometrical figures as externally self-existent, we saw a luminous point moving in space, and turning round a centre, drawing a curved line, without ever increasing its distance in relation to that centre, we would then seek a cause for this motion, and could not conceive it except as the act of a mind and an intelligence.

III. It is the very rarity of the fact of finality, it is said, that makes us infer a cause apart from nature, and an intentional cause analogous to our own. If finality were displayed in all phenomena like causality, we would have no more difficulty in attributing the one than the other to the power of nature; but these facts being scattered, we judge nature too feeble to produce them, and think

it necessary to have recourse to a miracle to explain them. Fortlage, in this connection, ingeniously compares this distrust of nature in general with the misanthrope's distrust of human nature.

Here, again, there is much confusion of ideas. The question whether the cause of finality is within or without nature is not the same as this, whether that causality is intentional or blind. Intentionality and transcendence are, as we have repeatedly said, two different things. One may conceive an immanent natural cause (a soul of the world, for instance), which, like the Providence of the Stoics, should act with wisdom and foresight. One may, on the other hand, conceive a transcendent cause, like the pure act of Aristotle, which should act on nature unconsciously, and by a sort of insensible attraction. Thus we should not necessarily exclude intelligence from finality if we proved that the cause of finality is within, not outside, nature. Consequently, if this kind of distrust, with which, according to the author, the forces of nature inspire us, were to disappear, and we were brought to consider it as the sole and sufficient cause of finality, it would still remain to inquire how nature can attain its end without knowing it — how it can have adapted means to ends, while knowing nothing of either; and the hypothesis of a finality without foresight would still remain incomprehensible. Thus it is not our distrust of nature that compels us to recognise intelligence in its works.

An example will render our distinction evident. Suppose a poet, regarded as mediocre, and of recognised tameness, were to produce by chance some brilliant work, some beautiful verses, it might be supposed that he was not the author of his work, that some one prompted and inspired him, although, in reality, there is nothing impossible in genius being manifested only in sudden leaps and intermittent flashes. There is more than one instance of a poet having produced but one sublime piece, and relapsing into the night of mediocrity. But if this poet, on the other hand, were then continuously to produce a succession of masterpieces, our distrust would disappear, and we would no longer need to seek elsewhere than in the genius of the poet himself the inspiring principle of his writings. But would we thereby have in the least degree proved that genius is a blind force, not self-possessed, foreseeing nothing, and acting without light and thought? So nature might be the proper cause of its products without our being entitled to draw any inference against the existence of an intelligence in nature itself.

It will, no doubt, be said that, experience giving us no sign of the immediate presence of an intra-mundane intelligence, we can only conceive a supreme intelligence by supposing it at the same time extra-mundane. We grant it; and it is one of the most decisive reasons in favour of the transcendence of a first cause. But, after all, the question of transcendence raises difficulties of another kind; and, therefore, it should be distinguished from that of an intelligent first cause. For instance, the difficulties that arise from the idea of creation ex nihilo, those which arise from the idea of substance, from the exact distinction between the Bret cause and secondary causes, are independent of those that are raised against the hypothesis of a pre-ordaining foresight. Accordingly, we say that this hypothesis may be disengaged from that of transcendence — that it rests on its own reasons, whatever the degree of intimacy attributed to the first cause in relation to nature.

Let us now add that, even if finality were as universally diffused through nature as causality, there would still be no occasion to set aside the idea of a contingency of nature, contingentia mundi; for this contingency affects causality as well as finality. Because all the phenomena of nature have a cause, it does not follow that that cause is immediately the first cause, and that there are no second causes; but nature, being by the very definition only the totality of second causes, is not in itself its own cause. Now, if finality were universal, like causality, it would simply follow that all that we call cause would become means, all we call effect would become end; but the chain of means and ends, no more than that of causes and effects, would be confounded with the absolute, and the question of contingency would remain intact.

IV. A new difficulty proposed by the German author is that the hypothesis of an intentional finality cannot explain the errors of nature, and the groping with which it gradually advances towards its end. This objection has already been discussed above;1 we need not refer to it. Let us merely say that, if the idea of a sovereign and absolute wisdom excludes the idea of groping, it is not so with the idea of a nature created by sovereign wisdom. The groping or gradation, in fact, may be the only means that a nature has at its disposal to express the absolute perfection of the creative act that gives birth to it. We will add that, if nature seems to you powerful and rich enough to be itself declared divine, d fortiori it must be beautiful enough for an image, shadow, or expression of the divine act.

V. The last objection is particularly interesting. It tends to put in opposition the belief of God's existence to the sentiment of nature, such as men feel it at the present time. It seems that to love nature it must be considered as divine, and not merely as the artificial work of the Deity.

No doubt it would be a great exaggeration to say that theism is irreconcilable with a lively sense of the beauties of nature. Nowhere have these beauties been more eloquently described than in the writings of Fenelon, Rousseau, and Bernardin de Saint-Pierre, which are directly intended to prove the existence of a Providence. But what might perhaps be maintained is that a certain manner of loving nature, and that precisely which has been developed in our age, supposes another religious philosophy than that of the Savoyard vicar. The old theodicy, it will be said, that conceives a God fabricating the universe as a watchmaker makes a watch, behoved to engender an entirely similar esthetic. Nature, to be beautiful, had to be arranged, cultivated, combed, pruned. The beautiful must exclusively consist in the proportion of parts, in a harmonious and sweet agreement: everywhere there were required in works of art plans well arranged and methodically executed. The earth was only a machine — that is, something cold, dry, more or less agreeable in parts, but without internal life, without flame, without a divine spirit. But since a new philosophy has taught us the divinity of nature, now that all is full of gods, the grand poetry of things has been revealed to us. The voice of the ocean, the roar of the winds, the abrupt depths produced by the elevation of the mountains, the splendour of glaciers, all speak to us of an ever-acting, ever-living power, that has not retired into its solitude after having acted one single time, we know not why, but which, on the contrary, is always here in communication with us, animating this nature that is called dead, but is not, since it speaks to us with accents so pathetic, and penetrates us with seductions so intoxicating. Here is God; and Goethe did not mean to lessen Him when, like the old Indians, he saw Him everywhere in the rocks, forests, lakes, in that sublime sky — in that totality, in short, of which He is the eternal soul, the inexhaustible source. The theist, on the other hand, only admires His cold and pale image, the wretched copy of His eternal perfections, — an insipid work that He has created without knowing why, tired, no doubt, of His immoveable eternity.

This whole argumentation supposes that, on the hypothesis of a supra-mundane and intelligent cause, nature would be no more than a machine, and the Creator could only be a workman, which would be to compare the divine activity with the lowest human occupations — that is, with handicrafts. These are very exaggerated consequences, derived from a metaphor. The comparison of the universe to a watch is one of the most convenient presented to the mind, and philosophy is no longer possible if every figure is forbidden on pain of being taken literally. The mechanism existing in the universe, and which may be considered by itself abstractly, warrants such a comparison, but does not exclude others. Because the Author of things has had regard to utility for His creatures, it does not follow that He has not had beauty in view also. As Leibnitz has said, mechanism does not exclude metaphysic. The architect who builds a temple like the Parthenon may have made a sublime work while occupying himself with its solidity. Whether immanent or transcendent, intentional or blind, the Cause of nature has been obliged to employ material means to express His thought, and the just combination of these means, to make a stable and solid work,

is imposed quite as much on the God of pantheism as on the God of creation; and, conversely, the employment of these material means, wisely combined, no more forbids the beautiful or the sublime to the God of creation than to the God of pantheism. If, then, the adherents of a transcendent and intentional cause have specially attached themselves to examples drawn from mechanics, it is not that they are more bound than others to maintain that everything in nature is mechanism, but that there is here one of those privileged facts in which is strikingly manifested the proper character of an intentional cause; and philosophy, as well as the sciences, is entitled to appeal to the most decisive facts, even though they should appear low to a false imagination. And besides, when it concerns the mechanism of the universe and the conception of the system of the world, who will venture to say that that is a small matter, and that the admiration which such a work must inspire is really unworthy of the Divine Being?

Thus those who have said that the world is a machine, are in no way deprived of the right to say that it is a poem as well. Wherein does the one exclude the other? The system of the world for geometricians is certainly only a mechanism. Does any one believe, however, that a geometrician will therefore become insensible to the beauties of the starry heaven and the infinite immensity? Will it be disputed that a building, in order to stand, needs to obey the laws of the exactest and driest mechanics? The gigantic arches of Gothic cathedrals are not supported by miracle. It is not angels or hidden powers that support their stones, but the abstract and dead laws of gravitation. And yet, is the mysterious grandeur of these mystical monuments less overwhelming, divine, and pathetic on that account? The soul of the architect has manifested or embodied itself in these dumb stones, but it has only been able to do so by observing the laws of mechanics. Why cannot the divine soul, if we may use such an expression, have also passed into its work, whether mechanical or not? Is it necessary that the architect's soul be present in the building substantially in order that it may be truly there? Is there not a kind of ideal presence, the thought of the Creator being communicated to His work, and existing apart from Him, but by him? Will it be said that the divine hymn of Stradella has not retained something of the soul of its author, although he is no longer here to sing it? Thus, that nature be beautiful, touching, and sub1"me, it is not necessary that God be present in it substantially; it is enough that He is there by representation, as a prince is present wherever his ambassador is, and communicates to him his dignity, without needing to be present in person.

Thus the esthetic objection proves nothing in favour of an instinctive and against an intentional finality. Nature, were it only a vast mechanism, might still be beautiful, as expressing a divine thought, just as the succession of the sounds of an instrument may be something sublime, although, for the physicist, it is only in reality a purely mechanical combination. But we have seen, besides, that the doctrine of transcendent and intentional finality is by no means obliged to reduce everything to mechanism. Nature may be composed of forces without being itself the supreme and absolute force. In fine, the species and degree of the participation of things in the Divine Being is one question, and intelligence in the ordaining cause is another. Were the world nothing but the phenomenon of God, there would still be room to inquire whether it is a phenomenon developed in the way of blind instinct, or of enlightened reason. But on the latter view it is not apparent why nature should be less beautiful than on the former.

In a word, the fundamental error of this whole otherwise very learned discussion — is the perpetual confusion between two distinct questions, that of immanence and that of intentionality, immanence not excluding intentionality and wisdom in the cause; and, secondly, the vagueness and indecision in which this term immanence, interiority, which is imputed to the first cause, is left. For immanence is not absolutely denied by any one; the only question is as to the degree, but the degree is not fixed.

Other difficulties have recently been raised among us against the hypothesis of an intelligent, and in favour of an instinctive, finality. Here, for instance, is how a contemporary philosopher expresses himself: ' We can only conceive In three ways the relation established in a system of phenomena between the end and the means. Either, in effect, the end exerts an external and mechanical action on the means; or that action is exerted not by the end itself, but by a cause that knows and desires to realize it; or, finally, the means arrange themselves in the fit order to realize the end. The first hypothesis is absurd, since the existence of the end is posterior in time to that of the means; the second is useless and blends with the third, for the cause to which recourse i& had is only a means not essentially differing from the others, and to which is accorded, by an arbitrary preference, the spontaneity denied to them.'1

In this passage it must be confessed that the author of this objection frees himself very easily from a traditional doctrine, defended by the greatest spiritualist and religious philosophers. It will not easily be allowed that the doctrine whereby intelligence co-ordinates the means, is reducible to that whereby ' the means arrange themselves in the fit order to realize their end.' May we not here say with Fenelon: ' What is stranger than to imagine stones that grow — that come out of the quarry, that ascend upon each other, leaving no space, that carry with them the cement to unite them, that arrange themselves so as to provide apartments, that receive beams above them to roof in the work'? Why, if I say that an architect has chosen and foreseen the means necessary for building, is it as if I said that these means all alone arranged themselves to build the house? To say that intelligence is only itself a means like the others, is even a very inexact expression. For can that be called a means that serves to discover means — to choose and distribute them? But even if so improper an expression were admitted, the question would remain the same as before — it would still be the question, whether the first means, and the condition of all the others, is not the knowledge of the end and the enlightened choice of the subordinate means. At least it would be necessary to distinguish between the principal and the secondary means, the one being the condition sine qud non of all the others. Thus nothing would yet have been proved. To maintain that ' knowledge only produces action by accident,' is one of the strangest doctrines that can be maintained in metaphysic; for it would follow that, precisely on the hypothesis of intelligence, actions would be fortuitous, — that the doctrine of Leibnitz would be the doctrine of chance, as well as that of Epicurus. The reason given for this paradox is as unsubstantial as the opinion itself is singular. For it is said intelligence can only conceive an end if feeling already impels us to it; thus it is useless. Every phenomenon can only be the result of a tendency. The knowledge that is added to the tendency adds nothing to it. I grant that the tendency towards an end needs no intelligence; but between the tendency and the end there is an interval, — there are intermediaries, middle terms that we call means. The question then is, whether the tendency towards the ends suffices to explain the choice and adaptation of the means. This is what the author does not take the trouble to prove, while it is the true point of the difficulty.

NOTE: Lachelier, Le fondement de l'induction, p. 96.

Tendency is one thing, preordination is another. To tend towards an end is not synonymous with acting for an end. These two finalities must be distinguished. The one might be called finality ad quod, the other finality propter quod.

Hunger, for instance, is a tendency. It is not the same thing as the industry that finds food. And if it be said that the pursuit of food is only itself the result of a tendency, — that, for instance, the animal goes towards what procures it pleasure, the insect towards the flower to which its smell or sight leads it, — it is not perceived that the question just is, how the particular tendency that impels it to satisfy a certain sense is exactly in agreement with the general tendency that impels it to desire preservation.

Let us take, for instance, the love of glory in a young man. This end can only be attained by the successive satisfaction of a multitude of partial tendencies; and the problem is now all these partial tendencies shall be subordinated to the dominant tendency. In youth, in point of fact, there is an immensity of other tendencies, which by no means harmonize with the tendency towards glory, and which are even very contrary to it; but it is the intellect and the will that exclude the one to satisfy the others. How does this elimination take place in brute and unconscious agents? How does the brute cause, imbued with innumerable tendencies towards an infinite number of objects, only obey those of them that conduct it to objects useful for its end? For example, how does the vital force, or whatever cause produces the organism, being the subject of a thousand chemical, physical, and mechanical tendencies, which could determine millions of possible combinations, exclude among all these combinations those that do not contribute to the end? And to say that it is by a sort of groping that nature discards successively the bad chances that arise, and ends by hitting the happy chance that satisfies the problem, would be to prove too much; for this explanation avails not against intentionality, but against finality itself.

To sum up. There is a common tendency at present in several schools to adopt a middle theory between the Epicurean theory of fortuitous combinations and the Leibnitzian of intelligent choice. This is the theory of instinctive finality, sometimes arbitrarily called the Will. This mongrel theory is nothing else than the old theory of hylozoism, which attributes to matter sympathies, antipathies, affinities, preferences, — things that are all absolutely opposed to the idea of it. All that can be attributed to matter, as regards power, is the capacity to produce motion. As to the direction of the motion, and the choice between the possible combinations of motion, it is an indefensible anthropomorphism to explain it by a second mysterious view, that consists in seeing without seeing, in choosing without knowing, and combining without thinking. Say simply that the adaptations of matter are only appearances and results; but to attribute to nature a desire without light, an intelligence without intelligence, an esthetic and artistic faculty that could dispense with consciousness and knowledge, is to take metaphors for realities, — /

The only substantial thing remaining in the objections that may be made against intentionalism is, that our vision always becomes obscure and dim when we come to the mode of action of the first cause, as our experience only gives us to know second causes. Thus no other course is left to us than to say nothing at all about it, as the Positivists do, or to speak of it by comparison with ourselves, always endeavouring to exclude whatever is incompatible with the idea of the perfect and absolute. There is no other method of determining anything of this first cause than the negative, excluding from God whatever belongs to the finite character of the creation; and the analogical method, attributing to God, ratione absoluti, everything with a character of reality and perfection. Every other method, pretending to discover a priori the attributes of the primary being, is a pure illusion; and even those who conceive this first cause as an instinct, and not an intelligence, do yet but borrow their type from experience.1

Thus it will be admitted that all foresight similar to that of man, and which implies time and difficulty, can have no place in the absolute. Is that to say, however, that all foresight is absent from it, as in blind instinct? Or is there not something that represents what we would call foresight, if the divine act were translated into human language? This is the question.

Let us examine, then, more closely this idea of foresight, as it occurs in human consciousness. It seems to imply two things incompatible with the absolute:—1st, The idea of preexisting matter, whose laws and properties must be mastered, and at the same time utilized; 2d, The idea of time.

1. Why has man need of foresight in preparing for the ends he pursues? Is it not because he finds before him a nature which, not having been made exclusively for him, presents a multitude of bodies submissive to laws which, in their actual form, do not in any way promote our convenience,

and are even oftener hurtful than useful to us, so that nature might have been as often presented under the aspect of a step-mother as of a beneficent mother. Man thus finding resistance in external forces, is obliged to calculate in order to overcome this resistance, and to make it subserve his designs. No doubt, indeed, given a determinate end, and pre-existing matter not prepared for that end, this matter can only be adapted by foresight, which is nothing but the reciprocal of experience. But could such a notion be comprehended in an absolute cause,—absolute mistress of the possible as of the real, — and which, being able to produce all by a sovereign fiat, has no difficulty to foresee, no obstacle to surmount, no matter to accommodate to its plans?

1 The learned philosopher whose opinion we have just discussed, will perhaps Bay that in the passage quoted the question is only as to nature, and not as to the first cause. But no one maintains that nature as such is an intelligent cause; it is meant only of the first cause. In denying, then, absolutely that finality is directed by intelligence, the author by implication makes his denial bear on the first cause.

On this first point, we reply that there is no necessary connection between the idea of foresight and that of pre-existing matter. In fact, when I pursue an end, I can attain it either by employing means that are not at my disposal, or by creating the means themselves; and although in the case of man this creation of means is never other than metaphorical, as the matter pre-exists, it is clear that the operation would not change its nature, if, in place of producing means by borrowing them from nature, I were endued with the faculty of absolutely creating them. For instance, to attain some end, —say, to make a metre to remain without alteration during so many years, — I need a metal hard enough not to change during that number of years, capable of resisting a certain degree of temperature, and which has so little marketable value as not to tempt cupidity; and not finding this metal in nature, I produce it by the aid of certain combinations. Is it not evident that if I could produce it immediately, the operation \\ould remain the same? and this matter, once created, would still have to be put in relation to the end, by adapting it, so that the creation of the means in no way excludes the adaptation of the means. Thus, granting that a given effect is an end (which is the hypothesis allowed at present by common consent), the production of the fit matter for this end is as much the effect of foresight as the adaptation of it in this manner would be. For, first, the production requires the adaptation besides; and, in the second place, that production itself is already adaptation, for we must first choose this matter, and then give it this form. Omnipotence being able to create every kind of matter without end, to create those that contribute to the end, and not others, is itself an act of adaptation; and, so far as the previous conception of the end should have determined this creation and not another, it is what we would call an act of foresight.

2. To what extent, however, can the term foresight, or intention, be here employed to represent the creative act? This question may still be asked. The creative act is absolutely one and indivisible; and, consequently, there can be no distinction between a consequent and an antecedent volition. That act not being in time, there is neither a post nor an ante; and our youngest scholars know that prescience or prevision is only an immediate vision. That is true; but if, on the other hand, the act be considered, not in its supernatural origin, but from the point of view of nature which is subject to generation, the act will be decomposed into diverse elements, and so far as the last is called end and recognised as such, the antecedents will be preordained in relation to that end; and if the whole act be considered as the act of an immediate knowledge or vision, the antecedents, relatively to the consequents, will be legitimately called acts of prevision. This will simply mean that no blind cause can have produced such acts; that they are acts of reason and of absolute reason; and that this absolute reason, so far as it is regarded in its effects, acts as if it were endued with foresight, prescience, and intention.

We do not hesitate to declare that the doctrine of an adequate conception of the absolute in the human mind cannot be maintained in philosophy. To say that things occur in the divine nature

exactly in the way we conceive them, would be to pretend that we can see God face to face, which, according to theology, is only possible in the future life. We only know God, according to Bacon, by a refracted ray, which evidently implies under a point of view that modifies the object, — in other words, in a symbolic manner. Thus we are not far from admitting with Kant that the doctrine of intentional finality is a doctrine relative to the mode of representation of the human mind, a hypothesis. Things occur, we say, as if & supreme wisdom had regulated the order of things. In these terms I do not believe that any philosopher can dispute the results of Kant's criticism. For what philosopher would ever dare to say, I know God as He is in Himself? And yet this is what must be said, if it be not granted that all our conceptions of God have something relative and subjective belonging to the imperfection of our faculties.

But while Kant absolutely maintains the subjectivity of human conceptions, and, enclosing us within an impassable circle, leaves beyond it only an absolutely indeterminate x, we admit, on the other hand, that these conceptions (when they are the results of the right use of our faculties) are in strict relation to things as they are in themselves, as the stick broken in the water strictly corresponds to the real stick, as the apparent heavens enable astronomers to discover the laws of the real heavens. By analogy we maintain that, if the highest manner of humanly conceiving the first cause of finality is the hypothesis of a supreme wisdom, this conception, to him who could penetrate to the deepest foundation of things, would be strictly translated into an attribute corresponding to the perfect being, so that goodness, wisdom, justice, and, in general, what are called the moral attributes of God, are not mere names relative to our way of feeling, but symbols, approximations more and more faithful to the absolute essence, considered in its relation to sensible things.

Consequently these approximations (as symbols of the absolute), assuming an objective and ontological character not possessed by pure poetic fictions, which are absolutely subjective, these approximations should be pushed as far as possible, taking most carefully into account the two data of the problem, — on the one hand, the facts to be explained; on the other, the nature of the absolute. Thus, foresight, being given as the only attribute intelligible to us that can explain the facts of finality, we ought, on the other hand, to free it from all that is incompatible with the idea of the absolute, and the residue of this operation will be the most adequate possible expression, humanly speaking, of the supreme cause of finality.

For instance, there is in human foresight a part that evidently belongs to the imperfection of the creature — namely, effort, groping, progressive and successive elaboration. We are not, then, to imagine the absolute as commencing by conceiving an end, then seeking means to realize it. then finding them, and putting them successively in operation. But is the idea of foresight bound to these accidents that are peculiar to human imperfection? We may apply to the attribute of the divine foresight what is habitually said of reasoning in God. Does God reason? No, it is said, if by that is meant that God seeks to prove to Himself a truth He did not know, and that He only discovers the truth step by step. But, on the other hand, if He sees all truths at a single glance, it is still the case that He sees them in their dependence and objective subordination. He sees the consequence in the principle, and distinct from the principle; but this is the essence of reasoning. It is the same with foresight. God sees all at one glance, but He sees the means as distinct from the end, and as being subordinate to it, and that is the essence of foresight. From the side of God there is thus only a single act: from the point of view of things there are two — namely, the act that perceives the end, and the act that distinguishes the means. Consequently, placing ourselves in the point of view of things, and by analogy with ourselves, we will call foresight the view of the end, as it suggests the creation of the means, or the view of the means, as it leads to the realization of the end. Thus it is that, in the single act of the divine volition, theologians have been able to distinguish three distinct acts, — an antecedent volition, a consequent volition, and a total volition,

— as mathematicians decompose a given force into hypothetical forces, of which it would be the result.

Thus the doctrine of the Nous, or of intentional finality, has for us no other meaning than this, that intelligence is the highest and most approximate cause we can conceive of a world of order. All other causes, chance, laws of nature, blind force, instinct, as symbolic representations, are beneath the truth. If, however, it be maintained, with the Alexandrians, that the true cause is still beyond,—namely, beyond intelligence, beyond volition, beyond love,— this may be quite true, nay, we risk nothing in allowing that it is certain; for the words of human speech are all inferior to the essence of the absolute. But since this supreme and final reason is absolutely beyond our grasp, it is useless to speak of it; and we have only to do with the highest manner of conception we can attain. It is in this sense we say with Anaxagoras:

NOTE: The philosopher whom we have discussed above (p. 377) has addressed to as the following correction, which oar readers will peruse with interest: —

' Favour me regarding the criticism that is applied to me. When I said that knowledge only produces the action by accident, I did not mean to say that it prod aces it by chance. I only meant to say that a being is inclined to the action, in so far as indued with tendency, and not as indued with intelligence; in other words, that intelligence in it simply coincides with the very principle of the action, and is not itself that principle (which does not prevent it from being able to direct that principle, which yet, as the example of the animals, especially of the inferior animals, and of vegetable nature proves, could strictly direct itself without it). I said, in a word, that intelligence produced the action by accident. I acknowledge myself culpable of affected brevity and of a slightly pedantic employment of the language of Aristotle, but not of so great an absurdity as would be the confusion of intelligence with chance.'

I admit the author's correction; but we still need to know how the tendency to the action can predetermine the action. It can do nothing else than push the action in an indeterminate manner, and it can only be 11 an incomprehensible concomitance that it encounters the willed effect. But it is this concomitance that has to be explained, and which intelligence explains. The author admits that intelligence can direct the action, but that that is not necessary, as is seen by the example of the vegetables and animals. But that precisely is the problem. We see a case where the cause is clearly manifested: why not suppose that it is the same in the cases where it is more obscure, whether the intelligence reside outside the being or reside in the being itself in a confused manner? Apart from intelligence or mechanism, there only remain* • hidden faculty that has no proportion to its effect*.

Chapter IV - The Pure Idea And Creative Activity

We have come to circumscribe the problem more and more narrowly; but still, the farther we advance, the more difficult becomes the solution, and the means of deciding become more difficult to manage. We have found that there is finality in nature; that this finality must have a cause; that this cause cannot be the mere mechanism which is destructive of all finality, nor what is above mechanism, instinct or vitality. It seems, therefore, that if the primary root of finality is neither matter nor life, it must be the soul, — that is, intelligence or thought; for there is nothing beyond, at least intelligible to us, except, perhaps, liberty. But liberty without intelligence and thought is only brute force, the Fatum of the ancients; and as to intelligent liberty, it is precisely what we call by a single word, and for brevity, intelligence.

But is intelligence the same thing as thought? Or, if it be agreed to give the same meaning to these two names, is not the fact thus expressed double? Does it not contain two elements, the thing

thought, and the thing thinking — the To cogitans, and the To cogitatum? If Descartes could say: Cogito, ergo sum, might he not have said as well: Cogito, ergo est aliquid cogitatum? Is not the thing thought an essential part of thought? When you say: A=A, is not there here an object distinct from the consciousness you have of it? And even if there were not an A in the world, is not this A that is in your thought distinct from the thinking subject, and opposed to it? Being a thing thought, it is not that which think*. This objective element, immanent in intelligence, is what is called the intelligible, the rational, and is logically anterior to intelligence; for there must be something intelligible, in order that there may be intelligence. The truth consists precisely in this intelligible in itself, and not in the consciousness we have of it. Let us call, with Plato and Hegel, this intelligible foundation of all reality, idea; let us call the internal and rational essence of things, thought; and we perceive that a new question may be raised — namely, what is the truly constituent element of thought? Is it the rational in itself, the intelligible, the idea? Is it, on the other hand, consciousness? In the first case, it is the objective of thought that is its substratum, and the subjective is no more than an accident, an accessory. In the second case, it is, on the contrary, consciousness that is the essential act of intelligence; it is it that renders possible the intelligible, that gives it life and being, that evokes it from nothing. For what is an intelligible that no one comprehends, a truth that no one knows?

From these two interpretations of the same fact may originate two hypotheses on the first cause of finality. While admitting by common consent that finality has its cause in thought, we may mean by this, either logical finality, that of the concept, of the pure idea (anterior to consciousness), or the finality of intelligence properly so called, — that is to say, conscious intelligence.

It is the first of these two doctrines that is the true foundation of the Hegelian philosophy, and which raises it far above materialist and purely naturalist doctrines, although the Left of this school has too quickly inclined to the side of naturalism.

Would not the true, the absolute type of finality, which is not in instinct, be found in the finality of the concept or the idea? In fact, every idea, every concept, contains, on the same ground as a work of art or a living being, an internal finality, a co-ordination of the parts to the whole. On this ground alone is it a concept, an idea. Suppose, in fact, that the elements of which a concept is composed were only in juxtaposition and not united, you will have several concepts, and not merely one. Suppose they are in discord, you have a contradictory concept, — that is, a non-concept. Every concept is thus a conciliation between a certain multiplicity and a certain unity; and this is what Plato calls an idea.

NOTE: An absolute multiplicity would be unintelligible; an absolute and indistinct unity would be equally so. There must thus be a union of the two elements, and a graduated scale from the one to the other. ' The wise men of to-day,' says Plato, • imperil unity and plurality sooner or later, which they should not. From unity they pass all at once to infinity, and the intermediate numbers escape them.' These intermediate numbers — that is to say, the genera — are the proper objects of knowledge, and make of nature in general an intelligible whole.

Thus the whole world might be regarded as a bundle of concepts, like to what Leibnitz called the union of germs. On this hypothesis, each concept would itself be a bundle containing others, and so on without end to the absolute concept, which is the universal sphere of concepts; not that it is simply the sum and collection of them, but it contains them in substance in all its plenitude. But each concept amounts to an agreement of the parts with the whole, and, consequently, contains an immanent finality. This is what results even from the ideas most generally received on the origin of created finality. In fact, it is generally admitted, after Plato, that God created animals on pre-existing types present to His mind. But these types must already have presented the same relations of finality as their copies; otherwise it must be believed that the divine intelligence only contained

outlines at first, which it afterwards perfected in becoming creative. The possible and the real are distinguished, and it is admitted that there must be a creator, in order that the possible may become real; but the possible itself is only such on condition of already containing intrinsic relations of accommodation. No doubt concepts may be combined, and this is secondary or finite finality; but this combination itself supposes preexisting concepts, in which the agreement of the parts with the whole is already given, and is not the work of a voluntary accommodation. If it be so in the idea, why should it not be the same in the realization of the idea? Or, rather, is there veritably a difference between the idea and the reality, between the model and the copy? If the idea is logically anterior to consciousness, it has already a mode of existence in itself anterior to the fact of being known. But what is this mode of existence? And who can prove to us that it is anything else than just what we call existence? Are things distinct from their ideas? Whereby and wherein are they distinct? We transfer our subjective ideas to the divine intelligence; we suppose that God may know possible things that are not real, which is only true of the finite intelligence. But in the absolute, to be thought and to be are only one and the same thing. Being is the intelligible, and the intelligible is being. There are not two men, man in himself and the real man; otherwise, as Aristotle says, a third would be needed to set them in harmony. To admit ideas distinct from things (or, what is equivalent, things distinct from ideas) is, as Aristotle says, to count twice the same beings, adding the words in themselves. Will it be said that things cannot be confounded with their ideas, because they are finite, contingent, and imperfect, and the world of ideas is only the world of the perfect and absolute? Why, this would just be to deny that things have their ideas, their eternal and preexisting models. If things have their ideas, these ideas represent them with their characters of contingency, limitation, and imperfection. Thus the plant in itself is represented as less perfect than the animal, the animal as less perfect than man. These, being changing things, are represented as changing, and their ideas contain the idea of change. What makes us believe that the totality of things constituting the world is finite, is that we ourselves Are one of these things, and that we only consider the w? ole from our limited point of view. But these limitations are only logical and relative, and the entire sphere of concepts is nevertheless an absolute sphere. Besides, has not Plato admirably shown that the not-being itself has its place among ideas? Without the not-being there were no distinction; all the genera would be confounded, thought would vanish with being.1

NOTE: Sep. lib. x. p. 596.

For the rest, we know that the question how far the idea is distinct from nature, is one of those that have divided the Hegelian school. Hegel maintains this distinction, which vanishes with his disciples. What with him is ideal becomes with them natural. But even if one maintained, with Hegel, the distinction of the idea and nature, of the abstract and the concrete existence of the idea, one might still say that nature is only the idea in motion, the idea externalized, and, consequently, that it must manifest externally the internal finality that constitutes it. Nature being only the idea, each of the terms of nature is only one of the terms of the idea. It is, therefore, a concept; and as the concept has an internal finality, the being that represents it has the same finality. It is only the concept realizing itself, the essence seeking and finding itself by degrees; but as the final end of each being is to attain all its essence, its whole idea, it is, therefore, definitively the end that realizes itself. What is the end of the animal? It is to live. But is it to live like the plant? No; as an animal. But is it merely to live like an animal in general? No; but as a given animal in particular. The end of each being is thus to live conformably to its own nature; it is its nature that is its end. And as, at the same time, this proper nature or essence is the cause of its development, the end is thus the cause. Here is the very essence of the final cause, the absolute identity of the end and the cause. It is because it is an animal, and such an animal, that it develops in such a direction, and it is in order to become that that it develops. Thus the in order to blends with the because. But both are confounded in the concept of the being. It is the concept of the bird that makes it have wings, and it has wings in order to realize the concept of the bird.

1 It might be said that there is a distinction between things and ideas namely, that things move, while ideas do not move. But if the doctrine of Kant be admitted on the subjectivity of the idea of time, this distinction would disappear. Motion would be a purely ideal fact, having reference only to one mode of conception.

In a word, whoever admits the theory of Platonic archetypes, must acknowledge that in this ideal world, that serves as model to the real, each type contains as pure essence and d priori, and without having previously been fabricated, the same relations of accommodation as, in the real world, the genera really existing. But since this accommodation may exist in itself before creation, without it being necessary to suppose an anterior cause, except the Absolute, that envelops all, and of which ideas are only the modes, why should these same types need for their realization another virtue than the virtue that gives them being, — that is to say, their own essence, and their relation to the Absolute? In this conception, finality is not the result of chance; there is no chance. It is not the result of mechanism, mechanism only being the totality of inferior notions, the poorest of all, and, consequently, the least intelligible. It is not the result of vitality and instinct; for vitality and instinct are precisely the facts of finality that must be explained. Finality has its cause in thought,— that is to say, in the necessity of things being rational in order to exist. Finality is the truth which, in the common opinion, is bound to the consciousness one has of it, while it is independent of it. Hegel has expressed this in m" of his finest pages, that sums up all his doctrine.

' When I know how a thing is, I possess the truth. It is thus one conceives the truth at first. But that is only the truth in its relation to consciousness, or formal truth, mere justness of thought. The truth, in a profounder sense, consists, on the other hand, in the identity of the object with the notion. This is the truth we mean, for instance, when we speak of a veritable state, of a veritable work of art. These objects are true when they are what they ought to be, — that is, when their reality corresponds to their notion. Thus viewed, the false {das Unwahre) is the bad. A bad man is a false man, a man who is not conformed to his notion. In general, nothing can exist in which this agreement of notion and reality is not found. The bad and the false themselves are only in so far as, and in the measure in which, their reality corresponds to its notion. The absolutely bad and the absolutely contrary to the notion fall and vanish, so to say, of themselves. The notion alone is that by which things exist, which religion expresses by saying that things are what they are by the Divine Thought that created and animates them. When we start from the idea, it need not be conceived as something inaccessible, and as placed beyond the limits of a region that cannot be reached. For it is, on the contrary, what is most present, and is found in every consciousness, although it be not there in its purity and clearness. We conceive the world as an immense whole that God has created, and that He has created because He finds His satisfaction in it. We also conceive it as ruled by Divine Providence. That is to say, the beings and multiplied events that compose the world »re eternally reduced to that unity from which they proceeded, and preserved in a state conformable to that unity. Philosophy has no other object than the speculative knowledge of the idea, and all research deserving the name of philosophy has only proposed to manifest in the consciousness this absolute truth, which the understanding only grasps in some sort by fragments.'1

The grandeur of the conception we have just set forth will not be disputed. It leaves far behind it all the materialist hypotheses, and even those of hylozoism, themselves so superior to materialism. It is not very certain that Plato himself, in his theory of ideas, had any other conception than that. Although its pantheistic character cannot be mistaken. it is yet distinguishable from Spinoza's hypothesis in two essential points: 1st, It reduces to the idea what Spinoza calls substance. The characteristic and determining element of the being is the rational, the intelligible, the logical; while for Spinoza it is the substratum, which is hardly distinguishable from the Aristotelian matter, and has no title to be called God. 2d, The idea is considered as a circle, which returns to itself: it sets out from and returns to itself. It is, therefore, final cause; while Spinoza's substance is lost in

its attributes, the attributes in their modes, so that the being seems always removed farther and farther from itself. The substance is thus only the efficient cause, and its progress is only downwards, its development is one-sided; while, in the philosophy of Hegel, the advance of the idea is progressive, and the motion is double, at once centrifugal and centripetal. The idea is the fusion of the two forces. The conception of Hegel is thus more spiritualistic; that of Spinoza more materialistic. Let us now see on what conditions the Hegelian conception will maintain its superiority over that of Spinoza, and whether it will not be just by reducing itself to the spiritualist conception properly so called.

NOTE: Hegel, Grande Encyclopedic, § 213.

The essential conception of Hegelianism is to substitute for things, to eliminate the thing (das Ding) as a caput mortuum, void of all content. A thing only is, and deserves to be, as it is intelligible and rational. Each thing possesses as much being as it has rational content. A heap of stones is only a being by accident, because the stones composing it have only extrinsic and fortuitous relations, and have nothing intelligible. If this conception, which is true, is admitted, it must follow that the being existing because of intelligibility, the absolute must be the absolutely intelligible. But what is an intelligible, but what is capable of being comprehended? What is the rational, but what satisfies the reason? What is the truth, but what is seen and recognised as true? What is a truth that no one knows, and that does not know itself? A truth absolutely unknown, which, on the one hand, does not rest on a substance, and, on the other, is not received in a mind, is nothing but a mere possibility. Bossuet has admirably said, in a famous passage which contains the marrow of what is excellent in Hegelianism: ' If I now ask where and in what subject these truths subsist, eternal and immutable as they are, I am obliged to own a being wherein truth eternally subsists and is always understood; and this being must be the truth itself, and must be all truth; and from it the truth is derived in all that is, and is understood apart from it.'

Thus a truth not understood is not a truth. Hegel says that the truth in its relation to consciousness is only a 'formal truth.' We, on the other hand, say that a truth without any relation to consciousness is only a formal truth, — that is, a potential truth. No doubt, if we speak of the human consciousness, subjective, particular, localized, the perception of that truth will only constitute, if you will, a formal truth. For the truth in itself, to be perceived by man, will only be an external denomination, as the names we give Him are to God, which can add nothing to His perfection. It by no means follows from this that consciousness does not form an integral part of truth. Only to an absolute truth there should be an absolute consciousness to correspond; the subjective element ought to be adequate to the objective. Hegel himself does not hesitate to define the idea, ' the identity of the subject and the object;' and he accuses the philosophy of Schelling of having too much sacrificed the subject to the object. But what can remain of the subject if knowledge, consciousness, be taken from it? The truth can, therefore, only cease to be formal, by being the adequate act of the intelligible and of intelligence, as Aristotle has defined it: it is the thought of the thought. For the rest, this is what Hegel himself expresses in this proposition, which is the conclusion of his Logic: 'The idea, as unity of the objective and subjective idea, is the notion of the idea that has no other object than the idea, or, what amounts to the same thing, which takes itself for its object. It is the idea that thinks itself.'11 Fenelon expresses the same thought more clearly when he says: ' It is thus evident that He [God] knows Himself, and that He knows Himself perfectly, — that is to say, that in seeing Himself, He equals by His intelligence His intelligibility; in a word, He comprehends Himself.'2

We perceive from this analysis that the Hegelian conception, properly understood, does not essentially differ from that which we propose. In fact, between an idea that thinks itself and an intelligence that thinks the truth, and makes but one with it, the difference would be difficult to grasp. We may indifferently, and according to the point of view selected, give prominence to the

rational and objective side of the idea, and we shall have the impersonal God; or give prominence to the subjective and conscious point of view, and we shall have the personal God. But these two points of view make but one; and in both systems intelligence, the Nous, will be at the origin of things. It is in this sense that the identity of being and thought may be admitted.

The absolute idea being thus at the same time absolute intelligence, how shall one conceive the ulterior development of other ideas? For it is this development that constitutes the world properly so called, or nature.

The question is this: Given the world as the external development of the absolute idea (whatever for the rest may be the cause of this externalization — to Hegel as to us an insoluble problem), the question is whether this development has its cause in the idea considered only in the objective and rational point of view, or in the idea considered in its totality, as the unity of subject and object. In the first case, the world will only be the impersonal development of the divine idea; there is nothing like intentionality, foresight, wisdom. The idea realizes itself by its intrinsic virtue; finality is only logical. But if the world is derived from the idea considered altogether (that is to say, subject-object), it may be affirmed quite as well that it is derived from the subject idea as from the object idea, — that is to say, from intelligence as from being, — and it will be free to us to say, as in the common philosophy, that intelligence has made the world. Therefore, finality is intentional, for intelligence, having made the world conformably to the idea which is itself, knowing the end, knows at the same time all the steps that conduct to the end; and this relation of subordinate knowledge to the final and total knowledge is what we call, in human language, foresight and intention—in a word, wisdom.

NOTE: Logic, § ooxxyt - Fenelon, Exist, de Dieu, 2me part. art. T.

Let us consider the matter on another side, so as to effect the complete transformation of the pure idea into creative activity.

It is, doubtless, with reason that Hegel has set forth the rational character of being, and advanced this proposition, that what is not rational is not real; but the rational as such, taken in the precision of its idea, is something inert, dead, immoveable, from which no action can proceed. Aristotle had made this objection to the ideas of Plato, but without reason; for Plato attributed a force to ideas, Sway us. He ascribed to them intelligence, life, and motion, and placed in Jupiter a royal soul. Without force, soul, or activity, the idea not only could not be developed, it could not even be. Existence is not a mere rationality, a simple concept. It is, as Herbart says,' an absolute position.' Being is because it is. It supposes itself. But this act of supposing itself is of another nature (taken strictly) than rationality. Granting that the idea supposes itself, and, in doing so, supposes the rest, still, in so far as it supposes itself, it is activity and not pure idea; and as we have seen that the idea itself is at once intelligence and truth, it is thus an intelligent activity. But an intelligent activity is nothing else than a will. The pure idea is thus a pure will, an absolute will.

What essentially constitutes finality, is that the relation of the parts to the whole is contingent; it is just this that is finality. If, in fact, it be admitted that matter, obeying necessary laws, ought by force to take the form of an organ fit for a certain function, the idea of finality must be sacrificed, and only blind necessity be admitted. But when we speak of an end, it is implied thereby that there is something that limits and circumscribes the mode of action of matter to determine it to a certain effect rather than another. This relation is, therefore, contingent, or, yet once more, there is no finality, which is no more in question. Meanwhile this relation of contingency remains always the same, whether as regards real matter or an ideal matter conceived d priori. Ideal matter is no more subject than real matter to a necessary law, determining it to become bird, mammifer, or man. It contains, no doubt, these forms potentially, for, in fact, it realizes them; but this bare power does

not suffice to produce these combinations, and to no purpose are they logically possible, — that is, do not imply a contradiction; they are impossible really because one of the elements of their possibility is precisely something that is not mere matter. Thus ideal matter, distinct or not from real matter, so far as it realizes relations of finality, has not its reason in itself. Ideally, as well as really, it only expresses a mere possibility, a subject of motions and indeterminate figures, but not of precise combinations or appropriated forms. In a word, no more can be said of the concept than of things; and if, in things themselves, the predetermination of the present by the future cannot have its cause or reason in the material substratum, in the Greek word ula of Aristotle, it is quite the same with the concept. The concept of matter does not contain more adaptation to an end than matter itself; in both cases the true cause must be beyond. If, then, there is a pure concept of the animal in itself, that concept cannot exist by itself. So far as it contains an ideal adaptation of matter to ends, it has in it something contingent, which car. only be explained by a will directed towards an end. It will be said that if the concept of matter does not oppose the formation of certain determinate bodies, — the elements, for instance, — it is not evident why it should be opposed to more complicated bodies. We will ask, in our turn, if even these first bodies are necessarily contained in the concept of matter, and if the idea of a substance which is only by hypothesis endued with motion can, strictly speaking, lead to the concept of anything determinate.

If, then, real matter does not guarantee us any order, the idea of matter does so no more; and inversely, if the idea of matter could give birth of itself to all other ideas, — that is to say, to all that presents an order, plan, form, or finality,—it is not evident why it should not be the same with real matter, and not merely with ideal matter. The pure idea is of no further use. But if, in fine, it is said that it is not the concept of matter that engenders determinate forms, but that it is the idea of nature altogether, the idea of the whole, which envelops and conditions all its parts,—the concept of matter being itself only the poorest and lowest of all, — I shall willingly admit this thought: but I still inquire, In virtue of what does the absolute idea accommodate the poorest and lowest concepts to the interests of the most elevated, when no relation of necessity exists between the one and the others? and what other way can there be of conceiving this accommodation, essentially contingent as we have seen it, if not by something which can only be called by the name of choice?

Will it still be said that necessity, no doubt, is not applicable to the concept of finality, as regards starting from the lowest notions to reach the highest, but, on the other hand, that it is the highest notions that necessarily engender their material conditions? that thus there may be at once finality and necessity, and, consequently, that it is useless to appeal to choice, foresight, intentionality? For example, as the notion of the circle implies the notion of radii and renders it necessary, as the concept of ten implies the concept of units, the latter the concept of fractions, and so on, so the concept of the animal would imply that of organs, the concept of the vertebrate that of a circulatory system. That a necessary and absolute synthesis would be established in an inverse direction to the impotent analysis of materialism, without the very slightest need to appeal to a previous consciousness of the synthesis, and above all a choice and will, as having co-ordinated all the rest. There is co-ordination, there is order: order is even the essence of things; but this order has nothing contingent, and is sufficiently explained as logical necessity and impersonal truth.

We reply that, whether the series be begun above or below, either the idea of finality must be renounced, or the idea of logical necessity. It is as impossible to comprehend that an end necessarily produces its conditions, as to comprehend that the conditions by inevitable destiny conduct to the end. To say that the function creates the organ, is not more intelligible than to say, the organ creates the function. That the idea of sight, for instance, is capable of commanding matter, of organizing it under the form of an eye; that the idea of life is capable of engendering organs of nutrition, is always absolutely unintelligible: it is to revert to the doctrine of occult qualities and of instinctive finality. In the concept, just as in reality, the end cannot be active of

itself; the end cannot be the same thing as what realizes the end. If it be said that glory made Alexander the conqueror of Asia, it is meant that the love and thought of glory—that is, the previous imagination of the result of his actions — determined Alexander. But it is with the logical concept as with the reality. In the concept of the eye, as well as in the real eye, sight has no necessary logical relation to matter, and, consequently, cannot predetermine it to become an eye.

Thus it is evident that the logical concept can no more explain finality than mechanism or instinct has done; or, at least, it only explains it if we change the logical into an intellectual concept,—that is to say, if we add to it the intelligence that changes the conditions into means, and for which the results are ends.

But we acknowledge that this whole deduction supposes that the Platonic exemplarism be renounced, which supposes beforehand all the concepts of things, including their finality, to be given in the divine intelligence a priori, which thereby removes them from the choice and action of God, and which destroys from the foundation the argument of final causes. According to this hypothesis there would be, in fact, in the divine intelligence, types eternal and absolute, like God Himself, in imitation of which He would have created the contingent and limited beings composing the universe. Every class of beings would have its model, its idea. The divine intelligence would contain from all eternity an ideal exemplar of the world; and not only of this actual world, but, according to Leibnitz, of all possible worlds, among which God would have chosen this as the best of all. Not only genera and species, but individuals themselves, would be eternally represented in God. Thus the world would exist under two forms: 1st, Under an ideal form in the divine nature; 2d, Under a concrete and real form outside of God.

Such a hypothesis evidently destroys all foresight and creative wisdom in the Supreme Being. For all things being represented beforehand, from all eternity, as they behoved to be, their finality thus equally exists in a necessary and eternal manner, without God intervening otherwise than to contemplate it. Let the divine idea, for instance, conceive the human body. In this idea are found represented all the relations that constitute the body, and, in particular, the relations of adaptation and of finality, without which there is no human body. Such an idea, being eternal, absolute, like God Himself, is not created by Him; it is not the product of His will nor of His power, for it is Himself. Must it not, therefore, be concluded that there may be relations of finality self-existing, before any foresight, and independent of any creation and of any personal combination? If foresight or choice is not in conception, no more is it in creation itself. In fact, when God wished to create the body, what had He to foresee and to combine, since all is foreseen and combined beforehand in His eternal thought, in the eternal model that rests in Him? He had nothing to do but to copy that eternal model, without having need of any particular act of thought to adapt means to ends. This adaptation is given in itself by the very nature of things, in the divine idea of a human body; and unless it be said there is no such idea, it is not evident in what creative labour consists; I can only see in it imitation pure and simple.

No doubt if we suppose, like Plato, matter existing apart from God, already having determinate properties, I would admit that there was room for combination, comparison, and foresight, to adapt the laws and properties of this matter to an ideal plan; but as such matter does not exist, and, consequently, opposes no obstacle to God, He has no difficulty to foresee nor to remove, no means to prepare; the world is given Him d priori, entire in all its parts, in its totality, in all its order. He has only a word to say, or to pronounce. In this I see great power, but no act of foresight.

Thus, on the hypothesis of exemplarism, or of Platonic paradigms, foresight would have no place in God. It would not be in the conception of the types, since they are eternally present to Him (aura Ko.& avra), holding of Him their essence, no doubt, but necessarily; it would not be in the execution of the work, since God would have nothing else to do than to execute what He had

conceived. It is said in the schools that God is the author ' of existences and not of essences.' But if it be so, as Gassendi said with reason to Descartes, ' What great thing, then, does God do when He produces existence? Certainly He does nothing more than a tailor, when he clothes a man with his apparel."

Reid makes similar objections to the theory of ideas, or eternal essences. ' This system only leaves the Creator, in the production of the universe, the sole merit of execution. The model had all the beauty and perfection that is admired 'n the copy, and the Deity had only to copy after a pattern that existed independent of him. . . . 2d, If the world of ideas, without being the work of a perfectly wise and good intelligent being, could have so much beauty and perfection, how can we infer from the order and beauty of this world, which is but an imperfect copy of the other, that it must have been made by a perfectly wise and good being? Either this argument is destroyed by the supposition of an ideal world that exists without cause, or else it applies to that ideal world itself.' 1

NOTE: Objections to the Fifth Meditation.

On the hypothesis of exemplarism, God would show in creating less invention and genius than the most commonplace of artists. The latter, in fact, as esthetic teaches us, has not only the merit of copying his model, but he creates one for himself, which he externally realizes. As to God, He would do nothing but slavishly copy the eternal model that He carries in Himself! Where would be omnipotence in an act so inferior? He creates, it is said, the material of things, and it is herein that His is superior to human art; but what is this matter compared with the form? Would he who should create marble be superior to him who creates the statue? Thus the dignity of the Creator appears to us much reduced, when no other honour is left to Him but to produce the substance of the world, while the world itself, in its harmonious and wise form, would be eternally represented d priori in His mind, without Him having in any way ordained it Himself and by a free volition.

Observe that on this hypothesis it is not merely the general essences that are thus represented in the divine understanding, but also individual essences. Not only man in himself, but Socrates in himself, Plato, Adam, and so on, are eternally represented there with their specific and individual characters; and the whole series of actions that each of them must accomplish, all the consequences, the whole chain of events, all is d priori in the divine mind. When God creates, He therefore does nothing but externally produce that ideal world — that photograph, by anticipation, of the real world. But is not this, as the opponents of optimism have so often objected, to subject God to fate,—to associate with Him, even as ideal, a world, or even worlds without end, with which He dwells, without having willed it?

NOTE: Essay s on the Intellectual Powers, vol. i. Essay iv. chap. ii. p 371.

If, then, we wish to maintain the theory of final causes, it is indispensable to push it farther, and to transfer it into the heart of the divine nature — to the very production of the divine types. Creation must be made to commence before the realized appearance of the world, its first lineaments must be discovered in the divine life itself.

We will admit, then, a sort of primary creation anterior to the creation of the world, and which we would willingly call the ideal creation. God, before creating the world, creates the idea of the world; He creates what Plato calls the ideal type that contains in it all the genera, species, and individuals of which the sensible or real world is composed.

But to say that God creates essences at the same time as existences, is this not saying with Descartes, that God is the author of the eternal verities, that He creates the true and the false,

good and evil? — a theory a hundred times refuted, and which in itself is indefensible; for, on the one hand, it makes of God a very tyrant, and, on the other, it puts in peril all certitude and all truth.

We must here establish a distinction between verities and essences. No doubt the truth — that is to say, the logical connection of ideas — cannot be the object of a free act of God, nor of any power in the world. No doubt, given a triangle, its three angles must necessarily be equal to two right angles. But is it necessary that a triangle be given? That is the question. A triangle is the synthesis of three lines arranged in a certain manner. But is this synthesis necessary, eternal, absolute, like God Himself? Must not there be a certain voluntary act to bring these three lines together, so as to intersect? Ah for man, it may be said that the idea of the triangle, and of geometrical figures in general, is inevitably imposed upon him, whether because he meets them in nature or because he sees them in the divine mind. But in God why should there be supposed of necessity a representation a priori of what does not yet exist? What contradiction is there in admitting that God, by a free act, produces the idea of the triangle, which being once given, carries with it all that is contained in its essence? God, on this hypothesis, does not create the truth, but He creates what, being once given, will be, for the mind that contemplates it, the occasion of discovering a crowd of truths. But these truths would not have existed if the idea that contains and envelops them had not been conceived.

It is the same with organic forms as with geometric. As soon as we suppose them given, there immediately follows a certain number of necessary truths, which would not exist if these forms were not given. For instance, given an animal, it is necessary for it to have means of nutrition and reproduction; and a certain mode of nutrition being given, certain organs are necessary. Cuvier has clearly proved that there was an anatomy a priori that could be constructed from this or that datum. But what does not seem necessary is that the idea of the animal should be given. Why should there be supposed an eternal animal, the absolute type of all existing animals? Would not that be an animal-God, if we may so speak? In order that this idea of the animal may exist, there must be an activity that makes the synthesis of all the elements of which the idea of the animal consists, and that distributes them conformably to a plan. No doubt it is not by chance and caprice that God creates such a combination, and even it has its laws. But I mean to say that if the creative activity did not exist, no more would such types exist. What I criticise is the conception of a God condemned to contemplate images of which the real examples nowhere exist. To my thinking, these models or essences must have their origin and causality in the divine power and will as well as existences.

To make this point of view more clearly understood, let us notice that in intelligence, as experience gives it to us, two things maybe distinguished, — contemplation and creation. There is contemplative intelligence and creative intelligence. When we learn a science, as geometry, algebra, etc., our intelligence does nothing but recognise and contemplate the presented truth, and it is still the same when we think of the truths we have once discovered. They are now for us only an object of contemplation. No doubt that is not a purely passive state of the mind, and Aristotle was right to consider contemplation as an activity. But is it the highest of activities? Is there not above it the creative activity, — that of the poet, the artist, the savant even? Here intelligence is not content to contemplate what exists; it produces itself what did not exist before. Moliere creates the type of the Misanthrope, Shakespeare that of Hamlet. Where had they seen those types? Nowhere, or at least nowhere entirely It is the poet himself that has given birth to these forms and types; he has combined their elements into a harmonious and living whole; so do the sculptor, painter, and architect. Where was St. Peter's at Rome before Michael-Angelo? He caused it to spring from his thought; and although the myth of Jupiter taking Minerva from his brain has been a thousand times mentioned, it becomes for us here more than a common metaphor — even the vivid and exact expression of the theory we maintain. In the genius of the savant it seems

that the two modes of intelligence unite; for, on the one hand, there is for him the contemplation of a truth he has not made, and, on the other, by his discovery, there is a creation of means by which he forces the truth to reveal itself; and the more creation there is, there is the more genius.

In pure contemplation, the intelligence derives nothing from its own self; it is only a mirror reflecting an object superior to it. And even if it be admitted, with Leibnitz, that pure knowledge is innate, or, with Plato, that the soul does nothing but remember, it is still the case that in knowledge acquired if there be spontaneous evolution, that evolution has nothing personal, nothing that the soul could consider as its individual work. It is not so in discovery, or in poetic and artistic production. In both these cases the soul not only has thoughts, it makes them. There is an internal elaboration and a fertilizing activity that can only be explained by the word creation.

So, too, the epithet ' creative genius' is well applied to those who have introduced new types, methods, or truths into the world.

The difference will now be understood that we make out between contemplation and creation; and who can deny that the second of these terms is superior to the other? This superiority is sufficiently attested by the different amount of pleasure procured by the two acts.

To enjoy a truth is evidently not so sweet as to enjoy the conquest of truth; to contemplate beautiful works of art cannot equal the pleasure of creating them; the pleasure of a virtue practised is nothing compared to the pleasure caused by a triumph over actual temptation; and, in general, productive activity is superior to mere contemplation.

When Aristotle considered contemplation as the highest of activities, he compared it to material activity that produces outside; but, in what he called contemplation, he did not pay attention to the difference we have mentioned. He did not observe that in pure intelligence there may still be two modes of activity — the one creative, the other purely contemplative, and, therefore, more passive. He only thought of the infinite pleasure that the discovery of truth procured him; and he did not perceive that even this discovery was not purely contemplative, but that there was on his part a display of inventive activity, and that it was in that very thing that his happiness consisted.

Those who have said that the search for truth is worth more than the possession of truth itself, have had a presentiment of the thought we express. But they deceived themselves nevertheless: it is not the search, but the discovery that is the supreme pleasure. For to seek without finding has never been a pleasure. No more is it when the artist is painfully seeking his theme that he is happy; it is when he has brought it forth. What is true is, that for the scientist discovery, and for the artist production, are the supreme happiness; but, the truth once found and the masterpiece achieved, they both pass on to other discoveries, to other thoughts.

It will now be understood what we call in God ideal creation. It is in Him an analogous act (save the difference of infinitude) to what we call the creative act in human genius.1

We therefore conceive two periods in the divine life, whether historically or logically distinct does not here much concern us. In the first period, God is in Himself collected, concentrated, gathered in Himself in His indivisible unity. This unity is not an empty and bare unity, whence all proceeds without one knowing why (for, being nothing in itself, it would have no reason to determine itself in one direction rather than another); it is an active and living unity; it is the absolute determination, the absolute concentration of being; it is the plenum.

God being thus conceived as the absolute unity, act, and consciousness, creation commences when God comes out of Himself, and thinks something else than Himself. But this very thing is creation.

There would thus be in some sort two creations,—the one concrete, historical, in time and space, composed of individualities that have their proper being, and are distinct from their Creator, at least in that superior state in which they become self-conscious; and another creation, which I call ideal, and which consists in the very invention of this world, which may be considered as conceived before being externally produced. If we call this world the word of God, the divine logos, we shall thus distinguish, with the Alexandrians and Philo, two kinds of word or logos — the internal and the manifested word. There will thus always be an ideal and a real world, a paradigm and a copy. But, properly speaking, these are purely logical distinctions, borrowed from the mode of action of the human intelligence, for which thinking and doing are two things. This duality is useless when applied to the creative activity. To invent and create are one and the same thing. The two creations thus blend into one. But then we know the meaning of the expressions, wisdom, art, science, applied to the works of creation. God is no longer a copyist, faithfully reproducing a fixed model; He is not a magician, who, by an act of will, evokes spirits pre-existing in a supra-mundane world. He is a true creator, who knows, who can, and who wills, all together; who wills at once the end and the means, — the end by an antecedent, the means by a consequent volition, — that is to say, in reality, by a unique and absolute volition, which we logically analyze to bring it down to our understanding.

NOTE: For the rest, Plato himself is not far from this thought (See Rep. lib. x., the idea of the bed): ' There are thus three species of beds—one which exists in itself and of which it may be said that God has made it, |»

Thus, as we said above,1 the type of creative activity is not mechanical industry, although it is from this datum that we set out to rise to the idea of divine art, and although there is even here a mode of action much superior to mechanical instinct. No more is it a calculating intelligence obliged laboriously to combine means to reach its end. It is creative genius, in which is contained the faculty of combining and foreseeing, while at the same time it is absorbed by a higher power; it is the point where intelligence is united to feeling and will in an indissoluble union. Such is the commentary, the most finished monogram that nature could offer us of divine wisdom; but let us not forget it is only a commentary. Our knowledge of the first cause, as all the great theologians have thought, is only analogical, and not ontological. God alone knows Himself as He. is; we can only know Him in relation to us.

NOTE: See Book ii. chap. ill.

It would, moreover, be to deceive ourselves, and wrongly to think that what is necessarily relative in our knowledge of God had been set aside, to seek to imagine something more than intelligence, by saying, for instance, that God is liberty, that He is love, etc. That would, in fact, be saying nothing more than what we say. No doubt, God is absolute liberty; but u liberty without intelligence is no liberty: it is caprice, or rather fate and chance. No doubt, God is love; but a love without light is no love, and may do more harm than good. Thus He is enlightened liberty and love; in a word, He is wisdom, as well as power and love. But it is, above all, as wisdom that He appears to us in creation, and thereby it is, above all, that our reason can find some way to Him. For although the world, by its immensity and infinity, proclaims an infinite power, such a power is not more the attribute of God than of His opposite. No doubt the world affords us proofs of goodness, or, at least, there are many good things in the universe; but there are also many bad things, and we know that a blind power might produce by chance both good and evil, as water is a benefit to him who is thirsty and a plague to him whom it inundates. But what a blind power cannot simulate are wise and industrious works, made with art. The apparent disorders that may be found mingled with these wise works prove nothing against them, for it is not here as with goodness. One may be good by chance; one cannot be wise by chance. We can understand that an apparent disorder is

accidentally met with in a work of wisdom, but not that a wise combination, and even a thousand million wise combinations, are accidentally shown in a blind production.

Some philosophers of these last times, who combine with extreme subtlety sentimental tendencies, have, above all, characterised the nature of God by love, and seem to have disdained wisdom as too vulgar an attribute. It seems it was 110 very great affair to know how to make a fly's wing; and, as proof of final causes, they will mention attraction, aspiration, tendency, love—rarely art, artifice, skill, knowledge. But attractions and tendencies may be reconciled with the idea of a blind and dissolute force, which casts away its surplus, and diffuses at once life and death. Such facts do not prove more in favour of Providence than its opposite. The art of nature, on the other hand, is a ' brilliant and prerogative' fact, as Bacon says, in presence of which all theories of fortuitous combinations and of blind instinct will always be shipwrecked. It is also a fact from which one cannot escape by indifference, by forgetting the problem, by a sort of design of not receiving. One may cease to ask whether the world is finite or infinite, if it has had a beginning or will have an end; for nothing obliges us to put these questions to ourselves. But one will never see a flower, a bird, or a human organism without experiencing a wonder that Spinoza rightly calls ' stupid,' for it amounts to stupefaction. Finality is in some sort the only idea that is necessarily implicated in experience. I can consult experience without thinking of the absolute; I can see things beside others without thinking of infinite space; I can neglect causality as an active power, and replace it by the relation of the antecedent to the consequent, or by the generalization of phenomena. But how can I see an eye without thinking that it is made in order to see, so far, at least, as I think as a man, and not as a systematic philosopher? The in order to, however, does not occur to the senses, is not a phenomenon of experience. It is an idea, only an idea; but an idea so bound to experience that it seems to make but one with it. What is vulgar in the idea of finality is precisely what constitutes its high metaphysical value. For the more that metaphysic connects itself with the common reason, the more chance has it of being a solid and necessary science. The more it rarities its conceptions, the more ground will it give for believing that they are only the artificial creations of an overwrought brain.

This is why we have specially given ourselves in this whole book to analyze and interpret the idea of combination, which at all times has been what most struck the vulgar. It is combination — that is to say, the rencounter of a very great number of heterogeneous elements in a single and determinate effect — that is the decisive reason of finality. The agreement and proportion existing between such a rencounter and such an effect would be a mere coincidence (that is, an effect without a cause) if the effect to be reached were not itself the cause of the combination. Mechanism, in explaining the production of each effect by its own cause, does not explain the production of an effect by the rencounter and agreement of causes. It is thus condemned, whatever effort it may make to dissemble such nonsense, to explain the universe by the fortuitous, — that is, by chance. Fortunate rencounters, favourable circumstances, unforeseen coincidences must be multiplied without end, and continually increase in number, as the universe passes from one degree to another, from one order of phenomena to another. Is it sought to explain this faculty of combination which nature possesses, and which is like that of the industrious animals and the innate art of insects, by an analogous cause, — that is to say, by a sort of instinct, — nature proceeding to its end, like the animal itself, without knowing and without willing it, by an innate tendency? In admitting such a hypothesis, we should do nothing but state the very fact of combination, while assigning to it some unknown cause, called instinct, by analogy, but which would tell nothing more than the fact to be explained — namely, that nature goes towards ends. The only way in which we could conceive an end is to view it as a predetermined effect. But how can an effect be predetermined except so far as it is designed beforehand, and preconceived in the efficient cause called to produce it? And can this preconception or predestination be for us anything but the idea of the effect? And, in fine, what can an idea be but an intellectual act, present to a mind in a consciousness?

Take away consciousness from an intellectual act, and what will remain but an empty dead concept, a potential concept? Take away this concept itself from the efficient cause, and what will remain but an indeterminate tendency, which nothing will lead towards one effect rather than another? Take away even this tendency, and what will remain? Nothing — at least, nothing that can serve to connect the present with the future; nothing that can explain the rencounter of causes with the effect. This rencounter being the problem to be solved, the knot to untie, even the hypothesis of tendency establishes a certain intermediary between cause and effect; the hypothesis of the concept adds to it a new intermediary; the conscious concept, such is the third degree, such is the true link of cause and effect. There the range of our vision stops; beyond begins the region of the Unknowable, which the Gnostics admirably called the Abyss and Silence. We too keenly feel the limits of our reason to. make our own conceptions the measure of the Absolute Being; but we have too much confidence in His veracity and goodness not to believe that human conceptions have a legitimate and necessary relation to things as they are in themselves. If, then, we have been able suitably to use our reason, if we have obeyed as strictly as possible the severe rules of the philosophic method, we are entitled to believe that the highest hypothesis that the human mind can form regarding the supreme cause of the universe would not be contradicted, but rather would be confirmed and cleared of its obscurities, if it were given to us, as the theologians say, to see God face to face by a direct and immediate vision. Such a hypothesis may well be but an approximation to the truth, and a human representation of the divine nature; but although inadequate to its object, it does not follow that it is unfaithful to it. It is its projection into a finite consciousness, its translation into the language of men, which is all that philosophy can demand.

Chapter V - The Supreme End Of Nature

The doctrine of final causes cannot escape, as it would seem, a final problem. If each of the things of the universe, taken separately, has been produced for another, for what, to what end, have they, taken altogether, been made? Unity of cause supposes unity of end. If a single cause has made all, it must have made all for a single end; and as the cause is absolute, the end must be absolute. In fine, as there are not two absolutes, the cause and the end must be identical, and, consequently, God must have made the world for Himself.

Here the difficulties commence. If God has made the world for Himself, it is evidently to enjoy it, to find His satisfaction and happiness in it, or else to glorify Himself. The common theological doctrine also is that God has made the world for His glory. But if it be so, whatever be the profit that God derives from the world —glory, disinterested joy, esthetic satisfaction—it matters little: in any case, He was without that joy before He created the world. He created it to procure it. Thus He was deprived of something before the creation, and therefore He was not perfect. For the perfect, as Bossuet says, 'is the being to whom nothing is awanting.' To suppose that God created the world for Himself, is thus to attribute to Him lack and privation. ' This doctrine,' says Spinoza,' destroys the perfection of God, for if God acts for an end, He necessarily desires something of which He is deprived. And although theologians and metaphysicians distinguish between an end pursued by indigence and an end by assimilation, they yet avow that God has made all for Himself, and not for the things He was to create, seeing that it was impossible before creation to assign any other end for the action of God than God Himself; and in this way they are forced to admit that all the objects that God proposed to Himself, while arranging certain means to attain them, God had been at one time without, and had desired to possess them.'

Another solution, which is not opposed to the preceding, and which is subordinate to it, is that God has created the world for man, and man Himself to honour and serve Him. But we have already said how narrow such a doctrine is, that only sees man in the world, and refers everything to him. This anthropocentric doctrine, as it has been called, appears to be connected with the geocentric

doctrine, that made the earth the centre of the world, and ought to disappear with it. The greatest philosophers of the 17th century, Descartes and Leibnitz, have expressly disavowed it: ' For,' says Descartes, ' even if it be a pious and good thought, as regards morals, to believe that God made all things for us, yet it is not at nil probable that all things have been made for us in such a way that God had no other end in creating them, ... for we cannot doubt that there is an infinity of things that are now in the world, or that have formerly been and have now entirely ceased to be, without any man having ever seen or known them, and that have never served him for any purpose.'

If, then, the end of the universe can neither be God nor man (nor d fortiori the creatures inferior to man), it seems to follow that we can conceive no end for the universe, which appears to invalidate the whole doctrine of final causes.

No doubt, it is always allowable to a philosopher, as Descartes here does, to suspend his judgment, and to pause in ignorance: this is a natural right in philosophy. We by no means admit that we should be told: Since you are ignorant of such a thing, it follows that you know nothing. Thus, even if the first causes were unknown, it would not follow that there are no second causes; and even though the last ends should escape us, we would not therefore be obliged to remain ignorant of the existence of secondary ends. In fine, as we rise from second causes to the first cause, without knowing how they communicate with it, it is the same with the relation of secondary ends to the last ends. But, indeed, the argument ad ignorantiam ought only to be employed in the last extremity.

Another hypothesis has recently been proposed to explain the wherefore of creation. ' It would seem,' says an eminent philosopher, ' that one cannot comprehend the origin of an existence inferior to the absolute existence, except as the result of a voluntary determination, whereby that high existence has spontaneously moderated, mortified, extinguished, so to say, something of its omnipotent activity. God has made all out of nothing, of that relative nothingness that is the possible, for He was first the author of this nothingness, as He was of being. From that which He annulled in some sort and annihilated of the infinite plenitude of His being (ae ipsum exinanivif), He has derived by a sort of awakening and resurrection all that exists.'1

This doctrine, as we see, instead of explaining creation by a want, a desire, or an imperfection of the Creator, would explain it, on the contrary, by a superabundance, an excess, a sort of plenitude, God having annihilated a part of Himself to make the world of it. Such a hypothesis does not appear much more admissible than the inverse doctrine. We are not less unfaithful to the notion of a perfect being in attributing to it superfluity, a sort of plethora of being, of which it should abandon a part as the gravid female casts its young, than in representing it as a germ that develops and grows. We admit that the supreme name of God is ' grace, gift, liberality;' but never has it been said that the Christian God ' creates the creature from His own being:' that is an essentially Oriental and non-Christian notion. The Christian nihilum is a true nihilum, and not a part of the divine substance annihilated.1 It is, as it would seem, profoundly to alter the Christian dogma to maintain that the world was made of something, even were that something a part of the divine substance. We cannot better reply to this hypothesis than by opposing the author to himself: 'God does not pass entirely into things,' says he elsewhere, in summing up the doctrine of Philo; ' nor does He give them, properly speaking, a part of Himself. He gives, He communicates, Himself, and yet He remains in Himself in His pristine integrity. Nothing comes from God by separation, but by a sort of extension that takes nothing from Him. Our soul is something that comes from the divine soul, and is not a section of tY.'2 In this interpretation, much nearer the truth, the world is not born of the superfluity of God, of a part of Himself which He had annihilated. Only the word extension is still saying too much — it gives too much room for the doctrine of emanation; and God is no more augmented than diminished by creation. Creation can thus be considered as a gratuitous gift, without one being obliged to have recourse to the desperate hypothesis of a God who annuls

Himself in creating. This metaphysical hypothesis adds nothing in point of probability and clearness to the only doctrine that can explain creation — the doctrine of divine love.

NOTE: Bayaisson, I'kil. du 19me slide, p. 262.

We are thus brought back to the previous dilemma. Either the supreme cause acts for an end adequate to itself, — that is to say, absolute, and that end can only be itself, but in that case it wants something to be entirely what it ought to be, and thus it is not perfect, it is not God,—or else the supreme cause acts for an end that is not itself, — for example, the welfare of created beings, — and then the end is not adequate to the cause. The absolute being acts for a relative end; the infinite being for a finite end. We cannot seemingly escape from this alternative.

NOTE: M. Ravaisson here confounds and involves In his explanation two distinct dogmas — incarnation and creation. Creation already seems an incarnation. This is to transform Christianity into Brahminism or Gnosticism, as M. A. Franck has justly remarked.

NOTE: Ravaisson, Estai tur la Mttafh. d'Aristote, t. ii. p. 306.

The difficulty raised by Spinoza would go much farther than he imagines. It is only a particular case of the general question of the relations of the finite to the infinite. In whatever manner this relation is conceived, it may still be said that, if the infinite did not remain eternally alone, it is because it needed the finite to exist. Thus, whether it be held that God produced the world by a necessary emanation, or that He created it freely, the objection still remains the same. Why did He create it? Why did He not remain wrapped up in Himself? The insoluble problem is this: Why is there anything but God?1 And to solve that problem one would need to be God. But since the world exists, it cannot be in contradiction to the divine nature. To say that this existence of the world has an end, and that that end is God, is not an additional difficulty.

The whole difficulty is to know how God can love anything but Himself; but it is the same difficulty as to know how God can think anything but Himself. That other thing can, according to us, coexist with God without either increasing or diminishing Him, without being added to Him or subtracted from Him, because it is not of a common measure with Him. No doubt this being has its root in Him, but eminenter, as the Schoolmen say, in this sense, that, in the idea of the absolute and the infinite, there is contained d priori the possibility of an infinite multiplication of being, without any change in the divine substance. This coexistence once admitted (and it is admitted by all philosophers who admit at once God and the world), the wherefore of creation can only be sought in the motive of good. It is by goodness that Plato, as well as Christianity, explains the production of things.

If it be held absolutely that God can have no other end than Himself, creation is inexplicable; for, as already possessing Himself, why should He still seek Himself hi a roundabout way? If it were Himself He sought through the world, a want and desire would then be legitimately ascribed to Him.

NOTE: See Saisset, I'kilos. Kelig. Part ii. 3d Meditation.

To solve this problem, Malebranche had uttered this singular and profound thought, that the end of creation was the incarnation of Jesus Christ. It was in prevision of the incarnation that the world had been made. The incarnation, in place of being a miracle, on this hypothesis, was reason itself, the ultimate law of the universe. ' God,' he says, ' finds in the incarnation of the Word a motive, not invincible, but sufficient to take the part of creator, a part little worthy of Him without this denouement which He finds in His wisdom to satisfy His goodness.' 1 This extraordinary doctrine

only escapes the philosophical difficulty to compromise theology. If the incarnation only took place for the glory of God, where is the merit of the Redeemer? What would become of the love and gratitude that are due to Him? But if we separate from this hypothesis all that relates to positive Christian dogma, there remains then the Brahminical doctrine of incarnation, — that is to say, pure pantheism. We have no longer to ask why God created the world, since the world is Himself.

Malebranche admirably says that the world is a ' profane' work, and that to be worthy of God it must become a ' divine" work. But to be divine must it contain God in substance? and is it not enough that it contain Him by participation, KounavLa? All that proceeds from God is divine, from that very fact, and so much the more as it contains more divine expression. That the creation be worthy of God, it is enough that the act itself be divine; it is not necessary that the terminus of the act be so.

The word end may signify two things: either the motive of the creative act, or the terminus of that act. God may act divinely even if the terminus of His action be not Himself. If it be held that God can only act for Himself, it must be held still further that He can only love Himself and will Himself; hence creation is impossible, and yet it exists. If creation be admitted, or the coexistence of God and the world, it must be allowed that God might pass beyond Himself; consequently, that the terminus of His action might be another than Himself. For the act to be divine, it is enough that the motive be so. Whether that motive be derived from His power, His wisdom, or His goodness, or from all the three attributes together, or even though that motive cannot be represented to the human understanding, it is enough that we conceive the possibility of it to prevent the act from losing its divine character, even if its terminus should remain profane. If God, as absolute perfection, cannot have created the world for an egoistic end (for then the simplest way would be not to create at all),—if, on the other hand, He cannot be supposed to have created by chance and sport'—it follows that He can only have made the world in the interest of created beings,—that is to say, by goodness. Such is, at least, the only way in which the human mind can conceive the reason of creation; such is, translated into human language, the only hypothesis that allows us to conceive the relation of the infinite and the finite, the imperfect and the perfect, the creator and the creature.

NOTE: Entretient Metaphys. Ix. 1. See Philosophie de Malebranche, by O1U Laprune, tome i. chap. vii. p. 389.

But evil? — Evil could only have been to the divine goodness a reason for not creating, if it behoved in the nature of things to outweigh the good in quantity; for that there should be some evil in the creation may very well be an inevitable consequence of creation itself, as the Stoics, the Alexandrians, and Leibnitz have proved. Atheists explain evil by saying that it is an inevitable consequence of natural laws. This explanation is precisely the justification of Providence. If, in effect, evil is a consequence of the laws of nature, either there must have been no nature, or evil behoved to coexist with nature. Let us suppose, for instance, that pain is a necessary consequence of feeling; either there must have been no sentient beings, or it was necessary that they should suffer. The whole question, then, comes to be, whether it was better that there should be a nature, or that there should be none; that there should be sentient beings, or that there should be none. If death is the consequence of life, God could only prevent death by suppressing life. God is then impotent, you will say. This difficulty has been sufficiently answered. All creation implies condition and limitation, and consequently defect, which is translated into suffering in the region of feeling, and into sin in the region of the will.

The only question, then, is whether the amount of evil outweighs the amount of good in the universe. Only in this latter case would Providence be without excuse. But we believe that experience and reason sufficiently attest that good, not evil, most prevails, not only in the universe

in general, but in human life in particular. Leibnitz wittily said: ' There are more houses than hospitals;' and one of his disciples, carrying his thought farther, added: ' There are more cooks than doctors.' It is difficult, for the rest, to decide such a question, if we limit ourselves to appealing to the facts and the humour of each one; the decision will too much depend on imagination and feeling. An ardent and sombre imagination will take all for evil; a sweet and amiable imagination will regard all as good. There must be other principles in order to decide. But if we ascend to principles, I think the word evil can have only one precise sense in philosophy, — namely, a principle of destruction, — while good, on the other hand, is a principle of conservation. Apart from this there is nothing but arbitrariness and fantasy. These definitions being stated, what manifestly proves that good outweighs evil is the fact that the world exists. Wherever the principle of destruction prevails over the contrary principle, nothing continues, and nothing can even be formed. A people devoted to anarchy necessarily dissolves, or is absorbed by others more powerful. But it is a certain fact that the world continues, and has done so long enough to assure us that it is not by accident. This is a sufficient proof that in the universe, taken as a whole, order prevails over disorder. Nay, more, not only does the world endure, but science teaches us that it has always gone from the simple to the complex, from the less to the more perfect. But the more complex a mechanism, the more difficult is it to preserve. Therefore the conservative force of the universe must always go on increasing; or rather, the principle of good that is in the universe must not only be conservative, but organizing, creative, promotive. There must be enough of good to overflow in new creations, and in creations more and more complicated.

Now these principles may be applied, not only to the abstract good of the universe in general, but also to felt good — to the good of sentient and conscious beings in particular. In effect, what is true of good and evil in themselves, is true of pleasure and pain. Pleasure must be a principle of conservation, and pain a principle of destruction; and from the simple fact that humanity lasts, pain must be infinitely less diffused than pleasure. Schopenhauer, the pessimist philosopher par excellence, thinks he can philosophically demonstrate the predominance of pain over pleasure; and he reasons thus: ' All life is summed up in effort, and effort is always painful; therefore life is pain.' This argument may be retorted thus. 1 Life is active; but action is always accompanied by pleasure; therefore life is pleasure.' And this latter argument seems to me much more solid than the former. It is by no means true that effort is always painful. On the contrary, it only is so exceptionally, and when it surpasses our strength; otherwise, a certain degree of effort is a pleasure, and without effort there is no pleasure. The effort that must be made to climb a mountain, the effort of a hunter in the pursuit of game, or of a thinker in the investigation of a problem, involves more pleasure than pain; and the pain is only a seasoning to the pleasure. But life in general, in a state of health, only demands a moderate effort, and that effort is just what is needed to feel that we live. Evil, therefore, does not come from effort, but from the conflict between external forces and our own. But now no one can prove that the external forces are necessarily victors in this conflict; rather the contrary is evident, otherwise the human race would not survive.

Leibnitz seems to believe that there is danger in maintaining that the welfare of the creatures is the only end that God proposed to Himself in creating the world; 'for then,' he says, ' no sin nor misfortune would happen, not even by concomitance. God would have chosen a succession of possibilities, whence all these evils would be excluded.' But in speaking of the good of created beings, we can mean nothing but ' the greatest good possible, which leaves intact all the explanations of Leibnitz. With this reservation, we maintain that the terminus of the divine action can only be the creature, and not the Creator; otherwise He would not have come forth from Himself, since by hypothesis He is absolute and perfect, and wants nothing.

Is that to say, however, that it is in the feeling of sentient and living beings that we shall find that end without which the universe would not deserve to exist? No doubt the happiness of created beings, living and sentient, is, and ought to be, one of the ends of creation. But is it its last end? Is

there in happiness (if it be identified with the good of the senses) a value so great, that God should have decided to create, merely on behalf of our fragile and transient enjoyments? Because God's end in creating was not the absolute itself, does it follow that He could act for an end containing nothing of the absolute? Can we attribute to the Almighty a merely human goodness, that only should propose to give pleasures like a mother to spoilt children? Must not His love understand our good in a higher way than we ourselves would do if we were consulted? But if there are creatures that have only feeling as their lot, enjoyment is for them the last end. But they themselves are only relative ends to the Creator; and as to the creatures in whom feeling is united to reason, the ends of the former must be subordinated to those of the latter.

Is it, then, intelligence (whether in man or in any other thinking creature) that is the end of nature? Does nature exist, as the Hindus have said, to be contemplated by man or by some reasoning being? 'But,' as Kant profoundly says, ' it is not man's faculty of knowing, the theoretic reason, that gives a value to all that exists, — that is to say, man does not exist that there may be one to contemplate the world. In effect, if that contemplation only shows us things without an end, the mere fact of being known can give no value to the world; and we must already suppose a final end for it, which itself furnishes an end for the contemplation of the world.'1 Thus, to be contemplated, to be known, is only one of the ends of the existence of the world, and there must be still another for the latter to have any value. Knowledge is, therefore, not the absolute end of the universe.

For these reasons Kant arrives at the conclusion that the supreme end of the universe, being neither in feeling nor in the contemplative intelligence, can only be in morality. 'The most vulgar minds,' says he, 'agree in replying that man can only be the final end of the creation as a moral being. What purpose does it serve, they will ask, that this man has so much talent and activity, that relatively to his interests, as well as to those of others, he has so much value, if he is without a good will, if, as regards his inner man, he is only an object of contempt?' In considering not only man, but every moral being in general, as the end of creation, ' we have a reason for being warranted to regard the world as a system of final causes.' The world has as its end to become the theatre, the instrument, and the object of morality. In order to be appropriated to that end, it must already be susceptible of finality; the lower degrees must be the steps whereby nature rises to its last terminus. There must be a succession of relative ends, to render possible this absolute end.

Critique of the Judgment, § lxxxv.

In effect, morality alone deserves the name of absolute end; and hereby the antinomy mentioned above finds its solution. God can only come forth from Himself for an absolute end; and, on the other hand, if He pursue this absolute end, it seems He can find no other than Himself, and, consequently, that He need not come forth from Himself. But it is one thing to say, God, in creating, had only Himself as end; and another thing to say, God had for end a nature, whose end should be Himself. The terminus of the divine action is nature; the terminus of nature is God. If you suppress the first of these propositions, nature would have no worth by itself: why, then, should God have created it? Why not remain at rest? If, on the other hand, the second be suppressed, nature would no longer have any final, absolute end; and why, again, should God have created it? But His action proceeds from Him, inasmuch as He creates a nature, and it is just this nature, as created nature, that is His object; and it returns to Him, in that this nature, not being self-sufficient, only finds its signification, its reason of being, and its end in the absolute.

But how does nature assume an absolute signification? Is it by self-annihilation in the absolute? No; for then it would have been much simpler not to create it. Is it in being absorbed in it, losing itself in it, and forgetting itself? No; these are so many forms of annihilation. If God created nature, it was that it should be, not that it should not be — to live, not to die. The end of nature is,

therefore, to realize in itself the absolute as far as possible, or, if you will, it is to render possible the realization of the absolute in the world. This is brought to pass by morality.

Meanwhile, let us not forget that if there are no ends in the universe, there are none for man any more than for nature; that there is no reason why the series of causes should be mechanical up to the appearance of man, and be some teleological from man onwards. If mechanism reigns in nature, it reigns everywhere, and in ethics as well as in physics. No doubt, there might still be subjective and contingent ends, pleasure or utility; but not unconditional and absolute, not truly moral ends. Morality is, therefore, at once the accomplishment and the ultimate proof of the law of finality.

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B. H. Roberts
What Is Man?
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The hymn to which we have just listened ("O my Father, Thou that dwellest,") produces, it seems to me, one of the most holy influences that can surround the Saints of God; and that, doubtless, for the reason that it touches one of the most holy themes connected with the Gospel of the Lord Jesus Christ; and it has suggested to me this afternoon a theme in connection with the Gospel that I believe to be one of the most instructive and inspiring that the mind of man can contemplate. If, therefore, I can obtain through your faith and the goodness of our Father in Heaven, His Spirit, I will speak upon it, and as an aid to its introduction will read to you one of the Psalms of David-the 8th:

O Lord our Lord, how excellent is thy name in all the earth! who hast set thy glory above the heavens.
Out of the mouth of babes and sucklings has thou ordained strength because of thine enemies, that thou mightest still the enemy and the avenger.

When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained;
What is man, that thou art mindful of him? and the son of man that thou visitest him?

For thou hast made him a little lower than the angels, and hast crowned him with glory and honor.
Thou madest him to have dominion over the works of thy hands; thou has put all things under his feet:
All sheep and oxen, yea and the beasts of the field;

The fowl of the air, and the fish of the sea, and whatsoever passeth through the paths of the seas.
O Lord our Lord, how excellent is thy name in all the earth!

David, doubtless, as was his habit, judging from many expressions in his writings, had been contemplating the heavens, the vastness of them, and the greatness of God's power as witnessed therein; for he says in another place, "The heavens declare the glory of God; and the firmament sheweth His handiwork. Day unto day uttereth speech, and night unto night showeth knowledge. There is no speech nor language, where their voice is not heard. Their line is gone out through all the earth, and their words to the end of the world."

Turning from a contemplation of the great works of the Creator, and looking upon man in his insignificance, very naturally he gave expression to the thought contained in this psalm-"What is man, that thou art mindful of him? and the son of man that thou visitest him?" But notwithstanding there seemed to be in the mind of the poet the idea of the insignificance of man, yet he was careful to observe that God had exalted him above the rest of His creatures that live upon the earth. He took note that the beasts of the field, all sheep and oxen, the birds of the air, and the fish of the sea, were all placed under the dominion of man.

Indeed, if you follow the thoughts of the Prophet David upon this subject, you will discover that in his mind this superiority in man and his dominion over the other creations of God argued for him some special relationship to Deity. True, there are some animals which in particular things seem superior to man; that is, there are some swifter of foot than he, others of keener sight; still others of more sensitive smell; but in none is there that combination which stamps man with superiority. Which of the animals has he not subdued and made subservient to his will? Some yield their strength, some their speed to serve him, and all pay him homage by submitting to his dominion.

Nor has man been content with subduing the animal creation alone. He is fast obtaining a mastery over the elements of nature. The winds and ocean currents have long been his servants. The element of fire adds to his comfort and aids him in his labors in a hundred ways. He has made the lightning bear his messages. He annihilates distance. He weighs the sun, the moon, and the stars in his balances, and tells us the materials of which they are composed, however great their distances.

All this argues for man a superiority over other earth-creatures; and this superiority, coupled with special favors conferred upon man by Deity, proclaims some special relationship between him and God. Man naturally desires to discover that relationship and has often asked, What is man that God is mindful of him? Of his wisdom, however, this is a task that man cannot perform; a problem that he cannot solve. If you doubt what I say, then I pray you take the results of philosophical investigation on the subject, set revelation aside and what have philosophers to offer as a solution of the problem of life?

One of the greatest geniuses that has arisen among men describes life as "a walking shadow; a poor player that struts and frets his hour upon the stage, and then is heard no more. It is a tale told by an idiot, full of sound and fury, signifying nothing." One of our great modern skeptics, Col. Ingersoll, said- "Life is a narrow vale between the cold and barren peaks of two eternities. We strive in vain to look beyond the heights, we cry aloud, and the only answer is the echo of our wailing cry. From the voiceless lips of the unreplying dead there comes no word."

1897
B. H. Robert
The Heavens Declare The Glory Of God; And The Firmament Showeth His Handiwork. Improvement Era Article; Brian H. Stuy, ed., Collected Discourses, 5 vols., 5:

And yet another line of evidence, which unites with these already pointed out to you. David, in one of his glorious outbursts of inspiration said:

The heavens declare the glory of God; and the firmament showeth His handiwork.
Day unto day uttereth speech, and night unto night showeth knowledge.
There is no speech nor language, where their voice is not heard.
Their line is gone out through all the earth, and their words to the end of the world.

The testimony of Moses, of Isaiah, Ezekiel and Jeremiah may be locked up for many generations in the Hebrew language, and may not for a long time become universal testimony for men; the testimony of the Nephite Prophets may be locked up in the mystery of the Reformed Egyptian language used by them; the testimony of Prophets today may for a season be limited to those nations who are visited by them and who can understand their speech; but God, all over the broad heavens, hath written the evidences of His existence; and, as Paul puts it: "The invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power and God-head, so that they [unrighteous men who deny God's existence] are without excuse." And when you turn away from the dome of heaven inlaid with suns and planetary systems, and with the microscope search out the secrets locked up in the world of atoms, you again meet evidences of the existence of God; and also see proofs of His wisdom, power and glory.

1899
Improvement Era Article

1899
James E. Talmage, Quorum of the Twelve Apostles
The Existence of God
Articles of Faith Book

The Existence of God-Since faith in God constitutes the foundation of religious belief and practise, and as a knowledge of the attributes and character of Deity is essential to an intelligent exercise of faith in Him, this subject claims first place in our study of the doctrines of the Church.

The existence of God is scarcely a question for rational dispute; nor does it call for proof by the feeble demonstrations of man's logic, for the fact is admitted by the human family practically without question, and the consciousness of subjection to a supreme power is an inborn attribute of mankind. The early scriptures are not devoted to a primary demonstration of God's existence, nor to attacks on the sophistries of atheism; and from this fact we may infer that the errors of doubt developed in some later period. The universal assent of mankind to the existence of God is at least strongly corroborative. There is a filial passion within human nature that flames toward heaven. Every nation, every tribe, every individual, yearns for some object of reverence. It is natural for man to worship; his soul is unsatisfied until he finds a deity. When men through transgression fell into darkness concerning the true and living God, they established for themselves other deities, and so arose the abominations of idolatry. And yet, even the most revolting of these practises testify to the existence of a God by demonstrating man's hereditary passion for worship.

2. Human Reason, operating upon observations of nature, strongly declares the existence of God. The mind, already imbued with the historical truths of the divine existence and its close relationship with man, will find confirmatory evidence in nature on every side; and even to him who rejects the testimony of the past, and assumes to set up his own judgment as superior to the common belief of ages, the multifarious evidences of design in nature appeal. The observer is impressed by the manifest order and system in creation; he notes the regular succession of day and night providing alternate periods of work and rest for man, animals, and plants; the sequence of the seasons, each with its longer periods of activity and recuperation; the mutual dependence of animals and plants; the circulation of water from sea to cloud, from cloud to earth again, with beneficent effect. As man proceeds to the closer examination of things he finds that by study and scientific investigation these proofs are multiplied many fold. He may learn of the laws by which the earth and its associated worlds are governed in their orbits; by which satellites are held subordinate to planets, and planets to suns; he may behold the marvels of vegetable and animal

anatomy, and the surpassing mechanism of his own body; and with such appeals to his reason increasing at every step, his wonder as to who ordained all this gives place to adoration for the Creator whose presence and power are thus so forcefully proclaimed; and the observer becomes a worshiper.

Everywhere in nature is the evidence of cause and effect; on every side is the demonstration of means adapted to end. But such adaptations, says a thoughtful writer, "indicate contrivance for a given purpose, and contrivance is the evidence of intelligence, and intelligence is the attribute of mind, and the intelligent mind that built the stupendous universe is God." To admit the existence of a designer in the evidence of design, to say there must be a contriver in a world of intelligent contrivance, to believe in an adapter when man's life is directly dependent upon the most perfect adaptations conceivable, is but to accept self-evident truths. The burden of proof as to the non-existence of God rests upon him who questions the solemn truth that God lives. "Every house is builded by some man; but he that built all things is God." Plain as is the truth so expressed, there are among men a few who profess to doubt the evidence of reason and to deny the author of their own being. Strange, is it not, that here and there one, who finds in the contrivance exhibited by the ant in building her house, in the architecture of the honey-comb, and in the myriad instances of orderly instinct among the least of living things, a proof of intelligence from which man may learn and be wise, will yet question the operation of intelligence in the creation of worlds and in the constitution of the universe?

Man's consciousness tells him of his own existence; his observation proves the existence of others of his kind and of uncounted orders of organized beings. From this we conclude that something must have existed always, for had there been a time of no existence, a period of nothingness, existence could never have begun, for from nothing, nothing can be derived. The eternal existence of something, then, is a fact beyond dispute; and the question requiring answer is, what is that eternal something-that existence which is without beginning and without end? Matter and energy are eternal realities; but matter of itself is neither vital nor active, nor is force of itself intelligent; yet vitality and activity are characteristic of living things, and the effects of intelligence are universally present. Nature is not God; and to mistake the one for the other is to call the edifice the architect, the fabric the designer, the marble the sculptor, and the thing the power that made it. The system of nature is the manifestation of an order that argues a directing intelligence; and that intelligence is of an eternal character, coeval with existence itself. Nature herself is a declaration of a superior Being, whose will and purpose she exhibits in her varied aspects. Beyond and above nature stands nature's God.

While existence is eternal, and therefore to being there never was a beginning, never shall be an end, in a relative sense each stage of organization must have had a beginning, and to every phase of existence as manifested in each of the countless orders of created things, there was a first, as there will be a last; though every ending or consummation in nature is but another beginning. Thus, man's ingenuity has invented theories to illustrate, if not to explain, a possible sequence of events by which the earth has been brought from a state of chaos to its present habitable condition; but by these hypotheses this globe was once a barren sphere, on which none of the innumerable forms of life that now tenant it could have existed. The theorist therefore must admit a beginning to life on the earth, and such a beginning is explicable only on the assumption of some creative act, spontaneous generation, or a contribution from outside the earth. If he admit the introduction of life upon the earth from some other and older sphere, he does but extend the limits of his inquiry as to the beginning of life; for to explain the origin of a rose-bush in our own garden by saying that it was transplanted as an offshoot from a rose-tree growing elsewhere, is no answer to the question concerning the origin of roses. Science of necessity assumes a beginning to vital phenomena on this planet, and admits a finite duration of the earth in its current course of progressive change; and as with the earth so with the heavenly bodies in general. The eternity of existence, then, is no more

positive as an indication of an eternal Ruler than is the endless sequence of change, each stage of which has both beginning and end. The origination of created things, the beginning of an organized universe, is utterly inexplicable on any assumption of spontaneous change in matter, or of fortuitous and accidental operation of its properties.

Human reason, so liable to err in dealing with subjects of lesser import, may not of itself lead its possessor to a convincing knowledge of God; yet its exercise will aid him in his search, strengthening and confirming his inherited instinct toward his Maker. "The fool hath said in his heart, There is no God." In this passage as in scriptural usage elsewhere, the fool is a wicked man, one who has forfeited his wisdom by wrongdoing, bringing darkness over his mind in place of light, and ignorance instead of knowledge. By such a course, the mind becomes depraved and incapable of appreciating the finer arguments in nature. A wilful sinner grows deaf to the voice of both intuition and reason in holy things, and loses the privilege of communing with his Creator, thus forfeiting the strongest means of attaining a personal knowledge of God.

1900
A. Wootton.
Revelation By Works and Word
Improvement Era Article

"I don't believe in revelation," is an expression common enough in this age of boasted enlightenment and achievement, but it is difficult to conceive of any human knowledge that is not the result of revelation, either second-hand or direct from Deity. The learning of the schools is mostly second-hand knowledge, much of it having passed through many hands and consequently become much diluted by mere opinion.

The knowledge that is obtained from nature by experiment and observation is far superior to that generally taught in the schools; still many of the schools are now adopting the laboratory method of instruction-that is, the pupil is brought into contact with nature that he may gain knowledge at first hand rather than taking for granted the statements of teachers or books. But, says one, "What has all this to do with revelation?" The answer is, much; for, as the piece of sculpture is only the expression of thoughts formed in the mind of the artist before he struck the chisel, so are all the forms and phenomena of created things the expression of the thoughts of the Creator; and every thought or feeling aroused in the mind of a little child by observation, or in the mind of the most profound philosopher by investigation and experiment, is only a reproduction of the thought of deity expressed in a handwriting more definite and intelligible than the combined powers of all languages of earth.

"The heavens declare the glory of God; and the firmament showeth his handiwork. Day unto day uttereth speech, and night unto night sheweth knowledge. There is no speech nor language, where their voice is not heard." (Psalm 19:1-3.)

The astronomer's heart swells with the contemplation of the grandeur of the heavenly bodies, and he experiences delight in observing the perfect harmony, yet diversity, of their movements. God is revealing to him through an unmistakable form of expression some of the thoughts and feelings experienced by him "in the beginning." When viewing the wonders displayed in the chemical or physical laboratory or through the microscope, man is only beginning to learn the alphabet of that language through which God designs to reveal the thoughts he experienced in the acts of creation.

The melody and harmony produced by a proper arrangement and blending of musical sounds give joy to the cultivated ear, and cause wonder at the variety and sweetness produced thereby. When

viewing the harmonious arrangement and blending of colors and the variety of form in the floral world, the human soul experiences a sense of extreme pleasure, which is intensified by cultivated power to interpret this language. The pleasant odor of flowers fills the soul with delight. All these are revelations to his children, in a slight degree, of the feelings Deity experienced when forming his plans, even before he carried the plans into execution and pronounced all things "good."

All the oral or written language on earth could never cause one to realize the scent of the rose, the colors of the rainbow, the taste of an orange, or the sound of a musical instrument. God's spoken words by his own voice or by the voices of angels or prophets, are often misunderstood, not through his inability to give expression to his will, but through our mental incapacity to comprehend, and the inefficiency of our language as a mode of expression for the thoughts of Deity; but his works are perfect modes of expressing his thoughts as far as man's capability to read them goes.

1903
Robert Flint, Corresponding Member Of The Institute Of France; Professor Of Divinity In The University Of Edinburgh
Theism Lecture IV - Nature Is But The Name For An Effect Whose Cause Is God
Book and Baird Lectures for 1876

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Lecture IV - Nature Is But The Name For An Effect Whose Cause Is God

I.
We have now to consider the principle of causality so far as it is implied in the theistic inference, and the theistic inference so far as it is conditioned by the principle of causality. It is not necessary to discuss the nature of the principle of causality in itself or for its own sake; it is even expedient, I believe, not to attempt to penetrate farther into its metaphysics and psychology than the work on hand imperatively requires. We must of course go as far as those have gone who have maintained on metaphysical or psychological grounds that the principle of causality warrants no theistic inference; we must show that their metaphysics and psychology are irrelevant when true, and false when relevant; but we may be content to stop when we have reached this result. The truth of theism has been very generally represented, both by those who admit and by those who deny the validity of the theistic inference, as much more dependent than it really is on the truth or falsity of some one or other of the many views which have been entertained as to the nature of causation, and the origin of the causal judgment. We are constantly being warned by theists that unless we accept this or that particular notion of causation, and account for it in this or that particular manner, we cannot reasonably believe in the existence of God; we are constantly being assured by anti-theists that belief in God is irrational, because it assumes some erroneous view of causation, or some erroneous explanation of the process by which causation is apprehended. But it will be found that representations of this kind seldom prove more than one-sidedness and immaturity of thought in those who make them. An accurate and comprehensive view of the nature of causation, and of our apprehension of it, will, it is true, have here, as elsewhere, great advantages over an erroneous and narrow one, but hardly any of the theories which have been held on these points can be consistently argued by those who hold them to invalidate theistic belief. Even utterly inadequate statements and explanations of the principle of causality—as, for example, those of Hume and J. S. Mill—are not more incompatible

with the theistic inference than they are with any other inference which is a real extension of knowledge. Unless they are understood and applied more rigidly than by those who propound them, they allow us to draw the theistic inference; if understood and applied so as to forbid our drawing

it, they logically disallow all scientific inference except such as is purely formal and deductive. In a word, if compatible with science they are compatible with theism, and if incompatible with theism they are incompatible with science.

When we assume the principle of causality in the argument for the existence of God, what precisely is it that we assume? Only this: that whatever has begun to be, must have had an antecedent, or ground, or cause which accounts for it. We do not assume that every existence must have had a cause. We have no right, indeed, to assume that any existence has had a cause until we have found reason to regard it as not an eternal existence, but one which has had an origin. Whatever we believe, however, to have had an origin, we at once believe also to have had a cause. The theistic argument assumes that this belief is true. It assumes that every existence, once new, every event or occurrence or change, must have a cause. This is certainly no very large assumption: on the contrary, if any assumption can claim to be selfevident, it surely may. Thought implies the truth of it every moment. Sensation only gives rise to thought in virtue of it. Unless it were true there could be no such thing as thought. To deny that the principle of causality, understood as has been indicated, is true, would be to deny that reason is reason; it would be equivalent to affirming that to seek for a reason is always and essentially an unreasonable process. And, in fact, so understood, the principle never has been denied. Hume even did not venture to deny it, although he ought in consistency to have denied it, and obviously desired to be able to deny it. He did not, however, deny that every object which begins to exist must have a cause,—he did not venture to do more than deny that this is either intuitively or demonstratively certain, and that any bond or tie can be perceived between what is called a cause and what is called an effect. The inquiry which he instituted was not whether we pronounce it necessary that everything whose existence has a beginning should also have a cause or not, but for what reason we pronounce it necessary. He assumed that we pronounce it necessary, and his elaborate investigation into the nature of causation was undertaken expressly and entirely to discover why we do so. The conclusion to which he came—viz., that the causal judgment is an "offspring of experience engendered upon custom "—was not only a very inadequate and erroneous one in itself, but inconsistent with the reality of what it professed to explain: still the admission which has been mentioned was what was professed to be explained.

Now, if it be true at all that every event, whether it be a new existence or a change in an old existence, presupposes an explanatory antecedent or cause, there can, of course, be no accepting in all its breadth one of the propositions which Hume urges most strenuously—viz., that the mere study of an event can tell us nothing about its cause. We may grant that it can tell us very little, — that Hume performed an immense service in showing how extremely little we can know of the particular causes of particular events apart from the study of both in connection, apart from observation, experiment, and induction,—but we cannot grant that the event itself teaches us absolutely nothing. If every event must have a cause, every event must have a sufficient cause. For these two statements, although verbally different, are really identical. The second seems to mean, but does not actually mean, more than the first. The whole cause of the elevation of a weight of ten pounds a foot high cannot be also the whole cause of the elevation of twenty pounds to the same height, for the simple reason that in the latter case the elevation of ten pounds—of half the weight—would be an event which had no cause at all. And this is universally true. If every event had not a sufficient cause, some events have no cause at all. This, then, I say, we necessarily know that the efficient cause of every event is a sufficient cause, however vague may be our knowledge of efficiency and sufficiency. »

If every event—using this term as convenient to denote either a new existence or a change in some existence—must have a cause, to prove that the universe must have had a cause we require to prove it to have been an event—to have had a commencement. Can this be done? That is the question in the theistic argument from causality. Compared therewith, all other questions which

have been introduced into, or associated with, the argument are of very subordinate importance. Now there is only one way of reasonably answering the question, and that is by examining the universe, in order to determine whether or not it bears the marks of being an event—whether or not it has the character of an effect. We have no right to assume it to be an event, or to have had a beginning. The entire argument for the Divine existence, which is at present under consideration, can be no stronger than the strength of the proof which we can adduce in favour of its having had a beginning, and the only valid proof of that which reason can hope to find must be derived from the examination of the universe itself.

What, then, is the result of such an examination? An absolute certainty that all the things which are seen are temporal,—that every object in the universe which presents itself to the senses has had a beginning,—that the most powerful, penetrating, and delicate instruments devised to assist our senses reach no cause which is not obviously also an effect. The progress of science has not more convincingly and completely disproved the once prevalent notion that the universe was created about six thousand years ago, than it has convincingly and completely established that everything of which our senses inform us has had a commencement in time, and is of a compound, derivative, and dependent nature. It is not long since men had no means of proving that the rocks, for example, were not as old as the earth itself— no direct means of proving even that they were not eternal; but geological science is now able to tell us with confidence under what conditions, in what order, and in what epochs of time they were formed. We have probably a more satisfactory knowledge of the formation of the coal measures than of the establishment of the feudal system. We know that the Alps, although they look as if they might have stood for ever, are not even old, as geologists count age. The morning and night, the origin and disappearance of the countless species of living things which have peopled the earth from the enormously remote times when the rocks of the Laurentian period were deposited down to the births and deaths of contemporaneous animals, have been again brought into the light of day by the power of science. The limits of research are not even there reached, and with bold flight science passes beyond the confines of discovered life—beyond the epochs of formation even of the oldest rocks—to a time when there was no distinction of earth and sea and atmosphere, as all were mingled together in nebulous matter, in some sort of fluid or mist or steam; yea, onwards to a time when our earth had no separate existence, and suns, moons, and stars were not yet divided and arranged into systems. If we seek, then, after what is eternal, science tells us that it is not the earth nor anything which it contains, not the sea nor the living things within it, not the moving air, not the sun, nor the moon, nor the stars. These things when interrogated all tell us to look above and beyond them, for although they may have begun to be in times far remote, yet it was within times to which the thoughts of finite beings can reach back.

There is no denying, then, that the universe is to a great extent an effect, an event, something which has begun to be, a process of becoming. Science is, day by day, year by year, finding out more and more that it is an effect. The growth of science is in great part merely the extension of the proof that the universe is an effect. But the scientific proof of the non-eternity of matter is as yet far from a complete one. It leaves it possible for the mind to refer the phases through which the universe has passed, and the forms which it has assumed, to an underlying eternal source in nature itself, and, therefore, not to God. And this is by far the most plausible and forcible way of combating the argument we are employing. It meets it with a direct counter-argument, which every person must acknowledge to be relevant, and which, if sufficiently made out, is obviously decisive. That counter - argument we are bound, therefore, to dispose of. It has been thus stated by Mr J. S. Mill: " There is in nature a permanent element, and also a changeable: the changes are always the effects of previous changes; the permanent existences, so far as we know, are not effects at all. It is true we are accustomed to say not only of events, but of objects, that they are produced by causes, as water by the union of hydrogen and oxygen. But by this we only mean that when they begin to exist, their beginning is the effect of a cause. But their beginning to exist is not an object,

it is an event. If it be objected that the cause of a thing's beginning to exist may be said with propriety to be the cause of the thing itself, I shall not quarrel with the expression. But that which in an object begins to exist, is that in it which belongs to the changeable element in nature; the outward form and the properties depending on mechanical or chemical combinations of its component parts. There is in every object another and a permanent element—viz., the specific elementary substance or substances of which it consists and their inherent properties. These are not known to us as beginning to exist: within the range of human knowledge they had no beginning, and consequently no cause; though they themselves are causes or con-causes of everything that takes place. Experience, therefore, affords no evidences, not even analogies, to justify our extending to the apparently immutable, a generalisation grounded only on our observation of the changeable." (Three Essays on Religion, pp. 142, 143)

On this I would remark, first, that mere experience does not take us to anything which we are entitled to call even apparently immutable. It only takes us, even when extended to the utmost by scientific instruments and processes, to elements which we call simple because we have hitherto failed to analyse them into simpler elements. It is a perfectly legitimate scientific hypothesis that all the substances recognised by chemists as elementary and intransmutable, are in reality the modifications or syntheses of a single material element, which have been produced under conditions that render them incapable of being affected by any tests or agencies which the analyst in his laboratory can bring to bear upon them. Indeed, unless this hypothesis be true, the theory of development, so generally accepted at present, can hardly be supposed to be of any very wide application, seeing that at its very outset it has to affirm the existence of no fewer than sixty-four true untransformable species. But suppose the so-called elementary substances of chemistry to be simple, no one can reasonably suppose them as known to us to be ultimate. In oxygen there may be no atoms which are not atoms of oxygen, but we know by experience only oxygen, not atoms of oxygen. No man has ever been able to put himself in sensible contact with what alone can be immutable in oxygen, if there be anything immutable in it, its ultimate atoms. No man has seen, heard, touched, or tasted an ultimate atom of any kind of matter. We know nothing of atoms—nothing of what is permanent in nature—from direct experience. We must pass beyond such experience—beyond all testimony of the senses— when we believe in anything permanent in nature, not less than when we believe in something beyond and above nature. The atomic theory in chemistry demands a faith which transcends experience, not less than the theistic theory in religion.

Then, secondly, although we grant that there is a permanent element in the physical universe, something in matter itself which is self-existent and eternal, we still need, in order to account for the universe which we know, an Eternal Intelligence. The universe, regarded even only so far as it is admitted by all materialists no less than by theists and pantheists to be an effect, cannot be explained, as materialists think, merely physically. The atoms of matter are, it is said, eternal and immutable. Grant them to be so. There are, however, countless millions of them, and manifestly the universe is one, is a single, magnificent, and complicated system, is characterised by a marvellous unity in variety. We must be informed how the universe came to be a universe,—how it came to have the unity which underlies its diversity,—if it resulted from a countless multitude of ultimate causes. Did the atoms take counsel together and devise a common plan and work it out? That hypothesis is unspeakably absurd, yet it is rational in comparison with the notion that these atoms combined by mere chance, and by chance produced such a universe as that in which we live. Grant all the atoms of matter to be eternal, grant all the properties and forces which, with the smallest degree of plausibility, can be claimed for them to be eternal and immutable, and it is still beyond all expression improbable that these atoms with these forces, if unarranged, uncombined, ununified, unutilised by a presiding mind, would give rise to anything entitled to be called a universe. It is millions to one that they would never produce the simplest of the regular arrangements which we comprehend under the designation of course of nature, or the lowest of

vegetable or animal organisms; millions of millions to one that they would never produce a solar system, the earth, the animal kingdom, or human history. No number of material atoms, although eternal and endowed with mechanical force, can explain the unity and order of the universe, and therefore the supposition of their existence does not free us from the necessity of believing in a single intelligent cause—a Supreme Mind—to move and mould, combine and adjust, the ultimate atoms of matter into a single orderly system. There at once rises the question, Is it really necessary to believe both matter and mind to be eternal? No, must be our answer. The law of parsimony of causes directly forbids the belief, unless we can show that one cause is insufficient to explain the universe. And that we cannot do. We can show that matter is insufficient,—that it cannot account of itself even for the physical universe,—but not that mind is insufficient, not that mind cannot account for anything that is in matter. On what grounds can it be shown that a mind possessed of sufficient power to originate the universe, the ultimate elements of matter being given, could not also have created these elements? that the Supreme Intelligence, which gave to each sun, and planet, and satellite its size, and shape, and position, and motion, could not have summoned into being their constituent particles? On none whatever. We may not understand how they could be created, but we have no reason for thinking that they could not be created; and it is surely far easier and far more reasonable to believe that they were created, than that a countless number of inconceivably small indivisible particles of matter, lying far beyond the range of any of our senses, but extending through immeasurable fields of space, should all, inconceivably minute although they be, be selfexistent and eternal. The man who asks us to accept the latter supposition, asks us, it seems to me, to believe what is not only as mysterious as the self-existence of Deity, but millions of millions of times more mysterious. I should require strong reasons for assigning infinitely great attributes to excessively little things, and to an inconceivable number of them; but I can in this instance find no reasons at all.

Then, in the third place, any plausible conceptions we can form of the ultimate nature of matter lead to the belief that even that is an event or effect, a something derivative and caused. It must be admitted that the most plausible of these conceptions are vague and conjectural. We have a practical and relative knowledge of matter which is both exact and trustworthy,—a knowledge of its properties from which we can mathematically deduce a multitude of remote consequences of an extremely precise character—but we are hardly entitled to characterise as knowledge at all any of the views which have been propounded as to what it is in itself. It is only the unreflecting who fancy that matter in itself is something very clear and obvious, which they may apprehend by merely opening their eyes and stretching out their hands. Those who have never reasoned on the subject are apt to imagine that the nature of matter is of all things the easiest to understand, and they unhesitatingly invest it with their own sensations and perceptions. That is the so-called commonsense view of matter; but the slightest inquiry proves it to be delusive and nonsensical. Colour, for example, is just what is seen, and sound just what is heard; they are not qualities inherent in objects independent of the eye and ear: the matter which is supposed to cause by its motions on our senses these and other perceptions of the material world, we cannot see, hear, or apprehend by any sense. Change our senses and the universe will be thereby changed, everything in it becoming something other than it was before, green perhaps red, the bitter sweet, the loudest noise a gentle whisper, the hardest substance soft. As soon. then, as we thoughtfully ask ourselves, What is matter? we begin to discover that it is in itself something utterly mysterious. The collection of phenomena which we call its properties are quite unlike the phenomena of mind in this most important respect, that whatever they may be they are not what they appear to be. A state of mind is what we feel it to be; a state of matter is certainly not what we seem to ourselves to perceive it to be. No one, of course, knew all this better than Mr Mill. He, as a philosopher, had asked himself what matter is; he had formed a theory in answer to the question. And what is his theory? Just this,—that we cannot find a permanent element in matter; that we have no right to suppose that there is a permanent real existence or actual substance in matter; that all that we are warranted to affirm about the ultimate nature of matter is that it is a permanent possibility,—the

permanent possibility of sensations. That was the conclusion at which he arrived when he theorised on matter without any theological aim. But he appears to have forgotten it when he came to criticise the argument for a first cause. He could not otherwise have written as if it were quite certain that there was in matter " a permanent element," not an underlying possibility but an inherent real substance. Had he remembered what his own theory as to the nature of matter was, he would have avoided as utterly untrue and misleading every expression which could suggest the notion of there being a permanent element in matter, and would have admitted that very probably the permanent possibilities of sensation, the causes of all material phenomena, lay in the Divine will, since he had been unable to find anything else permanent in which they could be supposed to subsist. That is a view which many profound thinkers have adoptee]. They have been led to hold that matter is essentially force, and nothing but force; that the whole material world is ultimately resolvable into forces; and that all its forces are but manifestations or outgoings of will-force. If so, the whole material world is not only dependent on, but is, the will of God, and has no being of any kind apart from the will of God. If so, God's will is not only the cause and controlling power of nature, but its substance, its self. And this view, that what alone substantially underlies all the phenomena we designate material is an acting mind, an energising will, has not only been reached by mental philosophers and idealistic speculators, but by those physicists who, like Boscovitch and Faraday, have found themselves forced to conclude that what is constitutive of matter is not indivisible particles, even infinitesimally small, but mere centres of force, since force necessarily implies some sort of substance, and, therefore, spirit where not matter.

But suppose the substratum of the universe to consist of a countless number of inconceivably small indivisible particles of matter, and do we not even on this hypothesis reach by a single step the truth on which theism rests, and on which only theism can be based? " None of the processes of nature," says one of the most eminent of our physical philosophers, "since the time when nature began, have produced the slightest difference in the properties of any molecule. We are therefore unable to ascribe either the existence of the molecules or the identity of their properties to the operation of any of the causes which we call natural. On the other hand, the exact quality of each molecule to all others of the same kind gives it, as Sir John Herschel has well said, the essential character of a manufactured article, and precludes the idea of its being eternal and self - existent. Thus we have been led, along a strictly scientific path, very near to the point at which science must stop. Not that science is debarred from studying the external mechanism of a molecule which she cannot take to pieces, any more than from investigating an organism which she cannot put together. But, in tracing back the history of matter, science is arrested when she assures herself, on the one hand, that the molecule has been made, and on the other that it has not been made by any of the processes we call natural." (1 President's Address in Transactions of the British Association for the Advancement of Science, 1870.)

I believe that no reply to these words of Professor Clerk-Maxwell is possible from any one who holds the ordinary view of scientific men as to the ultimate constitution of matter. They must suppose every atom, every molecule, to be of such a nature, to be so related to others, and to the universe generally, that things may be such as we see them to be; but this their fitness to be built up into the structure of the universe is a proof that they have been made fit, and since natural forces could not have acted on them while not yet existent, a supernatural power must have created them, and created them with a view to their manifold uses. Every atom, every molecule, must, even in what is ultimate in it, bear the impress of a Supernatural Power and Wisdom; must, from the very nature of the case, reflect the glory of God and proclaim its dependence upon Him.

In like manner the latest speculation* regarding the nature of matter—the vortex-atom theory of Sir William Thomson—seems, so far from having any tendency to exclude creative action, necessarily to imply it. He supposes that the atoms may be small vortex-rings in the ether, the rotating portions of a perfect fluid which fills all space. But a perfect fluid can neither explain its own existence nor

the commencement of rotation in any part of it. Rotation once commenced in a perfect or frictionless and incompressible fluid would continue for ever, but it never could naturally commence. There is nothing in a perfect fluid to account either for the origin or cessation of rotation, and consequently nothing, on the vortex-atom hypothesis, to account either for the production or destruction of an atom of matter. The origin and cessation of rotation in fluids are due to their imperfection, their internal friction, their viscosity. The origin or cessation of rotation in a perfect fluid must be the effect of supernatural action; in other words, every vortex-atom must owe the rotation which gives it its individuality to a Divine impulse.

A theist has certainly no need, then, to be afraid of researches into the ultimate nature of matter. Our knowledge thereof is exceedingly small and imperfect, but all that we do know of it, all that we can even rationally conceive of it, leads to the inference that it is not self-existent, but the work of God. The farther research is pushed, the more clearly, we may be assured, will this become apparent, for the more wonderfully adapted will the ultimate constituents of matter be found for assuming countless forms and composing countless objects — the air, the land, the sea, and starry heavens, with all that in or on them is. Research has already shown us reason to believe " that even chemical atoms are very complicated structures; that an atom of pure iron is probably a vastly more complicated system than that of the planets and their satellites; that each constituent of a chemical atom must go through an orbit in the millionth part of the twinkling of an eye, in which it successively or simultaneously is under the influence of many other constituents, or possibly comes into collision with them; that each of these particles is, as Sir John Herschel has beautifully said, for ever solving differential equations which, if written out in full, might perhaps belt the earth." See W. S. Jevons, Principles of Science, ii. 45Z, 453.) Now, what does this mean, if not that every ultimate atom of matter is full to the very heart of it with evidences of the power and wisdom of God, and that every particle of dust or drop of water is crowded with traces of the action of the Divine Reason, not less marvellous, it may be, than those which astronomy exhibits in the structure of the heavens and the evolutions of the heavenly bodies? Those who hoped that molecular science would help them to get rid of God have obviously made a profound mistake. It has already shown far more clearly than ever was or could have been anticipated, that every atom of matter points back beyond itself to the all-originating will of God, and refuses to receive the idolatrous homage of those who would put it in the place of God.

To these considerations it has to be added that some of our ablest physicists believe that in the present age a strictly scientific proof has been found of the position that the universe had a beginning in time. "According to Sir W. Thomson's deductions from Fourier's Theory of Heat, we can trace down the dissipation of heat by conduction and radiation to an infinitely distant time when all things will be uniformly cold. But we cannot similarly trace the heat - history of the universe to an infinite distance in the past. For a certain negative value of the time the formulae give impossible values, indicating that there was some initial distribution of heat which could not have resulted, according to known laws of nature, from any previous distribution. There are other cases in which a consideration of the dissipation of energy leads to the conception of a limit to the antiquity of the present order of things." (Jevons, Principles of Science, ii. 438.) If this theory be true, physical science, instead of giving any countenance to the notion of matter having existed from eternity, distinctly teaches that creation took place, that the present system of nature and its laws originated at an approximately assignable date in the past. The theory is supported by the most eminent physical philosophers of this country, and if there be any oversight or error in the principles or calculations on which it is founded, it would appear not to have been as yet detected. It is a theory on which, however, only specialists are entitled to pronounce judgment; and therefore, although those who assume that matter was not created are bound to refute it, I do not wish myself to lay any stress upon it—the more especially as I believe that apart from it there is amply sufficient evidence for holding that " Nature is but the name for an effect whose cause is God."

II.

It seems to me, then, that the universe, when examined, must be concluded to be throughout—from centre to circumference—alike in what is most permanent and what is most changeable in it,—an event or effect, and that its only adequate cause is a Supreme Intelligence. It is only such a cause which is sufficient to explain the universe as we know it, and that universe is what has to be explained. The assertion of Kant that the principle of causality cannot take us beyond the limits of the sensible world is only true if causality be confined to strictly material events which display no signs of law and order, and the progress of science is one long uninterrupted proof that no such events are to be discovered; that it is hopeless to look for them; that matter and its changes are ordained, arranged, adjusted phenomena. The assertion of Kant is clearly false, if we are not to exclude from the event anything which demands explanation; if we are to reason from the universe itself and not from its name; if we are to infer a particular cause from a knowledge of the nature of a given particular event. This, the so-called concrete use of the principle of causality, is the only use of it which is legitimate, the only use of it which is not extremely childish.

The opposite—the absurd — notion that the principle of causality is abstractly applied, has led some to argue that it leads legitimately to nothing else than an infinite regress—an eternal succession of causes and effects. But to whatever it may lead, it certainly does not lead to that conclusion, and has never led any human being, either legitimately or illegitimately, to that conclusion. Those even who have maintained that the principle of causality cannot lead to a first cause, to an eternal selfexistent cause, but only to an eternal succession of causes and effects, have all, without a single exception, allowed themselves to be led by it to a first cause and not to an eternal succession of causes. They have all believed what they say they ought to have disbelieved; they have all disbelieved what they say they ought to have believed. They have all accepted as true that there is a first and self-existent cause, although some have supposed it to be matter, some mind, some within the world, some without the world. They have differed as to what it is, but not as to that it is. None of them have adopted the conclusion to which they have said the argument founded on causation logically leads. No man has ever adopted that conclusion. The human mind universally and instantaneously rejects it as inconceivable, unthinkable, self-contradictory, absurd. We may believe either in a self-existent God or in a self-existent world, and must believe in one or the other; we cannot believe in an infinite regress of causes. The alternatives of a self-existent cause and an infinite regress of causes are not, as some would represent, equally credible alternatives. The one is an indubitable truth, the other is a manifest absurdity. The one all men believe, the other no man believes.

This takes away, it seems to me, all force from the objection that the argument founded on the principle of causality when it infers God as the self-existent cause of the universe infers more than is strictly warranted, a self-existent cause being something which does not in itself fall under the principle of causality. That every event must have a cause will be valid, it is said, for an endless series of causes and effects; but if you stop, if you affirm the existence of what is uncaused, of what is at once, as it were, cause and effect, you may affirm what is true, but you affirm also what is independent of the principle of causation. You claim more than your argument entitles you to; you are not developing a logical conclusion, but concealing under a term which seems to express the same idea what is really the vaulting of the mind to a higher idea which cannot be expressed under the form efficient cause at all.

Now, of course, a self-existent cause does not in itself come completely under the law of causality. That law cannot inform us what self-existence is. A self-existent cause, however, may be known as well as any other cause by its effects. The mind may rise to it from its effects. The principle of causality may lead up to it, although it does not include within itself the proof of the self-existence of the cause. It may at the last stage be attached to some other principle which compels the

affirmation of the self-existence of the cause reached; in other words, the affirmation that the first cause is a self-existent cause, may be a distinct mental act not necessitated by the principle of causality itself. It may either be held that this mental necessity is the reason why we cannot entertain the thought of an infinite regress of causes, or that the incapacity of the mind to regard the thought of an infinite regress of causes as other than self-contradictory, is the explanation of its felt necessitation to affirm a self-existent cause; in which latter case the principle of causality really necessitates a belief in the ungenerated and self-existent. Both of these views are plausible, and which of them is true is an interesting subject of metaphysical investigation, but it is one of no practical consequence in the inquiry on which we are engaged. The principle of causality can lead us up from all things which have on them the marks of having begun to be, and if we at length come to something which bears no such marks, be it matter or be it mind, no man can doubt, or does doubt, that something to be self-existent. This difficulty about arriving at a self-existent cause by the principle of causality, will be worth the attention of the theist when it is attended to by any one else,—when any atheist or any anti-theist of any kind is prepared to deny that the last cause in the order of knowledge, and the first in the order of existence, must be a self-existent cause— but not until then; and it is mere sophistry to represent it as of practical importance. Whenever we come to an existence which we cannot regard as an effect or thing generated in time, we, either in consequence of the very nature of the causal judgment, or of some self-evident condition or conditions of knowledge necessarily attached thereto, attribute to it self-existence and eternity. We may dispute as to whether this is done in the one or the other of these two ways, but that is a merely theoretical question; that every one does, and must, as a reasonable being, do it, is what no man disputes, or can dispute,—and this alone is of practical consequence.

Another admission must be made by every man who reflects carefully on the nature of causation. To say that the idea of cause can never demand belief in an uncaused cause, sounds as self-evident; to say that the idea of cause can find no satisfaction save in the belief of an uncaused cause, sounds as a paradox; but let a man meditate for a little with real thoughtfulness on the meaning of these^ two statements, and he cannot fail to perceive that(the former is an undeniable falsehood, and the" latter an undeniable truth. An uncaused cause, a first cause, alone answers truly to the idea of a cause. A secondary cause, in so far as secondary, in so far as caused, is not a cause. I witness some event—some change. I am compelled as a rational being to seek its cause. I reach it only to find that this cause was due to a prior cause. What has happened? The cause from which I have had to go back has ceased to be a cause; the cause to which I have had to go back has become the cause of two effects, but it will remain so only if I am not reasonably bound to seek a cause for it. If I am, its causality must pass over to its explanatory antecedent. We may go back a hundred, a thousand, a million times, but if the last cause reached be not truly a first cause, an uncaused cause, the idea of cause in our mind will be as unsatisfied at the end of our search as at the beginning, and the whole process of investigation will be aimless and meaningless. A true cause is one to which the reason not only moves but in which it rests, and except in a first cause the mind cannot rest. A first cause, however, is certainly not one which has been itself caused.

We are warranted, then, in looking upon the universe as an event or effect, and we may be certain that it is not the last link of an infinite chain of causes and effects, or of any series of causes and effects, long or short, suspended upon nothing. No chain or series can be, properly speaking, infinite, or without a first link or term. The universe has a First Cause. And its First Cause, I must proceed to remark, reason and observation alike lead us to believe must be one—a single cause. When one First Cause is sufficient to explain all the facts, it is contrary to reason to suppose another or several. We must prove that no one First Cause could account for the universe before we can be entitled to ascribe it to more causes than one. The First Cause, we shall further see afterwards, must have attributes which no two or more beings can be supposed to possess, which one being alone can possess. Then the character of the effect itself refers us back to a single cause. A belief in more gods than one not only finds no support in the universe, but, as the very word

universe indicates, is contradicted by it. For, numerous and diverse as are the objects in nature, they are so constituted and connected—so dependent on and related to one another—as to compose a whole which exhibits a marvellous unity in variety. Everything counteracts or balances or assists something else, and thus all things proclaim their common dependence on One Original. Co-ordinate things must all be derivative and secondary, and all things in nature are co-ordinate parts of a stupendous system. Each one of us knows, for example, that a few years ago he was not, and that in a few years hence the place which knows him now will know him no more; and each one of us has been often taught by the failure of his plans, and the disappointment of his hopes, and the vanity of his efforts, that there are stronger forces and more important interests in the world than his own, and that he is in the grasp of a Power which he cannot resist—which besets him behind and before, and hems him in on all sides. When we extend our view, we perceive that this is as true of others as of ourselves, and that it is true even, in a measure, of all finite things. No man lives or dies to himself; no object moves and acts absolutely from and for itself alone. This reveals a single alloriginating, all-pervading, all-sustaining principle. These manifold mutually dependent existences imply one independent existence. The limitations assigned to all individual persons and things point to a Being which limits them all. Particular causes and secondary movements lead back to " a cause of causes," "a first mover, itself immovable, yet making all things else to move."

The first cause must be far more truly and properly a cause than any secondary cause. In fact, as we have already seen, a secondary cause is not strictly a cause; so far as secondary, it merely transmits to its consequent what it has received from its antecedent. There may be a succession of a thousand such causes in a process, yet the first cause is also the last, and there is, in fact, all through, but one cause; the others merely convey and communicate its force. A machine, however numerous its parts and movements, does not create the least amount of force; on the contrary, the most perfect machine wastes and absorbs some of the force which is imparted to it. The universe, so far as subject to mechanical laws, is merely a machine which transmits a given quantity of force, but which no more creates it than it creates itself. The author of that force is the one true cause of all physical phenomena. Life is probably, and mind is certainly, not entirely explicable on mechanical principles; but neither life nor mind can be maintained to do more than to determine the direction or application of the power implanted in them, or rendered accessible to them, through the working of the first cause. All things must, consequently, " live, move, and have their being " therein. It is at their end as well as at their origin; it encompasses them, all round; it penetrates them, all through. The least things are not merely linked on to it through intermediate agencies which go back an enormous distance, but are immediately present to it, and filled to the limit of their faculties with its power. It is in every ray of sunlight, every breath of wind, and blade of grass; it is the source and life of all human minds and hearts. The pantheist errs not so much in what he affirms of it, as in what he denies to it.

This cause—the cause of causes—must, it is further obvious, be in possession of a power far beyond the comprehension of our reasons or imaginations. All other power is derived from its power. All the power which is distributed and distinguished in secondary causes must be combined and united in the first cause. Now, think what an enormous power there is displayed even in this world. In every half-ounce of coal there is stored up power enough, if properly used, to draw two tons a mile. How vast, then, the power which God has deposited in the coal-beds of the world alone! The inhabitants of this little island, by availing themselves of the natural forces which Providence has placed at their disposal, annually accomplish more work than could by any possibility be effected by the inhabitants of the whole earth, if they exerted merely the power which is in their own bodies, the power of human bones and muscles. And yet there can be little doubt that, even in this country, we make no use at all of many natural agents, and only a wasteful use of any of them. " Weigh the earth on which we dwell," says an astronomer; "count the millions of its inhabitants that have come and gone for the last six thousand years; unite their strength into one arm; and test its power in an effort to move the earth. It could not stir it a single foot in a thousand years; and yet,

under the omnipotent hand of God, not a minute passes that it does not fly far more than a thousand miles." The earth, however, is but a mere atom in the universe. Through the vast abysses of space there are scattered countless systems, at enormous distances, yet all related; glorious galaxies of suns, planets, satellites, comets, all sweeping onwards in their appointed courses. How mighty the arm which impels and guides the whole! God can do all that, for He continually does it. How much more He could do than He does, we cannot know. The power of no true cause, of no free cause, is to be measured by what it does. It must be adequate to produce its actual effects, but it may be able to produce countless merely possible effects. It has power over its powers, and is not necessitated to do all that it is capable of doing. It is difficult, perhaps, to show that the universe is not infinite. It is obviously unreasonable and presumptuous to deny that the power of its Author may be infinite. And yet we find men who do so. For example, the late Mr John Stuart Mill, for no better reasons than that nature sometimes drowns men, and burns them, and that child-birth is a painful process, maintained that God could not possibly be infinite. I shall not say what I think of such an argument. What it proves is not the finiteness of God, but the littleness of a human intellect. The mind of man never shows itself so small as when it tries to measure the attributes and limit the greatness of its Creator.

A first cause, we have already seen, must be a free cause. It cannot have been itself caused. It is absurd to look for it among effects. But we never get out of the sphere of effects until we enter that of free agency; until we emerge from the natural into the spiritual; until we leave matter and reach mind. The first cause must, indeed, be in—all through—the universe; but it must also be out of the universe, anterior to, and above the universe.

The idea of cause is a delusion—the search for causes an inexplicable folly—if there be no first cause, and if that first cause be not a free cause, a Will, a Spirit, a Person. Those who object to the causation argument, that it does not take us beyond the world—does not lead us up to a personal cause of the world—have failed to apprehend what causation signifies. Secondary causes may not be true causes, and yet reason be trustworthy, for there is that behind them on which it can fall back; but if there be no first cause, or if the first cause be not free, reason is throughout a lie. Reason, if honest and consistent, cannot in its pursuit of causes stop short of a rational will. That alone answers to and satisfies its idea of a cause.

The most rapid glance at the universe powerfully confirms the conclusion that its first cause can only be a Mind, a Reason. The universe is a universe; that is to say, it is a whole, a unity, a system. The first cause of it, therefore, in creating and sustaining it, must comprehend, act on, and guide it as a systematic whole; must have created all things with reference to each other; and must continually direct them towards a preconceived goal. The complex and harmonious constitution of the universe is the expression of a Divine Idea, of a Creative Reason. This thought brings me to my next argument and next lecture.

Lecture V - The Argument From Order

I.
The prevalence of order in nature has already been referred to as contributing to prove that the universe is an event, a generated existence, a something which once began to be. It will now be brought forward as in itself a manifestation of, and consequently a ground for believing in, a Supreme Mind. Where order meets us, the natural and immediate inference is that there is the work of intelligence. And order meets us everywhere in the universe. It covers and pervades the universe. It is obvious to the ordinary naked eye, and spreads far beyond the range of disciplined vision when assisted by all the instruments and appliances which science and art have been able to invent. It is conspicuous alike in the architecture of the heavens and the structure of a feather or a leaf. It goes back through all the epochs of human history, and all the ages of geological and

astronomical time. It is the common work of all the sciences to discover and explain the order in the universe. There is no true science which is not constantly making new and fuller discoveries of the order in nature,—the order within us and without us; not one which is not ever increasingly establishing that in order all things move and have their being. What is maintained by the theist is, that this order, the proof of which is the grand achievement of science, universally implies mind; that all relations of order—all laws and uniformities—are evidences of an intelligent cause.

The order which science finds in nature may be described as either general or special, although in strictness the difference between them is only a difference of degree, the former being the more and the latter the less general, or the former being the less and the latter the more special. In what may be called general order, that which strikes us chiefly is regularity; in what may be called special order, that which chiefly strikes us is adaptation or adjustment. In inorganic nature general order is the more conspicuous; in organic nature special order. Astronomy discloses to us relations of number and proportion so far-reaching that it almost seems as if nature were " a living arithmetic in its development, a realised geometry in its repose." Biology, on the other hand, impresses us by showing the delicacy and subtlety of the adjustment of part to part, of part to whole, and of whole to surroundings, in the organic world. There is, perhaps, sufficient difference between these two kinds of order to warrant their being viewed separately, and as each furnishing the basis of an argument for the existence of God. The argument from regularity has sometimes been kept apart from the argument from adjustment. The former infers the universe to be an effect of mind because it is characterised by proportion or harmony, which is held to be only explicable by the operation of mind. The latter draws the same inference because the universe contains countless complex wholes, of which the parts are so collocated and combined as to co-operate with one another in the attainment of certain results; and this, it is contended, implies an intelligent purpose in the primary cause of these things.

While we may readily admit the distinction to be so far valid, it is certainly not absolute. Regularity and adjustment are rather different aspects of order than different kinds of order, and, so far from excluding each other, they will be found implying each other. It is obvious that even the most specialised adjustments of organic structure and activity presuppose the most general and simple uniformities of purely physical nature. Such cases of adjustment comprehend in fact many cases of regularity. It is less obvious, but not less true, that wherever regularity can be traced adjustment will also be found, if the search be carried far enough. The regularity disclosed by astronomy depends on adjustment as regards magnitude, weight, distance, &c, in the celestial bodies, just as the adjustments brought to light by biology depend on the general regularity of the course of nature. There is no law of nature so simple as not to presuppose in every instance of its action at least two things related to one another in the manner which is meant when we speak of adjustment. It being thus impossible to separate regularity from adjustment as regards the phenomena of the universe, it seems unnecessary to attempt by abstraction to separate them in the theological argumentation, while giving a rapid general glance at the phenomena which display them.

The physical universe has, perhaps, no more general characteristic than this,—its laws are mathematical relations. The law of gravitation, which rules all masses of matter, great or small, heavy or light, at all distances, is a definite numerical law. The curves which the heavenly bodies describe under the influence of that law are the ellipse, circle, parabola, and hyperbola—or, in other words, they all belong to the class of curves called conic sections, the properties of which mathematicians had begun to investigate nearly twenty centuries before Newton established that whatever was true of them might be directly transferred to the heavens, since the planets revolve in ellipses, the satellites of Jupiter in circles, and the comets in elliptical, parabolic, and hyperbolic orbits. The law of chemical combination, through which the whole world of matter has been built up out of a few elements, always admits of precise numerical expression. So does the

law of the correlation of heat and gravitation. Each color in the rainbow is due to a certain number of undulations of the luminiferous medium in a given space. Each note in the scale of harmony is due to a certain number of vibrations per second. Each crystal is a geometrical construction. The pistils of flowers, and the feathers in the wings and tails of birds, are all numbered. If nature had not thus been ruled by numerical laws, the mathematical sciences might have existed, but they would have had no other use than to exercise the intellect, whereas they have been the great instruments of physical investigation. They are the creations of a mental power which, while occupied in their origination and elaboration, requires to borrow little, if anything, from matter; and yet, it is only with their help that the constitution of the material universe has been displayed, and its laws have been discovered, with that high measure of success of which physicists are so proud. But they could not have been applied to the universe at all unless its order had been of the exact numerical and geometrical kind which has been indicated; unless masses had attracted each other, and elements combined with each other, in invariable proportions; unless " the waters had been measured as if in the hollow of a hand, the heaven meted out as with a span, the dust of the earth comprehended in a measure, and the mountains weighed in scales and the hills in a balance." Now it is possible to deny that things have been thus weighed, measured, and numbered by a Creative Intelligence, but not that they have been weighed, measured, and numbered. If we are to give any credit to science, there can be no doubt about the weights and measures and numbers. This question, then, is alone left,—could anything else than intelligence thus weigh, measure, and number? Could mere matter know the abstrusest properties of space and time and number, so as to obey them in the wondrous way it does? Could what has taken so much mathematical knowledge and research to apprehend, have originated with what was wholly ignorant of all quantitative relations? Or must not the order of the universe be due to a mind whose thoughts as to these relations are high above even those of the profoundest mathematicians, as are the heavens above the earth? If the universe were created by an intelligence conversant with quantitative truth, it is easy to understand why it should be ruled by definitely quantitative laws; but that there should be such laws in a universe which did not originate in intelligence, is not only inexplicable but inconceivably improbable. There is not merely in that case no discoverable reason why there should be any numerically definite law in nature, but the probability of there being no law or numerical regularity of any kind is exceedingly great, and of there being no law-governed universe incalculably great. Apart from the supposition of a Supreme Intelligence, the chances in favour of disorder against order, of chaos against cosmos, of the numerically indefinite and inconstant against the definite and constant, must be pronounced all but infinite. The belief in a Divine Reason is alone capable of rendering rational the fact that mathematical truths are realised in the material world.

The celestial bodies were among the earliest objects of science, and before there was any science they stimulated religious thought and awakened religious feeling. The sun and moon have given rise to so extraordinary a number of myths that some authors have referred to them the whole of heathen mythology. There can be little doubt that the growth of astronomical knowledge contributed greatly to bring about the transition from polytheism to monotheism, and that so soon as the heavens were clearly understood to be subject to law, and the countless bodies which circle in them not to be independent agents but parts or members of a single mechanical or organic system, the triumph of the latter was for ever secured. No science, indeed, has hitherto had so much influence on man's religious beliefs as astronomy, although there may now appear to be indications that chemistry and biology will rival it in this respect in the future. And it has been thus influential chiefly because through its whole history it has been a continuous, conspicuous, and ever-advancing, ever-expanding demonstration of a reign of law on the most magnificent scale,—a demonstration begun when with unassisted vision men first attempted roughly to distribute the stars into groups or constellations, and far from yet ended when the same laws of gravitation, light, heat, and chemical combination which rule on earth have been proved to rule on orbs so distant that their rays do not reach us in a thousand years. The system of which our earth is a member is

vast, varied, and orderly, the planets and satellites of which it is composed being so adjusted as regards magnitude and mass, distance, rate, and plane of direction, &c, that the whole is stable and secure, while part ministers to part as organ to organ in an animal body. Our own planet, for example, is so related to the sun and moon that seed-time and harvest never fail, and the ebb and flow of the tides never deceive us. And the solar system is but one of hundreds of millions of systems, some of which are incalculably larger than it, yet the countless millions of suns and stars thus " profusely scattered o'er the void immense " are so arranged and distributed in relation to one another, and in accordance with the requirements of the profoundest mathematics, as to secure the safety of one and all, and to produce everywhere harmony and beauty. Each orb is affecting the orbit of every other—each is doing what, if unchecked, would destroy itself and the entire system—but so wondrously is the whole constructed that these seemingly dangerous disturbances are the very means of preventing destruction and securing the universal welfare, being due to reciprocally compensating forces which in given times exactly balance one another. Is it, I ask, to be held as evidence of the power of the human mind that it should have been able, after many centuries of combined and continuous exertion, to compute, with approximate accuracy, the paths and perturbations of the planets which circle round our sun and the returns of a few comets, but as no evidence even of the existence of mind in the First Cause of things that the paths and perturbations of millions on millions of suns and planets and comets should have been determined, with perfect precision, for all the ages past and future of their existence, so that, multitudinous as they are, each proceeds safely on its destined way, and all united form a glorious harmony of structure and motion?

A much more recent science than astronomy, the science of chemistry, undertakes to instruct us as to the composition of the universe, and it is marvellous how much it can tell us even of the composition of the stars. What, then, is its most general and certain result? Just this, that order of the strictest kind, the most definite proportions, are wrought into the very structure of every world, and of every compound object in the world, air and water, earth and mineral, plant and animal. The vast variety of visible substances are reducible to rather more than sixty constituent elements, each of which has not only its own peculiar properties but its own definite and unvarying combining proportions with other elements, so that amidst the prodigious number of combinations all is strictly ordered, numerically exact. There is no chemical union possible except when the elements bear to each other a numerically constant ratio. Different compounds are always the products of the combination of the elements in different yet strictly definite proportions, there being no intermediate combinations, no transitional compounds. If each element did not admit of union with many others, the world would be dead and poor, its contents few and unvaried; if their unions were not always regulated by law, disorder would everywhere prevail. How comes it that they are so made in relation to one another that their manifold unions are ever regulated by law, and generate an endless variety of admirable products? Who made them thus? Did they make themselves? or, did any blind force make them? Reason answers that they must have been made by an intelligence which wanted them for its purposes. When the proportions of the elementary constituents are altered, the same elements produce the most diverse substances with the most dissimilar and even opposite properties, charcoal and diamond, a deadly poison or the breath of life, theine or strychnine. These powers all work together for good; but if they worked even a very little differently—if the circumstances in which they work, not to speak of the laws by which they work, were altered—they would spread destruction and death through the universe. The atmosphere is rather a mixture than a combination of chemical elements, but it is a mixture in which the constituents are proportioned to each other in the only way which fits it to sustain the lives of plants and animals, and to accomplish its many other important services; and wonderful in the extreme is the provision made for the constant restoration of the due proportions amidst perpetual oscillations. One of the chiefs of modern chemistry, Baron Liebig, points to what takes place when rain falls on the soil of a field adapted for vegetable growth as to something which " effectually strikes all human wisdom dumb." " During the filtration of rain-water," he says, " through

the soil, the earth does not surrender one particle of all the nutritive matter which it contains available for vegetable growth (such as potash, silicic acid, ammonia, &c); the most unintermittent rain is unable to abstract from it (except by the mechanical action of floods) any of the chief requisites for its fertility. The particles of mould not only firmly retain all matter nutritive to vegetable growth, but also immediately absorb such as are contained in the rain-water (ammonia, potash, &c). But only such substances are completely absorbed from the water as are indispensable requisites for vegetable growth; others remain either entirely or for the most part in a state of solution." The laws and uses of light and heat, electricity and magnetism, and the adjustments which they presuppose, all point not less clearly to the ordinances of a supremely profound and accurate mind. In a word, out of a few elements endowed with definite powers, this world with its air and its seas, its hills and valleys, its vegetable forms and animal frames, and other worlds innumerable, have been built up by longsustained and endlessly-varied processes of chemical synthesis mostly conducted under conditions so delicately adjusted to the requirements of each case, that the ablest chemists, with all their instruments and artifices, cannot even reproduce them on any scale however small. Can these elements be reasonably thought of as having been unfashioned and unprepared, or these processes as having been uninstituted and unpresided over by intelligence?1 The sciences of geology and palaeontology disclose to us the history of our earth and of its vegetable and animal organisms. They prove that for countless ages, that from the inconceivably remote period of the deposition of the Laurentian rocks, light and heat, air and moisture, land and sea, and all general physical forces, have been so arranged and co - ordinated as to produce and maintain a state of things which secured during all these countless ages life and health and pleasure for the countless millions of individuals contained in the multitude of species of creatures which have contemporaneously or successively peopled the earth. The sea, with its winds and waves, its streams and currents, its salts, its flora and fauna, teems with adaptations no less than the land. Probably no one has studied it with more care or to more purpose than Lieutenant Maury; and his well-known work on its physical geography proceeds throughout on the principle that" he who would understand its phenomena must cease to regard it as a waste of waters, and view it as the expression of One Thought, a unity with harmonies which One Intelligence, and One Intelligence alone, could utter;" while many of its pages might appropriately be read as a commentary on these lines of Wordsworth,—

Huge ocean shows, within his yellow strand,
A habitation marvellously planned,
For life to occupy in love and rest.

The sciences referred to certify further, that as regards the various forms of life there has been from the time when it can be first traced to the present day " advance and progress in the main," and that the history of the earth corresponds throughout with the history of life on the earth, while each age prepares for the coming of another better than itself. But advance and progress presuppose intelligence, because they cannot be rationally conceived of apart from an ideal goal foreseen and selected. Volumes might be written to show how subtly and accurately external nature is adjusted to the requirements of vegetable and animal life, and how vegetable and animal life are inter-related; nay, even on how well the earth is fitted for the development and happiness of man. Think of the innumerable points of contact and connection, for example, between physical geography and political economy, which all indicate so many harmonies between the earth and man's economical condition, capacities, and history.

The vegetable and animal kingdoms viewed generally, are also striking instances of unity of plan, of progressive order, of elaborately adjusted system. There are general principles of structure and general laws of development common to all organisms, constituting a plan of organisation capable of almost infinite variation, which underlies all the genera and orders of living creatures, vegetable and animal. It comprehends a number of subordinate plans which involve very abstract conceptions,

and which even the ablest naturalists still very imperfectly comprehend. These higher plans would probably never have been thought of but for the detection of the numerous phenomena which seemed on a superficial view irreconcilable with the idea of purpose in creation. Just as it was those so-called "disturbances" in the planetary orbits, which appeared at first to point to some disorder and error in the construction of the sidereal system, that prompted Lagrange to the investigations which resulted in establishing that the order of the heavens was of a sublimer and more remarkable character than had been imagined, essentially including these apparent disturbances, so it has been the seeming exceptions to plan which are witnessed in rudimentary and aborted organs (such as the wing-bones in wingless birds, the fingerbones in horses, the legs below the skin in serpents, the teeth which never cut the gums in whales, &c), that have indicated to modern biologists a unity of organisation far more comprehensive and wonderful than had previously been suspected. The larger and more ideal order thus brought to light as ruling in the organic world is one which could only have originated in a mind of unspeakable power and perfection. And it not only thus testifies directly of itself in favour of a Divine Intelligence, but the recognition of it, while correcting in some respects earlier conceptions as to the place of utility in nature, far from proving that utility has been disregarded or sacrificed, shows that each organ has been formed, not only with reference to its actual use in a given individual or species, but to the capacity of being applied to use in countless other individuals and species.'

When we enter into the examination of organisation in itself, adjustment becomes still more obvious in the processes of growth, reproduction, fructification, &c, in plants and animals, and in the provisions for locomotion, for securing food and shelter, for sight, hearing, &c, in the latter. The great physician, Sir Charles Bell, devoted a whole treatise to point out those which are to be found in the hand alone. The arrangement of bones, muscles, joints and other parts in the limb of a tiger or the wing of an eagle are not less admirable. The eye and ear are singularly exquisite structures, the former being far the most perfect of optical, and the latter far the most perfect of acoustic instruments. Instances of this sort are, indeed, so remarkable, and so irresistibly convincing to most minds, that some theists have consented to rest on them exclusively the inference of a designing intelligence. They would grant that the evidences of purpose are only to be traced in organisation. The limitation is inconsistent and untenable, but not inexplicable. The adjustment of parts to one another, and their co-ordination as means to an end, are not more certainly existent in fitting the eye to see and the ear to hear than in securing the stability of the solar system, but they are more obviously visible because compressed into a compass easily grasped and surveyed; because organ and function are the most specialised kinds of means and ends; because organisms are the most curiously and conspicuously elaborate examples of order. And as the telescope can show us no end of the simple and majestic order of the heavens, so the microscope can show us no end of the exquisite and impressive order which discloses even

In Nature's most minute design,
The signature and stamp of power divine;
Contrivance intricate, expressed with ease,
Where unassisted sight no beauty sees.
The shapely limb and lubricated joint
Within the small dimensions of a point;
Muscle and nerve miraculously spun,
His mighty work, who speaks and it is done.
The Invisible, in things scarce seen revealed,
To whom an atom is an ample field.—(cowper.) 1

The traces of a Supreme Reason crowd still more upon the vision when we come to the human mind,

The varied scene of quick compounded thought,
And where the mixing passions endless shift.
—(Thompson.)

The mere existence of originated minds necessarily implies the existence of an unoriginated mind. " What can be more absurd," asks Montesquieu, " than to imagine that a blind fatalistic force has produced intelligent beings?" The complicated and refined adjustments of the body to the mind, and of the mind to the body, are so numerous and interesting that their study has now become the task of a special class of scientific men. A very little disorder in the organisation of the brain— such as even microscopic post-mortem examination may fail to detect—suffices to cause hallucinations of the senses, to shake intellect from its throne, to paralyse the will, and to corrupt the sentiments and affections. How precise and skilful must the adjustment be between the sound brain and sane mind! Who sufficiently realises the mystery of wisdom which lies in the familiar fact that the mind, by merely willing to use the members of the body, sets in motion instantaneously and unconsciously, without effort and without failure, cords and pulleys and levers, joints and muscles, of which it only vaguely, if at all, surmises the existence? The laws of our various appetencies, affections, and emotions, and their relations to their special ends or objects, the nature of the several intellectual faculties and their subservience to mental culture, and still more the general constitution of the mind as a system consisting of a multitude of powers under the government of reason and conscience, present to us vast fields filled with the evidences of Divine Wisdom.

There are others no less extensive and inexhaustible in the principles which underlie and maintain human society, and those which preside over the progressive development of humanity. Political economy is the department of social science which has been cultivated with most success. What, then, is its most comprehensive and best established theorem? This—that although the great majority of men are moved mainly by self-interest, and few seek with much zeal or persistency the general good, the result of their being left in perfect freedom to pursue their own advantage, so long as they do not outwardly violate the rules of justice, is far better for the whole society than if they conformed their conduct to any plan which human wisdom, aiming directly at the general good, could devise; nature having provided in the principles of the human constitution and the circumstances of human life for the selfish plans and passions of individuals so neutralising one another, so counteracting and counterpoising one another, as to secure the social stability and welfare—as to leave general ideas and interests to rule with comparatively little resistance. It is surely a natural inference from this that a Supreme Reason grasps all human reasons, and uses them in order to realise a purpose grander and better than any which they themselves contemplate. History viewed as a whole teaches the same truth on a wider scale. An examination of it discloses a plan pervading human affairs from the origin of man until the present day—a progress which has proceeded without break or stoppage, in accordance with laws which are as yet very imperfectly apprehended. Of the countless generations which have come and gone like the leaves of the forest, for unknown thousands of years, few have had the slightest glimpse of the order which connected them with their fellows, and embraced their every action; fewer still have sought to conform to it; the immense majority have set before them only mean and narrow schemes for personal good; all passions have raged and all vices prevailed in their turn; there have been confusion and tumult and war; and yet the order, progress, plan of which I speak, have been slowly and silently but surely built up. In this evolution of order out of the chaos of millions on millions of conflicting human wills seeking merely their own pleasure, there is, perhaps, even a more impressive proof of the operation of Divine Wisdom than in the origination and preservation of order among the multitudinous stars of heaven. The philosophical historian who has most conclusively shown by the scrutiny of the chief events in the annals of humanity the existence of such a progressive plan, is amply justified in arguing that it cannot have originated with man, or matter, or chance, but must be the work of God. " We have passed in review," he says, " all the theories imagined by philosophers and historians to explain the mysterious fact that there is in the life of man unfolded

in history a succession, a plan, a development, which cannot be referred to man himself. Some, despairing from the outset to find a solution, make of their ignorance a blind power which they call hazard. Evidently that is no solution. Hazard is a word, and nothing more. Other writers —the majority of writers—say that this mysterious power is nature, under the form of climate, or races, or the whole of the physical influences which act on the moral world. But what is nature? Whence has it this power, this foresight, this intelligence, which are so conspicuous in the course of our destinies? If nature is matter, and nothing but matter, that too is no answer. Who will believe that matter acts with wisdom—with intelligence? Where there is intelligent action there must be an intelligent being; therefore nature leads us to God. Finally, there are those who substitute for nature general laws. But do not laws suppose a legislator? and who can this legislator be, if not God? "

There is, then, everywhere, both in the physical and moral worlds, order an d adaptation, proportion and co-ordination, and there is very widely present progress—order which advances in a certain direction to a certain end, which is until realised only an ideal. This is the state of things which science discloses. The question is, Is this state of things intelligible on any other supposition than that of a designing mind? The theist holds that it is not; that it directly and imperatively demands an intelligent cause; that to assign it either to no cause, or to any other than an intelligent cause, is, in the strictest and strongest sense of the term, absurd. If we deny that there is such order as I have indicated, we set aside the entire teaching of all the sciences—we pronounce science to be from beginning to end a delusion and a lie. Men in the present day dare not do this. If we deny that such order implies the agency of a Supreme Intelligence, we contradict no express declaration of any of the sciences; we may accept all that they have to tell us about order, and they can tell us about nothing else. But notwithstanding this, it is far more reasonable, far less absurd, to deny that there is order in the universe, than to admit it and deny that its ultimate cause is an intelligence. Further, although we cannot be more certain of the cause than of the effect from which it is inferred, and consequently cannot be more certain that an intelligence has produced the order which is in the universe than that there is order therein, the theistic inference from the whole of that order may well be greatly stronger than the scientific proof of order in any particular instance. Men of science have probably never as good reasons for believing in the laws of order brought to light by their own special science, as the theist has for believing in a Supreme Intelligence because of the order which is the common and concurrent result of all the sciences, and which is obvious to every eye.

II.

The argument from order and adaption is often spoken of as " the argument from design." The phrase is an unfortunate one. The argument is not from but to design. To assume design and then to affirm that "every design must have a designer," is manifestly not serious reasoning, but a play upon words. To assume design at all is to assume precisely what one is most bound to prove; and to assume design in the universe is to assume what cannot be proved, yea, what the theist requires to show against the pantheist cannot be proved. In any other than a very loose and metaphorical sense design has no existence except in mind. There is no design in the sky, or the sea, or the land; there are only law, order, and arrangement therein, and these things are not designs although they imply designs. What we can describe as the designs of the lower animals are given to them with their constitutions, and are only a part of the instrumentality which fits them for their place in the world. Men have designs properly so called; but the argument for the existence of God from the evidences of a Supreme Wisdom in the progressive evolution of human history, instead of resting on these designs, is based on the fact that what has actually been realised has far transcended them. Science, as a mere exposition of the facts of the universe, can never show us Divine design, for the good reason that there is no such design in these facts, although, had it not existed elsewhere, they could never have been what they are. While this is true, it must in justice be added that most if not all of the advocates of theism who have presented the argument under consideration in the faulty

form,—" Design implies a designer; the universe abounds in design; therefore the universe, so far as it abounds in design, implies a designer,"—have erred more in expression than in thought. In reality they have not meant by design what is properly so called, and consequently have not begun their argument by assuming what was denied and in need of proof. In reality they have meant by design those characteristics of things which they hold to be the indications or evidences or correlatives of intelligence, and which they might have designated by such terms as order, adjustment, adaptation, fitness, progress, &c All attempts to refute their reasoning, therefore, by a strict and literal interpretation of the phrase " Design implies a designer," must be pronounced unfair. Censure of the phrase is warranted. Rejection of the argument on account of the phrase is superficial and unjust.

It has been held that the argument from order and adaptation is essentially different from the design argument. The reason given for this has been that the design argument is based on the analogy or supposed analogy between the works of nature and the products of human art. In this argument, we are told, we infer from the likeness which certain natural objects bear to artificial objects that there must be a likeness in their causes. We know, it is said, that only intelligent beings frame such structures as houses, ships, and watches; and seeing that there is in the mechanism of the heavens, the circulation of the blood, and the construction of the eye, arrangements and adjustments of a similar kind, we conclude that they also must have been framed by an intelligent being, who must be as much greater than man as the works of nature are greater than the works of art, for causes are proportional to their effects. Now this may be the design argument as some have presented it who had no particular wish to criticise it severely, and it certainly is the way in which Hume and Kant wished it to be presented; but it has no claim whatever to be considered the only proper form of the argument, and is, in fact, a very bad form of it. It is true that there is an analogy between the works of nature and the works of art, and that on the strength of this analogy the two classes of works, and also their causes, may be compared, but not true that the design argument, when correctly stated, either rests on such analogy or implies such comparison. The analogy and comparison may be drawn into, and, as it were, incorporated with the design argument, but that is rather as a means of illustration than as a condition of inference. When we infer from an examination of their construction that the eye and the ear have been designed by an intelligent being, we are no more dependent on our knowledge that a watch or a telescope has been designed by an intelligent being than we are dependent on our knowledge of the eye and ear being the products of intelligence when we infer that the watch and the telescope are the products of intelligence. There is an inference in both cases, and an inference of precisely the same nature in both cases. It is as direct and independent when the transition is to God from His works as when to our fellow-men from their works. We are greatly mistaken if we suppose that we have an immediate knowledge of the intelligence of the beings who make watches, houses, and ships; we only know that the beings who make these things are intelligent because such things could not be made without intelligence: in a word, we only know our fellow-creatures to be intelligent beings because they utter and arrange sounds so as to convey a meaning, execute movements which tend to an end, and construct machines. We have no more a direct perception or a personal experience of the intelligence of our fellow-men than we have of the intelligence of God. The mind which has given origin to the order and adjustments of the universe is not more absolutely inaccessible to sense and self-consciousness than the mind which gives origin to the order and adjustments of a watch. It is therefore impossible that our knowledge of the former should be dependent on our knowledge of the latter. In both cases the knowledge is inferential,—in both cases it is dependent on the immediate consciousness of intelligence in ourselves,—but the inference is in the former case neither longer nor less legitimate than in the latter. We deny, then, that there is any truth in the statement that the design argument rests on the analogy between the works of nature and the products of art. It rests directly on the character of the works of nature as displaying order and adjustment. It is essentially identical with the argument which we have expounded.

It is not less objectionable to speak of the argument from order and adaptation as being an argument from final causes than to speak of it as being an argument from design, unless the different significations of final cause be distinguished, and those which are irrelevant and illegitimate be excluded. For the expression "final cause" has various significations which are indeed intimately related, yet which cannot be employed indifferently without leading to utter confusion. These significations may be distributed into two classes. Each class contains three significations, and every signification of the first class has a signification of the second class to correspond to it. In fact, the significations of the first class are simply so many aspects of order or adaptation, and those of the second class so many aspects of design or intention; the former are order and adaptation viewed with reference to the intrinsic, the extrinsic, and the ultimate ends of things, and the latter are design and intention viewed with reference to the same three ends. Final cause sometimes means the intrinsic end of what is orderly and adjusted, the realisation of the nature of anything which is considered as a whole, a complex of order and adjustment. The combined stability and movement of the solar system is in this sense the final cause of the arrangements by which that result is secured. Sight is in this sense the final cause of the eye, because in sight the true nature of the eye manifests itself. Then, final cause sometimes means not the intrinsic but the extrinsic end of what is orderly and adjusted; not merely the realisation of the nature of anything, but its relationship to other things, its adaptations to then requirements, its uses; not merely the end of an arrangement regarded as a self-contained or completed whole, but the end or ends which it serves as a system surrounded by, connected with, and included in other systems. It is impossible to admit final cause in the sense of intrinsic end and to deny it in that of extrinsic end; for the universe is not a mere aggregate of systems placed alongside of one another, but otherwise unconnected—it is itself a system composed of an infinity of systems within systems. Nothing in nature stands alone; nothing lives to itself nor dies to itself. What is a whole with reference to something smaller than itself, is a part with reference to something larger than itself. The eye is a whole with reference to its own cords, lenses, fluids, and membranes, but it is a part with reference to the body; sight is therefore not more certainly its end than the uses of sight. How can a man admit final cause to be involved in the relationship between his stomach and bodily life, but deny it to be involved in the relationship between his stomach and the vegetable and animal substances with which he satisfies its cravings? Clearly the distinction between intrinsic and extrinsic ends is a narrow one, and exists not so much in the nature of things as in our way of looking at things. We have but to elevate and extend our own view, and what was before an extrinsic end is thereby changed into an intrinsic end. Admit, in fact, final cause anywhere, and you must admit it everywhere; admit anything to have an end, and you must admit all things to have an end; for the world is a grand and wondrous unity in which all objects depend on and serve one another, and all forces contribute to the attainment of a single comprehensive issue. Once accept the principle of finality, and there is no consistent stopping short of - the conviction of Aristotle, that on it hang the whole heavens and earth.

It is only when the word final cause is used in one or other of these two senses that we can with any propriety speak of reasoning from final causes to the existence of God. And these are just the senses in which the expression is now least used. Final cause is generally employed at present to signify design. It means, not the arrangement of causes and effects into systematic unities, the parts of which have definite relations to one another and a common issue, or the adaptation of these unities to support and serve one another, but purpose or intention in the Divine Mind with respect to such arrangement or adaptation. This sense of the word is so obviously general enough to refer both to intrinsic and extrinsic ends that it would be unnecessary to direct attention to the fact, were it not that we are much more apt to fall into error regarding extrinsic than intrinsic ends, and consequently, regarding the intention or purpose which refers to them. A thing has just one intrinsic end—namely, the single conspicuous and all-comprehensive function or issue in virtue of which we can regard it as being a whole or unity, and as possessed of a certain relative

independence or completeness. There is thus comparatively little possibility of error in determining what the intrinsic end is in a given instance, and comparatively little danger of presumption in affirming it to have been the end contemplated by the Divine Mind. There is no doubt, for example, that the eye is an instrument constructed in a way calculated to attain the intrinsic end—sight; and there can be no presumption in affirming that God must have had that end in view in the construction of the eye. If there be a God, and if He have had anything to do with the making of the eye, He must have designed that His creatures should see with their eyes. It is different with extrinsic ends. A thing has never merely one extrinsic end; it has always a multitude of extrinsic ends, for it is always related to a multitude of other things. If we would speak of the extrinsic end of a thing we must mean thereby the whole of its adaptations to other things, the entire circle of its external relationships, the sum of its uses. ■ But men have always shown themselves prone in judging of the extrinsic ends of things to single out some particular adaptation or use, or at least a few adaptations or uses, and to ignore or exclude all others. And especially have they shown themselves prone to judge of things merely from their relationship and utility to themselves, as if their happiness was the chief, if not sole end, of all things. This is, of course, an utterly erroneous method of judging, and necessarily leads to ridiculous thoughts about things, and to irreverent thoughts about God's designs in the creation of things. " It can," as Hegel tells us, " truly profit neither religion nor science if, after considering the vine with reference to the well-known uses which it confers upon man, we proceed to consider the cork-tree with reference to the corks which are cut from its bark to serve as stoppers for wine-bottles."

When we affirm, then, that final causes in the sense of intrinsic ends are in things, we affirm merely that things are systematic unities, the parts of which are definitely related to one another and co-ordinated to a common issue; and when we affirm that final causes in the sense of extrinsic ends are in things, we affirm merely that things are not isolated and independent systems, but systems definitely related to other systems, and so adjusted as to be parts or components of higher systems, and means to issues more comprehensive than their own. We cannot affirm that final causes in the sense of designs are in things; they can only exist in a mind. What do we mean when we hold that final causes in this sense truly are in the Divine Mind, and with reference equally to intrinsic and extrinsic ends? Merely that such order and adjustment as may actually be seen in things and between things—seen with the naked eye it may be, or only to be seen through the telescope or microscope—or which, if they cannot be seen, yet can by scientific induction be proved to be in and between things,—that that order and adjustment which actually exist, were intended or designed by God to exist. Of course every theist who sees evidences of God's existence in the harmonies of nature, must necessarily rise to final causes in this sense from final causes in the other senses which have been indicated; he must pass from material arrangements to the Divine Intelligence which he believes to be manifested by them. And there can be no shadow of presumption in any theist searching for final causes—Divine designs—in this sense and to this extent. What Descartes and others have said against doing so, on the ground that it is arrogant for a man to suppose he can investigate the ends contemplated by the Deity—can penetrate into the counsels of Divine Wisdom—has manifestly no force or relevancy, so long as all that is maintained is that the order which actually exists was meant to exist. The doubt or denial of that is irreverent. To admit the existence of God, and yet to refuse to acknowledge that He purposed and planned the adaptations and harmonies in nature, is surely as presumptuous as it is inconsistent. To assume that God is ignorant of the constitution and character of the universe, and has had no share in the contrivance and management of it, is to degrade Him to the level of the dream-and-dread-begotten gods of Democritus and Epicurus. Better not to think of God at all, than to think of Him in such a way.

The final cause of a thing, however, may mean, and with reference both to adjustment and design, neither its intrinsic nor extrinsic, but its ultimate end. It may mean, not merely that a thing is and was intended to be the mechanism or organism which science analyses and explains, and to stand in

the relationships and fulfil the uses which science traces, but also that it will have, and was intended to have, a destination in the far future. We may ask, What is the goal towards which creation moves? What will be the fate of the earth? In what directions are vegetable and animal life developing? What is the chief end of man? Whither is history tending? What is the ideal of truth which science has before it, and which it hopes to realise? of beauty, which art has before it? of goodness, which virtue has before it? And although to most if not all of these questions probably no very definite and certain answer can be given, to deny that they can in any measure be answered, to pronounce all speculation regarding ultimate ends as wholly vain, would justly be deemed the expression of a rash and thoughtless dogmatism. Science claims not only to explain the past but to foretell the future. The power of prevision possessed by a science is the best criterion of its rank among the sciences when rank is determined by certitude. And most significant is the boldness with which some of the sciences have of late begun to forecast the future. Thus, with reference to the end of the world, the spirit of prophecy, which until very recently was almost confined to the most noted religious visionaries, is now poured largely out upon our most distinguished physicists. This we regard as a most significant and hopeful circumstance, and trust that ere long the prophets of science will be far less discordant and conflicting in their predictions even of the remotest issues than they must be admitted to be at present.

While speculation as to final causes in the sense of ultimate ends is, within certain limits, as legitimate as it is natural, its results are undoubtedly far too meagre and uncertain to allow of our reasoning from them to the existence or wisdom of God. We must prove that there is a Divine Intelligence from what we actually perceive in things, and not from what we can conjecture ns to the final destinies of things. In fact, until we have ascertained that there is a Divine Intelligence, and in some measure what are the principles on which that Intelligence proceeds, our chance of reaching truth through speculation as to the ultimate ends of things is, in all probability, exceedingly small. It is on no hazardous speculations of this kind that we would rest an argument for the Divine existence, although questions have been raised as to the Divine character and government which will, at a later stage of the discussion, involve us to some extent in the consideration of ultimate ends.

When final cause is employed to signify design in any reference, be it to intrinsic, extrinsic, or ultimate ends, I have nothing to object to Bacon and Descartes's condemnation of it as illegitimate and unprofitable in science. I know of no science, physical or moral, in which, while thus understood, it can be of the slightest use as a principle of scientific discovery. It is as much out of place in the world of organic as of inorganic nature. It is quite incorrect to say that although it does not lead to the discovery of new truths in strictly physical science, it does so in physiology for example, or in psychology, or in ethics. It is only when it means merely the inherent order and adjustment of things—not when it means designs and purposes regarding them—that the search after it can possibly lead to scientific truth, and, when so un. derstood, it leads to truth in all sciences alike. It was the suggestive principle in Adams and Leverrier's discovery of the planet Neptune from certain unexplained perturbations of the planet Uranus, quite as much as in Harvey's discovery of the circulation of the blood from the observation of certain unexplained valves at the outlet of the veins and the rise of the arteries. It is involved in the very nature of the inductive process, and is only confirmed and enlarged by the progress of inductive research. It stands in no opposition to the principle of efficient causes, and is in no degree disproved by the discovery of such causes. Assertions to the effect that it has gradually been driven by the advance of knowledge from the simpler sciences into those which are complex and difficult,—that it is being expelled even out of biology and sociology—and that it always draws its confirmation, not from phenomena which have been explained, but from phenomena which await explanation,—are often made, but they rest almost exclusively on the wishes of those who make them. They have no real historical basis.

Lecture VI - Objections To The Argument From Order Examined

I.

The universe is a system which comprehends countless subordinate systems. It is full of combinations of parts which constitute wholes, and of means which conspire to ends. The natural and obvious explanation of the order and adjustments which it thus presents is that they are due to a mind or intelligence. And this is the only rational explanation of them. Mind can alone account for order and adjustment, for the co-ordination of parts into a whole, or the adaptation of means to an end. If we refer them to anything else, the reference is essentially contrary to reason, essentially irrational. It may seem at the first superficial glance as if there were a variety of hypotheses as to the origin of the order we everywhere see around us, all equally or nearly equally credible; but adequate reflection cannot fail to convince us that they must be reduced to a single alternative—to two antagonistic theories. Our only choice is between reason and unreason, between a sufficient and an insufficient cause, between, we may even say, a cause and no cause. This will be brought out by an examination of the various hypotheses which have been suggested by those who are unwilling to admit that the order of the world originated in mind. They try their best to suggest some other alternative than that which I have said is inevitable; but every suggestion they make only raises the alternative which they would avoid—mind or chance, reason or unreason, a sufficient explanation or an absurd one. Before proceeding to establish this, however, it may be necessary to remark on some direct objections which have been taken to the design argument,—objections which might be valid, although no explanation of order could be given or were even attempted.

The inference which the theist requires to draw from the existence of order in the universe is merely the existence of an intelligence who produced that order. It follows that it is an unfair objection to his argument to urge, as has often been urged, that it does not directly and of itself prove God to be the creator of the universe, but only the former of it—not the author of matter, but only of the collocations of matter. This objection, which men even like Hume and Kant and J. S. Mill have thought worth employing, is simply that the argument does not prove more than it professes to prove. It does not pretend to make all other reasoning for the Divine existence superfluous. It is no condition of its validity that it should stand alone; that it should contribute nothing to other arguments and receive nothing from them. The objection is thus entirely irrelevant. It may be a wise caution to those who would trust exclusively to it, and neglect or depreciate other arguments. It is no objection to its legitimacy.

It is remarkable, too, that those who have urged this objection have never felt that before employing it they were bound to satisfy themselves and to prove to others that order is a mere surface or superficial thing—outside of matter, superimposed on it. If order be something inherently and intrinsically in matter—be of its very essence—belong to what is ultimate in it; if matter and its form be inseparable,—then the author of its order must have been also the author of itself; and all that this objection shows us is, that those who have employed it have had mistaken notions about the nature of matter. Now, as I have already had to indicate, modern science seems rapidly perfecting the proof of this. The order in the heavens, and in the most complicated animal organisms, appears to be not more wonderful than the order in the ultimate atoms of which they are composed. The balance of evidence is in favour of the view that order extends as far and penetrates as deep as matter itself does. The human intellect is daily learning that it is foolish to fancy that there is anywhere in matter a sphere in which the Divine Wisdom does not manifest itself in and through order.

There is still another remark to be made on the objection under consideration. The immediate inference from the order of the universe is to an intelligent former of the universe, not to a creator. But this does not preclude the raising of the question, Is it reasonable to believe the former of the world merely its former? Must not its former be also its creator? On the contrary, the

inference that the order of the world must be the result of intelligent agency ought to suggest this question to every serious and reflective mind, and it should even contribute something to its answer. The order of the universe must have originated with intelligence. What is implied in this admission? Clearly that the order of the universe cannot have originated with matter,—that matter is unintelligent, and cannot account either for intelligence or the effects of intelligence. But if so, the intelligence which formed the universe must be an eternal intelligence. The supposition that matter is eternal must in this case be supplemented by the admission that mind is eternal. In other words, the affirmation that the former of the world is merely its former — the denial that its former is also its creator—means dualism, the belief in two distinct eternal existences,—an eternal mind and eternal matter. Whoever is not prepared to accept this hypothesis must abandon the affirmation and denial from which it necessarily follows. And who can, after due deliberation, accept it? The law of parsimony of causes absolutely forbids our assuming, for the explanation of anything, more causes than are necessary to account for it. It forbids, therefore, our belief in an eternal matter and an eternal mind, unless we can show reason tor holding that one of them alone is not a sufficient cause of the universe. Now those who grant the inference from order to intelligence, themselves admit that matter is not a sufficient First Cause of the universe as it actually exists. Do they find any person admitting that mind would be an insufficient First Cause? Do they themselves see any way of showing its insufficiency? Do they not even perceive that it would be foolish and hopeless to try to show that an eternal mind could not create a material universe, and that all they could show would be, the here quite irrelevant truth, that the human mind is ignorant of the manner in which this could be done? If the answers to these questions are what I believe they must be, it must also be acknowledged that the former of the universe can only be rationally thought of as also its creator.

I turn to the consideration of another equally futile objection to the argument from order. That argument, it is said, does not prove the Divine Intelligence to be infinite. The universe, as a system of order, is finite, and we have no right to conclude that its cause is in respect of intelligence, or in any other respect, infinite. We must attribute to the cause the wisdom necessary to produce the effect, but no more. The obvious reply is, that this is precisely what we do. The argument is not employed to prove the infinity of the Divine Intelligence, but to prove that the order and adaptations which everywhere abound in the universe must have had an intelligence capable of conceiving and producing them. It is an obvious and legitimate argument to that extent, and it is pushed no farther. The inference that the world had an intelligent author is as simple, direct, and valid, as that any statue, painting, or book had an intelligent author. When Mr Spencer, Mr Lewes, and Professor Tyndall argue that the cause of the universe cannot be known to be intelligent, because the reason of man, being finite, cannot comprehend the infinite, they overlook that the reason of man has no need to comprehend the infinite in order to apprehend such manifestations of the infinite as come before it. Just as a person reading the works of the able men who urge this weak objection feels certain that these books must have had their origin in minds endowed with certain intellectual powers, and cannot have been produced by chance, or blind forces, or bodies destitute of minds, and this although much in their minds is and always must be inscrutable to him; so, when he studies the books of nature and of history, he feels equally, and in the same way, certain, that they are the compositions of a most amazing intellect; and his certainty as to this need not be lessened, clouded, or in any degree affected, by the great and undubitable, but here irrelevant, truth—that the mind of God is in itself, in its essence, inscrutable; and in its greatness, its infinity, incomprehensible.

The argument from order must further be admitted to be sufficient to show, if valid at all, that the wisdom of the First Cause is of the most wondrous character. The more nature and mind and history are studied by any one who sees in them evidence of design at all, the more wondrous must the wisdom displayed in them be felt to be. Whoever realises that that wisdom is at once guiding the countless hosts of heavenly bodies in all their evolutions through the boundless realms of space,

and fashioning and providing for the countless hosts of microscopic creatures dwelling on the leaf of a flower or in a drop of water, everywhere accomplishing a multitude of ends by few and simple means, or effecting single and definite purposes by the most elaborate and complex contrivances, must feel that rash beyond all expression is the short-sighted mortal who can venture to affirm that it is not infinite. If "the Lord by wisdom hath founded the earth, and by understanding hath established the heavens," His wisdom and His understanding are at least so great that we cannot measure them, and have no right to pronounce them limited. The adjustments and harmonies of the universe, as we know it, indicate a depth and richness of wisdom in its Author which far pass our comprehension; and the universe which we know is probably less in comparison with the universe which God has made, than the leaf on which a host of animalcules live and die is in comparison with the vastest of primeval forests, or an ant-hill with the solar system. The universe which we see and know is a noble commentary on such words of Scripture as these: " I wisdom dwell with prudence, and find out knowledge of witty inventions. The Lord possessed me in the beginning of His way, before His works of old. I was set up from everlasting, from the beginning, or ever the earth was. When He prepared the heavens, I was there: when He set a compass on the face of the depth: when He established the clouds above: when He strengthened the fountains of the deep: when He gave to the sea his decree, that the waters should not pass His commandment: when He ap~ pointed the foundations of the earth: then I was by Him, as one brought up with Him; and I was daily His delight, rejoicing always before Him." But beyond the universe which we see and know, extend illimitable fields of space and stretches of time which we do not see and do not know, but which may be even more crowded with the works of Divine Intelligence than any which are within our range of bodily or mental vision. The ingenious authors of the book entitled 'The Unseen Universe' suppose the entire visible universe to be but a local product and temporary phase of a far older and greater universe, which itself again may be only an island in the ocean of a universe still more stupendous and refined. Whatever error may be mingled with this thought in the work mentioned, there is, I doubt not, at least this much of truth also, that the entire course of nature which science reveals is but a ripple, a current, in the ocean of God's universal action. The man whose mind is duly open to the possibility of this will not venture to pronounce the intelligence of God to be finite. The man who fails to recognise its possibility is very blind, very thoughtless.

It is scarcely credible that the evidences of God's wisdom should have been argued to be proofs of His weakness. And yet this has happened. " It is not too much to say," wrote Mr J. S. Mill, "that every indication of design in the Kosmos is so much evidence against the omnipotence of the Designer. For what is meant by design? Contrivance: the adaptation of means to an end. But the necessity for contrivance—the need of employing means—is a consequence of the limitation of power. Who would have recourse to means if to attain his end his mere word was sufficient? The very idea of means implies that the means have an efficacy which the direct action of the being who employs them has not. Otherwise they are not means, but an encumbrance. A man does not use machinery to move his arms. If he did, it could only be when paralysis had deprived him of the power of moving them by volition. But if the employment of contrivance is in itself a sign of limited power, how much more so is the careful and skilful choice of contrivances? Can any wisdom be shown in the selection of means when the means have no efficacy but what is given them by the will of him who employs them, and when his will could have bestowed the same efficacy on any other means? Wisdom and contrivance are shown in overcoming difficulties, and there is no room for them in a being for whom no difficulties exist. The evidences, therefore, of natural theology distinctly imply that the author of the Kosmos worked under limitations."

This, it seems to me, is very strange and worthless reasoning. According to it, the ability of God to form and execute a purpose is evidence not of power but of weakness. I wonder if Mr Mill imagined that the inability of God to form and carry out a purpose would have been evidence not of His weakness but of His power. Or did he suppose, perhaps, that both ability and inability were signs of

weakness, and that, consequently, for once opposites were identical? Or did he not think on the subject at all, and so reasoned very much at random? I confess I cannot see how ability to contrive things is weakness, or inability to contrive them power. I hold to Bacon's maxim that "knowledge is power," and refuse to admit that wisdom is weakness. But God, if omnipotent, it is said, did not need to contrive: His mere word must have been sufficient. Yes, is the obvious answer; His mere word, His mere will, was sufficient to produce all His contrivances, and has produced them all. There is no shadow of reason for suspecting that anything was difficult to Him or for Him. No such suspicion is entertained by those who employ the design argument; and those who would rationally object to that argument must find something else to insist on than the power of God's mere will. The will of God is everywhere as efficacious as He in His omnipotence and omniscience chooses that it should be. At the same time, if He desire certain ends, His will cannot remain mere will and dispense with the contrivance of appropriate means. If He wish to bestow happiness on human beings, He must create human beings, and contrive their bodies and minds. To speak of His will as able to " bestow the same efficacy on any means " is no less contrary to reason that it would be to speak of it as able to make the part greater than the whole. It is only in the world imagined by Mr Mill—one in which two and two might be five—that a sunbeam could serve the same purpose as a granite pillar or a steam-engine; and such a world, most people will assuredly hold, even omnipotence could not create. Infinite power and wisdom must necessarily work " under limitations" when they originate and control finite things; but the limitations are not in the infinite power and wisdom themselves—they are in their operations and effects. According to Mr Mill's argument, infinite power could not create a finite world at all: only a finite power could do so. That surely means that a finite power must be mightier than an infinite power; and that, again, is surely a plain self-contradiction, a manifest absurdity.

There is another objection which, although in itself unworthy of answer, has been urged so often and presented in so many forms, some of which are rhetorically impressive, that it cannot be wholly passed over. The design argument has been censured as " assuming that the genesis of the heavens and the earth was effected somewhat after the manner in which a workman shapes a piece of furniture "—as " converting the Power whose garment is seen in the visible universe into an Artificer, fashioned after the human model, and acting as man is seen to act "—as "transforming the First Cause into a magnified mechanist who constructs a work of art, and then sits apart from it and observes how it goes," &c Now the heavens and the earth are to such a wonderful extent exemplifications both of mechanical laws and aesthetic principles, that no man of sense, I think, will deny that they may most justly be compared to machines or works of art, or even pronounced to be machines and works of art. They are that, although they are more than that. An animal is a machine, although an organism too. Every organism is a machine, although every machine is not an organism. Art and nature are not antagonistic and exclusive. Man and all man's arts are included in nature, and nature is the highest art. While, however, it is legitimate and even necessary to illustrate the design argument by references to human inventions, the numerous and immense differences between the works of man's art and the processes of nature must not be overlooked; and there is no excuse for saying that they have been overlooked. It is precisely because the universe is so above anything man has made or can make, and because vegetable and animal organisms are so different from watches and statues, that the argument in question leads us to a divine and not to a merely human intelligence. It implies that both the works of God and the works of man are products of intelligence; but it does not require that they should have anything else in common. It recognises that the most elaborate and exquisite contrivances of man fall immeasurably below "nature's most minute designs." So far from requiring, it forbids our carrying any of the limitations or peculiarities of human contrivance over to that which is divine. Besides, the belief in design is held in conjunction with the belief in creation out of nothing. The same persons who recognise that there is a divine wisdom displayed in the constitution and course of nature believe the universe to have been called into being by the mere volition of the Almighty. But among all theories of the genesis of the heavens and the earth, that is the only one which does not represent

the First Cause as working like a man. Man never creates — he cannot create. To produce anything he must have something to work on—he must have materials to mould and modify.

II.

Those who refuse to refer the order and adaptations in the universe to a designing intelligence are bound to account for them in some other way. Has this been done? Has any person succeeded in tracing them back to any other principle which can be reasonably regarded as their cause, or as adequate to their production? This is the question which we have now to consider.

Matter, some would have us believe, is the origin of the order of the universe. Grant it, and there is still the question to be disposed of—What is the origin of matter? We have seen that this is a question which we are bound to raise; we have seen that there are strong reasons for holding that matter had an origin, had a beginning in time, and none whatever for regarding it as self-existent and eternal. The very existence of order and system, of mechanical adjustments and organic adaptations in the universe, seems to prove that matter must have had a beginning. If certain collocations of matter evince design, and must have had a beginning, the adaptation of the parts to form the collocation evinces design, and implies a beginning. And if matter had a beginning, its cause can only have been mind. To say that it originated with chance or necessity is plainly absurd. Chance and necessity are meaningless terms unless mind or matter be presupposed. There can be no accidents where neither mind nor matter exists. There can be no change where there is no law. Chance or accident is what occurs when two or more independent series of phenomena meet, without their meeting having been premeditated and provided for. When one series of causes leads a man to pass a house at a given moment of a given day, and another series of causes, coexistent with but wholly independent of the former series, determines that a heavy body shall fall from the roof of that house at that moment of that day and kill that man, the consequence—his death—is what may be properly called an accident, or matter of chance. One who believes, indeed, in the omniscience and universal foreordination and government of God, will hold that even in such a case the accident or chance is merely apparent; but he will not deny the right of the atheist to speak of chance or accident in this way, or to explain as matters of chance whatever he can. The word chance, or accident, can have no intelligible sense, however, unless there be such independent series of phenomena—unless there be mental and material existences, mental and material laws. Chance cannot be conceived of, even by the atheist, as the origin of existence. The same may be said of necessity. Matter or mind may act necessarily, but necessity cannot act without matter or mind. If it be requisite, therefore, to seek a cause for matter, mind alone can be assigned as its cause. If we are justified in seeking for the origin of matter at all, our choice of an answer lies between mind and absurdity, between a real and sufficient cause and an imaginary and in conceivable cause. Besides, how could matter of itself produce order, even if it were self-existent and eternal? It is far more unreasonable to believe that the atoms or constituents of matter produced of themselves, without the action of a Supreme Mind, this wonderful universe, than that the letters of the English alphabet produced the plays of Shakespeare, without the slightest assistance from the human mind known by that famous name. These atoms might, perhaps, now and then, here and there, at great distances and long intervals, produce, by a chance contact, some curious collocation or compound; but never could they produce order- or organisation, on an extensive scale or of a durable character, unless ordered, arranged, and adjusted in ways of which intelligence alone can be the ultimate explanation. To believe that their fortuitous and undirected movements could originate the universe, and all the harmonies and utilities and beauties which abound in it, evinces a credulity far more extravagant than has been ever displayed by the most superstitious of religionists. Yet no consistent materialist can refuse to accept this colossal chance-hypothesis. All the explanations of the order of the universe which materialists, from Democritus and Epicurus to Diderot and Lange, have devised, rest on the assumption that the elements of matter, being eternal, must pass through infinite combinations, and that one of these must be our present world—a special collocation among the countless millions of collocations, past and future.

Throw the letters of the Greek alphabet, it has been said, an infinite number of times, and you must produce the Iliad and all Greek books. The theory of probabilities, I need hardly say, requires us to believe nothing so absurd. Throw letters together, without thought, through all eternity, and you will never make them express thought. All the letters in the Iliad might have been tossed and jumbled together from morning to night by the hands of the whole human race, from the beginning of the world until now, and the first line of the Iliad would have been still uncomposed, had not the genius of Homer been inspired to sing the wrath of Achilles and the war around Troy. But what is the Iliad to the hymn of creation, and the drama of providence? Were these glorious works composed by the mere jumbling together of atoms, which were not even prepared beforehand to form things, as letters are to form words, and which had to shake themselves into order without the help of any hand? They may believe that who can. It seems to me that it ought to be much easier to believe all the Arabian Nights.

To ascribe the origination of order to law is a manifest evasion of the real problem. Law is order. Law is the very thing to be explained. The question is—Has law a reason, or is it without a reason? The unperverted human mind cannot believe it to be without a reason. " The existence of a law connecting and governing any class of phenomena implies a presiding intelligence which has preconceived and established the law. The regulation of events by precise rules of time and space, of number and measure, is evidence of thought and mind." So says Dr Whevvell; and the statement is amply justified by the fact, that all laws and rules in the universe imply that existences are related to one another in a way of which intelligent adjustment alone is the adequate and ultimate explanation. The existence of a law uniformly involves the coexistence of several conditions, and that is a phenomenon which, whenever the conditions and law are physically ultimate, and consequently physically inexplicable, clearly presupposes mind. Laws, in a word, are not the causes but the expressions of order. They are themselves the results of delicately accurate adjustments, which indicate the operation of a divine wisdom. There are chemical laws, for example, simply because there are chemical elements endowed with affinities, attractions, or forces the most diverse, yet so balanced and harmonised as to secure the welfare of the world. Besides, laws do not act of themselves. No law produces of itself any result. It is the agents which act according to the law that produces results, and the nature of the result produced depends on the number and character of the agents, and how each is situated and circumstanced. If the agents oppose each other, or are inappropriately distributed, they bring about disorder and disaster in conformity to law. There is no calamity, no evil, no scene of confusion, in the known world, which is not the result of the action of agents which operate in strictest accordance to law. The law of gravitation might rule every particle of matter, and yet conflict and confusion and death would prevail throughout the entire solar system were harmony and stability and life not secured by very special arrangements. Matter might have all its present inherent and essential laws, and yet remain for ever a chaos. Apart from a designing and superintending intelligence, the chances in favour of chaos and against cosmos, even allowing matter to have uncreated properties and laws, were incalculable. The obvious inference is that which Professor Jevons expresses in these words: " As an unlimited number of atoms can be placed in unlimited space in an unlimited number of modes of distribution, there must, even granting matter to have had all its laws from eternity, have been at some moment in time, out of the unlimited choices and distributions possible, that one choice and distribution which yielded the fair and orderly universe that now exists." Only out of rational choice can order have come.

The most common mode, perhaps, of evading the problem which order presents to reason, is the indication of the process by which the order has been realised. From Democritus to the latest Darwinian there have been men who supposed that they had completely explained away the evidences for design in nature when they had described the physical antecedents of the arrangements appealed to as evidences. Aristotle showed the absurdity of the supposition more than 2200 years ago. But those who deny final causes have gone on arguing in the same irrational

manner down to the present time. They cannot, in fact, do otherwise. They are committed to a false position, and they dare not abandon the sophism on which it rests. Nothing else can explain how any sane mind should infer that because a thing is conditioned it cannot have been designed. The man who argues that the eye was not constructed in order to see because it has been so constructed as to be capable of seeing, is clearly either unable to reason correctly, or allows his reasoning faculty to be terribly perverted by prejudice. That a result is secured by appropriate conditions can seem to no sound and unprejudiced intellect a reason for regarding it to have been undesigned. And yet what other reason is involved in all the attempts to explain away final causes by means of the nebular, Darwinian, and other development hypotheses?

M. Comte imagines that he has shown the inference of design, from the order and stability of the solar system, to be unwarranted, when he has pointed out the physical conditions through which that order and stability are secured, and the process by which they have been obtained. He refers to the comparative smallness of the planetary masses in relation to the central mass, the feeble eccentricity of their orbits, the moderate mutual inclination of their planes, and the superior mean density of their solid over their fluid constituents, as the circumstances which render it stable and habitable, and these characteristic circumstances, as he calls them, he tells us flow naturally and necessarily from the simple mutual gravity of the several parts of nebulous matter. When he has done this, he supposes himself to have proved that the heavens declare no other glory than that of Hipparchus, of Kepler, and of Newton.

Now, the assertion that the peculiarities which make the solar system stable and the earth habitable have flowed naturally and necessarily from the simple mutual gravity of the several parts of nebulous matter, is one which greatly requires proof, but which has never received it. In saying this, we do not challenge the proof of the nebular theory itself. That theory may or may not be true. We are quite willing to suppose it to be true; to grant that it has been scientifically established. What we maintain is, that, even if we admit unreservedly that the earth, and the whole system to which it belongs, once existed in a nebulous state, from which they have been gradually evolved into their present condition conformably to physical laws, we are in no degree entitled to infer from the admission the conclusion which Comte and others have drawn. The man who fancies that the nebular theory implies that the law of gravitation, or any other physical law, has of itself determined the course of cosmical evolution, so that there is no need for believing in the existence and operation of a Divine Mind, proves merely that he is not exempt from reasoning very illogically. The solar system could only have been evolved out of its nebulous state into that which it now presents if the nebula possessed a certain size, mass, form, and constitution—if it was neither too rare nor too dense, neither too fluid nor too tenacious; if its atoms were all numbered, its elements all weighed, its constituents all disposed in due relation to each other—that is to say, only if the nebula was, in reality, as much a system of order, for which intelligence alone could account, as the worlds which have been developed from it. The origin of the nebula thus presents itself to the reason as a problem which demands solution no less than the origin of the planets. All the properties and laws of the nebula require to be accounted for. What origin are we to give to them? It must be either reason or unreason. We may go back as far as we please, but at every step and stage of the regress we must find ourselves confronted with the same question—the same alternative.

The argument of Cotrtte, it is further obvious, proceeds on the arbitrary and erroneous assumption that a process is proved to have been without significance or purpose when the manner in which it has been brought about is exhibited. It is plain that on this assumption even those works of man which have cost most thought might be shown to have cost none. A house is not built without considerable reflection and continuous reference to an end contemplated and desired, but the end is only gradually realised by a process which can be traced from its origin onwards, and through the concurrence or sequence of a multitude of conditions. Would a description of the circumstances on

which the security and other merits of a house depend, —of the peculiarities in its foundation, walls, and roof, in its configuration and materials, which render it convenient and comfortable, or of the processes by which these peculiarities were attained,—prove the house to have been unbuilt by man, to have been developed without the intervention of an intelligent architect? It would, if Comte's argument were good; if it would not, Comte's argument must be bad. But can any one fail to see that such an argument in such a case would be ridiculous? The circumstances, peculiarities, and processes to which reference is made are themselves manifest evidences of design and intelligence. They are a part of what has to be explained, and a part of it which can be only explained on the supposition of a contriving and superintending mind. They entitle us to reject all hypotheses which would explain the construction of the house without taking into account the intelligence of its architect. The circumstances, peculiarities, and process described by Comte, as rendering the earth an orderly system and the abode of life, are no less among the evidences for the belief that intelligence has presided over the formation of the earth. They require for their rational comprehension to be thought of as the means and conditions by which ends worthy of intelligence have been secured. They require to be accounted for; and they cannot be so reasonably except on the supposition that they have been designed. If we reject that view we must accept this, that the present system of things is a special instance of order which has occurred among innumerable instances of disorder, produced by the interaction of the elements or atoms of matter in infinite time. These elements or atoms we must imagine as affecting all possible combinations, and falling at length, after countless failures, into a regular and harmonious arrangement of things. Now, we can in a vague, thoughtless way imagine this, but we cannot justify our belief of it either by particular facts or by general reasons. It is an act of imagination wholly divorced from intelligence. Thus to refer the origin and explanation of universal order to chance, is merely mental caprice.

If the evolution of the earth and the heavenly bodies from a nebula destroy neither the relevancy nor the force of the design argument, the development of complex organisms from simple ones, and the descent of all the plants and animals on earth from a very few living cells or forms, will not remove or lessen the necessity for supposing an intelligence to have designed all the organisms, simple and complex alike, and to have foreordained, arranged, and presided over the course of their development. Were it even proved that life and organisation had been evolved out of dead and inorganic matter, the necessity of believing in such an intelligence would still remain. Nothing of the kind has yet been proved. On the contrary, scientific experimentation has all tended to show that life proceeds only from life. But had it been otherwise—had this break and blank in the development theory been filled up—matter would only have been proved to be more wonderful than it had been supposed to be. The scientific confirmation of the hypothesis of what is called spontaneous generation would not relieve the mind from the necessity of referring the potency of life and all else that is wonderful in matter either to design or chance, reason or unreason—it would not free it from the dilemma which had previously presented itself.

The development of higher from lower organisms, of course, still less frees us from the obligation to believe that a supreme intelligence presides over the development. Development is not itself a cause, but a process,—it is a something which must have a cause; and the only kinds of development which have yet been shown to be exemplified in the organic world demand intelligence as their ultimate cause. I do not know that I can better prove that there is no opposition between development and design than by referring to an illustration made use of by Professor Huxley with a directly contrary view. To show that the argument from final causes, or what is often called the teleological argument, had, as commonly stated, received its death-blow from Mr Darwin, he wrote as follows: "The teleological argument runs thus -—an organ or organism (A) is precisely fitted to perform a function or purpose (B); therefore it was specially constructed to perform that purpose. In Paley's famous illustration, the adaptation of all the parts of the watch to the function or purpose of showing the time, is held to be evidence that the watch was specially

contrived to that end, on the ground that the only cause we know of competent to produce such an effect as a watch which shall keep time is a contriving intelligence, adapting the means directly to that end. Suppose, however, that any one had been able to show that the watch had not been made directly by any person, but that it was the result of the modification of another watch which kept time but poorly, and that this, again, had proceeded from a structure which could hardly be called a watch at all, seeing that it had no figures on the dial, and the hands were rudimentary, and that, going back and back in time, we come at last to a revolving barrel as the earliest traceable rudiment of the whole fabric And imagine that it had been possible to show that all these changes had resulted first from a tendency in the structure to vary indefinitely, and secondly from something in the surrounding world which helped all variations in the direction of an accurate time-keeper and checked all those in other directions,—then it is obvious that the force of Paley's argument would be gone. For it would be demonstrated that an apparatus thoroughly well adapted to a particular purpose might be the result of a method of trial and error worked by unintelligent agents, as well as of the direct application of the means appropriate to that end by an intelligent agent." (Lay Sermons, pp. 330, 331.)

Our great comparative physiologist would probably not write so at present. He may still not accept the design argument; but he is now well aware that it has not got its death-blow, nor even any serious wound, from the theory of evolution. He has since, on more than one occasion, shown the perfect compatibility of development with design. He might, perhaps, in defence of his earlier and less considerate utterances, maintain that no organ has been made with the precise structure which it at present possesses in order to accomplish the precise function which it at present fulfils; but he admits that the most thoroughgoing evolutionist must at least assume "a primordial molecular arrangement, of which all the phenomena of the universe are the consequences," and " is thereby at the mercy of the teleologist, who can always defy him to disprove that this primordial molecular arrangement was not intended to evolve the phenomena of the universe." Granting thus much, he is logically bound to grant more. If the entire evolution of the universe may have been intended, the several stages of its evolution may have been intended; and they may have been intended for their own sakes as well as for the sake of the collective evolution or its final result. If eyes and ears were contrived for a purpose, the eyes and ears of each species of animals may have been made with the precise structure which they exhibit for the precise purposes which they fulfil, although they may have been developed out of a different kind of eyes and ears, and will, in the lapse of ages, be developed into still other kinds. The higher teleology, the general designs, which Professor Huxley admits evolution cannot touch, is in no opposition to the lower teleology, the special designs, which he strangely supposes it to have definitively discarded.

Nothing can be more certain than that Dr Paley would have held the design argument to have been in no degree weakened by the theory of evolution, and that he would have been very much astonished by Professor Huxley's remarks on that argument. In referring to the mechanism of a watch as an evidence of intelligence in its maker, Dr Paley pointed out that our idea of the greatness of that intelligence would be much increased if watches were so constructed as to give rise to other watches like themselves. He must necessarily have admitted that the watch imagined by Professor Huxley was still more remarkable, and implied a still greater intelligence in its contrivance. The revolving barrel must have had wonderful capabilities, which only intelligence could confer. All the circumstances in which it was to be placed must have been foreseen, and all the influences which were to act upon it must have been taken into account, which could only be done by intelligence. All that helped variations in the direction of an accurate time-keeper must have been brought into requisition, and all that hindered it, or favoured variations in other directions, must have been detected and checked; but no unintelligent agents can be conceived of as accomplishing such work, or as more than the means of accomplishing it employed by a providential Reason. The greater the distance between the revolving barrel and the most elaborated watch — the greater the number of mechanisms between the first and the last of these

two terms, or between the commencing cause and the final result—the greater the necessity for a mind the most comprehensive and accurate, to serve as an explanation of the entire series of mechanisms and the whole process or development.

Mr Darwin, and a large number of those who are called Darwinians, profess to prove that all the order of organic nature may have been unintentionally originated by the mechanical operation of natural forces. They think they can explain how, from a few simple living forms, or even from a single primordial cell, the entire vegetable and animal kingdoms, with all their harmonies and beauties, have arisen wholly independent of any ordaining and presiding mind, by means of the operation of the law of heredity that like produces like; of variability from the action of the conditions of life, and from use and disuse; of over-production, or a ratio of increase so high as to lead to a struggle for existence; of natural selection, or the survival and prevalence of the fittest, and the disappearance and extinction of what is unsuited to its circumstances and inferior to its competitors; and of sexual selection. But the remarkable originality, ingenuity, and skill which they display in endeavouring to establish, illustrate, and apply these laws, make all the more striking the absence of freshness and independence, of force or relevancy, in the reasonings by which they would attach to them an irreligious inference. The same men who have adduced so many new facts, and thrown so much new light on facts previously known, in support of the real or alleged laws indicated, have not adduced a single new reason, and scarcely even set in a more plausible light a single old reason, for the denial of design. They assure us, copiously and vehemently, that the laws which they claim to have proved are in themselves a disproof of design; but they somehow forget that it is incumbent on them to bestow the labour requisite to make this manifest. They reason as if it were almost or wholly self-evident, whereas a little more thought would show them that all their laws imply mind and purpose.

There is a law of heredity: like produces like. But why is there such a law? Why does like produce like? Why should not all nature have been sterile? Why should there have been any provision for the propagation of life in a universe ruled by a mere blind force? And why should producer and produced be like? Why should offspring not always be as unlike their parents as tadpoles are unlike frogs? The offspring of all the higher animals pass through various embryological stages in which they are extremely unlike their parents. Why should they ever become like to them? Physical science cannot answer these questions; but that is no reason why they should not be both asked and answered. I can conceive of no other intelligent answer being given to them than that there is a God of wisdom, who designed that the world should be for ages the abode of life; that the life therein should be rich and varied, yet that variation should have its limits; that there should be no disorder or confusion; and who, to secure this result, decreed that plants should yield seeds, and animals bring forth, after their kind. He who would disprove design must certainly not start with the great mystery of generation.

Then, the so-called law of variability is the expression of a purpose which must have Reason at its beginning, middle, and end. There is in no organism an absolutely indefinite tendency to vary. Every variation of every organism is in some measure determined by the constitution of the organism. "A whale," as Dr Huxley says, " does not tend to vary in the direction of producing feathers, nor a bird in the direction of producing whalebone." But a tendency to definite variation is an indication of purpose. If a man could make a revolving barrel with a tendency to develop into a watch, he would have to be credited with having designed both the barrel and watch, not less than if he had contrived and constructed the two separately. Further, variation has proceeded in a definite direction. Darwin admits that there is no law of necessary advancement. There is no more reason in the nature of the case for improvement than for deterioration. Apart from the internal constitution of an organism having been so planned, and its external circumstances so arranged as to favour the one rather than the other, its variations could not have been more towards self-perfection than self-destruction. But variation, according to the Darwinians, has taken place in one

direction and not in another; it has been forward, not backward; it has been a progression, not a retrogression. Why? Only because of a continuous adjustment of organisms to circumstances tending to bring this about. Had there been no such adjustment, there might have been only unsuitable variations, or the suitable variations might have been so few and slight that no higher organisms would have been evolved. Natural selection might have had no materials, or altogether insufficient materials, to work with. Or the circumstances might have been such, that the lowest organisms were the best endowed for the struggle of life. If the earth were covered with water, fish would survive, and higher creatures would perish. Natural selection cannot have made the conditions of its own action—the circumstances in the midst of which it must operate. Therefore, there is more in progressive variation than it can explain: there is what only an all-regulative intelligence can explain.

Again, there is a law of over-production, we are told, which gives rise to a struggle for existence. Well, is this law not a means to an end worthy of Divine Wisdom? In it we find the reason why the world is so wonderfully rich in the most varied forms of life. What is called over-production is a productivity which is in excess of the means of subsistence provided for the species itself; but no species exists merely for itself. The ratio of the production of life is probably none too high for the wants of all the creatures which have to be supplied with food and enjoyment. And the wants of all creatures are what have to be taken into account; not the wants of any single species—not the wants of man alone. If we adequately realised how vast is the number of guests which have constantly to be fed at the table of nature, we would, I have no doubt, acknowledge that there is little, if any, real waste of life in the world. Then, the struggle to which the rate of production gives rise is, on the showing of the Darwinians themselves, subservient to the noblest ends. Although involving privation, pain, and conflict, its final result is order and beauty. All the perfections of sentient creatures are represented as due to it. Through it the lion has gained its strength, the deer its speed, the dog its sagacity. The inference seems natural that these perfections were designed to be attained by it; that this state of struggle was ordained for the sake of the advantages which it is actually seen to produce. The suffering which the conflict involves may indicate that God has made even animals for some higher end than happiness—that He cares for animal perfection as well as for animal enjoyment; but it affords no reason for denying that the ends which the conflict actually serves, it was also intended to serve. Besides, the conflict is clearly not a struggle for bare existence; it is, even as regards the animals, a struggle for the largest amount of enjoyment which they can secure, and for the free and full exercise of all their faculties. It thus manifests, not only indirectly but also directly, what its ends are. They are ends which can only be reasonably conceived of as having been purposed by an intelligence, and which are eminently worthy of a Divine intelligence.

But what of the law, or so-called law, of natural selection? In itself, and so far as physical science can either prove or disprove it, it is simply an expression of the alleged fact, that in the struggle of life, any variation, however caused, which is profitable to the individuals of a species, will tend to their preservation, will have a chance of being transmitted to their offspring, and will be of use to them likewise, so that they will survive and multiply at the expense of competitors which are not so well endowed. But natural selection, thus understood, is obviously in no opposition to design; on the contrary, it is a way in which design may be realised. Some might even hold that design cannot be conceived of as realised in any other natural way; that if not thus realised, it could only be miraculously realised. But Mr Darwin, and many of those who call themselves his followers, tell us not only that there is natural selection, but that blind forces and mechanical laws alone bring it about; that intention and intelligence have nothing to do with it. What proof do they give us? Alas! the painful thing is that they give us none. They point out the blind forces and the mechanical laws by which the selection is effected and its results secured; they show how they are adapted to accomplish their work: and then they assert that these forces and laws explain the whole matter; that no underlying and all-embracing reason has prepared, arranged, and used them. They see the

physical agencies and the physical process by which order and beauty have been attained—they do not see intelligence and design; and because they do not see them, they conclude that they have no existence. They describe the mechanism which their senses apprehend, and affirm it to have made itself, or at least to have been unmade, and to work of itself, because the mind which contrived it and directs it is inaccessible to sense. All their reasoning resolves itself into a denial of what is spiritual because it is unseen.

The only instances of natural selection which have been adduced to show that blind forces may bring about results as remarkable, and of the same kind, as those which are accomplished by intelligent agents, are manifestly irrelevant. They are of such a nature that every teleologist must hold them to imply what they are intended to disprove. When Professor Huxley points to the winds and waves of the Bay of Biscay as carefully selecting the particles of sea-sand on the coast of Brittany, and heaping them, according to their size and weight, in different belts along the shore; to a frosty night selecting the hardy plants in a plantation from among the tender ones; and to a hurricane transporting a sapling to a new seat in the soil,—he completely mistakes what the problem before him is. Fire and water can produce wonderful effects in a steam-engine; but the man who should infer, from there being no intelligence in the fire and water themselves, that intelligence must have had nothing to do with their effects when they were brought into contact in a steam-engine, would deserve no great credit for his reasoning. It is precisely Professor Huxley's reasoning. He looks at the fire and water separately, and completely ignores the engine. Because in a world which is a system of order and law a certain collocation and combination of physical conditions and forces will produce an orderly result, he infers that design and intelligence are not needed to produce such a result. I submit that that is illegitimate and irrelevant reasoning. It resolves itself into a denial of Divine and intelligent agency, because the senses apprehend merely physical elements and a physical process. It assumes a selected adaptation, which presupposes intelligence in order to get rid of intelligence. It begs the whole question.

The so-called law of sexual selection, if it be a law at all, is obviously teleological in its nature. Its end is the production of beauty in form and colour. Can blind physical forces, if not subservient to intelligence, be conceived of as working towards so essentially ideal a goal as beauty?

I think enough has now been said to show that the researches and speculations of the Darwinians have left unshaken the design argument. I might have gone farther if time had permitted, and proved that they had greatly enriched the argument. The works of Mr Darwin are invaluable to the theologian, owing to the multitude of "beautiful contrivances" and "marvellous adjustments " admirably described in them. The treatises on the fertilisation of orchids and on insectivorous plants require only to have their legitimate conclusions deduced and applied in order to be transformed into treatises of natural theology. If Paley's famous work be now somewhat out of date, it is not because Mr Darwin and his followers have refuted it, but because they have brought so much to light which confirms its argument.1

I have challenged the theology of Mr Darwin and those who follow his guidance in theology. I have no wish to dispute his science. I pass no judgment on his theories so far as they are scientific theories. It may be safely left to the progress of scientific research to determine how far they are true and how far erroneous. We ought not to assail them needlessly, or to reject the truth which is in them, under the influence of a senseless dread that they can hurt religion. In so far as they are true, they must be merely expressions of the way in which Divine intelligence has operated in the universe. Instead of excluding, they must imply belief in an all-originating, all-foreseeing, all-foreordaining, all-regulative intelligence, to determine the rise and the course and the goal of life, as of all finite things. That intelligence far transcends the comprehension of our finite minds, yet we apprehend it as true intelligence. It is no blind force, but a Reason which knows itself, and knows us, and knows all things, and in the wisdom of which we may fully confide, even when clouds

and darkness hide from us the definite reasons of its operations. We can see and know enough of its wisdom to justify faith where sight and knowledge are denied to us. Let us trust and follow it, and, without doubt, it will lead us by a path which we knew not, and make darkness light before us, and crooked things straight.

Appendices Related to Teleology and Design

Mathematics And The Design Argument

" Another science regarded as barren of religious applications, and even as sometimes positively injurious, is mathematics. Its principles are, indeed, of so abstruse a nature, that it is not easy to frame out of them a religious argument that is capable of popular illustration. But, in fact, mathematical laws form the basis of nearly all the operations of nature. They constitute, as it were, the very framework of the material world.

It seems, then, that this science forms the very foundation of all arguments for theism, from the arrangements and operations of the material universe. We do, indeed, neglect the foundation, and point only to the superstructure, when we state these arguments. But suppose mathematical laws to be at once struck from existence, and what a hideous case would the universe present! What then would become of the marks of design and unity in nature, and of the theist's argument for the being of a God? ... It is said, however, that mathematicians have been unusually prone to scepticism concerning religious truth. If it be so, it probably originates from the absurd attempt to apply mathematical reasoning to moral subjects; or rather, the devotees of this science often become so attached to its demonstrations, that they will not admit any evidence of a less certain character. They do not realise the total difference between moral and mathematical reasonings, and absurdly endeavour to stretch religion on the Procrustean bed of mathematics. No wonder they become sceptics. But the fault is in themselves, not in this science, whose natural tendencies, upon a pure and exalted mind, are favourable to religion."—Hitchcock's Religion of Geology, pp. 387-389.

" Nor can we fail to notice how frequently the law which men have invented proves to have been already known and used in nature. The mathematician devises a geometric locus or an algebraic formula from a prion considerations, and afterward discovers that he has been unwittingly solving a mechanical problem, or explaining the form of a real phenomenon. Thus, for example, in Peirce's ' Integral Calculus,' published in 1843, is a problem invented and solved purely in the enthusiasm of following the analytic symbols; but in 1863 it proved to be a complete prophetic discussion and solution of the problem of two pendulums suspended from one horizontal cord. Thus also Galileo's discussion of the cycloid proved, long afterward, to be a key to problems concerning the pendulum, falling bodies, and resistance to transverse pressure. Four centuries before Christ, Plato and his scholars were occupied upon the ellipse as a purely geometric speculation, and Socrates seemed inclined to reprove them for their waste of time. But in the seventeenth century after Christ, Kepler discovers that the Architect of the heavens had given us magnificent diagrams of the ellipse in the starry heavens; and, since that time, all the navigation and architecture and engineering of the nineteenth century have been built on these speculations of Plato. Equally remarkable is the history of the idea of extreme and mean ratio. Before the Christian era geometers had invented a process for dividing a line in this ratio, that they might use it in an equally abstract and useless problem—the inscribing a regular pentagon in a circle. But it was not until the middle of the present century that it was discovered that this idea is embodied in nature. It is hinted at in some animal forms, it is very thoroughly and accurately expressed in the angles at which the leaves of plants diverge as they grow from the stem, and it is embodied approximately in the revolutions of the planets about the sun. . . . Now, in all these cases of the embodiment in nature of an idea which men have developed, not by a study of the embodiment, but by an a priori speculation, there seems to us demonstrative evidence that man is made in the image of his Creator; that the

thoughts and knowledge of God contain and embrace all possible a priori speculations of men. It is true that God's knowledge is infinite, and beyond our utmost power of conception. But how can we compare the reasonings of Euclid upon extreme and mean ratio with the arrangement of leaves about the stem, and the revolutions of planets around the sun, and not feel that these phenomena of creation express Euclid's idea as exactly as diagrams or Arabic digits could do; and that this idea was, in some form, present in the creation? "—The Natural Foundations of Theology. By T. Hill, D.D., LL.D.

There is an ingenious and judicious little work by Charles Girdlestone, M.A., published in 1875, anc^ en" titled ' Number: a Link between Divine Intelligence and Human. An Argument.'

Astronomy And The Design Argument

The design argument has always drawn some of its data from astronomy. The order and beauty of the heavenly bodies, the alternation of day and night, the succession of the seasons, and the dependence of living creatures on these changes, are referred to as indications of God's character and agency in many passages of Scripture. Thus, to select only from the Psalms: "When I consider Thy heavens, the work of Thy fin gers, the moon and the stars, which Thou hast ordained; what is man, that Thou art mindful of him? and the son of man, that Thou visitest him?"—viii. 3, 4. "The heavens declare the glory of God; and the firmament shovveth His handiwork. Day unto day uttereth speech, and night unto night showeth knowledge."—xix. 1, 2. " He appointed the moon for seasons; the sun knoweth his going down. Thou makest darkness, and it is night: wherein all the beasts of the forest do creep forth. . . . The sun ariseth, they gather themselves together, and lay them down in their dens. Man goeth forth unto his work and to his labour until the evening. O Lord, how manifold are Thy works! in wisdom hast Thou made them all."—civ. 19-24. Among classical writers, Cicero has presented the design argument as founded on the arrangements and movements of the heavenly bodies in a very striking manner, when, referring to the instrument by which Posidonius had ingeniously represented them, he asks whether, if that instrument were carried into Scythia or Britain, any even of the barbarians of these lands would doubt that it was the product of reason, and rebukes those who would regard the wondrous system of which it was a feeble copy as the effect of chance. " Quod si in Scythiam aut in Britanniam, sphseram aliquis tulerit hanc, quam nuper familiaris noster effecit Posidonius, cujus singula? conversiones idem efficiunt in sole, et in luna, et in quinque stellis errantibus, quod efficitur in coelo singulis diebus et noctibus: quis in ilia barbarie dubitet, quin ea sphsera sit perfecta ratione? Hi autem dubitant de mundo, ex quo et oriuntur et fiunt omnia, casune ipse sit effectus, aut necessitate aliqua, an ratione ac mente divina.: et Archimedem arbitrantur plus valuisse in imitandis spharse conversionibus, quam naturam in efficiendis, praesertim cum multis partibus sint ilia perfecta, quam haec simulata, sollertius."—De Nat. Deorum, ii. 34, 35. The 'Astro-Theology ' ofWm. Derham, published in 1714, was perhaps the first work entirely devoted to the illustration of the design argument from astronomical facts and theories. Among comparatively recent works of a similar kind I may mention Vince's ' Confutation of Atheism from the Laws and Constitution of the Heavenly Bodies,' Whewell's 'Bridgewater Treatise,' Dick's 'Celestial Scenery,' Mitchell's ' Planetary and Stellar Worlds,' and Leitch's 'God's Glory in the Heavens.' They afford ample evidence of the erroneousness of Comte's assertion that " the opposition of science to theology is more obvious in astronomy than anywhere else, and that no other science has given more terrible shocks to the doctrine of final causes." Kepler did not think so, for he concludes his work on the ' Harmony of Worlds' with these devout words: "I thank Thee, my Creator and Lord, that Thou hast given me this joy in Thy creation, this delight in the works of Thy hands. I have shown the excellency of Thy work unto men, so far as my finite mind was able to comprehend Thine infinity. If I have said aught unworthy of Thee, or aught in which I may have sought my own glory, graciously forgive it." Nor did Newton, for he wrote: " Elegantissima hsecce compages solis, planetarum, et cometarum (et stellarum), non nisi consilio et dominio Entis cujusdam potentis et intelligentis oriri potuit." And in our own times such men as

Herschel, Brewster, Madler, &c, have protested against the notion that astronomy tends to atheism.

The late Professor De Morgan demonstrated in his ' Essay on Probability,' when only eleven planets were known, that the odds against chance, to which in such a case intelligence is the only alternative, being the cause of all these bodies moving in one direction round the sun, with an inconsiderable inclination of the planes of their orbits, were twenty thousand millions to one. "What prospect," are his own words, " would there have been of such a concurrence of circumstances, if a state of chance had been the only antecedent? With regard to the sameness of the directions, either of which might have been from west to east, or from east to west, the case is precisely similar to the following: There is a lottery containing black and white balls, from each drawing of which it is as likely a black ball shall arise as a white one: what is the chance of drawing eleven balls all white?—answer, 2047 to one against it. With regard to the other question, our position is this: There is a lottery containing an infinite number of counters, marked with all possible different angles less than a right angle, in such a manner that any angle is as likely to be drawn as another, so that in ten drawings the sum of the angles drawn may be anything under ten right angles: now, what is the chance of ten drawings giving collectively less than one right angle?—answer, 10,000,000 to one against it. Now, what is the chance of both these events coming together?—answer, more than 20,000,000,000 to one against it. It is consequently of the same degree of probability that there has been something at work which is not chance in the formation of the solar system."

There are several departments of science as much, or even more, adapted than astronomy, to furnish proofs of the wisdom of God; but there is none which affords us such evidence of His power, or so helps us to realise His omnipresence, our own nothingness before Him, and the littleness of our earth in the system of His creation. Those who wish to have impressions of this kind deepened may be recommended to read the works of Proctor and Flammarion.

What is said in the paragraph to which this note refers must not be so understood as to be inconsistent with the possibility or probability, if not demonstrated certainty, that the universe is not a perfectly conservative system, but one which is tending surely although slowly to the destruction of the present condition of things. This fact, if it be a fact, can no more affect the design argument in its relation to astronomy, than the decay of plants and the death of animals can affect it in relation to vegetable and animal physiology.

Chemistry And The Design Argument

The history of chemistry is of itself sufficient to disprove the view of Comte that the initial and conjectural stages of a science are those in which it affords most support to theology. It was only after the definitive constitution of chemistry as a science, only after the discovery of positive and precise chemical laws, that the teleological argument for the Divine existence began to be rested to a certain extent upon it.

The Honourable Robert Boyle, the founder of the Boyle Lectureship, was one of the most distinguished chemists of his age, a zealous defender of final causes, and the author of several treatises intended to diffuse worthy views and sentiments as to the character and operations of the Creator.

Probably the two best English treatises on the relationship of chemistry to theism are the Bridgewater Treatise of Dr Prout, ' Chemistry, Meteorology, and the Function of Digestion, considered with reference to Natural Theology' (3d ed., 1845), and the Actonian Prize Essay of Professor Fownes, ' Chemistry as exemplifying the Wisdom and Beneficence of God ' (1844). Both

writers were chemists of high reputation, but they were not very conversant with theology or philosophy, and have, in consequence, by no means fully utilised the excellent scientific materials which they collected.

This makes it all the more to be regretted that the late Professor George Wilson was not permitted to accomplish his design of writing " a book corresponding to the ' Religio Medici' of Sir Thomas Browne, with the title 'Religio Chemici.' " Among the fragments comprised in the work published under that title after his death, three essays—" Chemistry and Natural Theology," " The Chemistry of the Stars," and " Chemical Final Causes " —are most interesting and suggestive.

The attempts of writers like Moleschott and Biichner to draw atheistic inferences from the theories or hypotheses of modern chemistry have given rise to a multitude of answers, but it may be sufficient to refer to the ' Antimaterialismus ' of Dr L. Weiss. Liebig in his J Chemical Letters' manifests profound contempt for the materialistic and anti-theistic speculations attempted to be based on the science of which he was so illustrious a master.

Geology, Geography, Etc., And The Design Argument

The single fact that geology proves that every genus and species of organic forms which exist or have existed on the earth had a definite beginning in time, gives to this science great importance in reference to theism. It decides at once and conclusively what metaphysics might have discussed without result for ages. Its religious bearings are exhibited in Buckland's ' Geology and Mineralogy considered in reference to Natural Theology,' Hugh Miller's ' Footprints of the Creator,' Hitchcock's ' Religion of Geology,' and many other works. Lyell concludes both his ' Elements of Geology' and ' Principles of Geology' by affirming that geological research finds in all directions the clearest indications of creative intelligence; that " as we increase our knowledge of the inexhaustible variety displayed in nature, and admire the infinite wisdom and power which it manifests, our admiration is multiplied by the reflection, that it is only the last of a great series of pre-existing creations, of which we cannot estimate the number or limit in times past." (I regret to find that Sir Charles Lyell omitted from the last edition of his ' Elements ' the passage to which reference is made above. I have considered it better thus to note this fact than simply to expunge the lines regarding his testimony. (1880.))

The numerous adaptations which exist between the terrestrial and celestial economies are dwelt on in detail by M'Culloch in the second volume of his ' Proofs and Illustrations of the Attributes of God from the Facts and Laws of the Physical Universe,' and by Buchanan in ' Faith in God and Modern Atheism,' vol. i. pp. 132-156. These two authors have also treated of the adaptations subsisting between the organic and inorganic worlds. The Bridgewater Treatise of Chalmers was on ' The Adaptation of External Nature to the Moral and Intellectual Constitution of Man;' and that of Kidd on ' The Adaptation of External Nature to the Physical Constitution of Man.'

In Ritter's ' Geographical Studies,' Guyot's ' Earth and Man,' Kapp's 'Allgemeine Erdkunde,' Lotze's ' Mikrokosmus,' B. vi. c. 1, Duval's ' Des Rapports entre la Geographie et l'Economie Politique,' Cocker's ' Theistic Conception of the World,' ch. vii., &c, will be found a rich store of teleological data as to the fitness of the earth to be the dwelling-place and the schoolhouse of human beings. Of course, those who attempt to prove this thesis require carefully to resist the temptation to conceive of the relation of nature to man as not one of cause and effect, of action and reaction, of mutual influence, but as an immediate and inexplicable preestablished harmony like that which Leibnitz supposed to exist between the body and the soul. This was the theory which Cousin set forth in a celebrated lecture on the part of geography in history. Regarding it I may quote the words which I have used elsewhere: "This notion is not only purely conjectural, but inconsistent with the innumerable facts which manifest that nature does influence man, and that man does

modify nature. It is impossible to hold, either in regard to the body and soul, or in regard to nature and man, both the theory of mutual influence and of pre-established harmony. All that, in either case, proves the former, disproves the latter. The belief in a pre-established harmony between man and nature is, indeed, considerably more absurd than in a pre-established harmony between the body and soul; for when a body is born, a soul is in it, which remains in it till death, and is never known to leave it in order to take possession of some other body: but every country is not created with a people in it, nor is every people permanently fixed to a particular country. Imagination may be deceived for a moment by an obvious process of association into this belief of certain peoples being suited for certain lands, independently of the action of natural causes—-the Greeks, let us say, for Greece, the Indian for the prairies and forests of America, the Malayan for the islands of the Indian Archipelago; but a moment's thought on the fact that the Turk has settled down where the Greeks used to be— that mighty nations of English-speaking men are rising up where the Indian roamed, and that Dutchmen are thriving in the lands of the Malayan, should suffice to disabuse us. Besides, just as the dictum, ' Marriages are made in heaven,' is seriously discredited by the great number that are badly made, so the kindred opinion that every country gets the people which suits it, and every people the country, as a direct and immediate consequence of their pre-established harmony, is equally discredited by the prevalence of ill-assorted unions, a great many worthless peoples living in magnificent lands, while far better peoples have much worse ones."—Philosophy of History in France and Germany, pp. 191, 192.

The Organic Kingdom And Design

The order and system in the vegetable and animal kingdoms are undeniable general facts, whatever may have been the secondary agencies by which they have been produced; and the inference of design from these facts is valid, whatever may have been the mode of their production. The characters and relationships of organic forms constitute a proof of intelligence, whether their genera and species be the immediate and immutable expressions of the ideas of the Divine Mind, or the slowly-reached results of evolution. Of course, if there has been a process of evolution, it must have been one exactly fitted to attain the result. But the discovery or exhibition of such a process will be sufficient to cause a certain class of minds to believe that there has been no cause but the process—that the process completely explains both itself and the result, and leaves no room for intelligence.

The character of the order and system in the organic world is so extremely abstruse, subtle, and comprehensive, that all the attempts at classification in botany prior to De Candolle, and in zoology prior to Cuvier, were failures. The labours of the great naturalists and biologists of the present century have, doubtless, accomplished much; but the light reached is still but the feeble light of an early dawn. Yet that light is most pleasant and satisfying to the eye of the mind. The reason sees in it a profound significance and a wonderful beauty. How, it may well be asked, can a scheme of order which tasks to such an extent the powers of comprehension possessed by the human mind, and yet which is perceived, when discovered, to be admirably rational, be supposed to have originated elsewhere than in a Mind?

I can only mention a few out of the multitude of books which treat of design in the organic world. Among general works on natural theology it may be sufficient to refer to those of Paley, Buchanan, and Tulloch; and among special works, to Professor Balfour's ' Phyto-Theology; or, Botanical Sketches, intended to illustrate the Works of God in the Structure, Functions, and General Distribution of Plants;' M'Cosh's ' Typical Forms and Special Ends in Creations;' Agassiz's ' Structure of Animal Life; being Six Lectures on the Power, Wisdom, and Goodness of God, as manifested in His Works;' Kirby's ' Power, Wisdom, and Goodness of God, as manifested in the Creation of Animals;' R. Owen's ' Instances of the Power of God, manifested in His Animal Creation;' Roget's ' Animal and Vegetable Physiology, considered in reference to Natural Theology;' and Sir Charles Bell's ' The

Hand, its Mechanism and Vital Endowments, as evincing Design.' The three last-mentioned works are Bridgewater Treatises.

It is a duty to call particular attention to the work of M. Janet, ' Les Causes Finales.' Although M. Janet concedes, perhaps, too much to the opponents of finality, his treatise contains the ablest and most adequate discussion of the various problems suggested by the indications which organic nature gives of design that has yet appeared. It is eminently worthy of a careful study. There is an excellent English translation of it by W. Affleck, B.D.

Among the masters of biological science, Cuvier, V. Baer, Agassiz, and R. Owen may be named, as among those who have set the highest value on the principle of finality. The essay on Classification of Agassiz, and the various essays which Von Baer has published at different times, on what he calls " Zielstrebigkeit," are specially important.

Evidences Of Design In Organisms

"The savants are generally too much disposed to confound the doctrine of final cause with the hypotheses of an invisible force acting without physical means, as a deus ex machina. These two hypotheses, far from reducing themselves the one to the other, are in explicit contradiction; for he who says design says at the same time means, and, consequently, causes adapted to produce a certain effect. To discover this cause is by no means to destroy the idea of design; it is, on the contrary, to bring to light the condition, sine qua non, of the production of the end. To make clear this distinction we cite a beautiful example, borrowed from M. Claude Bernard. How does it happen, says this eminent physiologist, that the gastric juice, which dissolves all aliments, does not dissolve the stomach itself, which is of precisely the same nature as the aliments with which it is nourished? For a long time the vital force was supposed to intervene— that is to say, an invisible cause, which, in some way, suspended the properties of the natural agents, to prevent their producing their necessary effects. The vital force would, by a sort of moral veto, forbid the gastric juice to touch the stomach. We see that this would be a real miracle. Everything is explained when we know that the stomach is lined with a coating or varnish which is not attacked by the gastric juice, and which protects the walls which it covers. Who does not see that in refuting the omnipotence of the vital force, very far from having weakened the principle of finality, we have given to it a wonderful support? What could the most perfect art have done to protect the walls of the stomach, but invent a precaution similar to that which exists in reality? And how surprising it is that an organ destined to secrete and use an agent most destructive to itself, is found armed with a protective tunic, which must have always coexisted with it, since otherwise it would have been destroyed before having had time to procure for itself this defence—which excludes the hypothesis of long gropings and happy occurrences." — Janet, " Final Causes and Contemporaneous Physiology," Presb. Quart. Rev., April 1876.

Professor Tyndall gives a very graphic description of the combination of remarkable arrangements by which the human ear is fitted to be an organ of hearing. I quote from it the following words, and connect with them some striking observations of Max Miiller. " Finally, there is in the labyrinth a wonderful organ, discovered by the Marchese Corti, which is to all appearance a musical instrument, with its chords so stretched as to accept vibrations of different periods, and transmit them to the nerve-filaments which traverse the organ. Within the ears of men, and without their knowledge or contrivance, this lute of 3000 strings has existed for ages, accepting the music of the outer world, and rendering it fit for reception by the brain. Each musical tremor which falls upon this organ selects from its tensioned fibres the one appropriate to its own pitch, and throws that fibre into unisonant vibration. And thus, no matter how complicated the motion of the external air may be, those microscopic strings can analyse it and reveal the constituents of which it is composed."—On Sound, p. 325. " What we hear when listening to a chorus or a symphony is a

commotion of elastic air, of which the wildest sea would give a very inadequate image. The lowest tone which the ear preceives is due to about 30 vibrations in one second, the highest to about 4000. Consider, then, what happens in a presto, when thousands of voices and instruments are simultaneonsly producing waves of air, each wave crossing the other, not only like the surface waves of the water, but like spherical bodies, and, as it would seem, without any perceptible disturbance; consider that each tone is accompanied by secondary notes, that each instrument has its peculiar timbre, due to secondary vibrations; and, lastly, let us remember that all this cross-fire of waves, all this whirlpool of sound, is moderated by laws which determine what we call harmony, and by certain traditions or habits which determine what we call melody—both these elements being absent in the songs of birds—that all this must be reflected like a microscopic photograph on the two small organs of hearing, and there excite not only perception, but perception followed by a new feeling even more mysterious, which we call either pleasure or pain;—and it will be clear that we are surrounded on all sides by miracles transcending all we are accustomed to call miraculous." —Science of Language, second series, p. 115.

The structure of the eye has often been described as an evidence of design. There is an extremely interesting comparison of it with the photographic camera in Le Conte's ' Religion and Science,' pp. 20-33.

The whole reading public knows the masterly chapter on " The Machinery of Flight," in the Duke of Argyll's ' Reign of Law.'

Psychology And Design

The following writers treat at considerable length of the evidences of design to be traced in the constitution of the mind: Sir Matthew Hale in his * Primitive Origination of Mankind;' Barrow in the seventh of his ' Sermons on the Creed;' Bentley in the second sermon of his ' Boyle Lecture;' Crombie in the second volume of his ' Natural Theology;' Lord Brougham in his ' Discourse on Natural Theology,' sect. iii. pp. 52-80; Turton's 'Natural Theology Considered,' pp. 65-160; Chalmers's ' Natural Theology,' Book III.; Buchanan's ' Faith in God,' pp. 213-231; Tulloch's 'Theism,' pp. 182-247; and Ulrici's ' Gott und Mensch.'

The phenomena of animal instinct are of themselves an inexhaustible source of instruction as to the Divine wisdom and goodness. " The spinning machinery which is provided in the body of a spider is not more accurately adjusted to the viscid secretion which is provided for it, than the instinct of the spider is adjusted both to the construction of its web and also to the selection of likely places for the capture of its prey. Those birds a»d insects whose young are hatched by the heat of fermentation, have an intuitive impulse to select the proper materials, and to gather them for the purpose. All creatures, guided sometimes apparently by senses of which we know nothing, are under like impulses to provide effectually for the nourishing of their young; and it is most curious and instructive to observe that the extent of provision which is involved in the process, and in the securing of the result, seems very often to be greater as we descend in the scale of nature, and in proportion as the parents are dissociated from the actual feeding or personal care of their offspring. The mammalia have nothing to provide except food for themselves, and have at first, and for a long time, no duty to perform beyond the discharge of a purely physical function. Birds have more to do—in the building of nests, in the choice of sites for these, and after incubation in the choice of food adapted to the period of growth. Insects, much lower in the scale of organisation, and subject to the wonderful processes of metamorphosis, have to provide very often for a distant future, and for successive stages of development not only in the young but in the nidus which surrounds them. Bees, if we are to believe the evidence of observers, have an intuitive guidance in the selection of food which has the power of producing organic changes in the bodies of the young, even to the determination and development of sex, so that, by the administration of it, under what

may be called artificial conditions, certain selected individuals can be made the mothers and queens of future hives. These are but a few examples of facts of which the whole animal world is full, presenting, as it does, one vast series of adjustments between bodily organs and corresponding instincts. But this adjustment would be useless unless it were part of another adjustment—between the instincts and perceptions of animals and those facts and forces of surrounding nature which are related to them, and to the whole cycle of things of which they form a part. In those instinctive actions of the lower animals which involve the most distant and the most complicated anticipations, it is certain that the prevision involved is a prevision which is not in the animals themselves. They appear to be, and beyond all doubt really are, guided by some simple appetite, by an odour or a taste, and, in all probability, they have generally as little consciousness of the ends to be subserved as the suckling has of the processes of nutrition. The path along which they walk is a path which they did not engineer. It is a path made for them, and they simply follow it. But the propensities and tastes and feelings which make them follow it, and the Tightness of its direction towards the ends to be attained, do constitute an adjustment which may correctly be called mechanical, and is part of a unity which binds together the whole world of life, and the whole inorganic world on which living things depend."—Duke of Argyll on Animal Instinct (Cont. Rev., July 1875).

Instinctive actions will not be shown to be less evidences of Divine purpose by its being proved that intelligence, at least in the higher animals, probably always co-operates in some degree with instinct, or that much which is referred to instinct may be traced either directly to experience or to the hereditary transmission of qualities originally generated by experience.

History And Design

The quotation is from the eighteenth—the concluding —volume of the ' Etudes sur l'Histoire de 1'Humanity,' by Professor Laurent of Ghent. I have given some account of his historical doctrine, and endeavoured to defend the theistic inference which he has drawn from his laborious survey of historical facts against the objections of Professor J. B. Meyer, in my ' Philosophy of History in France and Germany,' pp. 321-330. Bunsen, in the work entitled ' God in History,' seeks to establish the same great thesis.

" History," says Niebuhr, " shows, on a hundred occasions, an intelligence distinct from nature, which conducts and determines those things which may seem to us accidental; and it is not true that history weakens our belief in Divine Providence. History is, of all kinds of knowledge, the one which tends most decidedly to that belief."—Lectures on the History of Rome, vol. ii. P- 59

Siissmilch's celebrated treatise, ' Gottliche Ordnung in der Veranderung des menschlichen Geschlechtes, &c.;' M'Cosh's ' Method of the Divine Government;' and Gillett's ' God in Human Thought,' vol. ii. pp. 724-792, may be consulted as regards the evidences of Divine purpose to be found in the constitution of society.

History Of The Teleological Argument

The proof of the Divine existence from the order and adaptations of the universe is known as the physicotheological or teleological argument. It has also been sometimes called the cosmological argument; the veryword cosmos, like the Latin mundus and our own universe, implying order. It is so obvious and direct that it has presented itself to the mind from very ancient times. It is implied in such passages of Scripture as Job xxxvii.-xli.; Ps. viii., xix., civ. j Isa. xl. 21-26; Matt. vi. 25-32; Acts xiv. 15-17, xvii. 24-28. Pythagoras laid great stress on the order of the world; and it was mainly on that order that Anaxagoras rested his belief in a Supreme Intelligence. Socrates

developed the argument from the adaptation of the parts of the body to one another, and to the external world, with a skill which has never been surpassed. His conversation with Aristodemus, as recorded in the ' Memorabilia ' of Xenophon, is of wonderful interest and beauty. Few will follow it even now without feeling constrained to join Aristodemus in acknowledging that " man must be the masterpiece of some great Artificer, carrying along with it infinite marks of the love and favour of Him who thus formed it." Plato presents the argument specially in the ' Timaeus,' and his whole philosophy is pervaded by the thought that God is the primary source and perfect ideal of all order and harmony. Aristotle expressly maintains that " the appearance of ends and means is a proof of design," and conceives of God as the ultimate Final Cause, Cicero (De Nat. Deor., ii. c. 37) puts into the mouth of Balbus an elaborate exposition of the design argument. The ' De Usu Partium ' of Galen is a treatise on natural theology, teaching design in the structure of the body.

This proof is found more frequently than any other in the writings of the fathers and scholastics. " When we see a vessel," says Theophilus, "spreading her canvas, and majestically riding on the billows of the stormy sea, we conclude that she has a pilot on board; thus, from the regular course of the planets, the rich variety of creatures, we infer the existence of the Creator."—Ad Autol., 5. Minucius Felix (c. 18) compares the universe to a house, and Gregory of Nazianzum (Orat. xxviii. 6) compares it to a lyre, in illustrating the same argument. Ambrose, Athanasius, Augustine, Basil the Greek, Chrysostom, &c, employ it. So do Albertus Magnus, Thomas Aquinas, &c.

The opposition of Bacon and Descartes to final causes had no influence in preventing theologians from insisting on their existence. From Boyle and Derham to Paley and the Bridgewater Treatises, an enormous literature appeared in England devoted to this end. Germany, also, in the second half of the eighteenth century, was almost as much overflooded with Lithotheologies, Hydrotheologies, Phytotheologies, Insectotheologies, &c, as it at present is with works on Darwinism. In France, Fenelon in his ' Demonstration de l'Existence de Dieu,' and Bernardin de Saint Pierre in his ' Etudes' and ' Harmonies de la Nature,' eloquently, although not perhaps very solidly or cautiously, reasoned from the wonders of nature to the wisdom of God.

Hume and Kant, by their criticisms of the design argument, rendered to it the great service of directing attention to the principles on which it proceeds. Theologians had previously gone on merely accumulating illustrative instances and instituting minute investigations into the constitutions of the complex objects which they selected with this view. Attention was thus distracted from what really needed argument. Hume and Kant showed men the real point at issue.

Although Kant rejected the argument, he speaks of it in these terms: " This proof deserves to be mentioned at all times with respect. It is the oldest, the clearest, and the most suited to the ordinary understanding. It animates the study of nature, because it owes its existence to thought, and ever receives from it fresh force. It brings out reality and purpose where our observation would not of itself have discovered them, and extends our knowledge of nature by exhibiting indications of a special unity whose principle is beyond nature. This knowledge, moreover, directs us to its cause—namely, the inducing idea, and increases our faith in a supreme originator to an almost irresistible conviction."

I must refer to the Notes from XIII. to XX. inclusive, for the titles of recent works on the design argument.

" The assertion appears to be quite unfounded that, as science advances from point to point, final causes recede before it, and disappear one after the other. The principle of design changes its mode of application, indeed, but it loses none of its force. We no longer consider particular facts as produced by special interpositions; but we consider design as exhibited in the establishment and adjustment of the laws by which particular facts are produced. We do not look upon each particular

cloud as brought near to us that it may drop fatness on our fields; but the general adaptation of the laws of heat and air and moisture to the promotion of vegetation does not become doubtful. We do not consider the sun as less intended to warm and vivify the tribes of plants and animals because we find that, instead of revolving round the earth as an attendant, the earth, along with other planets, revolves round him. We are rather, by the discovery of the general laws of nature, led into a scene of wider design, of deeper contrivance, of more comprehensive adjustments. Final causes, if they appear driven farther from us by such extension of our views, embrace us only with a vaster and more majestic circuit. Instead of a few threads connecting some detached objects, they become a stupendous network, which is wound round and round the universal frame of things."—Whewell, 'History of Scientific Ideas,' vol. ii. pp. 253, 254.

Creation And Evolution

Creation is the only theory of the origin of the universe. Evolution assumes either the creation or the self-existence of the universe. The evolutionist must choose between creation and non-creation. They are opposites. There is no intermediate term. The attempt to introduce one—the Unknowable—can lead to no result; for unless the Unknowable is capable of creating, it can account for the origin of nothing. All attempts to explain even the formation of the universe, either by the evolution of the Unknowable or by evolution out of the Unknowable, must be of a thoroughly delusive character. The evolution of what is known can alone have significance either to the ordinary or scientific mind. Nothing can be conceived of as subject to evolution which is not of a finite and composite nature. Nothing can be evolved out of a finite and composite existence which was not previously involved in it. And what gives to anything its limits and constitution must be more perfect than itself. To Trpunw ov a-iripfia. iarlv, dAAa To Te'Aciov.

"As many philosophers as adopt the supposition— such as the Pythagoreans and Spensippus—that what is best and most fair is not to be found in the principle of things, from the fact that though the first principles both of plants and animals are causes, yet what is fair and perfect resides in created things as results from these,—persons, I say, who entertain these sentiments, do not form their opinions correctly. For seed arises from other natures that are antecedent and perfect, and seed is not the first thing, whereas that which is perfect is."—Aristotle, 'Metaphysics,' xi. 7.

" It is manifest by the light of nature that there must at least be as much reality in the efficient and entire cause as in its effect; for whence can the effect draw its reality if not from its cause? And how could the cause communicate to it this reality unless it possessed it in itself? And hence it follows, not only that what is cannot be produced by what is not, but likewise that the more perfect—in other words, that which contains in kself more reality—cannot be the effect of the less perfect."—Descartes, 'Meditations,' iii.

" In not a few of the progressionists the weak illusion is unmistakable, that, with time enough, you may get everything out of next-to-nothing. Grant us, they seem to say, any tiniest granule of power, so close upon zero that it is not worth begrudging—allow it some trifling tendency to infinitesimal increment—and we will show you how this little stock became the kosmos, without ever taking a step worth thinking of, much less constituting a case for design. The argument is a mere appeal to an incompetency in the human imagination, in virtue of which, magnitudes evading conception are treated as out of existence; and an aggregate of inappreciable increments is simultaneously equated,—in its cause to nothing, in its effect to the whole of things. You manifestly want the same causality, whether concentrated on a moment or distributed through incalculable ages; only, in drawing upon it, a logical theft is more easily committed piecemeal than wholesale. Surely it is a mean device for a philosopher thus to crib causation by hair'sbreadths, to put it out at compound interest through all time, and then disown the debt."—Martineau, ' Essays Philosophical and Theological,' pp. 141, 142.

" Think of it! An endless evolution, an eternal working, an infinite causation, and yet an effect so finite. Nature has been working upward from eternity, and has just passed the long-armed ape who begat prognathus, as prognathus begat the troglodyte homo. What becomes of our doctrine of progress? As sure as mathematics, it should have been all evolved, all that we now have, over and over again—all out, or far more out than has come out, incalculable ages ago. An eternal antepast of progressive working. To what a height should it have arisen! It should have transcended all our ideals. The most exalted finite being should have been reached, the most exalted that our minds can conceive, instead of this creature man, so poor, so low; for you will bear in mind that I am speaking of him as measured by no higher scale of value than that afforded by this physical hypothesis—man evolved from nebular gas—man just coming out of darkness, and so soon to return to darkness again—e tenebris in tenebras. This all comes from that hideous vaTtpov irportpov, that inversion of all necessary thinking. Nature first, it says—matter first, an impalpable nebulous nihilism first, the lowest and most imperfect first; life, thought, reason, idea, their junior products, and God, therefore, the last product, if there be a God at all, or anything to which such a name can possibly be given. And we are asked to adopt this, and call it grand, whilst rejecting as narrow and soul-contracting the revelation which makes God first, reason first, idea first, the perfect first,—as has been said before—the imperfect and the finite ever a departure from it, whether in the scale of order or of time, whether as exhibited in processes of lapse and deterioration or the contrary seeming of recovery and restoration in cyclical rounds. The two schemes have two entirely different modes of speech. Says the mere physical hypothesis: In the beginning was the nebula, and all things were in the nebula, and all things were self-evolved from the nebula —even life, thought, consciousness, idea, reason itself, having no other source. The other speaks to us in language like this: 'Ev apxn Vv ° Adyos, " In the beginning was the Word," the Aoyos, the Reason, " and the Word was with God, and the Word was God. All things came into being by Him. In Him was life," £u>r], and "from this life"—not from motions, or molecules, or correlated forces, or the vibration of fibres, or the arrangements of nebular atoms, but from this life of the Logos, the eternal Reason—" came the light of men "— the mind, reason, conscience of humanity—even " the light that lighteth" every rational being " coming into the cosmos."—Prof. Lewis, 'The Kingdom of God' (Dickinson's Theological Quarterly, No. 6).

1905
Conference Address
Elder Brigham H. Roberts
The Various Modes Through Which God Reveals Himself To The Children Of Men
Conference Report, April 1905, Afternoon Session., p.97

I am going to ask you to listen to a few passages of scripture.

"The heavens declare the glory of God; and the firmament showeth His handiwork.
"Day unto day uttereth speech, and night unto night showeth knowledge.
"There is no speech nor language where their voice is not heard.
"There line is gone out through all the earth, and their words to the end of the world."

Such is the language of David, Prophet and King of Israel.

You who have followed me in the reading of these passages of the scripture, have doubtless already concluded in your minds that it is my purpose to call your attention to the various modes through which God reveals Himself to the children of men. You will observe that the first passage that I read calls attention to that species of revelation that is made known through the works of nature. "The heavens declare the glory of God." I presume there are no people living now or in past times

but must have been impressed to a greater or less extent by that revelation which God gives of Himself through His works. Not only Christian people, but the Mohammedan, the Buddhist, the Deist, are all impressed by that magnificent revelation of God's power and glory which may be seen in the magnitude of His works. The Deists, are of opinion that this revelation is all-sufficient as a foundation for natural religion. One high in authority among such people has declared that the wonderful structure of the universe and everything we behold in creation proves to us better than books can the existence of God, and at the same time proclaims His attributes. "It is by the exercise of our reason," he continues, "that we are enabled to contemplate God in His work and to meditate His ways. When we see His care and goodness extended over His creatures, it teaches us our duties towards each other, while it calls forth our gratitude to Him."

But great and magnificent as is this revelation of God's glory and power through His works, it is inadequate to meet all the requirements of man. There are great questions that the stars cannot answer. There are great problems that this world of ours cannot solve. I ask the question in the presence of this great revelation that comes from God, through nature, Whence is man, and the purpose of his existence? And the stars give no answer to that question. I ask the question. What is the purpose of human existence? And nature gives no reply. I ask the question, What is the end of human existence? And from nature there comes no satisfactory answer. So that this revelation through nature, however splendid it may be, is not sufficient for guidance to the children of men. So say the Christians of all sects. They hold that something must be learned more than can be learned through the revelations of nature. Hence they accept the revelations that come through the scriptures.

I desire to call attention to Christian faith on this point, and I desire also to expound our faith, if I can, upon this great subject.

1907
Henri Bergson, French Philosopher
Creative Evolution - Chapter 1 - The Evolution Of Life - Mechanism And Teleology
Book Which won Nobel Prize For Literature

Chapter 1 - The Evolution Of Life - Mechanism And Teleology

The existence of which we are most assured and which we know best is unquestionably our own, for of every other object we have notions which may be considered external and superficial, whereas, of ourselves, our perception is internal and profound. What, then, do we find? In this privileged case, what is the precise meaning of the word "exist"? Let us recall here briefly the conclusions of an earlier work.

I find, first of all, that I pass from state to state. I am warm or cold, I am merry or sad, I work or I do nothing, I look at what is around me or I think of something else. Sensations, feelings, volitions, ideas—such are the changes into which my existence is divided and which color it in turns. I change, then, without ceasing. But this is not saying enough. Change is far more radical than we are at first inclined to suppose.

For I speak of each of my states as if it formed a block and were a separate whole. I say indeed that I change, but the change seems to me to reside in the passage from one state to the next: of each state, taken separately, I am apt to think that it remains the same during all the time that it prevails. Nevertheless, a slight effort of attention would reveal to me that there is no feeling, no idea, no volition which is not undergoing change every moment: if a mental state ceased to vary, its duration would cease to flow. Let us take the most stable of internal states, the visual

perception of a motionless external object. The object may remain the same, I may look at it from the same side, at the same angle, in the same light; nevertheless the vision I now have of it differs from that which I have just had, even if only because the one is an instant older than the other. My memory is there, which conveys something of the past into the present. My mental state, as it advances on the road of time, is continually swelling with the duration which it accumulates: it goes on increasing—rolling upon itself, as a snowball on the snow. Still more is this the case with states more deeply internal, such as sensations, feelings, desires, etc., which do not correspond, like a simple visual perception, to an unvarying external object. But it is expedient to disregard this uninterrupted change, and to notice it only when it becomes sufficient to impress a new attitude on the body, a new direction on the attention. Then, and then only, we find that our state has changed. The truth is that we change without ceasing, and that the state itself is nothing but change.

This amounts to saying that there is no essential difference between passing from one state to another and persisting in the same state. If the state which "remains the same" is more varied than we think, on the other hand the passing from one state to another resembles, more than we imagine, a single state being prolonged; the transition is continuous. But, just because we close our eyes to the unceasing variation of every psychical state, we are obliged, when the change has become so considerable as to force itself on our attention, to speak as if a new state were placed alongside the previous one. Of this new state we assume that it remains unvarying in its turn, and so on endlessly. The apparent discontinuity of the psychical life is then due to our attention being fixed on it by a series of separate acts: actually there is only a gentle slope; but in following the broken line of our acts of attention, we think we perceive separate steps. True, our psychic life is full of the unforeseen. A thousand incidents arise, which seem to be cut off from those which precede them, and to be disconnected from those which follow. Discontinuous though they appear, however, in point of fact they stand out against the continuity of a background on which they are designed, and to which indeed they owe the intervals that separate them; they are the beats of the drum which break forth here and there in the symphony. Our attention fixes on them because they interest it more, but each of them is borne by the fluid mass of our whole psychical existence. Each is only the best illuminated point of a moving zone which comprises all that we feel or think or will—all, in short, that we are at any given moment. It is this entire zone which in reality makes up our state. Now, states thus defined cannot be regarded as distinct elements. They continue each other in an endless flow.

But, as our attention has distinguished and separated them artificially, it is obliged next to reunite them by an artificial bond. It imagines, therefore, a formless ego, indifferent and unchangeable, on which it threads the psychic states which it has set up as independent entities. Instead of a flux of fleeting shades merging into each other, it perceives distinct and, so to speak, solid colors, set side by side like the beads of a necklace; it must perforce then suppose a thread, also itself solid, to hold the beads together. But if this colorless substratum is perpetually colored by that which covers it, it is for us, in its indeterminateness, as if it did not exist, since we only perceive what is colored, or, in other words, psychic states. As a matter of fact, this substratum has no reality; it is merely a symbol intended to recall unceasingly to our consciousness the artificial character of the process by which the attention places clean-cut states side by side, where actually there is a continuity which unfolds. If our existence was composed of separate states with an impassive ego to unite them, for us there, would be no duration. For an ego which does not change does not endure, and a psychic state which remains the same so long as it is not replaced by the following state does not endure either. Vain, therefore, is the attempt to range such states beside each other on the ego supposed to sustain them: never can these solids strung upon a solid make up that duration which flows. What we actually obtain in this way is an artificial imitation of the internal life, a static equivalent which will lend itself better to the requirements of logic and language, just because we have eliminated from it the element of real time. But, as regards the psychical life

unfolding beneath the symbols which conceal it, we readily perceive that time is just the stuff it is made of.

~ There is, moreover, no stuff more resistant nor more substantial. For our duration is not merely one instant replacing another; if it were, there would never be anything but the present—no prolonging of the past into the actual, no evolution, no concrete duration. Duration is the continuous progress of the past which gnaws into the future and which swells as it advances. And as the past grows without ceasing, so also there is no limit to its preservation. Memory, as we have tried to prove,' is not a faculty of putting away recollections in a drawer, or of inscribing them in a register. There is no register, no drawer; there is not even, properly speaking, a faculty.

For a faculty works intermittently, when it will or when it can, whilst the piling up of the past upon the past goes on without relaxation. In reality, the past is preserved by itself, automatically. In its entirety, probably, it follows us at every instant; all that we have felt, thought and willed from our earliest infancy is there, leaning over the present which is about to join it, pressing against the portals of consciousness that would fain leave it outside. The cerebral mechanism is arranged just so as to drive back into the unconscious almost the whole of this past, and to admit beyond the threshold only that which can cast light on the present situation or further the action now being prepared—in short, only that which can give useful work. At the most, a few superfluous recollections may succeed in smuggling themselves through the half-open door. These memories, messengers from the unconscious, remind us of what we are dragging behind us unawares. But, even though we may have no distinct idea of it, we feel vaguely that our past remains present to us. What are we, in fact, what is our character, if not the condensation of the history that we have lived from our birth—nay, even before our birth, since we bring with us prenatal dispositions? Doubtless we think with only a small part of our past, but it is with our entire past, including the original bent of our soul, that we desire, will and act. Our past, then, as a whole, is made manifest to us in its impulse; it is felt in the form of tendency, although a / small part of it only is known in the form of idea.

From this survival of the past it follows that consciousness cannot go through the same state twice. The circumstances may still be the same, but they will act no longer on the same person, since they find him at a new moment of his history. Our personality, which is being built up each instant with its accumulated experience, changes without ceasing. By changing, it prevents any state, although superficially identical with another, from ever repeating it in its very depth. That is why our duration is irreversible. We could not live over again a single moment, for we should have to begin by effacing the memory of all that had followed. Eyen could we erase this memory from our intellect, we could not from our will Thus our personality shoots, grows and ripens without ceasing. Each of its moments is something new added to what was before. We may go further: it is not only something new, but something unforeseeable. Doubtless, my present state is explained by what was in me and by what was acting on me a moment ago. In analyzing it I should find no other elements. But even a superhuman intelligence would not have been able to foresee the simple indivisible form which gives to these purely abstract elements their concrete organization. For to foresee consists of projecting into the future what has been perceived (Jin the past, pr of imagining for a later time a new grouping, in a new order, of elements already perceived. But that which has never been perceived, and which is at the same time simple, is necessarily unforeseeable. Now such is the case with each of our states, regarded as a moment in a history that is gradually unfolding: it is simple, and it cannot have been already perceived, since it concentrates in its indivisibility all that has been perceived and what the present is adding to it besides. It is an original moment of a no less original history.

The finished portrait is explained by the features of the model, by the nature of the artist, by the colors spread out on the palette; but, even with the knowledge of what explains it, no one, not

even the artist, could have foreseen exactly what the portrait would be, for to predict it would have been to produce it before it was produced— an absurd hypothesis which is its own refutation. Even so with regard to the moments of our life, of which we are the artisans. Each of them is a kind of creation. And just as the talent of the painter is formed or deformed— in any case, is modified— under the very influence of the works he produces, so each of our states, at the moment of its issue, modifies our personality, being indeed the new form that we are just assuming. It is then right to say that what we do depends on what we are; but it is necessary to add also that we are, to a certain extent, what we do, and that we are creating ourselves continually. This creation of self by self is the more complete, the more one reasons on what one does. For reason does not proceed in such matters as in geometry, where impersonal premises are given once for all, and an impersonal conclusion must perforce be drawn. Here, on the contrary, the same reasons may dictate to different persons, or to the same person at different moments, acts profoundly different, although equally reasonable. The truth is that they are not quite the same reasons, since they are not those of the same person, nor of the same moment. That is why we cannot deal with them in the abstract, from outside, as in geometry, nor solve for another the problems by which he is faced in life. Each must solve them from within, on his own account. But we need not go more deeply into this. We are seeking only the precise meaning that our consciousness gives to this word "exist," and we y^ find that, for a conscious being, to exist is to change, to change is to mature, to mature is "to go on creating oneself endlessly. Should the same be said of existence in general?

A material object, of whatever kind, presents opposite characters to those which we have just been describing. Either it remains as it is, or else, if it changes under the influence of an external force, our idea of this change is that of a displacement of parts which themselves do not change. If these parts took to changing, we should split them up in their turn. We should thus descend to the molecules of which the fragments are made, to the atoms that make up the molecules, to the corpuscles that generate the atoms, to the "imponderable" within which the corpuscle is perhaps a mere vortex. In short, we should push the division or analysis as far as necessary. But we should stop only before the unchangeable.

Now, we say that a composite object changes by the displacement of its parts. But when a part has left its position, there is nothing to prevent its return to it. A group of elements which has gone through a state can therefore always find its way back to that state, if not by itself, at least by means of an external cause able to restore everything to its place. This amounts to saying that any state of the group may be repeated as often as desired, and consequently that the group does not grow old. It has no history.

Thus nothing is created therein, neither form nor matter. What the group will be is already present in what it is, provided "what it is" includes all the points of the universe with which it is related. A superhuman intellect could calculate, for any moment of time, the position of any point of the system in space. And as there is nothing more in the form of the whole than the arrangement of its parts, the future forms of the system are theoretically visible in its present configuration.

All our belief in objects, all our operations on the systems that science isolates, rest in fact on the idea that time does not bite into them. We have touched on this question in an earlier work, and shall return to it in the course of the present study. For the moment, we will confine our selves to pointing out that the abstract time t attributed by science to a material object or to an isolated system consists only in a certain number of simultaneities or more' generally of correspondences, and that this number remains the same, whatever be the nature of the intervals between the correspondences. With these intervals we are never concerned when dealing with inert matter; or, if they are considered, it is in order to count therein fresh correspondences, between which again we shall not care what happens. Common sense, which is occupied with detached objects, and also science, which considers isolated systems, are concerned only with the ends of the intervals and

not with the intervals themselves. Therefore the flow{j of time might assume an infinite rapidity, the entire past,! present, and future of material objects or of isolated systems might be spread out all at once in space, without there being anything to change either in the formulae of the scientist or even in the language of common sensed The number t would always stand for the same thing; it would still count the same number of correspondences between the states of the objects or systems and the points of the line, ready drawn, which would be then the " course of time."

Yet succession is an undeniable fact, even in the material worlds though our reasoning on isolated systems may imply that their history, past, present, and future, might be instantaneously unfurled like a fan, this history, in point of fact, unfolds itself gradually, as if it occupied a duration like our own. If I want to mix a glass of sugar and water, I must, willy nilly, wait until the sugar melts. This little fact is big with meaning. For here the time I have to wait is not that mathematical time which would apply equally well to the entire history of the material world, even if that history were spread out instantaneously in space. It coincides with my impatience, that is to say, with a certain portion of my own duration, which I cannot protract or contract as I like. It is no longer something thought, it is something lived. It is no longer a relation, it is an absolute. What else can this mean than that the glass of water, the sugar, and the process of the sugar's melting in the water are abstractions, and that the Whole within which they have been cut out by my senses and understanding progresses, it may be in the manner of a consciousness?

Certainly, the operation by which science isolates and closes a system is not altogether artificial. If it had no objective foundation, we could not explain why it is clearly indicated in some cases and impossible in others. We shall see that matter has a tendency to constitute isolable systems, that can be treated geometrically. In fact, we shall define matter by just this tendency. But it is only a tendency. Matter does not go to the end, and the isolation is never complete. If science does go to the end and isolate completely, it is for convenience of study; it is understood that the so-called isolated system remains subject to certain external influences. Science merely leaves these alone, either because it finds them slight enough to be negligible, or because it intends to take them into account later on. It is none the less true that these influences are so many threads which bind up the system to another more extensive, and to this a third which includes both, and so on to the system most objectively isolated and most independent of all, the solar system complete. But, even here, the isolation is not absolute. Our sun radiates heat and light beyond the farthest planet. And, on the other hand, it moves in a certain fixed direction, drawing with it the planets and their satellites. The thread attaching it to the rest of the universe is doubtless very tenuous. Nevertheless it is along this thread that is transmitted down to the smallest particle of the world in which we live the duration immanent to the whole of the universe.

The universe endures. The more we study the nature of time, the more we shall comprehend that duration means invention, the creation of forms, the continual elaboration of the absolutely new. The systems marked off by science endure only because they are bound up inseparably with the rest of the universe. It is true that in the universe itself two opposite movements are to be distinguished, as we shall see later on, "descent" and "ascent." The first only unwinds a roll ready prepared. In principle, it might be accomplished almost instantaneously, like releasing a spring. But the ascending movement, which corresponds to an inner work of ripening or creating, endures essentially, and imposes its rhythm on the first, which is inseparable from it.

There is no reason, therefore, why a duration, and so a form of existence like our own, should not be attributed to the systems that science isolates, provided such systems are integrated into the Whole. But they must be so reintegrated. The same is even more obviously true of the objects cut out by our perception. The distinct outlines which we see in an object, and which give it its individuality, are only the design of a certain kind of influence that we might exert on a certain point of space: it is the plan of our eventual actions that is sent back to |? our eyes, as though by a

mirror, when we see the surfaces j and edges of things. Suppress this action, and with it j consequently those main directions which by perception I are traced out for it in the entanglement of the real, and / the individuality of the body is re-absorbed in the universal interaction which, without doubt, is reality itself.

Now, we have considered material objects generally. Are there not some objects privileged? The bodies we perceive are, so to speak, cut out of the stuff of nature by our perception, and the scissors follow, in some way, the marking of lines along which action might be taken. But the body which is to perform this action, the body which marks out upon matter the design of its eventual actions even before they are actual, the body that has only to point its sensory organs on the flow of the real in order to make that flow crystallize into definite forms and thus to create all the other bodies—in short, the living body—is this a body as others are?

Doubtless it, also, consists in a portion of extension bound up with the rest of extension, an intimate part of the Whole, subject to the same physical and chemical \laws that govern any and every portion of matter. But, while the subdivision of matter into separate bodies is relative to our perception, while the building up of closed off systems of material points is relative to our science, the living body has been separated and closed off by nature herself. It is composed of unlike parts that complete each other. It performs diverse functions that involve each other. It is an individual, and of no other object, not even of the crystal, can this be said, for a crystal has neither difference of parts nor diversity of functions. No doubt, it is hard to decide, even in the organized world, what is individual and what is not. The difficulty is great, even in the animal kingdom; with plants it is almost insurmountable. This difficulty is, moreover, due to profound causes, on which we shall dwell later. We shall see that individuality admits of any number of degrees, that it is not fully realized anywhere, even in man. that is no reason for thinking it is not a characteristic property of life. The biologist who proceeds as a geometrician is too ready to take advantage here of our inability to give a precise and general definition of individuality. A perfect definition applies only to a completed reality; now, vital properties are never entirely realized, though always on the way to become so; they are not so much states as tendencies. And a tendency achieves all that it aims at only if it is not thwarted by another tendency. How, then, could this occur in the] domain of life, where, as we shall show, the interaction of antagonistic tendencies is always implied? In particular, it may be said of individuality that, while the tendency to individuate is everywhere present in the organized world, it is everywhere opposed by the tendency towards reproduction. For the individuality to be perfect, it would be necessary that no detached part of the organism could live separately. But then reproduction would be impossible. For what is reproduction, but the building up of a new organism with a detached fragment of the old? ""^Individuality therefore harbors its enemy at home. Its very need of perpetuating itself in time condemns it never to be complete in space. The biologist must take due account of both tendencies in every instance, and it is therefore useless to ask him for a definition of individuality that shall fit all cases and work automatically.

But too often one reasons about the things^ life in v the same way as about the, conditions of crude matter. Nowhere is the confusion so evident as in discussions about individuality. We are shown the stumps of a Lumbriculus, each regenerating its head and living thenceforward as an independent individual; a hydra whose pieces become so many fresh hydras; a sea-urchin's egg whose fragments develop complete embryos: where then, we are asked, was the individuality of the egg, the hydra, the worm?—But, because there are several individuals of antagonistic tendencies is always implied? In particular, it may be said that, in individuality, while the tendency to individuate is everywhere present in the organized world, it is everywhere opposed by the tendency toward reproduction. For the individuality to be perfect, it would be necessary that no detached part of the organism now, it does not follow that there was not a single individual just before. No doubt, when I have seen several drawers fall from a chest, I have no longer the right to say that the article was all of one piece. But the fact is that there can be nothing more in the present of the chest of drawers

than there was in its past, and if it is made up y^ti/-1' of several different pieces now, it was so from the date of manufacture. Generally speaking, unorganized bodies, which are what we have need of in order that we may act, and on which we have modelled our fashion of thinking, / are regulated by this simple law: the present contains nothing at all more than the post, and what is found in the effect was already in the cause. But suppose that the distinctive feature of the organized body is that it grows and changes without ceasing, as indeed the most superficial observation testifies, there would be nothing astonishing in the fact that it was one in the first instance, and afterwards many. The reproduction of unicellular organisms consists in just this—the living being divides into two halves, of which each is a complete individual. True, in the more complex animals, nature localizes in the almost independent sexual cells the power of producing the whole anew. But something of this power may remain diffused in the rest of the organism, as the facts of regeneration prove, and it is conceivable that in certain privileged cases the faculty may persist integrally in a latent condition and manifest itself on the first opportunity. In truth, that I may have the right to speak of individuality, it is not necessary that the organism should be without the power to divide into fragments that are able to live."* It is sufficient that it should have presented a certain systematization of parts before the division, and that the same systematization tend to be reproduced in each separate portion afterwards. Now, that is precisely what we observe in the organic world. We may conclude, then, that individuality is never perfect, and that it is often difficult, sometimes impossible, to tell what is an individual, and what is not, but that life nevertheless manifests a search for' individuality, as if it strove to constitute systems naturally isolated, naturally closed.

By this is a living being distinguished from all that our perception or our science isolates or closes artificially. It would therefore be wrong to compare it to an object. Should we wish to find a term of comparison in the inorganic world, it is not to a determinate material object, but much rather to the totality of the material universe that we ought to compare the living organism. It is true that the comparison would not be worth much, for a living being is observable, whilst the whole of the universe is constructed or reconstructed by thought. But at least our attention would thus have been called to the essential character of organization. Like the universe as a whole, like each conscious being taken separately, the organism which lives is a thing that endures. Its past, in its entirety, is prolonged into its present, and abides there, actual and acting. How otherwise could we understand that it passes through distinct and well-marked phases, that it changes its age—in short, that it has a history? If I consider my body in particular, I find that, like my consciousness, it matures little by little from infancy to old age; like myself, it grows old. Indeed, maturity and old age are, properly speaking, attributes only of my body; it is only metaphorically that I apply the same names to the corresponding changes of my conscious self. Now, if I pass from the top to the bottom of the scale of living beings, from one of the most to one of the least differentiated, from the multi-cellular organism of man to the unicellular organism of the Infusorian, I find, even in this simple cell, the same process of growing old. The Infusorian is exhausted at the end of a certain number of divisions, and though it may be possible, by modifying the environment, to put off the moment when a rejuvenation by conjugation becomes necessary, this cannot be indefinitely postponed. It is true that between these two extreme cases, in which the organism is completely individualized, there might be found a multitude of others in which the individuality is less well marked, and in which, although there is doubtless an ageing somewhere, one cannot say exactly what it is that grows old. Once more, there is no universal biological law which applies precisely and automatically to every living thing? There are only directions in which life throws out species in general. Each particular species, in the very act by which it is constituted, affirms its independence, follows its caprice, deviates more or less from the straight line, sometimes even remounts the slope and seems to turn its back on its original direction. It is easy enough to argue that a tree never grows old, since the tips of its branches are always equally young, always equally capable of engendering new trees by budding. But in such an organism—which is, after all, a society rather than an individual—something ages, if only the leaves and the interior of the trunk. And each

cell, considered separately, evolves in a specific way. Wherever anything lives, there is, open somewhere, a register in which it is being inscribed.

This, it will be said, is only a metaphor.—It is of the very essence of mechanism, in fact, to consider as metaphorical every expression which attributes to time an effective action and a reality of its own. In vain does immediate experience show us that the very basis of our conscious existence is memory, that is to say, the prolongation of the past into the present, or, in a word, duration, acting and irreversible. In vain does reason prove to us that the more we get away from the objects cut out and the systems isolated by common sense and by science and the deeper we dig beneath them, the more we have to do with a reality which changes as a whole in its inmost states, as if an accumulative memory of the past made it impossible to go back again. The mechanistic instinct of the mind is stronger than reason, stronger than immediate experience. The metaphysician that we each carry unconsciously within us, and the presence of which is explained, as we shall see later on, by the very place that man occupies amongst the living beings, has its fixed requirements, its ready-made explanations, its irreducible propositions: all unite in denying concrete duration. Change must be reducible to an arrangement or rearrangement of parts; the irreversibility of time must be an appearance relative to our ignorance; the impossibility of turning back must be only the inability of man to put things in place again. So growing old can be nothing more than the gradual gain or loss of certain substances, perhaps both together. Time is assumed to have just as much reality for a living being as for an hour-glass, in which the top part empties while the lower fills, and all goes where it was before when you turn the glass upside down. True, biologists are not agreed on what is gained and what is lost between the day of birth and the day of death. There are those who hold to the continual growth in the volume of protoplasm from the birth of the cell right on to its death.1 More probable and more profound is the theory according to which the diminution bears on the quantity of nutritive substance contained in that "inner environment" in which the organism is being renewed, and the increase on the quantity of unexcreted residual substances which, accumulating in the body, finally " crust it over.'" Must we however—with an eminent bacteriologist—declare any explanation of growing old insufficient that does not take account of phagocytosis? We do not feel qualified to settle the question. But the fact that the two theories agree in affirming the constant accumulation or loss of a certain kind of matter, even though they have little in common as to what is gained and lost, shows pretty well that the frame of the explanation has been furnished a priori. We shall see this more and more as we proceed with our study: it is not easy, in thinking of time, to escape the image of the hour-glass.

The cause of growing old must lie deeper. We hold that there is unbroken continuity between the evolution of the embryo and that of the complete organism. The impetus which causes a living being to grow larger, to develop and to age, is the same that has caused it to pass through the phases of the embryonic life. The development of the embryo is a perpetual change of form. Any one who attempts to note all its successive aspects becomes lost in an infinity, as is inevitable in dealing with a continuum. Life does but prolong this prenatal evolution. The proof of this is that it is often impossible for us to say whether we are dealing with an organism growing old or \with an embryo continuing to evolve; such is the case, for example, with the larvae of insects and Crustacea. On the other hand, in an organism such as our own, crises like puberty or the menopause, in which the individual is completely transformed, are quite comparable to changes in the course of larval or embryonic life—yet they are part and parcel of the process of our aging. Although they occur at a definite age and within a time that may be quite short, no one would maintain that they appear then *ex abrupto,* from without, simply because a certain age is reached, just as a legal right is granted to us on our one-and-twentieth birthday. It is evident that a change like that of puberty is in course of preparation at every instant from birth, and even before birth, and that the aging up to that crisis consists, in part at least, of this gradual preparation. In short, what is properly vital in growing old is the in-1 sensible, infinitely graduated, continuance of the change! of form. Now, this change is undoubtedly accompanied by phenomena of organic

destruction: to these, and to these alone, will a mechanistic explanation of aging be confined. It will note the facts of sclerosis, the gradual accumulation of residual substances, the growing hypertrophy of the protoplasm of the cell. But under these visible effects an inner cause lies hidden. The evolution of the living being, like that of the embryo, implies a continual recording of duration, a persistence of the past in the present, and so an appearance, at least, of organic memory.

The present state of an unorganized body depends exclusively on what happened at the previous instant; and likewise the position of the material points of a system defined and isolated by science is determined by the position of these same points at the moment immediately before. In other words, the laws that govern unorganized matter are expressible, in principle, by differential equations in which time (in the sense in which the mathematician takes this word) would play the role of independent variable. Is it so with the laws of life? Does the state of a living body find its complete explanation in the state immediately before? Yes, if it is agreed a priori to liken the living body to other bodies, and to identify it, for the sake of the argument, with the artificial systems on which the chemist, physicist, and astronomer operate. But in astronomy, physics, and chemistry the proposition has a perfectly definite meaning: it signifies that certain aspects of the present, important for science, are calculable as functions of the immediate past. Nothing of the sort in the domain of life. Here calculation touches, at most, certain phenomena of organic destruction. Organic creation, on the contrary, the evolutionary phenomena which properly constitute life, we cannot in any way subject to a mathematical treatment. It will be said that this impotence I is due only to our ignorance. But it may equally well express the fact that the present moment of a living body does not find its explanation in the moment immediately before, that all the past of the organism must be added to that moment, its heredity—in fact, the whole of a very long history. In the second of these two hypotheses, not in the first, is really expressed the present state of the biological sciences, as well as their direction. As for the idea that the living body might be treated by some superhuman calculator in the same mathematical way as our solar system, this has gradually arisen from a metaphysic which has taken a more precise form since the physical discoveries of Galileo, but which, as we shall show, was always the natural metaphysic of the human mind. Its apparent clearness, our impatient desire to find it true, the enthusiasm with which so many excellent minds accept it without proof—all the seductions, in short, visible effects an inner cause lies hidden. The evolution of the living being, like that of the embryo, implies a continual recording of duration, a persistence of the past in the present, and so an appearance, at least, or organic that it exercises on our thought, should put us on our guard against it. The attraction it has for us proves well enough that it gives satisfaction to an innate inclination. But, as will be seen further on, the intellectual tendencies innate to-day, which life must have created in the course of its evolution, are not at all meant to supply us with an explanation of life: they have something else to do.

Any attempt to distinguish between an artificial and a natural system, between the dead and the living, runs counter to this tendency at once. Thus it happens that we find it equally difficult to imagine that the organized has duration and that the unorganized has not. When we say that the state of an artificial system depends exclusively on its state at the moment before, does it not seem as if we were bringing time in, as if the system had something to do with real duration? And, on the other hand, though the whole of the past goes into the making of the living being's present moment, does not organic memory press it into the moment immediately before the present, so that the moment immediately before becomes the sole cause of the present one?—To speak thus is to ignore the cardinal difference between concretetime, along which a {gal system develops, and that abstraction which enters into our speculations on artificial systems. What does it mean, to say that the state of an artificial system depends on what it was at the moment immediately before? There is no instant immediately before another instant; there could not be, any more than there could be one mathematical point touching another. The instant "immediately before" is, in reality,

that which is connected with the present instant by the interval dt. All that you mean to say, therefore, is that the present state of the system is defined by equations into which differential coefficients enter, such as ds\dt, dv\dt, that is to say, at bottom, present velocities and present accelerations. You are therefore really speaking only of the present—a present, 'it is true, considered along with its tendency. The systems science works with are, in fact, in an instantaneous present that is always being renewed; such systems are never in that real, concrete duration in which the past remains bound up with, the present. When the mathematician calculates the future state of a system at the end of a time t, there is nothing to prevent him from supposing that the universe vanishes from this moment till that, and suddenly reappears. It is the moment only that counts— and that will be a mere instant. What will flow on in the interval—that is to say, real time—does not count, and cannot enter into the calculation. If the mathematician says that he puts himself inside this interval, he means that he is placing himself at a certain point, at a particular moment, therefore at the extremity again of a certain time If; with the interval up to 2" he is not concerned. If he divides the interval into infinitely small parts by considering the differential it, he thereby expresses merely the fact that he will consider accelerations and velocities—that is to say, numbers which denote tendencies and enable him to calculate the state of the system at a given moment. But he is always speaking of a given moment—a static moment, that is—and not of flowing time. In short, the world the mathematician deals with is a world that dies and is reborn at every instant—the world which Descartes was thinking of when he spoke of continued creation. But, in time thus conceived, how could evolution, which is the very essence of life, ever take place? Evolution implies a real persistence of the past in the present, a duration which is, as it were, a hyphen, a connecting link. In other words, to know a living being or natural system is to get at the very interval of duration, while the knowledge of an artificial or mathematical system applies only to the extremity.

Continuity of change, preservation of the past in the present, real duration—the living being seems, then, to share these attributes with consciousness. Can we go further and say that life, like conscious activity, is invention, is unceasing creation?

It does not enter into our plan to set down here the proofs of transformism. We wish only to explain in a word or two why we all accept it, in the present work, as a sufficiently exact and precise expression of the facts actually known. The idea of transformism is already in germ in the natural classification of organized beings. The naturalist, in fact, brings together the organisms that are like each other, then divides the group into sub-groups within which the likeness is still greater, and so on: all through the operation, the characters of the group appear as general themes on which each of the sub-groups performs its particular variation. Now, such is just the relation we find, in the animal and in the vegetable world between the generator and the generated: on the canvas which the ancestor passes on, and which his descendants possess in common, each puts his own original embroidery. True, the differences between the descendant and the ancestor are slight, and it may be asked whether the same living matter presents enough plasticity to take in turn such different forms as those of a fish, a reptile and a bird. But, to this question, observation gives a peremptory answer. It shows that up to a certain period in its development the embryo of the bird is hardly distinguishable from that of the reptile, and that the individual develops, throughout the embryonic life in general, a series of transformations comparable to those through which, according to the theory of evolution, one species passes into another. A single cell, the result of the combination of two cells, male and female, accomplishes this work by dividing. Every day, before our eyes, the highest forms of life are springing from a very elementary form. Experience, then, shows that the most complex has been able to issue from the-most simple by way of evolution. Now, has it arisen so, as a matter of fact? Paleontology, in spite of the insufficiency of its evidence, invites us to believe it has; for, where it makes out the order of succession of species with any precision, this order is just what considerations drawn from embryogeny and comparative anatomy would lead any one to suppose, and each new paleontological discovery brings

transformism a new confirmation. Thus, the proof drawn from mere observation is ever being strengthened, while, on the other hand, experiment is removing the objections one by one. The recent experiments of H. de Vries, for instance, by showing that important variations can be produced suddenly and transmitted regularly, have overthrown some of the greatest difficulties raised by the theory. They have enabled us greatly to shorten the time biological evolution seems to demand. They also render us less exacting toward paleontology. So that, all things considered, the transformist hypothesis looks more and more like a close approximation to the truth. It is not rigorously demonstrable; but, failing the certainty of theoretical or experimental demonstration, there is a probability which is continually growing, due to evidence which, while coming short of direct proof, seems to point persistently in its direction: such is the kind of probability that the theory of transformism offers.

Let us admit, however, that transformism may be wrong. Let us suppose that species are proved, by inference or by experiment, to have arisen by a discontinuous process, of which to-day we have no idea. Would the doctrine be affected in so far as it has a special interest or importance for us? Classification would probably remain, in its broad lines. The actual data of embryology would also remain. The correspondence between comparative embryogeny and comparative anatomy would remain too. Therefore biology could and would continue to establish between living forms the same relations and the same kinship as transformism supposes to-day. It would be, it is true, an ideal kinship, and no longer a material affiliation. But, as the actual data of paleontology would also remain, we should still have to admit that it is successively, not simultaneously, that the forms between which we find an ideal kinship have appeared. Now, the evolutionist theory, so far as it has any importance for philosophy, requires no more. It consists above all in I establishing relations of ideal kinship, and in maintaining \ that wherever there is this relation of, so to speak, logical affiliation between forms, there is also a relation of chronological succession between the species in which these forms are materialized. Both arguments would hold in any case. And hence, an evolution somewhere would still have to be supposed, whether in a creative Thought in which the ideas of the different species are generated by each other exactly as transformism holds that species themselves are generated on the earth; or in a plan of vital organization immanent in nature, which gradually works itself out, in which the relations of logical and chronological affiliation between pure forms are just those which transformism presents as relations of real affiliation between living individuals; or, finally, in some unknown cause of life, which develops its effects as if they generated one another. Evolution would then simply have been transposed, made to pass from the visible to the invisible. Almost all that transformism tells us to-day would be preserved, open to interpretation in another way. Will it not, therefore, be better to stick to the letter of transformism as almost all scientists profess it? Apart from the question to what extent the theory of evolution describes the facts and to what extent it symbolizes them, there is nothing in it that is irreconcilable with the doctrines it has claimed to replace, even with that of special creations, to which it is (usually opposed. For this reason we think the language of transformism forces itself now upon all philosophy, as the dogmatic affirmation of transformism forces itself upon science.

But then, we must no longer speak of life in general as an abstraction, or as a mere heading under which all living beings are inscribed. At a certain moment, in certain points of space, a visible current has taken rise; this current of life, traversing the bodies it has organized one after another, passing from generation to generation, has become divided amongst species and distributed amongst individuals without losing anything of its force, rather intensifying in proportion to its advance. It is well known that, on the theory of the "continuity of the germ-plasm," maintained by Weismann, the sexual elements of the generating organism pass on their properties directly to the sexual elements of the organism engendered. In this extreme form, the theory has seemed debatable, for it is only in exceptional cases that there are any signs of sexual glands at the time of segmentation of the fertilized egg. But, though the cells that engender the sexual elements do not

generally appear at the beginning of the embryonic life, it is none the less true that they are always formed out of those tissues of the embryo which have not undergone any particular functional differentiation, and whose cells are made of unmodified protoplasm. In other words, the genetic power of the fertilized ovum weakens, the more it is spread over the growing mass of the tissues of the embryo; but, while it is being thus diluted, it is concentrating anew something of itself on a certain special point, to wit, the cells, from which the ova or spermatozoa will develop. It might therefore be said that, though the germ-plasm is not continuous, there is at least continuity of genetic energy, this energy being expended only at certain instants, for just enough time to give the requisite impulsion to the embryonic life, and being recouped as soon as possible in new sexual elements, in which, again, it bides its time. Regarded from this point of view, life is like a current passing from germ to germ through the medium of a developed organism. It is as if the organism itself were only an excrescence, a bud caused to sprout by the former germ endeavoring to continue itself in a new germ. ~^The essential thing is the continuous progress indefinitely pursued, an invisible progress, on which each visible organism rides during the short interval of time given it to live. Now, the more we fix our attention on this continuity of life, the more we see that organic evolution resembles the evolution of a consciousness, in which the past presses against the present and causes the upspringing of a new form of consciousness, incommensurable with its antecedents. That the appearance of a vegetable or animal species is due to specific causes, nobody will gainsay. But this can only mean that if, after the fact, we could know these causes in detail, we could explain by them the form that has been produced; foreseeing the form is out of the question.' It may perhaps be said that the form could be foreseen if we could know, in all their details, the conditions under which it will be produced. But these projections are built up into it and are part and parcel of its being; they are peculiar to that phase of its history in which life finds itself at the moment of producing the form: how could we know beforehand a situation that is unique of its kind, that has never yet occurred and will never occur again? Of the future, only that is foreseen which is like the past or can be made up again with elements like those of the past. Such is the case with astronomical, physical and chemical facts, with all facts which form part of a system in which elements supposed to be unchanging are merely put together, in which the only changes are changes of position, in which there is no theoretical absurdity in imagining that things are restored to their place; in which, consequently, the same total phenomenon, or at least the same elementary phenomena, can be repeated. But an original situation, which imparts something of its own originality to its elements, that is to say, to the partial views that are taken of it, how can such a situation be pictured as given before it is actually produced?1 All that can be said is that, once produced, it will be explained by the elements that analysis will then carve out of it. Now, what is true of the production of a new species is also true of the production of a new individual, and, more generally, of any moment of any living form. For, though the variation must reach a certain importance and a certain generality in order to give rise to a new species, it is being produced every moment, continuously and insensibly, in every living being. And it is evident that even the sudden "mutations" which we now hear of are possible only if a process of incubation, or rather of maturing, is going on throughout a series of generations that do not seem to change. In this sense it might be said of life, as of consciousness, that at every moment it is creating something.

But against this idea of the absolute originality and unforeseeability of forms our whole intellect rises in revolt. The essential function of our intellect, as the evolution of life has fashioned it, is to be a light for our conduct, to make ready for our action on things, to foresee, for a given situation, the events, favorable or unfavorable, which may follow thereupon. Intellect therefore instinctively selects in a given situation whatever is like something already known; it seeks this out, in order that it may apply its principle that "like produces like." In just this does the prevision of the future by common sense consist. Science carries this faculty to the highest possible degree of exactitude and precision, but does not alter its essential character. Like ordinary knowledge, in dealing with things science is concerned only with the aspect of repetition. Though the whole be original,

science will always manage to analyze it into elements or aspects which are approximately a reproduction of the past. Science can work only on what is supposed to repeat itself—that is to say, on what is withdrawn, by hypothesis, from the action of real time. Anything that is irreducible and irreversible in the successive moments of a history eludes science. To get a notion of this irreducibility and irreversibility, we must break with scientific habits which are adapted to the fundamental requirements of thought, we must do violence to the mind, go counter to the natural bent of the intellect. But that is just the function of philosophy.

In vain, therefore, does life evolve before our eyes as a continuous creation of unforeseeable form: the idea always persists that form, unforeseeability and continuity are mere appearance—the outward reflection of our own ignorance. What is presented to the senses as a continuous history would break up, we are told, into a series of successive states. "What gives you the impression of an original state resolves, upon analysis, into elementary facts, each of which is the repetition of a fact already known. What you call an unforeseeable form is only a new arrangement of old elements. The elementary causes, which in their totality have determined this arrangement, are themselves old causes repeated in a new order. Knowledge of the elements and of the elementary causes would have made it possible to foretell the living form which is their sum and their resultant. When we have resolved the biological aspect of phenomena into physico-chemical factors, we will leap, if necessary, over physics and chemistry themselves; we will go from masses to molecules, from molecules to atoms, from atoms to corpuscles: we must indeed at last come to something that can be treated as a kind of solar system, astronomically. If you deny it, you oppose the very principle of scientific mechanism, and you arbitrarily affirm that living matter is not made of the same elements as other matter."—We reply that we do not question the fundamental identity of inert matter and organized matter. The only question is whether the natural systems which we call living beings must be assimilated to the artificial systems that science cuts out within inert matter, or whether they must not rather be compared to that natural system which is the whole of the universe. That life is a kind of mechanism I cordially agree. But is it the mechanism of parts artificially isolated within the whole of the universe, or is it the mechanism of the real whole? The real whole might well be, we conceive, an indivisible continuity. The systems we cut out within it would, properly speaking, not then be parts at all; they would be portions of the whole. And, with these partial views put end to end, you will not make even a beginning of the reconstruction of the whole, any more than, by multiplying photographs of an object in a thousand different aspects, you will reproduce the object itself. So of life and of the physico-chemical phenomena to which you endeavor to reduce it. Analysis will undoubtedly resolve the process of organic creation into an ever-growing number of physico-chemical phenomena, and chemists and physicists will have to do, of course, with nothing but these. But it does not follow that chemistry and physics will ever give us the key to life.

A very small element of a curve is very near being a straight line. And the smaller it is, the nearer. In the limit, it may be termed a part of the curve or a part of the straight line, as you please, for in each of its points a curve coincides with its tangent. So likewise "vitality" is tangent, at any and every point, to physical and chemical forces; but such points are, as a fact, only views taken by a mind which imagines stops at various moments of the movement that generates the curve. In reality, life is no more made of physico-chemical elements than a curve is composed of straight lines.

In a general way, the most radical progress a science can achieve is the working of the completed results into a new scheme of the whole, by relation to which they become instantaneous and motionless views taken at intervals along the continuity of a movement. Such, for example, is the relation of modern to ancient geometry. The latter, purely static, worked with figures drawn once for all; the former studies the varying of a function— that is, the continuous movement by which the figure is described. No doubt, for greater strictness, all considerations of motion may be

eliminated from mathematical processes; but the introduction of motion into the genesis of figures is nevertheless the origin of modern mathematics. We believe that if biology could ever get as close to its object as mathematics does to its own, it would become, to the physics and chemistry of organized bodies, what the mathematics of the moderns has proved to be in relation to ancient geometry. The wholly superficial displacements of masses and molecules studied in physics and chemistry would become, by relation to that inner vital movement (which is transformation and not translation) what the position of a moving object is to the movement of that object in space. And, so far as we can see, the procedure by which we should then pass from the definition of a certain vital action to the system of physicochemical facts which it implies would be like passing from the function to its derivative, from the equation of the curve {i.e. the law of the continuous movement by which the curve is generated) to the equation of the tangent giving its instantaneous direction. Such a science would be a mechanics of transformation, of which our mechanics of translation would become a particular case, a simplification, a projection on the plane of pure quantity. And just as an infinity of functions have the same differential, these functions differing from each other by a constant, so perhaps the integration of the physico-chemical elements of properly vital action might determine that action only in part—a part would be left to indetermination. But such an integration can be no more than dreamed of; we do not pretend that the dream will ever be realized. We are only trying, by carrying a certain comparison as far as possible, to show up to what point our theory goes along with pure mechanism, and where they part company. Imitation of the living by the unorganized may, however, go a good way. Not only does chemistry make organic syntheses, but we have succeeded in reproducing artificially the external appearance of certain facts of organization, such as indirect cell-division and protoplasmic circulation. It is well known that the protoplasm of the cell effects various movements within its envelope; on the other hand, indirect cell-division is the outcome of very complex operations, some involving the nucleus and others the cytoplasm. These latter commence by the doubling of the centrosome, a small spherical body alongside the nucleus. The two centrosomes thus obtained draw apart, attract the broken and doubled ends of the filament of which the original nucleus mainly consisted, and join them to form two fresh nuclei about which the two new cells are constructed which will succeed the first. Now, in their broad lines and in their external appearance, some at least of these operations have been successfully imitated. If some sugar or table salt is pulverized and some very old oil is added, and a drop of the mixture is observed under the microscope, a froth of alveolar structure is seen whose configuration is like that of protoplasm, according to certain theories, and in which movements take place which are decidedly like those of protoplasmic circulation.1 If, in a froth of the same kind, Even the external motions of a unicellular organism—of an amoeba, at any rate—are sometimes explained mechanically. The displacements of an amoeba in a drop of water would be comparable to the motion to and fro of a grain of dust in a draughty room. Its mass is all the time absorbing certain soluble matters contained in the surrounding water, and giving back to it certain others; these continual exchanges, like those between two vessels separated by a porous partition, would create an ever-changing vortex around the little organism. As for the temporary prolongations or pseudopodia which the amoeba seems to make, they would be not so much given out by it as attracted from it by a kind of inhalation or suction of the surrounding medium.* In the same way we may perhaps come to explain the more complex movements which the Infusorian makes with its vibratory cilia, which, moreover, are probably only fixed pseudopodia.

But scientists are far from agreed on the value of explanations and schemas of this sort. Chemists have pointed out that even in the organic—not to go so far as the organized—science has reconstructed hitherto nothing but waste products of vital activity; the peculiarly active plastic substances obstinately defy synthesis. One of the most notable naturalists of our time has insisted on the opposition of two orders of phenomena observed in living tissues, anagenesis and katagenesis. The role of the anagenetic energies is to raise the inferior energies to their own level by assimilating inorganic substances. They construct the tissues. On the other hand, the actual functioning of life (excepting, of course, assimilation, growth, and reproduction) is of the

katagenetic order, exhibiting the fall, not the rise, of energy. It is only with these facts of katagenetic order that physico-chemistry deals—that is, in short, with the dead and not with the living.1 The other kind of facts certainly seem to defy physico-chemical analysis, even if they are not anagenetic in the proper sense of the word. As for the artificial imitation of the outward appearance of protoplasm, should a real theoretic importance be attached to this when the question of the physical framework of protoplasm is not yet settled? We are still further from compounding protoplasm chemically. Finally, a physico-chemical explanation of the motions of the amoeba, and a fortiori of the behavior of the Infusoria, seems impossible to many of those who have closely observed these rudimentary organisms. Even in these humblest manifestations of life they discover traces of an effective psychological activity.' But instructive above all is the fact that the tendency to explain everything by physics and chemistry is discouraged rather than strengthened by deep study of histological phenomena. Such is the conclusion of the truly admirable book which the histologist E. B. Wilson has devoted to the development of the cell: "The study of the cell has, on the whole, seemed to widen rather than to narrow the enormous gap that separates even the lowest forms of life from the inorganic world.1" /L^ To sum up, those who are concerned only with the ' functional activity of the living being are inclined to believe that physics and chemistry will give us the key to biological processes.' They have chiefly to do, as a fact, with phenomena that are repeated continually in the living being, as in a chemical retort. This explains, in some measure, the mechanistic tendencies of physiology. On the contrary, those whose attention is concentrated on the minute structure of living tissues, on their genesis and evolution, histologists and embryogenists on the one hand, naturalists on the other, are interested in the retort itself, not merely in its contents. They find that this retort creates its own form through a unique series of acts that really constitute a history. Thus, histologists, embryogenists, and naturalists believe far less readily than physiologists in the physico-chemical character of vital actions.

The fact is, neither one nor the other of these two theories, neither that which affirms nor that which denies the possibility of chemically producing an elementary organism, [_can claim the authority of experiment. They are both unverifiable, the former because science has not yet advanced a step toward the chemical synthesis of a living substance, the second because there is no conceivable way of proving experimentally the impossibility of a fact. But we have set forth the theoretical reasons which prevent us from likening the living being, a system closed off by nature, to the systems which our science isolates. These reasons have less force, we acknowledge, in the case of a rudimentary organism like the amoeba, which hardly evolves at all. But they acquire more when we consider a complex organism which goes through a regular cycle of transformations. The more Humanity marks the living being with its imprint, the more obviously the organism differs from a mere mechanism, over which duration glides without penetrating. And the demonstration has most force when it applies to the evolution of life as a whole, from its humblest origins to its highest forms, inasmuch as this evolution constitutes, through the unity and continuity of the animated matter which supports it, a single indivisible history. Thus viewed, the evolutionist hypothesis does not seem so closely akin to the mechanistic conception of life as it is generally supposed to be. Of this mechanistic conception we do not claim, of course, to furnish a mathematical and final refutation. But the refutation which we draw from the consideration of real time, and which is, in our opinion, the only refutation possible, becomes the more rigorous and cogent the more frankly the evolutionist hypothesis is assumed. We must dwell a good deal more on this point. But let us first show more clearly the notion of life to which we are leading up.

The mechanistic explanations, we said, hold good for the systems that our thought artificially detaches from the whole. But of the whole itself and of the systems which, within this whole, seem to take after it, we cannot admit a -priori that they are mechanically explicable, for then time would be useless, and even unreal. The essence of mechanical explanation, in fact, is to regard the future and the past as calculable functions of the present, and thus to claim that all is given. On this hypothesis, past, present and future would be open at a glance to a superhuman intellect

capable of making the calculation. Indeed, the scientists who have believed in the universality and perfect objectivity of mechanical explanations have, consciously or unconsciously, acted on a hypothesis of this kind. Laplace formulated it with the greatest precision: "An intellect which at a given instant knew all the forces with which nature is animated, and the respective situations of the beings that compose nature—supposing the said intellect were vast enough to subject these data to analysis—would embrace in the same formula the motions of the greatest bodies in the universe and those of the slightest atom: nothing would be uncertain for it, and the future, like the past, would be present to its eyes."1 And Du Bois Reymond: "We can imagine the knowledge of nature arrived at a point where the universal process of the world might be represented by a single mathematical formula, by one immense system of simultaneous differential equations, from which could be deduced, for each moment, the position, direction, and velocity of every atom of the world. "» Huxley has expressed the same idea in a more concrete form: "If the fundamental proposition of evolution is true, that the entire world, living and not living, is the result of the mutual interaction, according to definite laws, of the forces possessed by the molecules of which the primitive nebulosity of the universe was composed, it is no less certain that the existing world lay, potentially, in the cosmic vapor, and that a sufficient intellect could, from a knowledge of the properties of the molecules of that vapor, have predicted, say the state of the Fauna of Great Britain in 1869, with as much certainty as one can say what will happen to the vapor of the breath in a cold winter's day." In such a doctrine, time is still spoken of: one pronounces the word, but one does not think of the thing. For time is here deprived of efficacy, and if it does nothing, it is nothing. Radical mechanism implies a metaphysic in which the totality of the real is postulated complete in eternity, and in which the apparent duration of things expresses merely the infirmity of a mind that cannot know everything at once. But duration is something very different from this for our consciousness, that is to say, for that which is most indisputable in our experience. We perceive duration as a stream against which we cannot go. It is the foundation of our being, and, as we feel, the very substance of the world in which we live. It is of no use to hold up before our eyes the dazzling prospect of a universal mathematic; we cannot sacrifice experience to the requirements of a system. That is why we reject radical mechanism.

But radical finalism is quite as unacceptable, and for the same reason. The doctrine of teleology, in its extreme form, as we find it in Leibniz for example, implies that things and beings merely realize a programme previously arranged. But if there is nothing unforeseen, no invention or creation in the universe, time is useless again. As in the \ mechanistic hypothesis, here again it is supposed that j all is given. Finalism thus understood is only inverted) mechanism. It springs from the same postulate, with this sole difference, that in the movement of our finite intellects along successive things, whose successiveness is reduced to a mere appearance, it holds in front of us the light with which it claims to guide us, instead of putting it behind. It substitutes the attraction of the future for the impulsion of the past. But succession remains none the less a mere appearance, as indeed does movement itself. In the doctrine of Leibniz, time is reduced to a confused perception, relative to the human standpoint, a perception which would vanish, like a rising mist, for a mind seated at the centre of things.

Yet finalism is not, like mechanism, a doctrine with fixed rigid outlines. It admits of as many inflections as we like. The mechanistic philosophy is to be taken or left: it must be left if the least grain of dust, by straying from the path foreseen by mechanics, should show the slightest trace of spontaneity. The doctrine of final causes, on the contrary, will never be definitively refuted. If one form of it be put aside, it will take another. Its principle, which is essentially psychological, is very flexible. It is so extensible, and thereby so comprehensive, that one accepts something of it as soon as one rejects pure mechanism. The theory we put forward in this book will therefore necessarily partake of finalism to a certain extent. For that reason it is important to intimate exactly what we are going to take of it, and what we mean to leave.

Let us say at once that to thin out the Leibnizian finalism by breaking it into an infinite number of pieces seems to us a step in the wrong direction. This is, however, the tendency of the doctrine of finality. It fully realizes that if the universe as a whole is the carrying out of a plan, this cannot be demonstrated empirically, and that even of the organized world alone it is hardly easier to prove all harmonious: facts would equally well testify to the contrary. Nature sets living beings at discord with one another. She everywhere presents disorder alongside of order, retrogression alongside of progress. But, though finality cannot be affirmed either of the whole of matter or of the whole of life, might it not yet be true, says the finalist, of each organism taken separately? Is there not a wonderful division of labor, a marvellous solidarity among the parts of an organism, perfect order in infinite complexity? Does not each living being thus realize a plan immanent in its substance?—This theory consists, at bottom, in breaking up the original notion of finality into bits. It does not accept, indeed it ridicules, the idea of an external finality, according to which living beings are ordered with regard to each other: to suppose the grass made for the cow, the lamb for the wolf—that is all acknowledged to be absurd. But there is, we are told, an internal finality: -each being is made for itself, all its parts conspire for the greatest good of the whole and are intelligently organized in view of that end. Such is the notion of finality which has long been classic. Finalism has shrunk to the point of never embracing more than one living being at a time. By making itself smaller, it probably thought it would offer less surface for blows.

The truth is, it lay open to them a great deal more. Radical as our own theory may appear, finality it is external _ or it is nothing at all.

Consider "the" most complex and the most harmonious organism. All the elements, we are told, conspire for the greatest good of the whole. Very well, but let us not forget that each of these elements may itself be an organism in certain cases, and that in subordinating the existence of this small organism to the life of the great one we accept the principle of an external finality. The idea of a finality that is always internal is therefore a self-destructive notion. An organism is composed of tissues, each of which lives for itself. The cells of which the tissues are made have also a certain independence. Strictly speaking, if the subordination of all the elements of the individual to the individual itself were complete, we might contend that they are not organisms, reserve the name organism for the individual, and recognize only internal finality. But every one knows that these elements may possess a true autonomy. To say nothing of phagocytes, which push independence to the point of attacking the organism that nourishes them, or of germinal cells, which have their own life alongside the somatic cells—the facts of regeneration are enough: here an element or a group of elements suddenly reveals that, however limited its normal space and function, it can transcend them occasionally; it may even, in certain cases, be regarded as the equivalent of the whole.

There lies the stumbling-block of the vitalistic theories. We shall not reproach them, as is ordinarily done, with replying to the question by the question itself: the "vital principle" may indeed not explain much, but it is at least a sort of label affixed to our ignorance, so as to remind us of this occasionally, while mechanism invites us to ignore that ignorance. But the position of vitalism is rendered very difficult by the fact that, in nature, there is neither purely internal finality nor absolutely distinct individuality. The organized elements composing the individual have themselves a certain individuality, and each will claim its vital principle if the individual pretends to have its own. But, on the other hand, the individual itself is not sufficiently independent, not sufficiently cut off from other things, for us to allow it a "vital principle" of its own. An organism such as a higher vertebrate is the most individuated of all organisms; yet, if we take into account that it is only the development of an ovum forming part of the body of its mother and of a spermatozoon belonging to the body of its father, that the egg (i.e. the ovum fertilized) is a connecting link between the two progenitors since it is common to their two substances, we shall realize that every individual organism, even that of a man, is merely a bud that has sprouted on the combined body of both its parents. Where, then,\ does the vital principle of the individual begin or end. Gradually we

shall be carried further and further back, to the individual's remotest ancestors: we shall find him solidary with each of them, solidary with that little mass of protoplasmic jelly which is probably at the root of the genealogical tree of life. Being, to a certain extent, one with this primitive ancestor, he is also solidary with all that descends from the ancestor in divergent directions. In this sense each individual may be said to remain united with the totality of living beings by invisible bonds. So it is of no use to try to restrict finality to the individuality of the living being. If there is finality in the world of life, it includes the whole of life in a single indivisible embrace. This life common to all the living undoubtedly presents many gaps and incoherences, and again it is not so mathematically one that it cannot allow each being to become individualized to a certain degree. But it forms a single whole, none the less; and we have to choose between the out-and-out negation of finality and the hypothesis which co-ordinates not only the parts of an organism with the organism itself, but also each living being with the collective whole of all others.

Finality will not go down any easier for being taken as a powder. Either the hypothesis of a finality immanent in life should be rejected as a whole, or it must undergo a treatment very different from pulverization.

The error of radical finalism, as also that of radical mechanism, is to extend too far the application of certain concepts that are natural to our intellect. Originally, we think only in order to act. Our intellect has been cast in the mold of action. Speculation is a luxury, while action is a necessity. Now, in order to act, we begin by proposing an end; we make a plan, then we go on to the detail of the mechanism which will bring it to pass. This latter operation is possible only if we know what we can reckon on. We must therefore have managed to extract resemblances from nature, which enable us to anticipate the future. Thus we must, consciously or unconsciously, have made use of the law of causality. Moreover, the more sharply the idea of efficient causality is defined in our mind, the more it takes the form of a mechanical causality. And this scheme, in its turn, is the more mathematical according as it expresses a more rigorous necessity. That is why we have only to follow the bent of our mind to become mathematicians. But, on the other hand, this natural mathematics is only the rigid unconscious skeleton beneath our conscious supple habit of linking the same causes to the same effects; and the usual object of this habit is to guide actions inspired by intentions, or, what comes to the same, to direct movements combined with a view to reproducing a pattern. We are born artisans as we are born geometricians, and indeed we are geometricians only because we are artisans. Thus the human-intellect, inasmuch as it is fashioned for the needs of human action, is an intellect which proceeds at the same time by intention and by calculation, by adapting means to ends and by thinking out mechanisms of more and more geometrical form. Whether nature be conceived as an immense machine regulated by mathematical laws, or as the realization of a plan, these two ways of regarding it are only the consummation of two tendencies of mind which are complementary to each other, and which, have their origin in the same vital necessities.

For that reason, radical finalism is very near radical mechanism on many points. Both doctrines are reluctant to see in the course of things generally, or even simply 0 in the development of life, an unforeseeable creation of form. In considering reality, mechanism regards only the aspect of similarity or repetition. It is therefore dominated by this law, that in nature there is only like reproducing like. The more the geometry in mechanism is emphasized, the less can mechanism admit that anything is ever created, even pure form. In so far as we are geometricians, then, we reject the unforeseeable. We might accept it, assuredly, in so far as we are artists, for art lives on creation and implies a latent belief in the spontaneity of nature. But disinterested art is a luxury, like pure speculation. Long before being artists, we are artisans; and all fabrication, however rudimentary, lives on likeness and repetition, like the natural geometry which serves as its fulcrum. Fabrication works on models which it sets out to reproduce; and even when it invents, it proceeds, or imagines itself to proceed, by a new arrangement of elements already known. Its principle is

that "we must have like to produce like." In short,; the strict application of the principle of finality, like that of the principle of mechanical causality, leads to the con-/ elusion that "all is given." Both principles say the same thing in their respective languages, because they respond to the same need.

That is why again they agree in doing away with time.

Real duration is that duration which gnaws on things, \and leaves on them the mark of its tooth. If everything is in time, everything changes inwardly, and the same concrete reality never recurs. Repetition is therefore possible only in the abstract: what is repeated is some aspect that our senses, and especially our intellect, have singled out from reality, just because our action, upon which all the effort of our intellect is directed, can move only among repetitions. Thus, concentrated on that which repeats, solely preoccupied in welding the same to the same, intellect turns away from the vision of time. It dislikes what is fluid, and solidifies everything it touches. We do not think real time. But we live it, because life transcends intellect. The feeling we have of our evolution and of the evolution of all things in pure duration is there, forming around the intellectual concept properly so-called an indistinct fringe that fades off into darkness. Mechanism and finalism agree in taking account only of the bright nucleus shining in the centre. They forget that this nucleus has been formed out of the rest by condensation, and that the whole must be used, the fluid as well as and more than the condensed, in order to grasp the inner movement of life.

Indeed, if the fringe exists, however delicate and indistinct, it should have more importance for philosophy than the bright nucleus it surrounds. For it is its presence that enables us to affirm that the nucleus is a nucleus, that pure intellect is a contraction, by condensation, of a more extensive power. And, just because this vague intuition is of no help in directing our action on things, which action takes place exclusively on the surface of reality, we may presume that it is to be exercised not merely on the surface, but below.

As soon as we go out of the encasings in which radical mechanism and radical finalism confine our thought, reality \ appears as a ceaseless upspringing of something new, which has no sooner arisen to make the present than it has already fallen back into the past; at this exact moment it falls under the glance of the intellect, whose eyes are ever the fear. This is already the case with our inner life. For each of our acts we shall easily find antecedents of which it may in some sort be said to be the mechanical resultant. And it may equally well be said that each action is the realization of an intention. In this sense mechanism is everywhere, and finality everywhere, in the evolution of our conduct. But if our action be one that involves the whole of our person and is truly ours, it could not have been foreseen, even though its antecedents explain it when once it has been accomplished. And though it be the realizing of an intention, it differs, as a present and new reality, from the intention, which \ can never aim at anything but recommencing or rearranging the past. Mechanism and finalism are therefore, here, only external views of our conduct. They extract its intellectuality. But our conduct slips between them and extends much further. Once again, this does not mean that free action is capricious, unreasonable action. To behave according to caprice is to oscillate mechanically between two or more ready-made alternatives and at length to settle on one of them; it is no real maturing of an internal state, no real evolution; it is merely— however paradoxical the assertion may seem—bending the will to imitate the mechanism of the intellect. A K conduct that is truly our own, on the contrary, is that of a n will which does not try to counterfeit intellect, and which, \\ \J remaining itself—that is to say, evolving—ripens gradually into acts which the intellect will be able to resolve in- \\ definitely into intelligible elements without ever reaching its goal. The free act is incommensurable with the idea, and its "rationality" must be defined by this very incommensurability, which admits the discovery of as much intelligibility within it as we will.

Such is the character of our own evolution; and such also, without doubt, that of the evolution of life.

Our reason, incorrigibly presumptuous, imagines itself possessed by right of birth or by right of conquest, innate or acquired, of all the essential elements of the knowledge of truth. Even where it confesses that it does not know the object presented to it, it believes that its ignorance consists only in not knowing which one of its time-honored categories suits the new object. In what drawer, ready to open, shall we put it? In what garment, already cut out, shall we clothe it? Is it this, or that, or the other thing? And "this," and "that," and "the other thing" are always something already conceived, already known.

(The idea that for a new object we might have to create a new concept, perhaps a new method of thinking, is deeply repugnant to us. The history of philosophy is there, however, and shows us the eternal conflict of systems, the impossibility of satisfactorily getting the real into the ready-made garments of our ready-made concepts, the necessity of making to measure. But, rather than go to this extremity, our reason prefers to announce once for all, with a proud modesty, that it has to do only with the relative, and that the absolute is not in its province. This preliminary declaration enables it to apply its habitual method of thought without any scruple, and thus, under pretense that it does not touch the absolute, to make absolute judgments upon everything. Plato was the first to set up the theory that to know the real consists in finding its Idea, that is to say, in forcing it into a pre-existing frame already at our disposal—as if we implicitly possessed universal knowledge. But this belief is natural to the human intellect, always engaged as it is in determining under what former heading it shall catalogue any new object; and it may be said that, in a certain sense, we are all born Platonists.

Nowhere is the inadequacy of this method so obvious as in theories of life. If, in evolving in the direction of the vertebrates in general, of man and intellect in particular, life has had to abandon by the way many elements incompatible with this particular mode of organization and consign them, as we shall show, to other lines of development, it is the totality of these elements that we must find again and rejoin to the intellect proper, in order to grasp the true nature of vital activity. And we shall probably be aided in this by the fringe of vague intuition that surrounds our distinct—that is, intellectual —representation. For what can this useless fringe be, if not that part of the evolving principle which has not shrunk to the peculiar form of our organization, but has settled around it unasked for, unwanted? It is there, accordingly, that we must look for hints to expand the intellectual form of our thought; from there shall we derive the impetus necessary to lift us above ourselves. To form an idea of the whole of life cannot consist in combining simple ideas that have been left behind in us by life itself in the course of its evolution. How could the part be equivalent to the whole, the content to the container, a by-product of the vital operation to the operation itself? Such, however, is our illusion when we define the evolution of life as a "passage from the homogeneous to the heterogeneous," or by any other concept obtained by putting fragments of intellect side by side. We place ourselves in one of the points where evolution comes to a head—the principal one, no doubt, but not the only one; and there we do not even take all we find, for of the intellect we keep only one or two of the concepts by which it expresses itself; and it is this part of a part that we declare representative of the whole, of something indeed which goes beyond the concrete whole, I mean of the evolution movement of which this "whole" is only the present stage!

The truth is, that to represent this the entire intellect would not be too much—nay, it would not be enough. It would be necessary to add to it what we find in every other terminal point of evolution. And these diverse and divergent elements must be considered as so many extracts which are, or at least which were, in their humblest form, mutually complementary. Only then might we have an inkling of the real nature of the evolution movement; and even then we should fail to grasp it

completely, for we should still be dealing only with the evolved, which is a result, and not with evolution itself, which is the act by which the result is obtained.

Such is the philosophy of life to which we are leading up. It claims to transcend both mechanism and finalism; but, as we announced at the beginning, it is nearer the second doctrine than the first. It will not be amiss to dwell on this point, and show more precisely how far this philosophy of life resembles finalism and wherein it is different.

Like radical finalism, although in a vaguer form, our philosophy represents the organized world as a harmonious whole. But this harmony is far from being as perfect as it has been claimed to be. It admits of much discord, because each species, each individual even, retains only a certain impetus from the universal vital impulsion and tends to use this energy in its own interest. In this cons\s\s adaptation. The species and the individual thus think only of themselves—whence arises a possible conflict with other forms of life. Harmony^ .therefore, does not exist in fact it exists rather in principle; I mean that the original impetus is a common impetus, and the higher we ascend the stream of life the more do diverse tendencies appear complementary to each other. Thus the wind at a street-corner divides into diverging currents which are all one and the same gust. Harmony, or rather " complementarity," is revealed only in the mass, in tendencies rather than in states. Especially (and this is the point on which finalism has been most seriously mistaken) harmony is rather behind us than before. It is due to an identity of impulsion and not to a common aspiration. It would be futile to try to assign to life an end, in the human sense of the word. To speak of an end is to think of a pre-existing model which has only to be realized. It is to suppose, therefore, that all is given, and that the future can be read in the present. It is to believe that life, in its movement and in its entirety, goes to work like our intellect, which is only a motionless and fragmentary view of life, and which naturally takes its stand outside of time. Life, on the contrary, progresses and endures in time. Of course, when once the road has been traveled, we can glance over it, mark its direction, note this in psychological terms and speak as if there had been pursuit of an end. Thus shall we speak ourselves. But, of the road which was going to be traveled, the human mind could have nothing to say, for the road has been created pari passu with the act of traveling over it, being nothing but the direction of this act itself. At every instant, then, evolution must admit of a psychological interpretation which is, from our point of view, the best interpretation; but this explanation has neither value nor even significance except retrospectively. Never could the finalistic interpretation, such as we shall propose it, be taken for an anticipation of the future. It is a particular mode of viewing the past in the light of the present. In short, the classic conception of finality postulates at once too much and too little: it is both too wide and too narrow. *•* In explaining life by intellect, it limits too much the meaning of life: intellect, such at least as we find it in ourselves, has been fashioned by evolution during the course of progress; it is cut out of something larger, or, rather, it is only the projection, necessarily on a plane, of a reality that possesses both relief and depth. It is this more comprehensive reality that true finalism ought to reconstruct, or, rather, if possible, embrace in one view. But, on the other hand, just because it goes beyond intellect—the faculty of connecting the same with the same, of perceiving and also of producing repetitions—the reality is undoubtedly creative, t. e. productive of effects in which it expands and transcends its own being. These effects were therefore not given in it in advance, and so it could not take them for ends, although, when once produced, they admit of a rational interpretation, like that of the manufactured article that has reproduced a model. In short, the theory of final causes does not go far enough when it confines itself to ascribing some intelligence to nature, and it goes too far when it supposes a pre-existence of the future in the present in the form of idea. And the second theory, which sins by excess, is the outcome of the first, which sins by defect. ln place of intellect proper must be substituted the more comprehensive reality of which intellect is only the contraction. The future then appears as expanding the present: it was not, therefore, contained in the present in the form of a represented end.^ And yet, once realized, it will explain the present as much as the present explains it, and even more; it must be viewed as an

end as much as, and more than, a result. Our intellect has a right to consider the future abstractly from its habitual point of view, being itself an abstract view of the cause of its own being;

It is true that the cause may then seem beyond our grasp. Already the finalist theory of life eludes all precise verification. What if we go beyond it in one of its directions? Here, in fact, after a necessary digression, we are back at the question which we regard as essential: can the insufficiency of mechanism be proved by facts? We said that if this demonstration is possible, it is on condition of frankly accepting the evolutionist hypothesis. We must now show that if mechanism is insufficient to account for evolution, the way of proving this insufficiency is not to stop at the classic conception of finality, still less to contract or attenuate it, but, on the contrary, to go further.

Let us indicate at once the principle of our demonstration. We said of life that, from its origin, it is the continuation of one and the same impetus, divided into divergent lines of evolution. Something has grown, something has developed by a series of additions which have been so many creations. This very development has brought about a dissociation of tendencies which were unable to grow beyond a certain point without becoming mutually incompatible. Strictly speaking, there is nothing to prevent our imagining that the evolution of life might have taken place in one single individual by means of a series of transformations spread over thousands of ages. Or, instead of a single individual, any number might be supposed, succeeding each other in a unilinear series. In both cases evolution would have had, so to speak, one dimension only. But evolution has actually taken place through millions of individuals, on divergent lines, each ending at a crossing from which new paths radiate, and so on indefinitely. If our hypothesis is justified, if the essential causes working along these diverse roads are of psychological nature, they must keep something in common in spite of the divergence of their effects, as school-fellows long separated keep the same memories of boyhood. Roads may fork or by-ways be opened along which dissociated elements may evolve in an independent manner, but nevertheless it is in virtue of the primitive impetus of the whole that the movement of the parts continues. Something of the whole, therefore, must abide in the parts; and this common element will be evident to us in some way, perhaps by the presence of identical organs in very different organisms. Suppose, for an instant, that the mechanistic explanation is the true one: evolution must then have occurred through a series of accidents added to one another, each new accident being preserved by selection if it is advantageous to that sum of former advantageous accidents which the present form of the living being represents.'"* What likelihood is there that, by two entirely different series of accidents being added together, two entirely different evolutions will arrive at similar results? The more two lines of evolution diverge, the less probability is there that accidental outer influences or accidental inner variations bring about the construction of the same apparatus upon them, especially if there was no trace of this apparatus at the moment of divergence. But such similarity of the two products would be natural, on the contrary, on a hypothesis like ours: even in the latest channel there would be something of the impulsion received at the source. Pure mechanism, then, would be refutable, and finality, in the special sense in which we understand it, would be demonstrable in a certain aspect, if it could be proved that life may manufacture the like apparatus, by unlike means, on divergent lines of evolution; and the strength of the proof would be proportional both to the divergency between the lines of evolution thus chosen and to the complexity of the similar structures found in them.

It will be said that resemblance of structure is due to sameness of the general conditions in which life has evolved, and that these permanent outer conditions may have imposed the same direction on the forces constructing this or that apparatus, in spite of the diversity of transient outer influences and accidental inner changes. We are not, of course, blind to the role which the concept of adaptation plays in the science of to-day. Biologists certainly do not all make the same use of it. Some think, the outer conditions capable of causing change in organ-) CJ isms in a direct manner, in a definite direction, through physico-chemical alterations induced by them in the living

substance; such is the hypothesis of Eimer, for example. Others, more faithful to the spirit of Darwinism, believe the influence of conditions works indirectly only, through favoring, in the struggle for life, those representatives of a species which the chance of birth has best adapted to the environment. In other words, some attribute a positive influence to outer conditions, and say that they actually give rise to variations, while the others say these conditions have only a negative influence and merely eliminate variations. But, in both cases, the outer conditions are supposed to bring about a precise adjustment of the organism to its circumstances. Both parties, then, will attempt to explain mechanically, by adaptation to similar conditions, the similarities of structure which we think are the strongest argument against mechanism. So we must at once indicate in a general way, before passing to the detail, why explanations from??? seem too insufficient. A Let us first remark that, of the two hypotheses just ' described, the latter is the only one which is not equivocal.

The Darwinian idea of adaptation by automatic elimination of the unadapted is a simple and clear idea. But, just because it attributes to the outer cause which controls evolution a merely negative influence, it has great difficulty in accounting for the progressive and, so to say, rectilinear development of complex apparatus such as we are about to examine. How much greater will this difficulty be in the case of the similar structure of two extremely complex organs on two entirely different lines of evolution! An accidental variation, however minute, implies the working of a great number of small physical and chemical causes. An accumulation of accidental variations, such as would be necessary to produce a complex structure, requires therefore the concurrence of an almost infinite number of infinitesimal causes. Why should these causes, entirely accidental, recur the same, and in the same order, at different points of space and time? No one will hold that this is the case, and the Darwinian himself will probably merely maintain that identical effects may arise from different causes, that more than one road leads to the same spot. But let us not be fooled by a metaphor. The place reached does not give the form of the road that leads there; while an organic structure is just the accumulation of those small differences which evolution has had to go through in order to achieve it. The struggle for life and /natural selection can be of no use to us in solving this part of the problem, for we are not concerned here with //what has perished, we have to do only with what has W survived. Now, we see that identical structures have been formed on independent lines of evolution by a gradual accumulation of effects. How can accidental causes, occurring in an accidental order, be supposed to have repeatedly come to the same result, the causes being infinitely numerous and the effect infinitely complicated?

The principle of mechanism is that "the same causes produce the same effects." This principle, of course, does not always imply that the same effects must have the same causes; but it does involve this consequence in the particular case in which the causes remain visible in the effect that they produce and are indeed its constitutive elements. That two walkers starting from different points and wandering at random should finally meet, is no great wonder. But that, throughout their walk, they should describe two identical curves exactly superposable on each other, is altogether unlikely. The improbability will be the greater, the more complicated the routes; and it will become impossibility, if the zigzags are infinitely complicated. Now, what is this complexity of zigzags as compared with that of an organ in which thousands of different cells, each being itself a kind of organism, are arranged in a definite order? P Let us turn, then, to the other hypothesis, and see how it would solve the problem. Adaptation, it says, is not merely elimination of the unadapted; it is due to the positive influence of outer conditions that have molded the organism on their own form. This time, similarity of effects will be explained by similarity of cause. We shall remain, apparently, in pure mechanism. But if we look closely, we shall see that the explanation is merely verbal, that we are again the dupes of words, and that the trick of the solution consists in taking the term "adaptation" in two entirely different senses at the same time.

If I pour into the same glass, by turns, water and wine, the two liquids will take the same form, and the sameness in form will be due to the sameness in adaptation of content to container. Adaptation, here, really means mechanical adjustment. The reason is that the form to which the matter has adapted itself was there, ready-made, and has forced its own shape on the matter. But, in the adaptation of n Tip prism to the circumstances it has to live in, where is the pre-existing form awaiting its matter? The circumstances are not a mold into which life is inserted and whose form life adopts: this is indeed to be fooled by a metaphor. There is no form yet, and the life must create a form for itself, suited to the circumstances which are made for it. It will have to make the best of these circumstances, neutralize their inconveniences and utilize their advantages—in short, respond to outer actions by building up a machine which has no resemblance to them. *Such adapting is not repeating, but replying,—an entirely different thing. If there is still adaptation, it will be in the sense in which one may say of the solution of a problem of geometry, for example, that it is adapted to the conditions. It is true indeed that adaptation so understood explains why different evolutionary processes result in similar forms: the same problem, of course, calls for the same solution. But it is necessary then to introduce, as for the solution of a problem of geometry, an intelligent activity, or at least a cause which behaves in the same way. This is to bring in finality again, and a finality this time more than ever charged with anthropomorphic elements. In a word, if the adaptation is passive. if it is mere repetition in the relief of what the conditions give in the mold, it will build up nothing that one tries to make it build; and if it is active, capable of responding by a calculated solution to the problem which is set out in the conditions, that is going further than we do—too far, indeed, in our opinion—in the direction we indicated in the beginning. But the truth is that there is a surreptitious passing from one of these two meanings to the other, a flight for refuge to the first whenever one is about to be caught in flagrante delicto of finalism by employing the second. It is really the second which serves the usual practice of science, but it is the first that generally provides its philosophy. In any particular case*Me talks as if the process of adaptation were an effort of the organism to build up a machine capable of turning external circumstances to the best possible account; then one speaks of adaptation in general as if it were the very impress of circumstances, passively received by an indifferent matter.

But let us come to the examples. It would be interesting first to institute here a general comparison between plants and animals. One cannot fail to be struck with the parallel progress which has been accomplished, on both sides, in the direction of sexuality. Not only is fecundation itself the same in higher plants and in animals, since it consists, in both, in the union of two nuclei that differ in their properties and structure before their union and immediately after become equivalent to each other; but the preparation of sexual elements goes on in both under like conditions: it consists essentially in the reduction of the number of chromosomes and the rejection of a certain quantity of chromatic substance.1 Yet vegetables and animals have evolved on independent lines, favored by unlike circumstances, opposed by unlike obstacles. Here are two great series which have gone on diverging. On either line, thousands and thousands of causes have combined to determine the morphological and functional evolution. Yet these infinitely complicated causes have been consummated, in each series, in the same effect. And this effect could hardly be called a phenomenon of "adaptation": where is the adaptation, where is the pressure of external circumstances? There is no striking utility in sexual generation; it has been interpreted in the most diverse ways; and some very acute enquirers even regard the sexuality of the plant, at least, as a luxury which nature might have dispensed with.1 But we do not wish to dwell on facts so disputed. The ambiguity of the term " adaptation," and the necessity of transcending both the point of view of mechanical causality and that of anthropomorphic finality, will stand out more clearly with simpler examples. At all times the doctrine of finality has laid much stress on the marvellous structure of the sense organs, in order to liken the work of nature to that of an intelligent workman. Now, since these organs are found, in a rudimentary state, in the lower animals, and since nature offers us many intermediaries between the pigment-spot of the simplest organisms and the infinitely complex eye of the vertebrates, it may just as well be alleged that the result has

been brought about by natural selection perfecting the organ automatically. In short, if there is a case in which it seems justifiable to invoke adaptation, it is this particular one. For there may be discussion about the function and meaning of such a thing as sexual generation, in so far as it is related to the conditions in which it occurs; but the relation of the eye to light is obvious, and when we call this relation an adaptation, we must know what we mean. If, then, we can show, in this privileged case, the insufficiency of the principles invoked on both sides, our demonstration will at once have reached a high degree of generality.

Let us consider the example on which the advocates of finality have always insisted: the structure of such an organ as the human eye. They have had no difficulty in showing that in this extremely complicated apparatus all the elements are marvelously co-ordinated. In order that vision shall operate, says the author of a well-known book on Final Causes, "the sclerotic membrane must become transparent in one point of its surface, so as to enable luminous rays to pierce it ...; the cornea must correspond exactly with the opening of the socket . . .; behind this transparent opening there must be refracting media . . .; there must be a retina" at the extremity of the dark chamber . . .; perpendicular to the retina there must be an innumerable quantity of transparent cones permitting only the light directed in the line of their axes to reach the nervous membrane, "'etc. etc. In reply, the advocate of final causes has been invited to assume the evolutionist hypothesis. Everything is marvelous, indeed, if one consider an eye like ours, in which thousands of elements are coordinated in a single function. But take the function at its origin, in the Infusorian, where it is reduced to the mere impressionability (almost purely chemical) of a pigment-spot to light: this function, possibly only an accidental fact in the beginning, may have brought about a slight complication of the organ, which again induced an improvement of the function. It may have done this either directly, through some unknown mechanism, or indirectly, merely through the effect of the advantages it brought to the living being and the hold it thus offered to natural selection. Thus the progressive formation of an eye as well contrived as ours would be ^explained by an almost infinite number of actions and redactions between the function and the organ, without the intervention of other than mechanical causes. The question is hard to decide, indeed, when put directly between the function and the organ, as is done in the doctrine of finality, as also mechanism itself does. For organ and function are terms of different nature, and each conditions the other so closely that it is impossible to say a priori whether in expressing their relation we should begin with the first, as does mechanism, or with the second, as finalism requires. But the discussion would take an entirely different turn, we think, if we began by comparing together two terms of the same nature, an organ with an organ, instead of an organ with its function. In this case, it would be possible to proceed little by little to a solution more and more plausible, and there would be the more chance of a successful issue the more resolutely we assumed the evolutionist hypothesis.
Let us place side by side the eye of a vertebrate and that of a mollusc such as the common Pecten. We find the same essential parts in each, composed of analogous elements. The eye of the Pecten presents a retina, a cornea, a lens of cellular structure like our own. There is even that peculiar inversion of retinal elements which is not met with, in general, in the retina of the invertebrates. Now, the origin of molluscs may be a debated question, but, whatever opinion we hold, all are agreed that molluscs and vertebrates separated from their common parent-stem long before the appearance of an eye so complex as that of the Pecten. Whence, then, the structural analogy?

Let us question on this point the twisted systems of evolutionist explanation in turn-f-the hypothesis of purely accidental variations, and that of a variation directed in a definite way under the influence of external conditions.

The first, as is well known, is presented to-day in two quite different forms. Darwin spoke of very slight variations being accumulated by natural selection. He was not ignorant of the facts of sudden variation; but he thought these "sports," as he called them, were only monstrosities incapable of

perpetuating themselves; and he accounted for the genesis of species by an accumulation of insensible variations.1 Such is still the opinion of many naturalists. It is tending, however, to give way to the opposite idea that a new species comes into being all at once by the simultaneous appearance of several new characters, all somewhat different from the previous ones. This latter hypothesis, already proposed by various authors, notably by Bateson in a remarkable book,' has become deeply significant and acquired great force since the striking experiments of Hugo de Vries. This botanist, working on the Oenothera Lamarckiana, obtained at the end of a few generations a certain number of new species. The theory he deduces from his experiments is of the highest interest. Species pass through alternate periods off stability and ^.transformation. When the period of "mutability" occurs, unexpected forms spring forth in a great number of different directions.'—We will not attempt to take sides between this hypothesis and that of insensible variations. Indeed, perhaps both are partly true. We wish merely to point out that |f fhfl yp potions invoked are accidental, they do not, whether small or great, account for a similarity of structure such as we have cited.

Let us assume, to begin with, the Darwinian theory of insensible variations, and suppose the occurrence of small differences due to chance, and continually accumulating.

It must not be forgotten that all the parts of an organism are necessarily coordinated. Whether the function be the effect of the organ or its cause, it matters little; one point is certain—the organ will be of no use and will not give selection a hold unless it functions. However the minute structure of the retina may develop, and however complicated it may become, such progress, instead of favoring vision, will probably hinder it if the visual centres do not develop at the same time, as well as several parts of the visual organ itself. If the variations are accidental, how can they ever agree to arise in every part of the organ at the same time, in such way that the organ will continue to perform its function? Darwin quite understood this; it is one of the reasons why he regarded variation as insensible.1 For a difference which arises accidentally at one point of the visual apparatus, if it be very slight, will not hinder the functioning of the organ; and hence this first accidental variation can, in a sense, wait for complementary variations to accumulate and raise vision to a higher degree of perfection. Granted; but while the insensible variation does not hinder the functioning of the eye, neither does it help it, so long as the variations that are complementary do not occur. How, in that case, can the variation be retained by natural selection? Unwittingly one will reason as if the slight variation were a toothing stone set up by the organism and reserved for a later construction. This hypothesis, so little conformable to the Darwinian principle, is difficult enough to avoid even in the case of an organ which has been developed along one single main line of evolution, e.g. the vertebrate eye. But it is absolutely forced upon us when we observe the likeness of the structure of the vertebrate eye and that of the mollusc, how could the same small variations, according to Darwin, Origin of Species, chap. vi.

culable in number, have ever occurred ill the same order on two independent lines of evolution, if they were purely accidental? And how could they have been preserved by selection and accumulated in both cases, the same in the same order, when each of them, taken separately, was of no use?

Let us turn, then, to the hypothesis of sudden variations, and see whether it will solve the problem. It certainly lessens the difficulty on one point, but it makes it much worse on another. If the eye of the mollusc and that of the vertebrate have both been raised to their present form by a relatively small number of sudden leaps, I have less difficulty in understanding the resemblance of the two organs than if this resemblance were due to an incalculable number of infinitesimal resemblances acquired successively: in both cases it is chance that operates, but in the second case chance is not required to work the miracle it would have to perform in the first. Not only is the number of resemblances to be added somewhat reduced, but I can also understand better how each could be

preserved and added to the others; for the elementary variation is now considerable enough to be an advantage to the living being, and so to lend itself to the play of selection. But here there arises another problem, no less formidable, viz., how do all the parts of the visual apparatus, suddenly changed, remain so well coordinated that the eye continues to exercise its function? For the change of one part alone will make vision impossible, unless this change is absolutely infinitesimal. The parts must then all change at once, each consulting the others. I agree that a great number of uncoordinated variations may indeed have arisen in less fortunate individuals, that natural selection may have eliminated these, and that only the combination fit to

endure, capable of preserving and improving vision, has survived. Still, this combination had to be produced. And, supposing chance to have granted this favor once, can we admit that it repeats the self-same favor in the course of the history of a species, so as to give rise, every time, all at once, to new complications marvelously regulated with reference to each other, and so related to former complications as to go further on in the same direction? How, especially, can we suppose that by a series of mere "accidents" these sudden variations occur, the same, in the same order,—involving in each case a perfect harmony of elements more and more numerous and complex— along two independent lines of evolution?

The law of correlation will be invoked, of course; Darwin himself appealed to it.1 It will be alleged that a change is not localized in a single point of the organism, but has its necessary recoil on other points. The examples cited by Darwin remain classic: white cats with blue eyes are generally deaf; hairless dogs have imperfect dentition, etc.—Granted; but let us not play now on the word " correlation." A collective whole of solidary changes is one thing, a system of complementary changes—changes so coordinated as to keep up and even improve the functioning of an organ under more complicated conditions—is another. That an anomaly of the pilous system should be accompanied by an anomaly of dentition is quite conceivable without our having to call for a special principle of explanation; for hair and teeth are similar formations,' and the same chemical change of the germ that hinders the formation of hair would probably obstruct that of teeth: it may be for the same sort of reason that white cats with blue eyes are deaf. In these different examples the "correlative" changes are only solidary changes (not to mention the fact that they are really lesions, namely, diminutions or suppressions, and not additions, which makes a great difference). But when we speak of "correlative" changes occurring suddenly in the different parts of the eye, we use the word in an entirely new sense: this time there is a whole set of changes not only simultaneous, not only bound together by community of origin, but so coordinated that the organ keeps on performing the same simple function, and even performs it better. That a change in the germ, which influences the formation of the retina, may affect at the same time also the formation of the cornea, the iris, the lens, the visual centres, etc., I admit, if necessary, although they are formations that differ much more from one another in their original nature than do probably hair and teeth. But that all these simultaneous changes should occur in such a way as to improve or even merely maintain vision, this is what, in the hypothesis of sudden variation, I cannot admit, unless a mysterious principle is to come in, whose duty it is to watch over the interest of the function. But this would be to give up the idea of "accidental" variation. In reality, these two senses of the word "correlation" are often interchanged in the mind of the biologist, just like the two senses of the word "adaptation." And the confusion is almost legitimate in botany, that science in which the theory of the formation of species by sudden variation rests on the firmest experimental basis. In vegetables, function is far less narrowly bound to form than in animals. Even profound morphological differences, such as a change in the form of leaves, have no appreciable influence on the exercise of function, and so do not require a whole system of complementary changes for the plant to remain fit to survive. But it is not so in the animal, especially in the case of an organ like the eye, a very complex structure and very delicate function. Here it is impossible to identify changes that are simply solidary with changes which are also complementary. The two senses of the ^word "correlation" must be carefully distinguished; it would be a downright paralogism to adopt

one of them in the premises of the reasoning, and the other in the conclusion. And this is just what is done when the principle of correlation is invoked in explanations of detail in order to account for complementary variations, and then correlation in general is spoken of as if it were any group of variations provoked by any variation of the germ. Thus, the notion of correlation is first used in current science as it might be used by an advocate of finality; it is understood that this is only a convenient way of expressing oneself, that one will correct it and fall back on pure mechanism when explaining the nature of the principles and turning from science to philosophy. And one does then come back to pure mechanism, but only by giving a new meaning to the word "correlation"—a meaning which would now make correlation inapplicable to the detail it is called upon to explain.
To sum up. if the accidental variations that bring about / evolution are insensible variations, some good genius must be appealed to—the genius of the future species—in order, to preserve and accumulate these variations, for selection

O will not look after this. If, on the other hand, the accidental variations are sudden, then, for the previous function to go on or for a new function to take its place, all the changes that have happened together must be complementary. So we have to fall back on the good genius again, this time to obtain the convergence of simultaneous changes, as before to be assured of the continuity of direction of successive variations. But in neither case can I parallel development of the same complex structures on independent lines of evolution be due to a mere accumulation of accidental variations. So we come to the second of the two great hypotheses we will have to examine. Suppose the variations are due, not to accidental and inner causes, but to the direct influence of outer circumstances. Let us see what line we should have to take, on this hypothesis, to account for the resemblance of eye-structure in two series that are independent of each other from the phylogenetic point of view.

Though molluscs and vertebrates have evolved separately, both have remained exposed to the influence of light. And light is a physical cause bringing forth certain definite effects. Acting in a continuous way, it has been able to produce a continuous variation in a constant direction. Of course it is unlikely that the eye of the vertebrate and that of the mollusc have been built up by a series of variations due to simple chance. Admitting even that light enters into the case as an instrument of selection, in order to allow only useful variations to persist, there is no possibility that the play of chance, even thus supervised from without, should bring about in both cases the same juxtaposition of elements coordinated in the same way. But it \ would be different supposing that light acted directly on the organized matter so as to change its structure and somehow adapt this structure to its own form. The resemblance of the two effects would then be explained by the identity, of the cause. The more and more complex eye would be something like the deeper and deeper imprint of light on a, matter which, being organized, possesses a special aptitude for receiving it.

But can an organic structure be likened to an imprint?

We have already called attention to the ambiguity of the term " adaptation." (The gradual complication of a form which is being better and better adapted to the mold of outward circumstances is one thing the increasingly complex structure of an instrument which derives more and more advantage from these circumstances is another. In the former case, the matter merely receives an imprint; in the second, it reacts positively, it solves a problem. Obviously it is this second sense of the word "adapt" that is used when one says that the eye has become better and better adapted to the influence of light. But one passes more or less unconsciously from this sense to the other, and a purely mechanistic biology will strive to make the passive adaptation of an inert matter, which submits to the influence of its environment, mean the same as the active adaptation of an organism which derives from this influence an advantage it can appropriate. It must be owned, indeed, that Nature herself appears to invite our mind to confuse these two kinds of

adaptation, for she usually begins by a passive adaptation where, later on, she will build up a mechanism for active response. Thus, in the case before us, it is unquestionable that the first rudiment of the eye is found in the pigment-spot of the lower organisms; this spot may indeed have been produced physically, by the mere action of light, and there are a great number of intermediaries between the simple spot of pigment and a complicated eye like that of the vertebrates.—But, from the fact that we pass from one thing to another by degrees, it does not follow that the two things are of the same nature. From the fact that an orator falls in, at first, with the passions of his audience in order to make himself master of them, it will not be concluded that to follow is the same as to lead. ^ Now, living matter seems to have no other means of turning circumstances to good account than by adapting itself to them passively at the outset. Where it has to direct a movement, it begins by adopting it. Life proceeds by insinuation,]) The intermediate degrees between a pigment-spot and an eye are nothing to the point: however numerous the degrees, there will still be the same interval between the pigment-spot and the eye as between a photograph and a photographic apparatus. Certainly the photograph has been gradually turned into a photographic apparatus; but could light alone, a physical force, ever have provoked this change, and converted an impression left by it into a machine capable of using it?

It may be claimed that considerations of utility are out of place here; that the eye is not made to see, but that we see because we have eyes; that the organ is what it is, and " utility " is a word by which we designate the functional effects of the structure. But when I say that the eye. "making Be" light, I do not merely mean that the eye is capable of seeing; I allude to the very precise relations that exist between this organ and the apparatus of locomotion. The retina of vertebrates is prolonged in an optic nerve, which, again, is continued by cerebral centres connected with motor mechanisms. Our eye makes use of light in that it enables us to utilize, by movements of reaction, the objects that we see to be advantageous, and to avoid those which we see to be injurious. Now, of course, as light may have produced a pigment-spot by physical means, so it can physically determine the movements of certain organisms; ciliated Infusoria, for instance, react to light. But no one would hold that the influence of light has physically caused the formation of a nervous system, of a muscular system, of an osseous system, all things which are continuous with the apparatus of vision in vertebrate animals. The truth is, when one speaks of the gradual formation of the eye, and, still more, when one takes into account all that is inseparably connected with it, one brings in something entirely different from the direct action of light. One implicitly attributes to organized matter a certain capacity sui generis, the mysterious power of building up very complicated machines to utilize the simple excitation that it undergoes.

But this is just what is claimed to be unnecessary. Physics and chemistry are said to give us the key to everything. Eimer's great work is instructive in this respect. It Ha well known what persevering effort this biologist has devoted to demonstrating that transformation is j brought about by the influence of the external on the internal, continuously exerted in the same direction, and I not, as Darwin held, by accidental variations. His theory rests on observations of the highest interest, of which the starting-point was the study of the course followed by the color variation of the skin in certain lizards. Before this, the already old experiments of Dorfmeister had shown that the same chrysalis, according as it was submitted to cold or heat, gave rise to very different butterflies, which had long been regarded as independent species, Vanessa levana and Vanessa prorsa: an intermediate temperature produces an intermediate form. We might class with these facts the important transformations observed in a little crustacean, Artemia salina, when the salt of the water it lives in is increased or diminished.1 In these various experiments the external agent seems to act as a cause of transformation. But what does the word " cause " mean here? Without undertaking an exhaustive analysis of the idea of causality, we will merely remark that three very different meanings of this term are commonly confused. A cause may act by impelling, releasing, or unwinding. The billiard-ball, that strikes another, determines its movement by impelling. The spark that explodes the powder acts by releasing. The gradual relaxing of the spring, that makes the

phonograph turn, unwinds the melody inscribed on the cylinder: if the melody which is played be the effect, and the relaxing of the spring the cause, we must say that the cause acts by unwinding. What distinguishes these three cases from each other is the greater or less solidarity between the cause and the effect. In the first, the quantity and quality of the effect vary with the quantity and quality of the cause. In the second, neither quality nor quantity of the effect varies with quality and quantity of the cause: the effect is invariable. In the third, the quantity of the effect depends on the quantity of the cause, but the cause does not influence the quality of the effect: the longer the cylinder turns by the action of the spring, the more of the melody I shall hear, but the nature of the melody, or of the part heard, does not depend on the action of the spring. Only in the first case, really, does cause explain effect; in the others the effect is more or less given in advance, and the antecedent invoked is— in different degrees, of course—its occasion rather than its cause. Now, in saying that the saltness of the water is the cause of the transformations of Artemia, or that the degree of temperature determines the color and marks of the wings which a certain chrysalis will assume on becoming a butterfly, is the word "cause" used in the first sense? Obviously not: causality has here an intermediary sense between those of unwinding and releasing. Such, indeed, seems to be Eimer's own meaning when he speaks or when he says that the variation of organized matter works in a definite way, just as inorganic matter crystallizes in definite directions.' And it may be granted, perhaps, that the process is a merely physical and chemical one in the case of the color-changes of the skin. But if this sort of explanation is extended to the case of the gradual formation of the eye of the vertebrate, for instance, it must be supposed that the physico-chemistry of living bodies is such that the influence of light has caused the organism to construct a progressive series of visual apparatus, all extremely complex, yet all capable of seeing, and of seeing better and better.' What more could the most confirmed finalist say, in order to mark out so exceptional a physic chemistry? And will not the position of a mechanistic philosophy become still more difficult, when it is pointed out to it that the egg of a mollusc cannot have the same chemical composition as that of a vertebrate, that the organic substance which evolved toward the first of these two forms could not have been chemically identical with that of the substance which went in the other direction, and that, nevertheless, under the influence of light, the same organ has been constructed in the one case as in the other? The more we reflect upon it, the more we shall see that 0 this production of the same effect by two different accumulations of an enormous number of small causes is contrary to the principles of mechanistic philosophy. We have concentrated the full force of our discussion upon an example drawn from phylogenesis. But ontogenesis would have furnished us with facts no less cogent. Every moment, right before our eyes, nature arrives at identical results, in sometimes neighboring species, by entirely different embryogenic processes. Observations of "heteroblastia" have multiplied in late years,1 and it has been necessary to reject the almost classical theory of the specificity of embryonic gills. Still keeping to our comparison between the eye of vertebrates and that of molluscs, we may point out that the retina of the vertebrate is produced by an expansion in the rudimentary brain of the young embryo. It is a regular nervous centre which has moved toward the periphery. In the mollusc, on the contrary, the retina is derived from the ectoderm directly, and not indirectly by means of the embryonic encephalon. Quite different, therefore, are the evolutionary processes which lead, in man and in the Pecten, to the development of a like retina. But, without going so far as to compare two organisms so distant from each other, we might reach the same conclusion simply by looking at certain very curious facts of regeneration in one and the same organism. If the crystalline lens of a Triton be removed, it is regenerated by the iris.' Now, the original lens was built out of the ectoderm, while the iris is of mesodermic origin. What is more, in the Salamandra maadata, if the lens be removed and the iris left, the regeneration of the lens takes place at the upper part of the iris; but if this upper part of the iris itself be taken away, the regeneration takes place in the inner or retinal layer of the remaining region.' Thus, parts differently situated, differently constituted, meant normally for different functions, are capable of performing the same duties and even of manufacturing, when necessary, the same pieces of the machine. Here we have, indeed, the same effect obtained by different combinations of causes.

Whether we will or no, we must appeal to some inner directing principle in order to account for this convergence of effects. Such convergence does not appear possible in the Darwinian, and especially the neo-Darwinian, theory of insensible accidental variations, nor in the hypothesis of sudden accidental variations, nor even in the theory that assigns definite directions to the evolution of the various organs by a kind of mechanical composition of the external with the internal forces. So we come to the only one of the present forms of evolution which remains for us to mention, viz., neo-Lamarckism.

It is well known that Lamarck attributed to the living being the power of varying use or disuse of its organs, and also of passing on the variation so acquired to its descendants. A certain number of biologists hold a doctrine of this kind to-day. The variation that results in a new species is not, they believe, merely an accidental variation inherent in the germ itself, nor is it governed by a determinism sui generis which develops definite characters in a definite direction, apart from every consideration of utility. It springs from the very effort of the living being to adapt itself to the circumstances of its existence./\The effort may indeed be only the mechanical exercise of certain organs, mechanically elicited by the pressure of external circumstances. But; it may also imply consciousness and will, and it is in this sense that it appears to be understood by one of the most eminent representatives of the

doctrine, the American naturalist Cope.1 Neo-Lamarckism \ is therefore, of all the later forms of evolutionism, the only one capable of admitting an internal and psychological principle of development, although it is not^ bound to do so. And it is _a]go the only evolutionism that seems to \ us to account for the building up of identical complex J organs on independent lines of development. For it is quite conceivable that the same effort to turn the same circumstances to good account might have the same result, especially if the problem put by the circumstances is such as to admit of only one solution. But the question re- mains, whether the term "effort" must not then be taken in a deeper sense, a sense even more psychological than any neo-Lamarckian supposes. For a mere variation of size is one thing, and a change of form is another. That an organ can be strengthened and grow by exercise, nobody will deny. But it is a long way from that to the progressive development of an eye like that of the molluscs and of the vertebrates. If this development be ascribed to the influence of light, long continued but passively received, we fall back on the theory we have just criticized. If, on the other hand, an internal activity is appealed to, then it must be something quite different from what we usually call an effort, for never has an effort been known to produce the slightest complication of an organ, and yet an enormous number of complications, all admirably coordinated, have been necessary to pass from the pigment-spot of the Infusorian to the eye of the vertebrate. But, even if we accept this notion of the evolutionary process in the case of animals, how can we apply it to plants? Here, variations of form do not seem to imply, nor always to lead to, functional changes; and even if the cause of the variation is of a psychological nature, we can hardly call it an effort, unless we give a very unusual extension to the meaning of the word. The truth is. it is necessary to dig beneath the effort itself and look for a deeper cause.

This is especially necessary, we believe, if we wish to get at a cause of regular hereditary variations. We are not going to enter here into the controversies over the transmissibility of acquired characters; still less do we wish to take too definite a side on this question, which is not within our province. But we cannot remain completely indifferent to it. Nowhere is it clearer that philosophers can not to-day content themselves with vague generalities, but must follow the scientists in experimental detail and discuss the results with them. If Spencer had begun by putting to himself the question of the hereditability of acquired characters, his evolutionism would no doubt have taken an altogether different form. If (as seems probable to us) a habit contracted by the individual were transmitted to its descendants only in very exceptional cases, all the Spenserian psychology would need re-making, and a large part of Spencer's philosophy would fall to pieces. Let

us say, then, how the problem seems to us to present itself, and in what direction an attempt might be made to solve it.

After having been affirmed as a dogma, the transmissibility of acquired characters has been no less dogmatically denied, for reasons drawn a priori from the supposed nature of germinal cells. It is well known how Weismann was led, by his hypothesis of the continuity of the germ-plasm, to regard the germinal cells—ova and spermatozoa—as almost independent of the somatic cells. Starting from this, it has been claimed, and is still claimed by many, that the hereditary transmission of an acquired character is inconceivable. But if, perchance, experiment should show that acquired characters are transmissible, it would prove thereby that the germ-plasm is not so independent of the somatic envelope as has been contended, and the transmissibility of acquired characters would become ipso facto conceivable; which amounts to saying that conceivability and inconceivability have nothing to do with the case, and that experience alone must settle the matter. But it is just here that the difficulty begins. The acquired characters we are speaking of are generally habits or the effects of habit, and at the root of most habits there is a natural disposition. So that one can always ask whether it is really the habit acquired by the soma of the individual that is transmitted, or whether it is not rather a natural aptitude, which existed prior to the habit. This aptitude would have remained inherent in the germplasm which the individual bears within him, as it was in the individual himself and consequently in the germ whence he sprang. Thus, for instance, there is no proof that the mole has become blind because it has formed the habit of living underground; it is perhaps because its eyes were becoming atrophied that it condemned itself to a life underground.1 If this is the case, the tendency to lose the power of vision has been transmitted from germ to germ without anything being acquired or lost by the soma of the mole itself. From the fact that the son of a fencing-master has become a good fencer much more quickly than his father, we cannot infer that the habit of the parent has been transmitted to the child; for certain natural dispositions in course of growth may have passed from the plasma engendering the father to the plasma engendering the son, may have grown on the way by the effect of the primitive impetus, and thus assured to the son a greater suppleness than the father had, without troubling, so to speak, about what the father did. So of many examples drawn from the progressive domestication of animals: it is hard to say whether it is the acquired habit that is transmitted or only a certain natural tendency—that, indeed, which has caused such and such a particular species or certain of its representatives to be specially chosen for domestication. The truth is, when every doubtful case, every fact open to more than one interpretation, has been eliminated, there remains hardly a single unquestionable example of acquired and transmitted peculiarities, beyond the famous experiments of Brown-Sequard, repeated and confirmed by other physiologists.1 By cutting the spinal cord or the sciatic nerve of guinea-pigs, Brown-Sequard brought about an epileptic state which was transmitted to the descendants. Lesions of the same sciatic nerve, of the restiform body, etc., provoked various troubles in the guinea-pig which its progeny inherited sometimes in a quite different form: exophthalmia, loss of toes, etc. But it is not demonstrated that in these different cases of hereditary transmission there had been a real influence of the soma of the animal on its germ-plasm. Weismann at once objected that the operations of Brown-S6quard might have introduced certain special microbes into the body of the guinea-pig, which had found their means of nutrition in the nervous tissues and transmitted the malady by penetrating into the sexual elements.' This objection has been answered by Brown-Sequard himself;1 but a more plausible one might be raised. Some experiments of Voisin and Peron have shown that fits of epilepsy are followed by the elimination of a toxic body which, when injected into animals,1 is capable of producing convulsive symptoms. Perhaps the trophic disorders following the nerve lesions made by Brown-Sequard correspond to the formation of precisely this convulsion-causing poison. If so, the toxin passed from the guinea-pig to its spermatozoon or ovum, and caused in the development of the embryo a general disturbance, which, however, had no visible effects except at one point or another of the organism when developed. In that case, what occurred would have been somewhat the same as in the experiments of Charrin, Delamare, and Moussu, where guinea-pigs in gestation,

whose liver or kidney was injured, transmitted the lesion to their progeny, simply because the injury to the mother's organ had given rise to specific "cytotoxins" which acted on the corresponding organ of the foetus.' It is true that, in these experiments, as in a former observation of the same physiologists,* it was the already formed foetus that was influenced by the toxins. But other researches of Charrin have resulted in showing that the same effect may be produced, by an analogous process, on the spermatozoa and the ova.' To conclude, then: the inheritance of an acquired peculiarity in the experiments of Brown-Sequard can be explained by the effect of a toxin on the germ. The lesion, however well localized it seems, is transmitted by the same process as, for instance, the taint of alcoholism. But may it not be the same in the case of every acquired peculiarity that has become hereditary?

There is, indeed, one point on which both those who affirm and those who deny the transmissibility of acquired characters are agreed, namely, that certain influences, such as that of alcohol, can affect at the same time both the living being and the germ-plasm it contains. In such case, there is inheritance of a defect, and the result is as if the soma of the parent had acted on the germ-plasm, although in reality soma and plasma have simply both suffered the action of the same cause. Now, suppose that the soma can influence the germ-plasm, as those believe who hold that acquired characters are transmissible. Is not the most natural hypothesis to suppose l that things happen in this second case as in the first, and that the direct effect of the influence of the soma is a general alteration of the germ-plasm? If this is the case, it is by exception, and in some sort by accident, that the modification of the descendant is the same as that of the parent. It is like the hereditability of the alcoholic taint: it passes from father to children, but it may take a different form in each child, and in none of them be like what it was in the father. Let the letter C represent the change in the plasm, C being either positive or negative, that is to say, showing either the gain or loss of certain substances. The effect will not be an exact reproduction of the cause, nor will the change in the germ-plasm, provoked by a certain modification of a certain part of the soma, determine a similar modification of the corresponding part of the new organism in process of formation, unless all the other

nascent parts of this organism enjoy a kind of immunity as regards C: the same part will then undergo alteration in the new organism, because it happens that the development of this part is alone subject to the new influence. And, even then, the part might be altered in an entirely different way from that in which the corresponding part was altered in the generating organism.

We should propose, then, to introduce a distinction between the hereditability of deviation and that of character. An individual which acquires a new character thereby deviates from the form it previously had, which form the germs, or oftener the half-germs, it contains would have reproduced in their development. If this modification does not involve the production of substances capable of changing the germ-plasm, or does not so affect nutrition as to deprive the germ-plasm of certain of its elements, it will have no effect on the offspring of the individual. This is probably the case as a rule. If, on the contrary, it has some effect, this is likely to be due to a chemical change which it has induced in the germplasm. This chemical change might, by exception, bring about the original modification again in the organism which the germ is about to develop, but there are as many and, more chances that it will do something else. In this latter case, the generated organism will perhaps deviate' from the normal type as much as the generating organism, but it will do so differently. It will have inherited deviation j and not character. In general, therefore, the habits formed by an individual have probably no echo in its offspring; and when they have, the modification in the descendants may have no visible likeness to the original one. Such is the hypothesis which seems to us most likely. In any case, in default of proof to the contrary, and so long as the decisive experiments called for have not been made, we must keep to the actual results of observation. Now, even if we take the most favorable view of the theory of the transmissibility of acquired characters, and assume that the ostensible acquired character is not, in most cases, the more or less tardy development of an innate character, facts show us that hereditary transmission

is the exception and not the rule. How, then, shall we expect it to develop an organ such as the eye? When we think of the enormous number of variations, all in the same direction, that we must suppose to be accumulated before the passage from the pigment-spot of the Infusorian to the eye of the mollusc and of the vertebrate is possible, we do not see how heredity, as we observe it, could ever have determined this piling-up of differences, even supposing that individual efforts could have produced each of them singly. That is to say that neo-Lamarckism is no more able than any other form of evolutionism to solve the problem.

In thus submitting the various present forms of evolutionism to a common test, in showing that they all strike against the same insurmountable difficulty, we have in no wise the intention of rejecting them altogether. On the contrary, each of them, being supported by a considerable number of facts, must be true in its way. Each of them must correspond to a certain aspect of the process of evolution. Perhaps even it is necessary that a theory should restrict itself exclusively to a particular point of view, in order to remain scientific, i.e. to give a precise direction to researches into detail. But the reality of which each of these theories takes a partial view may transcend them all. And this reality is the special object cision because it contemplates no practical application. Let us therefore indicate in a word or two; the positive contribution that each of the three present forms of evolutionism seems to us to make toward the solution of the problems that each of them leaves out, ascertain what point this threefold effort should, in our opinion, converge in order to obtain a more comprehensive, although thereby of necessity a less definite, idea of the evolutionary process. £^The neo-Darwinians are probably right, we believe, when they teach that the essential causes of variation are the differences inherent in the germ borne by the individual, and not the experiences or behavior of the individual in the course of his career. Where we fail to follow these biologists, is in regarding the differences inherent in the germ as purely accidental and individual. We cannot help believing that these differences are the development of an impulsion which passes from germ to germ across the individuals, that they are therefore not pure accidents, and that they might well appear at the same time, in the same form, in all the representatives of the same species, or at least in a certain number of them. Already, in fact, the theory of mutations is modifying Darwinism profoundly on this point. It asserts that at a given moment, after a long period, the entire species is beset with a tendency to change. The tendency to change, therefore, is not accidental. True, the change itself would be accidental, since the mutation works, according to De Vries, in different directions in the different representatives of the species. But, first we must see if the theory is confirmed by many other vegetable species (De Vries has verified it only by the (Enothera Lamarckiana),» and then there is the possibility, as we shall explain further on, that the part played by chance is much greater in the variation of plants than in that of animals, because, in the vegetable world, function does not depend so strictly on form. Be that as it may, the neo-Darwinians are inclined to admit that the periods of mutation are determinate. The direction of the mutation may therefore be so as well, at least in animals, and to the extent we shall have to indicate. molluscs and vertebrates. The idea of an "original impetus," moreover, will thus be made clearer.

We thus arrive at a hypothesis like Eimer's, according to which the variations of different characters continue from generation to generation in definite directions. This hypothesis seems plausible to us, within the limits in which Eimer himself retains it. Of course, the evolution of the organic world cannot be predetermined as a whole. We claim, on the contrary, that the spontaneity of life is manifested by a continual creation of new forms succeeding others. But this indetermination cannot be complete; it must leave a certain part to determination. An organ like the eye, for example, must have been formed by just a continual changing in a definite direction. Indeed, we do not see how otherwise to explain the likeness of structure of the eye in species that have not the same history. Where we differ from Eimer is in his claim that combinations of physical and chemical causes are enough to secure the result. We have tried to prove, on the contrary, by the example of the eye, that if there is "orthogenesis" here, a psychological cause intervenes.

Certain neo-Lamarckians do indeed resort to a cause of a psychological nature. There, to our thinking, is one of the most solid positions of neo-Lamarckism. But if this cause is nothing but the conscious effort of the individual, it cannot operate in more than a restricted number of cases—at most in the animal world, and not at all

in the vegetable kingdom. Even in animals, it will act only on points which are under the direct or indirect control of the will. And even where it does act, it is not clear how it could compass a change so profound as an increase of complexity: at most this would be conceivable if the acquired characters were regularly transmitted so as to be added together; but this transmission seems to be the exception rather than the rule. A hereditary change in a definite direction, which continues to accumulate and add to itself so as to build up a more and more complex ~ machine, must certainly be related to some sort of effort, / but to an effort of far greater depth than the individual effort, far more independent of circumstances, an effort common to most representatives of the same species, inherent in the germs they bear rather than in their sub- stance alone, an effort thereby assured of being passed on to their descendants. So we come back, by a somewhat roundabout way, to the idea we started from, that of an original impetus s » of life, passing from one generation of germs to the following generation of germs through the developed organ- isms which bridge the interval between the generations. [This impetus, sustained right along the lines of evolution among which it gets divided, is the fundamental cause of variations, at least of those that are regularly passed on, that accumulate and create new species. In general, when species have begun to diverge from a common stock, they accentuate their divergence as they progress in their evolution. Yet, in certain definite points, they may evolve identically; in fact, they must do so if the hypothesis of a common impetus be accepted. This is just what we shall have to show now in a more precise way, by the same example we have chosen, the formation of the eye in Two points are equally striking in an organ like the eye: the complexity of its structure and the simplicity of its function. The eye is composed of distinct parts, such as the sclerotic, the cornea, the retina, the crystalline lens, etc. In each of these parts the detail is infinite. The retina alone comprises three layers of nervous elements— multipolar cells, bipolar cells, visual cells—each of which has its individuality and is undoubtedly a very complicated organism: so complicated, indeed, is the retinal membrane in its intimate structure, that no simple description can give an adequate idea of it. The mechanism of the eye is, in short, composed of an infinity of mechanisms, all of extreme complexity. Yet vision is one simple fact. As soon as the eye opens, the visual act is effected. Just because the act is simple, the slightest negligence on the part of nature in the building of the infinitely complex machine would have made vision impossible. This contrast between the complexity of the organ and the unity of the function is what gives us pause.

A mechanistic theory is one which means to show us the gradual building-up of the machine under the influence of external circumstances intervening either directly by action on the tissues or indirectly by the selection of better adapted ones. But, whatever form this theory may take, supposing it avails at all to explain the detail of the parts, it throws no light on their correlation.

Then comes the doctrine of finality, which says that the parts have been brought together on a preconceived plan with a view to a certain end. In this it likens the labor of nature to that of the workman, who also proceeds by the assemblage of parts with a view to the realization of an idea or the imitation of a model. Mechanism, here, reproaches finalism with its anthropomorphic character, and rightly. But it fails to see that itself proceeds according to this method—somewhat mutilated! True, it has got rid of the end pursued or the ideal model. But it also holds that nature has worked like a human being by bringing parts together, while a mere glance at the development of an embryo shows that life goes to work in a very different way. Life does not proceed by the as- ^ satiation and addition of elements, but by dissociation and division. We must get beyond both points of view, both mechanism and finalism being, at bottom, only standpoints to which the human mind has been led by considering the work of man. But in what direction can we go beyond

them? We have said that in analyzing the structure of an organ, we can go on decomposing for ever, although the function of the whole is a simple thing. This contrast between the infinite complexity of the organ and the extreme simplicity of the function is what should open our eyes. In general, when the same object appears in one aspect as simple and in another as infinitely complex, the two aspects have by no means the same importance, or rather the same degree of reality. In such cases, the simplicity belongs to the object itself, and the infinite complexity to the views we take in turning around it, to the symbols by which our senses or intellect represent it to us, or, more generally, to elements of a different order, with which we try to imitate it artificially, but with which it remains incommensurable, being of a different nature. An artist of genius has painted a figure on his canvas. We can imitate his picture with many-colored squares of mosaic. And we shall reproduce the curves and shades of the model so much the better as our squares are smaller, more numerous and more varied in tone. But an infinity of elements infinitely small,

presenting an infinity of shades, would be necessary to obtain the exact equivalent of the figure that the artist has conceived as a simple thing, which he has wished to transport as a whole to the canvas, and which is the more complete the more it strikes us as the projection of an indivisible intuition. Now, suppose our eyes so made that they cannot help seeing in the work of the master a mosaic effect. Or suppose our intellect so made that it cannot explain the appearance of the figure on the canvas except as a work of mosaic. We should then be able to speak simply of a collection of little squares, and we should be under the mechanistic hypothesis. We might add that, beside the materiality of the collection, there must be a plan on which the artist worked; and then we should be expressing ourselves as finalists. But in neither case should we have got at the real process?" for there are no squares brought together. It is the picture, i.e. the simple act, projected on the canvas, which, by the mere fact of entering into our perception, is decomposed before our eyes into thousands and thousands of little squares which present, as recomposed, a wonderful arrangement. So the eye, with its marvelous complexity of structure, may be only the simple act of vision, divided for us into a mosaic of cells, whose order seems marvelous to us because we have conceived the whole as an assemblage.

If I raise my hand from A to B, this movement appears to me under two aspects at once. Felt from within, it is a simple, indivisible act. Perceived from without, it is the course of a certain curve, AB. In this curve I can distinguish as many positions as I please, and the line itself might be defined as a certain mutual coordination of these positions. But the positions, infinite in number, and the order in which they are connected, have sprung automatically from the indivisible act by which my hand has gone from A to B. Mechanism, here, would consist in seeing only the positions. Finalism would take their order into account. But both mechanism and finalism would leave on one side the movement, which is reality itself. In one sense, the movement is more than the positions and than their order; for it is sufficient to make it in its indivisible simplicity to secure that the infinity of the successive positions as also their order be given at once—with something else which is neither order nor position but which is essential, the mobility. But, in another sense, the movement is less than the series of positions and their connecting order; for, to arrange points in a certain order, it is necessary first to conceive the order and then to realize it with points, there must be the work of assemblage and there must be intelligence, whereas the simple movement of the hand contains nothing of either. It is not intelligent, in the human sense of the word, and it is not an assemblage, for it is not made up of elements. Just so with the relation of the eye to vision. There is in vision more than the component cells of the eye and their mutual coordination: in this sense, neither mechanism nor finalism go far enough. But, in another sense, mechanism and finalism both go too far, for they attribute to Nature the most formidable of the labors of Hercules in holding that she has exalted to the simple act of vision an infinity of infinitely complex elements, whereas Nature has had no more trouble in making an eye than I have in lifting my hand. Nature's simple act has divided itself automatically into an infinity of elements which are then found to be coordinated to one idea, just as the movement of my hand has dropped an infinity of points which are then found

to satisfy one equation. We find it very hard to see things in that light, because we cannot help conceiving organization as manufacturing. But it is one thing to manufacture, and quite another to organize. Manufacturing is peculiar to man. It consists in assembling parts of matter which we have cut out in such manner that we can fit them together and obtain from them a common action. The parts are arranged, so to speak, around the action as an ideal centre. To manufacture, therefore, is to work from the periphery to the centre, or, as the philosophers say, from the many to the one. Organization, on the contrary, works from the centre to the periphery. It begins in a point that is almost a mathematical point, and spreads around this point by concentric waves which go on enlarging. The work of manufacturing is the more effective, the greater the quantity of matter dealt with. It proceeds by concentration and compression. The organizing action the contrary, has something explosive about it: it needs at the beginning the smallest possible1 place, a minimum of matter, as if the organizing forces only entered space reluctantly. The spermatozoon, which sets in motion the evolutionary process of the embryonic life, is one of the smallest cells of the organism; and it is only a small part of the spermatozoon which really takes part in the operation.

But these are only superficial differences. Digging beneath them, we think, a deeper difference would be found.

A manufactured thing delineates exactly the form of the work of manufacturing it. I mean that the manufacturer finds in his product exactly what he has put into it. If he is going to make a machine, he cuts out its pieces one by one and then puts them together: the machine, when made, will show both the pieces and their assemblage. The whole of the result represents the whole of the work; and to each part of the work corresponds a part of the result.

Now I recognize that positive science can and should proceed as if organization was like making a machine. Only so will it have any hold on organized bodies. For its object is not to show us the essence of things, but to furnish us with the best means of acting on them. Physics and chemistry are well advanced sciences, and living matter lends itself to our action only so far as we can treat it by the processes of our physics and chemistry. Organization can therefore only be studied scientifically if the organized body has first been likened to a machine. The cells will be the pieces of the machine, the organism their assemblage, and the elementary labors which have organized the parts will be regarded as the real elements of the labor which has organized the whole. This is the standpoint of science. Quite different, in our opinion, is that of philosophy.

For us, the whole of an organized machine may, strictly speaking, represent the whole of the organizing work (this is, however, only approximately true), yet the parts of the machine do not correspond to parts of the work, because the materiality of this machine does not represent a sum of means employed, bid a sum of obstacles avoided: it is a negation rather than a positive reality. So, as we have shown in a former study, vision is a power which should attain by right an infinity of things inaccessible to our eyes. But such a vision would not be continued into action; it might suit a phantom, but not a living being. The vision of a living being is an effective vision, limited to objects on which the being can act: it is a vision that is canalized, and the visual apparatus simply symbolizes the work of canalizing. Therefore the creation of the visual apparatus is no more explained by the assembling of its anatomic elements than the digging of a canal could be explained by the heaping-up of the earth which might have formed its ' banks. A mechanistic theory would maintain that the earth had been brought cart-load by cart-load; finalism would add that it had not been dumped down at random, that the carters had followed a plan. But both theories would be mistaken, for the canal has been made in another way.

With greater precision, we may compare the process by which nature constructs an eye to the simple act by which we raise the hand. But we supposed at first that the hand met with no resistance. Let us now imagine that, instead of moving in air, the hand has to pass through iron

filings which are compressed and offer resistance to it in proportion as it goes forward. At a certain moment the hand will have exhausted its effort, and, at this very moment, the filings will be massed and coordinated in a certain definite form, to wit, that of the hand that is stopped and of a part of the arm. Now, suppose that the hand and arm are invisible. Lookers-on will seek the reason of the arrangement in the filings themselves and in forces within the mass. Some will account for the position of each filing by the action exerted upon it by the neighboring filings: these are the mechanists. Others will prefer to think that a plan of the whole has presided over the detail of these elementary actions, they are the finalists. But the truth is that there has been merely one indivisible act, that of the hand passing through the filings: the inexhaustible detail of the movement of the grains, as well as the order of their final arrangement, expresses negatively, in a way, this undivided movement, being the unitary form of a resistance, and not a synthesis of positive elementary actions. For this reason, if the arrangement of the grains is termed an "effect" and the movement of the hand a "cause," it may indeed be said that the whole of the effect is explained by the whole of the cause, but to parts of the cause parts of the effect will in no wise correspond. In other words, neither mechanism nor finalism will here be in place, and we must resort to an explanation of a different kind. Now, in the hypothesis we propose, the relation of vision to the visual apparatus would be very nearly that of the hand to the iron filings that follow, canalize and limit its motion.

The greater the effort of the hand, the farther it will go into the filings. But at whatever point it stops, instantaneously and automatically the filings coordinate and find their equilibrium. So with vision and its organ. \ According as the undivided act constituting vision advances more or less, the materiality of the organ is made of a more or less considerable number of mutually coordinated elements, but the order is necessarily complete and perfect. It could have been partial, because, once again, the process which gives rise to it has no parts. That is what neither mechanism nor finalism takes into account, and it is what we also fail to consider when we wonder at the marvelous structure of an instrument such as the eye. At the bottom of our wondering is always this idea, that it would have been possible for a part only of this coordination to have been realized, that the complete realization is a kind of special favor. This favor the finalists consider as dispensed to them all at once, by the final cause; the mechanists claim to obtain it little by little, by the effect of natural selection; but both see something positive in this coordination, and consequently something fractionable in its cause,—something which admits of every possible degree of achievement. In reality, the cause, though more or less intense, cannot produce its effect except in one piece, and completely finished. According as it goes further and further in the direction of vision, it gives the simple pigmentary masses of a lower organism, or the rudimentary eye of a Serpula, or the slightly differentiated eye of the Alciope, or the marvelously perfected eye of the bird; but all these organs, unequal as is their complexity, necessarily present an equal coordination. For this reason, no matter how distant two animal species may be from each other, if the progress toward vision has gone equally far in both, there is the same visual organ in each case, for the form of the organ only expresses the degree in which the exercise of the function has been obtained.

But, in speaking of a progress toward vision, are we not coming back to the old notion of finality? It would be so, undoubtedly, if this progress required the conscious or unconscious idea of an end to be attained. But it is really effected in virtue of the original impetus of life: it is implied in this movement itself and that is just why it is found in independent lines of evolution. If now we are asked why and how it is implied therein, we reply that, life is, more than anything else, a tendency to act on inert matter. The direction of this action is not predetermined; hence the unforeseeable variety of forms which life, in evolving, sows along its path. But this action always presents, to some extent, the character of contingency; it implies at least a rudiment of choice. Now a choice involves the anticipatory idea of several possible actions. Possibilities of action must therefore be marked out for the living being before the action itself. Visual perception is nothing else:1 the

visible outlines of bodies are the design of our eventual action on them. Vision will be found, therefore, in different degrees in the most diverse animals, and it will appear in the same complexity of structure wherever it has reached the same degree of intensity.
We have dwelt on these resemblances of structure in general, and on the example of the eye in particular, because we had to define our attitude toward mechanism on the one hand and finalism on the other. It remains for us to describe it more precisely in itself. This we shall now do by showing the divergent results of evolution not as presenting analogies, but as themselves mutually complementary.

1909
B. H. Roberts, First Council of the Seventy
II.-Creation-the Works of God
Seventies Course in Theology (3rd Year)

1. The Testimony of the Creation to the Existence of God:
When once the idea of the existence of God is suggested to the mind of man by the testimony of the fathers, and represented as he is by that tradition, as the Creator of the heavens and the earth, and also as the great governing and guiding power throughout the universe-very much is discovered in the marvelous works of nature to strengthen and confirm, almost to a certainty, the truth of that tradition.

Man is conscious of his own existence, and that existence is a stupendous miracle of itself; he is conscious, too, of other facts. He looks out into space in the stillness of night, and sees the deep vault of heaven inlaid with suns, the centers, doubtless of planetary systems, all moving in exact order and harmony, in such regularity that he cannot doubt that Intelligence brought them into being, and now sustains and directs the forces that preserve them. Thus the heavens declare the existence of God as well as His glory. This thought is in harmony with the tradition of his fathers, and he recognizes the identity between the Intelligence that he knows must control the universe, and the God of whom his fathers testify.

Nor is this all: but in the mysterious changes which take place on our own planet, in the gentle Spring, luxuriant Summer, fruitful Autumn and nature-resting Winter, with its storms and frosts-the "mysterious round" which brings us our seed time and harvest, and clothes the earth with vegetation and flowers, perpetuating that wonderful power we call life,-the strangest fact in all the works of nature-in these mighty changes so essential and beneficent, man recognizes the wisdom and power of God of whom his fathers bear record.

As the heavens declare God's existence and glory, so, likewise, do these changes and a thousand other things, connected without earth, until lost in wonder and admiration, one exclaims with Paul,

"The invisible things of him from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power and godhead." (Rom. 1:20.)

Or else He calls to mind another Scripture, still more sublime-

"The earth rolls upon her wings, and the sun giveth his light by day, and the moon giveth her light by night, and the stars also give their light, as they roll upon their wings in their glory, in the midst of the power of God. * * * Behold, all these are kingdoms, and any man who hath seen any or the least of these, hath seen God moving in his majesty and power." (Doc. & Cov. Sec. 88.)

"But wandering oft, with brute unconscious gaze,

Man marks not thee; marks not The Mighty hand,
That, ever busy, wheels the silent speres!"-Thompson.

This much we may say, in conclusion, tradition confirmed by the works of creation, lays a broad foundation for an intelligent belief in God's existence, intelligence, power, and glory.

2. The Law of Substance and the Universe. "Through all eternity the infinite universe has been, and is, subject to the law of substance: * * * * *

1. "The extent of the universe is infinite and unbounded; it is empty in no part, but everywhere filled with substance."

2. "The Duration of the world (i. e. universe) is equally infinite and unbounded; it has no beginning and no end; it is eternity."

3. "Substance is everywhere and always in uninterrupted movement and transformation; nowhere is there perfect repose and rigidity; yet the infinite quantity of matter and of eternally changing force remains constant." (Riddle of the Universe." Ernest Haeckel p. 242. Harper & Brothers, 1900. See his whole chapter xii, on the "Law of Substance." Also Seventy's Second Year Book, Lesson V.)

2. Extent and Greatness of the Universe-The Solar System:
The heavenly bodies belong to two classes, the one comprising a vast multitude of stars, which always preserved their relative positions, as if they were set in a sphere of crystal, while the others moved, each in its own orbit, according to laws which have been described. We now know that these moving bodies, or planets, form a sort of family by themselves, known as the Solar System. This system consists of the sun as its center, with a number of primary planets revolving around it, and satellites, or secondary planets, revolving around them. Before the invention of the telescope but six primary planets were known, including the earth, and one satellite, the moon. By the aid of that instrument, two great primary planets, outside the orbit of Saturn, and an immense swarm of smaller ones between the orbits of Mars and Jupiter, have been discovered; while the four outer planets-Jupiter, Saturn, Uranus and Neptune-are each the center of motion of one or more satellites. The sun is distinguished from the planets, not only by his immense mass, which is several hundred times that of all the other bodies of his system combined, but by the fact that he shines by his own light, while the planets and satellites are dark bodies, shining only by reflecting the light of the sun.

"A remarkable symmetry of structure is seen in this system, in that all the large planets and all the satellites revolve in orbits which are nearly circular, and, the satellites of the two outer planets excepted, nearly in the same plane. This family of planets are all bound together, and kept each in its respective orbit, by the law of gravitation, the action of which is of such a nature that each planet may make countless revolutions without the structure of the system undergoing any change." (Newcomb's Popular Astronomy, School Edition, pp. 103-4.

Part III of Newcomb's work which deals at length with the Solar System could also be considered with profit.)

3. Number and Distances of the Fixed Stars:
"Turning our attention from this system to the thousands of fixed stars which stud the heavens, the first thing to be considered is their enormous distance asunder, compared with the dimensions of the Solar System, though the latter are themselves inconceivably great. To give an idea of the relative distances, suppose a voyager through the celestial spaces could travel from the sun to the outermost planet of our system in twenty-four hours. So enormous would be his velocity, that it

would carry him across the Atlantic ocean, from New York to Liverpool, in less than a tenth of a second of the clock. Starting from the sun with this velocity, he would cross the orbits of the inner planets in rapid succession, and the other ones more slowly, until, at the end of a single day, he would reach the confines of our system, crossing the orbit of Neptune. But, though he passed eight planets the first day, he would pass none the next, for he would have to journey eighteen or twenty years, without diminution of speed, before he would reach the nearest star, and would then have to continue his journey as far again before he could reach another. All the planets of our system would have vanished in the distance, in the course of the first three days, and the sun would be but an insignificant star in the firmament. The conclusion is, that our sun is one of an enormous number of self-luminous bodies scattered at such distances that years would be required to traverse the space between them, even when the voyager went at the rate we have supposed." (Newcomb's Astronomy p. 104.) * * * * *

"The total number of stars in the celestial sphere visible with the average naked eye may be estimated, in round numbers, as 5000. The number varies so much with the perfection and training of the eye, and with the atmospheric conditions, that it cannot be stated very definitely. When the telescope is pointed at the heavens, it is found that for every star visible to the naked eye there are hundreds, or even thousands, too minute to be seen without artificial aid. From the counts of stars made by Herschel, Struve has estimated that the total number of stars visible with Herschel's twenty-foot telescope was about 20,000,000. The great telescopes of modern times would, no doubt, show a yet larger number; but a reliable estimate has not been made. The number is probably somewhere between 30,000,000 and 50,000,000." (Ibid. p. 422.)

4. The Design Argument:
"The Design Argument is wholly grounded on experience. Certain qualities, it is alleged, are found to be characteristic of such things as are made by an intelligent mind for a purpose. The order of Nature, or some considerable parts of it, exhibit these qualities in a remarkable degree. We are entitled, from this great similarity in the effects, to infer similarity in the cause, and to believe that things which it is beyond the power of man to make, but which resemble the works of man in all but power, must also have been made by intelligence, armed with a power greater than human." (John Stuart Mill. Essay on "Theism," see "Three Essays on Religion," p. 167. The whole essay, if possible, should be read.)

5. The Evidence of a Designer:
"The consideration of the external world around him, even in its broadest aspect, leads man up to the thought of an Eternal Cause; the study of its phenomena in detail with its marvelous intricacy of harmonious interaction produces the impression of design, and leads to the thought of a Designer-i. e., of an Eternal Cause that is intelligent and free. * * * * *

"The Design Argument is perhaps the most ancient and the most popular of all. It is never actually formulated in the Bible, for the Bible, as we have seen, never treats God's existence as the subject of argument. But its basis, the marvelous harmony of the created world, is the theme of more than one of the Psalms (cf. e. g. Pss. 19, 104, 147, 148); and St. Paul comes very near to stating the argument in so many words, when he says (Rom. 1, 20) in depreciation of pagan superstitions and immortality, that the 'everlasting power and divinity' of the Creator are clearly discernible from His works.

"Granted that the very existence of the world implies an Eternal Cause, what can we learn about that Cause? The nearest thing to a true first Cause of which I have experience, is my own personality; hence there is a presumption that the world's first Cause will be at least what we know as personal. But that presumption is not all we have to go upon. There are definite indications in nature, when more closely observed, that make it impossible to regard the Eternal Cause as a

merely mechanical originator of the world-process, that stamp it-or rather Him-as intelligent and free, a nature like my own rational nature, only far above and beyond it.

"Everywhere in nature we see the teleological principle (as it is called) at work, i. e., we see means adapted to ends, and the present subordinated to the future. This adaptation of means to ends manifests itself in a bewilderingly complex way-in each individual member of the great organism, in the lesser and greater groups, and in the whole. Everywhere, in fact, I see traces of purpose and design-for such adaptation speaks to me irresistibly of these. My only direct experience of like phenomena is in my own personality, and so I am led to infer a Designer." (Commentary on the Holy Bible." Dummelow, 1909, Art. Belief in God, pp. ci, cii.)

6. Incompleteness of the Evidences from Creation:
Some extol the evidences for the existence of God found in creation, out of all proportion to their merit. "The wonderful structure of the universe," said Thomas Paine, "and everything that we behold in the system of the creation prove to us far better than books can do, the existence of God and at the same time proclaim his attributes. It is by exercise of our reason that we are enabled to contemplate God in his works and imitate him in his ways. When we see his care and kindness extended over all his creatures it teaches us our duty towards each other, while it calls forth our gratitude to Him." And again, "'the Almighty Lecturer (Deity) by displaying the principles of science in the structure of the universe, has invited man to study and to imitation. It is as if he had said to the inhabitants of this globe we call ours, I have made an earth for man to dwell upon, and I have rendered the starry heavens visible to teach him science and the arts. He can now provide for his comfort, and learn from my munificence to all, to be kind to each other." Far be it from me to say any word that would detract from any class of evidence for the truth of God's existence; and for the evidence to be found in the works of creation, I have the profoundest esteem. They do indeed testify of the existence of intelligence higher than of man and these creations do convey to the mind not only the idea of the existence of these higher intelligences but to some extent they reveal their greatness and majesty and power; and also to some extent the munificence and beneficence of their nature. But the evidences of the works of nature are defective in that they scarcely indicate the relationship of these divine intelligences to man, or man's relationship to them, or the purpose and destiny of the creation. Standing alone on these evidences of the creation one asks in vain for a complete manifestation of God to man. Not so much as to his being-bare existence-but as to the kind of being he is. Is He personal or impersonal? Merely "a power outside ourselves"? or, Is He not only a power outside ourselves, but a power outside ourselves that makes for righteousness? and does He hold personal relations to man, and men definite and personal relations to Him? Why should man obey God? And what is man that God is mindful of him? On these questions the revelations from the works of nature are unsatisfactory, and certainly need the supplemental knowledge that comes from the direct revelations of God to man. Both John Stuart Mill and Dummelow state the weakness or incompleteness of this Design Argument. The former in his "Theism"-"Three Essays" pp. 167 et. seq., and the latter in his "Belief in God." Nearly all our modern writers on the subject of the "design argument" depreciate the treatment of it by Paley in his "Natural Theology."

1911
Elder Charles H. Hart, First Council of Seventy
The Argument From Creature To Creator, From Design To Designer
Conference Address, October 1911, Overflow Meeting., p.83-86

The question asked by one of old was, "Canst thou by searching find out God?" It is interesting to me to observe man's efforts, without the aid of divine revelation, to find out God. I would not disparage the argument from creature to creator, from design to designer; and yet I appreciate the

limitations that there are to that line of argument. We have in scripture some instances of this process of reasoning "from nature up to nature's God." For instance, the Psalmist David exclaims: "The heavens declare the glory of God, and the firmament showeth his handiwork. Day unto day uttereth speech, and night unto night showeth knowledge. There is no speech nor language where their voice is not heard." There is also in the Book of Mormon a beautiful instance that occurs in connections with the controversy between Korihor, the anti-Christ, and Alma, the great high priest. Korihor had been putting forth his agnostic arguments, and Alma meets him, in part, with this remark: "The scriptures are laid before thee, yea, and all things denote there is a God; yea, even the earth and all things that are upon the face of it, yea, and its motion; yea, and also all the planets which move in their regular form, doth witness that there is a Supreme Creator."

I noticed in the last number of the Improvement Era a beautiful selection along this line-

There is a God. The herbs of the valley, the cedars of the mountains, bless Him; the insect sports in his beam; the bird sings Him in the foliage; the thunder proclaims Him in the heavens; the ocean declares His immensity; man alone has said, "There is no God." Unite in thought at the same instant the most beautiful objects in nature. Suppose that you see at once all the hours of the day, and all the seasons of the year-a morning of spring and a morning of autumn-a night bespangled with stars and a night darkened with clouds-meadows enameled with flowers-forests hoary with snow-fields gilded by the tints of autumn-then alone you will have a just conception of the universe! While you are gazing on that sun which is plunging into the vault of the west, another observer admires him emerging from the gilded gates of the east. By what inconceivable power does that aged star, which is sinking fatigued and burning in the shades of evening, reappear at the same instant fresh and humid with the rosy dew of the morning? At every hour of the day, the glorious orb is at once rising, resplendent as noon-day, and settling in the west; or rather, our senses deceive us, and there is properly speaking, no east or west, no north or south in the world.

Proctor, the astronomer who once paid a just tribute to Orson Pratt whose memorial services are being celebrated today, Richard A. Proctor, in introducing his work entitled "Other Worlds than Ours," uses a scriptural quotation-"Lo, these are but a portion of His ways"-meaning the ways of the universe, the marvels of the universe-"Lo these are but a portion of His ways, they are but a whisper of His glory, and the thunder of His power who can comprehend?" And yet, notwithstanding all the evidences that we have of the existence of Deity-and the strong and legitimate argument that we have from design to designer, yet that is not of itself sufficient to reveal unto us all the attributes of God. Mr. Herbert Spencer, the great naturalist, after a life time in the study of nature, declared,

But one truth must ever grow clearer, the truth that there is an Inscrutable Existence everywhere manifested to, which we can neither find or conceive beginning or end.

Again,

Amid the mysteries which become the more mysterious the more they are thought about, there will remain this one absolute certainty, that we are ever in the presence of an Infinite Energy, from which all things proceed.

Sir Oliver Lodge declared:

To my mind a great world-soul intimately connected with our own, is the most reasonable explanation of the process by which things came to be.

But notwithstanding this process of reason, we should not lose sight of the fact that without revelation we could not know all the attributes of God,-could not "find out the Almighty unto perfection."

Peter tells us in holy writ that, "all flesh is as the grass and the glory of man as the flower of grass. The grass withereth and the flower thereof falleth away; but the word of' the Lord endureth forever. And this is the word which by the gospel is preached unto you." Just as the statue of the Prophet Joseph and the statue of his brother the Patriarch stand upon granite foundations, so the gospel of salvation is grounded upon the granite bedrock of ever-listing truth. It is an interesting fact that philosopher, poet and states. man, have grasped something of the great gospel truths. For instance, Joseph Smith placed emphasis upon the doctrine of faith. We have sir Oliver Lodge asserting: "Faith and trust in the love and goodness underlying the universe seems to me to be the most vital and helpful thing."

Emerson exclaims:

Belief and love,-a believing love will lift from your shoulders a vast load of care. O, my brothers, God exists There is a soul at the center of nature and over the will of every man so that none of us can wrong the universe* * The whole course of things goes to teach us faith. We need only obey. There is goodness for each of us and by lowly listening, we shall hear the right word.

Carlyle gives us to understand that skepticism means not intellectual doubt alone, but moral doubt; all sorts of infidelity, insincerity and spiritual paralysis. That our minds are not given us to doubt with and cavil with but to come to some sure understanding upon matters concerning which we are to act.

Hugo tells us:

We live by affirmation, quite as much as we do by bread. That faith is a necessity, and woe to the man who believes nothing.

Carlyle also reminds us that

For man's well-being, faith is properly the one thing needful; how with it martyrs otherwise weak, can cheerfully endure the shame and the cross; and without it, weaklings puke up their sick existence by suicide in the midst of luxury.

Tolstoi, in his book, "What I Believe," confesses-

I only passed from Nihilism to the church, because I felt the impossibility of living without faith-without a knowledge of what is good and evil, resting on something more than upon animal instincts.

Take the words of the statesman in addition to that of the philosopher. We have Senator Beveridge in his work, "The Young Man and the World," advising the young man who is about to become a teacher to see first to this question of faith:-"Speaking as one of the men of the street, as one of the millions, I think the best thing for you to attend to is this question of faith, Faith is only another name for power." Look to your faith then you who seek to save the souls of men. The Prophet Joseph taught the true relation between faith and works. Likewise one of the poets approaches a statement of our own belief in these words:

If faith produce not works, I see That faith is not a living tree. Thus faith and works together grow, No separate life they e'er may know. They're soul and body, hand and heart, What God hath joined, let no man part.

So we might go on with the views of the philosopher, poet, and statesman, corroborating this principle upon which the Prophet Joseph gave us corrected information.

There was published recently in Public Opinion a quotation from a speech or the writings of the great English premier, William E. Gladstone, in reference to the inconsistency of the skeptic. He said:

I contend that the skeptic is of all men the most inconsistent and irrational. He uses a plea against religion which he never uses against anything he wants to do or any idea he wants to embrace, viz, demonstrative evidence. Every day and all day long he is acting on evidence not demonstrative.

He then gives numerous illustrations, and goes on to say,

But when he comes to religion, he is seized with a great religious scrupulosity and demands as a pre-condition of homage to God what every where else he dispenses with and then ends with thinking himself more rational than other people.

This caused the editor of Public Opinion to remark:

We who believe ought not to stand upon the defensive. We have a right to demand that unbelief offer us some explanation of the phenomena of life, and show us that it is more probable than our explanation. What is your explanation of an intelligible universe if there is no intelligible God who has made us and who made it? What is your explanation of the fact that whenever man has emerged from a purely animal condition that there are altars and priests and temples and worship, if, in all these centuries he has found that worship unmeaning and unreal? What is your explanation of the fact that after eighteen centuries of moral and intellectual development and criticism and controversy, the Bible is still the world's best seller? What is your explanation of the fact that wherever the life and teachings of Jesus of Nazareth have become known He is the most revered and loved of all the figures in human history?

1913
Laurence Joseph Henderson, Assistant Professor Of Biological Chemistry, Harvard University
The Fitness of the Environment: An Inquiry Into The Biological Significance Of The Properties Of Matter
Book

In Part Delivered As Lectures at The Lowell Institute, February, 1913

Chapter I - Fitness

I - Purpose And Order
IDEAS of purpose and order are among the first concepts regarding their environment which appear, as vague anticipations of philosophy and science, in the minds of men. In truth, when the manifold phenomena and experiences of daily life stored in the memory are critically scrutinized, purpose and order seem naturally to suggest themselves as explanations of the universe. Day and night, the changing but recurring seasons, the fertilizing sunshine and rain, the flight of birds, the powers of

the human hand, and all the beauties and mysteries of nature cannot fail of such interpretation by the simple and untrained mind. Alike anthropology and the history of primitive civilizations bear witness to this natural tendency of thought. Such ideas precede exact knowledge and civilization, and arise spontaneously among savage peoples. They are the solvent of the chaos, as which the outer world first presents itself to our eyes and hands, and they are the fabric of all theologies.

As civilization has progressed, these early hypotheses have received endless criticism, and their definition has been continually sharpened. Meantime natural science has sought and provided ever more accurate accounts of the phenomena which first suggested them to man, and of countless other forms and transformations of matter and energy, and the discovery of laws of nature has steadily changed once quite mysterious order and purpose into the plainest of necessary results.

Upon the advent of modern science order speedily began to receive its true account when, after only a half century of progress, dynamics through Newton provided a formulation of the laws which govern the most striking of all the orderly phenomena of nature.1 Since Newton's day, the explanation of natural order as the automatic result of natural law has not ceased, and at length has become so nearly complete that the appearance of order under any circumstances is now taken as proof of the existence of a law. The fate of the hypothesis of purpose in nature has been less simple, because the discovery of law or even of the possibility of law, underlying adaptation and fitness was more difficult. Until the middle of the nineteenth century the countless adaptations of organisms to the environment and the manifest fitness of nature for the activities of living things seemed to many biologists only explicable as the result of some directing force.1 Even skeptics were nearly or quite unable, however strong their desire, to account for the facts with a plausible theory. The dogma of final causes had led a thousand times to the truth by teaching the investigator that the true description of an organ or physiological process was to be found ~m its utility to. the organism as 'a whole. Such considerations were far too numerous and too patent for science to shirk some explanation, and the only weighty explanation at hand seemed the teleological one.

Ii - Fitness

With a suddenness which to many seemed catastrophic Darwin's hypothesis of natural selection changed the whole aspect of the problem. Law appeared as the basis of purpose just as it had appeared as the basis of order, and adaptations became, in the judgment of most men, the necessary results of an automatic process. To-day, after a half century, there is no longer room for doubt that the fitness of organic beings for their life in the world has been won in whole or in part by an almost infinite series of adaptations of life to its environment, whereby, through. a_ corresponding series of transformations, present complexity has grown out of former simplicity?"

The great and fruitful ideas which Darwin brought to the attention of the whole world have long since been incorporated into human thought. Not the least important among them is the new scientific concept of fitness, as it emerges from the discussion of natural selection. Before Darwin, this concept possessed all the vagueness of an idea which, though in part founded on observation, was not to be explained with the help of existing scientific theories. But although Darwin's fitness involves that which fits and that which is fitted, or more correctly a reciprocal relationship, it has been the habit of biologists since Darwin to consider only the adaptations of the living organism to the environment.2

NOTE: The ideas which are associated with the names of de Yries, as well as the very different hypotheses of Driesch, Bergson, and others are, of course, concerned with the manner, not with the fact of adaptation and organic evolution.

NOTE: Far different was the earlier point of view. An examination of Whewell's Bridgewater Treatise at once reveals important, if often fallacious, discussions of environmental fitness; e.g. "It has been shown in the preceding chapters that a great number of quantities and laws appear to have been selected in the construction of the universe; and that by the adjustment to each other of the magnitudes and laws thus selected, the constitution of the world is what we find it, and is fitted for the support of vegetables and animals in a manner in which it could not have been, if the properties and quantities of the elements had been different from what they are. We shall here recapitulate the principal of the laws and magnitudes to which this conclusion has been shown to apply.

1. The Length of the Year, which depends on the force of the attraction of the sun, and its distance from the earth.

2. The Length of the Day.

3. The Mass of the Earth, which depends on its magnitude and density.

4. The Magnitude of the Ocean.

5. The Magnitude of the Atmosphere.

6. The Law and Rate of the Conducting Power of the Earth.

7. The Law and Rate of the Radiating Power of the Earth.

8. The Law and Rate of the Expansion of Water by Heat.

9. The Law and Rate of the Expansion of Water by Cold, below 40 degrees.

At first sight it may well seem that inquiry into such a problem must end unsuccessfully in vague and unprofitable guesses. Indeed the past has brought forth no lack of such vain attempts, usually guided by a devotion to the doctrine of design in the service of theology. Yet other sciences have grown since 1859, and physical and chemical data in abundance are now at hand to aid in a reconsideration of the environment's fitness, if such exist. Clearly it is well to seek among these data for a more precise formulation of the problem, which may then perchance lead to some more ambitious quest, or at least to new understanding of the old failure.

10. The Law and Quantity of the Expansion of Water by Freezing.

11. The Quantity of Latent Heat absorbed in Thawing.

12. The Quantity of Latent Heat absorbed in Evaporation.

13. The Law and Rate of Evaporation with regard to Heat.

14. The Law and Rate of the Expansion of Air by Heat.

15. The Quantity of Heat absorbed in the Expansion of Air by Heat.

16. The Law and Rate of the Passage of Aqueous Vapor through Air.

17. The Laws of Electricity; its relations to Air and Moisture.

18. The Fluidity, Density, and Elasticity of the Air, by means of which its vibrations produce Sound.

19. The Fluidity, Density, and Elasticity of the Ether, by means of which its vibrations produce Light." — Whewell, "Astronomy and General Physics Considered with Reference to Natural Theology." London, 1834, 4th ed., pp. 141-143.

It is hard to understand how such ideas could have fallen into oblivion.

III - The Environment

The world of pure senses is a world of matter and energy, space and time. After centuries of philosophical and scientific study, these, the very logical elements of science, are no doubt still without a final description. None the less is there sound foundation for the belief that our preliminary accounts of all four possess completeness in some respects and for certain purposes. Nor are we to-day less confident of the finality of some of our ideas regarding the nature of life and the vital processes, as they exist in this world. But both of these conclusions call for further consideration.

Matter

Many facts contribute to the belief, universal among chemists, that the known elements constitute by far the greatest part of a system of materials out of which the universe is formed,, within which all chemical changes (except certain phenomena of radium and a few other anomalies, including perhaps, unknown changes in the interiors of the celestial bodies) take place.

It is certain that nearly all, the chemical transformations upon the earth consist of rearrangements of the atoms of the known elements. A century and a half of scientific chemistry guarantee that conclusion with a security rarely attained in descriptive science. And the testimony of the spectroscope is equally conclusive that the visible stars, like the sun itself, are made up almost or quite exclusively of the same chemical elements: Such facts, so familiar that they require no comment or explanation, might sufficiently justify the acceptance of the chemist's known elements as the only important matter in the universe. But even more weighty evidence is at hand; I mean the so-called periodic^ classification of the elements.

It has long been evident that simple relationships exist in some cases between the atomic weights of similar elements. For example, the atomic weights of bromine, strontium, and selenium are approximately equal to the means of the atomic weights of chlorine and iodine, of calcium and barium, and of sulphur and tellurium respectively. More general relationships between the atomic weights and properties of the elements were first pointed out by Newlands in 1864 and were extended by Mendeleeff and Lothar Meyer a little later. Out of these studies has arisen the law that the properties of the elements are periodic functions of their atomic weights.

The essential characteristics of this law are best illustrated by a consideration of the relative volumes occupied by atoms of the various elementary substances, the so-called atomic volumes, which may be expressed by dividing atomic weights by specific gravities. The facts are graphically represented upon the accompanying diagram, where atomic weights are plotted horizontally, atomic volumes vertically.

Beginning with lithium the volumes fall to boron and carbon, then rise irregularly to sodium. A second fall leads to aluminium, a second rise to potassium, and then the rises and falls of the curve are repeated until, among the elements of higher atomic weight, gaps break the continuity of the relationship. On the whole curve similar elements occupy similar positions. Thus the alkali metals, lithium, sodium, potassium, rubidium, and caesium, occupy the crests of the waves; the halogens,

fluorine, chlorine, bromine, and iodine, fall about midway between crests and troughs, and a little further study discloses a host of other corresponding relationships.

Similar periodic variations may be shown to occur in other physical properties of the elements; — the melting points, the boiling points, the magnetic characteristics, etc. Even more striking are the periodic variations in chemical properties, including the general characteristics which first led to the idea of rational classification, and more specific qualities like the combining powers for hydrogen, oxygen, and other elements.

The clearest proof of the value of the periodic classification has been the .prediction of "new" elements, and accurate foreknowledge by their properties. Thus when Mendeleeff first described the system, the element germanium, discovered by Winkler in 1886, was unknown; but from the properties of the elements surrounding a gap in the system the Russian chemist was able to predict its properties with almost incredible exactness, as the following table shows.

Finally it is to be especially noted that, upon arranging the known elements in a table rationally constructed upon the basis of the above recorded facts, comparatively few spaces within the range of known atomic weights remain to be filled. The conclusion is obvious that very few elements now unknown are possible unless they possess very high atomic weights. But the apparent transmutation of radium into helium is a pretty clear indication that elements of very high atomic weight may be unstable. If they have existed in number and large quantity, they probably have long since ceased so to exist, except perhaps in the interior of celestial bodies, and they are not likely elsewhere to complicate natural phenomena by their unknown properties.

The behavior of radium and the classification itself suggest one further idea: the hypothesis that the elements are genetically related, that they have been evolved by some unknown process according to unknown laws. Certain it is that the properties of matter are no chance phenomena, and that transmutation has ceased to be merely a philosopher's dream.

All of these familiar facts of chemical science fully justify us in dealing with matter as a known factor in the study of life conditions in the universe. For, whatever may be the fate of present theories, our present practical knowledge of the behavior of matter cannot fail us in the future.

B - Energy

Contemporary with the work of Darwin and of Mendeleeff were the feats of Mayer, Joule, Helmholtz, Kelvin, and Clausius, whereby ideas of energy assumed their modern aspect. In the revolution wrought by these men imponderables and fluids vanished from this domain, and energy became that which, not being matter, is conserved. The new principles of the 'fifties have held their own until to-day. Meantime they have made of thermodynamics (the department of science which is especially concerned with the laws of energy transformation) a subject which few who cultivate the physical sciences may disregard. Countless developments and achievements of thermodynamics give very real ground for the belief that we may speculate about the transformations of energy in the universe with the same assurance that we have in discussing chemical changes.

Our reasons for confidence in the truth of current general notions of energy, and in their adequacy to account for any phenomena so far as energy is concerned, wherever life exists in the universe, are manifold, and not unlike those which have been reviewed in discussing the elements.

Centuries of search have revealed, in addition to that most obvious form which is studied in dynamics, a very small number of varieties or manifestations of energy, such as heat, electricity, magnetism, optical energy, and chemical energy. Such manifestations of energy are by no means

confined to the earth or to the solar system. Indeed Newton first worked out the general laws of dynamics and erected them into a complete science with the aid, not of terrestrial, but of astronomical phenomena.1 And recent most remarkable studies of the stars have enabled astronomers to account for obscure events in far distant parts of the universe by the application of the principles of dynamics. Similarly light, heat, and chemical energy, as we know them, are unquestionably universal. No doubt the manifestations of energy within the sun and stars, like the accompanying material phenomena there, can to-day only be surmised. For aught we know, these places may, as has been guessed, be the birthplace of elements and the seat of manifestations of energy quite different from what we have ever observed. But, however interesting and important such processes may be, it is not to be supposed that they are of direct moment in physiological processes. These conditions are far beyond the limits of our present investigation. Accordingly, everything that observation has taught confirms the belief that energy, like matter, is in general well known to us. Its manifestations are few, and they are universal. But just as the generalizations of science yield further assurance regarding matter, so they do not fail to confirm our conclusions in the study of energy. The law of the conservation of energy and the law of the degradation of energy, otherwise known as the first and second laws of thermodynamics, clearly indicate that the manifestations of energy are not accidental nor independent of one another. They are orderly, and they obey laws. Energy is one and indestructible.

Such are the apparently irrefragable conclusions of the brief half century of creative development, from the time when Young first used the word "energy" and Bolton and Watt first employed the idea of measuring energy in horse power, through the period of Carnot's brilliant intuition regarding the relation between heat and work, to the epoch of the foundation of thermodynamics.1 Today we know that just so much heat, neither more nor less, may be obtained by the complete conversion of a unit of electrical energy or by a given chemical process. We know, moreover, that not every conceivable change from one form of energy to another is possible. On the whole, energy can flow in but one direction; perpetual motion is impossible; and useful energy is steadily becoming degraded, dissipated, and useless.

Such laws are fully worthy of a place beside the periodic law, and they justify equal confidence in the adequacy of our current descriptions of matter and of energy for the purposes of biology.

Space And Time

Since Kant revolutionized modern philosophy, the whole world has steadily realized that between matter and energy on the one hand, and space and time on the other, there is a real and highly significant difference.2

But, however important such distinctions may be for the philosopher, the man of science in his practical task is obliged to put them aside and to make the best of whatever evidence experience, observation, and experiment may supply. Out of such studies space and time have emerged, usefully defined by mathematical criticism as substantial parts of the edifice of science.1

There is no small difficulty in the exposition of modern critical results regarding space and time, but fortunately there is little need of considering them on the present occasion. For in spite of all assaults of philosophers and mathematicians space remains for practical purposes more certainly than ever the Euclidian space of the ancients, only it has become somewhat richer in characteristics. And time is now and forever that which flows equably, wholly independent of all else, though almost all else is dependent upon time. It is Euclidian space in which the earth moves and describes its ellipse, parallel rays of light never do meet in our practical experience, and our crystals are in form the figures of Euclidian geometry. Our time flows ever in proportion to the swings of a pendulum, the propagation of light, and the progress of a chemical change. Time and space are thus bound to matter and energy by experience, and for practical purposes we accept all

four as science at present knows them.1 We cannot doubt that knowledge of them will increase and ideas of them change! But we can scarcely think that the present ideas are inadequate for our present purposes, or that, for life, matter will ever be other than the elements of the periodic classification, energy that set of quantities to which we apply the laws of thermodynamics, and time and space the concepts which were familiar to Galileo and Euclid.

IV - The Organism

Thus the growth of physical science has provided the speculative biologist with a very accurate and extensive description of the physico-chemical structure of the material universe and with a well-founded confidence in his right to make use of the description in investigating the relationship between life and the environment.

The biologist studies living organisms as inhabitants of this world, and by holding fast to physics and chemistry he has created modern physiology, a science which unites many, indeed nearly all, of the departments of physics and chemistry in the task of describing the processes of life.

That task has proved an arduous one, even in comparison with the other enterprises of science, and it must be confessed that few of the departments of physiology wear an aspect of finality which has long been familiar in Such sciences as mechanics and crystallography, for example. Yet, as time has passed, and the nature of the material basis of life and the conspicuous features of the mechanism which the organism presents for study have become more familiar, assurance has steadily grown of the possibility of deciding upon fundamental and essential characteristics of the life process. No doubt opinions have fluctuated, and in different periods of the history of science particular phenomena of living organisms have been examined, criticized, and then well-nigh forgotten. But gradually ideas, ever more and more precise, have arisen and been accepted.

Until very recent times, however, the main interest has centered upon morphological problems and upon the processes of growth and development. The ancient controversies regarding types and homologous parts, the question of spontaneous generation and the whole science of embryology, and inquiries into the nature of fermentation and the role of microorganisms are examples of the older tendencies. Such interests have, it need hardly be said, lost none of their importance, but they scarcely touch the physicochemical problem of the nature of living things. Yet there is in these subjects one point of view, a favorite of Cuvier's, now, though still familiar, less often emphasized, which states a most important characteristic of life in terms of matter and energy, space and time.1 Living things preserve, or tend to preserve, an ideal^ form, while through them flows a steady stream of energy and matter which is ever changing, yet momentarily molded by life; organized, in short. This idea, to which we must later return, could not possess in the early nineteenth century the significance and value which now attach to it. It needed the explanation which the study of metabolism has at length provided.

A - Metabolism

Metabolism is the term applied to the inflow and outflow of matter and energy and their intermediary transformations within the organism. Its serious investigation began with Lavoisier, the principal founder of modcation et a ce mouvement perpetual, qui rendent si difficile l'application des sciences generales." (" Rapport," p. 150, etc.) " Dans les corps vivant chaque partie a sa composition propre et distincte; aucune de leurs molecules ne reste en place; toutes entrent et sortent successivement: la vie est un tourbillon continuel, dont la direction, toute compliquee qu'elle, est, demeure constante, ainsi que l'espece des molecules qui y sont entramees, mais non les molecules individuelles elles-memes. . . . Ainsi la forme de ces corps leur est plus essentielle que leur matiere," etc. (Ibid. p. 200.) — " Eloges historiques," Vol. I, p. 200. Quoted by Merz, "A History of European Thought in the Nineteenth Century," Vol. I, p. 129. Edinburgh and London, 1898.

Modern chemistry, who by ingenious experiments discovered that the essential feature of the chemical process in the animal is combustion or oxidation, and that the amount of oxygen required by such combustion is not much less than that needed to burn substances which resemble the foods in the air. The problems which thus arose have been studied by a host of later investigators, notably by Liebig and Voit, and gradually a vast array of facts concerning the turnover of matter and energy in the body have been accumulated. Among other achievements is the proof that the principle of the conservation of energy applies to the living organism. These have teen chemical investigations, carried out by chemists, and for that reason, until quite recently, they have not received their due in general biology.

Meantime, as knowledge of the balance sheet, of the body, the total metabolism so-called, has been perfected, more and more interest has developed in the changes which attend the passage of matter and energy in their various stages through the organism. Such problems at once demand a physicochemical description of protoplasm as a necessary basis for their solution. The same demand has also arisen in other quarters.

Thus the microscope, with all its brilliant contributions to knowledge of the form and more gross structural elements of the cell, hardly at all contributes to knowledge of its v physico-chemical organization as a mechanism. Out of such needs a preliminary, if very imperfect, rational description of protoplasm has arisen, and gradually the physical and chemical laws governing protoplasm, its form, composition, and stability, its constituent parts and their mode of action, and the physical and chemical changes within it are being discovered.1 The idea of durable form in matter and energy that change can now be applied to the cell with greater advantage, in that descriptions of the form and of the change are now at hand, though as yet all too imperfect.

Another profoundly important contribution of the science of metabolism to our knowledge of the characteristics of life is the discovery of the cycle of matter through plants and animals.2 The plant takes up carbonic acid and water and a few other simple substances from air and soil, and transforms them into oxygen, which renews the air, and sugar, starch, and other substances, which are the food of the animal.1 These products the animal burns, thereby forming once more carbonic acid and water, which return to the plant and so pass through the cycle again and again. The changes in energy which accompany this process are quite different from the chemical changes. Starch and sugar and oxygen, formed in the leaf of the plant, are compounded of carbonic acid, water, and sunshine. This sunshine, or solar energy, when changed into the chemical energy of the carbohydrate, is preserved and transmitted to the animal.2 In his body it is set free as muscular force and heat, and then dissipated. Accordingly, when carbonic acid and water are combined to form sugar and oxygen in the leaf, it is always a new store of solar energy which they bear, and while matter goes round and round, energy is being constantly degraded and lost. The one process is cyclic, the other moves steadily in one direction from sunshine to the waste heat of the animal body.1

B - Organic Chemistry

Independent alike of general biology and of the science of metabolism there has grown up still another department of natural science, organic chemistry, which contributes very materially to the description and comprehension of living things. During a large part of the nineteenth century the efforts of chemists were mainly directed to the cultivation of this subject, which seeks to describe the molecular constitution of all the compounds of carbon, including nearly all the individual substances which make up animals and plants. Gradually, as organic chemistry has progressed, very complete descriptions of the atomic groupings within the molecules of fats,2 carbohydrates,3 and proteins,1 the chief of such things, and most of the other biologically important substances have been obtained, and we are at length in possession of exceedingly clear and reliable ideas as to the

chemical constitution of living matter. In fact, the nature and laws of the chemical composition of protoplasm are actually more certain than the nature and laws of its physical structure.2

In this manner, by slow degrees, the description of living things has progressed, and gradually the characteristics of life have become less obscure and their aspects more simple. It cannot be denied that many traits like consciousness and inheritance are, at least for the present, beyond the scope of respiration in terms of matter and energy, and the fundamental riddle shares this detachment.3 But the physico-chemical basis of life is firmly established in the world of our senses. On the whole the composition of living matter, its physical structure, the changes of matter and energy which constitute the metabolic process, together with the totality of such changes, which make up the fundamental economic process of that largest community which consists of all living beings, are all clearly defined.

NOTE: "For the conclusions we lately reached and the definition emerging from them, concern the order existing among the actions which living things exhibit; and this order remains the same whether we know or do not know the nature of that from which the actions originate. We found a distinguishing trait of Life to be that its changes display a correspondence with coexistences and sequences in the environment; and this remains a distinguishing trait, though the thing which changes remains inscrutable. The statement that the continuous adjustment of internal relations to external relations constitute Life as cognizable by us, is not invalidated by the admission that the reality in which these relations inhere is incognizable."—Herbert Spencer, "The Principles of Biology." New York and London, 1909, Vol. I. Revised and enlarged edition, pp. 122-123.

C - The Characteristics Of Life

Under the circumstances it is certainly no rash enterprise to seek a definition of some of the essential characteristics of life. Although it is probably far beyond our present power to make a complete study of the problem, I feel sure that a brief analysis will justify certain very definite conclusions. Life as we know it is a physico-chemical mechanism, and it is probably inconceivable that it should be otherwise.1 As such, it possesses, and, we may well conclude, must ever possess, a high degree of complexity, — physically, chemically, and physiologically; that is to~ ~ say, structurally and functionally. We cannot imagine life which is no more complex than a sphere, or salt, or the fall of rain, and, as we know it, it is in fact a very great deal more complex than such simple things. Next, living things, still more the community of living things, are durable. But complexity and durability of mechanism are only possible if internal and external conditions are stable. Hence, automatic regulations of the environment and the possibility of regulation of conditions within the organism are essential to life. It is not possible to specify a large number of conditions which must be regulated, but certain it is from our present experience that at least rough regulation of the environment – temperature, pressure, and chemical constitution of environment and organism are really essential to life, and that there is great advantage in many other regulations and in finer regulations. Finally, a living being must be active, hence its metabolism must be fed with matter and energy, and accordingly there must always be exchange of matter and energy with the environment.

Returning to the concept of the organism as a durable form through which flow matter and energy, it is now possible to make these ideas more vivid. The complex structure of the living being is relatively stable, alike in the chemical composition of its individual constituent molecules, in their proportions and amounts, in their aggregation into the invisible structural elements of protoplasm, in the visible parts of the cell, in the organs and tissues, and finally in toto, as a man or a tree. Similarly stable are the physical conditions within this structure: temperature, pressure, alkalinity, and osmotic pressure. Finally, that which surrounds it, the immediate environment, possesses also a high degree of stability, or if the organism be very complex, it may be that it has an efficient protection against change of environment; a skin which insulates, for instance. But in this case it

has also acquired an environment, a milieu interior for its cells, — like the blood and lymphe—which serves the same purpose as stability of the external environment, and exercises the further function of supplying food.

It is through this structure, in the process of metabolism, that matter and energy flow. Entering in various forms and quantities, they are temporarily shaped exactly to the form and condition of the organism; they conform to the characteristics of the kingdom, class, order, family, genus, species, and variety to which it belongs, and they assume even the characteristics of the individual itself.1 Then they depart through the various channels of excretion.

When these ideas are reduced to their very simplest forms, it appears that life must be highly complex in structure and function; that the conditions of the environment must be regulated, and that there must be very exact regulation of conditions, both structural and functional within the organism, and finally, that, while life is active, there must be exchange of both matter and energy with the environment. Complexity, regulation, and food are essential to life as we know it, and in truth we cannot otherwise conceive of life, or indeed of any other durable mechanism. For my part I do not doubt that these postulates are quite as true of the world of our senses as are the fundamental laws of matter and energy, space and time.

NOTE: Science is, of course, still at a loss for an adequate general explanation of such processes.

Obviously these few conclusions can make no claim to completeness. Fully to describe life, the discovery of many other fundamental characteristics is necessary, including such as are related to inheritance, variation, evolution, consciousness, and a host of other things. But in the formation and logical development of such ideas there is danger of fallacy at every step, and since the present list will suffice for the present purpose, further considerations of this sort are best dispensed with. This subject should not be put aside, however, without clear emphasis that the postulates which have been adopted above are extremely meager. The only motives for abandoning further search are the economy and the security which are thus insured, and the very great difficulty of extending the list. Any one who is familiar with similar efforts to elucidate the essential characteristics of life, such as that of Wallace,1 cannot, I fear, fail to perceive the extreme limitations which are imposed upon inquiry by assuming complexity, regulation, and metabolism exclusively. Perhaps in reality these postulates are only two. Metabolism might without difficulty be included under regulation, but the consideration of such purely logical questions is beside the present purpose. However, these are probably the characteristics of the organism which are best fitted for discussion in relation to the physico-chemical phenomena of matter and energy, and it is barely possible that no others bear the same simple relations to the outside world.

NOTE: A. R. Wallace, "Man's Place in the Universe." New York, 1903, Chaps. X and XI, especially the following statement: —"The physical conditions on the surface of our earth which appear to be necessary for the development and maintenance of living organisms may be dealt with under the following headings: —
" 1. Regularity of heat supply, resulting in a limited range of temperature.
"2. A sufficient amount of solar light and heat.
" 3. Water in great abundance, and universally distributed.
"4. An atmosphere of sufficient density, and consisting of the gases which are essential for vegetable and animal life. These are Oxygen, Carbonic-acid gas, Aqueous vapor, Nitrogen, and Ammonia. These must all be present in suitable proportions.
" 5. Alternations of day and night."

It must be remembered, however, that such conclusions depend upon reasoning from analogy, a dangerous way to proceed.

The Problem

We may now return to the problem of the fitness of the environment. So long as ideas of the nature of living things remain vague and ill-defined, it is clearly impossible, 'as a rule, to distinguish between an adaptation of the organism to the environment and a case of fitness of the environment for life, in the very most general sense. No doubt there are clear instances of both phenomena which require no close analysis for their interpretation. Thus the hand is surely an instance of adaptation, and the anomalous expansion of water on cooling near its freezing point an instance of environmental fitness. But how much weight is to be assigned to adaptation and how much to fitness in discussing the relations between marine organisms and the ocean? Evidently to answer such questions we must possess clear and precise ideas and definitions of living things. Life must by arbitrary process of logic be changed from the varying thing which it is into an independent variable or an invariant, shorn of many of its most interesting qualities to be sure, but no longer inviting fallacy through our inability to perceive clearly the questions involved.

Such is the purpose, and the justification, for setting up the postulates of complexity, regulation, and metabolism as inherent in that mechanism which is called the living organism. With them, at length, we face the problem which awaits us. To what extent do the characteristics of matter and energy and the cosmic processes favor the existence of mechanisms which must be complex, highly regulated, and provided with suitable matter and energy as food? If it shall appear that the fitness of the environment to fulfill these demands of life is great, we may then ask whether it is so great that we cannot reasonably assume it to be accidental, and finally we may inquire what manner of law is capable of explaining such fitness of the very nature of things.

Chapter VII - The Argument

THE statement of evidence for the biological fitness of the environment is at length completed. Whatever favorable properties of water, carbonic acid, and the compounds of the three elements, whatever results favorable to life, I have succeeded in finding, have been set forth.

Now, therefore, we may return to the examination of this evidence in the manner suggested in Chapter II. We may inquire into the exhaustiveness of the preceding treatment of important physical properties, seeking to discover what things have been overlooked. Thus it may be possible to decide the weighty question whether another group of elements can possess another group of equally important properties. Next, we may consider if there be other elements or compounds which rival carbon, hydrogen and oxygen, water and carbonic acid, in the qualities which make these fit for the organic mechanism, taking such properties as a whole. Unfortunately, in adopting this somewhat rigid logical method, tedious and perhaps unnecessary repetition is involved, but the advantages of care at this stage of the inquiry seem to be very great, for it is not easy to survey so large a field, and at best certainty that important oversights have been avoided is obviously impossible. For example, peculiarities like the anomalous expansion of water, or the relation of carbonic acid and water to the carbohydrates are not to be foreseen. On the other hand, the more general characteristics of matter are well known and, for the most part, must reveal themselves to diligent search.

I - Analysis Of The Evidence

First the natural phenomena which seem to be concerned in fitness may be brought together analytically, and their effect briefly summarized.

Natural Phenomena Which Promote Fitness In The Environment

I. The occurrence of great quantities of water and carbon dioxide outside the solid crust of an astronomical body.

II. Properties of Water.

a. Specific Heat.

b. Freezing Point.

c. Latent Heat of Fusion.

d. Latent Heat of Vaporization.

e. Vapor Tension.

/. (Thermal Conductivity.)

g. Expansion before Freezing.

h. (Expansion in Freezing.)

i. Solvent Power.

j. Dielectric Constant.

k. Ionizing Power.

I. Surface Tension.

III. Properties of Carbon Dioxide.

a. Solubility in Water.

b. Ionization Constant.

IV. Properties of the Ocean.

a. Number and Variety of Constituents.

b. Quantity of Dissolved Material.

c. Mobility.

d. Constancy of Temperature.

e. Constancy of Osmotic Pressure.
/. Constancy of Alkalinity.

g. Constancy of Composition. V. Chemical Properties of Carbon, Hydrogen, and Oxygen.

a. Number of Compounds.

b. Variety of Compounds.

c. Complexity of Compounds.

d. Number of Reactions.

e. Variety of Reactions.

/. Complexity of Reactions.

g. The Evenness and Lack of Energy Change of the Process of Hydrolytic Cleavage.

h. The Chemical Relationship of Carbonic Acid and Water to the Sugars.

i. Instability of the Sugars.

j. Variety and Reactions of the Sugars.

k. Heats of Reaction in Organic Chemistry.

I. The Number and Variety of Compounds and Reactions of Oxygen with Other Elements.

m. The Number and Variety of Compounds and Reactions of Hydrogen with Other Elements.

All the properties or other phenomena noted in the above table (except II /, and II K) are in character or in magnitude either unique or nearly so, and are in their effect favorable to the organism as denned in the fundamental postulates. Indeed, they constitute or bring about an extraordinary set of conditions favorable to life, — ubiquity, abundance, variety, stability, mobility, constancy of composition, and invariance of physico-chemical conditions in the environment; number, variety, complexity, adaptability, availability, activity, and richness in energy of the substances which take part in the metabolic processes and in the chemical and physical formation of the organism; constancy of physico-chemical conditions, such as temperature, alkalinity, colloidal disperseness, etc., within the organism; the efficiency of many physiological processes; the availability of electrical forces, etc.

In short, by many independent and united actions the above catalogued natural characteristics of the environment promote and favor complexity, regulation, and metabolism, the three fundamental characteristics of life upon which all our discussion has been based.

II - The Exhaustiveness Of The Treatment

One manner of judging the completeness with which different types of phenomena and properties, different elements and compounds, have been considered in the descriptive chapters preceding is to glance at the several departments of physical science, — chemistry, mechanics, heat, sound, light, magnetism, electricity, and physical chemistry.

In setting out to consider physical and 'Vl chemical properties we may perhaps begin with chemical phenomena in the narrowest . >/ \f sense. Such phenomena depend, according to the atomic theory, upon rearrangements^ 'y,. ' of atoms within molecules. They result in the conversion of individual substances into one another, and they are accompanied by rearrangements of energy.

In the first place, it is to be noted that enormous quantities of carbon, hydrogen, and oxygen, as water and carbonic acid, are, during a very long period of time, apparently inevitable constituents of the atmosphere of an astronomical body of sufficient size, after cooling has led to the formation of a crust. Further, it has been shown that in number, variety, complexity of forms and changes, and in the magnitude of the accompanying transformations of energy the known substances made

up of carbon and hydrogen, and those made up of carbon, hydrogen, and oxygen far surpass the compounds of any other elements. Likewise the known compounds of oxygen and hydrogen with other elements are the most numerous and important among inorganic substances. Two peculiarities of the carbon compounds, the formation and properties of the carbohydrates, and the nature of the process known as hydrolytic cleavage, add to this list of chemical characteristics which make for fitness.

These facts appear to indicate that in general chemical behavior, in certain special characteristics as well, and in the magnitude of the quantity of energy rendered available by their chemical changes, the elements carbon, hydrogen, and oxygen are uniquely and most highly fitted to be the stuff of which life is formed and of the environment in which it exists.

Mechanics has taken a place subordinate to chemistry in the present work. Nevertheless, it has been noted that the unique properties of water are the cause of the admirable mobility of that substance and of the whole environment, and therefore of the dynamical processes of geology, meteorology, etc., including soil formation; that it is surface tension which holds water in the soil; that the efficacy of water as a means of dissolving the greatest variety of substances in the greatest amounts, makes possible high osmotic pressures, as well as mobility of all the elements; and there are a host of other considerations which have been discussed above. In all such cases the properties of water have been found to be favorable influences for the welfare of the organism. Considering the comparative unimportance of mechanics in relation to the fundamental postulates, it seems clear that this department has not been overlooked.

Thermal processes and thermal effects are perhaps more conspicuous in the table. The thermochemical characteristics of organic compounds and the thermal properties of water are all very favorable to life. Stores of heat for the organism, constancy of temperature of both organism and environment, the permanence of bodies of water, and a multitude of other most important results flow from these properties and bear witness to their unique fitness.

Sound, light, and magnetism have not been considered, for they appear to bear only a secondary relation to the fundamental postulates.

In electricity no phenomena are more important than those of ionization in solution. To bring about ionization and thus make possible electrochemical processes, water is the very best medium, and the possibility of such processes is probably necessary to the organic mechanism.

In addition to the topics of physical chemistry already referred to under chemistry and the several departments of physics, the colloids and the ions of hydrogen and hydroxyl remain to be mentioned. It has been shown that the properties of water are exceptionally favorable to the existence and stability of colloidal systems; also that the properties of carbonic acid result in automatic regulation of the concentration of hydrogen and hydroxyl ions in the ocean and in the organism.

So far, then, as it is possible to judge by telling over the departments of physical science, our examination of physical and chemical properties has not been incomplete.

This conclusion may be further tested with the help of the ideas which underlie Willard Gibbs's " Phase Rule." According to this rule, the condition of equilibrium in any material system depends upon the number of its components, the number of its phases, temperature, pressure, and, in general, the concentrations of all the components. Without entering upon an explanation of the exact mathematical notions which determine the meaning of the terms " component" and " phase " it will here suffice to say that in general the number of components increases as the number of

separate chemical individuals increases, and that a phase is any solid, liquid, or gaseous part of the whole system which possesses homogeneity of composition. For instance, if a system is made up of sand, salt solution, ice, and aqueous vapor, each of these separate parts, in that it is homogeneous, is a phase.

NOTE: See, for instance, Findlay, "The Phase Rule and its Applications." London, 1911, 3d ed.

Now the properties of water have the result that more readily than other substances it exists simultaneously and in large quantities in the three phases of solid, liquid, and gas as ice, water, and aqueous vapor. This depends upon the high latent heats of fusion and vaporization, the high freezing point of water, and its vapor tension. Water enhances the complexity of the environment, and is one principal factor in the mobility of the environment as a whole. Further, it makes for stability; other things being equal, the greater the number of phases, the less the tendency to change. Among phases the disperse colloidal type is unique and of very great importance — almost the sole basis, indeed, of great physical complexity — and, as above shown, the peculiar properties of water highly favor the colloidal condition.

The solvent power of water much increases the number of components which may enter into a system of which it is a part; hence the large number of components of sea water, blood plasma, etc. The variety of compounds, both organic and inorganic, which contain carbon, hydrogen, or oxygen also causes enormous increase in the number of components of biological systems like protoplasm.

The effects of the properties of water above enumerated to regulate temperature are almost too numerous to mention. The specific heat of water, its latent heats of fusion and vaporization, and the high freezing point all contribute to the restriction of temperature range within the organism, in the waters, and over the whole surface of the earth. The vapor pressure of water has been shown to possess great and exceptional variability with change of temperature. This is the most important property of water meteorologically, and is the necessary condition for its ample circulation. The ratio between the gas pressure of carbonic acid and its concentration in water (absorption coefficient) has been shown to be the great factor in establishing the mobility of that substance. The total atmospheric pressure has not entered into our discussion, for it seems to have no important special relation to the properties of the three elements.

In short, the properties of water and of the carbon compounds provide for number, variety, and complexity of phases and components, and for constancy of temperature, while equally important and unique relationships between the properties of water and carbonic acid and their vapor or gas pressures exist, and exert much influence upon the meteorological cycle.

Thus, judged by the phase rule, the actual characteristics of the environment may be shown to contribute the factors which make for complexity and regulation of material systems. Now there can be no doubt that, when feasible, the ideal method — from the physicochemical point of view — to describe a material system is in the terms of the phase rule.1 Hence the characteristics which that

Ten years after the law of mass action was propounded by Guldberg and Waage, Willard Gibbs, Professor of Physics in Yale University, showed how, in a perfectly general manner, free from all hypothetical assumptions as to the molecular condition of the participating substances, all cases of equilibrium could be surveyed and grouped into classes, and how similarities in the behavior of apparently different kinds of systems, and differences in apparently similar systems, could be explained.

As the basis of his theory of equilibria, Gibbs adopted the laws of thermodynamics, a method of treatment which had first been employed by Horstmann. In deducing the law of equilibrium, Gibbs regarded a system as possessing only three independently variable factors — temperature, pressure, and the concentration of the components of the system — and he enunciated the general theorem now usually known as the rule contemplates are in certain respects the most important of characteristics. Accordingly the above test is a valuable indication of the adequacy of the preceding analysis of physical and chemical properties.

In order if possible to discover the nature of such properties of matter as may have been omitted in our study of fitness, I have examined the index of Landolt and Bernstein's " Physikalisch-chemischen Tabellen," a very extensive and comprehensive work. In addition to information regarding the arbitrary units of physical science, I find mention of the following properties which have not been considered in the present discussion: —

The Mechanical Equivalent of Heat.

The Dimensions of the Angles of Crystals.

The Refraction of Light.

Compressibility.

The Dimensions of the Molecules of Gases.

Elasticity.

The Electromagnetic Rotation of the Plane of Polarization of Light. Color.

Phase Rule, by which he defined the conditions of equilibrium as a relationship between the number of what are called the phases and the components of the system." — Findlay, "The Phase Rule and its Applications." London, 1911, 3d ed., p. 8.

Viscosity.

Torsion.

The Velocity of the Molecules of Gases.

Hardness.

Magnetism.

The Velocity of Light.

Optical Activity.

Friction.

The Velocity of Sound.

The Wave Length of Light.

To these may be added the phenomena of radioactivity, etc.

It is clear that in the present state of knowledge the consideration of most of these properties is uncalled for. However, it may perhaps be noted in passing that the compressibility of water is remarkably small, that of protoplasm even less.1 Hence even great changes in pressure do not readily damage the organism, and, indeed, a frog's muscle appears to function normally after undergoing a pressure of 500 atmospheres.2 Further, it is of decided consequence for many reasons that the optical properties of water are such that light readily penetrates it to considerable depths. As for color, landscape and modern chemical industry alike testify to the availability of carbon compounds as its source.

A final test of thoroughness may be based upon a consideration of other compounds and elements. Accepting the decision that no other properties can be so important to an active, complex, and regulated mechanism as those possessed nearly or quite as maxima by water, carbonic acid, and the compounds of the three elements, what are the possibilities of obtaining the same characteristics from other substances?

So far as chemical substances are now known, the only compound which can be even considered on this score as a substitute for water in the environment is ammonia, and in many respects, no doubt, ammonia might serve as well.1 However, chemical processes being what they are, it is impossible to imagine the presence of vast amounts of ammonia in an atmosphere, while the loss of the greater part of the energy which can be stored by tearing apart hydrogen and oxygen would be a very serious difficulty; but the loss of substantially all the incomparable chemical activity of oxygen is to all appearances an insurmountable obstacle to the substitution of ammonia for water in biological processes.

1 A full discussion of the properties of ammonia which qualify it as a substitute for water in the role of solvent and otherwise will be found in the article by E. C. Franklin, "The Ammonia System of Acids, Bases, and Salts," American Chemical Journal, Vol. 47, p. 285, 1912. In this paper the results of a long series of investigations are brought together. Especially important for the present purpose are the introductory remarks. "The many striking analogies between liquid ammonia and water as electrolytic solvents have been emphasized by the writer and his co-workers in papers which have appeared from time to time during the past decade. In all those properties which give to water its unique position among solvents, such as its abnormally high boiling point, its high specific heat, its high heat of volatilization, its high critical temperature and pressure, its high association constant,- its high dielectric constant, and its low boiling-point elevation constant, its power as an electrolytic solvent, and the facility with which it forms compounds with salts, liquid ammonia shows a remarkable similarity to water."

From time to time, loose discussion has arisen among chemists as to the possibility of substituting another element for carbon in the organic cycle. Such speculations have never been serious, but they have at least demonstrated that very few elements, probably only silicon, and perhaps boron, can even be imagined in such a role. It has, moreover, just been shown that there are many facts leading to the conclusion that only carbon among elements, and carbon itself only in conjunction with hydrogen, has the power to form the skeletons of compounds numerous, complex, and varied like those of organic chemistry. But, apart from this conclusion, it is certain that silicon and boron could not be mobilized like carbon. Quartz,

the oxide of silicon, is the most inert and immobile of rocks; the oxide of boron is only less available as a movable constituent of the environment; and there is no other stable compound of either element which can be compared with carbonic acid for its mobility. It must be remembered that this property is the result of two independent characteristics of the latter substance, its gaseous nature, and the precise degree of its solubility in water. Finally, the regulation of the reaction of aqueous solutions by means of carbonic acid has to be taken into account.

NOTE: " While the boiling point of liquid ammonia is 33.46° below zero, it still appears abnormally high when compared with the boiling temperatures of phosphine, arsine, stibine, methane, ethylene, hydrogen sulphide, hydrochloric acid, etc. The specific heat of liquid ammonia and the heat of fusion of the solid are greater than the corresponding constants for water or any other known substance, while its heat of volatilization, with the one exception of water, is the highest of any known liquid. The critical temperature of ammonia is abnormally high, and its critical pressure — the more characteristic constant — is higher than that of any other liquid excepting water. Ammonia is an associated liquid, and its dielectric constant, though much below that of water, is still high when compared with that of non-electrolytic solvents. Its boiling-point elevation constant is the lowest of any known liquid, namely 3.4, as compared with 5.2 for water. In its tendency to unite with salts and other compounds, it probably exceeds water, since salts with ammonia of crystallization are perhaps even more numerously recorded in the literature than are salts with water of crystallization. As a solvent for salts it is generally much inferior to water, though some salts, for example the iodides and bromides of mercury, lead, and silver, dissolve very much more abundantly in ammonia than they do in water, and it far surpasses the latter solvent in its ability to dissolve the compounds of carbon. Finally it exhibits conspicuous power as an ionizing solvent, the more dilute ammonia solutions at 33.5° being very much better conductors of electricity than aqueous solutions of the same concentration at 18°."

Hence it may be concluded that hydrogen, oxygen, and carbon, water and carbonic~ acid, are not to be rivaled in their own qualities, even as these cannot be balanced by others which they do not possess.

On the whole, then, we may believe that the physico-chemical characteristics of material systems and material processes have been comprehensively examined in the course of the present study. Accordingly, we may finally conclude that the fitness of water, carbonic acid, and the three elements make up a unique ensemble of fitness for the organic mechanism. The search, however incomplete, has certainly not overlooked properties so important and so numerous, or compounds and elements so unique, as those which have been considered and set forth.

With the assurance that, in such measure as the present state of science permits, our study has been indeed exhaustive, a final argument arises. So far as we can see, all the properties of water, carbonic acid, and the three elements are fit, according to our definition of fitness. There is nothing about these substances that is really and seriously inferior to the same thing in any other substance; and in all the subjects which we have reviewed not a single disability of the primary constituents of the environment has come to light.

III - Summary

For the convenience of my readers the argument which has been developed in the course of the preceding pages is here re-stated in outline.

I. Fitness is a mutual or reciprocal relationship between the organism and the environment.

II. Life is a mechanism (from the point of view of "physical science) . Accordingly it must be — a. Complex (physically, chemically, physiologically).

b. Durable, hence well regulated physico-chemically. This conclusion applies to —

1. The Organism. .

2. The Environment.1

c. Endowed with a metabolism.

Hence there must be exchange with the environment of —

1. Matter.

2. Energy.

III. The primary constituents of the natural environment are —

a. Water.

b. Carbonic acid.

IV. In places where life is possible the primary constituents of the environment are necessarily and automatically formed in vast amounts by the cosmic process.

V. Water, carbonic acid, and their constituent elements manifest great fitness for their biological role.

a. Water possesses a real number of unique or very unusual properties, e.g. thermal properties, solvent power, dielectric constant, surface tension, which together result in maximal fitness in certain respects, e.g. mobility, ubiquity, constancy of temperature and richness of the environment, richness of the organism in chemical constituents, variety of chemical processes, electrical phenomena, colloidal phenomena.

b. Carbon dioxide possesses very unusual properties, e.g. magnitude of absorption coefficient, strength as acid, which together result in maximal fitness in certain respects, e.g. mobility, ubiquity, richness of the environment and organism in other elements and compounds, constancy of reaction, etc.

c. Chemical compounds containing carbon, hydrogen, and oxygen possess unique properties, e.g. number, variety, complexity, activity, variety of chemical relations and reactions, heats of reaction, instability, etc., which together result in maximal fitness in certain respects, e.g. as sources of matter and energy for the processes of metabolism, as sources of complex structures, as the means of establishing complex functions, etc. VI. Oceans are formed automatically in the cosmic process.

VII. The ocean possesses unique properties, e.g. mobility, richness in dissolved substances, durability, and stability of physico-chemical conditions, depending chiefly upon the properties of water and carbonic acid, which together result in maximal fitness in certain respects, e.g. as milieu, and as source of matter for the processes of metabolism, to moderate and equalize temperature, etc. VIII. The physical and chemical properties which have been taken into

consideration include nearly all those which are known to be of biological importance or which appear to be related to complexity, regulation, and metabolism.

IX. There are no other compounds which share more than a small part of the qualities of fitness of water and carbonic acid; no other elements which share those of carbon, hydrogen, and oxygen. X. None of the characteristics of these substances is known to be unfit, or seriously inferior to the same characteristic in any other substance.

XI. Therefore the fitness of the environment is both real and unique.

In drawing this final conclusion I mean to assert the following propositions: —

I. The fitness of the environment is one part of a reciprocal relationship of which the fitness of the organism is the other. This relationship is completely and perfectly reciprocal;* the one fitness is not less important than the other, nor less invariably a constituent of a particular case of biological fitness; it is not less frequently evident in the characteristics of water, carbonic acid, and the compounds of carbon, hydrogen, and oxygen than is fitness from adaptation in the characteristics of the organism.

1 This is not to be understood as an assertion that the relationship is symmetrical. The fact is that each organism fits its particular environment, while the environment in its most general and universal characteristics fits the most general and universal characteristics of the organic mechanism.

II. The fitness of the environment results from characteristics which constitute a series of maxima — unique or nearly unique properties of water, carbonic acid, the compounds of carbon, hydrogen, and oxygen and the ocean — so numerous, so varied, so nearly complete among all things which are concerned in the problem that together they form certainly the greatest possible fitness. No other environment consisting of primary constituents made up of other known elements, or lacking water and carbonic acid, could possess a like number of fit characteristics or such highly fit characteristics, or in any manner such great fitness to promote complexity, durability, and active metabolism in the organic mechanism which we call life.

It must not be forgotten that the possibility of such conclusions depends upon the universal character of physics and chemistry. Out of^ the properties of universal matter and the characteristics of universal energy has arisen

mechanism, as the expression of physicochemical activity and the instrument of physicochemical performance. Given matter, energy, and the resulting necessity that life shall be a mechanism, the conclusion follows that the atmosphere of solid bodies does actually provide the best of all possible environments for life.
[graphic]

Chapter VIII - Life And The Cosmos

I - The Significance Of Fitness

A HALF century has passed since Darwin wrote "The Origin of Species," and once again, but with a new aspect, the relation between life and the environment presents itself as an unexplained phenomenon. The problem is now far different from what it was before, for adaptation has won a secure position among the greatest of natural processes, a position from which we may suppose it is certainly never to be dislodged; and natural selection is its instrument, even if, as many think, not the only one.1 Yet natural selection does but mold the organism; the environment it changes only

secondarily, without truly altering the primary quality of environmental fitness. This latter component of fitness, antecedent to adaptations, a natural result of the properties of matter and the characteristics of energy in the course of cosmic evolution, is as yet nowise accounted for. It exists, however, and must not be dismissed as gross contingency. The mind balks at such a view. Coincidences so numerous and so remarkable as those which we have met in examining the properties of matter as they are related to life, must be the orderly results of law, or else we shall have to turn them over to final causes 1 and the philosopher.

NOTE: Natural selection remains still a vera causa in the origin of species; but the function ascribed to it is practically reversed. It exchanges its former supremacy as the supposed sole determinant among practically indefinite possibilities of structure and function, for the more modest position of simply accelerating, retarding, or terminating the process of otherwise determined change. It furnishes the brake rather than the steam or the rails for the journey of life; or in better metaphor, instead of guiding the ramifications of the tree of life, it would, in Mivart's excellent phrase, do little more than apply the pruning knife to them. In other words, its functions are mainly those of the third Fate, not the first, of Siva, not of Brahma. — Patrick Geddes and J. Arthur Thomson, "Evolution." New York, Home University Library, 1911, p. 248.

NOTE: "But as my conclusions have lately been much misrepresented, and it has been stated that I attribute the modification of species exclusively to natural selection, I may be permitted to remark that in the first edition of this work, and subsequently, I placed in a most conspicuous position — namely, at the close of the Introduction — the following words: 'I am convinced that natural selection has been the main but not the exclusive means of modification.'" — Charles Darwin, "The Origin of Species by Means of Natural Selection." New York, reprinted from the Sixth London Edition, The Home Library, pp. 495-496.

There is, in truth, not one chance in countless millions of millions that the many unique properties of carbon, hydrogen, and oxygen, and especially of their stable compounds water and carbonic acid, which chiefly make up the atmosphere of a new planet, should simultaneously occur in the three elements otherwise than through the operation of a natural law which somehow connects them together. There is no greater probability that these unique properties should be without due cause uniquely favorable to the organic mechanism. These are no mere accidents; an explanation is to seek. It must be admitted, however, that no explanation is at hand.

For the coincidence of properties itself a rational explanation based upon known laws of nature is perhaps conceivable. Attention has already been called to the interconnection of such properties as latent heat of vaporization, thermal conductivity, molecular volume, the value of the van der Waals constant a, the dielectric constant, and ionizing power. Further, it is of course most probable that numerous other properties are necessarily associated with these; and finally it is not surprising that elements of low atomic weight, which become concentrated in the atmosphere on account of the small specific gravity of their gases, should possess unusual properties, like high specific heat, or if one property leads to another, many unusual properties. Be that as it may, chemical science is still a very long way from accounting for the simultaneous occurrence of the various characteristics of water, especially if we include such things as heat of formation, solvent power, the process of hydrolytic cleavage, the degree of solubility of carbon dioxide, the anomalous expansion on cooling near the freezing point, etc.

NOTE: Bacon compared final causes to vestal virgins. "Like them," he says, " they are dedicated to God, and are barren." — "The Advancement of Learning," Book H, p. 142.

There is, in fact, exceedingly little ground for hope that any single explanation of these coincidences can arise from current hypotheses and laws. But if to the coincidence of the unique

properties of water we add that of the chemical properties of the three elements, a problem results under which the science of to-day must surely break down. If these taken as a whole are ever to be understood, it will be in the future, when research has penetrated far deeper into the riddle of the properties of matter. Nevertheless an explanation cognate with known laws is conceivable, and in the light of experience it would be folly to think it impossible or even improbable.

Such an explanation once attained might, however, avail the biologist little; for a further problem, apparently more difficult, remains. How does it come about that each and all of these many unique properties should be favorable to the organic mechanism, should fit the universe for life? And for the answer to this question existing knowledge provides, I believe, no clew.1

Thus regarded, our new form of the old riddle appears twofold, and, on that account, for the present the more unanswerable. There is but one immediate compensation for this complexity; a proof that somehow, beneath adaptations, peculiar and unsuspected relationships exist between the properties of matter and the phenomena of life; that the process of cosmic evolution is indissolubly linked with the fundamental characteristics of the organism; that logically, in some obscure manner, cosmic and biological evolution are one. In short, we appear to be led to the assumption that the genetic or evolutionary processes, both cosmic and biological, when considered in certain aspects, constitute a single orderly development that yields results not merely contingent, but resembling those which in human action we recognize as purposeful. For, undeniably, two things which are related together in a complex manner by reciprocal fitness make up in a very real sense a unit, — something quite different from the two alone, or the sum of the two, or the relationship between the two.1 In human affairs such a unit arises only from the effective operation of purpose.

NOTE: The great difficulty appears to be that there is here no possibility of interaction. In our solar system, at least, the fitness of the environment far precedes the existence of the living organisms.

Now it is most clearly evident from the experience of centuries that ordinary teleology is dangerous doctrine in science, and in the past, accidents apart, it has been invariably sterile.2 A statement that the legs have been formed for the purpose of locomotion, no doubt possesses scientific validity, if it be properly interpreted. But the real scientific concern is for the bones and muscles, the tendons and ligaments which are employed in walking, and for the evolutionary process by which they have been adapted to their use. Nevertheless, biological science has not been able to escape the recognition of a natural, formative tendency, which Darwin identified as the result of natural selection. And now it appears to be necessary to postulate a like tendency in the evolution of inorganic nature. We have found that the properties of the environment, biologically considered, present the same fitness as the properties of life. In each case the fitness results, at least in part, from an evolutionary process. Through the main lines of later development these are both known, though in both cases we stop short, perhaps far short, of the origins — the origin of life and the origin of the universe — if indeed they have ever originated.1 Can we then deny that in the one as in the other process there is a tendency, a bent, a direction of flow or development?2 I think not,

NOTE: It is hardly necessary to point out that the properties of the elements are themselves quite free from variation of any sort.

Alike in the external and the internal worlds, the man of science sees himself in the midst of perpetual changes of which he can discover neither the beginning nor the end. If, tracing back the evolution of things, he allows himself to entertain the hypothesis that the universe once existed in a dif and it seems clear that the facts of physical science call for an explanation of the tendency to fitness of the environment in the same way that formerly the facts of biological science called for

an explanation of the tendency to fitness of the organism.

To postulate such a tendency is, however, in itself rather a philosophical than a scientific act, and so, too, must be conjecture regarding the origin of fitness. It is open to any one who may be so minded speculatively to enrich this tendency with characteristics of any sort. He may follow the lead of M. Bergson and call it impetus, with all which that term now implies, or he may turn to natural theology and regard it as proof of supernatural purpose and design, or he may find a model for teleological views in many other quarters. But one thing is certain, no such discussion, be it ever so important to the philosopher or the theologian, can directly contribute to scientific knowledge and comprehension of the underlying phenomena, which are the sole positive and certain knowledge of the subject that we possess. For these facts an explanation of a different sort would be necessary, something logically resembling natural selection, a natural process acting automatically through the properties of matter and energy, and never overstepping the limits of matter and energy, space and time; neither supernatural nor metaphysical, but purely mechanistic. Lacking any indication of what such an explanation may be, or how it is to be sought, we shall do well to turn to other considerations.

II - Vitalism

All the skill of trained biologists, multiplying and refining our knowledge of the forms of life, has even yet not availed to make clear the fundamental ideas of the science. Complexity exists here in the very nature of the case, and here,, if at all, the complete subjugation of natural phenomena to physical science may be expected to fail.

In an earlier chapter the painful advance of physics and chemistry into the domain of biology has been sketched, and it was then shown how progress is beset with well-nigh insuperable obstacles. Thus it is that biological thought has never attained to that finality which appears, at least by contrast, to characterize the greater body of opinions in physical science.

In particular two extreme views, though often commingled, have continually striven for the mastery. The one of these, purely scientific and wholly positive, declares the phenomena of life to be, while partly unknown, ultimately knowable as manifestations of matter...and energy. According to this view life is a mechanism and nothing more, in its positive scientific aspects at least. Without necessarily denying such assertions, the other view sees the unique properties of life to be dependent upon an equally unique force or tendency, operating in or through its physico-chemical organization. Either there is a peculiar vital force; or there is manifest in the organism a peculiar tendency; or at any rate life patently follows the path into which it was propelled by an original impetus, peculiar to life, unknown in other phenomena. All such views inherently partake of metaphysics, and have, therefore, ever aroused most determined opposition among the more orthodox devotees of science.

Descartes appears to have been the first person to adopt the modern scientific attitude toward life, and from him a very large proportion of French biologists, as well as those of other nations like Huxley and Du Bois Reymond, derive their philosophical views concerning their science. Descartes perceived, apparently the first among the moderns, that the scientific explanation of vital phenomena might be a physical one, in terms of matter and motion. Far in advance of his time he applied such ideas to the nervous system, thereby establishing the nature of reflex action and invading the very citadel of animism. Outside natural science, however, Descartes was far from being a mechanist. Since the early seventeenth century the conflict between vitalism and mechanism has ranged over the whole field of biology, and its history is most complicated. After Descartes, Lavoisier, by his studies of combustion within and without the body, made the next very important step. He was then followed by Liebig, Wohler, and a host of later chemists.

In the main the growth of exact science has steadily delivered over one vitalistic stronghold after another to the mechanists. And though in the first flush of triumph mechanism has sometimes seemed to gain more in a particular engagement than later proved to be the case, vitalism has perhaps not had a positive success in three centuries. Such a history no doubt depends upon the very nature of the situation; upon the inherent and inevitable weakness, within the domain of science, of vitalistic views.

Experience seems to show that the only kind of hypothesis which can find conclusive scientific support, or sound basis in the phenomena of matter and energy, is a mechanistic hypothesis. Exact and positive knowledge can demonstrate scientifically the truth of no other hypothesis with the finality which characterizes its proof of a mechanistic theory. Hence, so far as it ventures into the field of science at all, a vitalistic theory, when attacked by science, cannot effectually avail itself of the weapons of the assailant, and can never make a powerful counter attack. Its only method consists in a determined resistance, yielding little by little before the advance of positive knowledge and never gaining new territory, nor, except by accident, regaining what it has lost. Where this process is to end; in what respect and how far life is destined ever to remain a scientific riddle, can only be surmised.

The chief definitive triumphs of the mechanistic view are two: the elimination of vital force and of a belief in peculiarity of chemical composition from organic chemistry, through the actual successes of the laboratory in new syntheses; and the final recognition, based upon understanding of the principle of the conservation of energy, that, whatever else "vital force^ may be, it is certainly not force, — a form of energy. Thus limited, vitalism has been obliged to take refuge in a more restricted belief; namely, that the organism is somehow governed by a directive tendency which, like an architect, presides over its development; but that meanwhile the manifold processes of life and evolution go on within the world of physical science just as the work of the builder conforms to the laws of mechanics, though following the plan of the architect.

This view has been well stated by another great Frenchman, Claude Bernard: "Life is the directive idea or evolutive force of the being; . . . but it would be an error to believe that this metaphysical force operates after the manner of a physical force. . . . The metaphysical evolutive force by which we may characterize life is useless to science, because, existing apart from physical forces, it can exercise no influence upon them. Hence~ we must here separate the world of metaphysics from the world of positive phenomena

which serves it as foundation, but which has nothing to contribute to it. ... Summarizing, if we can define life with the help of a special metaphysical conception, it is none the less true that mechanical, physical, and chemical forces are the sole effective agents of the living organism, and that the physiologist has to take account of their action alone. We shall say with Descartes, 'One thinks....metaphysically, but one lives and acts physically.'" * Thus restricted, vitalism can apply only to formative processes and the like, though the vitalist still sees in the state of the organism effects of vitalistic control of its evolution, just as we perceive in a house not only the material structure, but the idea of the architect. Further, the origin of life itself remains shrouded in mystery. Meanwhile, for most men physiology has become merely biophysics and biochemistry, and mechanism is undoubtedly firmly established throughout every department of the science.

NOTE: Claude Bernard, 'La Science Experimentale,' 3me ed., p. 211: 'La vie est l'idee directrice ou la force evolutive de l'etre;. . . mais l'erreur serait de croire que cette force metaphysique est active a la facon d'une force physique. . . . La force metaphysique evolutive par laquelle nous pouvons caracteriser la vie est inutile a la science, parce qu'etant en dehors des forces physiques elle ne peut exercer aucune influence sur elles. H faut done ici separer le monde metaphysique du monde physique phenomenal qui lui sert de base, mais qui n'a rien a lui emprunter. . . . En resume,

si nous pouvons definir la vie a l'aide d'une conception metaphysique speciale, il n'en reste pas moins vrai que les forces mecaniques, physiques, et chimiques, sont seules les agents effectifs de l'organisme vivant et que le physiologiste ne peut avoir a tenir compte que de leur action. Nous dirons avec Descartes: on pense metaphysiquement, mais on vit et on agit physiquement.'" — Merz, "A History of European Thought in the Nineteenth Century." Edinburgh and London, 1903, Vol. H, pp. 379-380.

Such limitations of the vitalistic hypothesis, damaging though they may be, do not destroy its claim to consideration as a controlling factor of the processes of evolution, embryology, repair, etc., in spite of the fact that even here it has suffered serious though less complete reverses. In 1859 Darwin's natural selection offered itself as a possible substitute for vitalism in a part or the whole of this field, and soon gained very general acceptance. The survival of the fittest has now become in the Judgment of all biologists an unquestioned force in the molding of life. Therefore, at best, but a restricted scope within its restricted field remains to vitalism.

From the earliest days of the new hypothesis it has been widely recognized that to accept the survival of the fittest as one factor in the adaptation of life to its environment is quite a different matter from proving it to be the only force which directs evolution. An early eulogy by Du Bois-Reymond upon the work of Darwin clearly discloses the nature of the situation: "Here is the knot, here the great difficulty that tortures the intellect which would understand the world. Whoever does not place all activity wholesale under the sway of Epicurean chance, whoever gives only his little finger to teleology, will inevitably arrive at Paley's discarded 'Natural Theology,' and so much the more necessarily, the more clearly he thinks and the more independent his judgment . . . the physiologist may define his science as a doctrine of the changes which take place in organisms from internal causes. . . . No sooner has he, so to speak, turned his back on himself than he discovers himself talking again of functions, performances, actions, and purposes of the organs. The possibility, ever so distant, of banishing from nature its seeming purpose, and putting a blind necessity everywhere in the place of final causes, appears, therefore, as one of the greatest advances in the world of thought, from which a new era will be dated in the treatment of these problems. To have somewhat eased the torture of the intellect which ponders over the world-problem will, as long as philosophical naturalists exist, be Charles Darwin's greatest title to glory."

Recently the work of de Vries, "The Mutation Theory," has at length set fortlT'arnuHP her of trustworthy observations of the origin of species in plants with which natural selection, in the restricted original sense at least, can have nothing to do. The origin of species by mutation consists in a sudden discontinuous variation, and selection, therefore, has no opportunity to operate upon a series of numerous minute variations which themselves display no tendency of any sort whatever, in the manner demanded by the Darwinian hypothesis.2 Hence it appears certain that natural selection cannot be regarded as completely master of the situation; apart from the origin of life there remains a lacuna in biology which for the present no existing mechanistic hypothesis can fill.

NOTE: Du Bois-Reymond, "Darwin versus Galiani," "Reden," Vol. I, p. 211. Quoted from Merz, "History of European Thought in the Nineteenth Century," Vol. II, p. 435. To the same source I am indebted for several other quotations.

NOTE: Hugo de Vries, "The Mutation Theory." Chicago, 2 vols., 1909, 1910 (trans. Farmer and Darbishire).

Moreover, among other things, the ordinary processes of regeneration and repair have frequently been brought forward with some success as purposeful activities inexplicable by natural selection.1 Thus Du Bois-Reymond: "One of the greatest difficulties presents itself in physiology in the so-called regenerative power, and — what is allied to it — the natural power of healing; this may now be seen

in the healing of wounds, in the delimitation and compensation of morbid processes, or, at the farthest end of the series, in the re-formation of an entire fresh-water polyp out of one of the two halves into which it had been divided. This artifice could surely not have been learned by natural selection, and here it appears impossible to avoid the assumption of formative laws acting for a purpose. They do not become more intelligible by the fact that the regeneration of mutilated crystals, observed by Pasteur and others, points to similar processes in inanimate nature. Also the ability of organisms to perfect themselves by exercise has not found sufficient appreciation with regard to natural selection.

NOTE: "Still less explicable in any way thus far proposed are certain remedial actions seen in animals. An example of them was furnished in §67, where 'false joints' were described — joints formed at places where the ends of a broken bone, failing to unite, remain movable one upon the other. According to the character of the habitual motions there results a rudely formed hinge-joint or a ball-and-socket joint, either having the various constituent parts — periosteum, fibrous tissue, capsule, ligaments. Now Darwin's hypothesis, contemplating only normal structures, fails to account for this formation of an abnormal structure. Neither can we ascribe this local development to determinants: there were no appropriate ones in the germ-plasm, since no such structure was provided for. Nor does the hypothesis of physiological units, as presented in preceding chapters, yield an interpretation. These could have no other tendency than to restore the normal form of the limb, and might be expected to oppose the genesis of these new parts." — Herbert Spencer, "The Principles of Biology," Vol. I. New York and London, 1909, revised and enlarged edition, p. 862.

To sum up, it appears certain that at least in a few instances, and possibly quite generally, purposeful tendencies exist in the organism which seem to be inexplicable by natural selection or any other existing mechanistic hypothesis. It is not too much to hope that a scientific explanation of these phenomena in whole or in part may some day be found; but meantime they constitute the natural subject of vitalistic speculation. A field remains, though limited, where the physical scientist cannot yet successfully subdue the vitalist, however strong his conviction of the errors of vitalism.2

NOTE: The indeterminism which is based uniquely upon belief in freedom of the will appears to be foreign to the present discussion. It is, accordingly, entirely disregarded in the following considerations. Hence the conclusions of the present inquiry are not to be taken as cognate with such metaphysical hypotheses as the indeterminism of Kant and Lotze.

Vitalism therefore flourishes, as the recent remarkable works of Driesch and Bergson testify. Of these two authors the former is concerned to prove that pure mechanism is insufficient in biology, and that to mechanism must be added his entelechies;l the latter has gone beyond the vitalism of earlier authors, to give his own view of his speculations, and introduced the idea of the vital impetus.

The Vitalism Of Bergson

Upon analysis the theory of Bergson amounts to this, that there is an original creative impetus impelled upon life which, at all events in the main, is responsible for the course that organic evolution has taken. To quote his own words: "So we come back, by a somewhat roundabout way, to the idea we started from, that of an original impetus of life, passing from one generation of germs to the following generation of germs through the developed organisms which bridge the interval between the generations. This impetus, sustained right along the lines of evolution among which it gets divided, is the fundamental cause of variations, at least of those that are regularly passed on, that accumulate and create new species. In general, when species have begun to diverge from a common stock, they accentuate their divergence as they progress in their evolution. Yet, in certain definite points, they may evolve identically; in fact, they must do so if the

hypothesis of a common impetus be accepted. This is just what we shall have to show now in a more precise way, by the same example we have chosen, the formation of the eye in molluscs and vetebrates. The idea of an 'original impetus,' moreover, will thus be made clearer." * ... "If life realizes a plan, it ought to manifest a greater harmony the further it advances, just as the house shows better and better the idea of the architect as stone is set upon stone. If, on the contrary, the unity of life is to be found solely in the impetus that pushes it along the road of time, the harmony is not in front, but behind. The unity is derived from a vis a tergo: it is given at the start as an impulsion, not placed at the end as an attraction. In communicating itself, the impetus splits up more and more. Life, in proportion to its progress, is scattered in manifestations which undoubtedly owe to their common origin the fact that they are complementary to each other in certain aspects, but which are none the less mutually incompatible and antagonistic." 1

NOTE: Driesch, "The Science and Philosophy of the Organism." London, 1907 and 1908, two volumes.

NOTE: Bergson, "Creative Evolution," translated by Mitchell. New York, 1911, pp. 87, 88.

The contention of Bergson may be divided into two parts: a statement of belief in an original impetus, and his biological arguments in favor of such a view. The former, in so far as it is a question exclusively of an original impetus, appears to lie outside the scope of science, in company with speculations upon the origin of the universe; the latter, because it deals with the subject-matter of science, is open to scientific criticism, and from the standpoint of the biologist is certainly far from conclusive.2

Bergson's hypothesis is, however, in essence not less vitalistic than that of Driesch. Both philosophers assume the existence of a special vital characteristic, and explain the course which evolution has taken as a result of it. In short, modern vitalism consists in postulating a directive tendency which manifests itself in or through the organism alone, and is peculiar to life.

NOTE: In fact, until the mechanistic operation of Bergson's impetus can be clearly perceived, it must remain scientifically an unsound hypothesis.

In such speculations the properties of matter and the process of cosmic evolution have no place.1 Bergson, indeed, very definitely, and it would seem gratuitously, puts aside cosmic evolution and also, with certain slight reservations, the properties of matter as of no essential consequence in organic evolution; e.g. "This twofold result has been obtained in a particular way on our planet. But it might have been obtained by entirely different means. It was not necessary that life should fix its choice mainly upon the carbon of carbonic acid. What was essential for it was to store solar energy; but, instead of asking the sun to separate, for instance, atoms of oxygen and carbon, it might (theoretically at least, and, apart from practical difficulties possibly insurmountable) have put forth other chemical elements, which would then have had to be associated or dissociated by entirely different physical means. And if the element characteristic of the substances that supply energy to the organism had been other than carbon, the element characteristic of the plastic substances would probably have been other than nitrogen, and the chemistry of living bodies would then have been radically different from what it is. The-result. would have been living forms without any analogy to those we know, whose anatomy would have been different, whose physiology also would have been different. Alone, the sensory motor function would have been preserved, if not its mechanism, at least in its effects. —It is therefore probable that life goes on in other planets, in .other solar systems als67 under forms of which. we have no idea, in physical conditions to which it seems to us, from the point of view of our physiology, to be absolutely opposed. If its essential aim is to catch up usable energy in order to expend it in explosive actions, it probably chooses, in each solar system and on each planet, as it does on the earth, the fittest means to get this result in the

circumstances with which it is confronted. That is at least what reasoning by analogy leads to, and we use analogy the wrong way when we declare life to be impossible wherever the circumstances with which it is confronted are other than those on the earth. The truth is that life is possible wherever energy descends the incline indicated by Carnot's law and where a cause of inverse direction can retard the descent — that is to say, probably, in all the worlds suspended from all the stars. We go further: it is not even necessary that life should be concentrated and determined in organisms properly so called, that is, in definite bodies presenting to the flow of energy ready-made though elastic canals. It can be conceived (although it can hardly be imagined) that energy might be saved up, and then expended on varying lines running across a matter not yet solidified. Every essential of life would still be there, since there would still be slow accumulation of energy and sudden release." *

NOTE: Driesch, to be sure, has considered the problem of universal teleology, but unsuccessfully and with obvious vitalistic preconceptions such as individuality. His nearest approach to the thesis of the present work is to be found in the following lines: "I do not hesitate to confess that, apart from historical teleology relating to the sequence of one state of politics or economy upon another, and apart from phylogeny, there seems to me to be a certain sound foundation in the concept of the general harmony between organic and inorganic nature, a something which seems to show that nature is nature for a certain purpose. But I confess at the same time that I am absolutely unable to consider this purpose in any other than a purely anthropomorphic manner." — L.c, Vol. H, pp. 348-349.

B - Vitalism And Teleology

These conclusions appear to be based upon decisions regarding the essential physico-chemical conditions and characteristics of life arbitrarily reached in accordance with preconceived views, and quite without scientific justification. There is certainly no reason to ascribe greater importance to energy than to matter in the vital processes, and in the light of the facts with which the preceding chapters are concerned, such views seem absurd. Indeed, whoever is disposed to speculate about biological fitness — and not even the incomparable finesse of M. Bergson's dialectic can make fitness other than the most general result of the process of organic evolution — must now weigh well the cosmic processes. For, if allowance be made for the results of natural selection in the organic world, fitness of the environment has the greater claim to be considered.

NOTE: Bergson, I.e., pp. 255, 256.

The two fitnesses are complementary; are they then single or dual in origin? The simple view would be to imagine one common impetus operating upon all matter, inorganic and organic, through all stages of its evolution, in all its states and forms, and leading to worlds like our own through paths apparently purposeful and really not yet explained. Such, it seems to me, is the natural hypothesis for the vitalist to adopt. But then vitalism vanishes, only teleology remains; for the unique characteristic of life is gone. Yet, putting aside mechanistic differences, is it not now lost in any case? Has not modern vitalism in accepting the limitation to entelechies or impetus destroyed itself?

The situation, briefly, seems to be as follows: two evolutionary processes independently result in two complementary fitnesses; hence they are related. In the one process the origin of fitness is in part explained by a mechanistic hypothesis. Nevertheless, many philosophers, as is their right, declare that in this process a further extra-physical influence is to be assumed. But any one who makes such an assumption for the one process must certainly now make it for the other; thus he will be led to see impetus or entelechies everywhere. Under these circumstances it may be doubted if his acquaintance with the nature of his impetus or entelechies is so intimate that he will be able to distinguish the inorganic from the organic, for he has surrendered to science all the positive

physico-chemical differences between organic and inorganic bodies and processes. Hence, unless he is to make an arbitrary and unintelligible distinction, or to indulge in the spinning of cobwebs, his vitalism has ceased to be exclusively organic, in short has ceased to be vitalism at all, and has become mere universal teleology.

III - Cosmic Evolution

But, for the scientist, these are matters of little moment. He, at least, is not obliged to take any stand concerning them. This could hardly be better illustrated than by our new facts themselves. For it seems to be clear that where science is most self-sufficient, at the very basis of physical science itself, if anywhere, teleology is at work. Yet it is certain that physical science needs no teleology to explain its phenomena and processes. These are mechanisms, and since the publication of Newton's "Principia" no one has seriously doubted the fact.1

To-day there is as little room for doubt that a complete description of cosmic evolution in terms of matter and energy is possible; for it is sound scientific doctrine that what exists in the finished solar system depends upon what already existed in the nebula. The forms and states and quantities of matter and energy in the nebula determine the resulting solar system. Further, since both nebulae and solar systems are common occurrences, it is evident that nebulae themselves are in a general way determined by other antecedent conditions and phenomena, which turn out to be collisions between stars. Thus arises the suspicion that cosmic evolution may be in truth a cyclic process which had no beginning and will have no end7~ An alternative hypothesis regards the present form of our universe as the result of a gradual evolution from an earlier unknown form, the development of successive solar systems being mere incidents of the larger process, the evolution as a whole directively governed by the law of the degradation of energy.

NOTE: Laplace's reply to a question of Napoleon's, "Why the name of God did not occur in his ' Mecanique celeste,'" will be recalled: "Sire, je n'ai pas besoin de cet hypothese."

NOTE: Such a view, until quite recently, was universally rejected because it appeared to conflict with the second law of thermodynamics, — that of the degradation of energy. But lately it has been put forth by no less an authority than Arrhenius, who has advanced a theory to explain away the difficulty of the second law.

NOTE: "The recognition of the indestructibility of energy seemed to accentuate the difficulties of the cosmogonic problems. The theses of Mayer and of Helmholtz, on the manner in which the Sun replenished its losses of heat, have had to be abandoned. My explanation is based upon chemical reactions in the interior of the Sun in accordance with the second law of thermodynamics. The theory of the 'degradation' of energy appeared to introduce a still greater difficulty. That theory seems to lead to the inevitable conclusion that the Universe is tending towards the state which Clausius has designated as 'Warme Tod' (heat death), when all the energy of the Universe will be uniformly distributed through space in the shape of movements of the smallest particles. That would imply an absolutely inconceivable end of the development of the Universe. The way out of this difficulty which I propose comes to this: the energy is 'degraded ' in bodies which are in the solar state, and the energy is 'elevated,' raised to a higher level, in bodies which are in the nebular state." — Arrhenius, "Worlds in the Making," translated by Bonis. New York and London, 1908, p. xiii.

A - The Periodic System

In either hypothesis the remarkable systematic relationship between the elements which is manifest in the periodic classification has a peculiar place. If the second hypothesis be accepted, there seems to be little room for doubt that at an early period the chief cosmic process was the

evolution of the elements themselves; and in the first theory the nebula, whose properties depend almost wholly upon chemical constitution and chemical and molecular energy, occupies a unique position, like the leaf in the organic cycle, or spring among the seasons. Thus, whether or not the periodic system is to be regarded as the one remaining plain result of a process by which the elements were evolved, at least it takes precedence over the other properties of matter, and lies at the very foundation of the known processes of evolution. Clearly, no one can doubt that upon the properties of matter as determined by the periodic system, and upon the relative amounts of the different elements, the actual process of cosmic evolution from nebula to solar system is dependent.1

Hence, in accordance with the general method of science, we must assume that the origin of environmental fitness lies at least as far back as the phenomena of the periodic system, at least as far back as the evolution of the elements, if they were ever evolved. We simply cannot doubt that the origin of a body like the earth depends exclusively upon chance plus the properties of the elements, their relative amounts, the indestructible forces of nature, and the other known factors of mechanism. The perfect induction of physical science, based upon each and all of its countless successes in every department of physics and chemistry, conclusively proves that the whole process of cosmic evolution from its earliest conceivable state to the present is pure mechanism.2

Teleology

If, then, cosmic evolution be pure mechanism and yet issue in fitness, why not organic evolution as well? Mechanism is enough in physical science, which no less than biological science appears to manifest teleology; it must therefore suffice in biology.

Thus once more we arrive at the negation of vitalism. For this conclusion we possess two arguments: the argument that in such aspects as concern physical science, and apart from differences scientifically explicable, organic and inorganic phenomena are alike, and therefore a specifically vital teleology is unnecessary; and the argument that inorganic science unquestionably has no need of nonmechanistic teleology. Hence we are obliged to conclude that all metaphysical teleology is to be banished from the whole domain of natural science.1

What then becomes of fitness? Clearly there are two logical possibilities. Either there exists an unknown mechanistic explanation of that common issue of the organic and cosmic evolutionary processes, or there does not. If such an explanation be possible, at least it must be admitted that it is very hard to conceive. Yet, recalling the difficulty before the idea of natural selection arose of imagining any mechanistic explanation whatever of fitness, we shall do well not to decide against such a possibility.

On the other hand, it is conceivable that a tendency could work parallel with mechanism without interfering with it, according to a view which has been held by such thoroughgoing mechanists as Descartes, Claude Bernard, Virchow, DuBois-Reymond, and many another. Although I have no intention of here seeking a choice between these two hypotheses, being in fact convinced that now, at all events, no choice is scientifically possible, and doubting if properly speaking they are alternatives at all,1 I do feel concerned to remove from the latter view, if I may, some of the objections which are commonly raised against it in scientific circles, conscious that in this attempt I am overstepping the boundaries of natural science.

NOTE: "Either the multitudinous kinds of organisms which now exist, and the far more multitudinous kinds which have existed during past geologic eras have been from time to time separately made, or they have arisen by insensible steps, through actions such as we see habitually going on. Both hypotheses imply a Cause. The last, certainly as much as the first, recognizes this Cause as inscrutable. The point at issue is, how this inscrutable Cause has worked in the production of living

forms. This point, if it is to be decided at all, is to be decided only by examination of evidence. Let us inquire which of these antagonistic hypotheses is most congruous with established facts." — Herbert Spencer, "The Principles of Biology." New York and London, 1909, Vol. I, revised and enlarged edition, p. 416.

It is evident that a perfect mechanistic description of the building of a house may be conceived. Within the world of physical science the whole process is logically complete without consideration of the architect's design and purpose. Yet such design and purpose, whether or not in themselves of mechanistic origin, are at one and the same time determining factors in the result, and nowise components of the physical process. Now it seems clear that a similar effect of a tendency working steadily through the whole process of evolution is also at least conceivable, however small its bearing upon science, provided, like time itself, it be a perfectly independent variable, making up, therefore, with time the constant environment, so to speak, of the evolutionary process. The tendency must not be demonstrable either by weighing or by measuring, else it would amount to an interference within the mechanistic process, and it must not be itself liable to any kind of variation whose detection would directly reveal it. Where then can the origin of such a tendency be located? Why clearly, if we accept the induction in favor of mechanism, only where Bergson has shrewdly placed his vital impetus, at the very origin of things, just before mechanism begins to act. In short, our new teleology cannot have originated in or through mechanism, but it is a necessary and pre-established associate of mechanism. Matter and energy have an original property, assuredly not by chance, which organizes the universe in space and time.

This is in very truth a metaphysical doctrine; but it has strong claims to sympathetic regard from men of science. In the first place, it leaves mechanism with the perfectly free hand which that process has undoubtedly earned in the world of phenomena. Secondly, it does but add one further riddle, and that an old and familiar one, to those two already tacitly recognized by most scientists: the existence of the universe and the existence of life. Given the universe, life, and the tendency, mechanism is inductively proved sufficient to account for all phenomena.

The existence of the universe, on the other hand, is no concern of the scientist. Whatever else it may achieve, mechanism can never explain, cannot even face the problem of the existence of matter and energy. Within the world of science these are conserved; only outside that world can they have originated or not originated. As for the existence of life, in spite of our utter ignorance, it must be admitted that a half century has greatly diminished the number of substantial biologists who really look forward to its scientific explanation, and the greatest chemists have ever shared such a view. Liebig is reported by Lord Kelvin to have replied to the question whether he believed that a leaf or a flower could be formed or could grow by chemical forces, "I would more readily believe that a book on chemistry or on botany could grow out of dead matter." * Darwin, too, once said, "It is mere rubbish thinking at present of the origin of life; one might as well think of the origin of matter."2 Since Liebig's day the chemical organization of the cell has become in scientific knowledge vastly more complex than it was before, and I know of no biological chemist to whom the spontaneous, that is to say, the mechanistic, origin of a cell is scientifically Imaginable,1 though all believe that once formed, cells exist as mechanisms in a mechanistic universe.2 Thus the chemist puts his mind at rest regarding the existence of life, just as the physicist calms his regarding the existence of matter, simply by turning his back on the problem. Thereby he suffers nothing in his practical task as a man of science.

Returning now to fitness, we may be sure that, whatever successes science shall in future celebrate within the domain of teleology, the philosopher will never cease to perceive the wonder of a universe which moves onward from chaos to very perfect harmonies, and, quite apart from any possible mechanistic explanation of origin and fulfillment, to feel it a worthy subject of reflection. From this point of view, however, science need expect no interference, but without any last vestige

of former shackles may pursue the search after mechanistic explanations of all natural phenomena.1

NOTE: This is not to express an opinion concerning the problem of abiogenesis; all admit that we cannot disprove such a theory. But while biophysicists like Professor Schafer follow Spencer in assuming a gradual evolution of the organic from the inorganic, biochemists are more than ever unable to perceive how such a process is possible, and without taking any final stand prefer to let the riddle rest. But if life has originated by an evolutionary process from dead matter, that is surely the crowning and most wonderful instance of teleology in the whole universe.

NOTE: "An evolution is a series of events that in itself as series is purely physical, — a set of necessary occurrences in the world of space and time. An egg develops into a chick; a poet grows up from infancy; a nation emerges from barbarism; a planet condenses from the fluid state, and develops the life that for millions of years makes it so wondrous a place. Look upon all these things descriptively, and you shall see nothing but matter moving instant after instant, each containing in its full description the necessity of passing over into the next. Nowhere will there be, for descriptive science, any genuine novelty or any discontinuity admissible. But look at the whole appreciatively, historically, synthetically, as a musician listens to a symphony, as a spectator watches a drama. Now you shall seem to have seen, in phenomenal form, a story."—Royce, " The Spirit of Modern Philosophy." Boston and New York, 1896, 8th ed., p. 425.

At length we have reached the conclusion which I was concerned to establish. Science has finally put the old teleology to death^ Its disembodied spirit, freed from vitalism and all material ties, immortal, alone lives on, and from such a ghost science has nothing to fear. The man of science is not even obliged to have an opinion concerning its reality, for it dwells in another world where he as scientist can never enter.

I cannot hope to have provided more than a very imperfect illumination of certain aspects of teleology in this venture upon the foreign field of metaphysics, and I should wish to be understood as very doubtful of my success in stating what seem to me some of the philosophical conclusions to be drawn from the fitness of the environment.

There is, however, one scientific conclusion which I wish to put forward as a positive and, I trust, fruitful outcome of the present investigation. The properties of matter and the course of cosmic evolution are now seen to be intimately related to the structure of the living being and to its activities; they become, therefore, far more important in biology than has been previously suspected. For the whole evolutionary process, both cosmic and organic, is one, and the biologist may now rightly regard the universe in its very essence as biocentric.

1914
Robert C. Webb
"Science Falsely So Called"
Improvement Era Article

At the present day it is a familiar experience to be gravely informed that ours is pre-eminently the "scientific age." We learn in manifold connections that "science" and the "scientific method" are rapidly revolutionizing every department of human thought and endeavor. Nor is this altogether untrue: indeed, as no one can deny, the "scientific method," the method of practical research and experiment, consummated by sufficient demonstration,-the method by which may be achieved certain answers, "yes" or "no," to the question, "will it work?"-has gone far to making the world over, particularly in the mechanical and practical sciences. Because, dating from Watt's discovery

of the expansive energy of steam, in the latter half of the eighteenth century, the habit of subordinating theories as to what "should be" or "ought to be" to the practice of determining by patient and intelligent experiment "that which is," we are accustomed already to seeing results accomplished in actual fact, which have been for ages among the hazy dreams of "unpractical" brains. Thus, things which our forefathers of but a few generations past would have ascribed to "witchcraft," or, simply, to the "devil," are now merely the commonplaces of everyday life. Such are our telephones, our railroads, our steamships, the wireless transmission of intelligence, and dozens of other achievements, including the new-born science of aviation-the building and operating of real flying-machines. The scientific method is, indeed, the real wizardry of which people only talked and wrote in former times. If there was ever a "wizardry" of any other character, we might claim with some show of consistency that it must have been in some very real sense "scientific." (And does not the word "wizard" mean "one who knows?")

In the midst of all this, however, comes the clear warning of experience that, side by side with real science, there is also the "science falsely so called, which some professing have erred concerning faith," and numerous other matters, in addition. Although, as we have heard, this may be the "scientific age," there is no sense in accepting the opinions of every ingenious and persuasive word-spinner as contributions to real science. Yet this is the very thing that is done with as sickening a regularity as in the darkest years of the "dark ages." Nor is there any warrant for crediting a scientific character to the defectively supported conclusions of even the most capable scientists. Thus several of our foremost physicists, naturalists, astronomers, etc., have embraced the teachings of spiritism-have even attempted to clothe them with a semblance of scientific demonstration-yet such fact constitutes no over-impelling argument for their claims in the minds of the average among us. Just as in former days, people had their systems of astrology, which was not precisely the "star-science;" of demonology, which was a very insecure foundation for true medical theory and practice; and of phrenology, which was not what a scientific anatomist would consider an adequate "brain-science;" so, at the present day, we have our systems of Christian Science, so called, and of "scientific sociology," neither of which is scientific in the sense applied to the scientific method. There are other, and even more widely accepted systems of inference and opinion, which are with as little actual warrant called "scientific," just as there are, doubtless, very many men named Hunter, who never fired a gun, set a snare, or took a life, even to assuage the pangs of hunger. It is merely a matter of names in the first case, as in the second.

Under ordinary conditions it would be highly superfluous to treat this matter at all; since, of course, the adherents of unscientific "sciences" cannot be convinced of their errors by any really scientific line of reasoning or demonstration. To argue to a Christian Scientist, for example, that his system is not really scientific would merely evoke the answer that it certainly is "scientific in a higher sense," and there you are. Similarly, an attempt to reason with an evolution-theologist or a "higher critic" that he is laboring under numerous evident misconceptions would move him merely to a pitying reminder of the fact that his critic forgets the "great names" back of his opinions, and is not capable, evidently, of comprehending the aims and character of real "scholarship." And there our efforts rest again; since, as it seems, there is an aristocracy of "learning," and our names are not enrolled in its "Almanach." When, however, an utterly false system, which is dubbed or christened by its adherents "scientific" in some real sense, is erected into a standard for judging truth and reorganizing knowledge; when the cloven foot of its essential absurdity has tracked the broad areas of human thought, penetrating even to the sacred precincts of religion itself, it is high time that voices were being raised in protest against the further propagation of a false culture, and a challenge issued to the constructive atheism, which, as when the devil disguises as an angel, parades as the true "twentieth-century Christianity." We will state, therefore, that we purpose examining and challenging the truth, or even the scientific character, of the so-called "doctrine of evolution" and the so-called "higher criticism"-the second being merely a corollary of the first-not, primarily, because they are obnoxious to the type of religious thinking which we prefer, but

precisely because they are unintelligent, foolish, and baseless. Such an attitude at the present day may seem, to some, very surprising indeed; but the surprise will not be so great when we have discussed the real nature and limitations of science, and the conditions under which, in the world of sense experience, at least, a proposition may be said to be based on knowledge, and when, evidently, on mere assumption.

The word "science" comes into our language, through the French, from the Latin scientia, "knowledge," which derives, in turn, from the verb scire, "to know." It means, therefore, "knowledge," the material as well as the fact of positive sense experience and record of some actual order. Properly speaking, however, it signifies rather codified knowledge, in which numbers of known facts are arranged according to their evident similarities, dissimilarities and relationships; and thus involves analysis in individual cases as well as synthesis in the totality. The classification, which is an essential element in scientific study and greatly facilitates the acquisition of knowledge, is based upon the natural tendency of the mind to association of facts and experiences. To be really scientific, however, this association must be based upon essential elements, rather than upon the fortuitous conditions which determine it in many cases of ordinary experience. Sometimes such elements are small matters common to large groups of facts which differ widely in other particulars; again, they are important consideration which are made to separate several facts, otherwise closely similar. Thus, botanists form their great order Rosaceae, including with the rose group several familiar fruit trees, largely on the fact that all the plants in this order produce flowers of the same description. On the other hand, zoologists separate the termites, or white ants, so called, from the true ants, despite the similarity of their habits and general structure, on the basis of the fact that the termites have netted wings,-thus falling into the order Neuroptera-while the true ants have membranous wings-thus falling into the order Hymenoptera. No one would think, however, of classifying an octopus among birds, because it possesses a horny beak, somewhat resembling that of a parrot; nor, following Buffon's humorous suggestion, of classifying a crocodile among insects, because it possesses a hard covering, or "exo-skeleton."

Because, therefore, science deals essentially with existing facts, in their discovery, analysis and classification, on the basis of essential resemblances and differences, its formulation and use must involve a certain large and important field of inference and theory. Thus, from practical familiarity with the sparks produced in the discharge from Leyden jars, Mr. Franklin concluded that lightning was to be explained by a similar set of conditions in the clouds. This was a scientific inference, based on known facts, and subsequently verified by his famous experiment with the kite and the door key. On the basis of careful observation of natural facts and operations, scientists in other branches have been able to do still more surprising things. Unknown and unseen planets have been assumed to exist, with all the certainty of a demonstration, on the basis of observed aberrations in the behavior of known planets, which could be ascribed only to the influence of unknown bodies; and subsequent observation has verified the conclusions. Similarly, arguing solely from his knowledge of comparative anatomy, and his entire familiarity with the mechanical requirements in a living organism, Waterhouse Hawkins, the English naturalist, in building the life-size model of a megalosaurus at Sydenham, London, confidently formed its back with a hump, like the "withers" of a horse, in order, as he stated, to furnish a sufficient attachment for the mass of muscle necessary to support and move the great bulk of the head. Some anatomists were inclined to question the accuracy of his judgment, but the subsequent discovery of a nearly complete skeleton of an animal of this species confirmed his conclusion. In very similar fashion, after the development of scientific chemistry had indicated the fact that the known elements fall into natural series, in the order of their atomic weights, and then of their other characteristics, it was found that several gaps existed. Other elements were, therefore, predicated, and their atomic weights and other qualities were accurately estimated, as shown by their subsequent identification and isolation; thus vindicating the validity of the so-called "periodic law" of the elements.

In spite of all these surprising achievements of formal science, it must be insisted that inference is a very uncertain guide apart from strict consistency with known facts. In short, when inference and theory extend beyond the just limits of known facts and established laws, and strike out into the unknown, they cease to be scientific in any accurate sense, and constitute what is known as "philosophy," which is to say speculative thought. Nor is philosophy a certain guide, except when known facts regarding the universe and its constitution are kept consistently before the mind. This is shown eminently well in the history of philosophy from the beginning of recorded speculation to the present day. Starting out to explain the facts of existence, numerous philosophers have ended by actually inventing new and unheard-of varieties of universe, possessed of all orders of astounding attributes, and have accomplished nothing but to furnish interesting examples of the operation of the mind, very often under conditions analogous to what, in the language of electrical science, is called a "short circuit"-involving an internal circulation of energy, devoid of effect in useful work on the outside. Thus, following on a closely-knit line of "iron logic," Descartes reached the conclusion that the material world consists in a plenum, which is to say a "fulness," and that no movement could be possible, except in circles. Leibnitz, arguring with similar ability, postulated a universe composed entirely of self-contained and mutually unrelated monads, in which by his principle of emboitement des germes, with the involved power of simulating objective experiences, constitutes the total of our life in an apparent world of subject and object. Bishop Berkeley argued that there could be no material world, except so far as it existed as a "perception," by an essential act of "spirit," which constitutes, he thought, the sum of all reality. Other philosophers have reached similar, or totally diverse, conclusions, merely because of the attempt, common to them all, to use the processes of pure thought, or logic, without regard to the limiting influence of facts in experience and sense perception. Thus, as we may see, logic is a dangerous instrument, except in the hands of a competent master. It is like a two-edged sword, as liable to cut the back of a careless wielder as to split the person of his antagonist. If a sword could be made with more than two edges, it would furnish an even better simile.

When we consider the fact that the real aim of systematic philosophy is to explain the universe-to discover and apply a "world formula," as Prof. Josiah Royce expresses it-the unescapable necessity of starting our speculations upon a basis of perfectly verifiable and relevant fact must be apparent. Without a foundation, only failure can result, in spite of profound reasoning and careful adherence to premises. This rule was never better exemplified than in the geocentric theory of astronomy, the Ptolemaic theory so-called, which, failing to recognize the now accepted fact that the sun, and not the earth, is the center around which the planets revolve, postulated a complicated series of cycles, epicycles and retrogressions, with other ingenious devices to account for observed facts on the basis of an utterly erroneous concept of the universe. It was in harmony, however, with every known, or assumed fact then available to astronomers; the further facts being quite inaccessible to the ancient observers, who had not been able to discover that the earth is a spheroid, and who ignored all the evident inconsistencies in their processes of reasoning on the known facts. Consequently, the whole complicated fabric of their system crumbled and vanished with the demonstration of its one vital and fundamental error.

The modern so-called "law" of evolution, considered as a practical "world formula," is a resultant of two distinct lines of speculative thinking, which, while differing in origin, and in nearly all particulars, have as a common aim the remodeling, or reinterpretation, of all branches of knowledge and experience, including the "data of the religious consciousness." The first of these, in point of time, as well as of ultimate influence, is distinctly philosophical, as embodied in the theories of the noted German thinker Hegel, which, until within a generation, enjoyed considerable favor among Protestant theologians. The second represents the zoological hypothesis of descent, as propounded by Darwin and other earlier investigators, and elaborated by Herbert Spencer into a "law," through the workings of which is produced a continuous change, or series of changes essential and inevitable, "from an indefinite incoherent homogeneity to a definite coherent

heterogeneity," with certain other concomitant consequences. This elaborate definition was an attempt to reduce to formal statement, with the widest applications, the simple Darwinian theory that all the numerous varieties of life-forms are to be considered as so many variations actually produced from a common ancestral type, necessarily simple in structure, by assuming the existence of a natural agency, analogous to the selective activity of the human stock-breeder-who selects individuals for mating, with the deliberate aim of producing some given qualities in the offspring-and which was called "natural selection." This agency, it was assumed, operates to produce such "favored races" as are best adapted to survive in the "struggle for life," thus giving the sanction to Spencer's principle of the "survival of the fittest."

However, the theory of descent, or development, according to which the unicellular egg-destined to mature into a highly complex, multicellular individual-is made the type of the universal law of nature, accounting for all variant life-forms, and all other variations whatever, was originated long before the day of Darwin and Spencer. By the assumption of various theories to enforce the central idea of derivative descent, it was familiar in the writings of numerous naturalists and philosophers for quite a century. Hegel gave it expression in his famous "law of trichotomy," the fundamental principle of his system of logic, which was intended to illuminate all branches of knowledge on the theory that every formal idea consists of three essential elements, (1) the statement, (2) the counter-statement, or contradiction, (3) the synthesis, by which the two find reconciliation and harmony in a higher union, or complete comprehension. This rule of thesis-antithesis-synthesis, applied to the problem of creation, postulated "pure, original, indeterminate being" (the "thing-in-itself," the "Absolute"), projecting itself into its antithesis, the "relative" (called Werden, or "becoming"), a potentiality which, in turn, eventuates every form of determinate being (called Dasein, or "existence") the eternally completing process of creation, in which is involved a return toward, a "reconciliation" with the "Absolute," as manifesting the perfection of the creative idea. This beautiful and suggestive concept, which was not wholly original with Hegel-its outlines being discernible in Hindu speculations, and some other connections-when applied to theology, explained the doctrine of the Trinity, also that of the Atonement; applied to history, the necessary progress, as argued, from imperfect to perfect, from ignorance to finished knowledge, from evil to complete good. The trouble was that it explained too much, and that it explained it too easily; being, like certain domestic implements, not perfectly "fool-proof." Thus multitudes of half-fledged minds were enabled, by its help, to wallow complacently in a conceit of omniscience, even as they do today with the kind assistance of the evolution hypothesis. Thus, Hegel's "law," rather than the speculations of zoological theorists, seems to be responsible for the presently-current notion of certain and inevitable progress into perfection, an idea which seems to be involved in Tennyson's fervid lines:

Is there evil but on earth? or pain in every peopled sphere?
Well, be grateful for the sounding watchword, 'Evolution' here,
Evolution ever climbing after some ideal good,
And Reversion ever dragging Evolution in the mud.
-Locksley Hall, Sixty Years After.

The similarity of its thought with that of the present seems obvious when we remember Hegel's bold comparison between himself and Christ, with a very strong suggestion of advantage in his own case; since he lived 1800 years later, hence at a period further advanced in the grand process.

Thus, whether fathered by Hegel or the zoologists, it seems clear that the doctrine of evolution was not originally an attempt to explain puzzling facts and phenomena, but rather a speculative hypothesis, whose justification is sought in facts and alleged facts. It is the central dogma of the new dogmatism, which the faithful must support by any available arguments, even at the cost of remodeling all branches of human knowledge, as was actually attempted by both Hegel and

Spencer, and with no wondrous results in either instance. It is the prevailing fashion in philosophy, which attracts the allegiance of many minds, just as fashions in clothing appeal to the tastes of some women and a few men. It is the modern substitute for God, divine providence, and revelation, which speciously explains error and wrong, as, in Emerson's phrase, "good in the making." It is a consoling "conviction" for all sorts of feeble minds, who can thus gain fresh assurance of the finality of their own pet conclusions, as an integral part of a grand process of "man's gradual discovery of God and statement of His eternal truth." In all these particulars it is a dangerous and regrettable influence, encouraging superficial thinking and actual degradation of learning to the supporting of a gratuitous dogma. Its influence in religious thinking is seen in the development of the loose and negative attitude, popularly dignified by the term "liberalism," which indicates, precisely, lack of positive conviction and a general unworthy and really unreligious complacency of mind. In this particular it parallels the influence of Hegelian philosophy, as explained by Prof. Francis Bowen as follows:

One source of the great popularity of Hegelianism, especially with politicians and theologians, may be found in its conciliatory character. It has a strong tendency to bridge over the separation of parties and differences of creeds, and to effect compromises between jarring opinions. * * * * The law of trichotomy, which is the basis of the Hegelian logic, enables us to take up any two contradictory ideas, and melt them into one synthetic notion which includes them both. Hence, a consistent and expert Hegelian may repeat any theological creed, join any political party, or defend any philosophical system, without prejudice to the opinions which he formerly avowed.-Modern Philosophy.

At the present day the matter is even worse, since the socalled doctrine of evolution is an even better breeder of essential hypocrisy than even the ingenious speculations of Hegel and all his disciples. Schopenhauer, a violent opponent of Hegelianism, and at the same time an equally strong antagonist of materialism, as expressed in the vapid speculations of mere scientific specialists, "who know nothing else," speaks feelingly of "the steady growth of unbelief in the face of all hypocritical dissembling and the outward conformity to the Church." This is to be seen even now, when men do not hesitate to make formal subscription to creeds and formularies with contemptible mental reservations. Which they dignify under such names as "revised views," "larger understandings," and "new meanings." Thus, even while it is fashionable to hold that this "evolution" process has changed the meaning of words, along with the physical conformation of animals, we will find candidates for ordination in sects, professing full belief in the redemptive work of Christ, shamelessly advertising the fact that they are "unable to believe," for example, the virgin birth of Christ, because that, like the story of Jonah and the whale, it involves "violence to the law of evolution." This alleged law would, we may judge, seem to be the "real gospel" of our up-to-date preachers, who do not hesitate even to flaunt essential atheism before the public in "new understandings of the being and nature of God." When we hear such expressions, we may understand merely that the word "God" is used as a synonym for the "law of evolution," in spite of all the elaborate flounderings and speculatings by which ingenious writers and so-called "thinkers" have attempted to disguise it.

Spencer and Huxley are the Paul and Peter of the "new theology," and Hegel is its John the Baptist. It must be said, however, to the credit of both Spencer and Huxley that they were outspoken in their profession of "agnosticism," which is to say the formal recognition of the essential inability of the human reason to deal with matters apart from the realm of observable and verifiable fact-which is to say, with "final causes." They recognized that our knowledge, unless supplemented, as we may suppose, by something beside, is limited by the horizon of perceptible fact, and that we possess no senses that can discern things beyond the horizon. But, there are always "camp-followers" with every army, and even the most careful thinkers-whatever their errors in matters of opinion-have hordes of self-styled "disciples," who are of the kind characterized in the popular

adage as those who "rush in where angels fear to tread." An outspoken "atheist" may be credited with the virtue of frankness, but an unbeliever in the livery of Christianity is a hateful spectacle-a mere charlatan. We will not insult the dignities by calling him a "wolf in sheep's clothing;" he is merely "an ass in a lion's skin."

1914
The Evolution Hypothesis: What It Is
Robert C. Webb
Improvement Era Article

Could the theory of evolution have remained a zoological speculation, attempting to furnish an explanation for the origin of life-forms, it might have served a useful end in stimulating research into obscure details of anatomy, paleontology, etc., as has certainly been its influence, in some measure, under present conditions. When, however, it is brought to bear upon all other sciences, the stimulating effect is less impressively obvious. It has ceased, in fact, to be a mere hypothesis of specialists in the natural sciences, and has become the foundation of a cult. It cannot be urged, therefore, that a "layman" in natural science shows "presumption" in questioning the validity of the original hypothesis, since he would be but following in the footsteps of the natural scientists themselves, who have not hesitated to invade the fields of logic, philosophy, ethics, theology, etc., in which they have shown themselves, not merely "laymen," but also amateurs of the crassest variety. Their voluminous writings, also, have made the general principles of natural science so accessible to the average reader that none but an ignoramus could fail to understand the main points. Furthermore, it is inadmissible to claim, as some have claimed, that specialists in science, knowing the facts gleaned by investigation, are, of necessity to be credited with such deeper insights, or such command of logical principles that it is proper to accept their explanations, even of the facts most familiar to them. Principal Dawson remarked of Darwin, as reported, that he was a "very good zoologist, but a very poor logician"-nor was this the opinion of a mere "layman"-and this judgment applies with singular force to very many of the foremost followers of Darwin and his opinions. They are very good natural scientists, undoubtedly, but amazingly poor philosophers, and wreched logicians.

The uncritical enthusiasm with which many natural scientists have invaded other special fields of thought and research is well exemplified in the following passage by Professor Joseph Le Conte:

Everyone is familiar with the main facts connected with the developement of an egg. * * * Now this process is evolution. It is more,-it is the type of all evolution. It is that from which we get our idea of evolution, and without which there would be no such word. * * * The process pervades the whole universe, and the doctrine concerns alike every department of science,-yea, every department of human thought. It is literally one-half of all science.-Evolution and its Relation to Religious Thought.

Edward Clodd is equally emphatic in making precisely similar claims; although the consistency of his reasoning might be questioned by some. He writes:

If the theory of evolution be not universal, the germs of decay are in it. And here we pass from what is interesting to what is of serious import for us, because if the phenomena of mind are not capable of a like mechanical explanation as the phenomena of stars and planets, and of vegetable and animal life, evolution remains only a speculation to fascinate the curious. It can, in that case, furnish no rule of life or motive to conduct, and man, the roof and crown of things,' would be the sole witness against their unity and totality. If there be in him any faculty which is no part of the contents of the universe, if there be anything done by him which lies outside the range of

causation, then the doctrine of the Conservation of Energy falls to pieces, for man has the power to add to that which the physicist demonstrates can neither be increased nor lessened.-Story of Creation.

The influence of such thinkers acts, of course, to confirm the conviction of our current "rationalism" that the assumption of a mechanical universe, whose mechanism is perfectly obvious to the scientific investigator of the present day, must, of necessity, be preferable to one in which, as any careful thinker must admit, there is an inestimable substratum of unknown, unintelligible and unimaginable fact, necessarily existing, however, since that which evidently exists demands a cause or justification that is fairly beyond the reach of the investigator. The complacency with which small minds will bask in the conceit of intellectual all-sufficiency has ever been notable in the advocates of the various "world-formul" which have successively claimed the name of "science."

Thus, Galileo, and others, were bitterly denounced in their age for denying the current notions of the universe, and teaching "heresies concerning the antipodes." And why not? Was not the flatness of the earth a perfectly obvious fact? How could it be a sphere, when the people on the "under side" must fall off? This is only typical "rationalism," which assumes that a theory in closest accord with familiar and obvious experiences must necessarily be more nearly true than one which insists, with all logical consistency, that we do not even know that we understand the "obvious experiences," or that they can be justified to the reason, any more readily than things unknown, and perhaps, unknowable.

However, "rationalism" has ever been so irrational that it has been unable to discern the fact that a good part of its thinking consists of words rather than perfectly comprehended, or intelligible, ideas. Thus, following the traditional remark of the old philosopher, Archimedes, who stated that, could he get a foothold outside the world somewhere, he could move the earth with a lever, many persons still assume that they could accomplish not only this feat, but also that, were they so placed in space as to have the materials convenient, they could, on the basis of their present knowledge, make a very fair "bluff" at creating a universe on their own account. Their "knowledge" is so simple and obvious that it must be a surprise that the joy of discovery has been reserved for themselves. In some such spirit, we find Romans writing thus:

"When Kepler was unable to explain by any known causes the paths described by the planets, he resorted to a supernatural explanation, and supposed that every planet was guided in its movements by some presiding angel. But when Newton supplied a beautifully simple physical explanation, all persons with a scientific habit of mind at once abandoned the metaphysical explanation. Now, to be consistent, the above-mentioned professors, (Sir William Hamilton, et al) and all who think with them, ought still to adhere to Kepler's hypothesis in preference to Newton's explanation; for, excepting the law of parsimony (Hamilton's), there is certainly no other logical objection to the statement that the movements of the planets afford as good evidence of the influence of guiding angels as they do of the influence of gravitation.-Scientific Evidence of Organic Evolution.

This passage is a very fair example of the very thing previously mentioned. While, as Romanes says, the theory of gravitation explains the movements of the planets, and while it is evidently unnecessary, if not unwarranted, to accept Kepler's explanation of angelic pilots, since we know nothing whatever about the ultimate cause and nature of the force producing the phenomena, it is true, nevertheless, that a theory of creation which postulates only the forces and activities obvious to our science is not a theory, hypothesis or explanation of any kind, but a stupid fiction devised by an ignorant mind. We evidently know nothing of final causes, in their methods of operation at least, but it is absurd to deny their existence because they are unintelligible to us. We might as well deny the existence of the dynamo, which we cannot see, and assume that the current that lights the

lamps in our homes circulates eternally in a closed circuit, without a constant source of generation, which we have not seen, and may never see. The German philosopher Schopenhauer, although himself the promulgator of some theories not wholly obvious, protested against the activities of our zoological speculators as follows:

Knights of the crucible and retort should be made to understand that the mere study of chemistry qualifies a man to become an apothecary, but not a philosopher. Certain other like-minded investigators of nature, too, must be taught that a man may be an accomplished zoologist, and have the sixty species of monkeys at his fingers' ends, yet on the whole be an ignoramus to be classed with the vulgar, if he has learned nothing else, save, perhaps, his school catechism. But in our time this frequently happens. Men set themselves up for enlighteners of mankind, who have studied chemistry, or physics, or mineralogy, and nothing else under the sun; to this they add their only knowledge of any other kind, that is to say, the little they may remember of the doctrines of their school catechism, and when they find that these two elements will not harmonize, they straightway turn scoffers at religion, and soon become shallow and absurd materialists. They may, perhaps, have heard at college of a Plato and an Aristotle, of a Locke and especially of a Kant; but as these folks never handled crucibles and retorts, or even stuffed a monkey, they do not esteem them worthy of further acquaintance. They prefer calmly to toss out of the window the intellectual labor of two thousand years and treat the public to a philosophy concocted out of their own rich mental resources on the basis of the catechism on the one hand, and on that of crucibles and retorts or the catalogues of monkeys on the other. They ought to be told in plain language that they are ignoramuses, who have much to learn before they can be allowed to have any voice in the matter. Every one, in fact, who dogmatizes at random, with the naive realism of a child on such matters as God, the soul, the world's origin, atoms, etc., is simply one of the vulgar. Send him to the servants' hall, where his wisdom will best find a market.-Will in Nature, Preface (Second ed.)

The principal advantage of a thorough acquaintance with the principles established by Aristotle, Locke, Kant, and others, is that the essential laws of logic are thus to be mastered, and we do not find ourselves attempting to demonstrate one theory by evidences which argue to another, quite different in significance, although assuming some of the same facts and conditions. Yet, as if Schopenhauer had really "sized up" the thought of the present day, we will find, unmistakably and undeniably, that the hypothesis of evolution, the foundation of the "glorious hopes" and delectable consummations, so dear to our modern "liberal" dogmatists and irrational "rationalists," is based on sophistry of the rankest type and on an essential ignorance of the simplest laws of logic.

Now, in making an analysis of this so-called "doctrine," there are several things to be carefully considered. In the first place, in the writings of the most prominent "evolutionists" the word "evolution" is evidently used in two essentially different senses: first, as an evident synonym for the word "development" or biological variation in any sense; second, to designate the hypothesis that organic forms, from the lowest to the highest, have been produced by a process of growth, analogous to the development of an egg into a bird, from the lowest and simplest form possible, the unicellular amboid protoplasm, which, as supposed, was the earliest life-form in this world.

In the second place, all the facts, apparent facts or alleged facts, while arguing for variation in form, do not argue for the philosophical dogma of organic evolution with any certainty or consistency; while the main allegations upon which this dogma is erected are, simply speaking, not true.

In the third place, while no one can deny the fact of variation who has any knowledge of the science of breeding domestic cattle, has ever thought of the numerous varieties of dogs, pigeons or human beings, or who has ever heard of Burbank and his researches in the practical production of new breeds of vegetable life; and, while, in default of precise knowledge of limits in possibility, we

do not know whether variations could be carried so far as to produce a real "species," the fact remains that there is no evidence in nature of a "progressive development" from simple to complex, nor the slightest warrant for the notion of a "steady growth from imperfection to perfection, from ungood into good."

In the fourth place, the greater bulk of the evidences advanced for the evolution hypothesis, and confidently urged in its support, do not argue to an advance from the simple to the complex, from the imperfect to the perfect. We may insist, without fear of successful contradiction, that they argue definitely that, except in minor details of adjustment to new environments, etc., the majority of alleged proved variations of life-forms are real "degradations" in structure, rather than improvements, or that such improvements as may be alleged are, in general, achieved at the expense of other organs and functions. This fact is seen in the alleged development of our one-toed horse from the three-toed miohippus of the Miocene period, the four-toed orohippus of the Eocene period, and the still earlier reported form with the normal five toes. Such advantages in size, speed and superior dentition as may have been achieved, meanwhile, are accompanied by a parallel mutilation of the typical mammalian hand, until it becomes a mere one-fingered support or pedestal, devoid of further possibilities of improvement in the primal "plan" of the type of handed animals.

If the development of the modern horse from a primitive five-toed animal be admitted as fully as possible, it is perfectly evident that it establishes the fact of variation, and not of organic evolution in the Spencerian sense; since the process by which a five-toed animal may beget remote descendants having but one toe on each foot positively furnishes no clue whatever to the still more primitive, but, as yet wholly supposititious process, by which the mammalian hand with its typical equipment of five fingers was originally eventuated. A moment's reflection will show this, also the great difference between a progress upward in the scale, and a progress downward, in any particular. Nature is full of good presumptive evidences of degradation, but is singularly churlish in similarly good "exhibits" on developmental improvements. The whale, alleged to be descended from a true land animal, has gained his ability to live in the water, as assumed, and to propel himself by the great expanse of his tail, by the total loss of his hinder limbs, of which no suggestion remains save a rudimentary pelvis. The fact that rudimentary teeth are said to be found in the jaws of very young whales, and that they are subsequently supplanted by the baleen, is only further evidence of the same import, since the process in course of which hind limbs and teeth disappear is positively not typical of the supposed process by which they were first devloped. It will be unnecessary to discuss here the essential improbability that any such animal as a whale was gradually developed from a normal four-legged land mammal; or even to remind the reader that the geological record furnishes no indications of "intermediate types." It will also be unnecessary to insist that the several types of two, three, and four-toed horses differ among themselves even more than do the modern dog, with four tracking toes on each foot, and the modern fox with five tracking toes on the front feet and four on the rear. No one has as yet suggested the lineal relationship of dogs and foxes. It would be just to say, however, that such apparently misplaced arguments as those applying to horses and whales were injected into evolutionary literature for the purpose of combatting the arguments of unscientific and slovenly advocates of "special creation" who committed the blunder of denying the actuality of variation of any degree, under natural conditions. Consequently, in the mind of Huxley, and other defenders of the evolution hypothesis, such "evidences of variation" were brought forward as subsidiary arguments, although repeatedly used by others as direct arguments. At the present day, however, they cannot be used even in a subsidiary significance.

With all the wealth of effort that has been expended in the development of the "development hypothesis," there is to this very day a most significant absence of true intermediate types-"links," so called-between the great natural divisions of living things. If as evolutonists suppose, all life-forms have been gradually developed from primitive and simple types, and the process has

occupied immense periods of time-for these people talk of millions of years, just as our exponents of "high finance" talk of millions of dollars-it would be only probable that many such "links" should have been unearthed. Nor, in view of the vast periods of time mentioned, can the "imperfection of the geological record" be urged as a sufficient explanation. This does not mean that there are no forms of indeterminate character between orders or phyla. There are, indeed, many such, although not in the line of alleged direct descent. Several animals, those included in the order Monotremata, both structurally and functionally, suggest birdlike qualities; there were in geological times birdlike reptiles and reptile-like birds, also birds with teeth and reptiles with beaks; there are today viviparous fish, that bring forth their young alive, and egg-laying animals that appear to be mammals; there is a fishlike marine animal, the amphioxus or lancelet, which suggests both vertebrate and invertebrate forms, but whch is evidently neither the one nor the other consistently-it has no true backbone. Now, a casual student of zoology and paleontology might see in these, and similar indeterminate forms, true "links" in the orderly chain of development, but they are not so accepted by competent anatomists, notably Professor Huxley himself. They are, in fact, what Huxley calls "intercalary types;" which is to say, exceptional, irregular, ununiform, in the sense in which the "intercalary days" were formerly placed at the end of every several years to round out the defective ancient calendar, although not properly in the year. Speaking of several of the most hopeful examples of these "intercalary types," the Anoplotherium-"intermediate in character between the pigs, on the one hand, and the ruminants on the other"-the Paleotherium-which "similarly tended to connect together animals to all appearance so different as the rhinoceros, the horse and the tapir"-and the Archeopteryx-"which, to a certain extent, occupies a midway place between a bird and a reptile"-he has the following:

Like the Anoplotherium and the Paleotherium, Archeopteryx tends to fill up the interval between groups which, in the existing world, are widely separated, and to destroy the definitions of zoological groups based upon our knowledge of existing forms. And such cases as these constitute evidence in favor of evolution, in so far as they prove that, in former periods of the world's history, there were animals which overstepped the bounds of existing groups, and tended to merge them into larger assemblages. They show that animal organization is more flexible than our knowledge of recent forms might have led us to believe; and that many structural permutations and combinations, of which the present world gives us no indication, may nevertheless have existed.

But it by no means follows, because the Paleotherium has much in common with the Horse, on the one hand, and with the Rhinoceros on the other, that it is the intermediate form through which Rhinoceroses have passed to become Horses or vice versa: on the contrary, any such supposition would certainly be erroneous. Nor do I think it likely that the transition from the reptile to the bird has been effected by such a form as Archeopteryx. And it is convenient to distinguish these intermediate forms between two groups, which do not represent the actual passage from the one group to the other, as intercalary types, from those linear types which, more or less approximately, indicate the nature of the steps by which the transition from one group to the other was effected.

I conceive that such linear forms, constituting a series of natural gradations between the reptile and the bird, and enabling us to understand the manner in which the reptilian has been metamorphosed into the bird type, are really to be found among a group of ancient and extinct terrestrial reptiles known as the Ornithoscelida. The remains of these animals occur throughout the series of the Mesozoic formations, from the Trias to the Chalk, and there are indications of their existence even in the later Paleozoic strata.

Most of these reptiles at present known are of great size, some having attained a length of forty feet or perhaps more. The majority resembled lizards and crocodiles in their general form, and many of them were, like crocodiles, protected by an armor of heavy bony plates. But, in others,

the hind limbs elongate and the fore limbs shorten, until their relative proportions approach those which are observed in the short-winged, flightless, ostrich tribe among birds.

The skull is relatively light, and in some cases the jaws, though bearing teeth, are beaklike at their extremities and appear to have been enveloped in a horny sheath. In the part of the vertebral column which lies between the haunch bones and is called the sacrum, a number of vertebrae may unite together into one whole, and in this respect as in some details of its structure, the sacrum of these reptiles approaches that of birds.

But it is in the structure of the pelvis and of the hind limb that some of these ancient reptiles present the most remarkable approximation to birds, and clearly indicate the way by which the most specialized and characteristic features of the bird may have been evolved from the corresponding parts in the reptile."-Lectures on Evolution, II.

It is notable that this discussion really constitutes a full confession of the essential weakness of the evolution hypothesis as an explanation of nature. First, it rejects, on excellent anatomical grounds that the "hopeful links" mentioned are linear, although insisting, without warrant, except in evolutionary premises, that they evidence change in type. Second, it proposes as true linear types certain reptiles with birdlike features, although these resemble most closely the flightless, ostrich-like birds, which, on developmental theory must be degraded types, having lost the power of flight, although having perfectly formed wings. Third, it utterly forgets that the bird's wing forms a serious obstacle to developmental explanation, as will be explained later.

1914
Fatal Objections to the Evolution Hypothesis
Robert C. Webb
Improvement Era Article

[Third of a series of articles written for the ERA by Dr. Webb, on allied subjects. Each article is complete in itself, but students should read the whole series.-EDITORS.]

In the passage previously quoted from Professor Huxley we find him expressing the opinion that the class of birds "may have been evolved" from some representatives of the extinct reptilian order known as Ornithoscelida. This opinion he then attempts to enforce by a fairly detailed examination of the points of anatomical resemblance between the two types of life-forms, with particular attention to one of the smaller species, known as Compsognathus, which "was a bipedal animal," whose limbs, "in some respects, are more completely birdlike than those of the Ornithoscelida." On the basis of such resemblances as he points out, some zoologists have confidently stated that the ancestry of birds is settled, and that, whether the "intermediate forms" be discovered or not, the indications are too strong to permit of further doubt or discussion. The fact remains, however, that, in spite of all the actual and seeming resemblances between birds and saurians of the order mentioned, there is one all-essential point which has positively not been illuminated-and this is the derivation of the bird wing, not to mention the subsidiary, although highly important, matter of its feathers.

The wing, together with its involved power of flight, is so serious an obstacle to the hypothesis of organic evolution that the failure of anatomists to give it detailed attention is worthy of remark. As is familiar to most intelligent readers of the present day, the wings of all vertebrate flying animals, both living and extinct, are merely modified hands. That is to say, the wing of such an animal, structurally considered, is strictly the homologue of a five-fingered hand, the fingers of which have been very greatly lengthened; so as to act as a framework for the flying surface, intended to

support the body of the animal in the air, as well as to assist in propelling him forward in flight. Such a "flying surface" may consist either of a teguminous membrane, as in the bat, presumably also in the extinct pterodactyls, or, as in birds, of a number of light, flattened, filamentose, overlapping, modified-bristle structures, known as feathers. There are also three types of wing structure, differing acording to the number of the fingers involved in forming the framework, also according to their positions. The first is the bat-type, in which the four fingers are arranged to spread out, and thus support the continuous membrane constituting the flying surface, leaving the thumb standing out at the top, to afford a means by which the animal can take hold of any object to which it may wish to attach itself, usually by the use of the claw. The second type of wing structure may be called the pterodactyl type, because found on representatives of the extinct reptilian order Pterosauria, and shows an immensely elongated fifth finger (the "little finger"), which acts as one side of the framework supporting the flying surface membrane, attached, probably, between it and the body and hind limbs of the animal; leaving three fingers and the thumb free for purposes of prehension. The third type of wing is that of the birds, which resembles the bat wing in the fact that the four fingers of the "hand" are involved in forming the rigid support of the flying surface, leaving the thumb alone free, but differs from the bat type in the fact that the flying surface is composed entirely of the overlapping feathers, the inner ends of which are inserted in the length of the "pinion," formed by anchylosis of the four fingers into a straight and inflexible unit. In most typical bird wings there are to be distinguished rudiments of but two fingers, apparently, although in others, as is claimed, the suggestions of four fingers may be discerned in the bones.

Now, although the wing of every vertebrate type is quite homologous to the five-fingered hand, so far, at least, as the bony framework is concerned, the demand of enthusiastic theorists that we accept the proposition that it was actually developed from a true hand-which is to say that an animal possessing only a true hand, useful either for prehension, or for elastic support of the body, actually begat, by natural generation, remote descendants having the primitive hand elaborated and enlarged so as to form a wing capable of flight-is merely making an enormous demand upon human credulity. This statement gains particular force when we consider that the geological record, be it perfect or imperfect, furnishes not one remotest suggestion as to any supposititious stages of development, through which an original true hand grew into a wing, nor even the smallest element of circumstantial evidence that any such process ever took place on earth. In addition to this, as a moment's reflection will show, the development of the power of flight demands the production, not only of an efficient wing, of such expanse of surface as would enable the animal to lift its weight from the ground, but also such further modifications of the total structure of the body, as would enable it to assume a position in the air, in which it could propel itself forward, with a minimum of resistance from the condensation of the atmosphere in front of it. The importance of this consideration increases considerably in view of the experience of engineers with practical flying-machines, or "aeroplanes," by which it has been demonstrated-according to published calculations-that the pressure of the air, condensed by continuous displacement in the forward movement of the apparatus, shows an increase, expressed in pounds per square inch of flying surface, in direct ratio as the square of the velocity of the machine, expressed in foot-pounds per second. Human ingenuity has taken advantage of this fact to so shape the artificial flying surface, or "plane"-it is really a true "geometric curve," or projected "helicoid," set with the smaller arc to the front-that the front pressure really co-operates with the thrust-velocity imparted by the movement of the propeller, to support the contrivance in the air. Nature has accomplished the same ends by somewhat different devices, but, in both cases, as we find, the smallest possible vertical resistance is offered by the horizontally-moving "flying-machine;" and this is a mechanical necessity in successful flight by any form of apparatus.

From data furnished by the science of mechanics, therefore-and this is the department of knowledge which has been foremost in the work of building the fabric of our civilization-we may

confidently assert that, while it is possible to conceive that, given an efficient wing and a general physical structure calculated to reduce resistance in flight, the power of flying could have been increased from the merest beginnings to the highest reach, it remains true, nevertheless, that a structure, in some real and effective sense, calculated for this form of travel, must have existed before even the humblest beginnings could have been attempted. But, as is perfectly evident, mere specialists in anatomy, ancient or modern, could hardly be expected to realize such conditions; and the geological record is utterly silent upon transition forms in the alleged development of birds, bats or pterodactyls from previously-existing flightless ancestors. Professor Huxley, to be sure, has large hopes in the analogies offered by the order Ornithoscelida, particularly by the representative known as Compsognathus, in which he finds a birdlike conformation of the sternum (breast bone) and greatly elongated hind limbs, like "the short-winged, flightless, ostrich tribe among birds." He fails to specify the fact, however, that his Compsognathus was, in all probability, a jumping animal, such as is the kangaroo, and possessed much shortened fore limbs, which furnish very unpromising beginnings for wings of any degree of efficiency. Such animals, like the "ostrich tribe among birds," with which he compares them, might have been degraded forms, which, on the theory of variation, have lost the power of flight, with persistence in the habit of running on the ground, or of jumping, or hopping, like passerine birds. In such animals, as in the "ostrich tribe," the consequent immense development of the legs would largely embarrass any efforts of nature to increase the power of flight. Thus, if the "ostrich tribe" is a transition form, it is certainly a transition in the process by which some particular structure-in this case the wing-is undergoing a modification essentially toward atrophy and ultimate disappearance; as is well demonstrated in such closely allied, or analogous, forms as the extinct Dinornis of New Zealand, or the Apteryx, in which the fore limbs, as wings or arms of any kind, have utterly disappeared.

Such facts evidence also that, in structures most closely suggesting the possibility of derivative variation, the evidence points to the conclusion that such variation is in the direction of degradation in some particular function-thus the horse loses four of his toes, apteryx loses his fore limbs and whales lose their hind limbs-which is in no sense typical, or even indicative, of the supposed process by which such functions or organs were originally developed out of simpler elements. Until, therefore, we learn of some evidences more conclusively convincing than mere anatomical analogies and resemblances, we may safely rely upon the statement that the wing of the flying animal of any order furnishes the one all-sufficient refutation of the doctrine of descent in the sense assumed by Spencer. It is more than that: mechanically considered, it is an excellent argument for "purposive design" and "special creation," although, as already admitted such theory of origins need not compel us to deny all possibility of variation. There seems to be good "presumptive or circumstantial evidence" in favor of considerable variation in the direction of degradation and atrophy of function and structure. Indeed, cases of this kind of variation furnish by far the greater number of "evidences for organic evolution" (of the Spencerian type) offered by anatomists, from Huxley to the present day.

There are, however, several other structures and organisms in nature, in the examination of which precisely similar conclusions seem nearly inevitable to the observer who bears in mind the fundamental principles of physics and mechanics, which certainly enter into such matters as properly as any consideration of structural resemblances. In short, in judging of the sufficiency of any such theory as that of organic development, which assumes a steady progress from simple to complex, from "low" to "high" in the structural scale, we are very much in the position of jurymen set to determine the guilt or innocence of an accused criminal on the basis of "circumstantial evidence." The whole question before their minds lies in the consideration of the possibility of a "reasonable doubt," which implies that some other explanation than that argued by the prosecutor may be assumed. In the case of derivative descent, the total silence of the geological record on the matter of "transition forms" where they are most sorely needed; the conclusion of Huxley and other competent anatomists that some of the most suggestive "intermediate types," as already seen, are

more properly "intercalary," or exceptional, rather than "linear;" and the total failure of some of his most confidently urged analogies of structure to account for the supposed variations in form, throw the whole matter into the category of "circumstantial evidence." Nor are the most serious of "reasonable doubts" eliminated. Another example of this is to be found in the following passage from the late Duke of Argyle, who, although "a lord of high degree," was a scientist of no mean equipment. In course of discussing several leading difficulties in the way of the evolution theory, he writes:

The case which presents all these problems in the most striking form is the case of the Whales, and especially the case of that species which, from the commercial products of its organism, is most widely known. Both the organs which in this creature are present as rudiments alone, and those which, on the contrary, are very highly developed and most wonderfully specialized, are equally significant. Constructed exclusively for oceanic life, it yet possesses in a rudimentary form some of the most characteristic bones of the terrestrial mammalia. Upon the assumption that no organic structure can possibly have any other origin than ordinary generation, and that they can never have been originated except by actual use, nor be found incomplete except as the consequences of disuse, then of course the conclusion seems unavoidable that the Whale is the lineal descendant, by ordinary generation, of some animal that once walked upon the land. Accordingly, I have heard a very high authority on biological science declare that not only did he accept this conclusion, but that he could conceive no other solution of the problem presented by the facts.

Yet it is evident that it rests entirely on the two preliminary assumptions above specified. Of the first of these two assumptions-that no organic structure has ever come into existence except by ordinary generation-we cannot even conceive it to be true. But putting this aside, of the second of the two assumptions, namely, that organic structures can never have been developed except by actual use, it may be confidently said that it is certainly unfounded. We cannot be sure that the calling into existence of new germs-a process in which the whole animal world must confessedly have begun-is a process which was adopted only once, and has never been repeated in the whole course of time. We cannot, therefore, be certain that the Cetacea, which constitute a very distinct division in the animal kingdom, have not thus begun, with predetermined lines and laws of growth which stand in close relation to the development of all the terrestrial mammalia. But, even if we adopt the assumption that this alternative is impossible or inconceivable, the second assumption is certainly unjustifiable-that by the methods of ordinary generation rudimentary organs can never have arisen except by actual use, nor can have been atrophied except by subsequent disuse. The whole course of organic nature contradicts this assumption absolutely. All organs pass through rudimentary stages on their way to functional activity. And if ordinary generation has been made to do the work of forming new species, the original germs in which the process began must presumably have passed through the same characteristic steps.

There is, perhaps, no creature so highly specialized. The baleen in the mouth is one of the most wonderful cases of an organic apparatus expressly made for one definite and very peculiar work-namely, that of forming a net or sieve for entangling and catching the millions of minute crustaceans and other organisms which swarm in the Arctic seas. It is one of the structures which classifiers call aberrant-cases in which the directive agency-evidently supreme in all organic development-has pursued a certain line of adaptation into the rarest and most extreme conditions determined by a very peculiar food. In the pursuit of that line of adaptation it is really not much of a puzzle that one particular element in the vertebrate skeleton [teeth] should be passed over and left, as it were, aside, because it is a part of the original plan which could be of no service here. There is no rational ground for supposing that this particular bit of internal structure must necessarily have been developed into functional use in some former terrestrial progenitor. Organic beings are full of structures which are variously used, and of others which are so embryonic that they can never have been of any use at all. On the other hand, it is a very violent supposition that

the external structure of the Whale can ever have been inherited from a terrestrial beast by the normal processes of ordinary generation. The changes are not only too enormous in amount, but too complicated in direction, to lend themselves to such an explanation. The fish-like form of the whole creature-the provision of an enormous mass of oily fat, called blubber, completely enveloping the internal organs, for the double purpose of protecting from cold those organs which are dependent on a warm mammalian blood, and of so adjusting the specific gravity of the whole creature as to facilitate flotation on the surface of the ocean, where alone respiration can be effected by the mammalian lung-the development of a caudal appendage which does not represent the mammalian tail, but is constructed on an entirely different type-the assigning to that tail a function which it never serves in the mammalia-that of propulsion in the medium which is its habitat-all these, together with the baleen in the mouth, constitute an asemblage of characters departing so widely from the whole mammalian class, that if the creature possessing them has acquired them through no other process than ordinary descent from parents which were terrestrial beasts, then we are attributing to ordinary generation everything which is intelligible to us as a truly creative power. The stages through which such an enormous metamorphosis could only have been conducted, if they were sudden and rapid, would have been visibly a creative work; and if they were slow and gradual they must have followed certain lines of growth as steadily, as surely, and with as much prevision, as we can conceive in any intellectual purpose of our own. Nothing, therefore, is gained by those who dislike the idea of rudimentary organs being regarded as provisions for a future in some one original Plan, when they try to escape from that idea by supposing that this rudimentary condition can be due to nothing but degeneration. That element of prevision of, and provision for, the future, which they choose to call the super-natural, pursues them through every step of their substituted fancies-and that, too, in the case of the Whales in a more immanent degree.-"Organic Evolution Cross-Examined."

In reading this passage, one must be impressed with the fact that the belief in the hypothesis of evolution, as a sufficient explanation for the appearance of all life-forms on the earth, partakes very essentially of the nature of a "faith that could remove mountains"-except, as is evident, it does not remove them. When we attempt by a merely empirical theory to explain the facts of life, we speedily find, as the writer above quoted sufficiently indicates, that we are ascribing to our "mere natural agency" the acts and attributes of a transcendent and supernatural Creator. This may seem no particularly strong objection in the minds of some readers, who will doubtless seize such an opportunity to enlarge upon the near-miraculous power of the "evolutionary force" in nature. It is well to understand, however, that, if this is the case, we may assert that science (codified knowledge) has nothing to do with it, and that in making such exaggerated claims for any alleged "natural force," we are fairly outriding the strict and proper bounds of science, have developed a cerebral "short-circuit," and become philosophical speculators. Science has nothing to do with discussing divine and supernatural creative activities, "under another name:" that is lexicology, not natural science. It should treat nature precisely as an engineer treats a machine, calculating the contrivance by the possibility, under given conditions, of producing the known effects to be ascribed to known causes, the several forms of energy, etc. If one claims or assumes a form of energy not familiar to science, and whose effects are not understood in its laws, and demonstrated capable of producing the desired, or supposed, results, he has merely contrived a new kind of "Keely motor," which will not "mote," as the newspapers used to express it facetiously; and that, in spite of the fact that, like Keely, he is able to persuade a Leidy, or other scientists, that he is "on the track of some tremendous, undiscovered form of energy," he has not made good his claim. The whole question is, then, as to whether any definition of the "natural forces" supposed to be back of the avowedly "mechanical" theory of evolution, there has been presented any scientifically consistent and intelligible explanation for wings, whales, and other "aberrant structures." If not, the theory is proved, in so far forth, insufficient, illogical and unscientific: hence, also, untrue.

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Evolution Arguments Analyzed
Robert C. Webb
Improvement Era Article

[The fourth of a series of articles written for the ERA by the author, on allied subjects. Each article is complete in itself, but students should read the whole series.-EDITORS.]

As already insisted, the so-called "doctrine" of evolution, which is to say, the theory of descent, by which, eggwise, all living things emerge gradually from an assumed simple, one-celled ancestor, according to the process of "cosmic gestation," is properly speaking a conclusion of philosophical speculation rather than one of scientific demonstration. It is, in fact, essentially philosophy, such as it is, and its tendencies most closely approximate what, in ancient times, was described by the term "hylozoism," which is to say, the assumption that the world in its ultimate material is living, and that all life-forms are its offspring. Thus, all the phenomena of life, even life itself, considered even as a "mode of energy," are to be explained on the basis of facts existing in, or supposed to exist in, nature. In spite of the fact that this is positively not a demonstrated "datum" of science, and is to be accounted for, as a theory, solely by the inborn tendency of some minds to exaggerate the significance of the familiar and "commonplace" into what philosophers term "materialism," it is argued repeatedly in the writings of such men as Huxley and Haeckel, and thus allowed to be classed as "scientific."

For example, Huxley argues that "the fundamental proposition of evolution" involves that "the whole world, living and not living, is the result of the mutual interaction, according to definite laws, of the forces possessed by the molecules of which the primitive nebulosity of the universe was composed." (Genealogy of Animals). To the same effect, Professor Haeckel, with his characteristic zeal and "cock-sureness," does not hesitate to state that "the monera, consisting only of protoplasm (i.e., devoid of the nucleus which characterizes the organic cell), bridge over the deep chasm between organic and inorganic nature, and show how the simplest and oldest organisms must have originated from inorganic carbon compounds." (Heutige Entwickelungslehre, etc.)

Of course, no one having the faintest comprehension of the meanings of words could hesitate to class such statements as good examples of "materialistic atheism." It cannot but surprise us, however, to find that even this unsugared and nauseating "bolus" has been swallowed with all apparent relish by numerous professing Christian writers, who have, thereupon, erected the modern acceptable dogma of "immanent deity," as opposed to the thought of a God in any sense transcendent to, or separate from His creation, and have gravely informed us that the "concepts" of God, as found in the Old Testament, can no longer be accepted. Indeed, one "Christian thinker" recently produced a book of "theological readjustments," in which he did not hesitate to say that the deity considered as separate from creation should be conducted to the confines of the universe, and "politely given his conge," which is to say, courteously banished. Of course, while the idea of the "divine immanence" is an essential doctrine of Christianity, as of all true religious thinking, the fact remains that to deny His transcendence, as our modern "new lights" actually do, means precisely atheism and pantheism. Nor has this sophistical tendency even the virtue of superior comprehensibility; it does not, as claimed, make the idea of God any more real, or His presence any more obvious.

Such conclusions as the above are bad enough in themselves, because of their logical unsoundness, not to mention the wholly unscientific nature of the thought tendency which bases them, but, even with this concession to absurdity, it would be unnecessary to attack the groundwork of the evolution hypothesis, were it not for the further corollaries of the most unscientific, indefensible and obnoxious description touching human nature, its origin, history, significance and ultimate

destiny. And in the miserably sophistical and utterly unscientific fabric of what we may term the "new anthropology," the foolish excesses of the so-called "higher criticism" of the Bible, which is primarily a corollary to the new perverse method of interpreting, or rather of dogmatising about, human history, are only a small part of the total befuddlement of current thinking on vital subjects. We may, however, take courage from Schopenhauer's prophetic words-as it proved-on the then prevalent Hegelian obsession, which also led to an attempted remodeling of all branches of human knowledge:

All this is in accordance with the age and must have its course. In every time some such thing occupies the contemporary public more or less noisily; then it dies off so completely, vanishes so entirely, without leaving a trace behind, that the next generation no longer knows what it was. Truth can bide its time, for it has a long life before it. * * * Truth depends upon no one's favor or disfavor, nor does it ask anyone's leave: it stands upon its own feet, and has Time for its ally; its power is irresistible, its life indestructible.-Will in Nature: Introduction.

As already suggested, the evident assumption of our current philosophy is that nature, as the subject of scientific investigation, is the only real revelation of God. It is not remarkable, therefore, to find that its "interpretation" proceeds along the lines already too familiar with all other real or professed revelations. In the "interpretation" of the Bible, for example, as has been familiar from time immemorial, less effort has been expended in careful study to discover at what precise ideas the writers were attempting to argue than in the bald-faced practice of "reading-in," by which passages, sentences, phrases, torn from their contexts, and as forms of words, merely, have been used to support notions originated in the brains of the "eisegete" himself, and, with the most doubtful propriety to be attributed in any way to the scriptural writer quoted. Also, in how many cases, both in Biblical and in "heathen" literature has a mere "figure of speech," a trope, or literary embellishment, been taken as a literal statement of fact, and made the basis of great and significant doctrines! But the Christian and "heathen" literary eisegetes of all ages have their counterparts among the "scientific" apologists, who-just as though human reason had not expanded and matured, in the meantime-employ precisely similar methods in the interpretation of nature. Thus, the famous "five heads of evidence" familiar in evolutionary books, as embodying "complete proofs" of the evolution hypothesis, are precisely of the same variety of method as the crassest example of Biblical eisegesis. Nor, in considering them, as we now propose to do, is it necessary to reflect so much on the ultimate truth or untruth of the hypothesis in discussion as to decide whether these vaunted "evidences" establish it. Remembering that science can deal only with established and evident fact, or with such hypotheses and theories as are susceptible of demonstration, we may determine, also, whether we have to do in this instance with science or with philosophical speculation, whether, in short, the alleged conclusion is an inevitable corollary of the facts presented to our notice, or whether these same facts are not marshaled for the mere purpose of supporting an a priori assumption, just as passages of scripture have so often been impressed to the support of a gratuitous dogma, in the traditional process of "twisting texts to suit the sects."

The five king-arguments for the support of the theory of evolution, understood to imply the derivation of all species of lifeforms by the process, as alleged, of "cosmic gestation," from the simplest possible original form, or forms, are, as follows:

I. THE ARGUMENT FROM CLASSIFICATION, which asserts that the undoubted fact of the resemblances, which lie at the basis of the classification of living things into groups, larger and smaller, more inclusive and less inclusive,-phyla, classes, orders, genera, species and varieties-argue directly to derivative descent, through natural generation, from common types correspondingly remote, and correspondingly more "generalized" in structure, until the basic simplest structure is reached.

II. THE ARGUMENT FROM MORPHOLOGY, which claims to demonstrate the same community of origin by the similarity of structures, used for the same, for similar, or for varying purposes, in groups of life-forms, otherwise diverse. Thus, we find the five-fingered hand used for prehension in man and some other animals, appearing as the paddle of the whale, the wing frame of bats and birds, and, slightly modified by the loss of individual digits, etc., as the elastic supporting paws of the carnivora. We are reminded, also, that the skeletons of all vertebrates present complete homologies of structure in the number and positions of the several bones, and that all insects are composed of the same number of body segments. The argument that dissimilar structures, used for similar functions, such as the eyes of vertebrates, insects and molluscs (octopi, nautili, etc.,) is supposed to indicate the same conclusion with similar cogency, indicating independent side-lines of development.

III. THE ARGUMENT FROM SUCCESSION, which claims to demonstrate derivative descent, from lower to higher, from the fact that the life-forms found in the lower rock formations are simpler and lower structurally than those found in the higher, and that the higher forms, such as the mammals and the human species, did not appear, in the form of fossils preserved in the rock deposits, until very recent times geologically speaking.

IV. THE ARGUMENT FROM GEOGRAPHICAL DISTRIBUTION, which attempts to establish the same conclusions, on the basis of the variant forms to be found in the several quarters of the globe. Thus, certain forms and types of animals are confined to certain definite regions, and are to be found nowhere outside of them, and each continent has its distinctive fauna and flora, which serves to show that the divisions by oceans, etc., have persisted for ages, and that the lines of variation have been independent. This is particularly argued from the distinctive fauna of Australia and New Zealand, which differ very essentially from those of other world regions.

V. THE ARGUMENT FROM EMBRYOLOGY, which presents several alleged structural resemblances between the embryo of the higher animals and the mature forms of certain "lower" animals, their presumed ancestors, thus making each individual really a "recapitulation" of his own ancestral history.

It must be remarked that these five "arguments" have been used since the early days of evolution controversy, and that they were framed primarily to controvert the opinions of those writers who denied the fact or possibility of variation under natural conditions of existence. When, however, as at the present time, thoughtful people generally are quite ready to admit that variation is both possible and actual in the state of nature, and demand only facts to demonstrate that it is a process of the widest significance, the essential inconclusiveness of several of these "arguments" cannot fail to be apparent.

In accord with these observations, we shall find that, while the facts relative to geographical distribution may be hostile to the theory that all life-forms were produced by "special creation" in the regions which they inhabit, we still find no compelling evidence in the direction of any theory of a "continuous progressive change" from the simplest types upward, and, in several instances no warrant for believing in any modification of structure along definite lines. In the case of the Australian continent, for example, the distinctive character of its animal life is apparent, and, if judged by many facts, the theory that it has been separated from all other known lands from a very early period may be held to be established. But, as we find, its "antiquated animal forms"-such as the marsupials and the monotremata-have remained "antiquated," in spite of the fact that, dating from the day on which Australia was separated, presumably, from Papua, the Malay Archipelago, and the mainland of Asia, perhaps, such forms have elsewhere disappeared, and have been supplanted by "more highly organized" forms, derived, as we are told, from similarly "antiquated" ancestral stocks. In Australia, however, the "upward process" has been checked, and no further

variations have taken place-none, at least, that have established new types of life-forms. Why this is the case we are not informed, but it certainly suggests that such changes as take place through variation are not to be credited to an internal force, or destiny, which gradually conforms the race to some predetermined type, in a manner analogous to the process by which the embryo inevitably matures into the "destined form" determined by its respective parentage. The cases of the marsupalia and monotremata are particularly interesting in this connection, since they are valuable "intercalary forms," anatomically suggestive of "incompleteness" and "transition." It is gratifying, however, that so zealous an advocate of evolution as Prof. Huxley should furnish us with a partial explanation of this very condition. He says in part of the several zoological regions of the ancient and modern worlds:

Now the truth which Mr. Darwin perceived and promulgated as the 'law of the succession of types' is, that in all these provinces, the animals found in Pliocene or later deposits are closely affined to those which now inhabit the same provinces; and that, conversely, the forms characteristic of other provinces are absent. North and South America, perhaps, present one or two exceptions to the last rule, but they are readily susceptible of explanation. Thus, in Australia, the later Tertiary mammals are marsupials (possibly with the exception of the Dog and a Rodent or two, as at present). In Austro-Columbia (South America and Mexico) the later Tertiary fauna exhibits numerous and varied forms of Platyrrhine Apes, Rodents, Cats, Dogs, Stags, Edentata and Opossums; but, as at present, no Catarrhine Apes, no Lemurs no Insectivora, Oxen, Antelopes, Rhinoceroses, nor Didelphia other than Opossums. And in the widespread Arctogeal province (North America, Europe, etc.), the Pliocene and later mammals belong to the same groups as those which now exist in the province. The law of succession of types, therefore, holds good for the present epoch as compared with its predecessor.

But it is very remarkable that while the Miocene fauna of the Arctogeal province, as a whole, is of the same character as the existing fauna of the same province, as a whole, the component elements of the fauna were differently associated. In the Miocene epoch, North America possessed Elephants, Horses, Rhinoceroses, and a great number and variety of Ruminants and Pigs, which are absent in the present indigenous fauna; Europe had its Apes, Elephants, Rhinoceroses, Tapirs, Musk-deer, Giraffes, Hyenas, great Cats, Edentates, and Opossum-like Marsupials, which have equally vanished from its present fauna; and in Northern India, the African types of Hippopotamuses, Giraffes, and Elephants were mixed up with what are now the Asiatic types of the latter, and with Camels and Semnopithecine and Pithicine Apes of no less distinctly Asiatic forms.-Paleontology and the Doctrine of Evolution.

Huxley traces similar correspondences in the Eocene formations, so far as they were available to him, and concludes that the evidence, on the whole, is distinctly favorable to Evolution, lending itself readily to the theory that present species have descended from past species. This is, however, merely supposing variation within the limits of types-although the "doctrine of colonies," elsewhere mentioned by Huxley, might account for it-and gives no suggestion of the notion that any of the greater groups has ever passed into another, the very point on which we need conclusive evidence, if we are to accept "organic evolution" as an established truth. Although, then, as Huxley states, these evidences present "no sort of difficulty" to evolution explanation, and that there is "nothing * * * to forbid" the theory of ancestral relation, it must be insisted that there is also nothing which compels us to accept it as an inevitable explanation. In other words, although we may allow Huxley the consoling assurance that the facts mentioned may not antagonize the evolution process, they do not establish the theory postulating the process, or even render it more distinctly conclusive.

The so-called "arguments" from both classification and morphology lead to precisely similar conclusions. Science tells us simply that all life-forms fall into certain groups, determined by their

anatomical resemblances, and, with proper logical consistency, can tell us nothing regarding the supposed origin of these several groups of classification, since this is a matter of inference and argument, in the support of which facts fail through the greater part of its statement. However attractive, therefore, may seem the various inferences on origins and ancestral relationships, they are not properly science, because not conclusively demonstrable. Confining our estimate of the truly scientific to what is known and undeniable, we find, in the animal kingdom, for example, that certain general anatomical characteristics are possessed by all its members, and determine their differences from members of the vegetable kingdom, however greatly such characteristics may be confused and uncertain in representatives of the "lower orders" on either side of the line. We know also that each of the nine great phyla of this kingdom is formed on the recognition of a definite general "plan" of structure, found more or less definitely in all its members, and to be seen in representatives of no other phyla whatsoever. Thus, the spinal column is the characteristic mark of all vertebrates; the segmental structure, of the arthropoda, or "articulates," etc. Such special organs as the five-fingered hand, teeth, etc., appear as the structural basis of numerous variations of the general "plan" of structure-occasionally even being absent, or so profoundly modified as to appear as quite different structures-but they are mere structural elements, not organs for some certain purpose, since they are variously modified to serve different and widely diverse purposes in different connections. Thus, in considering any possible explanation of origins and descent, it is reasonable to ask an explanation of the query as to whether the organ exists before the function is developed, or whether the tendency to develop the function, as found in the ovum, produces or modifies the structure. Such a question is a serious one in the consideration of any such hypothesis as that of organic evolution; since the presence of a given organ, used for widely diverse purposes in several representatives of the vertebrate phylum, suggests strongly that it is merely an element in a broad general plan of structure, which is taken in special instances as the best available instrument for the accomplishment of certain given functions, without direct bearing on any question touching ancestry or derivative variation by natural generation. In accordance with this theory, we find that teeth are used for mastication only by the higher vertebrates, most others using them only for seizing and holding the food, rather than for dividing it into fragments convenient for swallowing: some also, like the carnivora, use teeth for weapons of offense, while rodents use them for gnawing hard substances. Nor is the difference between a rodent and another mammal merely one of tooth-arrangement and size-the self-restoring property of the rodent's teeth arguing far greater and deeper variations on the primal "plan." The several various adaptations of the hand have already been noticed, but we find that the characteristic tail is quite as suggestive. Such animals as opossums and some monkeys use it as a true prehensile organ, by which the body may be suspended; in the kangaroo it appears as a sort of "third leg," which can support the body in the sitting posture; in the whale it appears as an instrument of propulsion; in the beaver it assists in swimming, as well as to afford a natural tool for spreading the materials used in building its dwelling; in the horse it has a good use in switching of troublesome insects; in man the small rudiment of a tail (the coccyx) is of use in supporting the weight of the body in the sitting posture; in many other animals it seems to have no particular function beyond expressing emotions. The hypothesis of descent furnishes no satisfactory explanation of these variations of function, although proposing various guesses as to the development of special structures. Thus some theorists state that the jaw of the vertebrate is a variation of the "uppermost segment" of an articulated animal, the ribs indicating so many more such segments; while the teeth are to be explained as structures similar to the bony spines found on some fishes, for example, which have "grown in." Such theories seem to be mere surmises. On the other hand, when nature develops a function, it evidently takes advantage of some existing structure, characteristic of a phylum "plan." Thus, although the hand is the characteristic prehensile organ, we find an extreme special development of the nose in elephants for the same purpose, while in some ruminants, and other herbivorous animals, the tongue is used for grasping and holding the food to be severed by the teeth.

Several scientists, notably Spencer and Owen, have compared the formation of crystals with the development of life-forms: consequently we may adopt the same analogy, although aware that it extends only to the evident similarities in two processes of producing definite forms, in which, under stress of favorable environing forces and conditions, amorphous matter assumes definite and predicable forms. For example, in snowflakes, which are crystalline structures formed by the "congelation of the minute globules which constitute the clouds, when the temperature is below zero," we find a very distinct "generic plan"-the "hexagram," or six-pointed star-which, whether showing the bare outlines, or having the "rays" highly and ornately elaborated, is invariably present. Nor can it be claimed, with any accuracy or consistency, that, apart from the merest outlines, indicating the general directions along which the crystallizing forces act, the less ornate form, in any given case, exists before the more ornate variant appears in time. Such is evidently the case, since the regularity, as well as the elaborateness of the figure, seems to depend upon physical conditions, such as the degree of temperature, the state of the atmosphere, the rapidity of the crystallizing process, etc. In such conditions the numerous variants of the snowflake plan spring into existence without previous progress from simple to complex. But we know absolutely nothing about the conditions in which the first life-forms came into being: consequently, we can offer as an established fact no explanation whatever of the variations on the several "generic plans" known among them. Such "plans" must have existed, in posse, in the germs-and this explains why that a developing germ always follows the characteristics in development of its immediate ancestors. In fact, the whole secret of variation of any degree lies in the influences, whatever they may be, that can modify the germ potentiality. The attempt, so frequently made, to explain the origin of life in chemical or electrical action is merely a presumption on our knowledge; since no such "actions" are known to science-not even in the "saline solutions" that, as we are told, can promote the development of unfertile eggs of sea urchins, and other low orders of animal life: this is a sort of artificial "parthenogenesis," not a creation of life.

1914
Robert C. Webb
The Evolution Hypothesis and the Geological Record
Improvement Era Article

[The fifth of a series of articles written for the ERA by the author, on allied subjects. Each article is complete in itself, but students should read the whole series.-EDITORS.]

The arguments for organic evolution drawn from the succession in time of the appearance of organic types, and from embryology, as setting forth, as is claimed, a "recapitulation" of the ancestral history of the individual, are, apparently, the best reasoned of the entire five heads of "evidence." The fact, so often indicated, that the geological record shows a certain succession in life-forms, from those comparatively "low" in the scale, to those "highest" and most elaborated, may be held to indicate that the "higher" forms appeared actually later in time than the "lower," although, whether by so many successive "special creations," as was argued by Agassiz and his "school," by a process of derivative descent, or in some other manner, is really as much of an open question now, as in the earliest days of geological science. This may seem like a foolish and indefensible statement, but when we consider the fact, already indicated, that the bulk of the so-called "evidences of variation" suggest rather real degradations of special organs, as in the cases of horses and whales, for example, the evolutionary significance of the apparent succession of life-forms, from "lower" to "higher," as argued from the rock records, is not so clear. In fact, a careful examination of the conditions involved quickly demonstrates the conclusion that the facts are incapable of supporting the Spencerian hypothesis of organic evolution, except in a very general sense, by inference, and by a certain not overwhelming percentage of the facts.

In the first place, the geological record does not establish the conclusion that there was a gradual ascent from the simplest life-forms to the more complex. Although the fossils found in the lowest and earliest formations indicate that the prevailing types in regions where sedimentary rocks were being deposited were, first mollusca, second low arthropods, third ganoid fishes, none of them distinctly in the very lowest ranges of organism, there is no direct conclusive evidence that the prevailing life-forms of still earlier periods represented still "lower" types, from which those in the Silurian rocks were, presumably, derived by natural descent. Consequently any conclusions in the premises, apart from obvious deductions from established facts, are mere inferences and suppositions, and not even "circumstantial evidences." There is found, to be sure, in a serpentine marble of the Laurentian (Eozoic) formations of Canada, what several authorities have concluded to represent the remains of a species of rhizopod (Protozoon), and have called Eozoon ("dawn animal"), as indicating, perhaps, "the earliest known form of animal life." But whether or not Eozoon is really a fossil remnant, as some have strongly doubted, the presence of very extensive deposits of marble, graphite and iron ore in the same formations strongly suggest the contemporaneous existence of other, and, perhaps, more advanced forms of organism-the marble and graphite indicating the existence of mollusca or coral-builders (Anthozoa) and vegetation, respectively-the graphite (carbon) being in such quantities as to suggest a vegetation as plentiful and long continued as that of the Carboniferous Age; while the iron ore, according to the conclusions of many geologists and chemists indicates merely ancient "bog-iron" deposits, resulting from the deoxidizing action of vegetable organisms. In these cases, of course, subsequent metamorphosis of the rocks must have eliminated all traces of fossil remains. Consequently, we have no data on their character or relative position in the scale of life.

In the second place, the geological record is necessarily and inevitably incomplete in life forms, a fact which has been sufficiently heralded by evolutionists, who argue that, were the record "complete," all "missing links," all "breaks in the chain" of life development, must infallibly have been recorded. The incompleteness of the record indicates, however, other, and perhaps as important considerations to the scientific investigator. Thus, the popular assumption that geology has demonstrated the earliest life-forms to have been marine, with the inference that land forms must have been derived from them by variation, is a clear presumption on the facts. Without referring to the immense improbability that a true water-dweller could ever have been modified into a true land-dweller, we must insist that the rock records tell us nothing whatever regarding the existence or non-existence of land forms contemporaneous with the earliest recognized marine deposits. And this must be held true for two very excellent reasons: first, that sedimentary rocks, which are the only ones containing the fossil remains of organic forms, are deposited only on sea bottoms, lake bottoms, at the mouths of rivers, as bogs, or along ocean shores, where the breakers pound the primeval rocks into sand, which is later deposited in beds, eventually becoming rock; second, that no remains of land animals can occur as fossils in a rock deposit, unless representing individuals that have been drowned or devoured by water-dwelling carnivores, who have dropped the bones on the bottom. Consequently, there is no inevitable necessity which would compel the presence of land remains in the rocks of any period, except under the general conditions specified.

Now, regarding the conditions in which we should logically expect to find the remains of land animals plentiful in the rocks, we may say that they should be fulfilled when there exist highstanding land areas, filled with lofty mountains and elevated hills and plateaus, such as would form the abundant water-sheds of large and strong-flowing rivers. The rivers afford constant opportunity for carrying the bodies of land animals and plants, and depositing them at their mouths, or in the seas or lakes into which they empty, thus insuring some record in the forming rocks. But what does geology say of this? It certainly records that the earliest lands, those at least existing above sea level during the Paleozoic Time, were, on the whole, low-lying, with few lofty elevations, consequently few large and powerful streams to carry terrestrial remains, if any, and leave them in the sedimentary deposits. Indeed, so characteristic is such a land configuration of

this ancient time that geologists have accepted as an established principle that the lower ranges of mountains are regularly the oldest in upheaval, while the loftier elevations are of comparatively recent occurrence. This fact alone should account for the absence of land forms in the Paleozoic rocks, before the Carboniferous Age, except for the few reported remains of scorpions, etc., in the upper Silurian. The remains of land snails, insects, centipedes, etc., occur often in the Carboniferous formations, when the deposits were formed largely from land plants growing in bogs-mostly cryptogams of the fern, and allied types-which were utterly different in character from the marine vegetable life of the lower deposits. The scattered and occasional remains of true land dinosaurs (reptiles) have been reported in the Permian rocks of the upper Carboniferous. Nor are there any suggestions of "intermediate forms," either plant or animal, previous to this stage.

The higher land animals appear, geologically, for the first time in the Triassic and Jurassic formations of the lower Mesozoic, when quite a different configuration of the dry land had already been established. With the close of the Paleozoic Time occurred an immense upheaval, in course of which the Appalachian range of eastern North America, as well as most of the Rocky Mountain system, on the west, came into existence. With the establishment of these vast water-sheds, remains of land animals become increasingly more common in the fossil-bearing rocks. The inevitable conclusion is, that, whether or not land life existed in the Paleozoic Time, it is perfectly evident that we have a good explanation for the fact that there are no traces of land forms in the lower measures, also for their presence in the later deposits. Even Professor Huxley strongly inclines to similar lines of explanation when he states deliberately (Paleontology and the Doctrine of Evolution), that all genera of life forms must be assumed to be far older than would be supposed from the date of their first known appearance as fossils in the rocks.

In another point, also, the "evidential value" of the rock records has been largely overestimated, and this lies in the fact that the earlier deposits were made, evidently, in comparatively shallow waters, leaving us no information as to the forms of life existing in greater depths of ocean, if there were such. The prevailing, or characteristic, life-forms of the shallower seas, therefore, furnish the principal records recognized as of this time. However, there must have been a steady and long-continued subsidence of the sea bottom in some areas, to compensate, perhaps, the rise of dry land in others, throughout the entire Paleozoic Time, as we may assume to explain the extreme thickness-depth-of the deposits containing the remains of its life-forms. Indeed, if we assume that the same thickness of rock in any two geological "regions" indicates, even approximately, a corresponding rate of deposit, it may be said that, judging on this standard, the Paleozoic formations represent over two-thirds of all geologic time: nor does this estimate make account of the vast deposits of metamorphic rock, which, by the theories of many geologists, represent still older sedimentary deposits, whose original character has been obliterated by the action of heat and other natural forces. But the characteristic marine life-forms of the Silurian, or lower Paleozoic,-fixed molluscs and arthropods, in the main, with fucoids and a few corals-certainly indicate that the portions of the sea inhabited by them were very shallow; since in none of these forms do we recognize deep-sea dwellers. Thus, with the slow, but steady subsidence of the sea bottom, as shown in known deposits, there were probably formed vaster depths in other, and perhaps unknown, areas of ocean, before the close of the Silurian formations. Whether the deposits formed in such regions are represented by some formations containing deep-sea life-forms, which have usually been supposed to be of later origin, because superposed on the former rocks, we cannot undertake to determine. The fact remains, however, that we have positively no assurance of more than the few beginnings of knowledge of the total conditions of early geologic life, or of the seas, islands or continents, in which it was manifested; or of the forms in which it must have appeared. It remains true, however, that such known forms as have persisted to the present time have come down practically unchanged; also that such extinct life-forms as trilobites, which, as frequently indicated, resemble embryonic stages of modern crustaceans, have never seemed to advance toward a "cosmic maturity"-they disappear suddenly at the close of the Paleozoic Time.

Any further consideration of the geological record establishes the conclusion that the arguments in favor of Spencerian evolution are progressively weakened. In the first place, and nearly fatal to the theory it must seem, we find no evidences worth recording of series of small changes through immense periods: the newer forms of organism, as a rule nearly invariable, appear suddenly, and without preliminary warnings or preparations. In the second place, such upward-moving variations as have been supposedly established are of the most immaterial description, as is admitted by candid writers, Huxley among them, who may claim intimate acquaintance with the facts. Such conditions seem strange, if not positively destructive to the hypothesis that the geological record is really a record of progress from the relatively lower and simpler forms, to the highest and most complex. In his notable address before The Geological Society in 1871, Professor Huxley makes the following statements:

I stated (speaking on a previous occasion) that geographical provinces, or zones, may have been as distinctly marked in the Paleozoic Epoch as at present; and those seemingly sudden appearances of new genera and species, which we ascribe to new creations, may be simple results of migration.

One of the latest pieces of foreign intelligence which has reached us is the information that the Austrian geologists have, at last, succumbed to the weighty evidence which M. Barrande has accumulated, and have admitted the doctrine of colonies. But the admission of the doctrine of colonies implies the further admission that even identity of organic remains is no proof of the synchronism of the deposits which contain them.

At the epoch of the Trias, therefore, the Marsupialia must have already existed long enough to have become differentiated into carnivorous and herbivorous forms. But the Monotremata are lower forms than the Didelphia, which last are intercalary between the Ornithodelphia and the Monodelphia. To what point of the Paleozoic Epoch, then, must we, upon any rational estimate, relegate the origin of the Monotremata?

The investigation of the occurrence of the classes and of the orders of the Sauropsida in time points in exactly the same direction. If, as there is good reason to believe, true Birds existed in the Triassic Epoch, the ornithoscelidous forms by which Reptiles passed into Birds must have preceded them. In fact there is, even at present, considerable ground for suspecting the existence of Dinosauria in the Permian formations; but, in that case, lizards must be of still earlier date. And if the very small differences which are observable between the Crocodilia of the older Mesozoic formations and those of the present day furnish any sort of approximation toward an estimate of the average rate of change among the Sauropsida, it is almost appalling to reflect how far back in Paleozoic times we must go, before we can hope to arrive at that common stock from which the Crocodilia, Lacertilia, Ornithoscelida, and Plesiosauria, which had attained so great a development in the Triassic Epoch, must have been derived.

"The Amphibia and Pisces tell the same story. There is not a single class of vertebrated animal, which, when it first appears, is represented by analogues of the lowest known members of the same class. Therefore, if there is any truth in the doctrine of evolution, every class must be vastly older than the first record of its appearance upon the surface of the globe. But if considerations of this kind compel us to place the origin of vertebrated animals at a period sufficiently distant from the Upper Silurian, in which the first Elasmobranchs and Ganoids occur, to allow of the evolution of such fishes as these from a Vertebrate as simple as the Amphioxus, I can only repeat that it is appalling to speculate upon the extent to which that origin must have preceded the epoch of the first recorded appearance of vertebrate life.-Paleontology and the Doctrine of Evolution.

There was evidently an element of "firm faith" in the constitution of Professor Huxley, which enabled him to believe in his pet hypothesis, precisely after the manner of a religious fanatic, even after he has catalogued enough difficulties in its way to convince any logical mind that his

conclusions are far from obvious. Thus, the migrations which, as he formerly held "may" have taken place, he supposes at this writing to have been established by "the weighty evidence which M. Barrande has accumulated" to argue to "the doctrine of colonies." But, as must be evident, any such doctrine merely seeks to evade the fact that there is no evidence of preparatory variations before the sudden appearance of a new type, by the unmitigated assumption that such must have taken place elsewhere, and that in the case of every known record, evidently. We may fully admit the truth of the colonies doctrine in any number of cases-since M. Barrande has accumulated so much "weighty evidence"-but when it is invoked, repeatedly and constantly to explain the presence of life-forms, assumed to have been evolutionally developed elsewhere,-and the scenes of this supposed variation process never seem to be fully identified-it is certainly sadly overworked; and all for the mere purpose of avoiding the supposed alternative of immediate "special creation," which is so often ridiculed by "scientists." When invoked, as above, to "explain" the absence of "intermediate forms" in the case of land animals, we cannot contradict it, of course, but, when used to explain the same fact in regard to fishes, etc.,-the evolution of Elasmobranchs and Ganoids "from a vertebrate as simple as the Amphioxus," for example-the absurdity of the process of reasoning need not be pointed out, when we consider the conditions under which organic remains are preserved in sedimentary rocks as previously explained.

Proceeding, however, to discuss the statements made in a former address, Huxley states that:

If we confine ourselves to positively ascertained facts, the total amount of change in the forms of animal and vegetable life, since the existence of such forms is recorded, is small. When compared with the lapse of time since the first appearance of these forms, the amount of change is wonderfully small. Moreover, in each great group of the animal and vegetable kingdoms, there are certain forms which I termed persistent types, which have remained, with but very little apparent change, from their first appearance to the present time.

In answer to the question, 'What, then, does an impartial survey of the positively ascertained truths of paleontology testify in relation to the common doctrines of progressive modification, which suppose that modification to have taken place by a necessary progress from more to less embryonic forms, from more to less generalized types, within the limits of the period represented by the fossiliferous rocks?' I reply, 'It negatives these doctrines; for it either shows us no evidence of such modifications, or demonstrates such modification as has occurred to have been very slight; and as to the nature of that modification, it yields no evidence whatsoever that the earlier members of any long-continued group were more generalized in structure than the later ones.

He then proceeds to qualify his former statements on these points by a line of arguments, whose sufficiency may be judged by any candid reader, as follows:

So far, indeed, as the Invertebrata and the lower Vertebrata are concerned, the facts and the conclusions which are to be drawn from them appear to me to remain what they were. For anything that, as yet, appears to the contrary, the earliest known Marsupials may have been as highly organized as their living congeners; the Permian lizards show no signs of inferiority to those of the present day; the Labyrinthodonts cannot be placed below the living Salamander and Triton; the Devonian Ganoids are closely related to Polypterus and Lepidosiren.

But when we turn to the higher Vertebrata, the results of recent investigations, however we may sift and criticize them, seem to me to leave a clear balance in favor of the doctrine of the evolution of living forms one from another. Nevertheless, in discussing this question, it is very necessary to discriminate carefully between the different kinds of evidence from fossil remains which are brought forward in favor of evolution.

Every fossil which takes an intermediate place between forms of life already known, may be said, so far as it is intermediate, to be evidence in favor of evolution, inasmuch as it shows a possible road by which evolution may have taken place. But the mere discovery of such a form does not, in itself, prove that evolution took place by and through it, nor does it constitute more than presumptive evidence in favor of evolution in general. Suppose A, B, C, to be three forms, while B is intermediate in structure between A and C. Then the doctrine of evolution offers four possible alternatives. A may have become C by way of B; or C may have become A by way of B; or A and C may be independent modifications of B; or A, B, and C may be independent modifications of some unknown D. Take the case of Pigs, the Anoplotheridae and the Ruminants. The Anoplotheridae are intermediate between the first and last; but this does not tell us whether the Ruminants have come from the Pigs, or the Pigs from Ruminants, or both from Anoplotheridae, or whether Pigs, Ruminants, and Anoplotheridae alike may not have diverged from some common stock.

But if it can be shown that A, B, and C exhibit successive stages in the degree of modification, or specialization of the same type; and if, further, it can be proved that they occur in successively newer deposits. A being in the oldest and C in the newest, then the intermediate character of B has quite another importance, and I should accept it, without hesitation, as a link in the genealogy of C. I should consider the burden of proof to be thrown upon any one who denied C to have been derived from A by way of B, or in some closely analogous fashion; for it is always probable that one may not hit upon the exact line of filiation, and, in dealing with fossils, may mistake uncles and nephews for fathers and sons."Ibid.

Of course, the lecture in which these passages occur was delivered over forty years ago, and the science of paleontology has made great progress in the mean time. It is an important document, however, as showing the confidence with which the evolution hypothesis was urged, even with "defective evidence"-quite as confidently as at the present. It is also valuable as a study, since Huxley was undoubtedly an honest man, and, apart from the inevitable mental bias, due to his "convictions," also a good logician. In spite of all the advances made since his day, the general conditions remain about the same as stated above. The greater percentage of supposed "links" and "evidences" are still drawn from the types of the higher vertebrates, and the larger proportion of these, in turn, are precisely what Huxley would have called "intercalary types." They admit of inference and presumption, to be sure, but not of sufficiently complete "demonstration" to warrant the corollaries so plentifully drawn from the variation, supposedly established by them. Another matter which is quite often forgotten in this connection is that, while pigs, ruminants and Anoplotheridae may represent so many "stations" in a line of constant variation in form and function, which may be held to be established (for the sake of argument, if nothing more), the bearing of such examples of modification, like that of the horses from their supposed five-toed ancestors, is not immediate upon the Spencerian hypothesis of organic evolution from the simplest possible form of living organism to the most complex. They example merely that there is such a thing as variation in nature-or, at least, that we may assume that there is-and leaves us at a very long distance away from any idea of the origin of life on earth, or even of the genus, order, family or class in which the examples of variation are assumed to have occurred. In fact, even admitting all the variations that zoologists and paleontologists claim to have demonstrated, the process by which they attempt to place them in line on the "upward road" of organic evolution is logic, and not natural science. We find our evolutionists, accordingly, still arguing, with Huxley, as to what "might" or "may" have happened, but still furnishing very defective "proof" of the main contention of organic evolution of the Spencerian type. They also fail to remember that their "doctrine," in all its essential features, was before most of the facts and alleged facts were known, and that the best of them are still using the arguments originated, apparently, by Robert Chambers (in his Vestiges of the Natural History of Creation) in

1915
Robert C. Webb
Evolution Not Supported By Embryology
Improvement Era Article

[Sixth of a series of articles written for the ERA by Dr. Webb, on allied subjects. Each article is complete in itself, but students should read the whole series.-EDITORS.]

The so-called "argument from embryology" for the hypothesis of organic evolution is nearly the most famous of all the supposed "evidences" in its behalf. In considering the embryo as, in some sense, an epitome or "recapitulation" of its generic history, it is also nearly the oldest formal argument for the hypothesis; representing, in fact, the point at which the word "evolution" was first introduced into the vocabulary of biology. As far back as the time of Harvey-he who "discovered" the circulation of the blood-the study of embryology was well under way toward a scientific formulation; although it suffered the retarding influence of several fantastic theories, before it was finally established. Among these was the theory, fathered probably by Albrecht von Haller (1708-77), that the germ in ovo is a perfect "miniature model" of the adult individual, and that, furthermore, the fertile ovum contains, not only this "animalcule," as they termed it, but also, germ within germ, ad infinitum, the simulacra, potential but complete, each in itself, of the individuals to be begotten by the "outermost," or first of the "models," which is supposed to represent the individual emerging into life at the completion of any given process of gestation. The successive appearances (births) of these "models," generation after generation, was supposed to constitute a vital succession, which was termed "evolution," or the "unfolding" of the destinies which had been "preformed" from the beginning of time. Although, in its formal statement, any such theory as this one would be ridiculed by biologists of the present day, the same idea is involved in the current popular understanding of evolution as the racial working-out of an involved potentiality of development, which is latent in every germ, through the process describable as "cosmic gestation." It certainly accords with Professor Le Conte's definition of evolution as a "continuous progressive change by means of resident forces."

In modern evolution literature the ascribed significance of the developing embryo is the reverse of that mentioned above. Now, it is not so clearly the preformed epitome of all coming generations, but rather the "recapitulation" of the past. Thus, the modern evolutionist sees in its growth a very definitely marked "reenactment" of the main features of the process by which, supposedly, the race represented by the embryo was first originated. This idea is frequently expressed in some such statements as that "the embryonic life of man is almost an epitome of the animal kingdom, beginning with characters common to the moners and worms, and ending with the vertebrates." (Packard.) The beginnings of this theory are presented in Chambers' "Vestiges of Creation," which outlines the development of the human brain, through all the various stages in which it resembles the brains of lower animals, from the "avertebrate" type to the human, during the period of gestation. It has since been much elaborated by such enthusiasts as Haeckel and Le Conte, who do not hesitate to represent it as in the highest sense significant and established. The same analogies are extended to every part of the developing organism. Thus Haeckel is quoted as "identifying" no less than twenty-two separate types of organism exemplified by stages in the growth of the embryo. Prominent among these are "structureless protoplasm, (moner), egg, morula, planula, gastrula (sac stage), ascidian (exhibiting what some regard as the homologue of a spinal marrow), amphioxus, low shark, amphibian, monotreme, marsupial, lemurid, tailed monkey, tailless ape, Papuan (Anthropogenie)." Such statements are made with a confidence and naivete that might lead the general unbiological reader to suppose that the resemblances referred to were somewhat other than of a rather vague and general character, which is not the case.

Professor Le Conte gives the following estimate of the development of the human brain, which is worthy quotation, not only for sake of fairness, but also in way of exhibiting the quality of his logical analysis, and the temper of dogmatic certainty which he assumes. He says:

Now, why should this peculiar order be observed in the building of the individual brain? We find the answer, the only conceivable scientific answer to this question, in the fact that this is the order of the building of the vertebrate brain by evolution throughout geological history. We have already seen that fishes were the only vertebrates living in Devonian times. The first form of brain, therefore, was that characteristic of that class. Then reptiles were introduced; then birds and marsupials; then true mammals; and lastly man. The different styles of brains characteristic of these classes were, therefore, successively made by evolution from earlier and simpler forms. In phylogeny 1 this order was observed because these successive forms were necessary for perfect adaptation to the environment at each step. In taxonomy 2 we find the same order, because, as already explained, every stage in advance in phylogeny is still represented in existing forms. In ontogeny 3 we have still the same order, because ancestral characteristics are inherited, and family history recapitulated in the individual history.-Evolution and Its Relation to Religious Thought.

As a preparation for his invasion of the field of "religious thought," Professor Le Conte evidently assumes the seat of authority of the "new dogmatism," making a series of utterly indefensible statements, to be accepted, apparently, "because he knows the facts"-of biology. We may judge of his qualifications as a philosopher by his method of handling his facts. Thus, as we shall argue, the "order observed in the building of the individual brain" is not explained only by his "only conceivable scientific answer:" there are other answers quite as conceivable and quite as scientific. His assumption that "fishes were the only vertebrates living in Devonian times" is an unmitigated dogma, and one in which he is contradicted by Huxley's theories, as already seen. As for his jumble of learned terms, we might excuse his pedantry, but for the fact that the type of "religion" which he, and his school, would foist upon the world has no other excuse than to afford a pretense of piety to people who lack courage to acknowledge that they are really atheists. But this is the role of our evolution "theologies."

In addition to the indicated similarities to be observed in the process of developing the individual vertebrate and human brain, quite analogous stages are to be observed in the progressive upbuilding of the heart, and have been suggested in connection with several other organs. The most triumphantly used argument, however, is that which urges the fact that the embryo, at a certain stage, shows true gill slits, like a fish or other water-breather-and the statement of this fact is frequently made in italic type-which is urged as a certain evidence of the persistence of "ancestral structures," supplanted by quite different organs in the adult animal. Dr. Romanes sums the general points of the argument, as follows:

Now this progressive inheritance by higher types of embryological characteristics common to lower types is a fact which tells greatly in favor of the theory of descent, whilst it seems almost fatal to the theory of design. For instance, to take a specific case, Mr. Lewes remarks of a species of salamander-which differs from most salamanders in being exclusively terrestrial-that, although its young ones can never require gills, yet, * * * * when placed in the water the young ones swim about like the tadpoles of the water newt. Now, to suppose that these utterly useless gills were specially designed, is to suppose design without any assignable purpose; for even the far-fetched assumption that a unity of ideal is the cause of organic affinities, becomes positively ridiculous when applied to the case of embryonic structures, which are destined to disappear before the animal is born. Who, for instance, would have the courage to affirm that the Deity had any such motive in providing, not only the unborn young of specially created salamanders, but also the unborn young of specially created man, with the essential anatomical feature of gills?

But this remark leads us to consider a little more attentively the anatomical features presented by the human embryo. The gill-slits just mentioned occur on each side of the neck, and to them the arteries run in branching arches as in a fish. This, infact, is the stage through which the branchiae of a fish are developed, and, therefore, in fishes the slits remain open during life, while the so-called 'visceral arches' throw out filaments which receive the arterial branches coming from the aortic arches, and so become the organs of respiration, or branchiae. But in all other vertebrata (i. e., except fishes and amphibia) the gill-slits do not develop branchiae, become closed (with the frequent exception of the first), and so never subserve the function of respiration. Or, as Mr. Darwin states it, 'At this period the arteries run in arch-like branches, as if to carry the blood to the branchiae, which are not present in the higher vertebrata, though the slits on the sides of the neck still remain, marking their former position.

At a later period the human embryo is provided with a very conspicuous tail, which is considerably longer than the rudimentary legs occurring at that period of development, and which Professor Turner has found to be provided with muscles-the extensor, which is so largely developed in many animals, being especially well marked.

Again, as Mr. Darwin says, 'In the embryos of all air-breathing vertebrates, certain glands, called the corpora Wolffiana, correspond with and act like the kidneys of mature fishes;' and during the sixth month the whole body is covered very thickly with wool-like hair-even the forehead and ears being closely coated; but it is, as Mr. Darwin observes, 'a significant fact that the palms of the hands and the soles of the feet are quite naked, like the inferior surfaces of all four extremities in most of the lower animals,' including monkeys."-Scientific Evidence of Organic Evolution.

The average evolutionist discussion of embryology might readily lead the casual and superficial reader to suppose that the development of the embryo of any species of animal is one long series of protean changes, or kaleidoscopic rearrangements of elements, in which it masquerades, first in one semblance, then in another, before settling down to the sober business of life. Such a person might even conceive the notion that a developing embryo, taken at any "typical period," and placed in a favorable environment, might be expected to begin its independent existence, there and then, as an "ascidian, amphioxus, low shark, amphibian," or even a "tailed monkey," and grow old and die in that form, without further development, precisely like the gill-breathing young of the land-dwelling "salamanders" mentioned by Romanes. That such is not the case, however, scarcely needs be said. The embryo of any higher animal is essentially and unalterably an embryo merely, an incomplete being in process of forming, and, if removed prematurely from its natural environment, before a definite very advanced period, will infallibly perish. Furthermore, the specified structural and functional analogies to certain lower animals, shown, as stated, by vertebrate embryos, are of the most superficial and empirical character, mere casual resemblances, in fact, which would lead no one to suspect a "recapitulatory" significance, apart from the desire to discover fresh "evidence" for a preassumed theory.

Because the effort of theorists is to accumulate as large a number as possible of facts in supposed support of their hypothesis, we find such writers as Haeckel mentioning among recapitulated "ancestral types," the "morula, planula, astrula," mere stages of inevitable cell-division all, to be observed in the process of developing any many-celled individual from the one-cell ovum. Why this process includes the several stages found, we cannot, of course, undertake to determine. That such stages surely indicate "ancestral types," rather than the simple rule of all cell-work whatever, ancestral or not, is a statement utterly gratuitous and unsupported; and that in spite of the fact that some of the lowest orders of life do actually show the "gastrula," and other forms of many-cell structure as permanent life-forms. Such "animals" as the one-celled amoeba, for example, reproduce by "division;" a process in which the original cell and its nucleus both give out a portion

of the substance forming the original individual, thus forming a new one, which performs the same function over and over again, thus continuing the "species." The difference between this order of being and those consisting of many cells is that, in the latter case, the numerous consecutive cell-divisions-one into two, two into four, four into eight, etc.,-are made for the definite purpose of beginning the building-up of tissues and organs, in the structure of which all the individual cells co-operate to form an active unit, and, under normal conditions, attempt no semblance of separate existence, either singly or in groups.

One fact which writers like Haeckel neglect to mention in the "recapitulation" connection is the actual "difference in kind" between the behavior of amoeba and the development of Coelenterata of the gastrula type, in the formation of which a hollow sphere, composed of numerous distinct, but closely-associated cells, becomes turned in upon itself, as it were, so as to form a double-walled sac. Nor, even admitting that the gastrula type of creature may have resulted from an "acquired habit" in numerous separate one-cell individuals of associating to form sphere or gastrula "colonies," which later became true many-celled individuals, is there any certain explanation of further assumed development into the "higher" and more complex forms of creature; certainly and assuredly of nothing in any way resembling the processes occurring in the course of developing a vertebrate, or other higher animal by ordinary ovulation or gestation.

The life-story of the developing embryo indicates surely that the one object involved in the several stages of cell-division, by which the one original cell subdivides to form an association of numerous smaller cells, is to afford the vehicle for the embryo itself, which, as we may state here, does not result from further transformations of the total mass of cells-by which, for example, the gastrula passes into a "bi-gastrula," and that into something still more differentiated, by any number of stages that might be imagined-but is formed from a select few of them, in a definite locality, and is protected and nourished by the remainder. Nor is there any very evident analogy between this process and the "delegation" of functions to separate sets of cells or organisms, as seen in the colony-forming zoophytes.

In order to support our contention that the early stages, at least, of cell-division and combination in the process of developing and nourishing the embryo, argue to no "ancestral references" whatever, we may outline these stages. After the formation of the cell-cluster known as "morula"-this is the Latin word for mulberry, and is used because of the resemblance-we find that in the central cavity, formed by the numerous associated cells, a special form of cell-combination begins, in a definite area known as the "embryonal disc," and quickly spreads, giving rise to the three-layered "blastoderm" (i. e., "germ-skin"). The next stage is the appearance, on the "embryonal disc" of a definite thickening, upon which appears the so-called "primitive groove," the first rudiments of the "longitudinal axis" of the vertebrate animal. At a similar stage in the development of arthropods, for example, we find, instead of such a groove, a series of segments, characteristic of the transverse divisions of the mature body structure, which is suggestive of the fact that the difference between vertebrate and invertebrate life-forms is to be discerned upon the first definite appearance of the germ. This vertebrate "primitive groove" becomes closed at both ends, by the meeting and fusing of its ends, thus forming an outline resembling a flattened ring, or a very much elongated letter "o." Its edges then close longitudinally, transforming it into a tube. At one end of this closed "groove" is begun the development of the head, and at the other, of the lower extremities of the trunk. The embryo, thus laid down in the bare outline of the creature to develop from it, is now enclosed in the folds of the decidua, formed from the inner layer of the blastoderm, known as the "hypoblast," which thus produces its enveloping sac, known thereafter as the "amnion."

Thus, as is evident, the embryo arises, not from a recombination of all the cells of the "morula," or of the derived "blastoderm," but from a selected few of them, gathered at a definite region on its

wall. In other words, the process of germ-development seems to begin as a substitution, rather than a metamorphosis, in course of which the part absorbs the whole, and a new type of life-form builds itself up from the material of the old. It may be admissible to compare the process to the growth of a parasitic organism, which begins by involving certain few cells in a definite locality, and aims to absorb into itself the entire cell-structure, for its own use and nourishment. In view of such facts, we may understand that Haeckel's first five "recapitulatory stages" are very imperfectly obvious.

(This subject in the series of articles will be concluded in the February number.)

1915
Robert C. Webb
Thoughts on the Origin of Life
Improvement Era Article

[The seventh of a series of articles written for the ERA by the author, on allied subjects. Each article is complete in itself, but students should read the whole series.-EDITORS.]

In the preceding articles on the subject of the evolution hypothesis we have attempted to discuss the involved issues and arguments with regard to the main contention that all life-forms have been developed through the operation of natural generation from the simplest one-celled creatures. precisely as any animal of the present day emerges from the one-celled egg. In spite of the fact that paleontologists have presented numerous presumptive evidences for a considerable range of variation, particularly among the higher vertebrates, we have contended that such constitute extremely meagre supports to the main contention; also that, logically speaking, the careful thinker must bear consistently in mind that variation and organic evolution are positively not co-extensive terms. Their evident interchangeable use by even competent scientists is wholly unwarranted. But it would be unnecessary to call attention to this inconsistency were it not for the fact that the (to-date) largely inconclusive hypothesis of evolutionary development is a highly-esteemed "working principle" with all sorts of destructive critics of vital religion and common sense.

Very many scientists, in attempting to deal with the essential and ultimate facts of creation, have espoused the theory that life is essentially a mode of the universal energy. Although, of course, such a statement can give the mind no clue to the explanation of "consciousness" and other facts manifested in life-forms-since it is not perfectly intelligible that the "brain secretes thought, just as the liver secretes bile," as some have held, nor yet that all material particles are accompanied with atoms of "mind stuff," as Clifford and others have stated-yet, in view of the fact that all manifestations of life in a living organism are characterized by the presence and activity of certain forces, chemical, electrical, etc., we may assume it to represent an essential part of the truth. In any event, it is a theory so widely supported by scientific writers-some of them suggest a chemical or electrical "origin" of life-that we are in very slight danger of criticism in assuming it in some sense accurate.

In using the term "energy," we are to be understood as referring to the basis of all the forces found at work in the material world, which, under favoring conditions, is "transmutable" into heat, light, electrical activity, etc., according to the theory accepted by physicists. The meaning of this term "transmutability" may be understood in the current explanation of the transmission of energy from the sun to the earth. Considering the sun to be what it seems, a vast centre of most intense activity, we are accustomed to the statement that it lights and warms our earth by rays transmitted to us through interstellar space. In spite of the fact, as believed, that the interstellar space is utterly dark, also so utterly devoid of temperature as to be below the "absolute zero" of physicists-

the theoretical point at which gases cease to contract (493 Fahrenheit below the freezing point)-we know that solar energy, entering our atmosphere and striking the surface of the earth, becomes transformed into the modes of force known as heat and light, also, probably, into electrical activities of several orders. We can not, however, as a certain writer has expressed it, "hear the awful roar of the sun," and this fact is to be explained quite consistently on the basis of physical theory. All forms of energy are, as believed, manifested in undulatory or vibrating activities in physical substance; differing most evidently among themselves according to their characteristic wave-lengths and frequencies. This fact has led some physicists to assume that all may be arranged in series of "octaves," after the analogy of the musical scale. Arranging forces according to wave-lengths, we have a very wide range of comparison as between the so-called "Hertzian waves"-which form the basis of wireless telegraphy-having waves of from one to several feet in length, and the so-called Roentgen, or X-rays, whose characteristic wave-length is calculated at about 1-250,000,000 inch. Audible sounds range from the "lowest," consisting of about 16 vibrations per second, to the "highest," consisting of 38,000 per second. Sound waves may be measured in terms of inches or of intelligible fractions of an inch, but, when we come to light we find a series of wavelengths, varying from 38,000 to the inch up to 62,000 to the inch. Thus, as we need not be surprised to hear, certain forces, such as sound, manifest through undulatory activities in the atmospheric air, while others, such as light, undulate in the interstitial ether. Accordingly, we need air for the transmission of sound. In the same manner, we need other favoring conditions for the manifestation of other modes of energy.

Regarding the ultimate facts involved in any order of physical energies, we know, of course, nothing at all. Some writers have suggested that the ultimate energy is simply a manifestation of divine power and presence in all creation, which is probably as near to a precise statement as the human mind is capable of formulating. Other writers have suggested that such a description of the one, ultimate energy of the universe involves also that life, viewed as vital or "spiritual" energy, is, in itself, the ultimate mode of expression. However this may be, it remains true that life, as we know it in the physical organisms of this world is found manifested only in certain physical and chemical conditions-as, for example, typically, within the 180 degrees, Fahrenheit, between the freezing and boiling points of water, extremes beyond which life usually ceases. As to whether life can exist under other conditions than the several physical and chemical limits, within which protoplasm-"the physical basis of life"-can be vitalized, science, of course, knows nothing. Nor are we concerned to discuss the matter here.

Although we may hold that life, so far at least as it has a distinct physical manifestation, is a mode of energy, it would seem that we are justified in holding that it differs from other modes and manifestations in the fact that its characteristic is concentrated or localized activity, rather than generalized or diffused, as with other forces in nature. Thus, even though all forces must have a source of some kind-such as the sun, for the light, heat, etc., in the world-we find that their characteristic is to radiate into all directions, or to set up their vibrations in the air, ether, and other media. With life, however, there is no such thing as diffusion. It is to be found, not pervading the atmosphere, but expressed in "living things," all of which, from the lowest simple cell to the highest and most elaborate creature, differ from unvitalized substance in the common possession of individuality. Nor can the term "individuality" be applied to unvitalized objects in the same sense as belongs to living things. Even with the crystals of various substances, whose production has often been compared to the essential process by which life-forms come into being, we have "individualization" only as the consequence of activity in the substance, tending to produce separate, definitely-shaped pieces, under such conditions as cooling, the evaporation of a solvent medium (such as water), or the exercise of some certain stress. The size or perfection of crystals seems to be a consequence of the intensity of the change in condition which occasions their production, but the shape, or conformation, according to which one of the six "systems" of crystallization is followed, results from the properties of the substance itself, and is characteristic of it. This latter fact is well exemplified by the study of crystals in polarized light, through which-as

for example, in the examination of sugars-profound facts concerning molecular arrangements, etc., have been revealed. Other physical conditions, also, contribute to variation in configuration. Thus moisture collected on a window pane or a stone pavement crystallizes along lines resembling vegetation, but, when in the form of finely-divided atmospheric mist, the six-pointed snowflake is the result.

In comparing crystals and life-forms-as several others have done before us-it may be in place to call attention to the essential difference between the two. In the case of the crystal we have rather a resultant arrangement of the molecules of matter, which seems to indicate that the forces giving it form have ceased to act (although, if we understand them, some authorities seem to hold to a quite contrary conclusion), whereas, in the case of living things, on the other hand, the characteristic material form, in any given case, arises at the start from the activities of certain forces existing, presumably, in the germ, or, at least, directed and determined by its qualities; comes to perfection, persists so long as the vital forces continue to act, and, on their cessation, enters immediately on inevitable dissolution. Both crystals and organisms, therefore, are, in a very real sense, examples of the results of certain energies acting upon matter, since both, in the processes of formation, at least, are shown to be certain centres of activity. Here, however, the analogy seems to cease.

In view of the above facts, and of others, also, we may be justified in asserting that the essential fact regarding the organism is the specific directive or determinative principle in the germ-that which involves that the forces at work in the development of the mature form shall follow a certain specific line of development, and no other-which is, in a very intelligible sense, a focus or vortex of activity, differing from all other such foci or vortices, either in its own or other species, in a manner analogous to the difference between sound-tones or color-tints. The differences in the latter connections, as already suggested, are to be stated in the terms of the wave-lengths and frequencies of the activities set up by the action of the several modes of energy. Whatever may be the correct terms of expression in the case of vital force, the fact remains that there are to be found in nature or art several closely suggestive illustrations.

Sound and light, in certain definite connections, at least, furnish suggestive working analogies to the presumed activities which produce the original germ-elements out of which "develop" organisms as we know them. Thus, a fact presented to the attention of the sentient organism in the terms of either hearing or vision produces a distinct impression upon the brain-such impression, as has been suggested by some theorists, consists in some definite modification in the structure of some certain cell in the cerebrum-by virtue of which a more or less definite "idea" becomes an element of memory, associative thinking, concept-forming and the ability to discriminate, express or recognize (on repetition) the original matter of sensation. Although no subtlety of human science has yet enabled anyone to "read" a brain, and decipher the individual impressions formed in its mass by the presumed modification of cell-structures, it may be possible to hold that such individual impressions or "modifications"-by virtue of which, for memory, for associative thinking or reasoning, under proper conditions of co-ordination, also, for the expressive faculty (as in art, etc.), the imaginative function of the brain can produce a definite "concept" corresponding more or less accurately to the original "percept"-are in a very real and intelligible sense analogous to the cell-modifications or specific potentialities, by virtue of which the egg produced by a parent of a given species infallibly develops into another individual of the same species. Furthermore, in both cases, the production of the "actual" (the mature form) from the "potential" or germinal is a process taking place in precisely the same substance, to wit, protoplasm, "the physical basis of life." Nor is it evident that these "morphological phenomena" of either generation or ideation result from inherent properties of protoplasm, as the characteristic crystals of specific substances-salt, quartz, adrenalin, etc.-result from the inherent properties of such substances, expressed under certain favoring conditions. Vital phenomena seem to result from certain impulses originated

independently, but "focalized" upon a "plastic" substance, capable, for some obscure reason, of manifesting certain functions which belong to the energy acting upon it, rather than to the substance itself.

Assuming that "cerebral phenomena" are good working analogies for the "morphological phenomena" in protoplasm-ideas resulting in the one case and organisms in the other-we find that the impulses in the former connection produce cell-modifications through the action of perfectly mechanical instruments, the organs of the several senses. The organs are constructed to receive impressions from the outer world of fact, and to translate them into terms capable of producing brain-records. Although the modus operandi in this connection is exceedingly obscure, the science of mechanics furnishes some suggestive analogies, which enable us to understand in a way how the potential becomes the actual, both in ideation and generation, or how the "germ" in both instances becomes the "organism."

In the case of sound, for example, we have a wonderfully suggestive analogy for either of the above-mentioned processes in the mechanical phonograph and its record. In this instrument a minute stylus point, secured to a sensitive diaphragm, is caused to travel over the surface of some impressionable substance, like wax or metal foil, and to produce a groove varied by a series of punctures of different areas and depths, as the diaphragm vibrates under the pressure of the successive sound-pulsations that strike it. We have at the completion of the process a "record" which a practiced eye, helped by a microscope, can discriminate from others, but which cannot be "interpreted" until another stylus is drawn along the groove in precisely similar manner. When this "reproducer" stylus follows the path, falling successively into each pit and puncture in turn, and causing its attached diaphragm to reproduce the movements of the "recorder" diaphragm, the result is an entirely recognizable reproduction of the original sounds that caused the formation of the "record" in the beginning.

This partial and mechanical analogy may be made even more suggestive in this connection when we consider the possibilities of the machine under discussion, and of the "record" produced by its operation. If, for example, some certain musical air is performed on a given instrument before the recorder diaphragm, we have upon the surface of the cylinder or disc a record of a succession of fundamental tones, combined with a series of overtones characteristic of the timbre of that particular instrument, and both of these may be perfectly reproduced from the record, as already explained. If, now, we make a second record of the same air, played, however, by two instruments, we will have a record combining the timbres of both with the same fundamentals, and resulting in a very different musical effect. If, again, a third record is formed for the same air, not only with the two instruments, but also with the human voice in singing, we have four diverse elements in the record, the two differing timbres of the two instruments, the timbre of the human voice, and, superposed upon its vibrations, the shaping of the sounds into the forms of articulate speech. We may see, therefore, that corresponding portions of the records in the first case and in the third, however faithfully they may reproduce precisely the same fundamental tones, differ in other essential and original particulars, which constitute in them radically diverse sound-potentialities. Nor could we conceive of any proposition that the more complex record could be, in any sense, "developed" or elaborated upon the first; since the differences consist in the essential qualities of the original impulses originating the records-the third containing elements which do not appear at all in the first.

The lesson involved in the artificial sound-record may be, perhaps, even more suggestively learned in the Poullsen magnetic phonograph, or "phonautograph". In this instrument a flexible steel ribbon is drawn lengthwise between the poles of two very small electro-magnets, the windings of which are in circuit with the secondary of a telephone induction coil. Words, or other sounds, affecting the telephone transmitter, constantly vary the resistance of the primary coil, or battery circuit,

consequently also the durations and intensities of the currents carried on it; induce corresponding currents in the secondary, and thus constantly vary the magnetization of the cores of the small electro-magnets, whose poles are in proximity to the steel tape. The result of this operation is that the moving steel tape is locally magnetized at numerous successive points in its length, and with constantly varying degrees and qualities of magnetization. When, however, a telephone receiver is connected in circuit with the windings of the small electro-magnets, and the now locally magnetized steel tape is again drawn along between the poles as before, the iron of the magnet cores is excited magnetically by each successive spot or centre of magnetization, currents are induced in the windings, and the original sounds-words or musical tones-originally spoken, sung or played into the transmitter, are reproduced in the receiver. In this instrument, instead of the minute series of mechanical punctures, we have tiny vortices of magnetic circulation; each of which differs from all the other magnetic spots in the fact that it contains the potentiality of reproducing, only and precisely, the sounds that originally gave it existence.

These mechanical and magnetic effects demonstrate the fact that, in the case of one form of undulating energy-sound-such "foci" as the punctures on the phonograph record, or spots of localized magnetism on the steel tape of the phonautograph, are, precisely, potentialities for the production of ultimate consequences utterly different from anything suggested by their construction or physical appearance. Why it is that a phonographic record, resulting from a musical air played on a violin, for example, should be capable of reproducing, not only the air, considered as a succession of fundamental tones, but also the harmonics characteristic of the violin, while the same air played on a horn or flute, consisting of the same fundamentals, differs in possessing harmonics characteristic of the horn or flute, is a question that could be answered only after the most exhaustive investigation. It is even imaginable, however, that, on the basis of such an exhaustive investigation, human ingenuity could compass the feat of producing "phonographic records" mechanically, even taking advantage of knowledge based on thorough familiarity with the essential facts, by introducing weird and unfamiliar timbres-thus "tapping out a tune" that no earthly instrument ever played. As strange and remarkable things have been accomplished.

All this is imaginable because of the fact that each separate component of any such records as we have been discussing represents a group of elements, which, in its entirety, differs from any other having the same fundamentals, in respect of such proportions as may be expressed by one combination of numbers, rather than another. In the magnetic phonograph, for example, it is evident that the several sounds, recorded and reproduced, differ originally merely as the resistance of an electric circuit is modified with a constantly varying frequency. But in these elements we have the potentiality of building tones, timbres and words. This fact is to be seen even more strikingly in Professor Bell's "radiophone" apparatus, in which a ray of light, focused through a lens upon the silvered surface of a metal diaphragm-which, vibrating under the pressure of sound undulations, constantly varies its reflecting surface (according to the amount of distortion imposed upon it), consequently, also, the amount of light actually reflected through given periods-is directed upon a cell of selenium, included in circuit with a battery and a magnet telephone receiver. As is well known, the resistance of the metalloid selenium to the passage of the electric current varies directly as the amount of light that strikes upon its surface-its resistance in total darkness is twice as high as in full sunlight. Yet, in the "radiophone" apparatus, its action in constantly modifying the current passing on the telephonic circuit (according to the amount of illumination) enables the magnet receiver to reproduce all the complex sounds that originally agitated the silvered diaphragm, as already explained. Here the result is a concern, merely, of ohms and milliamperes, of circuit resistance and current intensity, combined with nothing else, except a varying time-element.

All such conditions help to illustrate how we may form a conception of the fact that an organic cell or germ, informed by vital energy, represents a potentiality of producing effects utterly

unrecognizable in, and not to be suspected from its present appearance or structure. The organism developed from it, after the cycle of its metamorphosis has been completed, is the product of "evolution" in the sense proper to the original use of that term in biological science, as already explained. That is to say, it is the out-working, the unfoldment, of an involved plan or destiny, which was "stored" in it precisely as sound was "stored" in the mechanical or magnetic record already described. As the current phrase has it, it "was there" from the beginning of the cell's life, waiting, like the "stored-up echo" in the phonographic record, for the conditions favorable to its complete emergence from the "potential" or possible, into the actual world, as we know it.

The involved potentiality of each germ-cell to subdivide and recombine into new forms, until the perfect destined individual is produced, may be compared to some order of "valency"-to use a term familiar in chemical and other sciences-which is conceivable as a factor expressible in terms of the relative proportions of component elements. Thus the typical cell of one species differs from the typical cell of another, conceivably, just as corresponding elements of two sound-records, possessing identical fundamentals but differing harmonics. Indeed, the thought is as beautiful as it seems to be accurate, that the fundamental distinctions between natural forces and elements are found to be expressible in the terms of number and proportion. The same idea was developed in the Buddhistic teaching on Karma, which, as the leading principle in the doctrine of "metempsychosis" (Samsara), represents each individual as dissolving at death into a sort of "echo," so that-adopting a musical metaphor-as the consequence of its release, it may form the impulse for the production of a new individual in a favoring environment, very much as the vibrations issuing from a bell of given tone may evoke a "response" from another bell of the same tone, even across a wide distance. The tone and pitch of the bell, its numerically-expressible equivalent or significance-also the resultant of its size, shape and bulk of metal-may be said to be its Karma (Sanskrit, "act" or "doing"), stated in the terms of the frequency and amplitude of its sound vibrations per second. Although the doctrine of Karma was primarily a moralistic solution, it has always been treated as if it had a definite ontological significance. It is thus explained by Professor Rhys Davids, a noted authority:

Buddhism claims to have looked through the word soul for the fact it purports to cover; and to have found no fact at all, but only one or other of twenty different delusions which blind the eyes of men. Nevertheless, Buddhism is convinced that if a man reaps sorrow, disappointment, pain, he himself, and no other, must at some time have sown folly, error, sin; and if not in this life, then in some former birth. Where then, in the latter case, is the identity between him who sows and him who reaps? In that which alone remains when a man dies, and the constituent parts of the sentient being are dissolved; in the result, namely, of his action, speech, and thought, in his good or evil karma (literally his 'doing'), which does not die. * * * But the peculiarity of Buddhism lies in this, that the result of what a man is or does is held, not to be dissipated, as it were, but to be concentrated together in the formation of one new sentient being,-new, that is, in its constituent parts and powers, but the same in its essence, its being, its doing, its karma."-Buddhism, pp. 103-104.

Of course, in the system to which it belongs, the doctrine of Karma represents one possible intellectual device to escape the unintelligible hypothesis of "immaterial spirit", even while acknowledging the reality of "things unseen and eternal". Instead of an "immaterial" essence, which the mind can scarcely avoid identifying with nothingness, it supposes that the resultant of life is, as it were, a "chord" of vital energies-as may be understood partially from our former musical analogies-which can, in effect, exert a "formative pressure", as the modern physicist might term it, upon a suitable receptive substance. From another point of view, also, is the doctrine significant in the present discussion-this is in the fact that, as taught, the Karma of an individual man, or of the world or universe itself, is the fundamental element that discriminates him, or it, from the universal. Indeed, this tendency to "act", or to "do" certain definite and involved things, is the only

reason why the fundamental Akasa ["ether?"] is to be perceived in the appearance of "stars, earths, worlds, and changes changing them", or why the "delusion of individual existence" remains the obstacle to attaining Nirvana [the universalized life?]. Quite apart from all the philosophical consequences which the doctrine was believed by its original formulator to involve, it argues to, and well illustrates the theory that, in modern terms, the primal germ-element of each individual being is to be considered as a "focus" or "vortex" of energy, of some such character as is suggested by the previously-used analogies. A somewhat similar use of this doctrine of Karma has been made by Professor Huxley, who says:

What actually happens, in all but the lowest organisms, is that one part of the growing germ (A) gives rise to tissues and organs; while another part (B) remains in its primitive condition, or is but slightly modified. The moiety A becomes the body of the adult and, sooner or later, perishes, while portions of the moiety are detached and, as offspring, continue the life of the species. Thus, if we trace back an organism along the direct line of descent from its remotest ancestor, B, as a whole, has never suffered death; portions of it, only, have been cast off and died in each individual offspring * * * If we could restore the continuity which was once possessed by the portions of B, contained in all the individuals of a direct line of descent, they would form a sucker, or stolon [using the simile of the strawberry plant], on which these individuals would be strung, and which would never have wholly died."-Evolution and Ethics, Note 1.

The tendency of a germ to develop according to a certain specific type, e. g. of the kidney bean seed to grow into a plant having all the characters of Phaseolus vulgaris is its 'Karma'. It is the last 'inheritor and the last result' of all the conditions that have affected a line of ancestry which goes back for many millions of years to the time when life first appeared on the earth. The moiety of the substance of the bean plant is the last link in a once continuous chain extending from the primitive living substance: and the characters of the successive species to which it has given rise are the manifestations of its gradually modified Karma.-Ibid., Note 6.

In these passages Huxley follows the Buddhistic understanding of Karma with perfect consistency: the essential element of the doctrine of metempsychosis is invoked to explain an essential situation in the doctrine of derivative descent. Thus he speaks of a "gradually-modified Karma." [In Buddhistic acceptation, Karma is to be "modified" only as the "moral significance" of the being approaches to or moves away from the ideal "universal life," in which the "delusion of personality" is "blown out"-"Nirvana-ed."] It is doubtful, however, if his inferences in this particular are perfectly logical. Considered as an expression for "potential being", or organism, Karma, as we have seen, is an enlightening term. Taken, however, as Huxley takes it-and as evolutionists in general take the matter of potentiality in the vital germ, as an element susceptible of indefinite variation in its essential constitution-we find that the Buddhistic device for escaping the "absurdities of immaterialism" by assuming a mere effect or potency for "merit or demerit", in a moral sense, for "things done and undone" [so that each succesive "new individual" is morally scaled to begin doing and neglecting precisely where his predecessor left off] is a very unsatisfactory metaphor for biological situations.

From all that we know or may surmise regarding the germinal elements of living things, not only as seen in the partial mechanical analogies, with which we have attempted to illustrate them, but also in all the facts brought to our notice in common observation and experience, it may be held to be fairly evident that the tendency to develop along certain definite lines into organic maturity represents an original impulse from without, and in no sense a product of matter, or of any of the forces of which we have knowledge in material nature. The fact of variation in nature seems to be established, as is also the artificial method of "crossing," by which a quality present in one type of organism may be "engrafted" upon another, making a new "breed," but neither of these has any logical relation to the theory that new elements, not previously known in nature, are to be

considered producible by any influences analogous to "artificial selection." In other words, returning again to the metaphor of sound phenomena, we may hold that, on the basis of our knowledge of vital germs, variation in the natural world is either (1) suppression, by which full development is prevented, as we will presently explain, or (2) opportunity, in which obstacles to full development are removed. Neither of these conditions affects-much less alters-the essential germ potentiality, any more than one of the numerous "stops" of a reed or pipe organ, while modifying the timbre of the tone, can change its "fundamental" character.

Whether our persistently-used musical metaphor be fully illustrative, or not, we may insist, logically enough, that it is valid to the extent, at least, that the original vital germ element is, as we know it, positively not neutral or passive-so as to be modified by "external influences" or environments of any kind-but entirely active, and possessed of a definite significance of its own. The "Karma" of the red ant, or of the Greenland whale, for example, as produced in the respective parental eggs, brings forth its kind unerringly, although a mere "valency", or, as previously explained, a "numerically-conceivable potentiality", in a speck of matter, indistinguishable-except for size, shape, etc.,-from most other specks of similar import. Just as already explained, the minute scratch or puncture of the phonographic record contains, in posse, some definite sound, different from all others in point of timbre, volume and pitch, so each minute germinal protoplast contains in nature's equivalent terms the certainty of the several qualities proper to the species to which the germ belongs. The germ of the bird contains the certain potential equivalent of beak, wings and feathers; that of the fish, the invisible determining cause of fins, scales and gills; that of man, the rudiments of the "idea" of spiritual possibilities, together with the tendency to build up a brain that should think. The involved potentialities of the germinal principle seem nearly endless, as we may guess from the multiplicity of "special instincts" manifested among living things, and which we are asked to believe represent only so many "acquired habits". By what order of phonograph-like "record", for example, is there impressed upon the tiny brain of the garden wasp the certain knowledge of the area on the body of a larva of alien species, in which a sting puncture will produce paralysis, instead of death, thus preserving the ill-fated victim as food for her unlaid young? [Such instinct must be inherited and "innate"-a cell is "born" with an "idea" involved in its structure, instead of derived from sense experience-since she never saw her own parents, who might have taught her the "trick."] There are hundreds of such "records" that might be mentioned, and all exist wrapped among the "possibilities" of the parental germs. So precise is the knowledge involved, often-times-as in the nest-building instinct, which, as it were, depends on a whole "cell-literature" of architecture-that certain older philosophers offered as solution of the situation the statement, "God is the mind of the brutes" (Deus est anima brutorum).

If, however, it can be demonstrated from the rock records, or by experiment, that all life-forms, as we know them, certainly came forth in the course of countless ages of gradual change from a common "indefinite homogeneous" original, each new form, Proteus-like, following every predecessor, we may reasonably assume on the ground of all the knowledge that we possess of germ-potentialities and developments, that all must have existed potentially, or in imminent possibility, from the beginning, awaiting only the favoring opportunity to burst into actual existence-just as solar energy hurries toward the earth's atmosphere, in order that it may become transformed into the modes of light and heat. Even assuming that environment, in the form of "natural selection", or whatever we may elect to call it, is a provocative, rather than a permissive, cause of variation, we merely ascribe to its influence a depth and subtlety of influence that is, simply speaking, undiscoverable to science. In either case we state merely all that could be meant by the term "special creation", when examined in the light of scientifically-established fact. [For "special creation" need not imply what Herbert Spencer characterized as "the carpenter theory of creation", representing God as forming the world as a man makes a box.] We have on the one hand the belief in the fundamental and unalterable germ-potentiality, which is the organism in possibility; on the other, merely a guess at the creative influence that could modify it-changing its

"fundamental", as well as its "harmonics". Positively no valid objection can be urged to the statement that the "organic equivalents" mentioned above could have existed in original primeval germs, and sprung into developed existence under favoring circumstances-whatever such may have been-any more than that ages of slow upbuilding were necessary to make a germ-equivalent the correspondent of the developed fact, be that bone, muscle, or other structure. Our former analogies tell us this.

But, as already suggested, environment plays a great part in life-history, and there is variation of life-forms in numerous instances. Environment may suppress possibilities, just as the conditions of "domestication" modify animals, so as to cause them to lose, wholly or partially, many of their proper characteristics. From the standpoint of the animals, domestication always involves a distortion of nature. [A suppressive environment might be to a living organism precisely what a small room would be to a large volume of musical sound: in the latter case harmony is distorted into painful cacophony.] Such conditions may be assumed to exist in nature, as seen when birds or insects, from habit, forced or original, disuse and finally, as it might seem, lose the power of flight-even, in some cases, the organs of flight, also. In the same manner, as we might imagine, if seeking for an "explanation", that the trilobites of the Paleozoic Time, which, as some zoologists have indicated, "resemble the embryonic forms of some higher crustacea", were "let and hindred" from their proper development by the conditions of life-such as they may have been-which obtained in their day. Their sudden disappearance from the rock records in the early Mesozoic measures might be held to indicate some such alteration in these conditions, as would permit development into the "maturity" which nature had intended from the beginning. A partial analogy may exist in the so-called Axolotl, a problematic tadpole-like creature, which some authorities have asserted is merely the undeveloped "larva" of some true newt, and which others claim has actually been known to assume a land-dwelling "maturity", under favoring conditions. It might seem, according to some showings, to represent, under natural conditions, the same sort of permanent "tadpolism"-if we may coin a term-as has been artifically produced by certain experimenters with the young of ordinary toads and frogs. [These "permanent tadpoles" not only do not "mature", but, as we are told, actually breed in the larval state.] Similar distortive, or suppressive, influences, whatever they may have been, might also be assumed to explain the appearance and persistence-for a time-of some of the huge and unwieldy reptiles of ancient days. Why should an "orderly progress upward" produce such "anatomical absurdities" as have existed at various periods of the world's history? The suppressive and distortive influence of environment might also be invoked to explain the presence of "rudimentary organs" in men and other animals.

Given the conditions favorable to the appearance of life, and we have the earliest germs-all scientists and theorists admit this. Given the possibility of the simplest germs, and we have no warrant, apart from our tendency to theorize and dogmatize, for denying the possibility of the most complex germ-potentiality-nor yet, its development. Such favoring conditions may not have been those that now exist on earth-we may reasonably assume that they were not-but we know of nothing to prevent the belief that all were "originally created", any more than we know of conditions hostile to the production of any of the colors of the spectrum, or of any of the tones of the musical gamut, even before there was as yet an instrument devised to produce them. It is useless to theorize, however, after we have reached the confines of facts as we know them. One significant lesson, however, lies in the story of the vital germ, considered as a focus of vital energy, which, as it may be, is also a focus of creative activity. The following is a very suggestive treatment of this very situation:

An Englishman questions a Hindu sage on the mysteries of life.

Pundit (Reading)-"The spirit of a man, whereby he strives.
Flashes from star to star-if so it will-

And-if it will-sleeps in the smallest drop
Of midmost heart-blood". Yama sayeth so.
Sahib- Yet, Pundit, this is hard to comprehend!
How can it be that what hath plenitude
To range from star to star should hide itself
I' the hollow of a heart?
P. I answer thee
Out of the great Upanishad, surnamed
Khandogya! Gather up you fruit
Dropped by the parrots from the Banyan tree!
What seest thou therein?
S. A scarlet fig
Not larger than a Moulvie's praying bead!
P. Break it, and say again!
S. I break it, Sir,
And see a hundred little yellow seeds!
P. Break it, and say again!
S. I break a seed;
It is as slight as though a silkworm's egg
Were crushed; and in the midst a germ, a speck!
P. Break it, and say again!
S. The speck is gone
In touching, Guru! There is nothing now!
P. Yet, in that "nothing" lay (thou knowest well!)
The Nyagrodha tree, the Banyan tree,
Comely and vast as it was formed to grow;
With all its thousand downward-dropping stems
Waiting to fall from all its thousand boughs,
And all its lakhs and lakhs of lustrous leaves
Waiting to push to sunlight, and so make
New canopies of flower and fruit and shade,
Where creatures of the field, fowls of the air,
Monkey and squirrel folk might find their home,
And man and cattle 'neath its ample roof
Have shelter from the noon. This Forest King-
Of bulk to overspread a Raja's camp-
Was wrapped in what thou sayest passeth sight.
-Edwin Arnold, The Secret of Death.

1916

Alfred Russel Wallace (Co-Disoverer with Charles Darwin of Evolution)

The World of Life: a Manifestation of Creative Power, Directive Mind and Ultimate Purpose

Book, Moffat, Yard & Company, 1916

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Preface

In the present volume I have attempted to summarise and complete my half-century of thought and work on the Darwinian theory of evolution. In several directions, I have extended the scope and application of the theory, and have shown that it is capable of explaining many of the phenomena of living things hitherto thought to be beyond its range.

Among these are the detailed distribution of plants and animals, which I have discussed at some length. It occupies about one-fourth of the volume (Chapters II. to VI.), and brings out certain facts and conclusions which I believe will be of interest to all plant-lovers, and also be not without a certain value to botanists.

Next in importance are three chapters (X., XL, and XII.) devoted to a general review of the Geological Record and a discussion of the various problems arising out of it. Some of the conclusions to which this examination leads us are, I believe, both important and of much general interest .

In Chapter VIII. I have endeavoured to show natural selection actually at work in the continually perfecting that wonderful co-adaptation of the most diverse forms of life which pervades all nature. Some little-known aspects of bird-migration are here discussed, and proof is given of the enormous importance of mosquitoes for the very existence of considerable proportion of our birds, including most of our most favoured pets and songsters. This chapter will, I think, have a special interest for every bird-lover.

In Chapter IX. I deal with some little-known phenomena in that hitherto neglected field of enquiry which I have termed "Recognition Marks." Besides the ohvious uses implied by their name, I have shown that they are of great importance — perhaps absolutely essential — in the process of the evolution of new species. During the enquiry I have arrived at the somewhat startling conclusion that the exquisite variety and beauty of insect-coloration and marking have not been developed through their own visual perceptions, but mainly — perhaps even exclusively — through those of higher animals. I show that brilliant butterflies do not, and almost certainly cannot, recognise each other by colour, and that they probably do not even perceive colour at all except as to a certain extent presenting visual differences.

But besides the discussion of these and several other allied subjects, the most prominent feature of my book is that I enter into popular yet critical examination of those underlying fundamental problems which Darwin purposely excluded from his works as being beyond the scope of his enquiry. Such are the nature and causes of Life itself, and more especially of its most fundamental and mysterious powers — growth and reproduction.

I first endeavour to show (in Chapter XIV.) by a careful consideration of the structure of the bird's feather; of the marvellous transformations of the higher insects; and, more especially of the highly elaborated wing-scales of the Lepidoptera (as easily accessible examples of what is going on in every part of the structure of every living thing), the absolute necessity for an organising and directive Life-Principle in order to account for the very possibility of these complex out-growths. I argue that they necessarily imply first, a Creative Power, which so constituted matter as to render these marvels possible; next, a directive Mind, which is demanded at every step of the process we

term growth and often look upon as so simple and natural a process as to require no explanation; and, lastly, an ultimate Purpose, in the very existence of the whole vast life-world in all its long course of evolution throughout the eons of geological time. This Purpose, which alone throws light on many of the mysteries of its mode of evolution, I hold to he the development of Man, the one crowning product of the whole cosmic process of life-development; the only being which can to some extent comprehend nature; which can perceive and trace out her modes of action; which can appreciate the hidden forces and motions everywhere at work, and can deduce from them all a supreme and overruling mind as their necessary cause.

If we accept some such view as I have now indicated, I show (in Chapters XV. and XVI.) how strongly it is supported and enforced by a long series of facts and co-relations which we can hardly look upon as all purely accidental coincidences. Such are the infinitely varied products of living things which serve man's purposes and man's alone — not only by supplying his material wants, and by gratifying his higher tastes and emotions, but as rendering possible many of those advances in the arts and in science which we claim to be the highest proofs of his superiority to the brutes and of hia advancing civilisation.

From a consideration of these better-known facts I proceed (in Chapter XVII.) to an exposition of the mystery of cellgrowth; to a consideration of the elements in their special relation to the earth itself and to the life-world; while in the last chapter I endeavour to show the purpose of that law of diversity which seems to pervade the whole material Universe. As an "excursus," I devote Chapter XIX. to a discussion of the nature, extent, and uses of Pain, as strictly deduced from the law of Evolution. Strangely enough, this has never, I believe, been done before; and it enables us to answer the question —" Is Nature Cruel?" with a decided negative.

This outline of the varied contents and objects of my book, will, I hope, be useful to my readers, and especially to my reviewers, by directing their attention to those parts of the work in which they may be more especially interested.

I also wish to point out that, however strange and heretical some of my beliefs and suggestions may appear to be, I claim that they have only been arrived at by a careful study of the facts and conditions of the problem. I mention this because numerous critics of my former work — Man's Place in the Universe (to which this may be considered supplementary) — treated the conclusions there arrived at as if they were wholly matters of opinion or imagination, and founded (as were their own) on personal likes or dislikes, without any appeal to evidence or to reasoning.

I have now only to express my thanks to the friends and strangers who have kindly assisted me with numerical and other data for various portions of my work; as well as to those publishers and authors who have allowed me to use the engravings or photographs with which my book is illustrated. They are in every case (I believe) acknowledged in the text, or on the various plates and figures.

Bboadbtonc, WimBorne,
November 1910. "—

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Chapter I - WHAT LIFE IS, AND WHENCE IT COMES

When primeval man first rose above the brutes from which he was developed; when, by means of his superior intellect, he had acquired speech and the use of fire; and more especially when his reasoning and reflecting faculties caused him to ask those questions which every child now asks about the world around it — what is this? and why is that ? — he would, for the first time, perceive and wonder at the great contrast between the living and the not-living things around him.

He would first observe that the animals which he caught and killed for food, though so unlike himself outwardly, were yet very like his fellow-men in their internal structure. He would see that their bony framework was almost identical in Bhape and in substance with his own; that they possessed flesh and blood, that they had eyes, nose, and ears; that presumably they had senses like his own, sensations like his own; that they lived by food and drink as he did, and yet were in many ways so different. Above all, he would soon notice how inferior they were to himself in intellect, inasmuch as they never made fires, never used any kind of tools or weapons; and that, 'although many of them were much stronger than he was, yet his superiority in these things, and in making traps or pitfalls to capture them, showed that he was really their superior and their master.

Gradually, probably very slowly, he would extend these observations to all the lower forms of life, even when both externally and internally he could find no resemblance whatever to his own body; to crabs and winged insects, to landshells and sea-shells, and ultimately to everything which by moving and feeding, by growing and dying, showed that it was, like himself, alive. Here, probably, he would rest for awhile, and it might require several generations of incipient philosophers to extend the great generalisation of "life" to that omnipresent clothing of the earth's surface produced by the infinitely varied forms of vegetation. The more familiar any phenomenon is — the more it is absolutely essential to our life and well-being — the less attention we pay to it and the less it seems to need any special explanation. Trees, shrubs, and herbs, being outgrowths from the soil, being incapable of any bodily motion and usually exhibiting no indications of sensation, might well have been looked upon as a necessary appendage of the earth, analogous to the hair of mammals or the feathers of birds. It was probably long before their endless diversity attracted much notice, except in so far as the fruits or the roots were eatable, or the stems or foliage or bark useful for huts or clothing; while the idea that there is in them any essential feature connecting them with animals and entitling them to be classed all together as members of the great world of life would only arise at a considerably later stage of development.

It is, in fact, only in recent times that the very close resemblance of plants and animals has been generally recognised. The basis of the structure of both is the almost indistinguishable cell; both grow from germs; both have a varied life-period from a few months to a maximum of a few hundreds of years; both in all their more highly organised forms, and in many of their lower types also, are bisexual; both consist of an immense variety of distinct species, which can be classified in the same way into higher and higher groups; the laws of variation, heredity, and the struggle for existence apply equally to both, and their evolution under these laws has gone on in a parallel course from the earliest periods of the geological record.

The differences between plants and animals are, however, equally prominent and fundamental. The former are, with few exceptions, permanently attached to the soil; they absorb Dourishment in the liquid or gaseous state only, and their tissues are almost wholly built up from inorganic matter, while they give no clear indications of the possession of sensation or voluntary motion. But notwithstanding these marked differences, both animals and plants are at once distinguished from all the other forms of matter that constitute the earth on which they live, by the crowning fact that they are Alive; that they grow from minute germs into highly organised structures; that the functions of their several organs are definite and highly varied, and such as no dead matter does or can perform; that they are in a state of constant internal flux, assimilating new material and throwing off that which has been used or is hurtful, so as to preserve an identity of form and structure amid constant change. This continuous rebuilding of an ever-changing highly complex structure, so as to preserve identity of type and at the same time a continuous individuality of each of many myriads of examples of that type, is a characteristic found nowhere in the inorganic world.

So marvellous and so varied are the phenomena presented by living things, so completely do their powers transcend those of all other forms of matter subjected to mechanical, physical, or chemical laws, that biologists have vainly endeavoured to find out what is at the bottom of their strange manifestations, and to give precise definitions, in terms of physical science, of what "life" really is. One authority (in Chambers's Encyclopaedia) summed it up in three words—"Continuity, Rhythm,

and Freedom,"—true, perhaps, but not explanatory; while Herbert Spencer declared it to be —" the definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external co-existences and sequences." This is so technical and abstract as to be unintelligible to ordinary readers.

The following attempt at a tolerably complete definition appears to sum up the main distinctive characters of living things:—

Life is that power which, primarily from air and water and the substances dissolved therein, builds up organised and highly complex structures possessing definite forms and functions: these are preserved in a continuous state of decay and repair by internal circulation of fluids and gases; they reproduce their like, go through various phases of youth, maturity, and age, die, and quickly decompose into their constituent elements. They thus form continuous series of similar individuals; and, so long as external conditions render their existence possible, seem to possess a potential immortality.

The characteristics here enumerated are those which apply to both plants and animals, and to no other forms of matter whatever. It is often stated that crystals exhibit the essential features of some of the lowest plants; but it is evident that, with the exception of the one item of "definite form," they in no way resemble living organisms. There is no doubt, however, that crystals do exhibit definite forms, built up by the atoms or molecules of various elements or compounds under special conditions. But this takes us a very small way towards the complex structure and organisation of living things.

There are still people who vaguely believe that "stones grow," or that "all matter is really alive," or that, in their lowest and simplest forms, the organic and the inorganic are indistinguishable. For these ideas, however, there is not a particle of scientific justification. But the belief that "life" is a product of matter acted upon by chemical, electrical, or other physical forces, is very widely accepted by men of science at the present day, perhaps by a majority. It is, in fact, held to be the only scientific view, under the name of "monism "; while the belief that "life" is sui generis, that it is due to other laws than those which act upon dead or unorganised matter, that it affords evidence of an indwelling power and guidance of a special nature, is held to be unscientific — to be, in fact, an indication of something akin to, if not actually constituting, an old-fashioned superstition. That such a view is not uncommon may be shown by a few extracts from scientific writers of some eminence.

The well-known German biologist Ernst Haeckel, in a recent work, makes the following statement:

"The peculiar phenomenon of consciousness is not, as Du BoisEeymond and the dualistic school would have us believe, a completely transcendental problem; it is, as I showed thirty-three years ago, a *physiological* problem, and, as such, must be reduced to the phenomena of physics and chemistry" (The Eiddle of the Universe, p. 65, translated by Joseph M'Cabe).

Again he says:

"The two fundamental forms of substance, ponderable matter and ether, are not dead, and only moved by extrinsic force, but they are endowed with sensation and will (although, naturally, of the lowest grade); they experience an inclination for condensation, a dislike of strain; they strive after the one and struggle against the other" (p. 78).

In these two passages we have a self-contradiction in meaning if not in actual words. In the first, he reduces consciousness to phenomena of physics and chemistry; in the second he declares that both matter and ether possess sensation and will . But in another passage he says he conceives "the

elementary psychic qualities of sensation and will which may be attributed to atoms to be unconscious" (p. 64).
It is this quite unintelligible theory of matter and ether possessing *sensation* and *will,* being able to *strive* and *struggle* and yet be *unconscious,* which enables him to say:
"We hold with Goethe that matter cannot exist and be operative without spirit, nor spirit without matter. We adhere firmly to the pure, unequivocal monism of Spinoza: Matter, or infinitely extended substance, and Spirit (or Energy), or sensitive and thinking substance, are the two fundamental attributes, or principal properties, of the all-embracing essence of the world, the universal substance" (p. 8).
Here we have yet another contradiction — that the *thinking infinite substance* is *unconscious!* This leads to his theory of the "cell-soul," which is the origin of all consciousness, but which is itself *unconscious.* This he reiterates emphatically. He tells us that at a certain grade of organisation " consciousness has been gradually evolved from the psychic reflex activity, and now conscious voluntary action appears" (p. 41). Along with these strange conceptions, which really explain nothing, he propounds his "Law of Substance" as the one great foundation of the universe. This is merely another name for "persistence of force" or "conservation of energy," yet at the end of the chapter expounding it he claims that, "in a negative way, it rules out the three central dogmas of metaphysics— God, freedom, and immortality" (p. 83). A little further on he again states his position thus:
"The development of the universe is a monistic mechanical process, in which we discover no aim or purpose whatever; what we call design in the organic world is a special result of biological agencies; neither in the evolution of the heavenly bodies, nor in that of the crust of the earth do we find any trace of a controlling purpose — all is the result of chance."
Then, after discussing what is meant by chance, he concludes:
"That, however, does not prevent us from recognising in each 'chance' event, as we do in the evolution of the entire cosmos, the universal sovereignty of nature's supreme law, *the law of substance"* (p. 97).
Again, he defines his position still more frankly:
"Atheism affirms that there are no gods or goddesses, assuming that god means a personal, extra-mundane entity. This 'godless world-system' substantially agrees with the monism or pantheism of the modern scientist. It is only another expression for it, emphasising its negative aspect, the non-existence of any supernatural deity" (p. 103).
These vague and often incomprehensible assertions are interspersed with others equally unprovable, and often worded so as to be very offensive to religious minds. After having put forth a host of assertions as to a possible future state, which exhibit a deplorable ignorance of the views of many advanced thinkers in all the Churches, he says:
"Our own 'human nature' which exalted itself into an image of God in an anthropistic illusion, sinks to the level of a placental mammal, which has no more value for the universe at large than the ant, the fly of a summer's day, the microscopic infusorium, or the smallest bacillus. Humanity is but a transitory phase of the evoration of an eternal substance, a particular phenomenal form of matter and energy, the true proportion of which we soon perceive Then we set it on the background of infinite space and eternal time" (p. 87).
The writings of Haeckel, the extremely dogmatic and assertive character of which have been illustrated in the preceding quotations, have had an immense influence on many classes of readers, who, when a man becomes widely known as a great ^authority in any department of science, accept him as a safe guide in any other departments on which he expresses his opinions. But the fact is that he has gone altogether out of his own department of biological knowledge, and even beyond the whole range of physical science, when he attempts to deal with problems involving "infinity" and "eternity." He declares that "matter," or the material universe, is infinite, as is the "ether," and that together they fill infinite space, and that both are "eternal" and both "alive." None of these things can possibly be *known,* yet he states them as positive *facts.* The whole teaching of astronomy by the greatest astronomers to-day is that the evidence now at our command points to

the conclusion that our material universe is finite, and that we are rapidly approaching to a knowledge of its extent. Our yearly increasing acquaintance with the possibilities of nature leads us to the conclusion that in infinite space there *may* be other universes besides ours; but if so, they may possibly be different from ours — *not* of matter and ether only. To assert the contrary, as Haeckel does so confidently, is surely not *science,* and very bad philosophy.

He further implies, and even expressly states, that there is no spirit-world at all; that if life exists in other worlds it must be *material,* physical life; and that, as all worlds move in cycles of development, maturity, and destruction, all life must go through the same phases — that this has gone on from all eternity past, and will go on for all eternity to come, with no past and no future possible, but the continual rise of life up to a certain limited grade, which life is always doomed to extinction. And it is claimed that this eternal succession of futile cycles of chance development and certain extinction is, as an interpretation of nature, to be preferred to any others; and especially to those which recognise mind as superior to matter, which see in the development of the human intellect the promise of a future life, and which have in our own day found a large mass of evidence justifying that belief.

With Professor Haeckel's dislike of the dogmas of theologians, and their claims to absolute knowledge of the nature and attributes of the inscrutable mind that is the power within and behind and around nature, many of us have the greatest sympathy; but we have none with his unfounded dogmatism of combined negation and omniscience, and more especially when this assumption of superior knowledge seems to be put forward to conceal his real ignorance of the nature of life itself. He evades altogether any attempt to solve the various difficult problems of nutrition, assimilation, and growth, some of which, in the case of birds and insects, I shall endeavour to set forth as clearly as possible in the present volume. A9 Professor Weismann well puts it, the *causes* and *mechanism* by which it comes about that the infinitely varied materials of which organisms are built up "are always in the right place, and develop into cells at the right time," are never touched upon in the various theories of heredity that have been put forward, and least of all in that of Haeckel, who comea before us with what he claims to be a solution of the Riddle of the Universe.

Huxley on the Nature and Origin of Life

Although our greatest philosophical biologist, the late Professor T. H. Huxley, opposed the theory of a "vital force" as strongly as Haeckel himself, I am inclined to think that he did so because it is a mere verbal explanation instead of being a fundamental one. It conceals our real ignorance under a special term. In his Introduction to the Classification of Animals (1869), in his account of the Rhizopoda (the group including the Amoebae and Foraminifera), he says:

"Nor is there any group in the animal kingdom which more admirably illustrates a very well-founded doctrine, and one which was often advocated by John Hunter, that *life is the cause and not the consequence of organisation;* for in these lowest forms of animal life there is absolutely nothing worthy of the name of organisation to be discovered by the microscopist, though assisted by the beautiful instruments that are now constructed. . . . It is structureless and organless, and without definitely formed parts. Yet it possesses all the essential properties and characters of vitality. Nay, more, it can produce a shell; a structure, in many cases, of extraordinary complexity and most singular beauty.

"That this particle of jelly is capable of guiding physical forces in such a manner as to give rise to those exquisite and almost mathematically-arranged structures — being itself structureless and without permanent distinction or separation of parts — is to my mind a fact of the profoundest significance" (p. 10).

This was written only a year after the celebrated lecture on "The Physical Basis of Life," in which Huxley made statements which seem opposed to those above quoted, and which certainly appear to be less philosophical. For example, he says that when carbon, hydrogen, oxygen, and nitrogen are combined with some other elements, they produce carbonic acid, water, and nitrogenous salts. These compounds are all life less. "But when they are brought together under certain conditions they give rise to the still more complex body, protoplasm, and this protoplasm exhibits the

phenomena of life" (p. 52). Then follows an exposition of the well-known argument as to water and crystals being produced by the "properties" of their constituent elements, with this conclusion:

"Is the case any way changed when carbonic acid, water, and nitrogenous salts disappear, and in their place, under the influence of pre-existing living protoplasm, an equivalent weight of the matter of life makes its appearance?" (p. 53).

But here we have the words I have italicised introduced which were not in the previous statement; and these are of fundamental importance considering the tremendous conclusion he goes on to draw from them —" that the thoughts to which I am now giving utterance are the expression of molecular changes in that matter of life which is the source of our other vital phenomena." At the end of the lecture he says that " it is of little moment whether we express the phenomena of matter in terms of spirit, or the phenomena of spirit in terms of matter — each statement has a certain relative truth." But he thinks that in matters of science the materialistic terminology is in every way to be preferred.

This is vague and unsatisfactory. It is not a mere question of terminology; but his statement that "thought is the expression of molecular change in protoplasm" is a mere begging of the whole question, both because it is absolutely unproved, and is also inconsistent with that later and clearer statement that "life is the cause of organisation "; but, if so, life must be antecedent to organisation, and can only be conceived as indissolubly connected with spirit and with thought, and with the cause of the directive energy everywhere manifested in the growth of living things.

In the present volume I am endeavouring to arrive at a juster conception of the mystery of the Life-World than that of Professor Haeckel, and by a very different method. I shall endeavour to give a kind of bird's-eye sketch of the great lifedrama in many of its broader and less-known phases, showing how they all form parts of the grand system of evolution, through adaptation to continuous changes in the outer world. T shall also endeavour to penetrate into some of the less trodden paths of nature-study, in order to exhibit the many indications that exist of the preparation of the Earth for Man from the remotest eons of geological time.

Chapter II - SPECIES TIIEIB NUMBEBS, VAEIETY, AND DI&TEIBUTION

When we begin to inquire into the main features, the mode of development, the past history, and the probable origin of the great World of Life of which we form a part, which encloses us in its countless ramifications, and upon whose presence in ample quantity we depend for our daily food and continued existence, we have perpetually to discuss and to deal with those entities technically known as species, but which are ordinarily referred to as sorts or kinds of plants and animals. When we ask how many kinds of deer or of thrushes, of trout or of butterflies, inhabit Britain, we mean exactly the same thing as the biologist means by species, though we may not be able to define what we mean so precisely as he does.

Many people imagine, however, that Darwin's theory proves that there are no such things as species; but this is a complete misconception, though some biologists use language which seems to support it. To myself, and I believe to most naturalists, species are quite as real and quite as important as when they were held to be special creations. They are even more important, because they constitute the only definite, easily recognised, and easily defined entities which form the startingpoint in all rational study of the vast complex of living things. They are now known to be not fixed and immutable as formerly supposed; yet the great mass of them are stable within very narrow limits, while their changes of form are so slow, that it is only now, after fifty years of continuous search by countless acute observers, that we have been able to discover a very few cases in which a real change — the actual production of new species — appears to be going on

before our eyes. The reader may therefore rest assured that there is no mystery in the word species, but that he may take it as meaning the same as kind, in regard to animals and plants in a state of nature, and that he will have no difficulty in following the various discussions and expositions in which this term is necessarily so prominent. The reason why species is the better term is because kind is used in two distinct senses — that of species when we speak of kinds of deer, of squirrels, or of thrushes, but also that of a genus or a family when we speak of the deer, squirrel, or thrush kind, as meaning the whole group of these animals. If we used the word tribe instead of kind in this latter sense, all ambiguity would be avoided.

Few persons who have not studied some branch of natural history have any idea of the vast extent, the infinite variety, the omnipresence and the intermingling of the varied species of animals and plants, and still less of their wonderful co-adaptation and interdependence. It is these very characteristics that are least dwelt upon in books on natural history, and they are largely overlooked even in works on evolution. Yet they form the very basis of the phenomena to be explained, and furnish examples of development through survival of the fittest, on a larger scale and often of easier comprehension than the special cases most frequently adduced. It is this ground-work of the whole subject that we will now proceed to consider.

The Distribution of Local and World Species

The first important group of facts which we have to consider is that which relates to the number of existing species of the two great divisions of life, plants and animals, and their mode of distribution over the earth's surface.

Every one who begins to study and collect any group of animals or plants is at once struck by the fact that certain fields, or woods, or hills are inhabited by species which he can find nowhere else; and further, that, whereas gome kinds are very common and are to be found almost everywhere, others are scarce and only occur in small numbers even in the places where alone they are usually to be found. These peculiarities are most strongly marked in the case of plants, and in a less degree among insects and land-shells; and in the former group they are easily seen to depend mainly on such obvious peculiarities as soil and moisture, exposure to sun or wind, the presence or absence of woods, streams, or mountains.

But besides these inorganic causes — soil, climate, aspect, etc.— which seem primarily to determine the distribution of plants, and, through them, of many animals, there are other and often more powerful causes in the organic environment which acts in a variety of ways. Thus, it has been noticed that over fields or heaths where cattle and horses have free access seedling trees and shrubs are so constantly eaten down that none ever grow to maturity, even although there may be plenty of trees and woods around. But if a portion of this very same land is enclosed and all herbivorous quadrupeds excluded, it very quickly becomes covered with a dense vegetation of trees and shrubs. Again, it has been noticed that on turfy banks constantly cropped by sheep a very large variety of dwarf plants are to be found. But if these animals are kept out and the vegetation allowed to grow* freely, many of the dwarfer and more delicate plants disappear owing to the rapid growth of grasses, sedges, or shrubby plants, which, by keeping off the sun and air and exhausting the soil, prevent the former kinds from producing seed, so that in a few years they die out and the vegetation becomes more uniform.

A modified form of the same general law is seen when any ground is cleared of all vegetation, perhaps cultivated for a year or two, and then left fallow. A large crop of weeds then grows up (the seeds of which must have been brought by the wind or by birds, or have lain dormant in the ground); but in the second and third years these change their proportions, some disappear, while a few new ones arrive, and this change goes on till a stable form of vegetation is formed, often very

different from that of the surrounding country. Such changes as these have been observed by local botanists on rail way banks, of which I have given several examples in my Island Life (p. 513, footnote). All these phenomena, and many others which will be referred to later, are manifestly due to that " struggle for existence" which is one of the great factors of evolution through "survival of the fittest."

A Lincolnshire clergyman (Rev. E. Adrian Woodruffe-Peacock of Cadney) has long studied the distribution of plants in a very minute and interesting manner, more especially in his own parish, but very extensively over the whole county. His more exact method is to divide up a field into squares of about 16 feet each way with pegs, and then to note on special forms or note-books (1) a list of the species found in each square, and (2) the frequency (or proportion) of the occurrence of each species. From these the frequency over the whole field can be estimated, and the botanical peculiarities of various fields very accurately determined. By comparing the detailed flora of each field with its surface-geology, aspect, altitude, degree of moisture or aridity, etc., a very accurate conclusion as to the likes and dislikes of particular plants may be arrived at .

As an example of the detailed treatment of a rather uncommon yet widely distributed plant, he has sent me a copy of his paper on the Black Horehound (Ballota nigra), a species not uncommon over much of Central Europe, but scattered over Central and Southern Britain only in a few favourable localities. In Lincolnshire it is found all over the county in suitable spots, but prefers a warm, open, and limy soil, as shown by 150 records giving notes of its occurrence. The general results of the inquiry are thus given:

When the sheets of notes are analysed the following points come out. It is a hedge and ditch-side species, but it seems to prefer a bank to the flat in the proportion of 10 to 1; the sunny bank to the shady side of a road running east and west in nearly the same proportion. On sandy soils it seems to get away from the villages to a greater distance than on clays, but perhaps the rabbit may explain this. It extends from Cadney village along hedge and ditch banks on roadsides as far as the Sandy Glacial Gravel extends in any direction. It is found in bushy ground, in old quarries and gravel pits, and on the decaying mud-capping of limestone walls. It is exterminated by stock in pasture, unless it is protected by the stinging-nettle or by the fouling of the ground by rabbits. It is apparently never found in meadows. It is even sometimes eaten by cows, when the much-loved Lamium album (the white dead-nettle) is left untouched; but it would seeem to be taken as a corrective or relish rather than as food. It is found so rarely in the open that it would almost appear to be a shade species of bushy ground.

To sum up, Ballota nigra can only survive (in Lincolnshire) when unconsciously protected by man; for its natural requirements, a bushy, open, limy, lightly stocked soil is practically not to be found.

This careful study of a single species of plant gives us an excellent picture of the struggle for existence on the outer limit of the range of a species, where it first becomes rare, and, when the conditions become a little less favourable, cease3 to exist. How this struggle affects the flora of limited areas under slightly different conditions is shown by the same writer's comparison of meadow and pasture.

Two fields of each were chosen in the same parish and with the same subsoil (Sandy Glacial Gravel) so as to afford fair examples of each. With the one exception of the mode of cultivation they were as alike as possible. Both had at some remote period been ploughed, as shown by faint ridges, but no one living or their immediate predecessors could remember them in any different condition from the present one. The four fields (29 acres together) contained in all 78 species of plants; but only 46 of these were found in both pasture and meadow. The number of species in each was nearly the same — 60 in the meadows, 64 in the pastures; 14 species being found only in the meadows and 18

in the pastures. Broadlyspeaking, therefore, one-fifth of all the species growing on these 29 acres became restricted to well-defined portions of them according as these portions were grazed by farm stock or regularly mown for hay.

Again, Mr. Woodruffe-Peacock states, that the assemblage of plants that form pasture-lands not only varies with every change of soil and climate, but also with any change of the animals that feed upon them; so that any one experienced and observant can tell, by the presence of certain plants and the absence of others, whether horses, cattle, or sheep have been the exclusive or predominant animals that have grazed upon it.

Another point of some importance is the greater stability in the flora of meadow as compared with that of pasture land. In the former only one plant was an accidental straggler, while in the latter there were 12, or two-thirds of the peculiar species. These are mostly rare, and are very often not truly British plants, so that they cannot be considered as permanent pasture plants. The more stable meadow flora is no doubt largely due to the fact that few of the late-flowering plants are allowed to produce seed, and though seed may be often introduced by birds or the wind, many of these species soon die out. It thus appears that though pastures are actually richer in species than meadows, yet the latter have a more permanent character, as almost all those peculiar to pastures are comparatively rare and therefore very liable to disappear through very slight changes of conditions.

These various facts, and many others which cannot be here given, serve to show us how very delicate are the mutual relations and adjustments of plants to their total environment. In proportion as that environment is subject to change of any kind, some rare species die out, while others become diminished in numbers. And what takes place in single fields or other small areas, when closely studied, must certainly occur on a much grander scale over the whole earth, and especially in those countries and periods when great changes of climate or of physical geography are taking place. These detailed studies of "Meadow and Pasture Analysis "— as their author terms them — thus demonstrate on a very small scale that " struggle for existence" which, as we shall see further on, is always present, acts in an almost infinite number of ways, and is one of the most important factors in the developmental changes of the World of Life. We will now proceed to give some of the numerical facts of plant distribution, in various areas small and large, as well as over the whole earth; but it will be advisable first to give a brief account of the way in which this is usually dealt with by botanists.

Four years before the appearance of the Origin of Species the great Swiss botanist, Alphonse De Candolle, published one of the most remarkable and interesting botanical works in existence, his Geographie botanique raisonnee, in two thick volumes. He not only brought together all the then available facts as to plant distribution in every part of the world, studied them from almost every point of view, and grouped them in relation to every known agency that might be supposed to influence their distribution, but at every step he most carefully and ingeniously discussed the problems involved, often of a very intricate nature, with a view to arriving at a more or less complete explanation.

It is impossible here to give any adequate notion of this great work, but a few of the chief subjects treated may be mentioned. The effects of temperature and of light upon the growth and vitality of plants are first examined, and some very interesting conclusions are reached, among others the great importance of the time during which any particular degree of heat continues. This discussion occupies the first three chapters. Sixteen long chapters then deal with "Botanical Geography," in which all the geographical conditions that affect the distribution of plants are elaborately discussed, such as altitude, latitude, aspect, humidity, geological and mineralogical causes, both in their direct and indirect action, and as applying to cultivated as well as wild plants. The areas

occupied by species, both as regards size and shape, are then discussed, and the causes that lead to their variations investigated. He then shows what are the actual areas in various parts of the world, and under various geographical conditions, and thus arrives at the causes of great extension of certain species from west to east in the north temperate zone, or along sea-shores or river-banks in the tropics; while the normal area is considered to be "massive" rather than elongated.

Coming then to detailed facts, he shows that about 200 species (out of the total then known of about 120,000) have areas equal to one-third or more of the entire land surface of the globe. Further, in certain Families (usually called Natural Orders) there are plants which range from the Arctic regions to the southern extremity of the great continents. Among the former are our common Marsh Marigold (Caltha palustris) and Common Sundew (Drosera rotundifolia), which are found in all Northern Europe, Asia, and America; while our common Sowthistle (Sonchus oleraceus) is found scattered over the whole globe, tropical as well as temperate, and is perhaps the nearest of any known plant to being truly cosmopolitan.

By a laborious comparison the author arrives at the conelusion that the average area occupied by the species of flowering plants is tilth part of the whole land surface of the globe. But the area varies enormously in different parts of the world. Thus, in the whole Russian Empire, species have a mean area of Atth the land surface, owing to the fact that so many range east and west over a large part of Europe and North Asia; while in South Africa the mean range is only ufajth of that surface, which expresses the fact of the extreme richness of the latter flora, many of the species composing which have extremely restricted ranges. He also reaches the conclusion that in passing from the pole to the equator the mean areas of the species become smaller. A few examples of very limited areas are the following: — Several species of heaths are found only on Table Mountain, Cape of Good Hope; Campanula isophylla grows only on one promontory of the coast of Genoa; the beautiful Alpine Gromwell (Lithospermum Gastoni), on one cliff in the Pyrenees; Wulfenia Carinthiacaj on one mountain slope in Carinthia; Primula imperialis, on the summit of Mount Pangerago in Java, and many others.

In order to compare the plants of different parts of the world in their various relations, De Candolle divides the whole land surface into fifty botanical regions, each distinguished by the possession of a considerable proportion of peculiar species of plants. These regions are of greatly varying extent, from No. 18, comprising the whole of Northern Asia, to No. 10, limited to the small island of Tristan d'Acunha in the South Atlantic.

The list is as follows: —

A. De Candoixe's Botanical Regions

1. Arctic zone.

2. Europe, temperate.

3. Mediterranean.

4. Azores, Madeira, Canaries.

5. Sahara, Cape Verde Islands. 8. Guinea N., Soudan.

7. " S., Congo, Benguela.

8. Island of St. Helena.

9. South Africa.

10. Tristan d'Acunha.

11. Islands of Kerguelen, St. Paul,

etc.

12. Madagascar, etc.

13. Mozambique, Zanzibar.

14. Abyssinia to Egypt.

15. Persia, Euphrates.

16. Caucasus, Armenia.

17. Tartary east of Caspian.

18. Siberia, Ural to Kamschatka,

Lake Aral.

19. Asia Central.

20. Afghanistan to Indus.

21. Nepal to Bhutan.

22. China, Japan.

23. Philippines.

24. Siam, Cochin China,

25. Burma and Assam.

26. Bengal, Ganges.

27. Peninsular India, Ceylon.

28. Malacca, N. Ireland.

29. Australia, New Zealand.

30. Fiji to Marquesas.

31. Mariannes, Carolines.

32. Sandwich Islands.

33. N.W. America.

34. Canada and United States.

35. Texas, California, Mexico.

36. West India Islands.

37. Venezuela.

38. Colombia.

39. Peru.

40. Galapagos.

41. Bolivia and Andes.

42. Guayanas.

43. Amazonia.

44. Brazil N.E.

45. " W., Paraguay.

46. " S.E.

47. Uruguay, La Plata.

48. Chile, Juan Fernandez.

49. Patagonia, Falkland Islands.

50. The Antarctic Archipelago.

By an extensive comparison of floras all over the world it is found that less than five per cent, of the total of the known species are found in more than two of these regions. Families which have very few annual species show a still smaller percentage (three per cent) ; while those whose species are mostly trees or shrubs have less than two per cent which extend to more than two regions.

He also finds that those with fleshy fruits have a wider dispersal than those with dry fruits, and those with very small seeds, wider than those with larger seeds. Eighteen species only are found to be spread over half the land surface of the globe. There are no trees or shrubs among these; grasses are most abundant among them; and composites — the daisy and aster family — the least! This last conclusion seems very strange in view of the fact that this family has its seeds so frequently provided with special means of dispersal, either by the wind or by animals. But he also points out, what is now well known to botanists, that the species of Compositse are not usually very widely spread; and also that several other natural orders in which the seeds are usually winged for wind-dispersal are not more widely distributed than those whose seeds are not winged. These facts

certainly prove that the dispersal of seeds by wind or by birds has been brought about for the purpose of securing ample means of reproduction within the area to which the whole plant has become specially adapted, not to facilitate its transmission to distant lands or islands which, only in a very few cases, would be suited for its growth and full development. Very extensive dispersal must, therefore, in most cases be looked upon as an adventitious result of general adaptation to the conditions in which a species exists.

De Candolle's work also treats very fully the subject of the comparative preponderance of the various natural orders of plants in different regions or countries. This mode of studying plant-distribution was introduced by our greatest English botanist, Robert Brown, and it is that most generally used by modern botanical writers on distribution. It consists in the characterisation of the vegetation of each region or district by the proportionate abundance in species belonging to the different natural orders.

This is used in many different ways. In one the minimum number of orders whose species added together form one-half of the whole flora are given. Thus, it was found that in the Province of Bahia (Brazil) the 11 largest natural orders comprise half the whole number of species. In British Guiana 12 orders are required, and in British India 17. Coming to temperate regions, in Japan there are 16, in Europe 10, in Sweden 9, in Iceland and in Central Spain 8. The general result seems to be that those regions which are very rich in their total number of plants require a larger number of their preponderant orders to make up half the total flora; which implies that they have a larger proportion of orders which are approximately equal in number of species.

Another mode of comparison is to give the names of the first three or four, or even ten or twelve, of the orders which have the greatest number of species. It is found, for example, that in equatorial regions Leguminosae usually come first, though sometimes Orchids are most abundant; in temperate regions the Composites or the Grasses; and in the Arctic, Grasses, followed by Cruciferse and Saxifrages. A few of the tables constructed by De Candolle are given as examples.

Bettish Guiana. (Schomburgh)
3254 species

Leguminosa 469 species

Orchidem 214"

RubiacesB 176"

Melastomacete 126"

The Andes or New Grenada (Humboldt)
1041 species

Compositse 86 species

Leguminosso 65"

Rubiace» 49"

Grammese 42"

Orchidea? 41"

Other examples will be given when discussing the comparative relations of the various temperate and tropical floras of the world.

Chapter III - THE NUMERICAL DISTRIBUTION OF BRITISH PLANTS: TEMPERATE FLORAS COMPARED

Proceeding from the more to the less familiar regions we will begin with a few of the facts as to the flora of our own country. Partly owing to its insular character, and also because it has few lofty mountains or extensive forests, the number of species of flowering plants is somewhat (but not much) below that of most continental countries of equal area. It contains about 1800 species, as a rough mean between the estimates of different botanists.1 It may seem curious that there should be any such difference of opinion, but one of the facts that have always been adduced as showing that species are not fixed and immutable entities is the frequent occurrence of varieties, which are sometimes so peculiar and so apparently constant that they are treated by some botanists as distinct species, by others as sub-species, and by others again as forms or varieties only. These modifications of a species are usually confined to a more limited area than the species itself, and are occasionally connected with each other or with the parent species by intermediate forms. Again, when these varieties are cultivated, and especially when a large number of plants are raised from their seeds, they are apt to revert partially or wholly to the parent form. Another source of difference of opinion among botanists is, as to the treatment of those plants, found usually near human habitations, which are supposed to have been originally introduced, either purposely or accidentally, from foreign countries. Such are the wild Larkspur and Monkshood, the ??????

In all the tables and comparisons of "Floras" in this work, unless where ferns are specially noted, flowering plants only are intended, even when the term " plants" is used. Red Valerian, the Balm, the Martagon Lily, and many others. This explanation is necessary in order to avoid any supposition of positive error when the figures here given do not agree with those of any of the text-books or local floras.

The chief differences arise, however, from the increased study of certain difficult groups leading to the separation of large numbers of slightly differing forms, that hardly any one but an expert can distinguish, as distinct species. The most important of these are the Brambles (the genus Rubus) and the Hawkweeds (the genus Hieracium). During the last thirty years the numbers of these have more than doubled, according to the standard authority for British botanists — The London Catalogue of British Plants. The numbers in an early and late edition are as follows: —

In the last two cases two well-known plants — the little "eyebright" of our turfy banks, and the "yellow rattle" of peaty meadows, which have been each considered to form a single species from the time of Linnseus to that of Bentham and Hooker — are now subdivided into a number of distinct species, each claimed to be well recognisable and constant. With such' rapid changes in the estimate of species in so well-known a flora as our own it may be thought that the number of species in foreign countries is even more uncertain. This, however, is by no means the case, as the great majority of the species of plants as well as of animals offer little difficulty, and present few fixed varieties (though abundance of variation), so that for general comparisons the figures obtainable are very fair approximations, and give us interesting and valuable information.

About one-third of the total number of our species of wild flowering plants belong to what the late Mr. H. C. Watson termed the British type; that is, they are found in suitable places over the whole of Great Britain, and in most districts are so plentiful that they may be termed common plants — such are the Alder, Birch, and Hazel among trees and shrubs; the Honeysuckle, Ivy, Heather or Ling, Daisy, Chickweed, Nettle, and a host of others. Another group is abundant in England, but absent

from the Highlands or from Scotland generally, such as the Dwarf Gorse and Yellow Dead-Nettie. Several arctic or alpine plants are peculiar to the Highlands, a considerable number of species are found only in our eastern counties, while as many or more are characteristic of the west.

More curious perhaps than all these are the cases of plants found only in one small area, or two or three isolated patches; and of others which are limited to a single station, sometimes of a few acres or even a few yards in extent. Such are the Cotoneaster, found only on Great Orme's Head in N. Wales; the Yellow Whitlow-Grass, on Worms Head in S. Wales; the pretty white-flowered Potentilla rupestres, on a single mountain-top in Montgomeryshire; the small liliaceous plant, Simethus bicolor, in a single grove of pine trees near Bournemouth, now probably exterminated by the builder, and another plant of the same family, Lloydia serotina, limited to a few spots in the Snowdon range; the beautiful alpine Gentiana verna, in upper Teesdale, Yorkshire, and others confined to single mountains in the Highlands. Between the extremes of widespread abundance and the greatest rarity, every intermediate condition is found; and this is, so far as we know, a characteristic of every part of the world. This, again, affords a striking proof of that struggle for existence which has already been referred to, acting, as Darwin was the first to point out, first to limit tho range of a species, often so that it exists only in two more or less isolated areas, then to diminish the number of individuals in these areas, and finally to reduce them to a single group which ultimately succumbs to an increased stress of competition or of adverse climatal changes, when a species which may have once been flourishing and widespread altogether ceases to exist. The rarity of a species may thus be considered as an indication of approaching extinction.

Numerical Distribution of Plants in Britain

We will now give a few numerical statements as to the comparative abundance of the species of plants in large and small areas in various parts of the world, such facts having a special application to the theory of evolution. The 55 counties of England and Wales (counting the three Ridings of Yorkshire as counties) have usually areas from 500 to 2500 square miles; and a considerable number of them have had their plants enumerated in special catalogues or floras. The following are the approximate numbers of the flowering plants in a few of these: —

This table of the distribution of plants in our counties is very instructive, because it shows us the influence of diversity of soils on the number of species that can grow and maintain themselves naturally as wild plants. This is largely dependent on the extreme diversity of the geology of our island, almost every geological formation from the oldest to the most recent being represented in it. This variety of Boil seems to be much more important than diversity of surface due to altitude, so that our lowland counties are quite as rich as those which are hilly or mountainous. Again, we see that, within moderate limits, greater area has little influence on richness of the flora, the largest, West Yorkshire, having only about one-fifth more species than the smallest, Middlesex, with only about one-twelfth the area.

The preponderating importance of variety of soil and surface conditions affording good stations for plants, such as woods, hedgerows, streams, bogs, etc., is well shown by'a few special comparisons that have been made by experienced botanists.

The Parish of Cadney (Lincolnshire), a little over 3 square miles in area, has 720 species of flowering plants; the county nearly 900 times as large, having 1200.

The Parish of Edmondsham (in Dorsetshire), covering less than 3 square miles, has 640 species; the county, 340 times as large, having 1010 species.

An equally remarkable instance was given by Mr. H. C. Watson fifty years ago, and no doubt from his own observations, as he resided in the county.

Here we see that 10 square miles contained nearly as many species as 60, and nearly two-thirds the numher in 760 square miles; while the single square mile produced nearly half the number in the whole county.

Taking still smaller areas, Mr. Woodruffe-Peacock found fields in Lincolnshire and Leicestershire, of from 10 to 25 acres, to yield from 50 to 60 species of plants; while a plot of 16% feet square (or 1 perch) would usually have 20 to 30 species. Old and long-disused stone-quarries are often very rich, one of about two acres producing sometimes as many species as the fields of eight or ten times the area. On a plot of turf 3 feet by 4, at Down in Kent, Mr. Darwin found 20 species of flowering plants growing.

These facts of the distribution of plants in our own islands prove, that for moderately large areas in the same country possessing considerable diversity of soil and general conditions affecting plant-life, the majority of the species are, as a rule, so widely scattered over it that approximately similar areas produce a nearly equal number of species. Further, we find that areas of successively smaller and smaller sizes have a very much greater number of species relatively than larger ones; so that, as we have seen, 10 square miles may show almost as much variety in its plant-life as an adjacent area of 60 square miles, and that a single square mile may sometimes contain half the number of species found in 700 square miles.

This characteristic of many small areas being often much richer in proportion to area than larger ones of which they form a part, is a necessary result of the great differences in the areas occupied by the several species and the numbers of the individuals of each; from those very common ones which occur abundantly over the whole country, to others which, although widespread, are thinly scattered in favourable situations, down to those exceptional rarities which occur in a very few spots or in very small numbers. Those spots or small areas which present the most favourable conditions for plant life and are also most varied in soil, contour, water-supply, etc., will, when in a state of nature, be occupied by a large proportion of the common and widespread plants, together with so many of the less common or the rare species which find the requisite conditions in some part of its varied soil and aspects, as to produce that crowding together of species and luxuriance of growth which are such a joy to the botanist as well as to the less instructed lover of nature.

All these peculiarities of vegetation are to be met with in every part of the world, and often in a more marked degree than with us. But this depends very much on diversities of climate and on the extent of land surface on which the entire flora has been developed. The total number of species depends mainly on these two factors, and especially on the former. The variety of species is small in arctic or sub-arctic lands, where the long and severe winter allows of only certain forms of vegetable and animal life; and it is equally if not more limited in those desert regions caused by the scarcity or almost complete absence of streams and of rain. It is most luxuriant and most varied in that portion of the tropics where the temperature is high and uniform and the supply of moisture large and constant, conditions which are found at their maximum in the Equatorial Zone within twelve or fifteen degrees on each side of the equator, but sometimes extending to beyond the northern tropic, as on the flanks of the Himalayas in north-eastern India, where the monsoon winds carry so much moisture from the heated Indian Ocean as to produce forests of tropical luxuriance in latitudes where most other parts of the world are more or less arid, and very often absolute deserts.

Temperate Floras compared

I will now endeavour to compare some of the chief floras of the Temperate Zone, both as regards the total number of species in fairly comparable areas, and the slight but clearly marked increase of the number in more southern as compared with more northern latitudes.

I will first show how this law applies even in the comparatively slight difference of latitude and climate within our own country. Dividing Great Britain (without Wales) 1 into three nearly equal portions — Scotland north of the Forth and Clyde, Mid-Britain, and South Britain, including all the southern counties; with areas of 22,000, 26,000, and 31,000 square miles — the number of species (in 1870) was, respectively, 930, 1148, and 1230. At the same period the total of Great Britain was 1425 species. These figures are all obtained from Mr. H. C. Watson's Cybele Britannica, and must therefore be considered to be fairly comparable. We see here that the whole of the Scottish Highlands, with their rich alpine and sub-alpine flora, together with that of the sheltered valleys, lakes, and mountainous islands of the west coast, is yet decidedly less rich in species than Mid-Britain, while both are less rich than South Britain, with its more uniform surface, but favoured with a more southern climate.

The following table shows these facts more distinctly: —

The above figures have been kindly extracted from Watson's volume by my friend the late Mr. W. H. Beeby.

Making a comparison of some countries of Europe we have similar results more clearly shown.

Wales is omitted in order to make the three divisions more equal, and contrasted in latitude only.

The above table shows us a continuous and well-marked increase as we go from north to south, the irregularities in this increase being well accounted for by local conditions and by allowing something for differences of area. Sweden is so much poorer than Britain, owing to its having been completely ice-clad during the glacial epoch, while much of southern Britain was free. Germany is poorer than France, partly on account of its severer continental climate, but also owing to France possessing a greater variety of surface, owing to its including a portion of the loftiest Alps in the south-east, the isolated Pyrenees in the south, the Jura and Vosges mountains on the north-east, and its central volcanic ranges, together with its southern Mediterranean coast, and a very extensive western and northern coast-line. It also has a more diversified soil, owing to far less of its surface being buried under glacial debris. Italy has still greater advantages of a similar kind, and its slight superiority to France, with less than half the area, is about what we should expect. It well illustrates the fact, already ascertained, that difference of area within moderate limits is of far less importance than comparatively slight

Advantages in Boil and climate

Turning now to North America, the following figures from the latest authorities have been supplied by my friend Mr. T. D. A. Cockerell:—

The number of species in proportion to area and position is apparently less than in Europe, though the corresponding latitudes are farther south. Germany and Switzerland combined, with an area less than one-third of the north-eastern and central States, have about as many species; while France, in about the same average latitude, but with less than onethird the area, has considerably more. The south-eastern States extending to 30° S. lat. have about the same number of species as Europe from the Alps and Carpathians southward, while the area of the latter is very much smaller and its latitude about eight degrees farther north.

The whole Mediterranean flora was estimated by Griesbach and Tchikatcheff, in 1875, to comprise 7000 species in an area of about 550,000 square miles; so that the best comparisons that we can make between large European and American areas show a decided superiority in the former. This is no doubt partly due to the much severer winter climate in corresponding latitudes of North America; and perhaps the long persistence of such conditions before the glacial period may be the main cause of the whole phenomenon.

It is, however, in temperate Asia that we find what seem to be the richest extra-tropical floras, at least in the northern hemisphere. The great work of Boissier, Flora Orientalis (1880), describes 11,876 species in the region of East Europe and South-West Asia, from Greece to Afghanistan inclusive, the area of which may be roughly estimated at 2,000,000 square miles. It is a region of mountains and desert3 intermingled with luxuriant valleys and plains, and almost tropically warm in its southern portion. So much of it is difficult of access, however, that the collections hitherto made must fall far short of being complete. Its extreme richness in certain groups of plants is shown by the fact that Boissier describes 757 species of Astragalus or Milk-vetch, a genus of dwarf plants spread over the whole northern hemisphere, but nowhere so abundant as in this region. Europe has 120 species.

The only other extensive area in temperate Asia the plants of which have been largely collected and recently catalogued (by Mr. W. B. Hemsley of the Kew Herbarium) is China and Corea, occupying a little more than iy2 million square miles. The enumeration, completed in 1905, shows 8200 species of flowering plants actually described. But as large portions of this area have never been visited by botanists, and as new species were still flowing in rapidly at the close of the enumeration, there can be little doubt that the total will reach, before many years have elapsed, 10,000 or perhaps 12,000 species. It is, moreover, an area that is especially rich in trees and shrubs, and as these are less collected by the travelling botanist than the herbaceous plants, it becomes still less easy to speculate on the actual number of species this country really contains. Japan, which is probably better known, has about 4000 species in less than one tenth the area, and is thus a little richer than France. It agrees, however, very closely with the Western Himalayas as estimated hy Sir J. D. Hooker.

Coining to the southern hemisphere, we find several examples of exceedingly rich floras. The first to be noticed is Chile, where, in an area of 250,000 square miles, 5200 species of flowering plants have been found. In Australia, New South Wales, with an approximately equal area, has 3105 species, while West Australia has 3242 species in what is probably not more than one-fourth the area, as so much of that Colony is absolute desert.

But richer than either of these is extra-tropical South Africa, where, in about a million square miles, 13,000 species are known, and there are still probably many to be added. The richest portion of this area is the Cape Region, as defined by Mr. H. Bolus, where, in 30,000 square miles, there are about 4500 species of flowering plants. This area is the same as that of southern Britain, and about one-third that of West Australia excluding the tropical portions and the desert.

All these rich areas in the southern hemisphere agree in one respect, they are limited inland by mountains or deserts, and their coast-line is bordered by a considerable extent of sea less than 1000 fathoms deep, and another still larger extent under 2000 fathoms. There is thus a high probability that in all these cases the flora was originally developed in a much larger and more varied area, and that it has been, in comparatively recent times, very greatly reduced in extent, thus crowding the various species together. This has, no doubt, caused the extinction of some, while others show that they are on the road to extinction by their limitation to very narrow areas, as is especially the case with many of the orchids, the heaths, and other characteristic South

African groups. Of course the mere submergence of a large amount of lowlands would not, of itself, enable any of its plants to invade the adjacent undisturbed land; but the subsidence would no doubt have been very slow, and might have included the degradation of lofty mountains.

It would also be accompanied by a lowering of some of the existing area. This would modify the climate in various ways, leading probably to a higher temperature and more moisture, thus giving more favourable conditions generally for a great variety of plants.

For easy reference it may be well to give here a table showing the main facts as to these warm-temperate floras.

S.E. United States.

Mediterranean

Greece to ->
Afghanistan
China and Corea...

Japan

Himalayas, West...
Algeria

Chile

N.S. Wales

W. Australia

Victoria

Tasmania

New Zealand

South Africa

The Cape Region..

Temperate Floras of Smaller Areas compared We will now deal with a series of smaller areas (comparable to our counties) which I have been able to collect from various parts of the world; and I propose to arrange them in order of latitude, from north to south, so as to show 11 more distinctly the influence of climate. Each main division of the globe will be considered separately for convenience of reference, and we begin with Europe, for which materials are the most accessible, though still far from abundant.

The recent publication of a flora of Harjedal, a province of central Sweden, with a mountainous surface and abundant forests, shows how poor is a sub-arctic area which has recently been buried under an ice-sheet. The real wonder is that it should have acquired so rich a flora by the natural means of dispersal from more southern lands.

(I am indebted to Mr. Herbert H. Field for all the data in this table, except where otherwise stated. They are from the original authorities, and he has kindly brought them up to date as far as possible, so that they may be fairly comparable.)

Although very unequal in extent, the various Swiss cantons, which form the bulk of this table, are remarkably similar in their botanical riches, the smallest, most northerly, and least alpine (Schaffhausen) having more than two-thirds the number of species of the Valais, the most southerly, nearly the largest, and the most alpine, the main chain of the Alps for nearly 100 miles forming its southern boundary, and the Bernese Alps its northern. But Schaffhausen geographically connects eastern France with western Germany, and partakes of the rich flora of both countries. This table of the Swiss cantons is also very interesting in showing us that alpine floras are really no richer in species than those of the lowlands, if we compare approximately equal areas. A remarkable illustration of this is the comparison of the Ofengebietes, a district including snowy peaks, forests, and lowland meadows, having almost exactly the same number of species as an equal area near Strasburg, or one around the town of Hertford! Switzerland, though so very unlike Great Britain in situation, climate, and physical conditions generally, yet reproduces in its cantons that curious uniformity in species-production that we found to be the case in our counties. But as Switzerland, though only one-fifth of our area, has a greater number of species by one-third, that superiority is, as a rule, reproduced in its subdivisions. Susa, in Piedmont, with its fertile valleys and snowy Alps, has by far the richest flora of the whole series, due to its warm climate, variety of surface, and complete shelter from the north. Mytilene, the farthest south, has doubtless been impoverished botanically by its large population and extensive fruit culture.

It is, I think, clear that, other things being equal, an alpine flora is not at all richer than a lowland one; but, as we shall see further on, there are indications that the high alpine flora really partakes of that poverty which appertains to high latitudes. It is the novelty and beauty of alpine plants that are so attractive to the botanist and so entrancing to the lover of nature, that give an impression of abundance which is to some extent deceptive, and this is increased by the fact that whole groups of plants which are more or less rare in the lowlands are plentiful at higher altitudes. Two other circumstances add to this impression of abundance — alpine flowers are mostly very dwarf, and being all at the same level, attract the eye more than when distributed over various heights from that of the creeping herb to the summit of lofty trees; and, in addition to this, the shortness of the season of growth leads to a much larger proportion of the species flowering together than on the lowlands at the same latitude.

Extra-European Temperate Floras

The number of floras which are available for comparison with those of Europe are few in number and very widely scattered; but they serve to illustrate the fact already dwelt upon, that the differences of species-population in fairly comparable areas approach to a general uniformity all over the world.

Boulder County is probably one of the most favourably situated areas in the United States. It is only a little west of the centre of the country; it comprises warm valleys and one of the highest of the Rocky Mountain summits, Long's Peak, and being in the latitude of southern Italy and Greece, has abundant sunshine and a warm summer temperature. It thus agrees in physical conditions with some of the alpine cantons of Switzerland, and the number of its flowering plants is almost identical with the average of Zurich, St. Gall, Schwyz, etc., which have almost the same mean area.

Washington, D.C., with, an undulating surface just above the sea-level, and a fair amount of forest and river-swamp, agrees very well with the mean of Strasburg and Schaff hausen, somewhat similarly situated, but at a higher latitude.

The two mountain areas in Japan, which Mr. Hayati informs me have been well explored, show an unexpected poverty in species, being much below any of the Swiss cantons of equal area. This is the more remarkable as Japan itself is equal to the most favoured countries in Europe — France and Italy; and this again indicates the combined effect of altitude and insularity in diminishing species-production, the lower parts of these Japan mountains being highly cultivated.

In the southern hemisphere we come first to the Cape Peninsula, as limited by Mr. Bolus, and often thought to be the richest area of its size in the world. There are 80 species of heaths and nearly 100 species of orchises in this small tract only a little larger than the Isle of Wight . No other similar area in the temperate zone approaches it, though it is possible that an equally rich area of the same extent might be found in temperate Sikhim, where several distinct floras meet and intermingle. But as the Valais is nearly as rich as Sikhim, and Susa with one-fourth the area is still richer, it is quite possible that smaller areas may be found as rich as that of the Cape Peninsula. The best third of the Susa district would probably approach closely if it did not quite equal it. Temperate Australia is another country which has obtained a high reputation for its floral riches, for much the same reason as the Cape of Good Hope. In 1810 Robert Brown made known the extreme interest of the Australian flora, both from its numerous hitherto unknown types of vegetation and the variety and beauty of its flowering shrubs. It was therefore supposed that the country was not only botanically rich in new species and genera, but actually so in the number of its species in proportion to area, and this may really be the case with limited portions of West Australia (for which I have been able to obtain no detailed information), but is certainly not the case for New South Wales, Victoria, or Tasmania. Cumberland County, which contains Sydney and the celebrated Botany Bay, is only a little richer than our counties of about the same area, while the celebrated district of Illawarra only produces about the same number of plants as does Middlesex, which has, exclusive of London, a less area. Many parts of Europe in a similar latitude are much more productive.

There is, however, one world-wide group of plants in which, as regards small areas, eastern temperate Australia seems to be pre-eminent — that of terrestrial Orchids. Mr. H. Bolus, in his work on the Orchids of the Cape Peninsula, states that there are 102 species in an area of 197 square miles; and he quotes Mr. Fitzgerald, the authority on the Orchids of Australia, that "within the radius of a mile" he remarks, "certainly no such concentration would be found on the Cape Peninsula." I think it probable that the "radius of a mile" is meant a mile beyond the city and suburbs of Sydney, in which case it might be an area of from 10 to 20 square miles. Or it might mean a picked area of about 4 square miles of uncultivated land some miles away. That this latter is quite possible is shown by my friend Mr. Henry Deane, who has for many years studied the flora of 20 square miles of country around Hunter's Hill, on the Paramatta River, to the north-west of Sydney, and he here obtained 59 species of Orchids out of a total of 618 flowering plants. The sequence of the first eight orders in number of species is as follows: —

1. Orchidese 59

2. Myrtacese 55

3. Legumino8EB 53

4. Proteacese 35

5. Composite 32

6. Graminete 31

7. Cyperaceae 30

8. EpacridesB 25

In New South Wales, as a whole, Leguminosre are first and Orchids fifth in order. There is probably no other purely temperate flora in which Orchids so distinctly take the first place as in the vicinity of Sydney.

The contrast in the numbers of species, in approximately comparable areas, between these two groups of warm-temperate floras is fairly well marked throughout, there being, with few exceptions, a decided preponderance in the southern hemisphere. South Africa is undoubtedly richer than China, though its area is less; and perhaps than the oriental region of Boissier; while Chili compares favourably with Japan or the Western Himalayas. Still, the differences are not very pronounced, and are such as appear due to their past history rather than to any existing conditions. Those in the northern hemisphere (except perhaps in the case of the Mediterranean coasts) have probably been for a considerable period stationary or expanding; while those in the south have almost certainly been far more extensive, and in later geological time have been contracting, and thus crowding many species together, as already explained.

Chapter IV - THE TROPICAL FLORAS OF THE WORLD

the idea of the tropics is always associated with that of a grand development of luxuriant vegetation, yet this characteristic by no means applies to the whole of it, and the inter-tropical zone presents almost as much diversity in this respect as the temperate or even the frigid zones. This diversity is due almost wholly to the unequal and even erratic distribution of rainfall, and this again is dependent on the winds, the ocean currents, and the distribution and elevation of the great land masses of the earth.

Once a year at each tropic the sun at noon is vertical for a longer period continuously than in any other latitude, and this, combined with the more complex causes above referred to, seems to have produced that more or less continuous belt of deserts that occurs all round the globe in the vicinity of those two lines, but often extending as far into the tropics as into the temperate zone. In a few cases similar conditions occur so near the equator as to be very difficult of explanation. It will be instructive to review briefly these arid regions, since they must have had considerable influence in determining the character of the tropical vegetation in their vicinity. Beginning with the Sahara, pre-eminently the great desert of our globe, if we take it with its extension across Arabia, we find that it occupies an area nearly equal to the whole of Europe, and that the African portion extends as far to the south as to the north of the tropic of Cancer. It thus eats away, as it were, a great slice of what in other continents is covered with tropical vegetation, and forms a vast barrier separating the tropical and temperate floras, such as exist * in no other part of the world. Passing eastward, the desert regions of Baluchistan, Tibet, and Mongolia are situated farther and farther north; while abundant rainfalls and a truly tropical vegetation extend far beyond the tropic into what is geographically the temperate zone. This is especially the case along the southern slopes of the Himalayas and their extension into Burma and southern China.

In the western hemisphere we have the desert regions of Utah, Arizona, and parts of northern Mexico all in the temperate zone.

In the southern hemisphere the desert interior of central and western Australia reproduces the Sahara on a smaller scale. In Africa there is the Kalahari desert, mostly south of the tropic, but on the west coast extending to about 15° from the equator. In South America an arid belt of almost complete desert extends along the coast from near the equator to Coquimbo in Chili, whence crossing the Andes it stretches south-eastward into Patagonia. Even more extraordinary is the fact that in north-eastern Brazil, in the provinces of Ceara, Pernambuco, and Bahia, are considerable areas which have such small and uncertain rainfall as to be almost deserts, and are practically uninhabitable. And this occurs only a few hundred miles beyond the great Amazonian forests of Maranham in 3° S. latitude.

With the exception of these areas of very deficient rainfall, it will, I believe, be found that the intertropical regions of the globe are the most productive in species of plants, and, further, that as we approach the equator, where the temperature becomes more uniform throughout the whole year and the amount of rain and of atmospheric moisture is also more evenly distributed, the variety of the species reaches a maximum. There is some evidence to show that this is the case not only in the region of the great forests, but also in those less humid portions which are more or less open country with a vegetation of scattered trees and shrubs, to"ether with herbaceous and bulbous plants which cover the ground only during the season of periodical rains, as will be shown later on.

The Tropical Flora of Asia

As no part of the Asiatic continent (except the Malay Peninsula) approaches within eight degrees of the equator, its tropical area is very limited, barely reaching one and a quarter million square miles; and even if we add to it the whole of the Malay Archipelago, the Philippines, New Guinea, and tropical Australia, it will not much exceed two millions. Yet these countries are in general so richly clothed with a tropical vegetation, that the actual number of their species will almost certainly surpass those of Africa, with three times their tropical area, and may approach, though I do not think they will equal, those of tropical America, or even of tropical South America only. Portions of this area have been well explored, especially the great peninsulas forming India proper, Burma, and Indo-China; but the two latter are only sufficiently known to show their extreme richness botanically, and the same may be said of the numerous large islands of the Malay Archipelago. We may, I think, be certain that what is known of these two sub-regions is less than what remains to be made known.

Sir Joseph Hooker estimates the whole flora of British India at 17,000 species, including the desert flora of the Indus valley and the rich temperate and alpine floras of the Himalayas above an elevation of 6500 feet in the east and above 4000 or 5000 in the west. But as I am here dealing with tropical floras, it is only necessary for me to give such figures as are available for the specially tropical portions of it.

The Indian Peninsula, bounded on the north by a curving line of hills and mountains which run not far from the line of the geographical tropic, is somewhat poor when compared with the abounding riches of Burma and Indo-China; yet it possesses areas, especially in the Western Ghats and the Nilgiris, of great botanical richness and beauty, much of which is still inadequately explored. Arid conditions prevail over much of its surface, both in the north and in the central plains, but these are interspersed with deep moist valleys containing a vegetation allied to that of Assam. As a result of this greater aridity than that of the countries farther east, the peninsula is much poorer in Orchids, having only 200 species against 700 in Burma; but it has a great excess in Grasses, Umbelliferae, Labiate, and Boragineae, and a corresponding poverty in Melastomaceae, Gesneraceae, Myrtaceae, Palms, and other more peculiarly tropical orders.

Ceylon, though so closely connected with the peninsula, has a distinct flora, nearly 800 of its species and 23 of its genera being "endemic," that is, wholly peculiar to it. It has much stronger affinities with the Malayan flora, due in part, no doubt, to its moister and more uniform insular climate, but also to some features of its past history.

The figures given in the table of the chief tropical floras of the world (p. 45) indicate, so far as possible, the actual numbers of the species now existing in collections, and, for purposes of comparison, require certain allowances to be made.

Burma and Indo-China are much less known than Peninsular India, yet in a smaller area each has a considerably larger number of species; while the Malay Peninsula, which is more completely forest-clad, is in proportion to its area still richer, due mainly to its more equable equatorial climate. The following table of the chief natural orders is taken from Mr. Hemsley's Introduction to the Flora of Mexico and Central America: —

British India (17,000 species)

1. Orchidese 1060

2. Leguminosae 831

3. Graminese 800

4. Robiacese 611

5. Euphorbiacese 624

6. Acanthacese 503

7. Composite 598

8. Cyperacesj 385

9. Labiatae 331

10. Urticacese 305

11. Asclepiadese 249

12. Rosacese 218

The sequence of the orders is taken from Sir J. Hooker's Sketch of the Flora of British India, a most interesting and instructive pamphlet published in 1906, but the numbers of species are inserted from Mr. Hemsley's work dated 1888. Since then the total numbers have increased from 13,647 to 17,000, about one-fourth, so that the above figures will have to be increased in that proportion; but they will have increased unequally, as shown by the fact that the orchids are estimated by Sir. J. Hooker at 1600.

There is apparently no other extensive region as varied in soil and climate as British India, in which Orchids occupy the first place in the sequence of the orders. This is due to their great numbers in Burma, but even more to the fact that in the whole range of the Himalayas epiphytic Orchids extend far into the temperate zone, while in the more eastern ranges they are pre-eminently

abundant. This is well shown by the well-explored district of Sikhim, in which Orchids take the first place, not only in the tropical lowlands, but in the 'temperate zone from 6500 to 11,500 feet above the sea-level. It is possible that in some parts of the temperate Andes, where Orchids are known to be extremely plentiful, the same proportion may exist; but no such district appears to have been yet sufficiently explored by botanists. Before going further it will be as well to give the sequence of the orders in the districts already referred to.

Tropical Sikhim (up to 6500 feet) (2000 species)

1. Orchidese (1)

2. Leguminosse (2)

3. Grammea (3)

4. Urticacese (8)

5. Euphorbiacee (5)

6. Cyperacese (7)

7. Rubiaeeae (4)

8. Composite (9)

9. Asclepiadea;

10. Acanthaceae (6)

The numbers enclosed in brackets give the sequence in Burma, which is very similar, except that Scitamineae (the Gingerworts) is the tenth order, while Asclepiadeae is excluded.

The Malay Peninsula differs still more from the flora of north-eastern India, in being more exclusively equatorial and typical Malayan, and in this case I am able, through the kind assistance of Mr. J. T. Gamble, to give the number of species for the first twelve orders, which will be interesting for comparison with others to be given further on.

Malay Peninsula (5138 species)

1. Orchidacece 540

2. Rubiacese 312

3. Leguminose 266

4. Euphorbiacese 255

5. AnonaceoB 178

6. Palms; 163

7. Lauracese 153

8. Graminese 144

9. Zingiberaceae (Scitaminese) 137

10. Gesneraceae 131

11. Acanthaceae 128

12. Cyperacese 127

Ferns 368 species.

This may be considered a typical Malayan flora of the lowlands, the mountains not being sufficiently extensive or lofty to favour the abundance of Compositffi found in Sikhim and Burma; while the Anonacese (custard apples)'; the Lauraceae (true laurels), producing cinnamon, cassia, and many other species and odoriferous nuts, barks, and fruits, and, above all, the noble order of Palms, which have always been considered the most characteristic of the vegetable productions of the tropics, all take a higher place than in any part of India. Sir Joseph Hooker estimates the known palms of Burma at 68, so that it is hardly probable that any future additions will bring them to an equality with the much smaller Malay Peninsula. This affords another, illustration of the increase in the number of species of Pa^s as we approach the equator, and renders them, with the Rubi'acea&;"iim' Euphorbiacese, and the Orchids, the most typical of equatorial orders of plants.

Through the kindness- of- Professor R. fi. Yapp I am able to give here two beautiful photographs" "taken by himself in the Malayan forests, which give an -excellent idea of the general character of the vegetation, though unfortunately not many of the trees or other plants shown can be identified; but a few remarks may be made as to their general character.

Very prominent on the large trunk in the foreground is the bird's-nest fern (Asplenium nidus), very common in the forests and also in our hot-houses. Above it is a climbing fern (Acrostichum scandens). On the left is a light-coloured slender tree with knobs or spines, and having many climbers about it. This may be a palm.

Among the tangled vegetation in every direction are slender lines, upright, oblique, or beautifully curved; these are the lianas or forest-ropes, many being rattans (palms), but others belong to various dicotyledonous plants of many natural orders; and these form one of the most constant and characteristic features of the damp equatorial forests both in the eastern and western hemispheres. The slender shrub to the left, with a spray of foliage showing light against the dark trunk, may be an Ixora. On the left, crossing the spined trunk, is one of the climbing palms or rotangs (commonly called "rattan" in England), while the dense mass of vegetation to the right is largely composed of slender bamboos.

The other view (Fig. 2) is more characteristic of the dense Malayan forest, where trees of all sizes, climbers of many kinds, and tangled undergrowth of dwarf palms, shrubs, and herbs, fill up every spot on which plants can obtain a footing. The large twisted climber in the foreground is perhaps a Bauhinia (Leguminosse), though it may belong to any of a variety of genera, and even orders, which form such ropes. The distinct ribbed leaf showing to the left of the most twisted part is probably one of the Melastomacese. The dwarf palms in the foreground are also very characteristic. Just above where the twisted climber goes out of sight is a climbing fern (Acrostichum scandens), and it seems to grow on a knobbed or spined trunk like the one in the other picture. A close examination will show that the five or six trunks of tall trees visible have each peculiarities of growth or of bark

which prove them to belong to quite distinct species. The very straight one to the left of the rope-climber is a palm. The abundance of climbers is shown by the numerous very fine white or black lines here and there crossing the picture, especially in the lower portion, each representing a liana or forest-cord striving to work its way upward to the light. In the original photograph the tangled mass of foliage in the foreground is seen to consist of a great variety of plants. The fern with very narrow fronds at the base of the rope ia Nephrolepis cordifolia, while the large closely pinnate leaves in the foreground, as well as the smaller ones, truncate at the ends, are various species of palms. The prints, unfortunately, do not show all the details in the original photographs.

Professor O. Beccari, in the interesting volume on his explorations in Borneo, tells us that when building a house on the Mattang mountain in Sarawak, three straight trees, each about 9 inches diameter, were found growing at such a distance and position as to be exactly suitable for three of the corner posts of the house in which he afterwards resided during some months' collecting there. When the tops were cut off, and he could examine them, he found them to belong to three different genera of two natural orders, and also that they were all new species probably peculiar to Borneo. Another illustration he gives of the great productiveness of these forests in species of trees is, that in the two months he lived in his forest home he obtained fifty species of Dipterocarps (an order in which he was much interested) in two months' collecting and within a mile of his house. This order of plants consists entirely of large forest-trees, and is especially characteristic of the true Malay flora from the Peninsula to Java, Celebes, and the Philippines. It is probably at its maximum in Borneo, as Professor Beccari gives it as the twelfth in the sequence of orders as regards number of species: (1) Rubiacese; (2) Orchidacese, 200 species; (3) Euphorbiacese; (4) Leguminosae; (5) Anonacese; (6) Melastomaceae; (7) Palma;, 130 species; (8) Urticacese; (9) Myrtaceae; (10) Aracese; (11) Guttiferse; (12) Dipteroearpeae, 60 species. This list, it must be remembered, refers to the "primeval forests" alone, taking no account of the widespread tropical flora found in old clearings and in the vicinity of towns and villages.

Before leaving the Asiatic continent I must say a few words as to the figures given in the table for the plants of IndoChina, comprising the whole territory between Burma and China, which has been at least as well explored by French botanists as have Burma and the Malay Peninsula by ourselves. Having been unable to obtain any statistical information on this area from English botanists, I applied to M. Gagnepain, of the botanical department of the Natural History Museum of Paris, who has kindly furnished me with the following facts. They have at the Museum very large collections of plants from all parts of this territory, collected from 1862 onwards, but great numbers of the species are still undescribed. Only small portions of the flora have been actually described in works still in process of publication; but, from his knowledge of this extensive herbarium, he believes that the flora of Indo-China, as actually collected, comprises about 7000 species.

Flora of the Malay Islands

The great archipelago (usually termed the Malayan, or "Malaisia"), which extends from Sumatra to New Guinea, a distance of nearly 4000 miles, and from the Philippines to Timor, more than 1000 miles, comprises an actual land area of 1,175,000 square miles, which is fully equal to that of all tropical Asia, even if we include the lower slopes of the Eastern Himalayas. This great land-area has the advantage over the continent of being mainly situated within ten degrees on each side of the equator, and having all its coasts bathed and interpenetrated by the heated waters of the Indian and Pacific Oceans. These conditions have led to its being almost wholly forest-clad, and to its possessing a flora comparable in luxuriance and beauty with that of the great Amazonian plain, situated almost exactly at its antipodes.

The western half of this archipelago has undoubtedly been united with the continent at a comparatively recent geological epoch, and this portion of it, both in its animal and vegetable life,

is nearly related to that of the Malay Peninsula and Siam; but the three chief islands, Sumatra, Borneo, and Java, are of such great extent, and have such differences, both of geological structure and of climate, as to give to each of them a distinct individuality, combined with, in all probability, a wealth of species fully equal to that of the adjacent continent.1 The remainder of the Archi??????????

The Director of Kew Gardens informs me that, in 1859, the flora of the "Netherlands India," extending from Sumatra to New Guinea but excluding the Philippines, was estimated by the Dutch botanists to possess 9118 pelago has had, however, a different origin, and has been much longer isolated. Celebes and the Philippines have certain features in common, indicating a remote but partial union with, or approximation to, the Asiatic continent, and probably subsequent submergence to an extent that has greatly impoverished their mammalian fauna. New Guinea, however, , stands alone, not only as the largest island in the world (excluding Australia), but as, in some respects, the most remarkable, both by its extraordinary length of about 1500 miles, and its possession of a range of snow-capped and glaciated mountains. Biologically it is unique by having produced tjie wonderful paradise-birds, numbering about 50 species; while its. true land-birds already known amount to about 800 species, a number very far beyond that of any other island — Borneo, with its almost continental fauna, having about 450, and the great island-continent of Australia about 500.

But, as regards plant-life, this vast archipelago is much less known than that of inter-tropical Asia, though it will, I believe, ultimately prove to be even richer. Of the two larger western islands, Sumatra and Borneo, I can obtain no estimate of the botanical riches, and the same is the case with the whole of the Moluccas. Java is better known, but still inadequately. There remains for consideration the Philippines, Celebes, and New Guinea, as to which we have recent information of considerable interest.

Since the Americans have established themselves in the Philippines they have done much to make known its natural products; and Mr. E. D. Merrill, botanist to the Bureau of Science at Manilla, has greatly increased our former scanty knowledge of its very interesting flora. He has been so kind as to send me several of his published papers, as well as a complete MS. list of the families and genera of vascular plants, with the number of species known to inhabit the islands up to species of flowering plants then known. As such large portions of all the islands are almost unknown botanically, it seems not improbable that the actual numbers may be three times as many.

August 1909. This shows the large total of 4656 indigenous flowering plants already collected, though extensive areas in all the islands, and more especially in the great southern island Mindanao, are altogether unexplored. Besides these, there are no less than 791 ferns and their allies, a number which is probably not surpassed in any other country of equal extent and as imperfectly explored. The Malay Peninsula has rather more flowering plants, but its ferns are only 368, as given in Mr. Ridley's list, issued in 1908. The following is the sequence for the first twelve orders (excluding introduced plants) from Mr. Merrill's lists: —

Philippines (4656 species)

1. Orchideae 372

2. RubiacesB 267

3. Leguminosae 258

4. Euphorbiacea 227

5. Urticacea?, with Horaces; .. 221

6. Grammea 2 IS

7. Cyperacea 137

8. Myrtacese 105

9. Palm» 100

10. Asclepiadese 94

11. Melastomacea 86

12. Composite 83

Ferns 791 species.

Comparing this with the Malay Peninsula (p. 48), we find the first four orders in similar places of the sequence, while Anonaceae, Scitamineae, and Melastomaceae give way to Myrtaceae, Palmae, and Asclepiadeae.

The Philippine flora has a large proportion of its species peculiar to it. In some families, such as the Ericaceae, Gesneraceai, Pandanaceae, etc., almost all are so. Among species of limited range some interesting facts have been ascertained by Mr. Merrill. Of identical or closely allied species in surrounding countries, 39 have been found to extend to northern India, 38 to China, and 21 to Formosa, while only 9 have been noted in the nearer islands of Borneo, Java, and Sumatra. But the most decided similarity is found between the Philippines and Celebes, 76 species having been found either identical or represented by allied species; and, considering how very imperfectly the Celebesian flora is known, the amount of similarity may be expected to be really very much greater. A similar relation of the mammals, birds, and insects of the two island groups have been pointed out in my Island Life, and leads to the conclusion that the islands have, at some distant period, been almost or quite united.

The Flora of Celebes

Very little was known of the flora of this extremely interesting island till 1898, when Dr. S. H. Koorders published a large quarto volume of nearly 750 pages, giving the results of his own collections during four months in the north-east peninsula (Minahasa) together with all that had been made known by the few botanists who had previously visited the islands.

Dr. Koorders himself collected or examined 1571 species, of which nearly 700 were trees; and he has given lists of 468 species which had been collected in various parts of the island by other botanists, making a total of 2039 species of flowering plants. The great peculiarity of the flora is indicated by the fact that nineteen of the genera of trees are not known in Java; while the affinities are, on the whole, more Asiatic than Australian, as is the case with the animals. The closest affinity is with the Philippines, as with the birds and mammals, as indicated by a new genus of trees (Wallacesdendron cclebicum), allied species having been since found in the adjacent group. Dr. Koorders also remarks that some of the plants have very peculiar forms, almost comparable with those I have pointed out in its butterflies. One of these is no doubt the new fig-tree (Ficus minahassa), a drawing of which forms the frontispiece of this volume. It is about 40 feet

high, the fruits hanging thickly from the branches in strings 3 or 4 feet long, giving it a very remarkable appearance. His general result is, that the flora is very rich in peculiar species, but rather poor in peculiar genera.

As this work is wholly in Dutch, I cannot give further details, but having counted the species in each natural order I will add a list of the ten largest orders for comparison with others here given: —

1. Urticacese 158

2. Lcguminosae 105

3. Rubiaceae 103

4. Euphorbiacea 100

5. Orchideie 81

6. PalmacesB 78

7. Gramineae 71

8. Composite 63

9. Myrtaceae 68

10. Meliaceae 58

I will add a few words on a point of special interest to myself. Having found that the birds and mammals of the eastern half of the Archipelago were almost wholly different from those in the western half, and that the change occurred abruptly on passing from Bali to Lombok, and from Borneo to Celebes (as explained in chapter xiv. of my Malay Archipelago), the late Professor Huxley proposed that the straits between them should be called "Wallace's Line," as it forms the boundary between the Oriental and Australian regions. But later, as stated in my Island Life, I came to the conclusion that Celebes was really an outlier of the Asiatic continent but separated at a much earlier date, and that therefore Wallace's Line must be drawn east of Celebes and the Philippines.

The Flora of New Guinea

Early botanical explorers in New Guinea were disappointed by finding the flora to be rather poor and monotonous. This was the case with Prof. O. Beccari, who collected on the northwest coast; and Mr. H. O. Forbes, of the Liverpool Museum, informs me that he formed the same opinion so long as he had collected on the lowlands near the coast, but that on reaching a height of near 1000 feet a much richer and quite novel flora was found. Prof. Beccari, who is at this time studying the palms from various recent Dutch, British, and German collections, now thinks that the number of species in New Guinea is probably as great, in equal areas, as in Borneo or the Malay Peninsula, but that the species are not so distinctly marked as in those countries. They are what he terms second-grade species as compared with the first-grade species of the latter. But he forms this opinion chiefly from the palms, of which he makes a special study.

Dr. Lauterbach, who is engaged in describing the new plantcollections recently obtained, is evidently much impressed by them. He states that down to 1905 there were known from German New Guinea 2048 species of flowering plants, while about 1000 additional species had been found in

other parts of the island. But the last Dutch expedition, from the portions of the collections he has examined, will probably add another 1000 species. Again he says that from collections recently made by Schlechter in German New Guinea, and through letters from him, an " immense increase in the number of species is in prospect." A few more years of such energetio collecting will disclose more of the treasures of this the largest of the great tropical islands, while its grand central chain of mountains may be expected to produce a large amount of novelty and beauty. Dr. Lauterbach's conclusion, in a letter to Prof. Beccari, is as follows: " I believe, indeed, that one would not estimate it too highly if one reckoned the sum total of the Papuan Phanerogams at a round number of 10,000." Considering that New Guinea has more than double the area of the Philippines (which Mr. Merrill also estimates may contain 10,000 species); that it is nine times the area of the Malay Peninsula, which has already more than 5000 species described; that it has the enormous length of 1500 miles, all between 0° and 11° of S. latitude; that it has an extremely varied outline; that it possesses abundant diversity of hill and valley, and a central range of mountains which have now been proved to rise far above the line of perpetual snow; and finally, that it is almost everywhere clad with the most luxuriant forests, and enjoys that moist and equable equatorial climate which is proved to be most favourable to vegetable as well as to insect life, it seems to me probable that it may ultimately prove to be among the richest areas on the earth's surface. In bird-life it seems likely to surpass any other equal area, and it may do so in plants also, but in the luxuriance of insect-life I am inclined to think that it will not equal the richest portions of equatorial America.

The only other tropical flora in the eastern hemisphere included in my table is that of Queensland, which is mostly within the tropics, but a large part of the interior consists of elevated plains with a rather arid climate where little of the luxuriance of tropical vegetation is to be met with. Probably not more than one-fourth of the area is clothed with a typical tropical vegetation, but this has as yet been very partially explored botanically. The number of species compares best with that of the Indian peninsula, with which it agrees nearest in area; and both these countries, though very rich in certain districts, cannot be considered to present examples of the full luxuriance of tropical vegetation.

Floras of Tropical Africa and America

The floras of the remainder of the tropics are, for various reasons, of less interest for the purposes of this work than those of the eastern hemisphere, and a very brief reference to them will be here given. Although Africa has a tropical area nearly equalling those of Asia and America combined, it has a flora of less extent and of less botanical interest than that of either of them. Its area of luxuriant tropical forest is comparatively of small extent, and much of it is yet unexplored, so that the number of species in the latest enumeration is perhaps more than might have been expected. The islands belonging to Africa — Madagascar, Mauritius, Bourbon, and the Seychelles — are, however, of extreme interest, on account of the remarkable character, as well as the extreme speciality, both of their plants and animals. As, however, these peculiarities have been rather fully discussed in chapter xix. of my Island Life, it is not necessary to repeat them here. I may state, however, that in Mauritius there are about 40 peculiar genera, nearly all of shrubs or trees, while no less than 5 peculiar genera of palms are found in the Seychelle Islands. The following table of the sequence of orders in Madagascar may be of interest for comparison with those of other large floras.

Madagascar (5000 species)

1. Legum incase 346 5. Cyperacese 160

2. Compositae 281 6. RubiacesD 147

3. Euphorbiacese 228 7. Acanthacese 131

4. Orchidesa 170 8. Gramineas 130

Ferns 318 species.

The above table was made when the whole flora consisted of 3740 known species. As it is now increased to nearly 5000, the figures given will have to be increased by one-third on the average. But as this increase may be very unequal, they have been left as given.

Flora of Tropical America

We have seen reason to believe that the temperate flora of North America is somewhat poorer than that of Europe and northern Asia, though the south temperate zone as represented by Chili is exceptionally rich. But there can be little doubt that its whole tropical flora is extremely rich; and it may not improbably be found to contain nearly as many species of plants as all the rest of the tropical world. This may perhaps be indicated by the fact that it has fourteen or fifteen natural orders quite peculiar to it, while the remainder of the globe has about the same number; but, taking account of three other orders that are almost exclusively American, Mr. Hemsley is of opinion that the balance is on the side of America.

America has the great advantage of possessing the largest continuous or almost continuous extent of tropical forest on the globe. The vast Amazonian plain forms its central mass of about two millions of square miles of almost continuous forest. From this there are northward extensions over the Guianas and parts of Venezuela, along the north-east branch of the Andes to Trinidad, and thence through Panama and Honduras to the lowlands of eastern and western Mexico. Southward it sends out numerous branches along the great river valleys into central and western Brazil, and thence along the eastern slopes of the Andes to beyond the southern tropic; while all along the Atlantic coast there is a belt of equal luxuriance, spreading out again in the extreme south of Brazil and Paraguay to about 30° of south latitude. We could thus travel continuously for about five thousand miles from Mexico to northern Argentina in an almost unbroken tropical forest, or about the same distance down the Amazon valley to Paranahyba in northern Brazil, and then, after a break of a few hundred miles, along the east coast forests for about two thousand miles more. This probably equals, if it does not surpass, the tropical forest area of the rest of the globe.

We must also take into account the fact that, as a rule, tropical forests differ from those of the temperate zone in the species not being gregarious, but so intermingled that adjacent trees are generally of distinct species, while individuals of the same species are more or less widely scattered. When, from some commanding elevation, we can look over a great extent of such a forest, we can usually see, at considerable intervals, a few, perhaps a dozen or more, small patches of identical colour, each indicating a single tree of some particular species which is then in flower. A few days later we see a different colour, also thinly scattered; but in the region of the most luxuriant tropical forests we never see miles of country thickly dotted with one colour, as would often be the case if our European oaks or beeches, birches or pines, produced bright-coloured flowers. This fact would alone indicate that the tropical forests are wonderfully productive in species of trees and woody climbers, and hardly less so in shrubs of moderate size, which either live under the shade of the loftier trees or line the banks of every river, stream, or brooklet, or other opening to which the sun can penetrate. In those latter positions there is also no lack of herbaceous plants, so that the whole flora is exceedingly rich, and the species composing it rapidly change in response to the slightest change of conditions.

The difficulty of collecting and preserving plants in these forest-clad areas is so great, and the number of resident botanists who alone could adequately cope with the work is comparatively so small, that it is not surprising to find that the great forest region of tropical America is still very imperfectly known. Only two considerable areas have been systematically collected and studied — in North America the entire tropical portion from South Mexico to Panama commonly known as "Central America "; and in South America the vast areas of Brazil, itself comprising more than half of tropical South America. The comparatively easy access to this latter country, the attraction of its gold and diamond mines, its extensive trade with England and with other civilised countries, have all led to its being explored by a long series of botanists and travellers, the result of whose labours have been incorporated in a monumental work, the Flora Brasiliensis of Martius, recently completed after more than half a century of continuous labour.

The number of species described in this work is 22,800, an enormous figure considering that its area is less than half that of tropical Africa, and that probably two-thirds of its surface has never been thoroughly examined by a botanist. The Central American flora, as described by Mr. Hemsley,1 in less than one-third of the area of Brazil has about 12,000 species, and this is no doubt a much nearer approach to its actual numbers than in the case of Brazil.

As regards the additions that may yet be made to that flora, and especially to the great forest region of adjacent countries, I will quote the opinion of a very competent authority, the late Dr. Richard Spruce, who assiduously studied the flora of the Amazon valley and the Andes for fourteen years, and himself collected about 8000 species of flowering plants, a large proportion of which were forest-trees. In a letter to Mr. Bentham from Ambato (Ecuador), dated 22nd June 1858, he writes: " I have lately been calculating the number of species that yet remain to be discovered in the great Amazonian forest from the cataracts of the Orinoco to the mountains of Matto Grosso. Taking the fact that by moving away a degree of latitude or longitude I found about half the plants different as a basis, and considering what very narrow strips have up to this day been actually explored, and that often very inadequately, by Humboldt, Martius, myself, and others, there should still remain some 50,000 or even 80,000 species undiscovered. To any one but me and yourself, this estimation will appear most extravagant, for even Martius (if I recollect rightly) emits an opinion that the forests of the Amazon contain but few species. But allowing even a greater repetition of species than I have ever encountered, there cannot remain less than at least half the above number of species undiscovered."

Spruce was one of the most careful and thoughtful of writers, and would never have made such a statement without full consideration and after weighing all the probabilities. In the same letter he describes how, when leaving the Uaupes River after nine months of assiduous collecting there in a very limited area, a sunny day after continuous rains brought out numerous flowers, so that as he floated down the stream he saw numbers of species quite new to him, till the sight became so painful that he closed his eyes to avoid seeing the floral treasures he was obliged to leave ungathered! At Tarapoto he observed that some flowers opened after sunset and dropped off at dawn, so that they would be overlooked by most collectors, while of many the flowering season was very limited, sometimes to a single day. Join to this the scarcity of individuals of many species scattered through a trackless forest, and it is evident that the true floral riches of these countries will not be fully appreciated till numerous resident botanists are spread over the entire area.

From the facts of distribution given by Mr. Hemsley we learn that about one-twelfth of the species of Central America are found also in South America, and that about 700 are found in the eastern portion from Venezuela to Brazil, so that probably not more than 500 reach the latter country. The combined floras of Brazil and Central America, even as now imperfectly known, will therefore reach about 34,300 species. Now, considering how very rich the eastern slopes of the Andes are known to be, and that the average width of the forest zone between Brazil and the Andes is from

400 to 500 miles, while the plateaux and western slopes also have a rich and distinct flora and fauna, I think it will be admitted, that whatever the combined floras of Brazil and Central America may amount to, that number will be nearly or quite doubled when the entire floras of Venezuela, the Guianas, Colombia, Ecuador, and Peru are thoroughly explored. As, roughly speaking, Brazil contains about half the great tropical forests of South America, and allowing that its portion is the best known, we may fairly add one-third of Spruce's lower estimate (25,000) to its present numbers, which will bring the whole to very nearly 40,000 species. By doubling this, we shall reach 80,000 as. the probable number of species existing in tropical South America.

As this number is considerably more than half the latest estimate of the number of flowering plants yet known in the whole world (136,000 species),1 more than half of which number will be absorbed by the comparatively well-known temperate floras, it will be apparent that we have at present a very inadequate idea of the riches of the tropical regions in vegetable life. This result will be further enforced by additional facts to be adduced later.

I will here give a table of the few known statistics for tropical America, which, though very fragmentary, will serve to show the basis on which the preceding estimate of probable numbers rests.

Note.— The number of Trinidad plants is from a Herbarium List by Mr. J. H. Hart, F.L.S., Superintendent of the Botanical Gardens, published in 1908. He states, however, that "a large amount of material has not been arranged under natural orders" and that "the later added specimens have not been arranged for several years past." But he adds, "As it now stands, there is a good representation of the Trinidad flora."

Mr. W. B. Broadway of Tobago, who has lived several years in Trinidad and has studied its flora, informs me that from his own observation he believes that many hundreds of additional species remain to be collected; and this is what we should expect, as the island is a continental one; while Jamaica, though larger, is almost oceanic in character, and is therefore almost certain to have a less complete representation of the tropical American flora than the former island.

The great work on the flora of Mexico and Central America deals, unfortunately for my present purpose, with an area in which temperate and tropical, arid and humid conditions are intermingled to a greater extent even than in the case of British India already referred to. Mexico itself comprises about four-fifths of the whole area, and nearly half its surface is north of the tropio and is largely composed of lofty plateaux and mountains. It thus, 9upports a vegetation of a generally warm-temperate but rather arid type; and these same conditions with, a similar flora, also prevail over the great plateau of southern Mexico. This type of vegetation extends even farther south into the uplands of Guatemala, so that we only get a wholly tropical flora in the small southern section of the area from Nicaragua to Panama.

The following table of the twelve largest orders in the whole flora will be of interest to compare with that of British India:

Mexico And Central America (11,088 species)

The most remarkable feature in this table is the great preponderance of Compositse characteristic of all the temperate and alpine floras of America, and the presence of Cactaceae, Solanacefe, Piperacese, and Malvaceae among the 12 predominant orders, the first of the four being confined to America.

It may be noted that of the 12 most abundant orders 8 are the same in these two very widely separated parts of the earth. But even this table greatly exaggerates the actual difference between the two very distinct floras. There are 175 natural orders in British India, and of these only 20 are absent from the Mexican region. Of these 20 orders 18 have less than 10 species (5 of them having only 1 species), so that, judging from the great types of plants, the difference is wonderfully small We can therefore understand Sir Joseph Hooker's view, that there are only two primary geographical divisions of the vegetable kingdom, a tropical and a temperate region.

It must be remembered, however, that even when the series of orders in two remote areas are nearly identical, there may be a very marked difference between their floras. Orders that are very abundant in one area may be very scarce in the other; and even when several orders are almost equally abundant in both, the tribes and genera may be so distinct in form and structure as to give a very marked character to the flora in which they abound. Thus the Urticaceae include not only nettles, hops, and allied plants, but mulberries, figs, and breadfruit trees. Even with so much identity in the natural orders, there is often a striking dissimilarity in the plants of distinct or remote areas, owing to the fact that the genera are very largely different, and that these often have a very distinct facies in leaf and flower. Thus, though the Myrtaceae are found in hot or warm countries all over the world, the Eucalypti, so abundant in Australia, give to its vegetation a highly peculiar character. So the Onagraceae are found in all the temperate regions, yet the Fuchsias of South-temperate America are strikingly different from the Willow-herbs of Europe or the (Enotheras of North America; and there are thousands of equally characteristic genera in all parts of tbe world.

In Mr. Hemsley's elaborate table of the General Distribution of Vascular Plants, he gives, in Central America, the number of species of each order in Nicaragua, Costa Rica, and Panama respectively, these three states constituting the tropical section of the whole area, and the same for six subdivisions of the rest of the area. But the numbers added together will give more than the actual number of species in the combined flora, because an unknown portion of the species will be found in twc or three of these divisions. But he gives the total numbers for these three states and also for the remainder of the nine areas. He also gives the numbers which are "endemic" in these two groups of areas separately and in the whole flora f I have therefore been able to ascertain the proportion which the endemic bear to the total in Mexico and Guatemala, which I find to be as 3 to 4 very nearly, so that by deducting one-fourth of the sum of the species in these areas I obtain the number existing in the combined area. But as it is known that in the tropics species have a less range than in the temperate zone, I deduct one-fifth in the case of the three tropical areas, which will, I believe, approach very nearly to the actual number of species in the combined floras as given in the following table. Nicaragua, Costa Rica, And Panama (3000 species)

1. Orchideae 286

2. ComposifsB 197

3. Leguminosae 176

4. Kubiaceae 146

5. Graruinese 90

6. Euphorbiacea: 72

Ferns

7. Gesneracese' 69

8. Cyperaoeae 68

9. Melastomacea 67

10. Urticacese 58

11. Aroidesa 54

12. Palmae 50

This table brings out clearly the extra-tropical character of Mexico as compared with these tropical sections of Central America. No less than five orders of the former twelve have to be omitted (Cactaceae, Labiate, Solanaceae, Piperaceae, and Malvaceae), which are replaced by the more exclusively tropical Gesneraceae, Melastomaceae, Urticaceae, Aroideae, and Palmae. Here, in two adjacent areas differing about 12° in mean latitude, there is a more pronounced difference in the prevalent orders of plants than exists between two great regions on opposite sides of the globe. Another characteristic tropical feature is seen in the large number of ferns, which are nearly onehalf those of the whole number found in Mexico and Central America, which has an area nine times as great.

Of the other tropical American floras little need be said. Jamaica and Trinidad are the only West Indian islands of the larger group for which I have been able to get recent figures. Mr. L. N. Brittan, of the New York Botanical Gardens, who has collected in the former island, estimates the species at 2722, which, for a sub-oceanic island, is a large amount. Trinidad, which is almost a part of the continent, should be much richer, and its existing collections, not quite reaching 2000, are certainly much below its actual number of species. The Galapagos, now probably fairly well known, but possessing only 445 species, show us how scanty may be the flora of a group of islands of considerable size and situated on the equator, when the conditions are not favourable for plant-immigration or for the growth of plants at or near the sea-level, as has been pointed out in my Island Life.

The Flora of Lagoa Santa

There is, however, one small area in the Campos of Brazil in about 20° S. lat. and 2700 feet above the sea-level, which has been thoroughly explored botanically by a Danish botanist, Professor Eug. Warming, who lived there for three years with his fellow-countryman Dr. Lund, who first studied the fossil vertebrates in the caves of the district. This was in 1803-66; and after studying his collections for twenty-five years with the assistance of many other botanists he published in 1892 a quarto volume giving a most careful account of the vegetation in all its aspects, with numerous very characteristic illustrations, both of individual plants and of scenery, forming one of the most interesting botanical works I have met with. Unfortunately it is printed in Danish, but a good abstract (about thirty pages) in French renders it accessible to a much larger body of readers.

This flora is strictly limited to an area of sixty-six square miles, so that every part of it could be easily explored on foot, and again and again visited as different species came into flower or ripened their fruit. The surface is undulating and in parts hilly, with a lake, a river, some low rocky hills, marshes, and numerous deeply eroded ravines and valleys, often with perpendicular rocky sides, where there is perpetual moisture and a rich forest-vegetation. But everywhere else is for half the year arid and sun-baked, covered with scattered deciduous trees and shrubs, and during the rains producing a fairly rich herbaceous vegetation. It is, in fact, a good example of the campos that

occupy such a large portion of the interior of Brazil, though perhaps above the average in productiveness.

An open country such as this is, of course, much easier to examine thoroughly than a continuous forest, which, though actually richer, calls for a much longer period of exploration before all its riches can be discovered. But though the country is so open, with trees and shrubs spread over it in a parklike manner, Mr. Wanning tells us that trees of the same species are so widely scattered that it is sometimes difficult to find two of the same kind. Another interesting fact is, that the number of species of all kinds — trees, shrubs, and herbs — is twice as great in the patches of forest as in the open campos, while the two are so distinct that he believes them to have hardly a species in common.

Through the kindness of Professor Warming I am able to reproduce here a few of his characteristic drawings and photographs, with descriptions furnished by himself. These offer a striking contrast to the photographs of typical Malayan vegetation at pp. 48 and 50.

As shewn in the view on p. 69 (Fig. 3) the vegetation covering the hills is what is termed "campos limpos," consisting of grasses and herbs with small shrubs, but with few trees scattered in the grass-land. These trees are low, the stema and branches tortuous or twisted. In the valleys where the soil is richer in humus and always moist, there is thick forest.

The soil in all the campos is red clay. In the distance is seen the smoke of fires on the campos. In . the foreground is a "campo cerrado," i.e. a campo with many trees, but never so close that the sun does not shine on the dense carpet of high grasses and herbs under the trees; which latter belong mostly to the Leguminosae, Ternstromiaceae, Vochysiaceae, Anonaceae, Bignoniaceae, etc.

Fig. 4 is a view taken in the " Campo cerrado," showing the stunted form of the trees which characterise it. In the background are calcareous cliffs, in which are the fossil-producing caves. At the foot of the cliffs the trees are closer and higher; and on the top is a more open and dry forest, each kind of forest having its peculiar species of trees.

Fig. 5 (facing p. 72) is a view taken close to the rocks. The upper branches of Mimosas and other trees are shown, which grow at the foot of the cliffs, one of them being a tree of the custard-apple family, whose branches are fruit-laden. Numerous tall cactuses (Cereus cwrulescens) are seen growing up from the rock itself, and several stinging and thorny plants. Other genera growing on the rocks are Opuntia, Pereskia, Peperomia, Epidendrum, Tradescantia, Gloxinia, Amaryllis, Bomarea, Griffinia, and many others, so that we have here a curious mixture of forest trees and climbers with moistureloving plants and those characteristic of arid conditions, all growing close together if not actually intermingled.

Before describing a few of the special peculiarities of the campo vegetation of Lagoa Santa, I will here give some numerical data of interest to botanical readers. The sequence of the orders in this very interesting flora is as follows: —

Lagoa Santa (2490 species)

1. Cornpositse 266

2. Leguminosae 235

3. Gramineae 158

4. Crchidaces; 120

5. Euphorbiaceae 106

6. Myrtaceae 106

7. Rubiacea) 94

8. Cyperacero 77

9. Malpigbiacese 64

10. Melastomacere 62

11. Labiate 49

12. Asclepiadese 48

Ferns and allies 106 species.

The chief feature which distinguishes this flora from that of Nicaragua and Costa Rica is the presence in some abundance of the highly characteristic South American order Malpighiacese, the high position of Hyrtacese, with Labiates and Asclepiads in place of Aroids and Palms. Of the rather numerous Orchids about 70 are terrestrial, 50 epiphytes. There are over 40 genera, of which Spiranthes has 16 species, Habenaria 12, while 22 have only 1 species each. The very large American genus Oncidium has only 5 species, while the grand genus Cattleya, so abundant in many parts of Brazil, seems to be entirely absent.

Adaptations to Drought

The plant figured on the next page, like many others of the campos, has its roots swollen, and woody, forming a store of water and food to enable it to withstand the effects of drought and of the campo-fires. The old stems show where they have been burnt off, and the figures of many other plants with woody roots or tubers, figured by Mr. Warming, show similar effects of burning.

Still more remarkable is the tree figured on p. 74 (Fig. 7), which is adapted to the same conditions in a quite different way, as are many other quite unrelated species.1 The group of plants is really an underground tree, and not merely dwarf shrubs as they at first appear to be. What look like surfaceroots are really the branches of a tree the trunk of which, and often a large part of the limbs and branches, are buried in the earth. The stems shown are the root-like branches, which are 4—5 inches diameter, while the growing shoots are from 2 to 3 feet high. The whole plan (or tree) is from 30 to 40 feet diameter. As the branches approach the centre they descend into the earth and form a central trunk. A French botanist, M. Emm. Liais, says of this species: " If we dig we find how all these small shrubs, apparently distinct, are joined together underground and form the extremities of the branches of a large subterranean tree which at length unite to form a single trunk. M. Benault of Barhacena told me that he had dug ahout 20 feet deep to obtain one of these trunks." The large subterranean trees with a trunk hidden in the soil form one of the most singular features of the flora of these campoa of Central Brazil.

The above facts are from Mr. Warming's book, supplemented by some details in a letter. They are certainly very remarkable; and it is difficult to understand how this mode of growth has been

acquired, or how the seeds get so deep into the ground as to form a subterranean trunk. But perhaps the cracks in the dry season explain this.

A large part of these campos is burnt every year at the end of the dry season, but as the vegetation is scanty the fires pass quickly onwards and do not appear to kill or injure the trees or even the small herbaceous plants. In fact, numbers of these plants as soon as the rains come produce foliage earlier than where there has been no fire, and often produce flowers when unburnt trees or shrubs of the same species remain flowerless. Mr. Warming and other botanists believe that the practice of firing the campos was a native one long before the European occupation, and that many of the plants have become adapted to this annual burning so as to benefit by it.

It is interesting to note here the opinions of two eminent botanists, only thirty years ago, as to the comparative riches of certain tropical and temperate countries. In his great work on The Vegetation of the Globe, Griesbach thus refers to the Brazilian flora: "The results of the explorations of Martius, Burchell, and Gardiner, cannot be compared with those furnished by the Cape. The number of endemic species may perhaps reach 10,000, but the area is twenty times greater than that of Cape Colony, and we may conclude that, as regards its botanical riches, the Erazilian flora is very far from rivalling that of the extremity of South Africa." Gardner, however, after spending three years in collecting over a large portion of the interior of Brazil, though chiefly in the campos and mountain ranges, concludes his account of his travels with these words: "The country is beautiful, and richer than any other in the world in plants." This general statement may not be strictly true, but it seems clear that the facts already adduced are sufficient to show that, as regards the comparison of temperate with tropical floras, there can be no doubt as to the superiority of . the latter. This point will, I think, be made still clearer in the following discussion of some almost unnoticed facts. In the case of Brazil and Cape Colony, however, it is clear that Griesbach was greatly in error. The whole area of extra-tropical South Africa has probably been as well explored botanically as Brazil, the richest portions of which have been only as it were sampled. Yet we find less than 14,000 species in the former against 22,800 in the latter. It will be now shown that when smaller and better known areas are compared the superiority of the tropics is more clearly apparent.

The Floras of Small Areas and their Teachings

The conclusions already reached by the examination of the chief floras of the world, whether in areas of continental extent, or in those more approaching to the average of our counties, that, other things being equal or approximately so, the tropics are far more prolific in species, will receive further confirmation, and I think demonstration, from data I have collected as to the botanical richness of much smaller areas, which having been more thoroughly explored afford more reliable evidence. They also afford very suggestive facts as to the best mode of future exploration which may enable us to arrive at a fair approximation as to the total world-population of flowering plants.

For the convenience of readers I give here two tables I have prepared of the floras of small areas in tropical and temperate zones, each arranged in the order of their area in square miles for convenience of reference and comparison.

I will now briefly discuss the various interesting questions raised by a consideration of these tables.

It is, I believe, still a very common opinion among botanists that the wonderfully diversified flora of the Cape Region of South Africa is the richest in the whole world in so limited an area. This is partly owing to the fact that such a large proportion are beautiful garden plants, which for sixty years, from 1775 to 1835, poured in a continued stream into Europe and seemed almost inexhaustible. The

wonderful group of heaths, of which there are about 350 species, all beautiful and many among the most exquisite of flowers; the almost equally numerous pelargoniums, the brilliant ixias, gladioli and allies, the gorgeous proteas, the wonderful silver-tree, the splendid lilies and curious orchises, the endless variety of leguminous shrubs, and the composites including the everlasting flowers, together with hundreds of other delicate and beautiful little greenhouse plants,— formed an assemblage which no other country could approach. Rich as it is, however, there is now reason to believe that West Australia — Swan River Colony in its original restricted sense — is quite as productive in species, while evidence is slowly accumulating that many parts of the tropics are really still more productive.

The first to be noticed of these rich tropical areas of small extent is the island of Penang in the Straits of Malacca, which, though only 106 square miles in area, contains 1813 species. Sir Joseph D. Hooker, in his Sketch of the Flora of British India (1906), terms this " an astonishing number of species," and remarks on the large proportion which are arboreous, and of the altitude of the island being only 2750 feet. Here, therefore, in an area considerably less than that of the Cape Peninsula, the species are actually more numerous, and this was evidently a new and astonishing fact to one of the greatest of our living botanists.

But the somewhat larger island of Singapore shows us that this amount of productiveness is quite normal; for though it is 206 square miles in extent, it is almost flat, the greatest elevation being only a few hundred feet. A large part of the surface is occupied by the town and suburbs, while the original forest that covered it has been almost all destroyed. Yet Mr. Ridley finds it to have recently contained 1740 species, and when the town was founded and the forest untouched, it almost certainly had 2000 or even more.

We have seen also that Lagoa Santa in South Brazil, 2700 feet above sea-level, with a much smaller area than Penang, and a much less favourable climate, has one-third more species, mainly collected by one enthusiastic botanist during three years' work in this limited district. Here are no mountains, the whole country being an undulating plateau, while for six months there is so little rain that the trees almost all lose their leaves. The aridity causes the trees to be mostly stunted and unshapely; the leaves are clothed on one or both surfaces with felt or dense hairs; and the stems of herbaceous plants are often swollen into thick tubers either underground or just above it. There is thus a manifest struggle for existence against the summer drought with intense sun-heat, and it would hardly be imagined that under such conditions the number of species would equal or exceed that of some of the most luxuriant parts of the tropics.

I will now pass on to a consideration of the two last items in the tablo of small tropical floras, which are more instructive and even amazing than any I have met with in the course of this inquiry. When I was in Java about fifty years ago I ascended the celebrated mountains Gede and Pangerango, the former an active, and the latter, much the higher, an extinct volcano. The two, however, form one mountain with two summits. During the ascent I was much impressed by the extreme luxuriance of the forest-growth, and especially of the undergrowth of ferns and herbaceous plants. I was told by the gardener in charge of the nursery of cinchonas and other plants, that 300 species of ferns had been found on this mountain, and I think 500 orchids. I was therefore anxious to learn if any figures for the plants of the whole mountain could be obtained, and was advised by the Director of Kew Gardens to apply to Dr. S. Koorders of the Reijks Museum, Leiden. In reply to my inquiries, Dr. Koorders wrote me as follows: —

The botanical mountain-reserve on the Gede (Pangerango) is indeed very interesting and very rich, but I know other parts of Java with a much larger number of phanerogams, e. g., the small island of Noesa Kambangan near Tjilatjap. On that island I collected on an area of about 3 square kilometres

(= 1% square mile) 600 of arborescent species of phanerogams, and about 1800 Bpecies of not-arborescent species. This island is about 0 — 50 m. altitude (=164 feet).

On Mount Pangerango, between 5350 feet and the top, 10,000 feet, the number of forest-trees is about 350 species on the same area, and about 1400 species of not-arborescent phanerogams.

On Teading the above, I thought at first that Dt. Koorders must have made a mistake, and have meant to write 30 instead of 3 square kilometres. So I wrote to him again asking for some further information, and pointing out that Eambangan Island was many times larger than the area he had given. To this he replied that he "only explored a small part methodically," and that the number of species he gave me "were found in that part only." 1 It thus became clear ??????????

It may seem to some readers, as it did at first to myself, that it is impossible to have over two thousand species of flowering plants growing naturally on about a square mile. But a little consideration will show that it is by no means so extraordinary as it seems. Let us suppose that the average distance apart of trees in an equatorial forest is ten yards, which I think is much more than the average; then in a square mile there will be 176 X 176 = 30,976 trees. But in Kambangan Island there are 600 that no mistake had heen made. I was further satisfied of this by referring to a small volume by M. Jean Massart, entitled Un Botaniste en Malaisie. He there describes the "mountain reserve" on Pangerango as being 300 hectares of virgin forest, extending from the limits of cultivation to near the summit. As "300 hectares" is the same area as "3 square kilometres," there can be no doubt as to the figures given. M. Massart also states that Dr. Koorders was head of the "forest-flora" department of the Buitenaorg Botanical Gardens, and that he had established eighteen other reserves in various regions of Java. Each of these reserves is under a native superintendent, who allows no tree to be cut down without orders, and watches for the flowering and fruiting of every species of tree. One specimen at least of all the species is numbered, and paths made and kept in order, so that they can be easily visited, and the flowers or fruit gathered for the herbarium. Dr. Koorders has now obtained specimens of about 1200 trees indigenous to Java, while 3500 specimens have been numbered in the reserves. This number is without counting either shrubs or climbers.

I give here a reproduction of a charming little photograph taken in West Java more than fifty years ago by my friend, the late Walter Woodbury, and I believe in the southern country not very far from the island which Dr. Koorders found so rich (Fig. 8). The intermingling of dwarf palms and ferns, with the varied foliage of shrubs and herbaceous plants, and the abundance of lianas hanging everywhere from the trees overhead, give an impression of tropical luxuriance beyond even that of the Malayan photographs pp. 48 and 49.

The system of small forest reserves in tropical or other species of trees in 1} square mile, so that each species would be represented on the average by 60 individuals. But, as some are comparatively common, others rare, there would in some cases be only 3 or 4 specimens, while many, having from 50 to 100, would be really abundant, but, if fairly scattered over the whole area, even these might require searching for to find two or three specimens; which accords with the facts as testified by all botanical travellers.

Perfectly known countries seems to me to offer so many advantages that the adoption of it in Java by the Dutch botanists must, I think, be looked upon as an important discovery. It has the great advantage of being at once economical and effective; it brings about the maximum of scientific result with the minimum of cost, of time and of labour. It has proved that the careful and systematic study of very small areas is calculated to extend our knowledge of the vast world of plantlife more than any other that has hitherto been adopted. The plan is to have, in any extensive country or island, a suitable number of what may be termed "botanical reserves" (but which will

also serve as zoological reserves, especially for bird and insect life) ; these to be of small size, say one square mile each, to be kept absolutely in a state of nature, except the provision of numerous paths giving access to at least one specimen of every species of tree the reserve contains. Experience in Java seems to show that one man, or two if necessary, can keep the paths open, watch for the flowering and fruiting of trees, gather and send specimens to the head of the department, and also, I presume, serve as guide to any botanical visitors to the reserve. But when the trees had been all found, numbered, and named, the same superintendent or keeper would have time and opportunity for the collection of specimens of all the shrubs, climbers, epiphytes, and herbs that grew in the reserve, identifying the place of all the rarer species by direction and distance from the nearest named tree, the epiphytes, orchids, ferns, mosses, etc., being identified by the tree they grew upon being numbered, and made accessible by a path. Of course this area of 3 square kilometres, or about a square mile, may not be in all cases sufficient, but it seems likely to be the most suitable for luxuriant tropical forests. In more open country, as at Campo Santo, a space of from 10 to 50 square miles might be advisable, because the trees on such an area might be as easily found as in a mile of unbroken forest, and would not be much more numerous. In any new tropical country of which we obtain possession, or where there are still large areas of virgin forest, it would be advisable to reserve one square mile in each square degree, say one in every 5000 square miles.

There are many incidental advantages in this thorough determination of the plants growing on a definite if small area over that which has usually been adopted of, as it were, skimming the cream of the flora of enormous areas, such as most of our botanical collectors have been obliged to adopt. The first advantage is that the census of species in each of the reserved areas can be easily made exhaustive, and therefore comparable with other similar reserves. Then, when a few well-chosen "reserves" are similarly treated, the change of species in each degree of latitude and longitude can also be determined with considerable accuracy. In like manner the change of species for each 1000 or 500 feet of elevation can also be found. Again, the proportion of forest trees to the whole of the flowering plants in each locality will enable the whole flora of a large district to be determined as to numbers by ascertaining the number of species of trees only in a few small areas.

As an illustration of this mode of computation Dr. Koordera has found that on the Pangerango mountain the trees form one-fifth of the whole flora, while on Kambangan Island they form one-fourth. If there are, as Dr. Koorders tells me, about 1200 species of trees actually found in Java, and if, on account of the eastern part of the island having much les9 lowland forest, we take one-fifth as the more probable proportion for the whole, then the flora of Java may be estimated at a minimum of 6000 species; and if the number of the trees is found to be greater, then at a proportionately higher number. Hence it is very important that in each local flora the number of its trees, shrubs, and herbs should be separately given. It appears that a forest reserve of 17 square miles has been established on the Bay of Manilla; but, as it is as yet very imperfectly explored, it would be more useful to thoroughly explore two or three well-chosen areas of one square mile each.

It is really deplorable that in so many of our tropical dependencies no attempt has been made to preserve for posterity any adequate portions of the native vegetation, especially of the virgin forests. As an example, the island of Singapore was wholly covered with grand virgin forest at the beginning of last century. When I was there in 1854 the greater part of it was still forest, but timber-cutting and clearing for gambir and other plantations has gone on without restriction till there is now hardly any true virgin forest left; and quite recently the finest portion left has been allowed to be destroyed by a contractor in order to get granite for harbour works, which might almost as easily have been obtained elsewhere. The grand forest trees were actually burnt to make way for the granite diggers!

Surely, before it is too late, our Minister for the Colonies should be urged without delay to give stringent orders that in all the protected Malay States, in British Guiana, Trinidad, Jamaica, Ceylon, Burma, etc., a suitable provision shall be made of forest or mountain "reserves," not for the purpose of forestry and timber-cutting only, but in order to preserve adequate and even abundant examples of those most glorious and entrancing features of our earth, its native forests, woods, mountain slopes, and alpine pastures in every country under our control. It is not only our duty to posterity that such reserves should be made for the purpose of enjoyment and study by future generations, but it is absolutely necessary in order to prevent further deterioration of the climate and destruction of the fertility of the soil, which has already taken place in Ceylon and some parts of India to a most deplorable extent. For this end not only must timber-producing forests of an ample size be secured, but on all mountain slopes continuous belts of at least 400 or 500 yards wide should be reserved wherever forests still exist, or where they have been already lost be reproduced as soon as possible, so as to form retainers of moisture by the surface vegetation, checks to evaporation by the shade of the trees, guards against torrential rains, mud slides, snow slides where such are prevalent, and protection against winds. On level or nearly level ground, where such varied uses would not be required, similar belts at greater distances apart should be saved for local uses and amelioration of climate, besides "botanical reserves" of adequate extent to give a representation of each type of vegetation in the country.

I would also strongly urge that, in all countries where there are still vast areas of tropical forests, as in British Guiana, Burma, etc., all future sales or concessions of land for any purpose should be limited to belts of moderate breadth, say half a mile or less, to be followed by a belt of forest of the same width; and further, that at every mile or half-mile, and especially where streams cross the belts, transverse patches of forest, from one to two furlongs wide, shall be reserved, to remain public property and to be utilised in the public interest. Thus only can the salubrity and general amenity of such countries be handed on to our successors. Of course the general position of these belts and clearings should be determined by local conditions; but there should be no exception to the rule that all rivers and streams except the very smallest should be reserved as public property and absolutely secured against pollution; while all natural features of especial interest or beauty should also be maintained for public use and enjoyment.

The great Roraima mountain in British Guiana, for example, with at least half a mile of forest around its base, should, so far as we are possessors of it, be absolutely secured; and generally, every important mountain summit, with ample means of access, should also be reserved, so that they may not be monopolised or defaced by the greed of speculative purchasers. It should always be kept in mind that the reckless clearing of large forest-areas, especially in the tropics, produces devastation which can never be repaired. It leads to the denudation of the rich surface soil by torrential rains; this soil has been produced by countless ages of forest growth, and it will require an equal lapse of time to reproduce it.

Returning now to the more direct teachings of small areas when methodically studied, I may add that Dr. Koorders has informed me that some years since he made a visit to Minahassa, in N. Celebes, and in four months, between the sea-level and 6500 feet, he collected or observed about 2000 species of flowering plants, of which about 700 were forest trees. As these last are Dr. Koorders' special study it is to be presumed he paid great attention to them, yet he could hardly have obtained such a complete knowledge of them in a few months as in the "reserves" of Java, where, in successive years, not a single species could have escaped discovery. This would imply that the forest flora of North Celebes is even richer than that of Java, and it is almost certainly more peculiar. And if the larger islands of the Moluccas — Gilolo, Batchian, and Ceram — are equally rich (and they have all the appearance of being so), then every estimate yet made of the species-population of the whole Archipelago must be very far below the actual numbers.

There must be hundreds of young botanists in Europe and America who would be glad to go to collect, say for three years, in any of these islands if their expenses were paid. There would be work for fifty of them, and if they were properly distributed over the islands from Sumatra to New Guinea in places decided upon by a committee of botanists who knew the country, with instructions to limit their work to a small area which they could examine thoroughly, to make forest trees their main object, but obtain all other flowering plants they met with, a more thorough and useful botanical exploration would be the result than the labours of all other collectors in the same area have accomplished, or are likely to accomplish, during the next century. And if each of these collectors had a moderate salary for another three years in order to describe and publish the results of their combined work on a uniform plan, and in a cheap form, the total expense for all the nations of Europe combined would be a mere trifle. Here is a great opportunity for some of our millionaires to carry out this important scientific exploration before these glorious forests are recklessly diminished or destroyed — a work -which would be sure to lead to the discovery of great numbers of plants of utility or beauty, and would besides form a basis of knowledge from which it would be possible to approach the various great governments urging the establishment, as a permanent possession for humanity, of an adequate number of such botanical, or rather biological, "reserves" as I have here suggested iD every part of the world.

Before leaving the very interesting problems suggested by the floras of " small areas," I will point out that in the tropics, in warm temperate and in cool temperate zones alike, the evidence goes to show that mountain floras are not so rich in species as those of the plains. I have already shown that it is the case in our own islands, in Switzerland and in South Europe. The table of extra-European small areas (p. 40) shows that the great Japanese mountain, Fujiyama, with a larger area and an altitude of over 12,000 feet, has a smaller number of species than Mt. Nikko, with a smaller area and an altitude of only 8000 feet, both mountains being cultivated to the same height (800 feet), and both being equally well explored. And now, coming to the tropics, we find in Java two areas of the same extent and fully explored by the same botanist, one on a grand mountain slope from 4500 to 9500 feet, and celebrated for its rich flora, the other at the sealevel, and the latter is decidedly the richest. Yet we find Gardiner, in his Travels in Brazil, taking the very opposite of this for granted. He says, at the end of his work: "No good reason has yet been suggested to account for the greater number of species which exist on a given space on a mountain than on a plain," The answer seems to be that there is no such *general* fact to be explained. There may often, no doubt, be more plants on *some* mountains than on the adjacent plains, especially on open plains where social plants abound. On mountains the botanist can often collect more species in the same time, because diversities of soil and station are more crowded together, but the accurate determination of the species on areas from one square mile up to some hundreds of miles shows that the fact is almost uniformly the other way.

It is also of special interest to note that the well-known fact in our own country, that a parish of 2 or 3 square miles in area often contains more than half the flora of the whole county many hundred times as great (as in the cases of Cadney, Edmondsham, and Thames Ditton, given in the table), appears to be even exaggerated in the more luxuriant tropical forests, where a single square mile often contains as many species as 100 miles in similar forests elsewhere.

It is, however, interesting to note that when we compare very small areas, measured by feet or yards instead of by square miles, it is the temperate floras which seem to have a decided advantage. Darwin records that on a piece of turf 3 feet X 4 feet long exposed to uniform conditions, (probably on the chalk downs of Kent or the Isle of Wight) he found twenty species of plants belonging to eighteen genera (Origin of Species, 6th ed. p. 88). Sir Joseph Hooker in the Himalayas, 11,480 feet above the sea, in the upper Lachen valley, found a much richer vegetation. He says: "Herbaceous plants are much more numerous here than in any other part of Sikhim; and sitting at my tent door I could, without rising from the ground, gather forty-three plants, of which

all but two belonged to English genera." And in a note he adds: "In .England thirty is on the average the equivalent number of plants which in favourable localities I have gathered in an equal area."

In my limited reading I have found no other reference to this form of species-abundance, nor do any of my botanical iHimalayan Journals (cheap ed.), p. 335.
??????? friends appear to have recorded such; but it would be interesting to know if any parts of Switzerland or the Pyrenees were as rich as the Himalayas. I should expect not, as the latter has a great advantage in area, and also I presume in climate. The snow protection in winter would be similar, but I presume the summer would be somewhat longer and the temperature more equable, while the more nearly vertical sun and much greater rainfall would probably lead to a more luxuriant development of species than in higher latitudes, or less elevated stations. Darwin points out that the production of short velvety flower-decked turf depends entirely on its being regularly cropped down by ruminants, preventing the-more delicate plants from being smothered by the coarser. Now, this group of animals is one of the latest developments of the world of life; and we thus learn that these delightful expenses of flower-enamelled turf are actually produced by the sheep or goats, the deer or antelopes whose presence gives them a further charm, and which were themselves developed just at the period when man appeared upon the earth, gifted with faculties which enables him alone to fully appreciate their beauty, and to utilise many of them as aids to his own civilisation.

Chapter V - THE DISTRIBUTION OF ANIMALS

THE sketch now given of the broader features of the distribution of plants over the various parts of the earth's surface will apply, with little modification, to the various classes of animal life, which, although having the power of locomotion, are yet by the necessity of acquiring food and preserving themselves from enemies, almost as strictly limited to definite areas as are plants themselves.

It will only be necessary to give a few facts to illustrate this, for which purpose insects and birds afford the most instructive materials. We will begin with the Lepidoptera, or Butterflies and Moths, in our own country and in a typical county. The following data have been kindly furnished by Mr. William Cole, F.L.S., Hon. Sec. of the Essex Field Club.

DISTRIBUTION OP LEPIDOPTERA
SqAM?I«.. *B^i"t*
Great Britain 87,500 2070
1,530 1655

In order to compare the numbers in a smaller area, I have only materials for the Macrolepidoptera or Butterflies and larger Moths.

aflSU Speei"
Great Britain 87,500 822
Essex 1,530 820
Epping Forest 10 428

It is interesting to note here the curious correspondence with the number of the flowering plants, which in the mean of twelve counties was almost the same as the area in miles; and here we find the total number of the Lepidoptera in Essex, which is not far from an average county, very nearly the same as its area. The number of species of these insects is also suggestive, in being about one-half greater than the number of flowering plants (1010) on which they almost all feed in their larval state. We know that many different species feed on some of our commonest plants — as the oak, poplar, elm, nettle, etc.— while some larvae feed on several distinct plants indiscriminately. But

probably the larger number feed on one species of plant only, and thus almost all our plants, except the very rarest, afford food for at least one lepidopterous larva.
Again, just as we found that a selected area of 10 square miles in Surrey had nearly two-thirds of the plants in the whole county, so here we find that a selected area of 10 square miles in Essex has nearly two-thirds of the Macrolepidoptera found in the county. Here, too, we see the result of the dependence of the insects on the plants, the great variety of the latter in Epping Forest (450 species) rendering possible a corresponding variety of the former.

Coleoptera {Beetles)

The enormous order of the beetles (Coleoptera) not being exclusively feeders on living plants, but both in their larval and perfect state often feeding on animal food or on vegetable debris, are probably more uniform in their numbers in different areas if not absolutely barren or very highly cultivated.

As it requires perseverance in collecting for many years in order to obtain all the beetles in even a very limited district, I think it probable that the above figures do not so closely represent the actual number of species inhabiting the county as in those given for the plants, or even the moths.

Great Britain
Essex
Area.
87,500
1,530
Species.
3260
1656

To show the vast numhers and variety of the insect tribes, I give here the approximate numbers of actually described insects, kindly furnished me by Mr. C. O. Waterhouse of the Entomological Department of the Natural History Museum.

Insect, of the World. Specie/"
Coleoptera (Beetles) 120,000
Lepidoptera (Moths and Butterflies) 60,000
Hymenoptera (Bees, Wasps, Ants, etc.) 45,000
Diptera (Flies, Gnats, Midges, etc.) 28,000
Rhynchota (Bugs, Cicadas, etc.) 18,000
Orthoptera (Locusts, Crickets, etc.) 8,000
Neuroptera (Dragon-flies, May-flies, etc.) 5,000
Several smaller Orders 5,000
Land Area, 48,000,000 square miles 240,000

If we consider that large areas of the most productive tropical regions are still almost unexplored by the entomologist, and that even in the best-known parts the less attractive groups are very little known, it is almost certain that the actual number of species of insects now in existence is double that above given, while it may be three or four times as many.

To show how difficult it is to ascertain how many species of insects are now known to exist, I give another recent estimate by Mr. A. E. Shipley, F. R. S., in his Presidential Address to the Zoological Section of the British Association in 1909. This was based upon a careful estimate by Dr. Giinther, in 1881, when Keeper of Zoology in the British Museum. His estimate then was 220,150 species of

insects. In the twenty-seven succeeding years, the *Zoological Record* gives the number of new species described in all parts of the world. During the whole of this time the numbers described have increased year by year, and Mr. Shipley has therefore taken the number for the year 1897 as an average of the whole (8364 n.s.), and multiplying this by 27 (allowing the odd 364 for synonyms) we have an addition of 216,000, which added to 220,000 gives a total now known of 486,000, an immense increase on the estimate of Mr. Waterhouse. Of course a far more correct way would be to add the number described as new, each year of the twenty-seven; but as this would involve the counting of all the descriptions in thousands of pages of close print, we cannot be surprised that such a labour was not undertaken.

It is hardly possible for any one who has not collected some special group of insects in countries where they abound, to realise what the numbers given above really mean. In the Malay Islands alone, I myself collected over a thousand distinct species of one of the most beautiful families of beetles — the Longicorn8 — of which about 900 were previously quite unknown. Of another immense family — the Curculionidse, or Weevils — I obtained also about 1000 species, of which the same proportion were new. While the former group are remarkable for grace of form, variety of marking, and often for exquisite colouration, the latter are equally interesting for their endless modifications of shape, more sober but beautifully marked bodies, strangely bossed surfaces, and, occasionally, the most brilliant metallic colours.

The interest of making such collections, in which the variety was so great as to seem absolutely endless, may be imagined by any lover of nature. But the interest in their study has been intensified by the firm conviction — the growth of half a century of thought upon the subject — that every detail of these wonderful modifications of structure, form, and colouration, have been due to general laws in operation for countless ages, and that every minutest character, as they occurred through successive variations and became fixed in each species, had a definite purpose; that is, were of use to the creatures which exhibited them. This, however, will be shown later on, when we have to deal with the more important factors of evolution — variation and heredity.

The Species of Birds

We will now pass on to the most familiar, the most beautiful, and the most wonderful of all living things — the birds. These form one of the culminating lines of development of the great world of life; they are the most specialised of all the higher animals; and so far as perfection of organised structure is concerned may be considered to hold a higher place than the mammals themselves. Were they not so familiar to us, we should consider it to be impossible that warm-blooded, active creatures, with a bony skeleton, could have their forelimbs (or arms) so modified as to be used exclusively for flight, and yet, with no organ of prehension but the mouth prolonged into a beak, sometimes aided by a foot, be completely adapted to obtain every kind of vegetable or animal food, to protect themselves from enemies, and to construct the most perfect abodes for their helpless young to be found among the higher animals.

Some zoologists consider that in the power of flight birds are surpassed by insects, but I cannot think this to be the case. If we take into consideration the weight they have to carry, the height they often attain above the earth, their perfect command over the direction and speed of their motion, and the exquisite and highly complex organ by which flight is effected, birds must take the higher place. The insect's flight is simpler and more automatic; that of the bird more elaborate in every part, more completely under the control of the creature's will . It is also, I believe, more varied in exact adaptation to the mode of life of each of the species.

As regards their variety of structure, the numbers of the species, and their mode of distribution over the earth's surface as compared with the other forms of life already considered, a few

examples will be sufficient to prove their general correspondence with other animals. It must be remembered, however, that in birds the numbers inhabiting the several countries are less precise and less comparable than in any other group. This is due to several causes. In all extra-tropical lands a large proportion of the species are migratory, and the facts observed are very similar over the whole of the north temperate zone. Some go to more northern lands in summer to breed, returning south in autumn; others leave us in autumn to winter in the south, returning to us in the spring; others, again, are birds of passage only, staying with us a few days or weeks on their way north or south. All these are considered to be truly natives, in our case to be "British birds." But others only visit us occasionally, some at very long intervals, while others, again, are mere "stragglers," who have lost their way or been driven to us by storms, and have only perhaps been recorded (seen or killed) once or twice. There is therefore a vast range for personal opinion as to what species should or should not be included as " British " or " European" or "Canadian" birds. If we add to this uncertainty the extreme variety of opinion as to the limits of " species," "subspecies," and "varieties," or "local races" of birds which now exist, we see how hopeless it is to expect uniformity in numerical estimates of the birds of different countries or regions. As an example of this difference of treatment, we may take two of the most recent estimates of the bird-population of the world. Dr. Giinther, in 1881, estimated the species of birds then known at 11,000, and Mr. Shipley added to this an average of 105 new species per annum — estimated from the Zoological Record — for the twenty-seven years elapsed since that date, bringing the total up to 13,835. But in the late Dr. Bowdler Sharpe's Hand List of the Genera and Species of Birds, just completed, the number is stated as being 18,937. This enormous divergence, as I am informed by another great authority on Ornithology, Dr. P. L. Sclater, is mainly, if not wholly, due to the fact, that Dr. Sharpe "includes as species all the numerous slight local forms which are called 'sub-species' by the new school of Ornithologists, many of which, in my opinion, do not present sufficient differences to require separation at all."

Keeping these difficulties in mind, the following estimates, for which I am largely indehted to my friend, Mr. Henry Dresser (author of a great work on the Birds of Europe), will be found interesting.

The numbers for Dorset are obtained by omitting all the "stragglers" and very rare visitors, including all that are regular immigrants or birds of passage, as well as those which, though irregular, are tolerably frequent visitors. Here, again, we see that a county area has rather more than half the British species, as was the case with flowering plants and some of the most extensive orders of insects.

The difficulty of obtaining really comparable figures for the countries and regions shown on page 96 is at present insuperable, but the approximations given are of considerable interest.

The same table exhibits several points of interest, especially as regards the correspondence of the proportionate numbers of such different organisms as birds and plants. As regards the Palsearctic and Nearctic regions (temperate Europe and Asia on the one hand, temperate North America on the other), we see that the birds of the former are about one and a half times those of the latter, the areas being nearly as two to one. The plants are probably not far from the same proportion; for if we take those of Europe with North Africa at 10,000, and add thereto those of the Flora Orientali3 of Boissier (12,000), and the China flora of Hemsley (9000), and allowing that the species common to any two of these may be about equal to additional species of the whole of North Asia and Japan, we get a total of 31,000 species, which is far beyond the highest estimate of the Nearctic flora with all the sub-species included.

The birds of the Ethiopian and Oriental Regions appear to be approximately equal in numbers. The flowering plants are even less known. Those of tropical Africa with Madagascar, Mauritius, etc., must reach about 22,000 species; while temperate South Africa has 13,000. Allowing the species

common to both to equal those yet undescribed from tropical Africa, we get a total of 35,000 species for the Ethiopian flora.

That of the Oriental Region is much more difficult to arrive at. Taking 15,000 species for the tropical portion of the flora of British India, and adding 7000 for Indo-China, 5000 for the Philippines, 4000 for Java, and the same for additional species of Malaysia proper (Malay Peninsula, Borneo, and Sumatra), and 2000 for Celebes, we have a total of 30,000, which, considering that the land area of this region is less than half that of the Ethiopian, shows what is probably a fair approximation to the number of its flowering plants; though I believe it will be below rather than above the actual amount.

Coming now to the Neotropical Region (including all South America and tropical North America), we find our estimate of the birds to be almost double that of either of the other tropical regions. By means of a rough estimate (p. 64) I have arrived at 80,000 species as a not improbable number of the flowering plants for the Neotropical Region; and allowing fully for future discoveries in the Malayan Islands and Indo-China, the numbers in the Oriental Region are not likely to much exceed half this number, thus agreeing very well with the proportionate numbers of birds in the same regions.

The Australian Region is of less importance from the point of view we are now considering, because it is not exclusively temperate or tropical, but nearly equally divided between the two. It also differs from the Oriental inasmuch a9 botanists usually claim the flora of the Moluccas and New Guinea as being essentially Malayan, and therefore belonging to the Oriental Region. But the flora of New Guinea has been stated by Sir Joseph Hooker to be so peculiar as almost to deserve to form a Sub-region of its own; and, till recently, the natural order Dipteraceae, consisting of lofty forest-trees with very distinctive botanical characters, was supposed to be limited to the Oriental Region, from the Himalayas to Java, Celebes, and the Philippines. They have, however, now been found both in the Moluccas and New Guinea; but as westerly winds blow for half the year with great steadiness between Celebes and New Guinea, it is not difficult to explain their presence in the latter country, as their solid but large-winged fruits would be easily drifted for long distances. At all events the extreme richness of New Guinea in both birds and plants, and not improbably in insects also, is a matter of very great interest.

Having shown by the best statistics available that the general phenomena of the numerical distribution of species over small or large areas correspond in their main features for such, diverse groups of organisms as plants, insects, and birds, it is quite needless — even if it were possible — to attempt a similar enumeration for other groups. In reality, with the one exception of land-shells, the materials do not exist for any other organisms. Even the mammalia and reptiles have never been systematically collected in tropical countries, as birds and insects have been collected, and what materials do exist are more difficult to obtain. But to give the general reader some notion of the extent of the whole world of life as now studied by biologists, I will give a tabular statement of the numbers supposed to be actually described, from the estimate made by Mr. Shipley above referred to in the case of insects.

As regards these figures, I am informed by Mr. R. Lydekker that he considers the Mammalia to be much exaggerated by writers who reckon slight local forms or varieties as distinct species. Thus 8 species have been made of the common brown bear, and 16 species of various local forms of mouse-deer (Tragulus). On the other hand, although the number of insects here given seems enormous, Mr. D. Sharp, a very experienced entomologist, thinks that the number actually existing is five times as great — that is, more than two million distinct species!

An Estimate Of The Described Species Of Living Animals. By A. E. Shipley, F.R.S. (B. Essn. Address, 1909).

Chapter VI - THE NUMERICAL DISTRIBUTION OF SPECIES IN RELATION TO EVOLUTION

The rather lengthy account I have given of the numerical distribution of species over both small and large areas, and in special relation to latitude and to climate, has a very definite object. In the first place, this distribution constitutes the primary and fundamental fact in the relation of species to the whole environment — it is, in fact, the broadest and most simple expression of that relation, and is thus a proper subject of inquiry in any general view of the world of life. Yet it has been strangely neglected both by botanical and zoological writers; and the largest and oldest collections of plants and animals in all countries have been so dealt with as to afford material for almost every form of biological research except this one.

The mere enumeration of the numbers of species, named or unnamed, with the localities of each specimen, in the great national collections of the world, would have afforded all the materials for such comparisons as I have here endeavoured to make. And if the facts were recorded in card-catalogues, instead of in the usual forms, there would be such a demand for sets of these cards applying to special groups and definite geographical areas, by most students or collectors, that the cost of such catalogues would be more than repaid.

This numerical relation of the various groups of organisms in different areas or geographical divisions of the earth has the further advantage of being interesting and intelligible to the general reader, as it involves the use of hardly any technical terms, and is therefore especially suitable for a work such as the present. We will now proceed to a brief consideration of the nature and meaning of the facts set forth in the preceding chapters.

The evidence, collected with extreme care for many years by Mr. Woodruffe-Peacock (as explained in Chapter II.), has shown us how curiously the number of species differs even on the smallest adjacent areas. In the same field, even when apparently alike everywhere in soil, in aspect, and in contour of surface, every plot of 16 feet square has its individuality. It will differ from each of the eight adjacent plots either in the number of the species it contains, or in the species themselves, or in the proportions of the individuals of the various species. They are thus seen to be affected by very small differences, such as moisture, or aridity; more or less shade from hedges, trees, or woods; shelter from or exposure to winds; by the vicinity of pits or quarries, woods, ponds, or streams.

Now this one fact of response to the minutest change of conditions in the arrangement of a few species over almost identical adjacent areas is as much a case of adaptation to the environment through the mutual interaction of the various species — a struggle for existence on the very smallest scale -— as any of those larger and more complex cases which Darwin first made known to us.

Coming now to the fields themselves of various shapes and dimensions, and each limited by definite boundaries of hedge and ditch, bank or wall, spinneys, plantation or woods, we have, in our country especially, a series of unit-areas which may be said to form the first step in the study of botanical geography, and which leads us on through successively larger areas to regions and continents.

In regard to these fields, the writer above quoted not only states their precise differences in the numbers of their species and the presence of certain species and absence of others which give to each its individuality, but he is able in many cases to define the causes of that individuality. Besides the or dinary variations of soil, we have to take account of the effects of diversity of

treatment as meadows, pasture, or fallow land, each resulting in a' characteristic grouping of species easily recognisable over wide areas. In pasture land each kind of domestic animal leads to the presence or absence of certain species, while in the vicinity of farms or villages, the presence of geese, pigs, or poultry has a distinctive influence.

What a new light these researches throw upon the development of the vegetation of each country during past ages! We see how the indigenous vegetation of oceanic islands, in the total absence of mammalia, must have gradually eliminated some of the chance immigrants by which they were first stocked, and favoured others often of later date, and how, in the competition with each other, those species which were most easily modified into a shrubby or arboreal type would have the advantage. Thus may we explain the composites, lobelias, violets, and plantains of the Sandwich Islands being mostly shrubs or even trees of considerable size, and so abundant in species as to form a characteristic feature of the vegetation. Numerous Caryophyllacese, Primulacese, and a Geranium are also shrubs or small trees. In the Azores a Campanula and a Sempervivum are shrubs.

Again, the knowledge we have recently gained of the wonderfully rich mammalian fauna of temperate North America in middle and late Tertiary times — camels, ancestral horses and cattle, mastodons, and many others, which disappeared at the on-coming of the glacial epoch — affords us a very important clue to the development of its special vegetation. Every change of animal life that so often occurred in all the continents — the union and separation of the sub-arctic lands at various epochs, the temporary separation of North and South America in late Tertiary times, and that of Africa from Europe and Asia during the Early and Middle Tertiary — must all have profoundly affected the special developments of the vegetation, as well as of the animal life, in the respective areas.

No less indicative of delicate response to variation of temperature, and therefore of close adaptation to the whole modified environment, is the continuous increase in the number of species with every important change of latitude. Although this increase is but slight for moderate changes, and is therefore liable to be masked by other favourable or adverse conditions of the environment, it yet makes itself visible in every continent; and in the comparison between the north or midtemperate and the tropical zones is so pronounced that in fairly comparable areas the tropical species are often (and probably on the average) double those of the temperate zones. This seems to be the case among the higher animals, as well as among all the vascular plants.

Now all this is indicative of long and minute adjustment to the special inorganic as well as the organic conditions; and the reason why the tropics as a whole far surpass the temperate zones in the number of their specific forms, is, not the greater amount of heat alone, but rather the much greater uniformity of climatical conditions generally, during long periods — perhaps during the whole range of geological time. Whatever changes have occurred through astronomical causes, such as greater excentricity of the earth's orbit, must necessarily have produced extremes of climate towards the poles, while the equatorial regions would remain almost unaffected, except by a slight and very slow rise or fall of the average temperature, which we know to be of little importance to vegetation so long as other conditions remain tolerably uniform and favourable.

It is this long-continued uniformity of favourable conditions within the tropics, or more properly within the great equatorial belt about 2000 miles in width, that has permitted and greatly favoured ever-increasing delicacy of adjustments of the various species to their whole environment. Thus has arisen that multiplicity of species intermingled in the same areas, none being able, as in the temperate zone, to secure such a superior position as to monopolise large areas to the exclusion of others. Hence also it has come about that the equatorial species seem to be better defined — more sharply distinguished from each other — than many of those of the temperate and northern zones. They are what Dr. Beccari terms first-grade species, as in the case of Borneo, an island which forms

part of what has quite recently been an equatorial continental mass. It is interesting to note that Mr. Th. D. A. Cockerell has arrived at a similar conclusion from his study of the rich fossil flora of Florissant, Colorado, of middle or late Tertiary age, which shows signs of a much milder climate than now prevails there. Many of these plants are of genera now extinct or only found in more southern lands, and this extinction is traceable to the great changes, inorganic and organic, that have since occurred in North America. He says (in a private letter):

There was first the invasion of Old World species via Behring's Straits; then an incursion of S. American forms via Panama; and then the glacial period at the end, crowding and destroying much of the flora and fauna. Since the glacial period in N. America, there has been room for expansion, and hence the very numerous and closely allied species of Aster, Solidago, Senecio, and other plants, as well as allied species of butterflies of the genera Argynnis, Colias, etc. These are, most of them, not at all on the same footing as the tropical species. ... I think tropical species are better defined than those of the temperate region.

It is a rather curious coincidence that if we take the mean area of the twelve English counties for which I have been able to give the figures, in geographical instead of English miles, the number of square miles will almost exactly equal the average number of their species of flowering plants. Below this area, in the mid-temperate zone, the proportion of species decreases, and above it increases, in both slowly at first and with many fluctuations, but afterwards very rapidly, more especially for the larger areas, so that it requires on a rough average about a two hundred-fold increase of area to double the number of species, and about a thousand-fold to quintuple it. But in all such comparisons we require a large number of fairly comparable cases to give a trustworthy average, and the materials for this do not seem to exist. Yet there is a striking general agreement between the numbers of the species in the various kingdoms, states, or colonies of Europe, North America, and Australia, requiring only slight allowances for greater area, better climate, or geological history to bring them into line with one another to a really remarkable degree.

It appears, then, that, whether we take small areas roughly approximating 100 square miles, or much larger areas of from 100,000 to 200,000 square miles, there is, over the whole world, an unexpected amount of agreement in the numbers of the flowering plants, but always showing a moderate increase from the colder to the warmer parts of the earth.

Differences of Temperate and Tropical Vegetation

One of the chief differences between the floras of the colder and of the warmer parts of the earth (already referred to) is the greater prevalence in the former of gregarious plants. Towards the northern limit of vegetation we find continuous forests of pines or firs, the same species often extending for hundreds or even thousands of miles; while woods of birches extend even farther north almost up to the limits of perpetual snow, and in this case a single species — our common birch — extends entirely across northern Europe and Asia, with allied species in North America. Farther south, forests of beeches, oaks, chestnuts, etc., are common, but seldom covering such large areas, being dependent on conditions of soil as well as of climate; while in the warmer parts of the temperate zone the forests are often made up of a great variety of trees, though never so completely intermingled as in the typical areas of the tropics.

Another, and perhaps more important character of the tropical flora, is the large number of distinct types of vegetation which are almost or quite peculiar to the warmest and most equable regions of the earth. This is indicated by the fact that about one-fourth of the natural orders of plants are either exclusively tropical or very nearly so, and that they comprise such remarkable forms as the epiphytic Orchids, the Bromelias, the Palms, the Pitcher-plants, Bananas, Breadfruits, the Coffea and Cinchona trees, and hundreds of others almost unknown except to botanists.

But the most striking feature of all is the wonderful adaptations by which every well-marked place or station is occupied by peculiar groups of plants. The epiphytes above referred to — plants which live upon trees, upon the trunks or branches, and especially in the forks, where they can root and establish themselves, not as parasites by sending their roots into the living tissues of the tree, but solely getting nourishment from the rain-water that trickles down the bark or the small quantity of decaying leaves or moss that collects there — such plants belong to many natural orders and are very numerous. Then there are the climbers, far more abundant than in any temperate forests, which either root in the ground and then, by various means, climb up to the summits of the loftiest trees, or which begin life by rooting in a lofty fork of a great tree, and then send down roots to the ground and branches into the air, sometimes remaining as a small bush or tree, at others growing so rapidly above, and clinging around the supporting tree so closely with its roots, as finally to kill its fosterparent, when its clinging roots unite and grow into a trunk, with hardly anything to show that one tree has replaced another. Then again there are numerous small trees of from 20 to 30 feet high, which live entirely in the shade beneath the great forest trees. Many of these have bright-coloured or conspicuous flowers growing directly out of the trunk, while there are none at all among the crown of leaves at the top. This appears to be an adaptation to bring the flowers within sight of the butterflies, bees, and other insects which fly near the ground, and thus secure for them the advantages of being cross-fertilised. Then again there are many delicate creeping plants, especially mosses and hepaticse, that cover the whole surfaces of the leaves of forest trees with an exquisite tracery, thus obtaining the perpetual moisture they require from condensation on the cool surfaces of the leaves.

In great river valleys, where by the annual rising of the stream miles of alluvial plains are regularly under water for several months, both trees and shrubs have become adapted to these strange conditions, and the greater part, if not all, the species are quite distinct from those which grow on the unflooded land.

All these, and many other characteristic features of tropical vegetation, can be explained by the general constancy of the inorganic conditions, especially the climatic ones, which have undoubtedly prevailed there during whole geological periods, subject only to those very slow changes due to elevation, depression, and denudation of the land itself. These latter have been so extremely gradual as to act as a gentle stimulus to the various agencies continually bringing about modification of specific forms; and as the climatal conditions throughout all these changes have continued to be highly favourable to the support of vegetation and of animal life, there has been a constant tendency to produce and maintain an almost exact equilibrium between the various species in the same area. None being better adapted to the environment than a great many others, none are able to monopolise large areas to the exclusion of others, as is the case in the more changeable temperate or cold regions. Whether we consider the differences between day and night temperatures, the variations of temperature from month to month or from year to year, or those extreme variations which we experience once perhaps in a generation or in a century, such as excessively cold winters, excessive droughts or excessive rains in summer, or long periods of dry and cold winds — all alike are unknown in the equatorial regions, save in a few limited and quite exceptional areas. In these more favoured portions of our earth there prevails such a general approach to uniformity of conditions (without ever reaching absolute uniformity) as seems best adapted to bring about the greatest productivity, together with extreme diversity in every department of the great world of life.

The large amount of diversity of species we have seen to occur in single fields long subject to almost identical conditions in our own country, with the additional fact that no plot of a few square yards has exactly the same grouping of species and individuals as any of the other plots, yet each plot produces very nearly the same number of species, will enable us in some degree to appreciate

the conditions of the tropics. There we see enormous areas subject to almost identical conditions of soil, climate, and rainfall, yet in every part of it exhibiting, amid a general uniformity of type, a wonderful diversity in the shapes and structures of the forms of life, and a no less wonderful balance and adaptation of each to all. How this result has been actually brought about in the course of evolution through the ages we shall better understand after a brief exposition of the factors which have been the immediate causes of the two great phenomena, continuous evolution, with continuous adaptation.

Chapter VII - HEREDITY, VARIATION, INCEEASE

In the preceding chapters I have shown how, from a consideration of the simple facts of the numerical distribution of species over the earth, together with the varying numbers of the individuals in each species and the area occupied by them, we are led to the conclusion that there is an ever-present struggle for existence between species and species, resulting in a continual readjustment to the environment. In this view there is no question, of any change of species, but merely of their redistribution; we perceive that during the process very rare or local species may, and certainly do, die out, but we have obtained no clue to the method by which new species arise to replace them.

This was the state of opinion among the most advanced writers before Darwin, and it is very clearly expressed in the admirable 42nd chapter of Sir Charles Lyell's Principles of Geology (11th edition, 1868, but which first appeared in the 9th edition, 1853, pp. 689-701) many years before the idea of the transmutation of species had been seriously entertained by men of science. This chapter may still be read with interest even by the evolutionist of to-day. The reader will then be better able to appreciate the enormous advance made by Darwin by his conception of "natural selection," dependent on the three fundamental factors — heredity, variation, and enormous powers of increase — all well known to naturalists, but whose combined effect had been hitherto unperceived and neglected. The two first of these factors we will now proceed to discuss and elucidate.

Perhaps the most universal fact — sometimes termed "law" — of the organic world is, that like produces like — that offspring are like their parents. This is so common, so well known to everybody, so absolutely universal in ordinary experience, that we are only surprised when there seems to be any exception to it. In its widest sense as applied to species there are no exceptions. Not only does the acorn always produce an oak, the cat a kitten, which grows into a cat, the sheep a lamb, and so throughout all nature, but each different wellmarked race also produces its like. We recognise Chinese and Negroes as being men of the same species as ourselves but of different varieties or races, yet these varieties always produce their like, and no case has ever occurred of either race producing offspring in every respect like one of the other races, any more than there are cases of cart horses producing racers or spaniels producing greyhounds.

Some people still think that mental qualities are not inherited, because it so often happens that men of genius have quite undistinguished parents, and that 'the children of men of great ability do not as a rule equal their fathers. But although such cases are frequent and attract attention because such apparent non-inheritance is unexpected and seems unreasonable, yet when large numbers of families are carefully examined there is found to be the same amount of mental aa of physical inheritance. This was proved by Sir Francis Galton in his work on Hereditary Genius, in which, by tracing the families of large numbers of public men of high position and some kind of exceptional talent or genius which was generally recognised, it was found that in their ancestral line there was always found some amount of distinction, though not always of the same kind or degree; and that if they left descendants for two or three generations, they, too, usually comprised some individuals of more than average ability.

To avoid any misconception on this point, it may be as well here to state briefly the numerical law of inheritance, which Galton arrived at by careful experiments in the breeding of plants and animals, and which is now generally accepted as affording a very close representation of the facts of inheritance under normal conditions. It is that the offspring of any two parents derive, on the average, one-half of their characteristics from those parents, one-fourth from their four grandparents, one-eighth from their eight great-grandparents, and so on to remote ancestry, the total result being that one-half of each individual's peculiarities is derived from its parents, while the other half comes from its whole previous ancestry. Hence arises the well-known fact that certain peculiarities of body or of character are apt to reappear in families during several centuries.

Now this simple law explains almost all the facts including the apparent failures of inheritance — all its irregularities in individual cases, together with its constancy and regularity when large numbers are examined. It shows us why, when families for several generations have been noted for beauty, for stature, for strength, or for talent, these characters will almost certainly be found developed in most of their children, who from three or four generations of ancestors have a good chance of deriving seven-eighths or fifteen-sixteenths of their entire organisations. If, on the other hand, the beauty or talent of parents were exceptional in their respective families, then their children, having a number of commonplace or inferior ancestors, would often be far inferior to their parents in the particulars in which the parents excelled, and in their case heredity would seem to have failed.

From this consideration there is deduced another general law, very easy to remember and of great use in explaining apparent deviations or incongruities. This is called the " law of recession towards mediocrity." It means that, whenever parents deviate considerably from the average of the population of which they form a part, their offspring will tend to return towards the average. For example, if both parents are decidedly below or above the average in height, in beauty of form, in any special faculty, as music, drawing, etc., their children will usually go back towards the average, though still retaining some of the parental excess or defect. It is owing to this law that very extreme developments, whether of body or of mind — gigantic stature or supreme genius — are rarely transmitted to the next generation. But if this special superiority has already persisted in the family for several generations, and both parents belong to this same superior stock, then the reversion towards mediocrity is less marked, and the special quality will almost certainly be transmitted, sometimes even in still larger degree, to some members of the family.

It is by acting on this principle that breeders of animals or plants for special purposes are able to improve the race. In each generation they choose the most perfect individuals, from their point of view, to be the parents of the next generation, rejecting or destroying all the inferior ones. It is in this way that our race-horses, our best milking cows, our heavy-woolled sheep, our quickly fattening pigs, our luscious pears and peaches, and hundreds of others, have been produced. Just in proportion as we have bred only from the best for a long series of generations does the transmission of these qualities become more certain and the "recession towards mediocrity" appear to be abolished. But it is not really abolished. The average to which there is a tendency to return has itself been raised by careful selection of the best for many generations, and the inferior individuals which were once the average of the race are now so far removed that they can exert only a very slight influence on each successive generation. Owing to the numerical law above referred to, after five generations of such selective breeding it is about 100 to 1 against the inferior characters of the original average stock reappearing in the offspring, while if the operation has been carried on for ten generations it is about 2000 to 1 against such inferior types presenting themselves. It is for this reason that our great Colonial sheep and cattle breeders find it to their advantage to give even thousands of pounds for pedigree bulls or rams in order to improve their stocks.

It is by what is substantially the same process, as we shall see farther on, that nature works to improve her stocks in the great world of life; and has been thus enabled not only to keep all in complete adaptation to an ever-varying environment, but to fill up, as it were, every element, every different station, every crack and crevice in the earth's surface with wonderful and beautiful creatures which it is the privilege and delight of the naturalist to seek out, to study, and to marvel at.

The Variation of Species, its Frequency and its Amount

Having now shown something of the nature of heredity, its universality and its limitations, we pass on to a rather fuller discussion of the nature and amount of those limitations, commonly known as the variability of species. It is this variability that constitutes the most important of the factors which bring about adaptation, and that peculiar change or modification of living things which we term distinct species. This change is often very small in amount, but it always extends to various parts or organs, and so pervades the whole structure as to modify to a perceptible extent the habits and mode of life, the actions and motions, so that we come to recognise each species as a complete entity distinct from all others.

There is no subject of such vital importance to an adequate conception of evolution, which is yet so frequently misapprehended, as variability. Perhaps owing to the long-continued and inveterate belief in the immutability of species, the earlier naturalists came to look upon those conspicuous cases of variation which forced themselves upon their attention as something altogether abnormal and of no importance in the scheme of nature. Some of them went so far as to reject them altogether from their collections as interfering with the well-marked distinctness of species, which they considered to be a fundamental and certain fact of nature. Hence, perhaps, it was that Darwin himself, finding so little reference to variation among wild animals or plants in the works of the writers of his time, had no adequate conception of its universality or of its large general amount whenever extensive series of individuals were compared. He therefore always guarded himself against assuming its presence whenever required by using such expressions in regard to the power of natural selection as, "If they vary, for unless they do so, natural selection can effect nothing."

This was the more strange because wherever we look around us we find, in our own species, in our own race, in our own special section of that race, an amount of variation so large and so universal as to fully satisfy all the needs of the evolutionist for bringing about whatever changes in form, structure, habits or faculties that may be desired. By simply observing the people we daily meet in the street, in the railway carriage, at all public assemblages, among rich and poor, among lowlyborn or high-born alike, variability stares us in the face. We see, for instance, not rarely, but almost daily and everywhere, short and tall men and women. We do not require to measure them or to be specially good judges of height to be able to observe this — the difference is not one of fractions of an inch only, but of whole inches, and even of several inches. We cannot go about much without constantly seeing short men who are about 5 feet 2 inches high, and tall men who are 6 feet 2 inches — a difference of a whole foot, while in almost every town of say 10,000 inhabitants, still greater differences are to be found.

But this special variation, so large and so frequent that it cannot be overlooked, is only one out of many which we may observe daily if we look for them. Some men have long legs and short bodies, others the reverse; some are long-armed, some are big-handed, some big-footed, and these differences are found in men differing little or nothing in height. Again we have big-headed and small-headed men, long-headed and roundheaded, big-jawed, big-eared, big-eyed men, and the reverse; we see dark and light complexions, smooth or hairy faces; black, or brown, or red, or flaxen-haired men; slender or stout men, broad or narrow-chested, clumsy or graceful, energetic and active, or lazy and slow. Characters, too, vary just as much. Men are taciturn or talkative, cool

or passionate, intelligent or stupid, poetical or prosy, witty or obtuse. And all these characteristics, whether physical or mental, are combined together in an infinite variety of ways, as if each of them varied independently with no constant or even usual association with any of the others; whence arises that wonderful diversity of appearance, attitudes, expression, ability, intellect, emotion, and what we term as a whole character, which adds so much to the possibilities and enjoyments of social life, and gives us in their higher developments such mountain peaks of human nature as were manifested in Socrates and Plato, Homer and Virgil, Alexander and Phidias, Buddha and Confucius in the older world; in Shakespeare and Newton, Michael Angelo, Faraday, and Darwin in more recent times.

And with all this endless variation wherever we look for it, we are told again and again in frequent reiteration, that variation is minute, is even infinitesimal, and only occurs at long intervals in single individuals, and that it is quite insufficient for natural selection to work with in the production of new species.

This blindness, no doubt, arose in some persons from the ingrained idea of man's special creation, at all events, and that it was almost impious to suppose that these variations could have had anything to do with his development from some lower forms. But among naturalists the idea long prevailed, as it does still to some extent, that in a state of nature there is little variation. Yet here, too, they might have found a clue in the fact, so often quoted, that a shepherd knows every individual sheep in his flock, and the huntsman every dog in his well-matched pack of hounds, and this notwithstanding that in both cases these animals are selected breeds in which all large deviations from the type form are usually rejected.

Of late years, however, variations occurring in a state of nature have been carefully examined and measured, and it is to some of these that we will now appeal for the proof of everpresent variation of the character and amount needed for the production of new species and of every kind of adaptation by means of natural selection or the survival of the fittest. Before giving examples of the variation of the higher animals it will be advisable to show what is meant by the "law of frequency" of variations which has been established by the measurement of several thousands of men in various countries of Europe. These when recorded by means of a diagram are found to form a very regular curve, which becomes more and more regular the larger are the numbers measured. The importance of this is that when we have only small numbers of animals to deal with, and we find great irregularity in their diagrams, we are sure that if we had measurements of hundreds or thousands the curves would be equally regular; and this has now been found to be the case.

The law alluded to is that the number of individuals showing any particular amount of variation is in inverse proportion to its departure from the mean value in the species. It is very closely represented by a special curve called by mathematicians the "curve of error," but for our purpose may be termed the curve of frequency.

The diagram here given represents this curve obtained by measuring the heights of a large number of men taken at random.

The horizontal scale shows the heights given in feet and inches, and the vertical scale the numbers measured of successive heights. The central line through the highest point of the curve marks the average of the whole number measured, there being in this case (though not always) very nearly the same number of individuals above and below the mean height.

The peculiarity of the curve is that it rises very slowly from the height marking that of the shortest individual measured — here a fraction above 4 feet 8 inches — then more and more rapidly for about one-third of the height, then more rapidly and nearly regularly to near the summit, when it

bends in rather abruptly to the mean height, and then descends in a nearly corresponding curve as heights are above the average, till it ends just short of 6 feet 8 inches.

By adding together the numbers on both sides of the curve we find that in this particular group of 2600 men none were quite so short as 4 feet 8 inches or quite so tall as 6 feet 8 inches. But in any other group of the same number the extremes might be a little more or less, perhaps a quarter of an inch or rarely a whole inch. We should have to measure a million, or even several millions, to get the average height and the proportionate greatest and least heights; and even then we should not get near the absolute limits of our race, as we know that at long intervals giants and dwarfs appear, differing by many inches, or even by a foot, from all others living at the time. But, omitting these rare occurrences, the measurements of a few thousand among a fairly mixed population will give us the mean height of the whole, very nearly; as well as the proportionate numbers of those of particular heights, as, for example, at 5 feet 3 inches or 6 feet 3 inches. But even the mean height does not remain the same if the mode of life changes. It is certain that the larger proportion now living in crowded cities than there were a century ago has considerably dwarfed our population.

We will now give an example of variation in a wild animal in order to show that man and the animals and plants which he has domesticated or cultivated do not differ in this respect from those existing in a state of nature.

The diagram here given is formed from the measurements of six separate portions of twenty male specimens of the Bobo'-link or Rice-bird (Dolichonyx oryzivorus), very common in. North America. All were obtained in the same place on the same day, so that there could be no suspicion of their being in any way selected as especially variable. It is a little larger than our yellow-hammer, and is therefore of a convenient size to be shown on a diagram of its actual dimensions, thus' giving a better notion of the amount of variation of the several parts than if reduced to a smaller scale.

The vertical lines, numbered at top and bottom, 1-20, show the measurements of the twenty specimens of this bird, and the figures at the sides, 0-5, mark the inches. The. specimens are arranged in the order of length of body, shown by the upper somewhat irregularly curved line of dots. This is seen to vary from 4*4$ inches to a little less than 5 inches. The next lower line shows the length of the wing of each specimen, and we at once see the want of correspondence with that of the body. No. 5, with a quite short body, has the longest wing of all; while No. 16, with a long body, has nearly the shortest wing. The third line, showing the tail-lengths, is equally remarkable, for No. 6 shows the longest tail with quite a short body, while No. 16, with one of the shortest tails, has a long body; so that Nos. 6 and 16, measured in the usual way to the end of the tail, would be found of exactly the same size, though the one is really % inch shorter than the other.

The next three lines show the varying lengths of the tarsus (commonly termed the leg), the middle toe, and the outer toe, and they too show very distinct and often contrasted divergences in proportion to their small total length. Thus Nos. 14 and 18 have nearly the shortest legs with large bodies. The middle toe in 7 is as long as in 19 and 20, while the outer toe is decidedly longer than in 19, and in 12 decidedly shorter than in 2.

It is particularly important to note here that this remarkable amount of variation occurs in only twenty birds taken at random. But the species is one of the most populous in North America, occurring in enormous flocks over the whole continent, from 54° N. lat. in summer, and migrating as far south as Paraguay in winter. There must, therefore, be an average population of (probably) hundreds of millions, giving a much greater range of variation, and an ever-present abundance of variations of all the parts and organs of the species.

In my Darwinism (chapter iii.) I have given sixteen diagrams of variation, showing that it occurs to an approximately equal extent in mammals and reptiles as well as in birds, and in a large number of their parts and external organs; while many examples of variation occur among the lower animals, especially insects, and also to an amazing extent among plants. During the last twenty years an enormous amount of work has been done in the investigation of variation in all its phases and complexities, and an excellent account of these has been given by Dr. H. M. Vernon in his Variation in Animal9 and Plants, 1903 (International Scientific Series), to which my readers are referred for fuller information, but a few of his conclusions may be here given. He says:

Every organism varies in respect of all its characters, whatever be their nature. The amount of this variation differs greatly, but it is always present in a greater or less degree.

And again, referring to a diagram showing the variations of a squirrel, he says:

Variation of a similar nature — though of a varying degree — is present in all organisms, to whatever class of the animal or vegetable kingdom they belong.

Referring to the diagram of human stature at p. 116, it is found that about half the whole number measured vary a little more than 2 inches above or below the mean, or a little more than 3 per cent of the mean height. This is termed the percentage of mean error, and Mr. Vernon gives us an interesting table of the same percentage for different parts of the body derived from very large numbers of measurements of different races of men. It is as follows: —

Per cent.

Nose length 9.46

"breadth 7.57

"height 15.2

Forehead height 10.4

Under-jaw length 4.81

Mouth breadth 5.18

Per cent.

Head length 2.44

"breadth 2.78

Upper arm length 6.50

Fore arm length 3.85

Upper leg length 5.00

Lower" 5.04

Foot length 5.92

Here we see that the different parts of the human body vary more, proportionally, than does its whole height; and we must always remember that these variations are all, to a large extent, independent of each other, just as we saw was the case with those parts shown in the bird diagram.

Again we must lay stress upon the fact that every part of every organism, outside or inside, important or insignificant, is subject to a similar and often more pronounced amount of variation, as numerous examples quoted in Mr. Vernon's book amply prove. So that we are fully justified in accepting as a demonstrated fact, that the whole structure of every organism, in every stage of its growth or development, varies in its different individuals, each one in a somewhat different manner, and to such a large extent as to afford the amplest store of material for modification and development in any direction that may be required.

This ever-present and all-pervading variability is probably the most important of the contributory factors of evolution, and must never for a single moment be lost sight of.

Powers of Increase of Plants and Animals

Of almost equal importance with ever-present variation is the power which all organisms possess of reproducing their kind so rapidly as to be able to take possession of any unoccupied spaces around them, and in many cases to expel other kinds by the vigour of their growth.

The rapidity of increase is most prominently seen among vegetables. These are capable, not only of a fivefold or tenfold annual increase, as among many of the higher animals, but one of many hundred or even thousandfold annually. A full-grown oak or beech tree is often laden with fruit on every branch, which must often reach 100,000, and sometimes perhaps a million in number, each acorn or nut being capable, under favourable conditions, of growing into a tree like its parent. Our wild cherries, hawthorns, and many other trees, are almost equally abundant fruit-bearers, but in all these cases it is only rarely (in a state of nature) that any one seed grows to a fruit-bearing size, because, all having a superabundance of reproductive power, an equilibrium has been reached everywhere, and it is only when some vacancy occurs, as when a tempest uproots or destroys a number of trees, or some diminution of grazing animals allows more seedlings than usual to grow up, that any of the seeds of the various trees around have a chance of surviving; and the most vigorous of these will fill up the various gaps that have been produced.

But it is among the herbaceous plants that perhaps even greater powers of increase exist. Where our common fox-glove luxuriates we often see its tall spikes densely packed with capsules, each crowded with hundreds of minute seeds, which are scattered by the wind over the surrounding fields, but only a few which are carried to especially favourable spots serve to keep up the supply of plants. Kerner, in his Natural History of Plants, tells us that a crucifer, Sisymbrium Sophia, has been found to produce on an average 730,000 seeds, so that if vacant spaces of suitable land existed around it, one plant might, in three years only, cover an area equal to 2000 times that of the land-surface of the globe. A close ally of this, Sisymbrium Irio, is said to have sprung up abundantly among the ruins of London after the great fire of 1666. Yet it is not a common plant, and is a doubtful native, only occurring occasionally in English localities.

Turning to the animal kingdom, we still find the reproductive powers always large and often enormous. The slowest breeding of all is the elephant, which is supposed to rear one young one every 10 years; but, as it lives to more than 100 years, Darwin calculates, that in 750 years (a few moments only in the geological history of the earth) each pair would, if all their offspring lived and bred, produce 19 millions of elephants.

The smaller mammals and most birds increase much more rapidly, as many of them produce two or more families every year. The rabbit is one of the most rapid, and Mr. Kearton calculates that, under the most favourable conditions, a single pair might in 4 or 5 years increase to a million. Australia, being favourable in climate, vegetation, and absence of enemies, they have so multiplied as to become a nuisance and almost a danger, and though their introduction was easy, it has so far been found impossible to get rid of them.

When the general adaptation of an animal to its whole conditions of life over a large area is favourable, an enormous population can permanently maintain itself in the face of what appear to be dangerous enemies. Two cases illustrate this, and at the same time show how the presence of civilised man leads to their rapid extinction.

In the eighteenth century the bison ranged over almost the whole of temperate North America, being abundant in Pennsylvania and Kentucky, as well as over the whole of the central plains, while it sometimes extended to the coast of the Atlantic. Within the memory of living persons it abounded west of the Mississippi in countless herds many miles in extent, as vividly described by Catlin the painter, in the stories of Mayne Reid, and in the narratives of numerous travellers and explorers.

The fact that such a large and rather clumsy animal should under natural conditions have occupied so large an area in such vast multitudes, is a sure proof that it had become so perfectly adapted to its whole environment as to effectually protect itself against the numerous enemies that inhabited the same area. Those powerful members of the cat tribe, the jaguar and the puma, would have been quite able to destroy the bison had it not been protected by its social instinct and high intelligence. The wolves which hunt in packs, and are equally powerful and ferocious with those of Europe, must also have been most dangerous enemies; but the bisons always associated in numerous herds, and were so well guarded by the old males, that they appear to have suffered little from these animals. The immense shaggy covering to the head, neck, and breast of the male buffaloes, together with their short, powerful horns, were an almost perfect protection; and we must consider these animals to have constituted one of the highest developments of the great tribe of herbivorous quadrupeds.

The extension of railways over the whole country about the middle of the century, and the fact that, as the herds diminished buffalo skins became more valuable, led to its rapid extermination; and at the present time only a small and dwindling herd exists in the Yellowstone Park, and another in north-western Canada.

Even more remarkable has been the disappearance of the passenger pigeon (Ectopistes migratoria), so called from its great powers of flight and its migration in vast flocks all over North America. The population of this bird was almost incredibly great, as described by the American ornithologists Audubon and Wilson in the early part of the nineteenth century. It inhabited the whole of the wooded parts of North America from Mexico, within the tropics, to the northern shores of Hudson's Bay, and its former history is now the more interesting, because it has already become a creature of the past. In the American periodical, The Auk, of last year, is the following note:

The Passenger Pigeon — Only One Pair Left.— I have taken a special interest in the remaining birds belonging to the Milwaukee and Cincinnati flocks which have been in confinement for many years. In my last remarks on the species (Auk, 1908, p. 18) I stated that the remnants of these flocks then numbered but seven birds, with little or no chance of further reproduction. The number is now reduced to a single pair, and doubtless the months are numbered when this noble bird must be recorded as extinct.— Ruthven Deane, Chicago, 111.

In view of the above statement it will be both interesting and instructive to state briefly what were the facts as to the numbers of these birds about a hundred years ago (1811). Alexander Wilson gives the following account in his American Ornithology:

The roosting-places are always in the woods, and sometimes occupy a large-extent of forest. When they have occupied one of these places for some time the appearance it presents is surprising. The ground is covered to the depth of several inches with their dung; all the tender grass and underwood destroyed; the surface strewed with large limbs of trees broken down by the weight of the birds collecting one above another; and the trees themselves for thousands of acres killed as completely as if girdled with an axe. The marks of their desolation remain for many years. When these roosts are first discovered, the inhabitants from considerable distances visit them in the night, with guns, clubs, long poles, pots of sulphur, and various other engines of destruction. In a few hours they fill many sacks and load horses with them.

The breeding-place differs from the roost in its greater extent. In the western countries, viz., the States of Ohio, Kentucky, and Indiana, these are generally in backwoods, and often extend in nearly a straight line across the country for a great distance. Not far from Shelbyville, in the State of Kentucky, about five years ago, there was one of these breeding-places which stretched through the -woods in nearly a north and south direction, was several miles in breadth, and was said to be upwards of forty miles in extent. In this tract almost every tree was furnished with nests wherever the branches could accommodate them. The pigeons made their first appearance there about the 10th of April, and left it altogether with their young before the 25th of May. As soon as the young were fully grown, and before they left the nests, numerous parties of the inhabitants from all parts of the adjacent country came with wagons, axes, beds, cooking utensils, many of them accompanied by the greater part of their families, and encamped for several days at this immense nursery. Several of them informed me that the noise was so great as to terrify their horses, and that it was difficult for one person to hear another speak without bawling in his ear. The ground was strewed with broken limbs of trees, eggs, and young squab pigeons, which had been precipitated from above, and on which herds of hogs were fattening. Hawks, buzzards, and eagles were sailing about in great numbers, and seizing the squabs from the nests at pleasure, while from twenty feet upwards to the top of the trees the view through the woods presented a perpetual tumult of crowding and fluttering multitudes of pigeons, their wings roaring like thunder, mingled with the frequent crash of fallen timber; for now the axe-men were at work, cutting down those trees that seemed to be most crowded with nests, and contrived to fell them, in such a manner that in their descent they might bring down several others, by which means the falling of one large tree sometimes produced 200 squabs, little inferior in size to the old ones and almost one heap of fat. It was dangerous to walk under these flying and fluttering millions from the frequent fall of large branches, broken down by the weight of the multitudes above, and which in their descent often destroyed numbers of the birds themselves, while the clothes of those traversing the woods were completely covered with the excrements of the pigeons.

I passed for several miles through this same breeding-place, where every tree was spotted with nests, the remains of those above described. In many instances I counted upwards of ninety nesta in a single tree; but the pigeons had abandoned this place for another, sixty or eighty miles off, towards Green river, where they were said at that time to be equally numerous. From the great numbers that were continually passing over our heads to or from that quarter, I had no doubt of the truth of this statement. The mast had been chiefly consumed in Kentucky; and the pigeons, every morning a little before sunrise, set out for the Indiana territory, the nearest part of which was about sixty miles distant. Many of these returned before ten o'clock, and the great body generally appeared on their return a little after noon. I had left the public road to visit the remains of the breeding-place near Shelbyville, and was traversing the woods with my gun, on my way to Frankfort, when about ten o'clock, the pigeons which I had observed flying the greater part of the

morning northerly, began to return in such immense numbers as I never before had witnessed. Coming to an opening by the side of a creek called the Benson, where I had a more uninterrupted view, I was astonished at their appearance; they were flying with great steadiness and rapidity, at a height beyond gunshot, in several strata deep, and so close together that, could shot have reached them one discharge could not have failed bringing down several birds. From right to left as far as the eye could reach, the breadth of this vast procession extended, seeming everywhere equally crowded. Curious to determine how long this appearance would continue, I took out my watch to note the time, and sat down to observe them. It was then half-past one; I sat for more than an hour, but instead of a diminution of this prodigious procession it seemed rather to increase, both in numbers and rapidity, and anxious to reach Frankfort before night, I rose and went on. About four o'clock in the afternoon I crossed Kentucky river, at the town of Frankfort, at which time the living torrent above my head seemed as numerous and extensive as ever. Long after this I observed them in large bodies that continued to pass for six or eight minutes, and these again were followed by other detached bodies, all moving in the same south-east direction till after six o'clock in the evening. The great breadth of front which this mighty multitude preserved would seem to intimate a correspondiDg breadth of their breeding-place, which, by several gentlemen who had lately passed through part of it, was stated to me as several miles.

Wilson then gives a rough calculation of the probable numbers of this great flight of pigeons, and comes to the conclusion that its whole length was 240 miles, and that the number of birds must have been considerably more than 2000 millions. If each pigeon consumed only half a pint of food daily, the quantity would amount to over 17 millions of bushels daily. Audubon, who went through the same country about twenty years later, confirms Wilson's account in every essential part; and the language of the former is so simple and restrained, that there is evidently no attempt to exaggerate what he witnessed and was informed of by many independent observers. Waterton, with his usual scepticism as to the observations of other naturalists, treats the whole narrative as gross exaggeration or fabrication; on which the late Professor Alfred Newton remarks, that the critic would probably have been less severe had he known that, 150 years earlier, these pigeons so swarmed and ravaged the colonists' crops near Montreal, that a bishop of his own Church was constrained to exorcise them with holy water as if they had been demons. Professor Newton adds that the rapid and sustained flight of these pigeons is as well established as their former overwhelming abundance, birds having been killed in the State of New York whose crops contained undigested grains of Tice that must have been not long before plucked and swallowed in South Carolina or Georgia. The passenger pigeon has several times been shot in Great Britain, and Professor Newton believes that some of these crossed the Atlantic unassisted by man.

Considering the vast multitudes of these birds in a state of nature, notwithstanding the variety of birds of prey in North America, together with its unequalled powers of flight, it must be classed as one of the finest examples of what Darwin termed "dominant species," and may also be considered as the highest development of the special type of bird-life manifested in the order Columhse or Pigeons; and it will doubtless, by future generations of bird-lovers, be counted as a blot upon the boasted civilisation of the nineteenth century that, in its mad greed for wealth, it should have so devastated a whole continent as not to leave room in it for the continued existence of such grand and heautiful life-forms as the bison and passenger pigeonEqually remarkable, perhaps, is the Norwegian lemming, a little animal somewhat larger than our short-tailed field-mouse, but with a tail only half an inch long. This creature is always abundant in Lapland and northern Scandinavia, but only extraordinarily so at long intervals, when favourable conditions lead to its almost incredible multiplication. At intervals of from ten to twenty-five years a great army of them appears, which devours every green thing in its path. Great bands descending from the highlands of Lapland and Finland march in parallel lines about 3 feet apart, never turning aside, crossing lakes, and rivers, and even eating through corn and haystacks when these cross their path. The following

recent statement of the ascertained facts as to these strange migrations — from the work on Mammals by the late Sir H. Flower and R. Lydekker — will prove interesting:

The usual dwelling-place of the Lemmings is in the highlands or fells of the great central mountain chain of Norway and Sweden. South of the Arctic circle, they are, under ordinary circumstances, exclusively confined to the plateaus covered with dwarf birch and juniper above the conifer region, though in Tromso and Finmarken they occur in all suitable places down to the level of the sea. The nest is found under a tussock of dry grass or a stone, constructed of dry straws and usually lined with hair. The number of young in each nest is generally five, and at least two broods are produced annually. Their food is entirely vegetable, especially grass roots and stalks, shoots of the birch, reindeer-lichen and mosses, in search of which they form in winter long galleries through the turf or under the snow. They are restless, courageous, and pugnacious little animals. When suddenly disturbed, instead of trying to escape, they will sit upright, with their back against a stone or other object, hissing or showing fight in a very determined manner. (See Fig. 12.)

The circumstance which has given more popular interest to the Lemming than to a host of other species of the same order of animals is that certain districts of the cultivated lands of Norway and Sweden, where in ordinary circumstances they are quite unknown, are occasionally and at very uncertain intervals, varying from five to twenty or more years, literally overrun by an army of these little creatures, which steadily and slowly advance, always in the same direction, and regardless of all obstacles, swimming across rivers and even lakes of several miles in breadth, and committing considerable devastation on their line of march by the quantity of food they consume. In their turn they are pursued and harassed by a crowd of beasts and birds of prey, as bears, wolves, foxes, dogs, wild cats, stoats, weasels, hawks, and owls, and are never spared by man; even the domestic animals not usually predaceous, as cattle, goats, and reindeer, are said to join in the destruction, stamping them to the ground with their feet, and even eating their bodies. 'T'imbers also die from diseases apparently produced by overcrowdNone ever return by the course over which they have come, and the onward march of the survivors never ceases until they reach the sea, into which they plunge, and swimming outwards in the same direction as before, perish in the waves. ... So extraordinary was the sudden appearance of these vast bodies of Lemmings to the Norwegian peasants, that they supposed they must have fallen from the clouds.

The principal really ascertained facts regarding these migrations seem to be as follows: When a combination of favourable circumstances has occasioned a great increase in the numbers of Lemmings in their ordinary dwelling-places, a movement necessarily occurs at the edge of the elevated plateau, and a migration towards the low-lying land begins. The whole body slowly moves forward, advancing in the same general direction in which they started, but following more or less the course of the great valleys. They only travel by night, and they also stay in congenial places for weeks or months, so that, with unaccustomed abundance of food, notwithstanding all the destructive influences to which they are exposed, they multiply excessively during their journey, having families still more numerous and more frequently than in their usual homes. The progress may last from one to three years, according to the route taken and the distance to be traversed until the sea coast ii reached, which, in a country so surrounded by water as the Scandinavian peninsula, must be the ultimate goal of such a journey. This may be either the Atlantic or the Gulf of Bothnia, according as the migration has commenced from the west or east side of the elevated plateau. Those that finally perish in the sea are only acting under the same blind impulse which has led them previously to cross smaller pieces of water with safety.

The strange history of these small creatures, besides showing the enormous powers of increase in various types of life, also furnishes us with a fine example of adaptation to what would be, to most animals, extremely adverse conditions — high plateaus within or bordering on the Arctic circle, with its intense cold, its long periods of darkness, buried in snow in winter, and with a scanty and

stunted vegetation. Yet they appear to have a most enjoyable existence, and would evidently be able to overrun and occupy a much larger extent of aim ilarly inhospitable country did such exist in their vicinity; while in more fertile lands, with a milder climate and more luxuriant vegetation, they rapidly become extinct through disease or the attacks of enemies.

In Mr. W. H. Hudson's most interesting volume, A Naturalist in La Plata, he gives an account of a very similar rapid increase of field-mice, under extremely different conditions, in the chapter entitled A Wave of Life. In a concluding passage he so clearly summarises the whole course of events that I here extract it: —

Cover and food without limit enabled the mice to increase at such an amazing rate, that the ordinary checks interposed by predatory species were for a while inappreciable. But as the mice increased so did their enemies. Insectivorous and other species acquired the habits of owls and weasels, preying exclusively on them; while to this an innumerable array of residents was shortly added multitudes of wandering birds coming from distant regions. No sooner had the herbage perished, depriving the little victims of their cover and food, than the effects of the war became apparent. In autumn the earth so teemed with them that one could scarcely walk anywhere without treading on mice; while out of every hollow weed-stalk lying on the ground dozens could be shaken; but so rapidly had they been devoured by the trained army of persecutors that in spring it was hard to find a survivor even in the barns and houses. The fact that species tend to increase in a geometrical ratio makes these great and sudden changes frequent in many parts of the earth; but it is not often that they present themselves so vividly as in the foregoing instance, for here, scene after scene in one of Nature's silent, passionless tragedies, myriads of highly organised beings rising into existence only to perish almost immediately, scarcely a hard-pressed remnant surviving to continue the species.

It may, however, be concluded that not thus are species exterminated in any region that remains suitable for their existence. Long before they approach extinction, the very scarcity of them drives away, one after another, the crowd of enemies which had been attracted by their inordinate numbers, till the former balance of life is restored, and the rapid , powers of increase of the sufferers soon restores them to their normal population. It is against the adverse powers of inorganic nature that speedy reproduction is such a safe-guard. When fire or flood, droughts or volcanic outbursts have destroyed animal life over wide areas, the few survivors on the margin of the devastated area are able to keep pace with renewed vegetation and again stock the land with its former variety of living things.

The facts outlined in the present chapter, of abundant and ever-present variability with enormous rapidity of increase, furnish a sufficient reply to those ill-informed writers who still keep up the parrot-cry that the Darwinian theory is insufficient to explain the formation of new species by survival of the fittest.

They also serve to rule out of court, as hopelessly inefficient, the modern theories of "mutation" and "mendelism," which depend upon such comparatively rare phenomena as "sports" and abnormalities, and are, therefore, ludicrously inadequate as substitutes for the Darwinian factors in the world-wide and ever-acting processes of the preservation and continuous adaptation of all living things. The phenomena upon which these theories are founded seem to me to be mere insignificant byeproducts of heredity, and to be essentially rather self-destructive than preservative. They form one of nature's methods of getting rid of abnormal and injurious variations. The persistency of Mendelian characters is the very opposite of what is needed amid the ever-changing conditions of nature.

A critical examination of these theories is given in Mr. G. Archdall Beid's recent work, The Principles of Heredity. There is also a shorter and more popular criticism in the Introduction to Professor E. B. Poulton's Essays on Evolution (1908).

Chapter VIII - ILLUSTRATIVE CASES OF NATURAL SELECTION AND ADAPTATION

We have now learnt something of the great features of the "world of life" whose origin, development, and meaning we are seeking to comprehend; we have been enabled to visualize its enormous extent, its almost endless diversity of form, structure, and mode of existence; the vast population of the species that compose it, especially those which we term common. Further, we have seen something of the way in which large numbers of species inhabit the same area intermingled together, which they are enabled to do by each being adapted to some one station or particular kind of food which its peculiar organisation enables it to utilise; each occupying, as it were, a special place in the economy of nature.

We have also learnt something of the three great factors which are essential for the gradual modification of species into new and better adapted organisms — heredity, variation, and enormous powers of increase, leading inevitably to a struggle for existence, since of the many that are born only a few can possibly survive. We are, therefore, now prepared to examine, so far as we are able, the exact method of Nature's work in species-production.

One of the difficulties in the way of an acceptance of continuous evolution through variation and natural selection is, that though variation may be fully admitted, and though great changes of climate and some changes of land and sea have occurred in the human period, these do not seem to have led to the formation of new species, but only to the extinction, or change in the distribution, of a few of them. But of late years naturalists, having pretty well exhausted the well-defined species of the best-known parts of the world — Europe and North America — have paid more attention to varieties, and especially to those characteristic of islands or other wellmarked and somewhat isolated districts.

Having heen much struck, some forty years ago, hy the fact that two peculiar heetles are found in Lundy Island (in the Bristol Channel), another in Shetland, while some peculiar forms of butterflies and moths occurred in the Isle of Man, I thought it would be interesting to collect together and publish lists of all the species or varieties of animals and plants which had hitherto been found only in our Islands. This I attempted when writing my Island Life in 1880 and several specialists in various groups were kind enough to draw up lists for me. These were revised and much increased in the second and third editions; and in the latter (1902) they amounted to 5 birds, 14 fresh-water fishes, 179 lepidoptera, 71 beetles, 122 land and fresh-water molluscs, and 86 flowering plants. It is interesting to note that of these latter no less than 20 are found only in Ireland, where the insular conditions of climate that may be supposed to lead to modification are at a maximum. No less than 20 species of our Mosses and 27 of our Hepaticae are also not found in Europe, though a few of them are (and others may be) found in other parts of the world.

As there is no doubt that our islands were at no distant period (in a geological sense) united to the continent, and that since their separation they must, through the influence of the Gulf Stream penetrating around and among them, have acquired a milder, moister, and a more uniform climate, it seems quite probable that a considerable proportion of these numerous local forms are actual modifications of the allied continental forms due to adaptation to the changed conditions.

Since my book was published, an interesting addition to the list of peculiar birds has been made by Dr. Ernst Hartert, in an article entitled On Birds represented in the British Isles by peculiar Eorms. In this list, with MSS. additions up to the end of 1909, Dr. Hartert enumerates no less than 24 species, which have become more or less distinctly modified from their continental allies. These

include a distinct crossbill from the highlands of Scotland, all our British titmice, which seem to be especially modifiable, and several others. The complete list is as follows: —

1. Pyrrhula pyrrhula pileata .British Bullfinch.

2. Turdus musicus clarkci "Song-Thrush.

3. Pratincola rubicola hibenueus "Stonechat.

4. Garrulus glandarius rufitergum "Jay.

5. Loxia curvirostra scotica Scottish Crossbill.

6. Carduelis carduelis britannicus.... British Goldfinch.

7. Motacilla flava rayi Yellow Wagtail.

8. " alba lugubris Pied Wagtail.

9. Parus major newtoni British Great Titmouse.

10. " cseruleus obscurus "Blue Titmouse.

11. " ater britannicus "Coal Titmouse.

12. " palustris dresseri "Marsh Titmouse.

13. " atricapillus kleinschmidti...." Willow Titmouse.

14. " eristatuB scotica Scottish Crested Titmouse.

15. Aegithalus caudatus rosea British Long-tailed Titmouse.

16. Regulus regulus anglorum "Goldcrest.

17. Sitta europ«a britannica "Nuthatch.

18. Ccrthia familiaris britannica "Tree-creeper.

19. Erithacus rubecula melophilus "Robin.

20. Troglodytes troglodytes pirtensis.. .St. Kilda Wren.

21. Cinclus cinclus britannicus British Dipper.

22. Dendrocopus major anglicus "Great Spotted Woodpecker

23. " minor comminutus "Lesser Spotted Woodpecker.

24. Lagopus lagopus scoticus Bed Grouse.

This last has been generally treated as a well-marked species, but Dr. Hartert considers it, with all the others, to be a subspecies — a species in the making. It is certainly a very interesting fact that so many of our familiar birds are found to present constant differences from their continental allies. Most of these differences are of colour only, but some diversity of bulk and in the size of the bill indicate the commencement of structural modification; and these various differences from the nearest continental species in so many of our resident birds seem inexplicable on any other theory than that they are adaptations to the slight but undoubted difference of climatical conditions which characterise our islands.

In confirmation of this view, a few cases have been recorded in which nature has been caught, as it were, at work in the actual formation of new species at the present time. The first is that of the Porto Santo rabbits, carefully investigated by Darwin. In the history of an early Spanish voyage it is recorded that, a female rabbit having had a litter of young on board, they were all turned loose on this small uninhabited island near Madeira. This was about 1419, and from these alone the island became fully stocked, and remains so still, although the island is now fairly peopled. Darwin was able to examine two of these rabbits preserved in spirits, three others in brine, and two alive which had been in the Zoological Gardens for four years. These seven specimens, though caught at different times, closely resembled each other, they were all full grown, yet they were very much smaller than English wild rabbits, being little more than half the weight, and nearly three inches less in length. Four skulls of the Porto Santo rabbits differed from those of English wild rabbits in the supraorbital processes of the frontal bone being narrower; but they differed considerably in colour, the upper surface being redder, and the lower surface pale grey or lead colour instead of white; the upper surface of the tail, however, was reddish-brown instead of blackish-grey as in all wild European rabbits, while the tips of the ears had no black edging, as our rabbits always have.

We have here a very remarkable series of differences in size, colour, and even in the form of the skull; while it was noticed at the Zoological Gardens that they were unusually wild and active, and also more nocturnal in their habits than common wild rabbits. In this case, these rabbits would certainly have been described as a distinct species if they had been found in some more remote country to which it was certain that they had not been introduced by man.

Another example which shows nature at work, this time in the actual process of "selection" of the better adapted individuals, occurred quite recently. In February 1898, at the Brown University, Providence, Rhode Island, after a very severe storm of snow, sleet, and rain, 136 common sparrows were found benumbed on the ground, and were collected and brought to the Anatomical Laboratory. They were laid on the floor of a warmed room to see if any of them were alive, where after a short time 72 of them revived while 64 perished. The happy thought occurred to Professor H. C. Bumpus, that here was an opportunity of discovering whether there were any visible characters indicating why some of these birds, under exactly similar conditions, were destroyed while others survived. He therefore made a very minute and careful examination of all the birds, living and dead, with very interesting results, of which the following is a summary:

(1) Sex.— About two-thirds were males, one-third females. Of the former 51 lived, 36 died; of the latter 21 lived, 28 died, showing a decided superiority of the males in resisting cold and wet.

(2) Size.— Here the comparison was made of male adult birds, male young, and females, separately; in all three of these groups those which died were larger than those which survived. The difference was not very great, but it was clearly marked, and as it occurred in all three groups it could not possibly be imputed to chance.

(3) Weight.— This gives the same result as in the last case, the survivors being lighter than those which died, by the considerable proportion of one twenty-fifth.

(4) Length of the Sternum (breast-bone).— This character gives a rather unexpected result, those birds which survived having a decidedly longer sternum than those which perished. The difference is about .013 (a little more than one-hundredth) of the total length; but as the smaller birds on the whole survived, these evidently had their sterna proportionally very long. Now the sternum is an indication of the size of the pectoral muscles which move the wings in flight. The surviving birds therefore were those that could fly quickest and longest, and this probably led to the more rapid production of animal heat. Another advantage would be, that these muscles being larger proportionally there would be less exposure of the internal organs to the extreme cold.

The result of this interesting experiment is almost conclusive as to the reality of natural selection. In this case those which actually survived one of nature's most common tests — exposure to severe storms — and which must be presumed to have been the " fittest" at that particular time and place, were found to differ in just such characters, and in such moderate proportions as have been found to occur constantly in all the commoner species of birds, as well as of all other animals. It proves also that such small variations are, as Professor Lloyd Morgan terms it, of "survival value," a fact which is constantly denied on purely theoretical grounds.

It will perhaps make the subject a little clearer if I here enumerate briefly the exact causes which must have been at work in bringing about the changes in the rabbits of Porto Santo during the four and a half centuries that had elapsed from the time they were turned loose upon the island to the period when Darwin obtained his specimens. The island has an area of about 20 square miles; it is very hilly, of volcanic origin, with a dry climate and scanty vegetation. It is about 26 miles from Madeira, 400 from Africa, and 250 from the Canary Islands. The powers of increase of rabbits being so great, and the island being at that time uninhabited, they would certainly in a very few years have increased to so great a multitude as to consume all the available vegetation. As they approached to these numbers, and were obliged to expose themselves in the daily search for food, many birds of prey from the larger island, and probably others from the Canaries and from Africa — hawks, buzzards, falcons, and owls — would flock to this hitherto desert island to feed upon them, and would rapidly reduce their numbers.

Tip to this time, perhaps not more than a dozen or twenty years from their first introduction, they would have varied in size and colour as do the common domesticated rabbits from which Darwin thinks they were undoubtedly derived. Their numerous enemies would at first capture the larger, more bulky, and slower-moving individuals, then the white or black specimens, who would be more easily seen and pounced upon. This process, continuously acting for a few generations, would result in a smaller and more dusky-coloured race. The continuous attack persisting, the size would be again reduced, and the most agile and rapid in movement would alone survive. Thereafter, the nocturnal habit would be acquired by the day-feeders being almost exterminated, and owls would probably alone remain as formidable enemies. Lastly, the extreme wildness, sensitiveness to danger, perhaps to noise or movement of any kind, would be developed, while the reduction of the supraorbital process may perhaps have been beneficial by reducing the width of the head, and thus allowing them to enter small holes in the rocks more rapidly; or it may possibly be connected with the more nocturnal habits. We thus see that all the changes that have occurred in this interesting animal have no relation whatever to mere "isolation," which many writers still persist in claiming as a vera causa of specific change, but are all clearly traceable as the results of (1) rapid powers of multiplication; (2) that small amount of variability which we know occurs in all such animals; and (3) rigid selection through diurnal and nocturnal birds of prey, which we have seen to play so large a part in keeping down the numbers of the passenger pigeons in North America, the lemming in Scandinavia, and the mice in La Plata.

The two cases now adduced, showing how nature actually works in the production of slightly modified forms through "variation" and " survival of the fittest " will, I think, render the process of species-formation sufficiently intelligible. Very slight inorganic agencies have here been seen at work — in one case a single severe storm, in the other a change to an isolated habitat where slightly new conditions prevailed. But when in the course of those periods when geological changes were most actively at work, larger and more permanent climatic changes occurred, or when more marked diversities of soil and vegetation, with exposure to more severe competition, were brought about, those modifications of the environment would inevitably result in more marked and more varied adaptations of form, structure, or habits, bringing about what we everywhere recognise as perfectly distinct species.

In the present work I do not propose to go further into this matter, which has been treated with sufficient detail and with copious illustrations in my Darwinism and other works, as well as in Darwin's classical volumes, The Origin of Species and Animals, and Plants under Domestication. I will therefore now proceed to an account of some of those broader aspects of adaptation in the organic world, which, so far as I am aware, have hitherto received little attention.

Some Aspects of Organic Adaptation

Though such a very obvious fact, it is not always kept in mind, that the entire animal world, in all its myriad manifestations, from the worm in the soil to the elephant in the forest, from the blind fishes of the ocean depths to the soaring skylark, depends absolutely on the equally vast and varied vegetable world for its very existence. It is also tolerably clear, though not quite so conclusively proved, that it is on the overwhelming variety of plant species, to which we have already called attention, that the corresponding variety of animal species, especially in the insect tribes, has been rendered possible.

This will perhaps be better seen by a reference to one of the best-known cases of general adaptation, which, because so common and obvious, is often overlooked or misunderstood. All lovers of a garden are apt to regard as an unmitigated evil those swarms of insects which attack their plants in spring, and in recurrent bad years become a serious nuisance and commit widespread devastation. At one time the buds or leaves of their fruit trees swarm with various kinds. of caterpillars, while at others even the oak trees are so denuded of their leaves as to become an eyesore in the landscape. Many of our common vegetables, and even the grass on our lawns, are in some seasons destroyed by swarms of wire-worms which feed on their roots. Turnips, radishes, and allied plants are attacked by the turnip-fly, a small jumping beetle whose larva lives in the leaf itself, and which often swarms in millions. Then there are the aphides and froghoppers on our roses and other shrubs or flowers, and grubs which attack our apples, our carrots, and most other crops; and all these the gardener usually regards under the general term "blight," as a serious blot on the face of nature, and wonders why such harmful creatures were permitted to exist.

Most professional gardeners would be rather surprised to hear that all these insect-pests are an essential part of the world of life; that their destruction would be disastrous; and that without them some of the most beautiful and enjoyable of the living things around us would be either seriously diminished in numbers or totally destroyed. He might also be informed that he himself is a chief cause of the very evil he complains of, because, by growing the plants the insect-pests feed upon in large quantities, he provides for them a superabundance of food, and enables them to increase much more rapidly than they would do under natural conditions.

Let us now consider what happens over our whole country in each recurring spring. At that delightful season our gardens and hedgerows, our orchards, woods, and copses are thronged with feathered songsters, resident and migratory, engaged every hour of the day in building their nests,

hatching their eggs, or feeding and guarding their helpless offspring. A considerable proportion of these — thrushes, warblers, tits, finches, and many others — are so prolific that they have two or three, sometimes even more, families every year, so that the young birds reared annually by each pair varies from four or five up to ten or twenty, or even more.

Now, when we consider that the parents of these, to the number of perhaps fifty species or more, are all common birds, which exist in our islands in numbers amounting to many millions each, we can partially realise the enormous quantity of insect-food required to rear perhaps five or ten times that number of young birds from the egg up to full growth. Almost all of the young of the smaller birds, even when their parents are seed-eaters, absolutely require soft insect-food, such as caterpillars and grubs of various sorts, small worms, or such perfect insects as small spiders, gnats, flies, etc., which alone supply sufficient nourishment in a condensed and easily digestible form.

Many enthusiastic observers, by means of hiding-places near the nests or by the use of field-glasses, have closely watched the whole process of feeding young birds, for hours or even for whole days, and the results are extremely instructive. The chiff-chaff, for example, feeds its young on small grubs extracted from buds, small caterpillars, aphides, gnats, and small flies of various kinds; in a nest with five young, the hen-bird fed them almost all day from early morning to sunset, bringing mouthfuls of food at an average four times in five minutes. This may no doubt be taken as typical of a number of the smaller warblers and allied birds.
Blue tit, with a larger family, worked continuously for sixteen hours a day at midsummer, bringing about two thousand caterpillars to the ravenous young birds, who, taking the average at 10 (and they sometimes have 16) would swallow 200 each in the day. A pair of marsh tits were observed to feed their young entirely with small green caterpillars, and in one case made 475 journeys with food in seventeen hours.

A gold-crest with eight young brought them food 16 times in an hour for sixteen hours a day. A wren fed its young 278 times in a day. Even the common house-sparrow, itself a typical seed-eater, feeds its young on caterpillars or on small insects which it catches on the wing. A flycatcher was observed to sit on a dead branch of an ash tree near her nest, whence by short flights she caught small flies, etc., on the wing, bringing a mouthful to her young every two to five minutes.
As every schoolboy knows, the number of nests is very great to those who know how to look for them, some being found in almost every wood, copse, or hedgerow. As examples, in a small copse in Herts, nine different species of birds had nests with young, all within 50 yards of each other. In another case, nests of a tit, a flycatcher, and a wood-wren were found within 10 to 15 yards of each other. In the case of many small birds the whole period, from hatching the eggs to that of the young leaving the nest is only two weeks, but swifts require from a month to six weeks.

It must be remembered that the birds carefully clean out the nest after every meal, and in wet or very chilly weather carefully protect their young, and as they must also procure food for themselves, it is evident that their labours at this time are really prodigious. And this vast destruction of insect-life goes on unchecked for several months together, and the supply never seems to fail. When the parent birds leave the nest in search of food for their young, they may be seen to fly to some adjacent bush or branch of a tree, hop rapidly about it, and then perhaps fly off to another, having apparently decided that the first one had already been nearly exhausted. But in the few minutes of their absence they are always able to fill their mouths with small caterpillars, flies, grubs, etc., and return to the nest, not only from morning to night on one day, but the same day after day, for at least a fortnight and often much longer, till their first brood is fully fledged and able to provide for themselves. But unless the numbers of insects and their larvae were enormous, and were increased day by day by fresh hatchings from the egg as fast as they were devoured, hosts of these young birds would perish of hunger and cold. For if the parents had to range far away from their nests, and co\ild not find the necessary supply so quickly as they do, the

young birds would be subject to attack from some of their numerous enemies, would suffer from cold or wet, and as they grew older would often, in their frantic struggles with each other, fall out of the nest and quickly perish.

What wonderful perfection of the senses must there be in these various parent birds; what acuteness of vision or of hearing; what rapidity of motion, and what powerful instinct of parental love, enabling them to keep up this high-pressure search for food, and of watchfulness of their nests and young, on the continuance of which, and its unfailing success, the very existence of those young and the continuance of the race depends. But all this perfect adaptation in the parent birds would be of no avail unless the insect tribes, on which alone most of them are obliged to depend, were as varied, as abundant, and as omnipresent as they actually are; and also unless vegetation were so luxuriant and abundant in its growth and so varied in its character, that it can always supply ample food for the insects without suffering any great or permanent injury to the individual plants, much less to any of the species.

By such considerations as these we learn that what we call insect-pests, when they are a little more abundant than usual in our gardens and orchards, do not exist for themselves alone as an apparently superfluous and otherwise useless part of the great world of life, but are, and must always have been throughout long past geological ages, absolutely essential for the origination and subsequent development of the most wonderful, delightful, and beautiful of all the living things around us — our garden friends and household pets, and sweet singers of the woods and fields. Without the myriad swarms of insects everywhere devouring a portion of the new and luxuriant vegetation, the nightingale and the lark, the wren, the redbreast, and the fairy-like tits and goldcrests might never have come into existence, and if the supply failed would now disappear for ever!

The Uses of Mosquitoes

If now we go beyond our own country and see how birds fare in distant lands, we find the key to many of the secrets of bird-life in the greater or less abundance of insects which supply them with food at the critical season of their lives when they have to supply daily and hourly food to their newlyhatched broods. Amid all the infinite variety of the insect world there is probably no one order which supplies such an enormous quantity of food to birds and other creatures as the two-winged flies (Diptera) whose larvae are the maggots which quickly devour all kinds of dead beasts and birds, as well as all kinds of putrefying animal matter; but in the perfect state these insects abound in such swarms as also to supply food to whole groups of fly-catching birds. And among these no wellmarked and very restricted group is at once so hateful to mankind and so delightful to birds as the mosquitoes. It is commonly supposed that these particular insect-pests are more especially tropical; but though they are no doubt very abundant in many parts of the tropics, yet their fullest development is to be found in the icy plains of the Far North, especially within the Arctic circle both in the Eastern and Western hemispheres.

Sir William Butler in his works — The Wild Lone Land, and others on Arctic and sub-Arctic North America — describes them as often swarming in such abundance as to completely obscure the sun like a dense thundercloud; and they furnish abundant material for the wildly exaggerated stories in which Americans delight — such as the serious statement that they can pierce through the thickest cow-hide boots, and that an Irishman, seeking protection from them by covering his head with a copper kettle, they pierced it in such countless numbers that their combined strength enabled them to fly away with it!

Our best and most instructive writer on the wonderful birdmigrations to the Arctic regions is the late Mr. Henry Seebohm, who spent two seasons there, one in the north-east of Russia, at Ust-

Zylma, and at the mouth of the Petchora River, far within the Arctic circle; and another in Northern Siberia, at the mouth of the Yenesay River. He tells us, that — "Birds go to the Arctic regions to breed, not by thousands but by millions. The cause of this migration is to be found in the lavish prodigality with which Nature haa provided food. Seed or fruit-eating birds find an immediate and abundant supply of cranberries, crowberries, and other ground fruit, which have remained frozen during the long winter, and are accessible the moment the snow has melted, while insect-eating birds have only to open their mouths to fill them with mosquitoes."

Among the larger birds that come early to these regions to breed are two species of wild swans and the bean goose. So early as 10th May they began to arrive, passing over UstZylma (Lat. 66° N.) in flocks, where, by constructing a shelter, Mr. Seebohm was able to shoot one. Even these large birds find ample food on the tundra to breed there; for just before leaving the country, when near the mouth of the Petchora River, he saw them returning southward with their young.

He writes:

I had not gone more than a mile when I heard the cackle of geese; a bend of the river's bed gave me an opportunity of stalking them, and when I came within sight I beheld an extraordinary and interesting scene. One hundred, at least, old geese, and quite as many young ones, perhaps twice or even thrice that number, were marching like a regiment of soldiers. The vanguard, consisting of old birds, was half-way across the stream, the rear, composed principally of goslings, was running down the steep bank towards the water's edge as fast as their young legs could carry them. Both banks of the river where the geese had doubtless been feeding, were strewn with feathers, and in five minutes I picked up a handful of quills. The flock was evidently migrating to the interior of the tundra, moulting as it went along."

This species retires southwards before the winter, and visits UB every year in September or October being especially abundant in Ireland, where it is said to be found in every bog and marsh. On the Siberian tundra it no doubt feeds largely on the abundant berries, but also, of course, on the food it finds in swamps and river-margins.

Coming back to our more special subject of the mosquitoes, Mr. Seebohm writes as follows. After describing some of his early excursions after birds or their nests he adds:

That day (June 2nd) I recorded in my journal, with many groans, the arrival of the mosquitoes. Horrid-looking beasts, with bodies a third of an inch long, monsters, the Culex damnabilis of Rae, with proboscis infernali veneno munita. I foresaw that we should have opportunities enough to study the natural history of these blood-thirsty creatures to our heart's discontent.

About a month later he writes when searching for eggs, properly identified:

Doubtless the proper thing to have done would have been to lie down and watch the birds on to their nests; but to become the nucleus of a vast nebula of mosquitoes is so tormenting to the nerves, that we soon came to the conclusion that the birds had not begun to breed, and that it was no use martyrising ourselves to find their eggs. The mosquitoes were simply a plague. Our hats were covered with them; they swarmed upon our veils; they lined with a fringe the branches of the dwarf birches and willows; they covered the tundra with a mist.

But this was quite at the beginning of the season, and he adds:

We were told that this pest of mosquitoes was nothing as yet to what it would become later. 'Wait a while/ said our Job's comforter, 'and you will not be able to see each other at twenty paces

distance; you will not be able to aim with your gun, for the moment you raise your barrel half-a-dozen regiments of mosquitoes will rise between you and the sight.'"

And Mr. Seebohm described how he was protected by indiarubber boots and cavalry gauntlets, and a carefully constructed cage over his head, without which he never dare go out on the tundra (see Fig. 15).

Now this Arctic country, beyond the limit of forests and stretching to the polar ocean, which is buried for eight or nine months under six feet thick of snow, is yet, during its short summer, a very paradise for birds of all kinds, which flock to it from all over Europe and Central Asia in order to breed and to rear their young; and it is very largely, and for many species almost exclusively, this very abundance of mosquitoes and their larvae that is the chief attraction. In Mr. Seebohm's works, already quoted, and in his fine volume on the Geographical Distribution of the Plovers and allied birds, he gives a most graphic account of this country and of the birds flocking to it, which is worth quoting, as few people have any adequate idea of what the greater part of the Arctic regions really are in summer. After describing its extent and boundaries, he says:

I have called this district a paradise, and so it is for two or three months of the year. Nowhere else in the whole world can you find such an abundance of animal and vegetable life, brilliant flowers, birds both of gay plumage and melodious of song, where perpetual day smiles on sea and river and lake. For eight months or more (according to the latitude) every trace of vegetable life is completely hidden under a thick blanket which absolutely covers every plant and bush. Far as the eye can reach, in every direction nothing is to be seen but an interminable, undulating plain of white snow.

Then after describing the few animals that live there even during the winter, and the strange phenomenon in May of continuous day and almost perpetual sunshine, at midday hot enough to blister the skin, yet still apparently in mid-winter so far as the snow is concerned, he goes on to describe what there takes place:

The disc of snow surrounding the North Pole at the end of May extends for about two thousand miles in every direction where land exists, and is melting away on its circumference at the rate of about four miles an hour, and as it takes a week or more to melt, it is in process of being melted for a belt of several hundred miles wide round the circumference. This belt is crowded with migratory birds eager to push forwards to their breeding grounds — hurrying on over the melting snow so long as the south wind makes bare places soft enough to feed on, but perpetually being driven back by the north wind, which locks up their food in its ice-chest. ... In watching the sudden arrival of summer on the Arctic circle, both in the valley of the Petchora, in East Kussia, and in the valley of the Yenesay, in Central Siberia, I was impressed with the fact that the influence of the sun was nearly nothing, while that of the south wind was almost everything. The great annual battle between summer and winter in these regions is the one event of the year: it only lasts a fortnight, during which a cold winter is transformed into a hot summer.

He then gives a most interesting account of the breaking up of the ice on the great north-flowing rivers till they become roaring floods of muddy water, crowded with lumps of melted ice of all shapes and sizes. On the 20th May he had just crossed the Petchora to Ust-Zylma, over ice which was already cracking.

It was past midnight, and at any moment the crash might come. Cracks running for miles, with a noise like distant thunder, warned us that a mighty power was all but upon us, a force which seemed to impress the mind with a greater sense of power than even the crushing weight of water at Niagara, a force which breaks up the ice more than a mile wide, at least three feet thick, and

weighted with another three feet of snow, at the rate of a hundred miles in twenty-four hours. . . . We slept for a couple of hours, when, looking out of the window, we found that the crash had come; the mighty river, Petchora, was a field of pack-ice and ice-floes marching past towards the sea at the rate of six miles an hour. We ran out on to the banks to find half the inhabitants of Ust-Zylma watching the impressive scene.

A week later he writes:

Winter is finally vanquished for the year, and the fragments of his beaten army are compelled to retreat to the triumphant music of thousands of song-birds, amidst the waving of green leaves and the illumination of gay flowers of every hue. The transformation is perfect. In a fortnight the endless waves of monotonous white snow have vanished, and between the northern limit of forest growth and the shores of the Polar basin smiles a fairy-land, full of the most delightful little lakes and tarns, where phalaropes swim about amongst ducks and geese and swans, and upon whose margins stints and sandpipers trip over the moss and the stranded pond-weeds, feeding upon the larvae of mosquitoes, or on the fermenting frozen fruit of last year's autumn.

It is incredible how rapidly the transformation is completed. Twelve hours after the snow had melted the wood-anemone was in flower, and twenty-four hours after the yellow flowers of the marshmarigold opened. In a short time the country looked like an English garden run wild. On the Arctic Circle wild onions, wild rhubarb, pansies, Jacob's ladder, purple anemones, dwarf roses, and a hundred other flowers made the country quite gay; whilst on the tundras wild-fruits of various kinds — crowberry, cranberry, cloudberry, arctic strawberry — were blended with reindeer-moss and other lichens, together with the most characteristic flowers of an Alpine flora — gentians, saxifrages, forget-me-nots, pinks, monkshoods (both blue and yellow), and sheets of the Silene acaulis, with its deep-red flowers. The Alpine rhododendron was replaced by a somewhat similar shrub, Ledum pahistre; but the flora, on the whole, was like that of the Engadine brought down to the level of the sea.

Although the first rush of migratory birds across the Arctic Circle was almost bewildering, every piece of open water and every patch of bare ground swarming with them, a new species on an average arriving every two hours for several days, the period of migration lasted more than a month. Very little migration was observable till the last week in May, but during the next fortnight the migration was prodigious. In additions to enormous numbers of passerine birds, countless flocks of geese, swans, and ducks arrived, together with a great many gulls, terns, and birds of prey. During the next fortnight, from the 5th to the 19th of June, fresh species of passerine birds continued to arrive, and the main migration of the great plover family took place.

One of the objects of Mr. Seebohm's journey to the- Arctic regions was to obtain authentic eggs and nests of the grey plover. He found several, after long search. They were all situated in depressions on a slight ridge among black bog-lakes, and each had three or four eggs. The charming little picture on the next page shows both nest, eggs, and young birds.

In order to ascertain approximately how many species of birds visit the Arctic regions in the summer breeding season, I have made rough lists of all those enumerated by Mr. Seebohm in his two books, Siberia in Europe and Siberia in Asia, and find that they amount to 160 species. This is very nearly equal to the whole number of resident and migratory birds which breed in our own country (about 180); but they cannot be more than a portion of the species that actually migrate to the Arctic lands, as they were the result of two visits only of about a couple of months each, and only two very limited areas were explored. My friend, Mr. H. E. Dresser, who also knows these regions personally and has made a special study of their birds, has been so good as to make an enumeration of all the birds known to breed in the Arctic regions of Europe and Asia, and he finds it

to be land birds 89 species, waders and aquatics 84 species, equal to 173 in all. Considering how vast is the extent of the country, and how few ornithologists visit it, we may put the total number at at least 180, and possibly even 200 species.

The great accumulation of bird-life is, however, vividly pictured by Mr. Seebohm, and it is clear from all that he says — as well as by what he does not say — that the vast hordes of mosquitoes must be the chief support of the innumerable millions of young birds which have to be fed here, both passerine and wading birds. Of the former more than eighty species are named, including seven buntings, four tits, two grosbeaks, six pipits, eleven warblers, five wagtails, two sparrows, three woodpeckers, the beautiful waxwing, and a host of others, many of which are among our common birds. What a delight to them all must be this rush northward into a land of perpetual daylight, swarming with the most nutritious food, fruits and berries for the parents, inexhaustible clouds of mosquitoes — which Mr. Seebohm tells us are an especially large kind with bodies a third of an inch long — and the equal myriads of their larva? in every little pond or water-hole, as well as quantities of larger worms and larvae. The extreme discomforts as well as the cost of a journey to these far northern lands are so great that very few bird- or insect-collectors visit them, and it is not easy to obtain direct and accurate observations as to the actual part played by the myriad swarms of mosquitoes in attracting birds from almost every part of the northern hemisphere to go and breed there. Mr. H. E. Dresser, who has made a special study of Palsearctic birds and their eggs, has, however, obtained for me some very interesting information. He writes:

Colonel Feilden tells me that the young of the knot are fed chiefly on the larvae of mosquitoes.

He has also sent me a copy of the following interesting letter from an American ornithological correspondent, Mr. E. T. Seton: —

In reply to your recent favour I beg to say, that, in my forthcoming book on a canoe journey of 2000 miles which I made to the Arctic regions in 1907, 1 am setting forth at great length the numbers, virulence, and distribution of the mosquitoes, together with observations on those creatures which are immune from their attacks. ... I should say that the night-hawk (Chordeiles virginianus) is the most active enemy of this insect, feeding on it during the whole season. On one occasion I took over 100 mosquitoes from the throat of one of these night-hawks, that was carrying them home to feed its young. Many similar observations "have been recorded. Next in importance would come the broadbilled flycatchers of the American group Tyrannidae, and the more abundant though smaller species of the Mniotiltids. All of these I have seen feeding on the adult mosquitoes. Doubtless all of our thrushes do the same, although I do not recall any positive records. We are very safe, I take it, in cataloguing all of our small birds as enemies of the mosquitoes in the adult form. The various . small wading birds, and the small ducks and grebes, are believed to prey on the larval mosquitoes; but doubtless it is the insects and email fish that are to be credited with the principal destruction in this stage.

From his personal observations Mr. Dresser says:

I believe that most of the waders feed their young on them '(mosquitoes) in the high north. In north Finland and Lapland I found the small birds (warblers, swallows, etc.) feeding on mosquitoes, and the snow bunting fed its young on them.

There is, therefore, a concensus of evidence as to the preeminent attraction afforded by these insects to almost all birds which breed in the Arctic regions.

The beautiful view on the opposite page gives us an idea of the appearance of the upland tundra along the shores of the Arctic Ocean. Here the southern slopes of the low hills are the first to be

free from snow, and afford an abundant supply of last year's berries to the earliest migrants, as well as a variety of animal food for aquatic birds on the adjacent sea-shores in favourable situations.

The combined physical and emotional enjoyment in this birds' paradise, during the whole of the Arctic summer, for so large a number of species of birds and in such enormous multitudes, is probably unequalled in any other part of the world; and we have the satisfaction of knowing that it is perhaps the only example of Nature's short-lived but annual pleasure-gardens which will not be destroyed or rendered hideous by the destructiveness and greed of civilised man. When much of the beauty and luxuriance of nature has been banished from milder regions, these inhospitable Arctic lands will long remain in their wild luxuriance of summer beauty, where those who truly love nature will be able to witness one of the most wonderful illustrations of the myriad forms and complex adaptations which the world of life presents to us.

It is a significant feature of this adaptation, that of all the higher forms of life birds are the most completely protected from the blood-sucking and irritation of mosquitoes. Every part of the body is protected either with a dense mass of plumage, or by a horny integument on the bill and feet, so that they are probably quite undisturbed while enjoying the super-abundant feast nature has spread for them in those remote and usually repellent lands. We may conclude, therefore, that it is to the two special features of these Arctic tundras — their abundant berries preserved during the winter in a natural ice-house, and the myriad clouds of mosquitoes and their larvae—'that we owe the very existence of a considerable proportion of the bird-life in the northern hemisphere.

The Origin of Bird-migration

These vast Arctic plains even in Tertiary times when climates were milder, would, owing to the long winter nights, have always been snow-covered during several months in winter although its melting might have been earlier and the summer somewhat longer; there can be little doubt that the short summer with its perpetual sunshine was equally favourable to the production of a super-abundance of vegetable and insect food very similar to what now exists there, and in this fact, we find a very complete explanation of how bird-migration came about . Abundance of food suitable for both parents and young at the season of breeding, would inevitably attract birds of all kinds from more southern lands, especially as the whole area would necessarily have no permanent residents or very few, but would, each recurring season, be an altogether new and unoccupied but most fertile country, to be reached, from any part of the north temperate lands, by merely following up the melting snow. And as, a few months later, the myriads of young birds in addition to their parents were driven south by the oncoming of the cold and darkness, they would find it necessary to travel farther and farther southward, and would again find their way north when the proper season arrived. There would always be a considerable number of the old and experienced birds to show the way; and as, with increasing severity of the seasons, the area of the snow-covered plains would extend, and their capacity for feeding both old and young would be increased; there would at last be brought about that marvellous rush of the migrating flocks which Mr. Seebohm has so vividly described.

Before quitting the subject of migration, on which Mr. Seebohm's observations throw so much light, I will shortly describe the most wonderful exhibition of migration-phenomena in the world — that of the small island of Heligoland, 40 miles off the mouth of the Elbe in about the same latitude as Scarborough. Most of the migratory birds from Scandinavia and Artie Europe pass along the coasts of the German Ocean, and the lighthouse on Heligoland serves as a guide, and the island itself as a resting-place during bad weather. Mr. Seebohm's account of what he witnessed in the island, during nearly a month spent there in September to October 1875 (in chapter xx. of his Siberia in Europe) is most interesting; and I refer to it here chiefly for the sake of pointing out a very important error as

to the cause of a very singular fact recorded there, by Herr Gatke, who for fifty years, observed and registered the migrations both in spring and autumn, with great accuracy, and formed a collection of birds there, perhaps more extensive than could be made at any other station in Europe. The fact observed was, that, during the autumn migration, as regards many of the most abundant species, the young birds of the year, that is, those that had been hatched in the far north in the preceding June or July, and who were, therefore, only about three or four months old, arrived in Heligoland earliest and alone, the parent birds appearing a week or two later. This is the fact. It has been observed on Heligoland for half a century; every resident on the island knows it, and Mr. Seebohm declares that there can be no doubt whatever about it The inference from this fact (drawn by Herr Gatke and all the Heligolanders, and apparently accepted by almost all European ornithologists) is, that these young birds start on their migration alone, and before their parents, and this not rarely or accidentally but every year — and they believe also that this is a fact, one of the most mysterious of the facts of migration. Neither Mr. Seebohm nor Professor Lloyd Morgan (in his Habit and Instinct) express any doubts about the inference any more than about the fact. Yet the two things are totally distinct; and while I also admit the fact observed, I totally reject the inference (assumed to be also a fact) as being absolutely without any'direct evidence supporting it. I do not think any English observer has stated that the young of our summer migrants all gather together in autumn and leave the country before the old birds; the American observers state that their migrating birds do not do so; while many facts observed at Heligoland show that no such inference is required to explain the admitted fact. Let us see what these additional facts are.

The enormous rushes of migratory birds which rest at Heligoland always occur at night, and are very intermittent.

They usually take place on dark nights, sometimes in millions; at other times, a week will sometimes pass with only a few stragglers. Of one such pitch-dark night Mr. Seebohm writes: —

Arrived at the lighthouse, an intensely interesting scene presented itself. The whole of the zone of light within range of the mirrors was alive with the birds coming and going. Nothing else was visible in the darkness of the night, but the lanthorn of the lighthouse vignetted in a drifting sea of birds. From the darkness in the east, clouds of birds were continually emerging in an uninterrupted stream; a few swerved from their course, fluttered for a moment as if dazzled by the light, and then gradually vanished with the rest in the western gloom. ... I should be afraid to hazard a guess as to the hundreds of thousands that must have passed in a couple of hours; but the stray birds that the lighthouseman succeeded in capturing amounted to nearly 300.

He also tells us that 15,000 sky-larks have been caught on Heligoland in one night; and all agree that the count less myriads that are seen passing over Heligoland are but a minute fraction of those that really pass, high up and quite out of sight. This is shown by the fact, that if, on a dark night, it suddenly clears and the moon comes out, the swarms of birds immediately cease. Another fact is, that, on what the islanders call "good nights," the birds that come to rest seem to drop down suddenly out of the sky. One other fact is mentioned by Mr. Seebohm. It is that every year the regular migration season is preceded by a week or two, during which a few stragglers appear; and these are all old birds and many of them slightly crippled, or partially moulted, or without some of their toes, or only half a tail, or some other defect. These are supposed to be mostly unmated birds or those whose young have been destroyed. It is also supposed that, during favourable weather (for the birds) migration goes on continuously during the season of about six weeks, though for the most part invisible at Heligoland, but often audible when quite invisible.

Now, the fact of the young birds only appearing on Heligoland for the first week or so of the season of each species is easily explicable. Remembering that the autumnal migration includes most of the parent birds and such of their broods as have survived, it is probable that the latter will form at

least half or, more often, two-thirds of each migrating flock. But the young birds, not having yet acquired the full strength of the adults, and having had little, if any experience, in long and continuous flights, a considerable proportion of them on the occasion of their first long flight over the sea, on seeing the lighthouse and knowing already that lights imply land and food-crops below them, and being also much fatigued, will simply drop down to rest just as they are deseribed as doing. The old birds and the stronger young ones, however, pass high over head, till they reach the north coast of Holland, or, in some cases, pass over to our eastern coasts. We must also remember that the longer the birds are in making the journey overland, the more young birds are lost by the attacks of birds-of-prey and other enemies. Hence the earliest flocks will have a larger proportion of young birds than the later ones. The earlier flocks also, being less pressed for time will be able to choose fine weather for the crossing, and thus it will be only the young and quickly-fatigued birds that will probably fly low and come down to rest. Later on every recurrence of bad weather will drive down old and young alike for temporary shelter and rest. Thus all the facts are explained without having recourse to the wildly improbable hypothesis of flocks of immature birds migrating over land and sea quite alone, and a week in advance of their parents or guides.

What this World-wide Adaptation teaches us

This co-adaptation of two of the highest and most marvellous developments of the vast world of life — birds and insects — an adaptation which in various forms pervades all their manifestations upon the earth, from the snow-wastes of the tundra to the glorious equatorial forests; and the further co-adaptation of both with the vegetation amid which they have developed, suggest some very important considerations.

As we might expect, both birds and insects are comparatively rare in a fossil state, but there are sufficient indications that the latter were first developed. A considerable number have been found in the Coal Measures, especially numerous cockroaches. Ancestral forms of Neuroptera and Hemiptera allied to our may-flies and dragon-flies, bugs and aphides, are found in Devonian and Carboniferous rocks. The more highly organised insects with a complete metamorphosis, come later; beetles, dragon-flies, and bugs (Hemiptera) are rather common in Lias beds, and here, for the first time, we meet with a true ancestral bird with perfectly developed wings and feathers, and with toothed jaws, the celebrated Archaeopteryx. Diptera (flies) are also found here, as well as a wasp, somewhat doubtfully identified; while the most highly developed of all insects in structure and metamorphosis, as well as in size and beauty, the Lepidoptera, are first in Tertiary beds, at a time 'when birds allied to living forms also first appeared.

This general parallelism of development seems clearly to indicate that birds, in the full and varied perfection in which we now find them, are dependent on a correspondingly widespread development of insects; and more especially of those higher orders of insects, whose exceedingly diverse stages of larva, pupa, and perfect insect, afforded the special food for immature and full-grown birds respectively. We can see how the omnipresence of insects adapted to feed on every kind of vegetable food, as well as on all kinds of animal refuse, has afforded sustenance to the various kinds of small mammalia, reptiles, and birds, which have successively become specialised to capture and feed on them. The early birds with toothed jaws were able to feed upon the cockroaches and ancestral Neuroptera and beetles of the same period. As these early birds became more numerous, so they became successively specialised to feed upon particular kinds of insects or their larvae, however completely these might seem to be concealed or protected. Thus were gradually formed the true flycatchers (Muscicapidse) and the totally distinct American flycatchers or tyrant birds (Tyrannidae), which capture all kinds of insects on the wing; the swallows, and the very distinct swifts, so specialised as almost to live in the air, and to feed on this kind of food exclusively; the goatsuckers, which capture night-flying insects; the curious little nuthatches and creepers which hunt over trees for small beetles concealed in crevices of the bark; while the

marvellously specialised woodpeckers discover the larger grubs or caterpillars which burrow deeply into the wood of trees, and dig down to them with their wonderfully constructed hammer-and-chisel-like head and bill, and then pull them out on the tip of their extensile barbed tongue. In the tropics many distinct families of birds have been developed to grapple with the larger and more varied insect forms of those countries, so that it may be safely concluded that no group of the vast assemblage of insects but what has its more or less dangerous enemies among the birds. Even the great rapacious birds, the hawks, buzzards, and owls, when their special food, the smaller mammals and birds, fails them, will capture almost every kind of ground-feeding insects; while the enormous tribes which feed largely on fruits and seeds often make up for its deficiency by capturing such insects as are available.

One of the clearest deductions from these facts is, that the great variety of the smaller birds — warblers, stonechats, tits, wagtails, pipits, wrens, and larks — owes its origin to the continuous specialisation throughout the ages of new forms of birds adapted to take advantage of every fresh development of the insect tribes a3 they successively came into existence. As Darwin repeatedly impresses upon us, excessive powers of multiplication with ever-present variations, lead to the almost instant occupation of every vacant place in the economy of nature, by some creature best fitted to take advantage of it. Every slight difference in the shape or size of bill, feet, toes, wing, or tail, or of colour of the various parts, or of superior acuteness in any of the senses, such as we can see in the different allied species of these birds, has been sufficient to secure the possession of some one of these vacant places; and when this first partial adaptation has been rendered more and more perfect by the survival in each successive generation of those individuals best fitted for the exact conditions of the new environment, a position is reached which becomes at any future time a secure starting-point for further modification, either in the same or in any slightly diverging line, so as to be again fitted to occupy some other vacant place which may have arisen through the slightest changes either in the inorganic or the organic environment.

So long as we limit ourselves to a consideration of the mode in which any existing species has been produced, by the adaptive modification of some other pre-existing closely allied species, by means of the known facts of universal variation and of the constant survival of the best adapted, there is no difficulty whatever in accepting the "origin of species" from other species as a demonstrated fact; and this alone was the hitherto insoluble problem which Darwin first succeeded in solving. It is only in the extension of the process to isolated groups such as the whales, the elephants, the serpents, or the mammalia; or by enquiring how special organs, such as horns, teeth, ears, or eyes, could have begun their process of development, that difficulties appear, many of which seem, to some biologists, to be insuperable. But many of these difficult problems have been solved by more complete knowledge; while others have been rendered easy by the discovery of intermediate stages either through the investigations of embryologists, or of paleontologists, so that many of the greatest difficulties of Darwin's early opponents have quite disappeared. Some of these recent explanations have been referred to already, and many others are briefly described in my Darwinism. In that work also I have given so many illustrations of the way in which natural selection has worked, that it will be needless for me to go into further details here. I will, therefore, now proceed to an exposition of some problems of a more general nature, which involve difficulties and suggestions beyond the scope of Darwin's work, and which, I think, have not been sufficiently considered by later writers on evolution.

Chapter IX - THE IMPORTANCE OF RECOGNITION-MARXS FOR EVOLUTION

The great problem of the exact causes of the infinitely varied colours and markings of the different species of the higher animals, is now gradually receiving an adequate amount of attention, and in consequence an almost complete solution. In the Origin of Species Darwin dealt with only one branch of the subject — coloration for concealment, and that only incidentally; but he at once

accepted, and with enthusiasm, Bates's explanation of the beautiful phenomena of mimicry among insects, and also that of warning colours in the inedible caterpillars, first suggested by myself.

The whole subject, especially that of mimicry, is now so largely developed as to require many volumes for its adequate exposition; and I have myself given a summary of the more interesting facts in my Darwinism: I shall therefore deal very briefly with it here, with the one exception of that form of it which I have named "recognition marks." These, though the last to be generally accepted have received the least attention; but, after many years' consideration of the whole problem of evolution I have come to the conclusion that, of all the causes of distinctive marking (among the higher animals at all events), the need for easy recognition under the varied conditions of their existence is for most animals the most important. It is, however, on account of their being in most cases absolutely essential as a factor in the evolution of new species that I here devote the larger part of this chapter to their consideration.

Coloration for Concealment and for Visibility

Colour and markings for concealment pervade all nature. The hare on its form, the snipe in its covert, the vast majority of birds while sitting on their nests, the sand-coloured desert animals, and the prevalence of green colours in the inhabitants of tropical forests, are a few of the best-known examples. The uses of such colours in order to protect the Herbivora from enemies, or to conceal those which devour other animals from their prey was at once acknowledged, and it was seen how, with variability of colour as a constant fact, survival of the fittest might soon bring about the beautiful harmony of coloration we everywhere find to prevail. But it was also undeniable that there were almost equal numbers of animals of all classes and sizes, in which colours and markings occurred which could not by any possibility be interpreted as protective, because they seemed to render the creature glaringly conspicuous. Some of these, which were most prevalent among insects, were soon explained as "warning colours," because they were exhibited by species which were either so nauseous as to be inedible by most insect-eaters; or were armed with stings which might cause great pain or even los3 of life to an enemy which attacked them. When it was found that many other groups of insects which did not possess these protective qualities, yet acquired the same colours and often the same form; and when my fellow-traveller on the Amazon, «H. W. Bates, showed how this peculiar kind of "mimicry" was beautifully explained on the Darwinian hypothesis, not only was the theory itself greatly strengthened but a whole host of curious and beautiful colour-phenomena in Nature, hitherto unnoticed, were seen to come under some form of the same general principle. As one rather extreme example of mimicry I give the figures of a black wasp with whitebanded wings, which is closely imitated by a heteromerous beetle. These I captured myself in the forests of Borneo, flying together near the ground. They are of nearly the samo size. The wing-coverts (elytra) of the beetle are reduced to pointed scales, allowing the true wings to be always extended. This is most unusual in beetles, as is the white band across the wings in this order of insects (Fig. 23). This strange and most unusual modification of an inoffensive insect, so as closely to resemble one of another order which is protected by a dangerous sting, can be explained in no other way than through the advantage derived by the harmless beetle by being mistaken for the wasp. Of course, this change is the result of a very long series of slight modifications of the beetle, each bringing it a little nearer to the wasp, a series extending probably through thousands or even millions of generations.

Recognition-Marks

But though the subject of "mimicry" involves problems of extreme complexity and interest, and has therefore attracted the attention of numerous students, yet it is almost entirely confined to the insect world, and, taken as a whole, is not nearly so important a factor in the development of the great world of life as the class of "recognition "-colours of which I will now give a short account.

My attention was first directed to this subject during my visit to south Celebes in 1856-57, where, during about six months' collecting, I obtained the unusual number of fifteen different birds of prey, of which the majority were of the hawk sub-family. While skinning and preserving these birds, and after my return home, while determining the species, I could not help observing in many of them the varied and beautiful markings of the tail-feathers, by means of white spots or bands on all the feathers except the middle pair. The result was that when the tail was expanded during flight, it was seen to be marked very conspicuously by white bands, sometimes across the middle of the tail, sometimes at the end, sometimes with one band, sometimes with two or even three, so that the species were easily distinguished by this one character. But the chief peculiarity to be noticed was, that these bands were only seen during flight, the white markings being quite invisible when the birds were at rest. The importance of this fact I did not see till many years later, when, in connection with other similar facts,, it gave a clue to their meaning and purpose.

Now that we have learnt How rapid are the powers of increase of all animals, and the extreme severity of the process by which the population is kept down to a nearly fixed amount by the annual destruction of all the less adapted; and further, when we know how all the higher animals roam about in search of their daily food, we are able to understand how vitally important it is for all such animals to be able to recognise their own species from all others without fail and at considerable distances. This is essential for several reasons. The young and half-grown, if they have strayed away from the flock or herd, need to rejoin them as soon as possible; the two sexes of the same species require to know each other in the same way by unfailing marks whether they are approaching from behind or from the front; while the separate portions of flocks divided by the sudden attack of some enemy need to come together again as soon as possible. But there is a still more important use of these distinctive markings, since they are almost if not quite essential to the production of new species by adaptation to change of conditions, as will be shown later on.

I first gave a somewhat full account of this class of markings, with several characteristic illustrations, in my Darwinism, in 1889; but I had briefly treated the subject in my lecture on the Colours of Animals given at many places in the United States and Canada in 1886-87, and in England in 1888. No doubt some of the facts had been noted by other writers, but I think I was the first to claim for it a high place among the factors concerned in animal evolution. The clearest and most picturesque illustration of the subject I have seen is in a very short article by Mr. E. Seton Thompson in the American periodical "The Auk" for October 1897, from which I will quote the most important passage:

The common jack-rabbit1 when squatting under a sage-bush is simply a sage-gray lump without distinctive colour or form. Its colour in particular is wholly protective, and it is usually accident rather than sharpness of vision which betrays the creature as it squats. But the moment it springs it is wholly changed. It ia difficult to realise that this is the same animal. It bounds away with erect ears showing the black and white markings on their back and underside. The black nape is exposed. The tail is carried straight down, exposing its black upper part surrounded by a region of snowy white; its legs and belly show clear white, and everything that sees it is clearly notified that this is a jack-rabbit. The coyote, the fox, the wolf, the badger, etc., realise that it is useless to follow; the cotton-tail, the jumping rat, the fawn, the prairie dog, etc., that it is needless to flee; the young jack-rabbit that this is its near relative, and the next jack-rabbit that this may be its mate. And thus, though incidentally useful to other species at times, the sum total of all this clear labelling is vastly serviceable to the jack-rabbit, and saves it much pains to escape from real or imaginary dangers. As soon as it squats again all the directive marks disappear, and the protective gray alone is seen. In the bird-world the same general rule applies. When sitting, birds are protectively coloured; when flying, directively.

The African antelopes offer very striking examples of "recognition "-marks, especially those that inhabit Central and South Africa, where such indications are most needed. The land is generally open, often quite bare, but usually with scattered trees and bushes; and as these animals roam over a great extent of country in search of food or water, and are also liable to the attacks of many dangerous beasts of prey, their safety depends largely on their keeping together in small or large herds. There are nearly a hundred different kinds of antelopes known to inhabit Africa, the larger part of them being found in Central and South Africa. Almost all of these have very distinctive markings on a general ground-colour harmonising with the tint of the soil or rock. These markings are usually confined to white patches on the head and face, and on the hinder parts, so as to be visible in the two directions that are most serviceable.1 I have also come to the conclusion that the horns of these animals, though primarily developed as weapons of defence — for even the lion is occasionally killed by the horns of the gemsbuck — have been so changed in each species as to serve another purpose, as is so often the case in nature. Their curious modifications of form in closely allied species, and their extreme diversity in the whole group, leads me to conclude that their actual shapes have been produced quite as much for purposes of recognition as for attack or defence. While moving among high grass or bushes, or when at rest and "ruminating," the horns would often be the only part visible at a distance; and this, in a district inhabited by perhaps a dozen different species of these animals, would be of the greatest importance in guiding a wanderer back to his own herd, and for other purposes. To illustrate this I here give views of the horns or heads of twelve different species of antelopes all found in Central or South Africa, and thus often meeting in the same valley or veldt. To these I call the reader's special attention (Figs. 2435).

The first group of four shows two of the larger antelopes on the left, which, with a general likeness of form, possess individuality both in face-marks and in the curvature of the horns: while the two gazelles on the right are still more distinct. The next group consists of three species of the genus Cobus, in which the horns are each so distinct in size and curvature as to be easily recognisable at considerable distances; the fourth figure shows the horns of the gemsbuck, a very distinct species, not only in the body markings, but also in the almost perfectly straight and very long horns. The third group shows, at the top, the two species of kudu, the horns of which, though exactly alike in spiral curvature, are yet placed at such a different angle on the head as to be easily distinguishable. The two lower figures are of animals not closely allied, but, as one inhabits East and the other South Africa, their ranges probably overlap each other, or once did Bo. Here there is a somewhat similar bend in the horns, but their thickness and direction render them absolutely distinct from every point of view.

Now, as the antelopes are very closely allied to each other, both in structure and external form, it seems improbable that all the diversities in the horns (which are sometimes very great in closely allied species) should have been acquired for the sole purpose of fighting with each other or with an enemy. But as these animals all possess markings on the head and body which can only be interpreted as recognition-marks especially serviceable while in motion, it seems quite natural that the horns should have been modified to serve the same purpose while the animals are at rest, or when their bodies are wholly and their faces partially concealed by the grasses or bushes around them.

The essential character of directive or recognition-marks is strikingly shown by one of the best known of the African antelopes — the springbok — which in the early days of the Cape Colony swarmed over the whole of South Africa, even in the vicinity of Cape Town. Its chief feature is thus described in Chambers's Encyclopaedia:

Two curious folds of skin ascend from the root of the tail to near the middle of the back; they are closed when the animal is at rest, but when leaping or running they open out and disclose a large white patch, which is otherwise concealed.

We have here a structural peculiarity leading to the production of a distinctive white patch on a prominent part of the body, which patch is concealed when not required and when it might be dangerous, and only exhibited in the presence of some real or imaginary danger, for the springbok i3 said to be one of the most timid and cautious of all animals. This curious feature is more remarkable, and more clearly a proof of a mark designed to be seen, than even our rabbit's upturned tail when running); which, has been termed the "signal flag of danger," and in moonlight or evening twilight serves, on the approach of, an enemy, to guide the young, or those farthest from home, towards tbe family burrow.

Recognition-Marks in Birds

A large number of birds also possess these two kinds of recognition-markings, the one to be seen when resting or feeding, the other only during flight. As good examples of these I give figures of the head and wings of three allied species of stone-curlews, inhabiting Eastern Australia, the Malay Archipelago, and India, respectively, whose ranges sometimes overlap, and which are no doubt descended from a common ancestor. The head of each exhibits different markings, by which they can be easily distinguished while feeding on the ground; while the bolder markings on the wings enable them to keep together during their wanderings or migrations (Figs. 36, 37, and 38).

Markings of this character, though varied almost infinitely, occur in all classes of the higher animals, and very much in proportion as their mode of life requires them. When concealment is of more importance, then the recognition is made effective by differences of shape or of motions and attitudes, or by special cries, as in the cuckoo. Among the birds of the tropical forests, while the ground colour is often protective, as in the green of parrots, the smaller fruit-pigeons of the Malay Archipelago, many of the barbets, and hosts of other birds, yet the different species will be almost always charac

grow upon their branches, the general effect is by no means conspicuous.

Now, without this principle of the necessity for external differences for purposes of recognition of each species by their own kind, and especially of the sexes by each other, this endless diversity of colour and marking, when not protective, seems difficult to explain. The Duke of Argyll, in his interesting work, The Reign of Law, published six years after the Origin of Species, expressed this objection very forcibly. After describing many of the wonderful forms and ornaments of the humming-birds, he says:

Mere ornament and variety of form, and these for their own sake, is the only principle or rule with reference to which Creative Power seems to have worked in these wonderful and beautiful birds. ... A crest of topaz is no better in the struggle for existence than a crest of sapphire. A frill ending in spangles of the emerald is no better in the battle of life than a frill ending in spangles of the ruby. A tail is not affected for the purpose of flight, whether its marginal or its central feathers are decorated with white. . . . Mere beauty and mere variety, for their own sake, are objects which we ourselves seek when we can make the forces of nature subordinate to the attainment of them. There seems to be no conceivable reason why we should doubt or question that these are ends and aims also in the forms given to living organisms.

In a criticism of the Duke's book (written in 1867) I adduced sexual preference by the female bird as sufficiently explaining these varieties of plumage and colour, but I have since come to doubt the

validity of this, except so far as the plumes are an indication of sexual maturity; while I see in the need for outward marking, whether for purposes of recognition or as preventing intercrossing between incipient species, a sufficient cause for all such conspicuous indications of specific diversity as are found pervading the whole vast world of life. It now only remains to point out how these markings have been produced, even under conditions which some writers have considered must render their production for this purpose impossible, and therefore as constituting a valid objection to the whole theory of recognition-marks.

An Objection to Recognition Marks answered

In a book on Darwinism and Lamarckism, the late Captain Hutton, a well-known New Zealand naturalist, objected to the validity of recognition-marks as a cause for the development of specific characters, that there are, all over the Pacific, numerous cases of small fruit-pigeons of the genus Ptilopus, which each have distinctive markings, and are almost always confined to one island or a small group of islands. In most of these cases there is no other pigeon or other bird on the same island for which they could possibly be mistaken. He then says:

Consequently it appears certain that most of these species were developed singly, each in its own island. If this be the case, the colours which now distinguish the different species cannot be recognition-marks, because there is no other species in each island with which they could be confounded.

Shortly afterwards the late Dr. St. George Mivart made the same objection as regards the very numerous species of beautifully coloured lories which are found in all the islands around New Guinea and in the Western Pacific. He urged that the various peculiarities of colour cannot be useful as recognition-marks, because the colour and markings of each of the genera of these birds is so very distinct from that of all other birds inhabiting the same island, arid there is usually only one species in each island. This arguinent, looked at superficially, seems very strongt but it is not difficult to show that it is a complete fallacy; if .we follow out in detail what must have occurred in each case.

It is clear, admitting evolution (as both these writers did admit that each of the species of pigeon or lory now peculiar to an island must have originated from some parent species in the same or some other island; and there are only two possible suppositions — either the species originated in island A by modification of the present form, and then migrated to island B, afterwards becoming extinct in A; or it migrated from A to B and became modified into its present form in B. The latter case is by far the more probable, and as it is clearly that which the critics contemplated, let us see exactly what must have happened.

We know as a fact that, when any species reaches an island or other new habitat for the first time, if the conditions are favourable, it increases with marvellous rapidity, till the island is fully stocked and the supply of food at some time of the year begins to fail, or till some enemy — a rapacious bird, for instance — finds out the rich banquet, and is soon followed by others. The rabbit in New Zealand and Porto Santo, the sparrow in the United States, and many others, are examples of such rapid increase. But as soon as the island is fully stocked, a number equal, or nearly so, to the annual increase must die off every year, and these will inevitably be the least fitted to survive. Hence natural selection at once begins to act, and as the conditions, even in two adjacent islands, are never quite the same, and as with such a large population slight variations in many directions will be very numerous, some modification to a more perfectly adapted form will necessarily follow. Here comes the point which both critics failed to notice, that the modification of the species into a better-adapted one must have occurred in the island; and as it is universally admitted that intercrossing between the incipient species and the parent stock would be a serious check to

adaptation; and further, that varieties of the higher animals prefer to mate with their like, then any variation of colour in those better adapted will be advantageous, will lead to more rapid change, and will thus come to characterise the new form as distinguished from that of the lessadapted parental form.

It is clear, therefore, that species which are now peculiar to some island or other restricted locality, even when they are quite unlike anything else now living around them, must have become differentiated from some parent stock just in the same way as all other species have become differentiated. During all the initial stages, which may have occupied scores or hundreds of generations, some outward sign of the structural change that was taking place was an essential part of the process, as a means of checking interbreeding with the lessmodified parental form, which might linger on till the process was almost completed. Now, the distinctive recognition-mark seems to us to have no use; but as the original form from the adjacent island A may still occasionally visit or be driven to the island B, it would now be treated as a stranger, and thus prevent the better-adapted form being deteriorated by interbreeding with the less-adapted immigrant.

Recognition by Butterflies

This case shows how easy it is to make mistakes or arrive at wrong conclusions, unless we take account of all the details of a problem, and endeavour to follow out the exact processes of nature by the help of facts known to us. I can say this with more confidence, because I find that I have myself come to a hasty conclusion, which I now see to be erroneous, on one aspect of this very question; and as it involves a problem of some importance I will here state what it is. I find that in all my writings on this subject I have assumed, without going into details, that the theory of "recognition-marks," which so well accounts for a very widespread type of marking and coloration in birds and mammals, is also applicable to a large portion of the markings of insects, especially in the case of butterflies. But a little consideration shows that there is no resemblance between the two cases. Young mammals and birds grow up with their parents, and get to know their appearance in every detail. They also have usually brothers and sisters growing up with them, so that by the time they go out into the world to care for themselves they are thoroughly acquainted with the difference between themselves and other species, even those nearly allied to them. This complete knowledge is increased by the fact that they are able, through the mobility of 'the head and neck, to see almost every part of their own bodies, and thus know that they themselves do resemble their parents.

But with the butterflies, and most other insects, everything is different. The caterpillar never knows its parent, and when the butterfly emerges from the pupa and takes flight, it seems quite impossible that, among the numerous butterflies of all sizes, shapes, and colours that it may immediately encounter, it can possibly know, by sight, which are of its own race. It must be remembered that from the position of its eyes it cannot see itself except at so oblique an angle as to be almost useless; and when we consider the extreme diversity of the sexes in many butterflies this adds to the difficulty of supposing vision to be the primary means of recognition. But it may be a secondary means. It is well known that in some moths the females attract males by scores at night, and this can only be by scent, or something analogous to it . It is also known that the males of many butterflies emit a strong perfume which has been traced to certain peculiarly formed scales on the wings. Scales, apparently of a similar nature, have been found in several distinct families of butterflies and moths, and it seems probable that the function of these is in all cases to produce a perfume agreeable to the other sex, though only in a few cases is such perfume perceptible to us.

It seems probable, therefore, that the sexes of Lepidoptera are mutually attracted by a perfume agreeable to each other, but disagreeable or neutral to others of the same sex or to other species.

Each time this attractive odour was perceived and the source of it traced, the visual image of the insect would be connected with the smell, and thus only would the colour and markings of the species become known and be distinguished from that of other species. This being the case, we see that the complete scaly covering of so many of these insects serves a double purpose. It affords the means of using an extended surface for the highly important scentglands, which, by serving to bring together the sexes of each species and to prevent intercrossing, would facilitate differentiation and lead to that wonderful diversity of colour and marking accompanying comparatively slight differences of structure for which this order is so remarkable, and which are absolutely unequalled in the whole animal kingdom. This variety of colour, rendered possible by the large wing-surface covered with small but exquisitely organised scales, is utilised for securing the safety of the perfect insect to a sufficient extent to provide for the continuance of the race, thus keeping up that endless variety of form and colour which is, perhaps, one purpose of their existence.

The first great adaptation here, as throughout nature, is to secure concealment from their most dangerous enemies, and this is effected by various kinds of protective, deceptive, or warning coloration which in some form or other pervades the whole order, and forms a most fascinating subject of study. The protective coloration is mostly on the under sides of the wings of butterflies, and on the upper sides of the upper wings of moths, the parts respectively exposed to view when the insect is at rest. Great numbers are also deceptively coloured by eye-marks (ocelli), which resemble the eyes of mammals in such a way as to be very striking in the mingled light and gloom of the forest and in the general surroundings of each species. Large groups in all the tropical regions possess warning colours, either very bright and well contrasted, or of sober browns and yellows, and accompanied by such elongated wings, bodies, and antennae, that the facie9 of the whole group as well as of the individual species soon become known to insect-eating creatures.

Those which are protectively or deceptively coloured on the exposed portions of their wings often exhibit the most brilliant or gaudily contrasted colours elsewhere; but in these cases the flight is very rapid or jerky, and the insects are so continually hidden among the lights and shadows of the forest, that few enemies can capture them. The great expanse of the wings is itself an additional protection by diverting attention from the body; and it has thus become possible, without endangering the continuance of the species, to allow the development of that marvellous display of colour, the charm of which can only be fully appreciated by those who have for long periods sought it out in the forest regions of the Amazon, of the Eastern Himalayas, or of the Moluccas and New Guinea — the three most productive regions in the world for butterflies (and also for birds) of resplendent hues and in endless variety. A new Argument against Female Choice

Here again we find another, and I think a very conclusive argument against female choice having had any part in the production of beautiful and varied colours in the males of butterflies, or probably of any insects, since it is clear that the attraction is through another sense than that of sight, and all that vision can do in this direction is to enable the insect to recognise, perhaps at a greater distance, the individuals which are thus attractive. There is much evidence to support this view. H. Miiller, in his Fertilisation of Flowers, states that odour is pre-eminent in attracting insects to flowers, and, next to that, general conspicuousness rather than any special colour or form. And, by his detailed accounts of insects visiting flowers, we find that almost all the commoner butterflies visit a great variety of honey-bearing flowers without much regard to colour. Thus Argynnis paphia visited flowers of four different natural orders, whose flowers were white or pale red; the large cabbage butterflies visited seven different orders, including red, white, purple, yellow, or blue flowers; the small tortoise-shell visited an even greater range of flowers and colours, so that we have no reason to impute to these insects anything more than the power to recognise, after experience, any conspicuous flowers that produce pleasant odours and, usually, accessible honey.

A consideration of the whole evidence as to the purpose served by the excessively varied and brilliant coloration of butterflies leads us to the conclusion that its presence is due to general laws of colour-development — some of which will be discussed in later chapters — whose action is only checked when such development becomes injurious. In the case of butterflies, the comparatively short period that elapses between the emergence of the female from the chrysalis and the deposition of her eggs, and the still shorter period needed for the special functions of the more brilliantly coloured male together with his power of irregular but rapid flight, render it possible for the colour-development to attain a degree of variety and beauty beyond that of all Other living things. The larvss of Lepidoptera in their countless myriads undoubtedly constitute an important factor in supporting the gloriously varied bird-life of the tropics, as we have seen that they so largely support that of our temperate zones. It is the comparatively small surplus that escapes which is yet ample for the development of the perfect insects in such abundance as to keep up an approximately equal supply of larva; for the next generation of birds. When this is done they themselves become the prey of birds, lizards, and other insecteating animals.

Some General Conclusions from Recognition-Marks

We have thus been led by the study of colour as a means of recognition by birds and mammals to some very important general conclusions. The first is, that in both these groups, it has primarily a still more important function, that of facilitating the formation of new species during the early stages of adaptation to changed conditions of life. Its secondary, but still very important use in many groups, is for easy identification as already described. That this is the true state of the case is rendered almost certain by the occurrence of a large number of species in which the markings for recognition are now unnecessary though they were of the highest importance during the initial stages of evolution.

Another and still more curious result of the study of this subject is the evidence it affords that the most varied in colour and markings of all insects — the butterflies — do not, primarily, recognise each other by sight, but by some sense analogous to that of smell. This seems now to be almost certain, and it affords the explanation of what would otherwise be a great difficulty, how the males of polymorphic females, as in Papilio pammon in the East and Papilio ceneas in the West, numerous American Pieridse and many other groups, in which the females are coloured as if with the purpose of being as unlike their mates as possible, are able to recognise each other. Intuitive knowledge or "instinct" is now given up by every thinker; but the proof now given that the only known method of mutual recognition by Lepidoptera is by scent, explains the whole difficulty. The colours and markings of these insects have been produced in adaptive relation to their enemies almost exclusively, and this explains the fact that the strangely diverse females above referred to are, probably in every case, either protectively coloured or mimics of distasteful forms in their own district. The fact that several of the Eastern Papilios have fully tailed females while they themselves are round-winged, is another indication that sight can have no part in leading to mutual recognition between the sexes.

The almost universal presence of some form of recognitionmarks in birds and mammals, no less than the proof now afforded (and for the first time stated) of their entire absence in the Lepidoptera, affords, I think, ample justification for the importance I claim for them, and for the space I have devoted to them in the present volume.

Chapter X - THE EARTH'S SURFACE-CHANGES AS THE CONDITION AND MOTIVE-POWER OF ORGANIC EVOLUTION

Having now sketched in outline the main factors on which organic evolution depends — heredity, variation, and rapid powers of increase — and having shown by a sufficient number of examples that these factors are omnipresent features of organic life, only varying somewhat in the

proportions of their occurrence in different species, we are now prepared to indicate the conditions under which they have acted in the production of those numerous changes of form and structure which we observe in the various forms of life.

We have seen (in Chapter VI.) that so long as no considerable changes occur in the inorganic world, the effect produced by the constant interaction between species and species, or between plants and animals, results in changes of local distribution of the various species rather than in any important modification of the species themselves. And there really seems no reason why such changes should occur; because when once complete or sufficiently complete adaptation to conditions is brought about, the whole of the organic world will be in a state of stable equilibrium, with sufficient elasticity in all its parts to become adjusted to all minor periodical changes of climate, etc., by temporary changes in numbers, and by the local distribution of the slightly altered numbers. Once such an equilibrium is attained, there seems no reason why it should not be permanent. Natural selection would keep up the sufficient adaptation of each species, but would not tend to change them.

.Geology proves that the inorganic environment — tb/ earth's surface — is not stable; but that very considerable changes in climate, in the contour of the land surface, and even in the minor distribution of land and water, have continually occurred during past ages; and that just in proportion to the evidence for such changes do we find that changes have occurred in the forms of life inhabiting every part of the earth. A short statement of the nature of these two groups of coincident and interdependent changes will therefore be useful here.

The most general and most arresting facts of world-history, revealed by geology, are, that the superficial crust of the earth consists of various "rocks" (including in this term every kind of inorganic matter of which the crust is composed) deposited in more or less regular " strata" or layers, one above another; that these strata are sometimes horizontal, more often inclined at various angles to the horizon, and even occasionally vertical; usually continuing at about the same angle or slope for many miles, but often curved or waved, or even crumpled up and contorted in remarkable ways. These various strata consist of many distinct kinds of rock — sandstones, limestones, clayey or slaty rocks, metamorphic or gneissic rocks; and all of these give distinct evidence of having been deposited in water, both from mechanical texture and the arrangement of their component particles, and also by frequently having embedded in them the remains of various organisms, those that live in seas or lakes being by far the most abundant and varied. As an example of this abundance we may mention the Barton Cliffs on the Hampshire coast east of Christchurch, where, in a distance of a few miles, over a thousand distinct species of the fossilised shells of molluscs, radiates, and other marine animals have been found.

But the most suggestive fact from our present point of view is, that almost every mountain-range on the earth presents us examples of such stratified rock-strata, often with abundant fossils of marine animals, at enormous heights above the sealevel. Such are found in the Alps at 8000 feet, in the Andes at 14,000 feet, and in the Himalayas at 16,000 feet elevation. Innumerable cases of marine fossils at lesser heights are to be found in every part of the world, and in rocks of very various geological age. But the causes that have produced these great changes of level are still obscure. It is certain, however, that such changes have been exceedingly gradual in their operation, and have in all probability been of the same general nature as those going on at the present day — such as the earthquakes which, at irregular intervals, occur all over the world.

There is one very instructive mode of ascertaining the rate of certain changes of the earth's surface which was first pointed out hy Mr. Alfred Tylor more than half a century ago,1 and is generally accepted by geologists as of great value. The surplus water of the land is carried into the sea by rivers, each of which has a drainage area which contains a certain number of square miles. By

careful measurements, it is possible to ascertain how much water flows away every year, and also how much solid matter is suspended in the water, how much is chemically dissolved in it, and how much is pushed along its bed at the mouth. The sum of these three quantities gives us the cubic yards or cubic miles of solid matter denuded from the surface of each river-basin in a year; and from this amount we can easily calculate how much the whole surface is lowered each year, while some corresponding area of the adjacent seabottom, on which it is deposited, must be proportionally raised. These measurements have been very carefully made for a number of large and small rivers in various parts of the world, and the following results have been accepted as fairly accurate by Sir A. Geikie: —

The Mississippi lowers its basin 1 foot in 6000 years.
"Ganges *' '* " 2358"

"Hoang-Ho" "" 1464"

"Rhone " "" 1528"

"Danube " "" 6848"

« p0 " « " 729"

i See Phil. Mag., April 1853.

We can easily see here that the rapidity of denudation is proportionate to the height and extent of the mountain-ranges in which the river has its sources, combined with the amount of the average rainfall, and the proportion of plains to uplands in its whole basin. The Ganges has a large proportion of lowland plain in its area; the Hoang-Ho has less, and therefore denudes more rapidly. The Danube and the Mississippi both drain an enormous area of lowlands where denudation is slight, and the rainfall of both is moderate; they therefore lower their basins slowly. The Po drains an enormous extent of snowy Alps in proportion to its whole basin, and in consequence lowers the land perhaps more rapidly than any important river on the globe. On the whole, we may take these rivers as fairly representative. Their mean rate of denudation is very nearly one foot in three thousand years, and we may therefore, till more complete observations are made, take this as a measure of the average rate of denudation of most of the great continents.

Of course, the rate of lowering will be extremely unequal, being at a maximum in the mountains and a minimum in the plains, where it may not only be nothing at all, but if they are flooded annually they may be raised instead of lowered. In the loftier mountains with numerous peaks and precipitous slopes the average lowering may often be ten times, and sometimes even a hundred times, the mean amount. In such districts we can even see and hear the process continually going on. Under every precipice there is a more or less extensive mass of debris — the "screes" of our lake district; and every winter, chiefly through the action of rain and frost, the rocks above are split off, and can be heard or seen to fall. Even on grassy hills after a few hours' downpour of rain, innumerable trickles of muddy water course down in every direction; while every streamlet or brook — though usually of water as clear as crystal — becomes a rapid torrent of mudladen water. It is by a consideration of these every-day phenomena in operation over every square yard of thousands of square miles of surface that we are able to understand and appreciate the tremendous power of rain and rivers, greatly assisted by frost, in the disintegration of rocks, which lower the whole surface of the larfd at such a rate that, if we had means of accurate comparison with its condition a few thousand years ago, we should see that in many places the whole contour and appearance of the surface was changed.

When this mode of estimating the rate of subaerial denudation was first applied to well-known regions, geologists themselves were surprised at the result. For 1 foot in three thousand years is 1000 feet in three million years, a period which has always been considered very small in the scale of time indicated by geological changes. When we consider that the mean height of all Europe (according to a careful estimate by Sir John Murray) is a little under 1000 feet, we find, to our astonishment, that, at the average rate of denudation, the whole would be reduced almost to sea-level in the very short period of three million years, while all the other great continents would be reduced to the condition of " pene-plains" (as the American geologists term it) in about six or eight million years at the utmost. It is quite certain, therefore, that there must be some counteracting uplifting agency, either constantly or intermittently at work, to explain the often-repeated elevations and depressions of the surface which the whole structure and mechanical texture of the vast series of distinct geological formations with their organic remains, prove to have taken place.

The exact causes of these alternate elevations and depressions, sometimes on a small, sometimes on a gigantic scale, have not yet been satisfactorily explained either by geologists or physicists. Two of the suggested causes are undoubtedly real ones, and must be constantly acting; but it is alleged by mathematical physicists that they are not adequate to produce the whole of the observed effects. They are both, however, exceedingly interesting, and must be briefly outlined here. We require first, however, to trace out what becomes of the denuded matter that lowers the continental surfaces at so rapid a rate, and is poured into the sea at various points around their coasts; and this is the more necessary because recent researches on this matter have led to results as surprising as those of the measurement of the amount of denudation by rivers.

During the voyage of the Challenger round the world for the purpose of oceanic exploration, not only was the depth of the great oceans determined by numerous lines of soundings across them in various directions, but, by means of ingenious apparatus, samples of the sea-bottom were brought up from all depths, and especially along lines at right angles to the shore at short distances from each other. The exact physical and chemical nature of all these samples was accurately determined, and some most curious results were brought to light.

The earlier geologists had assumed, in the absence of direct evidence to the contrary, that the suspended matter poured into the sea by rivers was, sooner or later, by means of winds and waves and ocean currents, distributed over the whole of the ocean floors, and was gradually filling up or shallowing the oceans themselves. But the Challenger researches showed that this idea was almost as remote as possible from the truth. The actual facts are, that the whole of the land debris, with a few special and very minute exceptions, are being deposited on the sea-bottom very near the shore, comparatively speaking, and all but the very finest material quite close to it. Everything in the nature of gravel or sand, of which so much of the rocky strata consists, is laid down within a very few miles, only the finer muddy sediments being carried so far as from 20 to 50 miles from land; while the very finest of all, under the most favourable conditions, rarely extends beyond 150 and never exceeds 300 miles from land into the deep ocean. Mr. A. Agassiz also, has found that the extremely fine mud of the Mississippi River is never carried to a greater distance than 100 miles from its mouth. If we take even so much as 50 miles for the average distance to which the denuded matter is carried, we find the whole area of deposit around South America to be 60,000 square miles. But the area of that continent is about six million square miles, so that deposition goes on about a hundred times as fast as denudation; while over considerable areas where the deposits are of a sandy rather than of a muddy or slaty nature, it may go on a thousand times as fast . This is a most important fact which does not appear to have been taken into full consideration by geologists even to-day.

The correlative fact as to the ocean bed is, that over the whole of it, when more than the above-named distances from land, what are called "deep-sea oozes" are found. These are formed almost

entirely by the calcareous or silicious skeletons of minute organisms, together with small quantities of decomposed pumice and of meteoric or volcanic dust. Along with these in certain areas the remains of larger marine animals are found, especially the otoliths (or ear bones) of whales and the teeth of sharks. And the extreme slowness of the deposit of these oozes is shown by the fact that it is often impossible to bring up a dredging from the bottom that does not contain some of these bones or teeth. It seems as if much of the ocean bed were strewn with them! Now, these oozes, so easily recognised by their component materials and their organic remains, form no part of the upheaved crust of the earth on any of our continents. This is, of itself, a conclusive proof that oceans and continents have never changed places in the whole course of known geological time; for if they had done so (as is still maintained by many rather illogical writers) the epoch of submergence would be indicated by some fragments, at least, of the consolidated ocean ooze which must once have covered the whole continental area.

We now have to consider a quite different set of phenomena which have a very important bearing on the causes which have produced the elevations and depressions which have occurred over much of the land surface of the globe. It is a universal fact that as we descend into the crust of the earth (in deep wells or mines) the temperature rises at a tolerably uniform rate, which is found to be on the average one degree Fahr. for every 47*4 feet. This rate, if continued downwards, would reach the temperature of melted rock at a depth of about 20 miles. Hot springs in non-volcanic countries furnish an additional proof of the high temperature of the interior. Below the depth above indicated there would probably be some milea of rock in a plastic state, while irregularities would result from the nature of the rock, some being more easily melted than others.

Now, it has been ascertained that the various rocks of the crust are of less specific gravity in the solid state than when they are liquefied, so that the crust may be looked upon as actually floating upon the liquid interior, very much as the ice-sheets float upon the ocean. A curious confirmation of this has been given by measurements of the force of gravity, which show that near all great mountain masses gravity is diminished, not only by the amount due to the mass of the mountain itself, but to about double that amount. This is so universally the case that it has been concluded that the weight of the mountain mass is supported by a corresponding mass forced down into the fluid magma, and hence termed the "roots of the mountains"; just as every lofty iceberg must have a mass of submerged ice about nine times as great to support it in the water. This, of course, proves that the crust is flexible, and that just as any portion of it is upheaved or made thicker by additions above, a corresponding increase in thickness must occur below to keep it in equilibrium.

Thus are explained the very frequent phenomena of horizontal strata occurring in similar beds for thousands of feet thick, while each successive bed must have been formed at or near the surface. Such are the deposits recently formed in tbe deltas of great rivers, in many of which borings have been made from 350 to 640 feet deep, with indications that each successive layer was formed near the surface, and that during the entire process of deposition the whole area must have been sinking at a very regular rate. This can best be explained by the weight of the matter deposited causing the slow subsidence. Exactly similar phenomena occur through the whole series of the geological formations to the most ancient; in some cases strata eight miles in thickness showing proofs that the very lowest beds were not deposited in a deep ocean, but in quite shallow water near shore.1

Now, as we have seen that, over many areas not far from shore, deposition may occur 100 or even 1000 times as fast as denudation, and that this same area is continuously lowered by the weight forcing the crust downwards, we have a real and efficient cause for continuous subsidence and the formation of parallel strata of enormous thicknesses. It remains to account for the subsequent upheaval of these areas, their tilting up at various angles, and in many cases their being fractured, curved, or contorted often to an enormous extent and in a most fantastic manner.

Effects of a Cooling and Contracting Earth

It is universally admitted that the earth is a cooling and therefore a contracting body. The cooling, however, does not take place by conduction from the heated interior through the solid crust, the temperature of which at and near the surface is due wholly to sun-heat, but by the escape of heated matter to the surface through innumerable hot or warm springs; by a continuous flow of heated gases from volcanic areas; and frequent outbursts of red-hot ashes or liquid lavas from volcanoes. The springs bring up from great depths a quantity of matter in solution, and the whole of the above-mentioned agencies result not only in a very considerable loss of heat, but also in a very great outflow of solid matter, which, in the course of ages, must leave extensive cavities at various depths, and thus produce lines or areas of weakness which almost certainly determine the mode in which contraction will produce its chief effects.

As the outer crust for a considerable depth has its temperature determined by solar heat, and also because the temperature at which the rocks become liquid is tolerably uniform, the loss of heat, causing shrinkage of the globe as a whole, must occur in the liquid interior; and, as this becomes reduced in size, however slowly, it tends to shrink away from the crust. Hence the crust must readjust itself to the interior, and it can only do so by a process of crumpling up, owing to each successive concentric layer having a less area than that above it . This shrinkage has been compared with that of the rind of a drying-up apple. But the earth's crust having been for ages subject to ever-varying compressions and upheavals, and being formed of materials which are of unequal strength and tenacity, the actual results will be exceedingly unequal, and the inequalities will be most manifested along or near to certain lines of weakness caused by earlier shrinkage due to the same cause.

As the crust will be of greater extent than the contracted liquid core it has finally to rest upon, and as the chief effects of contraction are limited to certain directions and to comparatively small areas, and if the less fractured and more rigid portions settle down almost undisturbed upon the contracted interior, then considerable areas along, or parallel to, the lines of weakness must be crumpled, fractured, and forced upward, and thus produce great elevations on the surface, though small in proportion to the whole dimensions of the earth. Now, the ocean floors are enormous plains, except that they have, here and there, volcanic islands rising out of them. The water which covers them preserves uniform temperature, which, at the bottom, is not much above the freezing point of sea-water. We may conclude, therefore, that they are very nearly stable. Pendulum experiments show that the crust below these oceans is more dense than the subaerial crust, due, probably, to the uniform pressure and temperature they have been subject to for geologic periods. We may assume, therefore, that they do not become crumpled or distorted by the contraction of the liquid earth beneath them. The great plains of Russia, mostly of Triassic and Jurassic age, consist of nearly horizontal strata, while the Alps of Central Europe are greatly upheaved and contorted; and the same difference between adjacent areas is found in the United States, and most probably in all the great continents.

Mathematical physicists have calculated the possible upheavals that could be produced by a shrinking crust at probable rates of contraction, and have declared them to be too small to account for the elevation of the existing landmasses above the ocean floors, that is, for the whole differences of height of the land surfaces. But if, as the Rev. O. Fisher suggests, the oceanic basins were formed at an early stage of the earth's consolidation, by the separation from it of the moon in the way described by Sir George Darwin and accepted by Sir Robert Ball; and if the whole wrinkling effect of contraction is concentrated on a few lines or areas of weakness, always near existing mountains; and further, if this cause of elevation be supplemented by the continual subsidence of large areas along the margins of all the continents by the weight of new deposits producing a

pressure on the liquid interior, which must result in upward pressures elsewhere, then it seems possible that a combination of these causes may be sufficient.

Yet another cause of elevation has recently been demonstrated. After many unsuccessful attempts, the actual existence of semi-diurnal lunar tides within the earth's interior has been proved; and such tides must, it is said, generate a vast amount of heat, culminating at the bi-monthly periods of maximum effect. The heat thus produced would be greatest where the under surface of the crust was most irregular, that is, under the land surfaces, and especially under the "roots of mountains" projecting below the general level. Their cumulative results would, therefore, add to the upward forces produced by contraction along lines of weakness.1

But whether the various forces here suggested have been the only forces in operation or not, the fact of the repeated slow elevations and depressions of the earth's surface is undoubted. The most general phenomenon seems to have been the very slow elevation of great beds of strata, deposited one above another along the coasts of a continental mass, or sometimes along the shores of inland seas; immediately followed by a process of denudation of this surface by rain and rivers, which, as the elevation continued, carved it out into a complex series of valleys and ridges till it ceased to rise farther. The denudation continuing, the whole mass became worn away into lowland plains and valleys. Then, after a long period of quiescence, subsidence began, and as the land sank beneath the water new deposits were laid down over it. Sometimes repeated elevations and depressions of small extent occurred; while at very long intervals there was great and long-continued subsidence, and, while deeply buried under newer strata, the older masses were subjected to intense subterranean heat and compression, which altered their texture, and often crumpled and folded them up in the strangest manner conceivable. Then, perhaps, a long period of elevation brought them up and up, till they were many thousand feet above sea-level; and, when the superficial covering of newer beds had been all removed by denudation, the folded strata were themselves exposed to further denudation, and all the strange peaks and ravines and rushing cataracts of alpine mountains became revealed to us.

Thus, in alternate belts or more extended areas, our continents have been, step by step, built up throughout the ages, with repeated alternations of sea and land, of mountain and valley, of upland plateaus and vast inland seas or lakes, the indications of which can be clearly traced throughout the ages. And, along with these purely terrestrial changes, there have been cosmic changes due to the varying eccentricity of the earth's orbit and the precession of the equinoxes, leading to alternations of hot, short summers with long, cold winters, and the reverse; culminating at very distant intervals in warm and equable climates over the whole land surface of the globe; at other shorter and rarer periods in more or less severe "iceages," like that in which the whole north temperate zone was plunged during the Pleistocene period, long after the epoch when man had first appeared upon the earth.

Long Persistence of the Motive Power thus caused

It is in this long series of physical modifications of the earth's surface, accompanied by changes of climate, partly due to astronomical revolutions, and partly to changes in aerial and oceanic currents dependent on terrestrial causes, that we find a great motive power for the work of organic evolution, the mode of operation of which we now have to consider.

Before doing so, however, I would call attention to the fact of the very extraordinary complexity and delicacy of the physical forces that have continued to act almost uniformly, and with no serious break of continuity, during the whole vast periods of geological time. These forces have always been curiously balanced, and have been brought into action alternately in opposite directions, so as to maintain, over a large portion of the globe, land surfaces of infinitely varied forms, which,

though in a state of continuous flux, yet never reached a stationary condition. Everywhere the land is being lowered by denudation towards the sea-level, and part by part is always sinking below it, yet ever being renewed by elevatory forces, whose nature and amount we can only partially determine. Yet these obscure forces have always acted with so much regularity and certainty that the long, ever-branching lines of plant and animal development have never been completely severed. If, on the other hand, the earth's surface had ever reached a condition of permanent stability, so that both degrading and elevating forces had come to a standstill, then the world of life itself would have reached its final stage, and, wanting the motive power of environmental change, would have remained in a state of long-continued uniformity, of which the geological record affords us no indication whatever.

Readers of my book on Man's Place in the Universe will remember how, in chapters xi, to xiv., I described the long series of mechanical, physical, and chemical adjustments of the earth as a planet, which were absolutely essential to the development of life upon its surface. The curious series of geological changes briefly outlined in the present chapter are truly supplementary to those traced out in my former work. The conclusion I drew from those numerous cosmic adaptations was that in no other planet of the solar system were the conditions such as to render the development of organic life possible upon them — not its existence merely, which is a vastly different matter. That conclusion seemed to many of my readers, including some astronomers, geologists, and physicists, to be incontestable. The addition of the present series of adaptations, whose continuance throughout the whole period of world-life history is necessary as furnishing the motive power of organic development and adaptation, not only increases to an enormous extent the probability against the development of a similar " world of life," culminating in man, in any other known or reasonably conjectured planet, but affords, in my opinion, an exceedingly powerful argument for an overruling Mind, which so ordered the forces at work in the material universe as to render the almost infinitely improbable sequence of events to which I have called attention an actual reality.

Terrestrial Temperature Adjustments

Among the many wonderful adjustments in the human body, and in that of all the higher vertebrates, none perhaps is more complex, more exact, and apparently more difficult of attainment than those which preserve all the circulating fluids and internal organs at one uniform temperature, varying only four or five degrees Fahr., although it may he exposed to temperatures varying more than a hundred degrees. Hardly less wonderful are those cosmical and physical adjustments, which, during many millions of years, have preserved the earth's surface within those restricted ranges of temperature which are compatible with an ever-increasing development of animal and vegetable life.

Equally remarkable, also, is that other set of adjustments leading to those perpetual surface-changes of our globe which I have shown to be the motive power in the development of the marvellously varied world of life; and which has done this without ever once leading to the complete subsidence of any of the great continents during the unceasing motions of elevation and depression which have been an essential part of that great cosmic scheme of life-development of which I am now attempting an imperfect exposition.

That the temperature of the earth's surface should have been kept within such narrow limits as it has been kept during the enormous cycles of ages that have elapsed since the Cambrian period of geoldgy, is the more amazing when we consider that it has always been losing heat by radiation into the intensely cold stellar spaces; that it has always, and still is, losing heat by volcanoes and hot springs to an enormous extent; and that these losses are only counteracted by solar radiation and the conservative effect of our moisture-laden atmosphere, which again depends for its chief

conservative effect on the enormous extent of our oceanic areas. That all these agencies should have continued to preserve such a uniformity of temperature that almost the whole land surface is, and has been for countless ages, suitable for the continuous development of the world of life, is hardly to be explained without some Guiding Power over the cosmic forces which have brought about the result

Chapter XI - THE PROGRESSIVE DEVELOPMENT OF THE LIFE-WORLD, AS SHOWN BY THE GEOLOGICAL RECORD

In order to form any adequate conception of the world of life as a whole, of the agencies concerned in its development, and of its relation to man as its final outcome, we must endeavour to learn something of its past history; and this can only be obtained by means of the fossilised remains preserved in the successive strata or layers of the earth's crust, briefly termed "the geological record." In the preceding chapter I have endeavoured to indicate the forces that have been at work in continually moulding and remoulding the earth's surface; and have argued that the frequent changes of the physical environment thus produced have been the initial causes of the corresponding changes in the forms of organic life, owing to the need of adaptation to the permanently changed conditions; and also to the opening up of new places in the economy of nature, to be successively filled through that divergency of evolution which Darwin so strongly insisted upon as a necessary result of variation and the struggle for existence.

But in order to appreciate the extent of the changes of the earth's surface during the successive periods of life-development, it is necessary to learn how vast, how strange, and yet how gradual were those changes; how they consisted of alternate periods of not only elevation and depression, but also of alternations of movement and of quiescence, the latter often continuing for long periods, during which more and more complete adaptation was effected, and, perhaps in consequence a diminished preservation in the rocks, of the life of the period. Thus have occurred those numerous "breaks" in the geological record which separate the great "eras" and "systems" of the geologist. These phenomena are admirably explained in Professor James Geikie's attractive and well-illustrated volume on * Earth Sculpture or the Origin of Land Forms," published in 1898. Here I can only attempt to sketch in outline the successive stages of life which are exhibited in the rocks, and point out some of their most striking features with the conclusions to which they lead us.

During the latter part of the eighteenth century geologists were beginning to obtain some detailed knowledge of the earth's crust and its fossils, and arrived at a first rude division into primitive, secondary, and tertiary formations. The first were supposed to represent the epoch before life appeared, and comprised such rocks as granite, basalt, and crystalline schists. Next above these came various strata of sandstones, limestones, and argillaceous rocks, evidently of aqueous origin and often containing abundant fossils of marine, fresh-water, or terrestrial animals and plants. The tertiary were clearly, of more recent origin, and contained shells and other remains often closely resembling those of living animals. It was soon found, however, that many of the rocks classed as "primitive" either themselves produced fossils, or were found overlying fossiliferous strata; and, by a more careful study of these during the early part of the nineteenth century, the three divisions were more precisely limited — the first or "Primary," as containing the remains of Mollusca, Crustacea, and some strange fishes and amphibians; the " Secondary," by the first appearance of reptiles of many strange forms; and the "Tertiary," by abundance of Mammalia of all the chief types now existing, with others of new and apparently primitive forms, or serving as connecting links with living groups.

It is a very remarkable fact, not sufficiently dwelt upon in geological treatises, that this first grouping of the whole of the life-forms of the past into three great divisions, at a time when our knowledge of extinct animals and plants was extremely scanty as compared with what it is now, should still be in universal use among the geologists of the world. The exact limits of each of these

great divisions have been more accurately determined, but the abrupt change in the life-forms, and the world-wide unconformity in the stratification on passing from one division to the other, are as great as ever. The Primary or Palaeozoic period is still that of fishes and Amphibia; the Secondary or Mesozoic, that of reptiles, in amazing abundance and variety; and the Tertiary or Caino•zoic, that of an almost equal abundance of Mammalia, and with a considerable variety of insects and birds.

The exceptions to the generality of this classification are few, and are particularly interesting. Of the myriads of reptiles that characterise the Secondary era, only two of the nine orders into which they are subdivided have been found so far back as the Permian, the latest of the Paheozoic formations. One of these most primitive reptiles has a near ally in the strange, lizard-like Hatteria still surviving in some small islands on the coast of New Zealand; while others which seem to form connecting links with the earliest mammals may be the ancestral form from which have descended the unique types of the lowest living Mammalia, the ornithorhynchus and echidna of Australia.

So with the highest type of vertebrates, the mammals. About the middle of the nineteenth century small mammalian jaws with teeth were discovered in what was known as the dirt-bed of the Purbeck (Jurassic) formation at Swanage; others in the Stonesfield Slate of the same formation; and at a later period very similar remains were found in beds of the same age (and also in the Cretaceous) in North America. These are supposed to be primitive insect-eating Marsupials or Insectivora, and were all about the size of a mole or a rat; and it is a striking example of the imperfection of the geological record, that although they occur through the whole range of the Secondary period, from the Trias to the Cretaceous, their remains are still exceedingly scanty, and they appear to have made hardly any structural progress in that enormous lapse of time. Yet directly we pass from the Cretaceous to the Tertiary rocks, not only are Mammalia abundant and of fairly large size, but ancestral types of all the chief orders occur, and such highly specialised forms as bats, lemurs, and sea-cows (Sirenia) are found in its earliest division, the Eocene.

Either there is no record of the missing links in the Secondary formations, or, what is perhaps more probable, the break between the Secondary and Tertiary beds was of such enormous duration as to afford time for the simultaneous dying out of numerous groups of gigantic reptiles and the development in all the large continents of much higher and more varied mammals. This seems to imply that a large portion of all our existing continents was dry land during this vast period of time; the result being that the skeletons of very few of these unknown forms were fossilised; or if there were any they have been subsequently destroyed by denudation during the depression and elevation of the land which we know to have occurred.

We will now consider these great geological periods separately, in order to form some conception of the changes in the world of life which characterised each of them.

The Primary or Palaeozoic Era

The Palaeozoic differs from the two later eras of geology in having no known beginning. The earliest fossils are found in the Cambrian rocks; they consist of a few obscure aquatic plants allied to our Charas and Algse, and some lowly marine animals allied to sponges, crinoids, and annelids. But there are also many forms of shell-bearing Mollusca, which had already developed into the four great classes, lamellibranchs, pteropods, gasteropods, and cephalopods; while some groups of the highly organised crustaceans were abundant, being represented by water-fleas (ostracods) and numerous large and varied trilobites. Besides these, the curious Molluscoidea were fairly abundant, Terebratulse now first appear, and, as well as the genus Lingula, have continued to persist through all the subsequent ages to the present time. Great masses of rocks stratified and unstratified exist

below the Cambrian, but have mostly been metamorphosed by internal heat and pressure, and contain no recognisable organic remains.

Geologists have been greatly impressed by this sudden appearance of marine life in such varied forms and comparatively high organisation, and have concluded that the stratified formations below the Cambrian must probably have equalled the whole series which we now know above it. Dr. Croll declared, that "whatever the present mean thickness of all the sedimentary rocks of our globe may be, it must be small in comparison with the mean thickness of all the sedimentary rocks which have been formed "; while Darwin says, "Consequently, if the theory be true, it is indisputable that before the lowest Cambrian stratum was deposited long periods elapsed, as long as, probably longer than, the whole interval from the Cambrian age to the present day, and that during these vast periods the world swarmed with living creatures." 1 Thi8 view was supported by Sir Andrew Ramsay, DirectorGeneral of the Geological Survey, who possessed unrivalled knowledge of the facts as to the geological record. He says, speaking especially of the fossil fauna of the Cambrian age:

"In this earliest known varied life we find no evidence of its having lived near the beginning of the zoological series. In a broad sense, compared with what must have gone before, both biologically and physically, all the phenomena connected with this old period seem, to my mind, to be of quite a recent description; and the climates of seas and lands were of the very same kind as those the world enjoys at the present day." *

This consensus of opinion renders it highly probable that the existing geological record only carries us back to somewhere about the middle of the whole period during which life has existed upon the earth.

Passing through the long series of Lower Silurian strata, (now separated as Ordovician) we have fuller developments and more varied forms of the same classes found in the Cambrian; but in the Upper Silurian we meet with remains of fishes, the first of the great series of the vertebrates to appear upon the earth. They are of strange forms and low type, mostly covered with a kind of plate-armour, and apparently without any lower jaw. Hence they form a separate class — Agnatha ("without jaws"). They also appear to have had no hard, bony skeleton, as the only parts fossilised are the outer skin with its more or less armoured covering. The illustration (Fig. 39) shows one of the simpler forms, the whole surface being covered with small quadrangular flattened tubercles. The tail is somewhat twisted to show the bi-forked character. The mouth must have been an aperture underneath the head. Good specimens of these are rarely preserved.

In another family, Pteraspidae (Fig. 40), the skin-tubercles are united into plates and scales, while the head is covered with a dorsal shield, often terminating behind in a spine; and there is often a smaller shield beneath. A separate piece forms a projecting snout.

The. shields of these fishes are often preserved, while the complete body is very rare.

Another group (Fig. 41) has the head shield continuous or in two pieces, while the skin-tubercles are united into vertical plates on the sides of the body, as in the species here shown, while others have two or three rows of plates.

The highest group of these primitive fishes has the head and fore part of the body covered with large polygonal bony plates. As these died out in the Devonian epoch their place was taken by true fishes, having an ossified skeleton, a movable lower jaw, gill-covers, and pairs of pectoral and anal fins representing the four limbs of reptiles and mammals. The earliest of these were allied to our

sharks; and at each succeeding geological stage a nearer approach was made to the higher types of our modern fishes.

Class — Pisces

Modern type of tine fishes.

The older types persist in some of the lower forms. (B.M. Guide.)

This advance in development is well indicated by the gradual changes in the tail, as shown in the accompanying figures (42-44). The upper one is the oldest; but it soon became modified into the second, which in various modifications prevailed throughout the Palaeozoic and most of the Secondary periods; while the third perfectly symmetrical type did not appear till near the end of the latter, and only became predominant, as it is now, in the Tertiary period. Many of the earlier forms have tails which are quite symmetrical externally, but show a slight extension of the vertebrae towards the upper lobe. All three forms still exist, but the third is by far the most abundant.

In the highest Silurian beds land-plants allied to ferns and lycopods first appear, and with them primitive scorpions. In the succeeding Devonian and Carboniferous strata an extremely luxuriant land vegetation of a low type appeared and covered a large part of the existing lands. This supported a large variety of arthropods as well as true insects allied to mayflies and cockroaches, with a great number of Crustacea. Here, too, we come upon the next great step towards the higher land animals, in the appearance of strange Amphibia forming a distinct order — the Labyrinthodontia. They appear to have outwardly resembled crocodiles or lizards, and were rather abundant during the Carboniferous and Permian eras, dying out in the subsequent Triassic.

That portion of the Palaeozoic series of strata from the Sihirian to the Permian, during which a rich terrestrial vegetation of vascular cryptogams was developed, with numerous forms of arthropods, insects, primeval fishes and amphibians, comprises a thickness of stratified rocks somewhat greater than that of the whole of the Secondary and Tertiary strata combined. This thickness, which can be measured with considerable approach to accuracy, is generally supposed to afford a fair proportionate indication of the lapse of time.

There is a popular impression that in these remote ages the forces of nature were more violent, and their results more massive and more rapidly produced, than at the present time; but this is not the opinion of the best geological observers. The nature of the rocks, though often changed by pressure and heat, is in other cases not at all different from those of subsequent ages. Many of the deposits have all the characters of having been laid down in shallow water, and in several cases footprints of Amphibia or reptiles have been preserved as well as impressions of raindrops, so exactly corresponding with those which may be seen to-day in suitable places, that we cannot suppose the operations of nature to have been more violent then than now. All our great coal deposits of Palaeozoic age indicate long, and often repeated, but very slow depression of large areas of land, with intervening periods of almost perfect stability, during which dense forests had again time to grow, and to build up those vast thicknesses of vegetable matter which, when buried under successive rock-strata, became compressed into coal-seams, usually of several feet in thickness.

It is an extraordinary fact that in all the great continents, including even South America and Australia, coal-fields are more or less abundant at this period of the earth's history. This is proved by the identity or close similarity of the vegetation and animal life, as well as by the position of the coalbeds, in regard to the strata above and beneath them. It is true that coal is also found in some

Secondary and Tertiary strata, but these beds are much less extensive and the coal is rarely of such purity and thickness; while the later coal-fields are never of such world-wide distribution. It seems certain, therefore, that at this particular epoch there were some specially favourable conditions, affecting the whole earth, which rendered possible a rapid growth of dense vegetation in all situations which were suitable. Such situations appear to have been extensive marshy plains near the sea, probably the deltas or broad alluvial alleys of the chief great rivers; and the special conditions were, probably, a high and uniform temperature, with abundance of atmospheric moisture, and a larger proportion of carbon-dioxide in the air than there has ever been since.

We may, in fact, look upon this period as being the necessary precursor of the subsequent rapid development of terrestrial and aerial animal life. A dense and moisture-laden atmosphere, obscuring the direct rays of the sun, together with a superabundance of carbonic-acid gas and a corresponding scarcity of free oxygen, would probably have prevented the full development of terrestrial life with its magnificent culmination in such examples of vital activity as we see manifested in the higher mammalia, and especially in the more perfectly organised birds and insects. In this first and most widespread of the coal-making epochs we see the results of a world-wide and even cosmical adaptation which influenced the whole future course of life-development; while the later and more limited periods of coal-formation have been due apparently to highly favourable local conditions, of which the production of our deeper peat beds are the latest example.

If then, as I am endeavouring to show, all life development — all organic forces — are due to mind-action, we must postulate not only forces but guidance; not only such self-acting agencies as are involved in natural selection and adaptation through survival of the fittest, but that far higher mentality which foresees'all possible results of the constitution of our cosmos. That constitution, in all its complexity of structure and of duly co-ordinated forces acting continuously through eons of time, has culminated in the foreseen result. No other view yet suggested affords any adequate explanation; but this vast problem will be more fully discussed later on.

Thia earliest, but, aa some think, the most extended period of geological time, has been very cursorily touched upon, both because its known life-forms are more fragmentary and less generally familiar than those which succeeded them, and because the object here is to show reasons for considering it as essentially preparatory for that wonderful and apparently sudden burst of higher life-development of which we will now endeavour to give some account.

The Mesozoic or Secondary Formations

When we pass from the Palaeozoic to the Mesozoic era we find a wonderful change in the forms of life and are transported, as it were, into a new world. The archaic fishes wholly disappear, while the early Amphibia (Labyrinthodonts) linger on to the Trias, their place being taken by true reptiles, which rapidly develop into creatures of strange forms and often of huge dimensions, whose skeletons, to the uninstructed eye might easily be mistaken for those of Mammalia, as in fact some of them have been mistaken. The earliest of these new types, somewhat intermediate between Amphibia and reptiles, appear in the latest of the Palaeozoic strata — the Permian. These are the Theriomorpha (or "beast-shaped" reptiles), which show some relationship to true mammals which so quickly followed them in the lowest of the Mesozoic strata.

These early reptiles already show a large amount of specialisation. Some have greatly developed canine teeth, almost equalling those of the sabre-toothed tiger; others were adapted to feed on the luxuriant vegetation of the period, while their short, massive limbs made them almost as clumsy-looking as the hippopotamus. These strange creatures were first discovered in the Karoo formation of the Cape Colony, but have been found in a few places in India, Europe, and North

America, always either in the highest Primary (Permian) or lowest Secondary formation (Trias). Remains of allied forms have been found in the north of England and in the Trias of Elgin, Scotland. Their nearest surviving relatives are supposed to be the monotremes (echidna and platypus) of Australia, yet in the whole series of stratified rocks of Secondary and Tertiary times no intermediate form has yet been discovered.

A complete skeleton of one of the largest of these beastshaped reptiles is represented here (Fig. 45). The body of this strange animal was nearly seven feet long, and its small teeth show it to have been a vegetable feeder. The total length of some specimens was nearly ten feet, and the immense limbs were apparently adapted for digging, so that in loose soil it may have been of subterranean habits. In the same formation other allied but much smaller species were found.

Along with these were many creatures of the same general type, but as clearly carnivorous as the others were herbivorous. About a dozen distinct genera have been characterised, and as each probably comprised several species, and as these have as yet been all obtained from a few very limited areas, it is quite possible that the land animals of the Cape Colony at that early period may have been almost as numerous, as varied, and as conspicuous as they are to-day.

The two skulls here figured (Figs. 46 and 47) are of very different forms, and must have belonged to animals about the size of wolves; but there were many others of various shapes and sizes, some even equalling that of a large crocodile.

But at the same epoch, apparently, Europe and North America were equally well supplied with these strange reptiles. In Europe till recently only a few isolated bones or fragments of skulls had been discovered, but about five or six years ago a rich deposit was found on the banks of the river Dwina in Northern Russia. In a large fissure of the rocks quantities of nodules of very hard rock had been found, and being-easy to obtain, were broken up for mending roads; till Professor Amalitzky from Warsaw, visiting the spot, found that each of these nodules contained well-preserved fossils of extinct animals, which proved to be reptiles of the very same group as those of South Africa. Some of these nodules contained a skull; others contained the whole skeleton, these being sometimes eight feet long, and of strange forms corresponding to the crushed or distorted body of the animal. Thenceforth Professor Amalitzky devoted himself to the work of exploration by the aid of a grant from the Imperial Academy of St. Petersburg. The nodules are taken to Warsaw, where they are carefully opened, and the fossilised bones extracted, cleaned, and put together. Some of these are found to be almost identical with those of South Africa; others, quite distinct, though allied. Fig. 48 represents the skull of a huge carnivorous reptile, which must have been about the same size as the herbivorous Pariasauri (abundantly preserved in the nodules), upon which it doubtless preyed. As the skull is two feet long, and the whole head and body about nine feet, it must have far exceeded in size the largest lion or tiger, and probably that of any carnivorous land mammal that has ever lived.

In North America these reptiles were also present in considerable abundance. Some, forming the sub-order Theriodontia, were allied to the Pariasauri, and were probably herbivorous; while the Pariotrichidse were carnivores, as were also a very distinct family, the Clepsydropidse. Of this latter group one genus, Dimetrodon, is here figured as restored by Sir Ray Lankester (Fig. 49). This is supposed to be allied to the living Hatteria of New Zealand. These strange carnivorous reptiles of this early period may have preyed upon numerous herbivores which have not been preserved, as well as upon the primitive insects and land Crustacea, which at this period were probably abundant.

The remarkable thing is, that some hundreds of species of varied form and size, herbivorous and carnivorous, should have been gradually developed, arrived at maturity, and completely died out, during the comparatively short periods of the Permian and Trias, or the interval between them.

It is probable, however, that these transition periods really occupied a very great length of time, since all known reptiles seem to have originated during this era, though owing to unfavourable circumstances the connecting links have rarely been preserved. The singular Chelonia (turtles and tortoises) appear fully formed at the end of the Trias or in the earliest Jurassic beds, as do the crocodiles, the aquatic Plesiosaurians and Ichthyosaurians, the flying Pterodactyls, and the huge Dinosaurs. All these have more or less obscure interrelations, and their common ancestors cannot well be older than the Permian, since the preceding Carboniferous offered highly favourable conditions for the preservation of the remains of such land animals had they existed. To bring about the modification of some primitive reptile or amphibian into all these varied forms, and especially to bring about such radical changes of structure as to develop truly aerial and truly oceanic repFic. 48.—Skull Of The Gigantic Theriomorph Carnivorous Reptiles, must, with any reasonable speed of change, have required an enormous lapse of time, yet all these had their origin seemingly during the same period. Some account of the strange animals whose abundance and variety so especially characterised the Secondary period will now be given.

Order — Dinosauria

Some of the best known of these reptiles have been found in our own country, and we will therefore begin with the Iguanodon, of which teeth and bones were found near Maidstone (Kent) by Dr. Mantell in the early part of the last century, but no complete skeletons have been found. A closely allied species from Belgium of the same age (the Wealden) is here figured (Fig. 50). It was about thirty feet long, and is believed to have walked chiefly on its hind feet, and to have fed upon the foliage or fruits of good-sized trees. As shown in the restoration of the animal in its supposed usual attitude when alive (Fig. 51), it would stand about fourteen feet high. The fore-limbs are comparatively small, terminating in a hand of five fingers, the thumb being represented by a bony claw. The much longer hind legs, however, have feet with only three toes, much resembling those of running birds, and numerous impressions of such feet have been found in rocks of the same age, hence the group to which it belongs has been named Ornithopoda or "bird-footed." From the character of these it seems probable that the animal would walk on all fours and leap with its hind legs in the manner of a kangaroo.

The skull as shown by Fig. 52 is three and a half feet long, and the numerous close-set serrated teeth seem well adapted for grinding up large quantities of vegetable matter. The deep compressed tail indicates that it may have been used for swimming, and that the animal frequented lakes or marshes, and perhaps escaped its enemies by taking to the water. It appears to have had no protective armour.

Another group was named Stegosauria, "plated lizards," appearance of the living animal, here reproduced from his book. (Fig. 84.) The trunk could not therefore have hung down as in the modern elephants, and it seems hardly likely that with such tusks a trunk would have been developed. If a short one had been formed it would probably have been for the purpose of drinking and for pushing food into the mouth sideways. It is most interesting to see how the difficulty was overcome. In the next stage both pairs of tusks have become straightened out, the lower ones much reduced in length and the chin also somewhat shortened. That this process went on step by step is indicated by the Mastodons, which are elephants with a simpler form of teeth, and a pair of tusks like all living and recently extinct elephants (see Fig. 85). But when very young the American Mastodon had a pair of short tusks in the lower jaw, which soon fell out. In the character of its teeth generally, the Mastodon agrees with Tetrabelodon (which was originally classed as a

Mastodon) ; and there are Indian extinct species which show other stages in the reduction of the lower jaw.

We have here, therefore, a most remarkable and very rare phenomenon, in which we are able to see progressive evolution upon what seems to be a wrong track which, if carried further, might be disastrous. Usually, in such cases, the too much developed or injuriously developed form simply dies out, and its place is supplied by some lower or less modified species which can be more easily moulded in the right direction. But here (owing probably to some exceptionally favourable conditions), after first lengthening both lower jaw and lower tusks to keep pace with the upper ones, a reversal of the process occurs, reducing first the lower tusks, then the lower jaw, till these tusks completely disappeared and the lower jaw was reduced to the most useful dimensions in co-ordination with a greatly lengthened and more powerful trunk. Although in this case the gaps are still rather large, there can be no doubt that we have here obtained a view of the line of development of the most remarkable land mammals now living from a small generalised ungulate mammal, as indisputable and as striking as that of the horses from the little five-toed Eohippus of the American Eocene.

It may be here mentioned that the huge American Mastodon has been found in the same deposits with stone arrowheads, and was undoubtedly hunted by early man; as was also the huge mammoth whose beautifully curved tusks form its chief distinction from the living Indian elephant (Fig. 86). This species is abundant in the frozen mud at the mouths of the Siberian rivers; and in some cases the whole body is preserved entire, as in an ice-house, and the flesh has been sometimes roasted and eaten by the natives. Remains of skeletons have been found in our own country and over a large part of Northern Europe and Asia; while its portrait has been drawn from life by prehistoric man, either upon the tusks themselves or upon the flat portions of the horns of reindeer which he hunted for food.

No part of the world has so many distinct groups of Mammalia peculiar to it as South America, among which the most remarkable are the sloths and the armadillos; and all of them are found fossil in the middle or late Tertiary or the Pleistocene, from Brazil to Patagonia, and are often represented by strange forms of gigantic size. Some account of these will now be given. Darwin was one of the first collectors of these fossils on bis voyage in the Beagle, and during the last twenty or thirty years numerous travellers and residents, especially in Argentina, have more thoroughly explored the deposits of the pampas of various ages. Their great richness and importance may be indicated by the following enumeration of the chief orders of Mammalia represented in them.

Of the Peimates (or monkeys) all the remains are of the peculiar American families Cebidse and Hapalidse, with one extinct genus of the former. Bats (the order Chiroptera) are abundant, with several peculiar genera. The Insectivora are very rare in South America, but a fossil has been found supposed to belong to the peculiar West Indian family Solenodontidse. The Carnivora are chiefly represented by fossils of the American family Procyonidse (comprising the racoons and coati-mundis), of which several extinct genera have been obtained. The hoofed animals (Ungulata), which, from their great abundance in a living state in every part of the world, and their habit of living together in great herds often of many thousands, have been most frequently preserved in a fossil state, are here represented not only by all the chief forms that still inhabit the country, but also by some which are now only found in other continents, as well as by many which are altogether extinct. Among the former the most interesting are true horses of the genus Equus, as well as two peculiar genera of ancestral Equidse, distinct from those so abundant in North America. There are also several ancestral forms of the Llama tribe, one of which, Macrauchenia patachonica, was as large as a camel; and there are others so distinct as to form a separate family Proterotheriidse.

Another sub-order, Astrapotheria, were more massive animals, some of which equalled the rhinoceros in size. They consist of two distinct genera, only found in the Patagonian deposits of Mid-Tertiary age.1

Still more remarkable is another group — the Toxodontia — sometimes exceeding the rhinoceros in bulk, but with teeth which approached those of the Rodentia; of these there are various forms, which are grouped in three distinct families. The skeleton of one of the most remarkable of this group is shown in Fig. 87. Yet another distinct sub-order, Pyrotheria, which in its teeth somewhat resembled the extinct European Dinotherium, and which had a large pair of tusks in the lower jaw is found in the earlier Tertiary strata of Santa Cruz in Patagonia. The elephants also had a representative among these strange monsters in the form of a species of Mastodon, a genus also found in North America.

The very numerous and peculiar South American rodents commonly called cavies, including the familiar guinea-pig, are well represented among these fossils, and there are many extinct forms. Most of these are of moderate size, but one, Megamys, said to be allied to the viscachas, is far larger than any living rodent, about equalling an ox in size.

Perhaps more remarkable than any of the preceding are the extinct Edentata which abound in all these deposits. The entire order is peculiar to America, with the exception of the scaly ant-eater of Asia and the aard-vark of South Africa, and there is some doubt whether these last really belong to the same order. The living American edentates comprise three families, generally known as sloths, ant-eaters, and armadillos, each forming a well-marked group and all with a fair number of distinct species. But besides these, two extinct families are known, the Glyptodontidae and the Megatheriidae, the former being giant armadillos, the latter equally gigantic terrestrial sloths. Both of these lived from the Miocene period almost to our own time, and they are especially abundant in Pliocene and Pleistocene deposits. Some of the extinct forms of armadillo were very much larger than any now living; but it is among the Glyptodonts, which had a continuous shield over the whole body, that the largest species occurred, the shell being often 6 or 8 feet long. The skeleton of one of these is represented by Fig. 88. One of the most recent (Daedicurus) was 12 feet long, of which 5 feet consisted of the massive armoured tail, which latter is believed to have borne a number of movable horns. The earlier fossil species were of much smaller size, and, though far more abundant in the south, a few of them have been found in the Pliocene deposits of Texas. The extinct ground-sloths are even more remarkable, since they were intermediate in structure between the living sloths and the ant-eaters, but adapted for a different mode of life. Almost all are of large, and many of gigantic size. The Megatherium, which was discovered more than a century ago, was one of the largest, the skeleton (represented by a cast in the British Museum) being 18 feet long. Their massive bones show enormous strength, and they no doubt were able to uproot trees, by standing erect on the huge spreading hind feet and grasping the stem with their powerful arms, in order, to feed upon the foliage, as shown in the illustration (Fig. 89). The jaw-bones are lengthened out, indicating extended lips and probably a prehensile tongue with which they could strip off the leaves. An allied genus, Mylodon, which is somewhat smaller, has been found also in Kentucky in beds of the same age, the Pleistocene.

What renders these creatures so interesting is that they survived till a very recent period, and that they were contemporary with man. Both human bones and stone implements have been found in such close association with the bones or skeletons of these extinct sloths that they have been long held to have lived together. But a more complete proof of this was obtained in 1897. In a cavern in Patagonia, in a dry powdery deposit on the floor, many broken bones of a species of Mylodon were found; and also several pieces of skin of the same animal showing marks of tools. Bones of many other extinct animals were found there, as well as implements of stone and bone, remains of fires,

and bones of man himself. Among the other animal remains were those of an extinct ancestral horse, and on some of the bones there were found sbrivelled remains of sinews and flesh.

Allied forms are found in older deposits, as far back as the Miocene, but these are all of smaller size. They probably ranged all over South America, and the two genera Megatherium and Mylodon occur also in the most recent deposits of the southern United States. The numerous skeletons in the pampas of Argentina are usually found on the borders of old lakes and rivers, in the positions in which they died. They are supposed to have perished in the mud or quagmires while large animals lived there must have been much more woody vegetation than there is now. During the voyage of the BeagU, Darwin collected a large quantity of these interesting fossils, as described in his Naturalist's Voyage round the World (chap, v.). The skeleton and outline figure of a Mylodon shown in Fig. 90 was 11 feet in total length, but other species were larger.

A remarkable extinct genus, Scelidotherium, of which the complete skeleton is shown in Fig. 91, was about 10 feet long, and has less massive limbs than the Megatherium or Mylodon, and more elongated jaws. In some respects it approached the ant-eaters, and was probably, like them, terrestrial in its habits. About twelve distinct genera of these ground-sloths are now known, comprising a large number of species. They ranged all over South America and into the warmer parts of North America, and before the immigration of the horse and the sabre-toothed tiger in Pleistocene times, they must have constituted the larger and more important portion of the mammalian fauna of South America.

Extinct Mammals of Australia

The existing Australian mammals, although of varied form and structure, are almost all marsupials, the only exceptions being the aerial bats, and small rodents allied to rats, which latter might have entered the country by means of floating timber or trees from the nearest islands. These two orders are therefore of little importance geographically, although by counting the species it may be made to appear that the higher mammals (Placentalia) are nearly as numerous as the lower (Marsupialia). The wild dog, or dingo, is also apparently indigenous, but it may have been introduced by early man, as may some of the rodents. It is unfortunate that the deposits of Tertiary age in Australia seem to be very scanty, except recent gravels and alluvial muds, and none of these have produced fossils of Mammalia except in caves and driedup lakes, which are all classed as of Pleistocene age. These, however, are very productive in animal remains which are extremely interesting.

They consist of many living species, but with them numbers of extinct forms, some of gigantic size, but all undoubtedly allied to those living in Australia to-day. Thus, bones of kangaroos are found ranging in size from that of the smallest living species up to that of a donkey, and sometimes of very distinct forms and proportions. But with these have been found a huge wombat, the size of a large rhinoceros, of which the skull is here represented (Fig. 92). The complete skeleton has been quite recently obtained from Lake Callabonna in South Australia. It is found to be 12 feet long measured along the vertebrae, and 6 feet 2% inches high. As it has been found in various parts of the continent, it was probably abundant. Another smaller animal of somewhat similar form was the Nbtotherium, which was found in Queensland, together with the Diprotodon, about fifty years ago. A large phalanger was also found, which Professor Owen called the pouched lion (Thylacoleo

carnifex), but it is doubtful whether it was carnivorous (see Fig. 93). True carnivorous marsupials allied to the " Tasmanian wolf" (Thylacinus) and the Taamanian devil (Sarcophilus) are also found.

How and when the marsupials first entered Australia has always been a puzzle to biologists, because the only non-Australian family, the opossums, are not closely allied to any of the Australian forms, and it is the opossums only which have been found in the European early Tertiaries. But recent discoveries in South America have at length thrown some light on the question, since the Santa Cruz beds of Patagonia (Middle Tertiary) have produced several animals whose teeth so closely resemble those of the Tasmanian Thylacinus that Mr. Lydekker has no doubt about their being true marsupials allied to the Dasyuridse. There is also, in the same beds, another distinct family of small mammals — the Microbiotheridse of Dr. Ameghino — which, from a careful study of their dentition, are also considered by Mr. Lydekker to be "polyprotodont marsupials of an Australian type."

But even more important is the discovery of living marsupials of the Australian rather than the American type in the very heart of the South American fauna. In 1863 a small mouse-like animal of doubtful affinities was captured in Ecuador. But in 1895 a larger species of the same genus was obtained from Bogota; and it was then seen that they belonged to a group of which large numbers of fossil remains had been found in the Santa Cruz beds. By a comparison of these remains of various allied forms with the specimens of those now living, it seems no longer possible to doubt that marsupials of Australian type have existed in South America in Middle or Late Tertiary times, and that some of them survive to-day in the equatorial Andes, where their small size has probably saved them from extinction. Of these latter, Mr. Lydekker says: "In the skeleton the lower jaw exhibits the usual inflexion of the angle; and the pelvis carries marsupial bones. A small pouch is present in the female." These small marsupials have been named Camolestes, while their fossil allies are so numerous and varied that they have to be classed in three families — Abderitidse, Epanorthidse, and Garzoniidse. This is only mentioned here to show th© large quantity of materials upon which these conclusions are founded.

Teachings of Pleistocene Mammalia

For the purpose of the present work it is not necessary to go into further details as to the development of the higher forms of life, except to call attention to some other cases of the sudden dying out of great numbers of the more developed species or groups during the most recent geological period — the Pleistocene.

It has already been shown how, in temperate South America, the huge sloths and armadillos, the giant llamas, the strange Toxodontia, and the early forms of horses all disappeared at a comparatively recent epoch. In North America a similar phenomenon occurred. Two extinct lions; a number of racoons and allied forms, including several extinct genera; six extinct species of horses; two tapirs; two genera of peccaries; a llama and a camel; several extinct bisons, sheep, and deer; two elephants and two mastodons, and four genera of the wonderful terrestrial sloths, ranged over the whole country as far north as Oregon and the Great Lakes in quite recent times; while four genera of the great ground-sloths have been found as far north as Pennsylvania.

This remarkable assemblage of large Mammalia at a period so recent as to be coeval with that of man, is most extraordinary; while that the whole series should have disappeared before historical times is considered by most geologists to be almost mysterious. At an earlier period, especially during the Miocene (Middle Tertiary), North America was also wonderfully rich in Mammalia, including not only the ancestors of existing types, but many now quite extinct. At this time there were several kinds of monkeys allied to South American forms; numerous extinct Carnivora, including the great sabretoothed tiger, Machserodus; several ancestral horses, including the European Anchitherium; several ancestral rhinoceroses, the huge horned Brontotheriidcc, the Oreodontidae, and many ancestral swine. Almost all these became extinct at the end of the Miocene age.

In Europe we find very similar phenomena. During the Pleistocene age, the great Irish elk, the cave-lion and the sabre-toothed tiger, cave-bears and hyaenas, rhinoceroses, hippopotami and elephants, extinct species of deer, antelopes, sheep and cattle, were abundant over a large part of Europe (many even reaching our own country), and rapidly became extinct; and what renders this more difficult to explain is, that all of these and many others, with numerous ancestral forms, had inhabited Europe throughout the Pliocene and some even in Miocene times.

These very interesting changes in the northern hemisphere are paralleled and completed in far-distant Australia. In caves and surface deposits of recent formation a whole series of fossil remains have been found, all of the marsupial order, and most of them of extinct species and even extinct genera. But what is more extraordinary is, that several of them were larger than any now living, while some were as gigantic as the huge ground-sloths and armadillos of the Pampas. There were numerous kangaroos, some much larger than any living, including species allied to the tree-kangaroos of New Guinea; a Phascolomys (womhat) as large as a donkey; the Diprotodon, a thick-limbed animal nearly as large as an elephant, but allied both to the kangaroos and the phalangers. Equally remarkable was the Thylacoleo carnifex, nearly as large as a lion and with remarkable teeth (Fig. 93, p. 258). The very peculiar Nototherium, allied to the wombats, was nearly as large as a rhinoceros; and several others imperfectly known indicate that they were of larger size than their nearest living allies.

A number of very similar facts are presented by recently extinct birds. The Moas of New Zealand were of various sizes, but the largest was 8^ feet high when standing naturally, but when raising its body and neck to the fullest extent it would have perhaps reached to a height of 12 feet.

In Madagascar also there was a huge bird, the ^Epyornis, which was probably larger than the largest of the Moas, and whose egg, frequently found in sand-hills, sometimes measures 3 feet by 2^ feet in circumference, and will hold more than two gallons. It is almost certain that these huge birds were all coeval with early man, and in the case of the Moas this has been completely proved by finding their bones in ancient native cooking ovens. It is probable, therefore, that thedr final extinction was due to human agency.

Probable Cause of Extinction of the Pleistocene Mammalia

The complete extinction of many of the largest Mammalia, which were abundant in almost all parts of the world in Pleistocene times, has not yet received a wholly satisfactory explanation. The fact that the phenomenon is so neart to our own era renders it more striking than similar occurrences in remote ages. With the one exception of the glacial epoch, there has been very little modification of the earth's surface since the close of the Tertiary era; and in several cases species which undoubtedly survived that event have since become extinct. This great climatic catastrophe did undoubtedly produce extensive migration of Mammalia; but, owing to the fact that the ice-sheet had very definite limits, and that numbers of large mammals were merely driven southward, it is not held to be a sufficient cause for so general a destruction of the larger forms of life.

Another circumstance that puts the glacial epoch out of court as a sufficient explanation of the widespread extinction is that in two very remote parts of the earth, both enjoying a warm or even a sub-tropical climate—Australia on the one hand, and Brazil to Argentina on the other,— exactly the same phenomena have occurred, and, so far as all the geological evidence shows, within the same general limits of time.

It is no doubt the case that at each of the dividing lines of the Tertiary era — that is, in passing from the Eocene to the Miocene, or from the latter to the Pliocene, and thence to the Pleistocene — many large Mammalia have also become extinct. But in these cases a much greater lapse of time can be assumed, as well as larger changes in the physical conditions, such as extension of land or water, climate, vegetation, etc., which, combined with the special disabilities of very large animals, are sufficient to account for the facts. It may be well here to state again the causes which lead to the extinction of large animals rather than small ones, as given in my Darwinism (p. 394) more than twenty years ago, and also in my Geographical Distribution of Animals, i. p. 157 (1876):

In the first place, animals of great bulk require a proportionate supply of food, and any adverse change of conditions would affect them more seriously than it would affect smaller animals. In the next place, the extreme specialisation of many of these large animals would render it less easy for them to become modified in any new direction required by the changed conditions. Still more important, perhaps, is the fact that very large animals always increase 6lowly as compared with small ones — the elephant producing a single young one every three years, while a rabbit may have a litter of seven or eight young two or three times a year. Now the probability of useful variations will be in direct proportion to the population of the species, and, as the smaller animals are not only many hundred times more numerous than the largest, but also increase perhaps a hundred times as rapidly, they are able to become quickly modified by variation and natural selection, while the large and bulky species, being unable to vary quickly enough, are obliged to succumb in the struggle for existence.

To these reasons we may add that very large animals are less rapid in their motions, and thus less able to escape from enemies or from many kinds of danger. The late Professor 0. Marsh, of Yale University, has well observed:

In every vigorous primitive type which was destined to survive many geological changes, there seems to have been a tendency to throw off lateral branches, which became highly specialised, and soon died out because they were unable to adapt themselves to new conditions. . . . The whole

narrow path of the Suilline (hog) type, throughout the entire series of the American tertiaries, is strewn with the remains of such ambitious offshoots, many of them attaining the size of a rhinoceros; while the typical pig, with an obstinacy never lost, has held on in spite of catastrophes and evolution, and still lives in America to-day.

We may also remember that it is still more widely spread over the Old World, under the various forms of the hog-family (Suidae), than it is in America, under the closely allied peccary type (Dicotylidae).

That this is a true cause of the more frequent passing away of the largest animal types in all geological epochs there can be no doubt, but it certainly will not alone explain the dying out of so many of the very largest Mammalia and birds during a period of such limited duration as is the Pleistocene (or Quaternary) age, and under conditions which were certainly not very different from those under which they had been developed and had lived in many cases down to the historical period.

What we are seeking for is a cause which has been in action over the whole earth during the period in question, and which was adequate to produce the observed result. When the problem is stated in this way the answer is very obvious. It is, moreover, a solution which has often been suggested, though generally to be rejected as inadequate. It has been so with myself, but why I can hardly say. In his Antiquity of Man (4th ed., 1873, p. 418) Sir Charles Lyell says:

That the growing power of man may have lent its aid as the destroying cause of many Pleistocene species must, however, be granted; yet, before the introduction of fire-arms, or even the use of improved weapons of stone, it seems more wonderful that the aborigines were able to hold their own against the cave-lion, hyena, and wild bull, and to cope with such enemies, than that they failed to bring about their extinction.

Looking at the whole subject again, with the much larger body of facts at our command, I am convinced that the above somewhat enigmatic passage really gives the clue to the whole problem, and that the rapidity of the extinction of so many large Mammalia is actually due to man's agency, *acting in co-operation with those general causes* which at the culmination of each geological era has led to the extinction of the larger, the most specialised, or the most strangely modified forms. The reason why this has not been seen to be a sufficient explanation of the phenomena is, I think, due to two circumstances. Even since the fact of the antiquity of man was first accepted by European geologists only half a century ago, each fresh discovery tending to extend that antiquity has been met with the same incredulity and opposition as did the first discovery of flint weapons by Boucher de Perthes in the gravels near Amiens. It has been thought necessary to minimise each fresh item of evidence, or in many cases to reject it altogether, on the plea of imperfect observation. Thus the full weight of the ever-accumulating facts has never been adequately recognised, because each new writer has been afraid to incur the stigma of credulity, and therefore usually limited himself to such facts as he had himself observed, or could quote from his best-known contemporaries. On the other hand, the old idea that man was the latest product of nature (or of evolution) still makes itself felt in the attempt to escape from any evidence proving man's coexistence with such extinct species as would imply greater antiquity. In the chapter on The Antiquity of Man in North America (in my Natural Selection and Tropical Nature) I have given numerous examples of both these states of mind. And what makes them so specially unreasonable is, that all evolutionists are satisfied that the common ancestor of man and the anthropoid apes *must* date back to the Miocene, if not to the Eocene period; so that the real mystery is, not that the works or the remains of ancestral man *are* found throughout the Pleistocene period, but that

they are *not* also found throughout the Pliocene, and also in some Miocene deposits. There is not, as often assumed, one "missing link" to be discovered, but at least a score such links, adequately to fill the gap between man and apes; and their non-discovery is now one of the strongest proofs of the imperfection of the geological record.

When we find, as we do, that, with the one exception of Australia, proofs of man's coexistence with all the great extinct Pleistocene Mammalia are sufficiently clear, while that the Australians are equally ancient is proved by their forming so well-marked and unique a race, the fact that man should everywhere have helped to exterminate the various huge quadrupeds, whose flesh would be a highly valued food, almost becomes a certainty. The following passage from one of our best authorities, Mr. R. Lydekker, F.R.S., puts the whole case in a very clear light, though he does not definitely accept the conclusion which I hold to be now well established. He says:

From the northern half of the Old World have disappeared the mammoth, the elasmothere (a very peculiar, huge rhinoceros, whose skull was more than three feet long), the woolly and other rhinoceroses, the sabre-toothed tigers, etc.; North America has lost the megalonyx and the Ohio mastodon; from South America, the glyptodonts, mylodons, the megalothere, and the macrauchenia have been swept away; while Australia no longer possesses the diprotodon and various gigantic species of kangaroos and wombats. In the northern hemisphere this impoverishment of the fauna has been very generally attributed to the effects of the glacial period, but, although this may have been a partial cause, it can hardly be the only one. The mammoth, for instance, certainly lived during a considerable portion of the glacial epoch, and if it survived thus far, why should it disappear at the close? Moreover, all the European mastodons and the southern elephant *(Elephas meridionalis)* died out before the incoming of glacial conditions; and the same is true of all the extinct elephants and mastodons of Southern Asia. Further, a large number of English geologists believe the brick earths of the Thames valley, which contain remains of rhinoceroses and elephants in abundance, to be of post-glacial age. As regards the southern hemisphere, it can hardly be contended that glacial conditions prevailed there at the same time as in the northern half of the world.

It is thus evident that, though a very great number of large mammals were exterminated (perhaps partly by the aid of human agency) at the close of the Pleistocene period, when the group had attained its maximum development as regards the bodily size of its members, yet other large forms had been steadily dying out in previous epochs. And it would seem that there must be some general, deep-seated cause affecting the life of a species with which we are at present unacquainted. Indeed, as there is a term to the life of an individual, what is more natural than that there should also be one to the existence of a species. It still remains indeed, to account for the fact that the larger Pleistocene mammals had no successors in the greater part of the world, but perhaps, is in some way connected with the advent of man.

It is sometimes thought that early man, with only the rudest weapons, would be powerless against large and often well armed mammals. But this, I think, is quite a mistake. No weapon is more effective for this purpose than a spear, of various kinds, when large numbers of hunters attack a single animal; and when made of tough wood, with the point hardened by fire and well sharpened, it is as effective as when metal heads are used. Bamboo, too, abundant in almost all warm countries, forms a very deadly spear when cut obliquely at the point. The way in which even a man-eating tiger is killed by this means in Java is described in my Malay Archipelago (p. 82). Such a method would doubtless have been adopted even by Palaeolithic man, and would have been effective against any of the larger animals of the Pleistocene age.

It is therefore certain, that, so soon as man possessed weapons and the use of fire, his power of intelligent combination would have rendered him fully able to kill or capture any animal that has

ever lived upon the earth; and as the flesh, bones, hair, horns, or skins would have been of use to him, he would certainly have done so even had he not the additional incentive that in many cases the animals were destructive to his crops or dangerous to his children or to himself. The numbers he would be able to destroy, especially of the young, would be an important factor in the extermination of many of the larger species.

There remains, however, the question, well put by Mr. Lydekker, whether there is not some general deep-seated cause affecting the life of species, and serving to explain, if only partially, the successive dying out of numbers of large animals involving a complete change in the preponderant types of organic life at certain epochs; and to this question and some others allied to it a separate chapter must be devoted.

APPENDIX

THE THEORY OF CONTINENTAL EXTENSIONS

MOST writers consider that the preceding facts (see p. 241) go to prove the existence of a land-connection between South America and Australia in Early or Middle Tertiary times. This, however, seems to me to be highly improbable for reasons given at full in my Island Life. Its supposed necessity depends on the assumption that the geological record is fairly complete, even as regards these small mammals, and that their not being yet discovered in the northern continents proves that they never existed there. But the extreme rarity of the small Secondary Mammalia, though they have been found scattered over the whole northern hemisphere, and the limited area in South America in which these Tertiary marsupials have been found, taken in connection with the enormous areas of geologically unexplored land in Asia and Australia, should make us very cautious in assuming such vast and physically improbable changes of land and sea at such a comparatively recent epoch. The theory of land-connection also introduces enormous difficulties of various kinds which it is well briefly to consider. If we suppose an absolute land-connection in order to allow the marsupial type to have entered Australia from temperate South America, we have to face the incredible fact, that of the whole varied mammalian fauna of the latter country this one group only was transmitted. In these same deposits there are found ancestral hoofed animals of small size (Pyrotherium); numerous rodents allied to cavies and porcupines; a host of Edentata allied to sloths, ant-eaters, and armadillos. These, taken altogether, are many times more numerous than the marsupials; they were more varied in structure and mode of life; and it is almost incredible that not one representative of these somewhat higher forms should have reached the new country, or having reached it should have all died out, while the inferior group alone survived. Then, again, we know that birds and insects must have abounded in South America at the same period, while the whole 7000 miles of connecting land must have been well clothed with vegetation to support the varied life that must have existed upon it during the period of immigration. Yet no indication of a direct transference or interchange of these numerous forms of life in any adequate amount is found in either Australia or South Temperate America. We can hardly suppose such an enormous extent of land to have been raised above the ocean; that it should have become sufficiently stocked with life to serve as a bridge (7000 miles long!), and that a few very small marsupials only should have crossed it; that it then sank as rapidly as it had been formed; with the one result of stocking Australia with marsupials, while its other forms of life — plants, birds, insects, molluscs — show an unmistakable derivation from the Asiatic continent and islands. A careful examination of a large globe or South Polar map, with a consideration of the diagram of the proportionate height of land and depth of ocean at p. 345 of my Darwinism, together with the argument founded upon it, will, I think, convince my readers that difficulties in geographical distribution cannot be satisfactorily explained by such wildly improbable hypotheses. If the facts are carefully examined, it will be found, as I have shown for the supposed "Atlantis" and "Lemuria," that such hypothetical changes of sea and land always create more serious difficulties than those which they are supposed to explain. People never seem to consider what such an explanation really means. They never follow out in

imagination, step by step, the formation of any such enormous connecting lands between existing continents in accordance with what we know of the rate of elevation and depression of land, and the corresponding organic changes that must ensue. They seem to forget that such a vast and complete change of position of sea and land is not really known ever to have occurred.

Let us consider for a moment what the supposed land-connection between South America and Australia really implies. The distance is more than half as much again as the whole length of the South American continent, and 1000 miles farther than from Southampton to the Cape. This alone should surely give us pause. But unless we go as far south as the Antarctic circle, the depth of the intervening ocean is about two miles; and until we get near New Zealand there is not a single intervening island. There are here none of the indications we expect to find of any geologically recent depression of land on a vast scale. Of course we may suppose the connection to have been along a great circle within ten degrees of the South Pole, but that will not greatly shorten the distance, while we have not a particle of evidence for such a vast change of climate in Mid-Tertiary times as would be required to render such a route possible. But the mere physical difficulties are equally great. All land elevation or depression of which we have geological evidence has been exceedingly gradual, very limited in extent, and always balanced by adjacent opposite movements. Such movements appear to be slow creeping undulations passing over continental plateaus and their immediately adjacent submarine extensions. Sometimes the depressions seem to have taken the form of basins; but we cannot conceive of any elevation of continental dimensions, or depression of oceanic character as to depth and area, without the complementary movement to complete the undulation. A continental extension between South America and Australia would almost necessarily imply a subsidence of one or both of those countries over an equal area and to an equal depth; and, so far as I am aware, no geological evidence has been adduced of any such vast changes having occurred at so recent a period in either continent. I believe it can now be truly said that no stratigraphical geologist accepts the theory of frequent interchanges of continental and oceanic areas, which are so hastily claimed by paleontologists and biologists to be necessary in order to overcome each apparent difficulty in the distribution of living or extinct organisms, and this notwithstanding the number of such difficulties which later discoveries have shown to be non-existent.

Chapter XIII - SOME EXTENSIONS OF DARWIN'S THEOBY

During the fifty years that have elapsed since the Darwinian theory was first adequately, though not exhaustively, set forth, it has been subject to more than the usual amount of objection and misapprehension both by ignorant and learned critics, by old-fashioned field-naturalists, and by the newer schools of physiological specialists. Most of these objections have been shown to be fallacious by some of the most eminent students of evolution both here and on the Continent; but a few still remain as stumbling-blocks to many earnest readers, and, as they are continually adduced as being serious difficulties to the acceptance of natural selection as a sufficient explanation of the origin of species, I propose to give a short statement of what seem to me the three objections that most require an answer at the present time. They are the following:—

1. How can the beginnings of new organs be explained?

2. How can the exact co-ordination of variations, needed to produce any beneficial result, be effected with sufficient rapidity and certainty?

3. How is it that excessive developments of bulk, weapons, ornaments, or colours, far beyond any utilitarian requirements," have been so frequently produced?

These three objections are of increasing degrees of importance. The first is, in my opinion, wholly speculative and of no value, inasmuch as it applies to what happened in the earlier stages of

evolution, of which we have a minimum of knowledge. The second is of somewhat more importance; for, though in the great majority of cases of adaptation the ordinary well-known facts of variation and survival would amply suffice, yet there are conceivable cases in which they might be insufficient, and these cases are now explained by a very interesting combination of the effects of acquired modifications of the individual with the selection of congenital variations. The third is, I think, somewhat more important, as indicating a real deficiency in the theory, as originally stated, but which is now well supplied by an extension of that theory from the body itself to the reproductive germs from which its parts are developed. I will, therefore, endeavour to explain in as simple a manner as possible how these three objections have been overcome.

The Beginnings of Organs

The objection that the first slight beginnings of new organs would be useless, and that they could not be preserved and. increased by natural selection, was one of the most frequent in the early stages of the discussion of the theory, and was answered by Darwin himself in the later editions of his book. But the objection still continues to be made, and owing to the great mass of controversial literature continually issued from the press many of the objectors do not see the replies made to them; there is therefore still room for a somewhat more general answer, which will apply not only to certain individual cases, but to all. The most general and therefore the best answer I have yet seen given is that of Professor E. B. Poulton in his recently published Essays on Evolution. He says:

Organs are rarely formed anew in an animal, but they are formed by the modification of pre-existing organs; so that, instead of having one beginning for each organ, we have to push the beginning further and further back, and find that a single origin accounts for several successive organs, or at any rate several functions, instead of one.

He then goes on to show that the four limbs of vertebrates have been again and again modified, for running, for climbing, for burrowing, for swimming, or for flying, and that their first appearance goes back to Pakeozoic times in the paired fins of early fishes, while their actual origin must have been much further back, in creatures whose skeleton was not sufficiently solidified to be preserved.

There is, however, a more general explanation even than this, and one that applies to what has always been held to be the most difficult of all — that of the origin of the organs of sense.

The various sensations by which we come into relation with the external world — sight, hearing, smell, taste, and touch — are really all specialisations of the last and most general, that of material contact. We hear by means of a certain range of air-waves acting on a specially constructed vibrating organ; we smell by the contact of excessively minute particles, or actual molecules, given off by certain substances; we taste by the action of soluble matter in food on the papillae of the tongue; and we see by the impact of ether-vibrations on the retina; and as other ether-vibrations produce sensations of cold or warmth, or, when in excess, acute pain, in every part of the body, the modern view, that matter and ether are fundamentally connected if not identical, seems not unreasonable.

Now, as all our organs of sense, however complex, are built up from the protoplasm which constitutes the material of all living organisms, and as all animals, however simple, exhibit reactions which seem to imply that they have the rudiments of most, if not all of our senses, we may conclude that just in proportion as they have advanced in complexity of organisation, so have special parts of their bodies become adapted to receive, and their nervous system to respond to, the various contacts with the outer world which produce what we term sensations. There is therefore, probably, no point in the whole enormous length of the chain of being, from ourselves

back to the simple one-celled Amoeba, in which the rudiments of our five senses did not exist, although no separate organs may be detected. Just as its whole body serves alternately as outside or inside, as skin or as stomach, as limbs or as lips, so may every part of it receive a slightly different sensation from a touch outside or a touch inside, from an airvibration or from an ether-vibration, from those emanations which effect us as noxious odours or disgusting tastes. But if this view is a sound one, as I think it will be admitted that it is, how absurd is it to ask, "How did the eye or the ear begin?" They began in the potentiality of that marvellous substance, protoplasm, and they were rendered possible when that substance was endowed with the mysterious organising power we term life. First the cell was produced; and, from the continued subdivision of the cell at each subdivision taking a slightly different form and function, numerous one-celled animals were formed; and a little later the union of many cells of diverse forms and functions led to the endless multicellular creatures, constituting the entire world of life.

Thus every substance and every organ came into existence when required by the organism under the law of perpetual variation and survival of the fittest, only limited by the potentialities of living protoplasm. And if the higher senseorgans were so produced, how much easier was the production of such superficial appendages as horns and tusks, scales and feathers, as they were required. Horns, for instance, are either dermal or osseous outgrowths or a combination of both. In the very earliest known vertebrates, the fishes of the Silurian formation, we find the skin more or less covered with tubercles, or plates, or spines. Here we have the rudiments of all those dermal or osseous outgrowths which continue in endless modifications through the countless ages that have elapsed down to our own times. They appear and disappear, as they are useful or useless, on various parts of the body, as that body changes in form and in structure, and modifications of its external covering are needed. Hence the infinite variety in nature — a variety which, were it not so familiar, would be beyond the wildest flights of imagination to suggest as possible developments from an apparently simple protoplasmic cell. The idea, therefore, that there were, or could be, at any successive periods, anything of the nature of the abrupt beginning of completely new organs which had nothing analogous in preceding generations is quite unsupported by what is known of the progressive development of all structures through slight modification of those which preceded them. The objection as to the beginnings of new organs is a purely imaginary one, which entirely falls to pieces in view of the whole known process of development from the simplest cell (though in reality no cell is simple) to ever higher and more complex aggregations of cells, till we come to Mammalia and to man.

The Co-ordination of Variations

The next difficulty, one which Herbert Spencer laid much stress on, is, that every variation, to be of any use to a species, requires a number of concurrent variations, often in different parts of the body, and these, it is said, cannot be left to chance. Herbert Spencer discussed this point at great length in his Factors of Organic Evolution; and, as one of the illustrative cases, he takes the giraffe, whose enormously long neck and fore-legs, he thinks, would have required so many concurrent variations that we cannot suppose them to have occurred through ordinary variation. He therefore argues that the inherited effects of use and disuse are the only causes which could have brought it about; and Darwin himself appears to have thought that such inheritance did actually occur.

The points which Spencer mainly dwells upon are as follows: The increased length and massiveness of the neck would require increased size and strength of the chest with its bones and muscles to bear the additional weight, and also great additions to the strength of the fore-legs to carry such a burthen. Again, as the hind-legs have remained short, the whole body is at a different angle from what it was before the change from the ordinary antelope-type, and this would require a different shape in the articulating joints of the hips and some change in the muscles; and this would be the more important as the hind- and fore-legs now have unequal angular motions when galloping,

involving changed co-ordination in all the connected parts, any failure in which would diminish speed and thus be fatal to the varying individuals. Even the blood-vessels and nerves of these various parts would require modifications exactly adapted to the change in the other parts; and he urges that any individuals in which all these necessary variations did not take place simultaneously, would be at a disadvantage and would not survive. To do his argument justice, I will quote one of his most forcible paragraphs.

The immense change in the ratio of fore-quarters to hindquarters would make requisite a corresponding change of ratio in the appliances carrying on the nutrition of the two. The entire vascular system, arterial and venous, would have to undergo successive unbuildings and rebuildings to make its channels everywhere adequate to the local requirements, since any want of adjustment in the blood-supply to this or that set of muscles would entail incapacity, failure of speed, and loss of life. Moreover, the nerves supplying the various sets of muscles would have to be appropriately changed, as well as the central nervous tracts from which they issued. Can we suppose that all these appropriate changes, too, would be, step by step, simultaneously made by fortunate spontaneous variations occurring along with all the other fortunate spontaneous variations? Considering how immense must be the number of these required changes, added to the changes above enumerated, the chances against any adequate readjustments fortuitously arising must be infinity to one.

Now, this seems very forcible, and has, no doubt, convinced many readers. Yet the argument is entirely fallacious, because it is founded on the tacit assumption that the number of the varying individuals is very small, and that the amount of coincident variation is also both small and rare. It is further founded on the assumption that the time allowed for the production of any sufficient change to be of use is also small. But I have shown in the early chapters of this hook (and much more fully in my Darwinism) that all these assumptions are the very reverse of the known facts. The numbers of varying individuals in any dominant species (and it is only these which become modified into new species) is to be counted by millions; and as the whole number can, as regards any needed modification, be divided into two halves — those which possess the special quality required above or below the average — it may be said that nearly half the total number vary favourably, and about one-fourth of the whole number in a very large degree. Again, it has been shown that the number of coincident variations are very great, since they are always present when only a dozen or twenty individuals are compared; but nature deals with thousands and millions of individuals. Yet, again, we know that changes of the environment are always very slow as measured by years or generations, since not a single new species is known to have come into existence during the whole of the Pleistocene period; and as fresh variations occur in every generation, almost any character, with all its co-ordinated structures, would be considerably modified in a hundred or a thousand generations, and we have no absolute knowledge that any great change would be required in less time than this.

Objectors always forget that a dominant species has become so because it is sufficiently adapted to its whole environment, not only at any one time or to any average of conditions, but to the most extreme adverse conditions which have occurred during the thousands or millions of years of its existence as a species. This implies that, for all ordinary conditions and all such adverse changes as occur but once in a century of a millennium, the species has a surplus of adaptability which allows it to keep up its immense population in the midst of countless competitors and enemies. Examples of such thoroughly well-adapted species were the American bison and passenger pigeon, whose populations a century ago were to be counted by millions and thousands of millions, which they were fully able to maintain against all enemies and competitors then in existence. But civilised man has so modified and devastated the whole organic environment in a single century as to bring about an extermination which the slow changes of nature would almost certainly not have effected in a thousand or even a million of centuries. This happened because the changes were different in kind,

as well as in rapidity, from any of nature's changes during the whole period of the development of existing species.

But although I feel confident that the known amount of variation would amply suffice for the adaptation of any dominant species to a normally changing environment, I admit that there are conceivable cases in which changes may have been so great and so comparatively rapid as to endanger the existence even of some of those species which had attained to a dominant position; such, for instance, as the opening of a land passage for very powerful new Carnivora into another conresist one danger, then another; first to one aspect of the ever-changing environment, then to another; till during successive generations it becomes so perfectly adapted to a long series of more or less injurious conditions, that, under all ordinary conditions, it possesses a surplus of adaptation. And as this complete adaptation is as often exhibited in colour and marking as in structure, it is proved that the transmission of the effects of use and disuse are not essential to the most complex adaptations.

But a few years ago an idea occiirred independently to three biologists, of a self-acting principle in nature which would be of such assistance to any species in danger of extermination as, in some cases at all events, would enable it to become adapted to the new conditions. It would, in fact, increase the powers of natural selection, as above explained, to a degree which might sometimes make all the difference between life and death to a certain number of species. It depends upon the well-known fact that the use of any limb or organ strengthens or increases the growth of that part or organ. On this fact depends all training for athletics or games; and it is alleged by some trainers that any one, however weak naturally, can have his strength very greatly increased by systematic but carefully graded exercise. If, therefore, the survival of any animal in presence of a new enemy or unaccustomed danger depends upon increased powers of running, or jumping, or tree-climbing, or swimming, then, during the process of eliminating those individuals who were the worst in these respects, all the remainder would have to exercise their powers to the utmost, and would, in the act of doing so, increase their power of escaping the danger. Thus a considerable number would become capable of surviving, year after year, to a normal old age, and during this whole period would, year by year, have fresh descendants, and of these only the very best, the most gifted naturally, would survive. The increased adaptation during the life of the individual would not be transmitted, but the quality of being improvable during life would be transmitted, and thus additional time and a considerably increased population would give more materials for natural selection to act upon. With this help the species might become so rapidly improved that the danger from the new environment would be overcome, and a new type might be produced which would continue to be a dominant one under the new conditions.

Now, while it must be admitted, that under certain conditions, and with certain classes of adaptations, the normal effects of natural selection would be facilitated by the aid of individual adaptation through use of organs, yet its effect is greatly limited by the fact that it will not apply to several classes of adaptations which are quite unaffected by use or exercise. Such are the colours of innumerable species, which are in the highest degree adaptive, either as protecting them from enemies, as a warning of hidden danger (stings, etc.), as recognition-marks for young or for wanderers, or by mimicry of protected groups. Here the use is simply being seen or not seen, neither of which can affect the colour of the object. Again, nothing is more vitally important to many animals than the form, size, and structure of the teeth, which are wonderfully varied throughout the whole of the vertebrate sub-kingdom. Yet the more or less use of the teeth cannot be shown to have any tendency to change their form or structure in the special ways in which they have been again and again changed, though it might possibly have induced growth and increased size. Yet again, the scales or plates of reptiles, the feathers of birds, and the hairy covering of mammals, have never been shown to have their special textures, shapes, or density modified by the mere act of use. One common error is that cold produces length and density pf hair, heat the

reverse; but the purely tropical monkey-tribe are, as a rule, quite as well clothed with dense fur as most of the temperate or arctic mammals, while no birds are more luxuriantly feather-clad than those of the tropics. Neither is it certain that increased gazing improves the eyes, or loud noises the ears, or increased eating the stomach; so that we must conclude that this aid to the powers of natural selection is very partial in its action, and that it has no claim to the important position sometimes given it.

As many readers are ignorant of the extreme adaptability of many parts of the body, not only during an individual life, but in a much shorter period, I will here give an illustrative fact. A friend of mine was the resident physician of a large county lunatic asylum. During his rounds one morning, attended by one of bis assistants and a warder, he stopped to converse with a male patient who was only insane on one point and whose conversation was very interesting. Suddenly the man sprang up and struck a violent blow at the doctor's neck with a large sharpened nail, and almost completely severed the carotid artery. The warder seized the man, the assistant gave the alarm, while my friend sat down and pressed his finger on the proper spot to stop the violent flow of blood, which would otherwise have quickly produced coma and death. Other doctors soon applied proper pressure, and a competent surgeon was sent for, who, however, did not arrive for more than an hour. The artery was then tied up and the patient got to bed. He told me of this himself about two years afterwards, and, on my inquiry how the functions of the great artery had been renewed, he assured me that nothing but its permanent stoppage was possible, that numerous small anastomosing branches enlarged under the pressure and after a few months carried the whole current of blood that had before been carried by the great artery, without any pain, and that at the time of speaking he was quite as well as before the accident. Such a fact as this really answers almost the whole of Herbert Spencer's argument which I have quoted at p. 276.

Germinal Selection, an Important Extension of the Theory of Natural Selection

Although I was at first inclined to accept Darwin's view of the influence of female choice in determining the development of ornamental colour or appendages in the males, yet, when he had adduced his wonderful array of facts bearing upon the question in the Descent of Man, the evidence for any such effective choice appeared so very scanty, and the effects imputed to it so amazingly improbable, that I felt certain that some other cause was at work. In my Tropical Nature (1878) and in my Darwinism (1889) I treated the subject at considerable length, adducing many facts to prove that, even in birds, the colours and ornamental plumes of the males were not in themselves attractive, but served merely as signs of sexual maturity and vigour. In the case of insects, especially in butterflies, where the phenomena of colour, and to some extent of ornament, are strikingly similar to those of birds, the conception of a deliberate aesthetic choice, by the females, of the details of colour marking, and shape of wings, seemed almost unthinkable, and was supported by even less evidence than in the case of birds.

After long consideration of the question in all its bearings, and taking account of the various suggestions that had been made by competent observers, I arrived at certain conclusions which I stated as follows:

The various causes of colour in the animal world are, molecular and chemical change of the substance of their integuments, or the action upon it of heat, light, or moisture. Colour is also produced by the interference of light in superposed transparent lamellae or by excessively fine surface stria;. These elementary conditions for the production of colour are found everywhere in the surface-structures of animals, so that its presence must be looked upon as normal, its absence exceptional.

Colours are fixed or modified in animals by natural selection for various purposes: obscure or imitative colours for concealment; gaudy colours as a warning; and special markings either for easy recognition by strayed individuals or by young, or to divert attack from a vital part, as in the large brilliantly marked wings of some butterflies and moths.

Colours are produced or intensified by processes of development, either where the integument or its appendages undergo great extension or change of form, or where there is a surplus of vital energy, as in male animals generally, more especially at the breeding season.

Now the idea here suggested, of all these strange and beautiful developments of plumage, of ornaments, or of colour being primarily due to surplus vitality and growth-power in dominant species, and especially in the males, seems a fairly adequate solution of the problem. For the individuals which possessed it in the highest degree would survive longest, would have most offspring who were equally or even more highlygifted; and thus there would arise a continually increasing vitality which would he partly expended in the further development of those ornaments and plumes which are its result and outward manifestation. The varying conditions of existence would determine the particular part of the body at which such accessory ornaments might arise, usually, no doubt, directed by utility to the species. Thus the glorious train of the peacock might have begun in mere density of plumage covering a vital part and one specially subject to attack by birds or beasts of prey, and, once started, these plumes would continue to increase in number and size, as being an outlet for vital energy, till at last they became so enormously lengthened as to become dangerous by their weight being a check to speed in running or agility in taking flight. This is already the case with the peacock, which has some difficulty in rising from the ground and flies very heavily. Its enemies in India are tigers and all the larger members of the cat-tribe, and when any of these approach its feeding-grounds it takes alarm and at once flies up to the lower branches of large trees. In the Argus-pheasant it is the secondary wing-feathers that are exceedingly long and broad, so as to be almost as much a hindrance to strong or rapid flight as is the train of the peacock; and in both birds these ornamental plumes have evidently reached the utmost dimensions compatible with the safety of the species.

There can also be little doubt that in many of the birdsof-paradise and of the humming-birds, in the enormous crest of the umbrella-bird, in the huge beaks of the hornbills and the toucans, in the lengthy neck and legs of the flamingos and the herons, these various ornamental or useful appendages have reached or even overpassed the maximum of utility. In another class of animals we have the same phenomenon. The expansion of the wings in butterflies and moths reaches a maximum in several distinct families — the Papilionidae, the Morphidse, the Bombyces, and the Noctuse, in all of which it’s proboscis. The elephants thus arose as a kind of afterthought from a group of quadrupeds that were rapidly approaching their doom." (See figures in last chapter, p. 257.)

This last is a specially interesting case, because it is the only one in which, without change of general environment, or apparently of habits, a highly developed animal has retraced its latest steps, and then advanced in a new line of development, leading to the wonderful trunk and the enormous tusks of the modern elephant, as explained in Chapter XII. That these have now attained the maximum of useful growth is indicated by the fact that among the extinct forms are those in which they are developed to an unwieldy size, as in Elephas ganesa of North-West India, whose slightly curved tusks, sometimes nearly 10 feet long, must have put an enormous strain upon the neck, and the mammoth, whose greatly curved tusks were almost equally heavy.

Excessive Development of Lower Animals before Extinction

My friend Professor Judd has called my attention to the fact that many of the lower forms of life exhibited similar phenomena. The Trilobites (primitive crustaceans) which were extremely abundant in the Palaeozoic rocks, in their last stages "developed strange knobs and spikes on' their shells, so that they seemed to be trying experiments in excessive variation."

Excentric forms of Ammonites

At a later period the wonderfully rich and varied Ammonites show still more curious changes. Beginning in the Devonian formation they increased in variety of form and structure all through the succeeding formations, till they finally died out in the Cretaceous. The two species here figured from the Trias (Figs. 99, 100) may be taken as typical; but the variations in surface pattern are almost infinite. Visitors to Weymouth or Lyme Regis may find such in abundance under Lias cliffs, or in the former place along the shores of the backwater. As time went on Ammonites inFig. 98.—Acidosis dufremoyi. creased in maximum size, till in the Chalk formation specimens 2 or 3 feet diameter are not uncommon. One of the largest English specimens in the British Museum (Natural History) was found at Rottingdean, near Brighton, and is 3 feet 8 inches across; but the largest known is an allied species from the Upper Chalk of Westphalia, and has the enormous diameter of 6 feet 8 inches.

It is an interesting fact that the very earliest Ammonites were straight, and gradually became closely coiled. This form was maintained almost constant throughout the vast periods of the Mesozoic age, till towards the end, when the whole race was about to die out, they seemed to try to go back to their original form, which some almost reached (Fig. 105), while others, as Professor Judd remarks (in a letter), "before finally disappearing, twisted and untwisted themselves, and as it were wriggled themselves into extraordinary shapes, in the last throes of dissolution." These strange forms (Figs. 96-106) are reproduced from Nicholson's Palaeontology, and there are many others.

Special Features in the Development of Vertebrates

Another remarkable fact dwelt upon in Dr. Woodward's address is the remarkably small brains of those early types of vertebrates which were not destined to survive. The most striking cases are those of the Mesozoic reptiles and the early Tertiary ungulate mammals, which both increased to such an enormous bulk, yet retained throughout an almost ludicrously small brain, as described in the last chapter. The same was the case to a somewhat less extent with the carnivorous mammals, the Creodonta and Sparassodonta of the early Tertiaries both of the eastern and western hemispheres. These were sometimes as large as lions or bears, and had equally well developed canine teeth, but very small brains; and they all died out in Eocene or early Miocene times, giving way to small ancestral forms of our modern carnivores, which then increased in size and developed larger brains, culminating in the highly intelligent fox and dog, cat and leopard, of our own day.

Yet another singular feature of some of the more highly developed vertebrates is the partial or total loss of teeth. This is well shown in the camels, which have only a pair of incisors in the upper jaw; while the whole vast family of the deer, cattle, and sheep have a completely toothless pad in the front of the upper jaws. This is apparently better adapted for rapid browsing of grass and low herbage — which is stored up in the paunch for rumination when at rest; and the absence of teeth as a defence is compensated by the possession of horns in a great variety of form and structure.

Even more remarkable is the total loss of teeth by modern birds, although the early types of birds possessed them. The bill, however, is often a very effective piercing or tearing weapon; and their strongly grasping claws and hooked bill render the birds of prey almost as powerful and destructive as the smaller members of the cat-tribe. This partial or total disappearance of the teeth has no

doubt been helped on by the same principle which led to the persistent increase of useless appendages till checked by natural selection or till it led to the extinction of the entire race.

Germinal Selection

The numerous and varied phenomena which have been merely sketched in outline in the present chapter receive an approximate explanation by Professor Weismann's theory of germinal selection, which he first published in 1896. He appears to have been led to it by feeling the difficulty of explaining many of these phenomena by the " natural selection" of Darwin; but to have laid more stress on those of Section 2 of the present chapter than those of Section 3. He had in 1892 published his elaborate volume on The Germ-Plasm a Theory of Heredity, to which this later theory is a logical sequel.

During the last quarter of a century many striking discoveries have been made in what may be termed the mechanism of growth and reproduction; each successive advance in microscopic power and methods of observation have brought to light whole worlds of complex structure and purposive transformations in what was before looked upon as structureless cells or corpuscles. Some attempt will be made in a later chapter to discuss these primary life-phenomena; here it is only necessary to show briefly how Weismann's new theory helps us to understand the facts of life-development we have been dealing with. For this purpose I cannot do better than quote Professor Lloyd Morgan's very clear statement of the theory. He says:

The additional factor which Dr. Weismann suggests is what he terms ' germinal selection.' This, briefly stated, is as follows: — There is a competition for nutriment among those parts of the germ named determinants, from which the several organs or groups of organs are developed. In this competition the stronger determinants get the best of it, and are further developed at the expense of the weaker determinants, which are starved, and tend to dwindle and eventually disappear. The suggestion is interesting, but one well-nigh impossible to test by observation. If accepted as a factor, it would serve to account for the inordinate growth of certain structures, such as the exuberance of some secondary sexual characters, and for the existence of determinate variations, that is to say, variations along special or particular lines of adaptation.

It may be well to give here Weismann's own definition of what he means by "determinants," as quoted by Professor J. Arthur Thomson in his fine volume on Heredity (p. 435):

'I assume,' Weismann says, 'that the germ-plasm consists of a large number of different parts, each of which stands in a definite relation to particular cells or kinds of cells in the organism to be developed — that is, they are 'primary constituents' in the sense that their co-operation in the production of a particular part of the organism is indispensable, the part being determined both as to its existence and its nature by the predestined particles of the germplasm. I therefore call these Determinants, and the parts of the complete organism which they determine Determinates.

Professor Thomson continues thus:

But how many determinants are to be postulated in any given case? Weismann supposes that every independently variable and independently heritable character is represented in the germ-plasm by a determinant. A lock of white hair among the dark may reappear at the same place for several generations; it is difficult to interpret such facts of particular inheritance except on the theory that the germ-plasm is built up of a large number of different determinants. It may be pointed out that almost all biologists who have tried to form a conception of the ultimate structure of living matter have been led to the assumption — expressed in very varied phraseology — of ultimate protoplasmic

units which have the power of growth and division. It is in no way peculiar to Weismann to imagine biophors and to credit them with the powers of growing and dividing.

I quote these passages because Professor Thomson is thoroughly acquainted, not only with all Weismann's work, having himself translated some of them, but also with that of other European and American writers on this very difficult problem; and he arrives at the conclusion, that Weismann's theory is the most carefully and logically worked out, and that some such conception is essential for a comprehension of the wonderfully complex phenomena of heredity. He also quite agrees with the conception that as these vital elements of the germ-plasm grow and multiply during the life of the organism, they must be nourished by fluids derived from it, and that there must be slight differences between them in size and vigour, and a struggle for existence in which the most vigorous survive. These more vigorous determinants will lead to more vigorous growth of the special part or organ they determine — hair, horns, ornaments, etc.,— and wherever this increase is useful, or even not hurtful, to the species, it will go on increasing, generation after generation, by the survival of more and more vigorous determinants.

There is therefore both an internal and an external struggle for existence affecting all the special parts — organs, ornaments, etc.—of every living thing. With regard to the more important structures, such as the limbs, the organs of vision and hearing, the teeth, stomach, heart, lungs, etc., on which the very existence of the individual as well as of the species depends, survival of the fittest in due co-ordination with all other parts of the body will continually check any tendency to unbalanced development, and thus, generation by generation, suppress the tendency of the more vigorous determinants to increase the growth and vigour of its special determinates, by elimination of the individuals which exhibit such unbalanced growth. But in the case of appendages, ornaments, or brilliant colours, which may begin as a mere outlet for superfluous vital energy in dominant races, and then be selected and utilised for purposes of recognition, warning, imitative concealment, or for combat among males, there will not be the same danger to the very existence of the adult animal. It will, however, often happen that the increase through germinal selection will continue beyond the point of absolute utility to the individual; between which and the point of effective hurtfulness there may be a considerable margin. In this way we have a quite intelligible explanation of the enormous development of feathers or decorative plumes in so many birds, enormous horns in deer and antelopes, huge tusks in elephants, and huge canine teeth in other quadrupeds. This view is supported by the suggestive fact, that many of these appendages are retained only for a short period, during the breeding season, when vigour is greatest and food most abundant, and when therefore they are least injurious.

Again, when acting in an opposite direction, the theory serves to explain the rapid dwindling and final disappearance of some useless organs, which mere disuse is hardly sufficient to explain; such are the lost hind limbs of whales, the rudimentary wings of the Apteryx, the toothless beak of birds, etc. In such cases, after natural selection had reduced the part to a rudimental condition, any regrowth would be injurious, and thus determinants of increased vigour would be suppressed by the non-survival of the adult, leaving the weaker determinants to be crowded out by the competition of those of adjacent parts, the increased development of which was advantageous.

By this very ingenious, but, though speculative, highly probable hypothesis, extending the sphere of competition for nourishment and survival of the fittest from the organism as a whole to some of its elementary vital units, Professor Weismann has, I think, overcome the one real difficulty in the interpretation of the external forms of living things, in all their marvellous details, in terms of normal variation and survival of the fittest. We have here that "mysterious impetus" to increase beyond the useful limit which Dr. Woodward has referred to in his address already quoted, and which is also a cause of the extinction of species to which Mr. Lydekker referred us, as quoted towards the end of the preceding chapter.

Illustrative Cases of Extreme Development

Two examples of this extreme development have not, I think, yet been noticed in this connection. The wonderful long and perfectly straight spirally twisted tusk of the strange Cetaceous mammal, the narwhal, is formed by an extreme development, in the male only, of one of a pair of teeth in the upper jaw. All other teeth are rudimentary, as is the right tooth of the pair of which the left forms the tusk, often 7 or 8 feet long, and formed of a very fine heavy ivory. The use of this is completely unknown, for though two males have been seen playing together, apparently, with their tusks, they do not fight, and their food, being small Crustacea and other marine animals, can have no relation to this weapon. We may, however, suppose that the tusk was originally developed as a defence against some enemy, when the narwhal itself was smaller, and had a wider range beyond the Arctic seas which it now inhabits; and when the enemy had become extinct this strange weapon went on increasing through the law of germinal selection, and has thus become useless to the existing animal.

The other case is that of the equally remarkable Babirusa of the islands of Celebes and Bum, in which the canines of the males are so developed as to be useless for fighting (see Fig. 107). Here, too, there can be little doubt that the tusks were originally of the same type as in the wild boar, and were used for both attack and defence; but the ancestral form having been long isolated in a country where there were no enemies of importance, natural selection ceased to preserve them in their original useful form, and the initial curvature became increased by germinal selection, while natural selection only checked such developments as would be injurious to the individuals which exhibited them.

A Wider Application of the Principle of Germ-Selection

But it seems to me that the principle here suggested has a still higher importance, inasmuch as it has been the normal means of adding to and intensifying that endless variety of form, that strange luxuriance of outgrowths, and that exquisite beauty of marking and brilliancy of colour, that render the world of life an inexpressible delight to all who have been led to observe, to appreciate, or to study it. It is through the action of some such internal selecting agency that we owe much of what we must call the charming eccentricity of nature — of those exuberances of growth which cause the naturelover to perpetually exclaim, "What can be the use of this?" In the birds-of-paradise we had long known of the tailfeathers, the breast-shields, the masses of plumage from under the wings, the crests, the neck-tippets, all in wonderful variety of shape and colour. Then, in the island of Batchian I obtained a bird in which from the bend of the wing (corresponding to our wrist) there spring two slender and flexible white feathers on each side standing out from the wing during flight, whence it has been termed the standard-winged bird-of-paradise. Again, a few years ago, there was discovered in the mountains of German New Guinea another quite new type, in which, from the corner of each eye, a long plume arises more than twice the length of the bird's body, and having, on one side only of the midrib, a series of leaf-shaped thin horny plates of a beautiful light-blue colour on the upper surface, contrasting in a striking manner with the purple black, ochre yellow, and rusty red of the rest of the plumage.

In the comparatively small number of birds-of-paradise now known, we have a series of strange ornamental plumes which in their shape, their size, their colours, and their point of origin on the bird, exhibit more variety than is found in any other family oibirds, or perhaps in all other known birds; and we can now better explain this by the assistance of Weismann's law in a highly dominant group inhabiting a region which is strikingly deficient in animals which are inimical to bird-life in a densely forest-clad country.

To this same principle we must, I think, impute that superfluity of dazzling colour in many birds, but more especially in many insects, in which it so often seems to go far beyond usefulness for purposes of recognition, or as a warning, or a « distracting dazzle to an attacking enemy.

Even in the vegetable kingdom this same law may have acted in the production of enormous masses of flowers or of fruits, far beyond the needful purpose of perpetuating the species; and probably also of those examples of excessive brilliancy of colour, as in the intense blues of many gentians, the vivid scarlet of the Cardinal lobelia, or the glistening yellow of many of our buttercups. It is quite possible, therefore, that to this principle of "germinal selection" we owe some of the most exquisite refinements of beauty amid the endless variety of form and colour both of the animal and the vegetable world.

We may also owe to it the superabundant production of sap which enabled the early colonists of America to make almost unlimited quantities of sugar from the "sugar maple." Each tree will yield about four pounds of sugar yearly from about thirty gallons of sap; and it is stated by Lindley that a tree will yield this quantity for forty years without being at all injured; and large quantities of such sugar are still made for home consumption, the molasses produced from it heing said to be superior in flavour to that from the sugar-cane. Here surely is a very remarkable case of an excessive surplus product which is of great use to man, and, so far as we can see, to man only. The same phenomenon of a surplus product is presented by the Para rubber-trees (Siphonia, many species), from which, at the proper season, large quantities of the precious sap can be withdrawn annually for very long periods, without injuring the trees, or producing a diminution of the supply. There are also many other useful vegetable products, among those referred to in our fifteenth chapter, to which the same remark will apply; and it seems probable that we owe the whole of these, and many others not yet discovered in the vast unexplored tropical forests, to this farreaching principle of "germinal selection."

General Conclusions as to Life-Development

Before quitting the subject of the course of development of the entire world of life as shown by the geological record, to which the present chapter is in a measure supplementary, it will be well to say something as to its broader features from the point of view adopted in this work. This is, that beyond all the phenomena of nature and their immediate causes and laws there is Mind and Purpose; and that the ultimate purpose is (so far as we can discern) the development of mankind for an enduring spiritual existence. With this object in view it would be important to supply all possible aids that a material world can give for the training and education of man's higher intellectual, moral, and aesthetic nature. If this view is the true one, we may look upon our Universe, in all its parts and during its whole existence, as slowly but surely marching onwards to a predestined end; and this involves the further conception, that now that man has been developed, that he is in full possession of this earth, and that upon his proper use of it his adequate preparation for the future life depends, then a great responsibility is placed upon him for the way in which he deals with this his great heritage from all the ages, not only as regards himself and his fellows of the present generation, but towards the unknown multitude of future generations that are to succeed him.

All of us who are led to believe that there must be a being or beings high and powerful enough to have been the real cause of the material cosmos with its products life and mind, can hardly escape from the old and much-derided view, that this world of ours is the best of all possible worlds calculated to bring about this result. And if the best for its special purpose, then the whole course of life-development was the best; then also every step in that development and every outcome of it which we find in the living things which are our contemporaries are also the best — are here for a purpose in some way connected with us; and if in our blind ignorance or prejudice we destroy them

before we have earnestly endeavoured to learn the lesson they are intended to teach us, we and our successors will be the losers — morally, intellectually, and perhaps even physically.

Already in the progress of this work I have dwelt upon the marvellous variety of the useful or beautiful products of the vegetable and animal kingdoms far beyond their own uses, as indicating a development for the service of man. This variety and beauty, even the strangeness, the ugliness, and the unexpectedness we find everywhere in nature, are, and therefore were intended to be, an important factor in our mental development; for they excite in us admiration, wonder, and curiosity — the three emotions which stimulate first our attention, then our determination to learn the how and the why, which are the basis of observation and experiment and therefore of all science and all philosophy. These considerations should lead us to look upon all the works of nature, animate or inanimate, as invested with a certain sanctity, to be used by us but not abused, and never to be recklessly destroyed or defaced. To pollute a spring or a river, to exterminate a bird or beast, should be treated as moral offences and as social crimes; while all who profess religion or sincerely believe in the Deity — the designer and maker of this world and of every living thing — should, one would have thought, have placed this among the first of their forbidden sins, since to deface or destroy that which has been brought into existence for the use and enjoyment, the education and elevation of the human race, is a direct denial of the wisdom and goodness of the Creator, about which they so loudly and persistently prate and preach.

Yet during the past century, which has seen those great advances in the knowledge of Nature of which we are so proud, there has been no corresponding development of a love or reverence for her works; so that never before has there been such widespread ravage of the earth's surface by destruction of native vegetation and with it of much animal life, and such wholesale defacement of the earth by mineral workings and by pouring into our streams and rivers the refuse of manufactories and of cities; and this has been done by all the greatest nations claiming the first place for civilisation and religion! And what is worse, the greater part of this waste and devastation has been and is being carried on, not for any good or worthy purpose, but in the interest of personal greed and avarice; so that in every case, while wealth has increased in the hands of the few, millions are still living without the bare necessaries for a healthy or a decent life, thousands dying yearly of actual starvation, and other thousands being slowly or suddenly destroyed by hideous diseases or accidents, directly caused in this cruel race for wealth, and in almost every case easily preventable. Yet they are not prevented, solely because to do so would somewhat diminish the profits of the capitalists and legislators who are directly responsible for this almost world-wide defacement and destruction, and virtual massacre of the ignorant and defenceless workers.

The nineteenth century saw the rise, the development, and the culmination of these crimes against God and man. Let us hope that the twentieth century will see the rise of a truer religion, a purer Christianity; that the conscience of our rulers will no longer permit a single man, woman, or child to have its life shortened or destroyed hy any preventable cause, however profitable the present system may be to their employers; that no one shall be allowed to accumulate wealth by the labour of others unless and until every labourer shall have received sufficient, not only for a bare subsistence, but for all the reasonable comforts and enjoyments of life, including ample recreation and provision for a restful and happy old age. Briefly, the support of the labourers without any injury to health or shortening of life should be a first charge upon the products of labour. Every kind of labour that will not bear this charge is immoral and is unworthy of a civilised community.

The Teaching of the Geological Record

But this is a digression. Let us now return to a consideration of the main features of the course of life-development.

The first point to which our attention may be directed is, that the necessary dependence of animal life upon vegetation is the cause of some of the most prominent and perhaps the most puzzling features of the early life-world as presented to us by the geological record. In the Palaeozoic age we already meet with a very abundant and very varied aquatic life, in which all the great classes of the animal kingdom — sponges, zoophytes, echinoderms, worms, Mollusca, and vertebrates — were already fully differentiated from each other as we now find them, and existed in considerable variety and in great numbers. It is quite possible that the seas and oceans of those remote ages were nearly as full of life as they are now, though the forms of life were less varied and generally of a lower type. But, at the same time, the animal life of the land was very scanty, the only vertebrates that occupied it being a few Amphibia and archaic reptiles. There were, however, a considerable number of primitive centipedes, spiders, Crustacea, and even true insects, the latter having already become specialised into several of our existing orders. All these occur either in the Coal formation of Europe or the Devonian rocks of North America, which seems to imply that when land-vegetation first began to cover the earth a very long period elapsed before any correspondingly abundant animal life was developed; and this was what we should expect, because it would be necessary for the former to become thoroughly established and developed into a sufficient variety of forms well adapted to all the different conditions of soil and climate, in order that they might be able to resist the attacks of the larger plant-feeding animals, as well as the myriads of insects when these appeared. So far as we can judge, the vegetable kingdom was left to develop freely during the enormous series of ages comprised in the Devonian, Carboniferous, and Permian formations, to which we must add the gap between the latter and the Triassic — the first of the Secondary formations. By that time the whole earth had probably become more or less forest-clad, but with vegetation of a low type mostly allied to our ferns and horsetails, with some of the earliest ancestral forms of pines and cycads.

In the succeeding Secondary era the same general type of vegetation prevailed till near its close; but it was then everywhere subject to the attacks of large plant-devouring reptiles, and under this new environment it must necessarily have started on new lines of evolution tending towards those higher flowering plants which, throughout the Tertiary period, became the dominant type of vegetation. It seems probable that throughout the ages animal and vegetable life acted and reacted on each other. The earliest luxuriant land-vegetation, that which formed the great coal-fields of the earth, wa3 probably adapted to the physical environment alone, almost uninfluenced by the scanty animal life. Then reptiles and mammals were differentiated; but the former increased more rapidly, being perhaps better fitted to live upon the early vegetation and to survive in the heavy carbonated atmosphere. This in turn became more varied and better adapted to resist thenattacks; and when the new type had become well established it quickly replaced the earlier forms; and the highly specialised reptiles, unable to obtain sufficient nourishment from it, and being also subject to the attacks of Carnivora of increasing power, and perhaps to some adverse climatic changes, quickly disappeared. Then came the turn of the Mammalia, the birds, and the more specialised insects, which, during this vast period, had been slowly developing into varied but always rather diminutive forms, the birds and mammals feeding probably on insects, roots, and seeds; but, in proportion as the reptiles disappeared, they were ready to branch out in various directions, occupying the many places in nature left vacant by these animals, and thus initiated that wonderfully varied mammalian life which throughout the whole Tertiary periods occupied the earth's surface as completely, and almost as exclusively, as the reptiles had done during the middle ages of geological time.

The reactions of insects and flowers are universally admitted, as are those between birds and fruits; but the broader aspect of this reaction between animal and plant life as a whole has not, I think, received much attention. It does, however, seem to throw a glimmer of light on the very puzzling facts of the-vast development of Secondary reptilian life, the apparent arrest of

development of mammals during the whole vast period, and the rapid and abundant outgrowths of the higher types both of plants and of Mammalia in the Tertiary age.

The complete metamorphosis, broadly speaking, of both plant and animal life, on passing from the former to the latter epoch, is most startling. Such a change was, however, absolutely essential, not only for the production of the higher Mammalia and intellectual man, but also to provide for the infinitely varied needs of man's material, moral, and aesthetic development. The immensely varied plant-group of phanerogams has served to unlock for his service the myriad potentialities which lay hidden in protoplasm — the mysterious physical hasis of all life. To this vast series of herbs and shrubs and forest-trees he owes most of the charms, the delicacies, and the refinements of his existence — almost all his fruits, most of his scents and savours, together with a large part of the delight he experiences in mountain and valley, forest, copse, and flower-spangled meadow, which everywhere adorn his earthly dwelling-place.

To this we must add the infinitely varied uses to man of domestic animals, all supplied by the higher Mammalia or birds, while no single reptile has ever occupied or seems able to occupy the same place. We can only speculate on the part these have played in man's full development, but it must have been a great and an important one. The caring for cattle and sheep, the use of milk, butter, and cheese, and the weaving of wool and preparation of leather, must have all tended to raise him from the status of a beast of prey to that of the civilised being to whom some animals at all events became helpers and friends. And this elevation was carried a step further when the horse and the dog became the companions of his daily life, while fowls, pigeons, and various singingbirds added new pleasures and occupations to his home. That such creatures should have been slowly evolved so as to reach their full development at the very time when he became able to profit by them must surely be accepted as additional evidence of a foreseeing mind which, from the first dawn of life in the vegetable and animal cells, so directed and organised that life, in all its myriad forms, as, in the far-off future, to provide all that was most essential for the growth and development of man's spiritual nature.

If furtherance of this subject it would be necessary to put a definite bar to the persistence of a lower type which might have prevented or seriously checked the development of the higher forms destined to succeed them; and this seems to have been done in the case of the Mesozoic reptiles by endowing them with such a limited amount of intelligent vitality as would not lead to its automatic increase under the stress of a long course of development, though accompanied by continual change of conditions and enormous increase in size. Hence the "ridiculously small brains" (as they have been termed) of these huge and varied animals. We may learn from this phenomenon, and the parallel case of the huge Dinocerata among the Tertiary mammals, that development of a varied form and structure through the struggle for existence does not necessarily lead to an increase in intelligence or in the size and complexity of its organ the brain, as has been generally assumed to be the case.

If, as John Hunter, T. H. Huxley, and other eminent thinkers have declared, " life is the cause, not the consequence, of organisation," so we may believe that mind is the cause, not the consequence, of brain development. The first implies that there is a cause of life independent of the organism through which it is manifested, and this cause must itself be persistent — eternal — life, any other supposition being essentially unthinkable. And if we must posit an eternal Life as the cause of life, we must equally posit an eternal Mind as the cause of mind. And once accept this as the irreducible minimum of a rational belief on these two great questions, then the whole of the argument in this volume falls into logical sequence.

Life as a cause of organisation is as clearly manifested and as much a necessity in the plant as in the animal; but they are plainly different kinds (or degrees) of life. So there are undoubtedly

different degrees and probably also different kinds of mind in various grades of animal life. And as the life-giver must be supposed to cause the due amount and kind of life to flow or be drawn into each organism, from the universe of life in which it lives, so the mind-giver, in like manner, enables each class or order of animals to obtain the amount of mind requisite for its place in nature, and to organise a brain such as is required for the manifestation of that limited amount of mind and no more. Thus and thus only, as it seems to me, can we understand the raison d' etre of these small-brained animals. They were outgrowths of the great tree of life for a temporary purpose, to keep down the coarser vegetation, to supply animal food for the larger Carnivora, and thus give time for higher forms to obtain a secure foothold and a sufficient amount of varied form and structure, from which they could, when better conditions prevailed, at once start on those wonderful diverging lines of advance which have resulted in the perfected and glorious life-world in the midst of which we live, or ought to live.

This view of the purport, the meaning, and the higher function of the great and varied life-world brings us by a different route to what many of our better thinkers and teachers have tried to impress upon us — that our great cities are the "wens," the disease-products of humanity, and that until they are abolished there can be no approach to a true or rational civilisation.

This was the teaching of that true and far-seeing child of nature, William Cobbett; it is the teaching of all our greatest sanitarians; it is the teaching of Nature herself in the comparative rural and urban death-rates. Yet we have no legislator, no minister, who will determinedly set himself to put an end to the continued growth of these "wens "; which are wholly and absolutely evil . I will, therefore, take this opportunity of showing how it can be done.

There is much talk now of what will and must be the growth of London during the next twenty or fifty years; and of the necessity of bringing water from Wales to supply the increased population. But where is the necessity? Why provide for a population which need never have existed, and whose coming into existence will be an evil and of no possible use to any human beings but the landowners and speculators, who will make money by the certain injury of their fellow-citizens. If the House of Commons and the London County Council are not the bond-slaves of the landowners and speculators, they have only to refuse to allow any furthe* water-supply to be provided for London except what now exists, and London will cease to grow. Let every speculator have to provide water for and on his own estate, and the thing will be done — to the enormous benefit of humanity.

The same thing can, I presume, be done by Parliament for any other growing town or city. It can justly say: "When you have not a gallon of polluted water in your town, and when its death-rate is brought down to the average standard of rural areas, we will reconsider the question of your further growth." By that time, probably, there will be no public demand for enlarging our "wens" and a very strong and stern one for their cure or their abolition.

Chapter XIV - BIRDS AND INSECTS: AS PROOFS OF AN ORGANISING AND DIRECTIVE LIFE-PRINCIPLE

If we strip a bird of its feathers so that we can see its bodystructure as it really is, it appears as the most ungainly and misshapen of living creatures; yet there is hardly a bird but in its natural garment is pleasing in its form and motions, while a large majority are among the most beautiful in shape and proportions, the most graceful in their activities, and often the most exquisite and fascinating of all the higher animals. The fact is, that the feathers are not merely a surface-clothing for the body and limbs, as is the hairy covering of most mammals, but in the wing and tail-feathers form an essential part of the structure of each species, without which it is not a complete individual, and could hardly maintain its existence for a single day. The whole internal structure has been gradually built up in strict relation to this covering, so that every part of the skeleton,

every muscle, and the whole of the vascular system for blood-circulation and aeration have been slowly modified in such close adaptation to the whole of the plumage that a bird without its feathers is almost as helpless as a mammal which has lost its limbs, tail, and teeth.

Although birds are so highly organised as to rival mammals in intelligence, while they surpass them in activity and in their high body-temperature, yet they owe this position to an extreme retrogressive specialisation resulting in the complete loss of the teeth, while the digits of the fore limb are reduced to three, the bones of which are more or less united, and, though slightly movable, are almost entirely hidden under the skin.

The earliest fossil bird, the ArchaBopteryx, had three apparently free and movable digits on the fore limbs, each ending in a distinct claw; while the two bones forming the forearm appear to have been also free and movable, so that the wing must have been much less compact and less effective for flight than in modern birds. This bird was about as large as a rook, but with a tail of twenty vertebra, each about half an inch long and bearing a pair of feathers, each four inches in length and half an inch broad, while the wing feathers were nearly twice as long. The almost complete disappearance of the unwieldy tail, with the fusing together of the wing-bones, must have gone on continuously from that epoch. In the Cretaceous period the long tail has disappeared, and the wingbones are much more like those of living birds; but the jaws are still toothed. In the early Tertiary deposits bird-remains are more numerous, and some of the chief orders of modern birds seem to have existed, while a little later modern families and genera appear.

The important point for our consideration here is that, in the very earliest of the birds yet discovered which still retained several reptilian characteristics, true feathers, both of wings and tail, are so clearly shown as to leave no doubt of their practical identity with those of living birds.

It is therefore evident that birds with feathers began to be developed as early as (perhaps even earlier than) the membranous-winged reptiles (Pterodactyles), and that these two groups of flying vertebrates began on two opposite principles. The birds must have started on the principle of condensation and specialisation of the fore limb exclusively for flight by means of feathers; the other by the extension of one reptilian digit to support a wing-membrane, while reserving the others probably for suspension, as in the case of the thumb of the bats.

The Marvel and Mystery of Feathers

Looking at it as a whole, the bird's wing seems to me to be, of all the mere mechanical organs of any living thing, that which most clearly implies the working out of a preconceived design in a new and apparently most complex and dimcult manner, yet so as to produce a marvellously successful result. The idea worked out was to reduce the jointed bony framework of the wings to a compact minimum of size and maximum of strength in proportion to the muscular power employed; to enlarge the breastbone so as to give room for greatly increased power of pectoral muscles; and to construct that part of the wing used in flight in such a manner as to combine great strength with extreme lightness and the most perfect flexibility. In order to produce this more perfect instrument for flight the plan of a continuous membrane, as in the flying reptiles (whose origin was probably contemporaneous with that of the earliest birds) and flying mammals, to be developed at a much later period, was rejected, and its place was taken by a series 'of broad overlapping oars or vanes, formed by a central rib of extreme strength, elasticity, and lightness, with a web on each side made up of myriads of parts or outgrowth so wonderfully attached and interlocked as to form a self-supporting, highly elastic structure of almost inconceivable delicacy, very easily pierced or ruptured by the impact of solid substances, yet able to sustain almost any amount of air-pressure without injury. And even when any part of this delicate web is injured by separating the adjacent barbs from each other, they are so wonderfully constructed that the pressure and movement of

other feathers over them causes them to unite together as firmly as before; and this is done not by any process of growth, or by any adhesive exudation, but by the mechanical structure of the delicate hooked lamellae of which they are composed.

The two illustrations here given (Figs. 108, 109) show two of the adjacent fibre-like parts (barbs) of which the web of a bird's feather is composed, and which are most clearly shown in the wing-feathers. The slender barbs or ribs of which the web of the feather is made up can be best understood by stripping off a portion of the web and separating two of the barbs from the rest. With a good len9 the structure of the barbs, with their delicate hooked barhules interlocking with the, bentout upper margins of the barbules beneath them, can be seen, as shown in the view and section here given. The barbs (B, B in the figures) are elastic, horny plates set close together on each side of the midrib of the feather, and pointing obliquely outwards; while the barbules are to the barbs what the barbs are to the feather — excessively delicate horny plates, which

also grow obliquely outwards towards the tip of the barb. Laterally they touch each other with smooth, glossy surfaces, which are almost air-tight, yet allow whatever slight motions that may be required during use, while remaining interlocked with the barbules of the adjoining barb in the manner just described. They are the essential elements of the feather, on which its value both for flight and as a protective clothing depends. Even in the smallest wing-feathers they are probably a hundred thousand in number, since in the long wing-feather of a crane the number is stated by Dr. Hans Gadow to be more than a million.

What are termed the "contour-feathers" are those that clothe the whole body and limbs of a bird with a garment of extreme lightness which is almost completely impervious to either cold or heat. These feathers vary greatly in shape on different parts of the body, sometimes forming a dense velvety covering, as on the head and neck of many species, or developed into endless variety of ornament. They fit and overlap each other so perfectly, and entangle so much air between them, that rarely do birds suffer from cold, except when unable to obtain any shelter from violent storms or blizzards. Yet, as every single feather is movable and erectile, the whole body can be freely exposed to the air in times of oppressive heat, or to dry the feathers rapidly after bathing or after unusually heavy rain.

A great deal has been written on the mechanics of a bird's flight, as dependent on the form and curvature of the feathers and of the entire wing, the powerful muscular arrangements, and especially the perfection of the adjustment by which during the rapid down-stroke the combined feathers constitute a perfectly air-tight, exceedingly strong, yet highly elastic instrument for flight; while the moment the upward motion begins the feathers all turn upon their axes so that the air passes between them with hardly any resistance, and when they again begin the down-stroke close up automatically as air-tight as before. Thus the effective down-strokes follow each other so rapidly that, together with the support given by the hinder portion of the wings and tail, the onward motion is kept up, and the strongest flying birds exhibit hardly any undulation in the course they are pursuing. But very little is said about the minute structure of the feathers themselves, which are what renders perfect flight in almost every change of conditions a possibility and an actually achieved result.

But there is a further difference between this instrument of flight and all others in nature. It is not, except during actual growth, a part of the living organism, but a mechanical instrument which the organism has built up, and which then ceases to form an integral portion of it — is, in fact, dead matter. Hence, in no part of the fully grown feather is there any blood circulation or muscular attachment,. except as regards the base, which is firmly held by the muscles and tendons of the rudimentary hand (fore limb) of the bird. This beautiful and delicate structure is therefore subject to wear and tear and to accidental injury, but probably more than anything else by the continuous

attrition during flight of dustladen air, which, by wearing away the more delicate parts of the barbules, renders them less able to fulfil the various purposes of flight, of body-clothing, and of concealment, as well as the preservation of all those colours and markings which are especially characteristic of each species, and generally of each sex separately, and which, having all been developed under the law of utility, are often as important as structural characters. Provision is therefore made for the annual renewal of every feather by the process called moulting. The important wingfeathers, on which the very existence of most birds depends, are discarded successively in pairs at such intervals as to allow the new growth to be well advanced before the next pair are thrown off, so that the bird never loses its power of flight, though this may be somewhat impaired during the process. The rest of the plumage is replaced somewhat more rapidly.

This regrowth every year of so complex and important a part of a bird's structure, always reproducing in every feather the size and shape characteristic of the species, while each of the often very diverse feathers grows in its right place, and reproduces the various tints and colours on certain parts of every feather which go to make up the characteristic colours, markings, or ornamental plumes of each species of bird, presents us with the most remarkable cases of heredity, and of ever-present accurately directed growth-power, to be found in the whole range of organic nature.

The Nature of Growth

The growth of every species of organism into a highly complex form, closely resembling one or other of its parents, is so universal a fact that, with most people, it ceases to excite wonder or curiosity. Yet it is to this day absolutely inexplicable. No doubt an immense deal has been discovered of the mechanism of growth, but of the nature of the forces at work, or of the directive agencies that guide and regulate the forces, we have nothing but the vaguest hints and conjectures. All growth, animal or vegetable, has been long since ascertained to begin with the formation and division of cells. A cell is a minute mass of protoplasm, a substance held to be the physical basis of life. This is, chemically, the most complex substance known, for while it consists mainly of four elements — carbon, hydrogen, nitrogen, and oxygen — it is now ascertained that eight other elements are always present in cells composed of it — sulphur, phosphorus, chlorine, potassium, sodium, magnesium, calcium, and iron. Besides these, six others are occasionally found, but are not essential constituents of protoplasm. These are silicon, fluorine, bromine, iodine, aluminium, and manganese.

Protoplasm is so complex a substance, not only in the number of the elements it contains, but also in the mode of their chemical combination, that it is quite beyond the reach of chemical analysis. It has been divided into three groups of chemical substances — proteids, carbohydrates, and fats. The

i Verworu's General Physiology, p. 100.

first is always present in cells, and consists of five elements — carbon, hydrogen, sulphur, nitrogen, and oxygen. The two other groups of organic bodies, carbohydrates and fats, consist of three elements only — carbon, hydrogen, and oxygen, the carbohydrates forming a large proportion of vegetable products, the fats those of animals. These also are highly complex in their chemical structure, but being products rather than the essential substance of living things, they are more amenable to chemical research, and large numbers of them, including vegetable and animal acids, glycerin, grape sugar, indigo, caffeine, and many others, have been produced in the laboratory, but always by the use of other organic products, not from the simple elements used by nature.

The atomic structure of the proteids is, however, so wonderfully complex as to be almost impossible of determination. As examples of recent results, haemoglobin, the red colouring matter of the blood, was found by Preyer in 1866 to be as follows —

C60oH960■^154■Fel£>30179,

showing a total of 1894 atoms, while Zinoffsky in 1855 found the same substance from horse's blood to be —

C7i2Hll80■^214O24sT1elS2>

showing a total of 2304 atoms. Considering the very small number of atoms in inorganic compounds, and in the simpler vegetable and animal products, caffeine containing only 23 (C7H7(CH3)N402), the complexity of the proteids will be more appreciated.

Professor Max Verworu, from whose great work on General Physiology the preceding account is taken, is very strong in his repudiation of the idea that there is such a thing as a "vital force." He maintains that all the powers of life reside in the cell, and therefore in the protoplasm of which the cell consists. But he recognises a great difference between the dead and the living cell, and admits that our knowledge of the latter is extremely imperfect. He enumerates many differences between them, and declares that " substances exist in living which are not to be found in dead cell-substance." He also recognises the constant internal motions of the living cell, the incessant waste and repair, while still preserving the highly complex cell in its integrity for indefinite periods; its resistance during life to destructive agencies, to which it is exposed the moment life ceases; but still there is no "vital force "— to postulate that would be unscientific.

Yet in this highly elaborate volume of 600 closely printed pages, dealing with every aspect of cell-structure and physiology in all kinds of organisms, he gives no clue whatever to the existence of any directive and organising powers such as are absolutely essential to preserve even the unicellular organism alive, and which become more and more necessary as .we pass to the higher animals and plants, with their vast complexity of organs, reproduced in every successive generation from single cells, which go through their almost infinitely elaborate processes of cell-division and recomposition, till the whole vast complex of the organic machinery — the whole body, limbs, sense, and reproductive organs — are built up in all their perfection of structure and co-ordination of parts, such as characterises every living thing!

Let us now recur to the subject that has led to this digression — the feathers of a bird. We have seen that a full-grown wing-feather may consist of more than a million distinct parts — the barbules, which give the feather its essential character, whether as an organ of flight or a mere covering and heat-preserver of the body. But these barbules are themselves highly specialised bodies with definite forms and surface-texture, attaching each one to its next lateral barbule, and, by a kind of loose hook-and-eye formation, to those of the succeeding barb. Each of these barbules must therefore be built up of many thousands of cells (probably many millions), differing considerably in form and powers of cohesion, in order to produce the exact strength, elasticity, and continuity of the whole web.

Now each feather "grows," as we say, out of the skin, each one from a small group of cells, which must be formed and nourished by the blood, and is reproduced each year to replace that which falls away at moulting time. But the same blood supplies material for every other part of the body — builds up and renews the muscles, the bones, the viscera, the skin, the nerves, the brain. What, then, is the selective or directing power which extracts from the blood at every point where required the exact constituents to form here bone-cells, there muscle-cells, there again feather-

cells, each of which possesses such totally distinct properties? And when these cells, or rather, perhaps, the complex molecules of which each kind of cell is formed, are separated at its special point, what is the constructive power which welds them together, as it were, in one place into solid bone, in another into contractile muscle, in another into the extremely light, strong, elastic material of the feather — the most unique and marvellous product of life? Yet again, what is the nature of the power which determines that every separate feather shall always "grow" into its exact shape? For no two feathers of the twenty or more which form each wing, or those of the tail, or even of the thousands on the whole body, are exactly alike (except as regards the pairs on opposite sides of the body), and many of these are modified in the strangest way for special purposes. Again, what directive agency determines the distribution of the colouring matter (also conveyed by the blood) so that each feather shall take its exact share in the production of the whole pattern and colouring of the bird, which is immensely varied, yet always symmetrical as a whole, and has always a purpose, either of concealment, or recognition, or sexual attraction in its proper time and place?

Now, in none of the volumes on the physiology of animals that I have consulted can I find any attempt whatever to grapple with this fundamental question of the directive power that, in every case, first secretes, or as it were creates, out of the protoplasm of the blood, special molecules adapted for the production of each material — bone, muscle, nerve, skin, hair, feather, etc. etc.,— carries these molecules to the exact part of the body where and when they are required, and brings into play the complex forces that alone can build up with great rapidity so strangely complex a structure as a feather adapted for flight. Of course the difficulties of conceiving how this has been and is being done before our eyes is nearly as great in the case of any other specialised part of the animal body; but the case of the feathers of the bird is unique in many ways, and has the advantage of being wholly external, and of being familiar to every one. It is also easily accessible for examination either in the living bird or in the detached feather, which latter offers wonderful material for microscopic examination and study. To myself, not all that has been written about the properties of protoplasm or the innate forces of the cell, neither the physiological units of Herbert Spencer, the pangenesis hypothesis of Darwin, nor the continuity of the germplasm of Weismann, throw the least glimmer of light on this great problem. Each of them, especially the last, help us to realise to a slight extent the nature and laws of heredity, but leave the great problem of the nature of the forces at work in growth and reproduction as mysterious as ever. Modern physiologists have given us a vast body of information on the structure of the cell, on the extreme complexity of the processes which take place in the fertilised ovum, and on the exact nature of the successive changes up to the stage of maturity. But of the forces at work, and of the power which guides those forces in building up the whole organ, we find no enlightenment. They will not even admit that any such constructive guidance is required!

A Physiological Allegory

For an imaginary parallel to this state of things, let ua suppose some race of intelligent beings who have the power to visit the earth and see what is going on there. But their faculties are of such a nature that, though they have perfect perception of all inanimate matter and of plants, they are absolutely unable either to see, hear, or touch any animal living or dead. Such beings would see everywhere matter in motion, but no apparent cause of the motion. They would see dead trees on the ground, and living trees being eaten away near the base by axes or saws, which would appear to move spontaneously; they would see these trees gradually become logs by the loss of all their limbs and branches, then move about, travel along roads, float down rivers, come to curious machines by which they are split up into various shapes; then move away to where some great structure seems to be growing up, where not only wood, but brick and stone and iron and glass in an infinite variety of shapes, also move about and ultimately seem to fix themselves in certain positions. Special students among these spirit-inquirers would then devote themselves to follow

back each of these separate materials — the wood, the iron, the glass, the stone, the mortar, etc.— to their separate sources; and, after years thus spent, would ultimately arrive at the great generalisation that all came primarily out of the earth. They would make themselves acquainted with all the physical and chemical forces, and would endeavour to explain all they saw by recondite actions of these forces. They would argue that what they saw was due to the forces they had traced in building up and modifying the crust of the earth; and to those who pointed to the result of all this "motion of matter" in the finished product — the church, the mansion, the bridge, the railway, the huge steamship or cotton factory or engineering works — as positive evidence of design, of directive power, of an unseen and unknown mind or minds, they would exclaim, "You are wholly unscientific; we know the physical and chemical forces at work in this curious world, and if we study it long enough we shall find that known forces will explain it all."

If we suppose that all the smaller objects, even if of the same size as ourselves, can only be seen by microscopes, and that with improved instruments the various tools we use, as well as our articles of furniture, our food, and our table-fittings (knives and forks, dishes, glasses, etc., and even our watches, our needles and pins, etc.) become perceptible, as well as the food and drinks which are seen also to move about and disappear; and when all this is observed to recur at certain definite intervals every day, there would be great jubilation over the discovery, and it would be loudly proclaimed that with still better microscopes all would be explained in terms of matter and motion!

That seems to me very like the position of modern physiology in regard to the processes of the growth and development of living things.

Insects and their Metamorphosis

We now have to consider that vast assemblage of small winged organisms constituting the class Insecta, or insects, which may be briefly defined as ringed or jointed (annulose) animals, with complex mouth-organs, six legs, and one or two pairs of wings. They are more numerous in species, and perhaps also in individuals, than all other land-animals put together; and in either their larval or adult condition supply so large and important a part of the food of birds, that the existence of the latter, in the variety and abundance we now behold, may be said to depend upon the former.

The most highly developed and the most abundant of the insect tribes are those which possess a perfect metamorphosis, that is, which in their larval state are the most completely unlike their perfect condition. They comprise the great orders Lepidoptera (butterflies and moths), Coleoptera (beetles), Hymenoptera (bees, ants, etc.), and Diptera (two-winged flies), the first and last being those which are perhaps the most important as bird-food. In all these orders the eggs produce a minute grub, maggot, or caterpillar, as they are variously called, the first having a distinct head but no legs, the second neither head nor legs, while the third have both head and legs, and are also variously coloured, and often possess spines, horns, hair-tufts, or other appendages.

Every one knows that a caterpillar is almost as different from a butterfly or moth in all its external and most of its internal characters, as it is possible for any two animals of the same class to be. The former has six short feet with claws and ten fleshy claspers; the latter, six legs, five-jointed, and with subdivided tarsi; the former has simple eyes, biting jaws, and no sign of wings; the latter, large compound eyes, a spiral suctorial mouth, and usually four large and beautifully coloured wings. Internally the whole muscular system is quite different in the two forms, as well as the digestive organs, while the reproductive parts are fully developed in the latter only. The transformation of the larva into the perfect insect through an intervening quiescent pupa or chrysalis stage, lasting from a few days to several months or even years, is substantially the same process in all the orders of the higher insects, and it is certainly one of the most marvellous in the

whole organic world. The untiring researches of modern observers, aided by the most perfect microscopes and elaborate methods of preparation and observation, have revealed to us the successive stages of the entire metamorphosis, which has thus become more intelligible as to the method or succession of stages by which the transformation has been effected, though leaving the fundamental causes of the entire process as mysterious as before. Years of continuous research have been devoted to the subject, and volumes have been written upon it. One of the most recent English writers is Mr. B. Thompson Lowne, F.R.C.S., who has devoted about a quarter of a century to the study of one insect — the common blow-fly — on the anatomy, physiology, and development of which he has published an elaborate work in two volumes dealing with every part of the subject. He considers the two-winged flies to be the highest development of the insect-type; and though they have not been so popular among entomologists as the Coleoptera and Lepidoptera, he believes them to be the most numerous in species of all the orders of insects. I will now endeavour to state in the fewest words possible the general results of his studies, as well as those of the students of the other orders mentioned, which are all in substantial agreement.

In those insects which have the least complete metamorphosis — the cockroaches — the young emerge from the egg with the same general form as the adult, but with rudimentary wings, the perfect wings being acquired after a succession of moults. These seem to be the oldest of all insects, fossilised remains of a similar type being found in the Silurian formation. Locusts and Hemiptera are a little more advanced, and are less ancient geologically. Between these and the four orders with complete metamorphosis there is a great gap, which is not yet bridged over by fossil forms. But from a minute study of the development of the egg, which has been examined almost hour by hour from the time of its fertilisation, the conclusion has been reached, that the great difference we now see between the larva and imago (or perfect insect) has been brought about by a double process, simultaneously going on, of progression and retrogression. Starting from a form somewhat resembling the cockroach, but even lower in the scale of organisation, the earlier stages of life have become more simplified, and more adapted (in the case of Lepidoptera) for converting living tissues of plants into animal protoplasm, thus laying up a store of matter and energy for the development of the perfect insect; while the latter form has become so fully developed as to be almost independent of food-supply, by being ready to carry out the functions of reproduction within a few days or even hours of its emergence from the pupa case.

At first this retrogression of the first stage of growth towards a simple feeding machine took place at the period of the successive moults, but it being more advantageous to have the larva stage wholly in the form best adapted for the storing lip of living protoplasm, the retrogressive variations became step by step earlier, and at length occurred within the egg. At this early period certain rudiments of wings and other organs are represented by small groups of minute cells termed by Weismann imaginal discs, which were determined by him to be the rudiments of the perfect insect. These persist unchanged through the whole of the active larval stage; but as soon as the final rest occurs preliminary to the last moult, a most wonderful process commences. The whole of the internal organs of the larva — muscles, intestines, nerves, respiratory tubes, etc.— are gradually dissolved into a creamy pulp; and it has further been discovered that this is effected through the agency of white blood-corpuscles or phagocytes, which enter into the tissues, absorb them, and transform them into the creamy pulp referred to. This mass of nutritive pulp thenceforth serves to nourish the rapidly growing mature insect, with all its wonderful complication of organs adapted to an entirely new mode of life.

There is, I believe, nothing like this complete decomposition of one kind of animal structure and the regrowth out of this broken-down material — which has thus undergone decomposition of the cells, but not apparently of the protoplasmic molecules — to be found elsewhere in the whole course of organic evolution; and it introduced new and tremendous difficulties into any mechanical or chemical theory of growth and of hereditary transmission. We are forced to suppose that the

initial stages of every part of the perfect insects in all their wonderful complexity and diversity of structure are formed in the egg, and that during the subsequent rapidly growing development of the larva they remain dormant; then, that the whole structure of the fully grown larva is resolved into its constituent molecules of living protoplasm, still without the slightest disturbance of the rudimentary germs of the perfect insect, which at a special moment begin a rapid course of developmental growth. This growth has been followed, step by step through all its complicated details, by Mr. Lowne and many other enthusiastic workers; but I will call attention here only to the special case of the Lepidoptera, because these are far more popularly known, and the special feature which distinguishes them from most other insects is familiar to every one, and can be examined by means of a good pocket lens or microscope of moderate power. I allude, of course, to the wonderful scales which clothe the wings of most butterflies and moths, and which produce the brilliant colours and infinitely varied patterns with which they are adorned. Of course, the still more extensive order of the Coleoptera (beetles) present a similar phenomenon in the colours and markings of their wing-cases or elytra, and what i3 said of the one order will apply broadly to the other.

The wings of butterflies can be detected in very young caterpillars when they are only one-sixth of an inch long, as small out-foldings of the inner skin, which remain unchanged while the larva is growing; but at the chrysalis (or pupa) stage the wings expand to about sixty times their former area, and the two layers of cells composing them then become visible. At this time they are as transparent as glass; but two or three weeks before emergence of the imago they become opaque white, and a little later dull yellow or drab; twenty-four hours later the true colours begin to appear at the centre of each wing. It is during the transparent stage that the scales begin to be formed as minute, bag-like sacks filled with protoplasm; the succeeding whiteness is caused by the protoplasm being withdrawn and the sacks becoming filled with air. The pupal blood then enters them, and from this the colouring matter is secreted. The scales are formed in parallel lines along ridges of the corrugated wing membrane. The more brilliant colours seem to be produced from the dull yellow pigment by chemical changes which occur within the scales. A few days before emergence the scales become fully grown, as highly complex structures formed of parallel rows of minute cells, each scale with a basal stem which enters a pocket of the skin or membrane, which pockets send out roots which seem to penetrate through the skin.1 Another complication is the fact that the wonderful metallic colours of so many butterflies are not caused by pigments, but are "interference colours" produced by fine striae on the surface of the scales. Of course, where eye-spots, fine lines, or delicate shadings adorn the wings, each scale must have its own special colour, something like each small block in a mosaic picture.

As this almost overwhelming series of changing events passes before the imagination, we see, as it were, the gradual but perfectly orderly construction of a living machine, which at first appears to exist for the sole purpose of devouring leaves and building up its own wonderful and often beautiful body, thereby changing a lower into a higher form of protoplasm. Its limbs, its motions, its senses, its internal structure, are all adapted to this one end. When fully grown it ceases to feed, prepares itself for the great change by various modes of concealment— in a cocoon, in the earth, by suspension against objects of similar colours, or which it becomes coloured to imitate — rests awhile, casts its final skin, and becomes a pupa. Then follows the great transformation scene, as in the blow-fly. All the internal organs which have so far enabled it to live and grow — in fact, the whole body it has built up, with the exception of a few microscopic groups of cells — become rapidly decomposed into its physiological elements, a structureless, creamy but still living protoplasm; and when this is completed, usually in a few days, there begins at once the building up of a new, a perfectly different, and a much more highly organised creature both externally and internally — a creature comparable in organisation with the bird itself, for which, as we have seen, it appears to exist. And, in the case of the Lepidoptera, the wings, far simpler in construction than those of the bird, but apparently quite as well adapted to its needs, develop a more or less

complete covering of minute scales, whose chief or only function appears to he to paint them with all the colours and all the glittering reflections of the animal, the vegetable, and the mineral kingdoms, to an equal if not a greater extent than in the case of the birds themselves. The butterflies, or diurnal Lepidoptera alone, not only present us with a range of colour and pattern and of metallic brilliancy fully equal (probably superior), to that of birds, but they possess also in a few cases and in distinct families, changeable opalescent hues, in which a pure crimson, or blue, or yellow pigment, as the incidence of light varies, changes into an intense luminous opalescence, sometimes resembling a brilliant phosphorescence more than any metallic or mineral lustre, as described in the next chapter.

And what renders the wealth of coloration thus produced the more remarkable is, that, unlike the feathers of birds, the special organs upon which these colours and patterns are displayed are not functionally essential to the insect's existence. They have all the appearance of an added superstructure to the wing, because in this way a greater and more brilliant display of colour could be produced than even upon the exquisite plumage of birds. It is true that in some cases, these scales have been modified into scent-glands in the males of some butterflies, and perhaps in the females of some moths, but otherwise they are the vehicles of colour alone; and though the diversity of tint and pattern is undoubtedly useful in a variety of ways to the insects themselves, yet it is so almost wholly in relation to higher animals and not to their own kind, as I have already explained in Chapter IX. It is generally admitted that insects with compound eyes possess imperfect vision, and their actions seem to show that they take little notice of distant objects, except of lights at night, and only perceive distinctly what is a few inches or a few feet from them; while there is no proof that they recognise what we term colour unless as a greater or less amount of light.

But as regards the effect of the shading and coloration of insects upon the higher animals, who are almost always their enemies, there is ample evidence. Almost all students of the subject admit that the markings and tints of insects often resemble their environment in a remarkable manner, and that this resemblance is protective. The eye-like markings, either on the upper or under surfaces, are often seen to be imitations of the eyes of vertebrates, when the insect is at rest, and this also is protective. The brilliant metallic or phosphorescent colours on the wings of butterflies may serve to distract enemies from attacking a vital part, or, in the smaller species may alarm the enemy by its sudden flash with change of position. But while the colours are undoubtedly useful, the mode of producing them seems unnecessarily elaborate, and adds a fresh complication in the way of any mechanical or chemical conception of their production.

Chapter XV - GENERAL ADAPTATIONS OF PLANTS, ANIMALS, AND MAN

The adaptations of plants and animals, more especially as regards the cross-fertilisation of flowers by insects, forms a very important part of Darwin's work, and has been fully and popularly elaborated since by Grant Allen, Sir John Lubbock (now Lord Avebury), Hermann Miiller, and many other writers. I have also myself given a general account of the whole subject both in my Tropical Nature, and my Darwinism; but as there are some points of importance which, I believe, have not yet been discussed, and as the readers of this volume may not be acquainted with the vast extent of the evidence, I will here give a short outline of the facts before showing how it bears upon the main argument of the present work.

Another reason why it is necessary to recapitulate the evidence is that those whose knowledge of this subject is derived from having read the Origin of Species only, can have no idea whatever of the vast mass of observations the author of that work had even then collected on the subject, but found it impossible to include in it. He there only made a few general, and often hypothetical, references both to the facts of insect-fertilisation, and to the purpose of cross-fertilisation. On the latter point he makes this general statement: "I have come to this conclusion (that flowers are

coloured to attract insects) from finding it an invariable rule that when a flower is fertilised by the wind it never has a gaily-coloured corolla." Then a few lines farther on he adverts to beautifully coloured fruits and says: "But the beauty serves merely as a guide to birds and beasts, in order that the fruit may be devoured and the matured seed disseminated; I infer that this is the case from having as yet found no exception to the rule that seeds are always thus disseminated when embedded within a fruit of any kind if it be coloured of any brilliant tint."

Such general statements as those here quoted do not make much impression. The astonishment and delight of botanists and plant-lovers can, therefore, be imagined when, a few years later, by his book on the Fertilisation of Orchids by Insects, and his papers on the Different Forms of Flowers in the primrose, flax, lythrum, and some others; he opened up a vast new world of wonder and instruction which had hitherto remained almost unnoticed. These were followed up by his volumes on The Effects of Cross- and Self-Fertilisation (in 1876), and by that on Different Forms of Flowers on Plants of the same Species (in 1877) giving the result of hundreds of careful experiments made by himself during many years, serving as the justification for the few general observations as regards flowers and insects, which form the only reference to the subject in the Origin of Species.

The facts now admitted to be established by these various researches are: (1) that crosses between different individuals of the same species, either constantly or occasionally, are beneficial to the species by increasing seed-production and vigour of growth; (2) that there are innumerable adaptations in flowers to secure or facilitate this cross-fertilisation; (3) that all irregular flowers — Papilionaceae, Labiates, Schrophulariaceae, Orchideae, and others — have become thus shaped to facilitate cross-fertilisation. Darwin's general conclusion, that "nature abhors perpetual self-fertilisation," has been much criticised, but chiefly by writers who have overlooked the term "perpetual." He has also shown how the wonderful variety in form and structure, and the beauty or conspicuousness of the colours of flowers, can all be readily explained, on this theory, through the agency of variation and natural selection, while by no other theory is any real and effective explanation possible. But besides these there are very numerous other i Origin of Species, 6th edition, p. 101.

adaptations in flowers to secure them from injurious insects or from the effects of rain or wind in damaging the pollen or the stigmas, as beautifully shown in Kerner's very interesting volume on Flowers and their Unbidden Guests — a book that forms an admirable sequel to Darwin's works, and is equally instructive and interesting.

Of late years writers who are very imperfectly acquainted with the facts proclaim loudly that Darwin's views are disproved, on account of some apparent exceptions to the general conclusions he has reached. Two of these may be here noticed as illustrative of the kind of opposition to which Darwinism is exposed. The bee-orchis of our chalky downs, though conspicuously coloured and with a fully-developed labellum, like the majority of its allies which are cross-fertilised by insects, yet fertilises itself and is never visited by insects. This has been held to show that Darwin's views must be erroneous, notwithstanding the enormous mass of evidence on which they are founded. But a further consideration of the facts shows that they are all in his favour. In the south of Europe, while the bee-orchis is self-fertilised as in England, several allied species are insect-fertilised, but they rarely produce so many seed-capsules as ours; but, strange to say, an allied species (Ophrys scolopax) is in one district fertilised by insects only, while in another it is self-fertilised. Again, in Portugal, where many species of Ophrys are found, very few of the flowers are fertilised and very few ripe seed-capsules are produced. But owing to the great number of seeds in a capsule, and their easy dispersal by wind, the plants are abundant. These and many other facts show that for some unknown cause, orchises which are exclusively insect-fertilised, are liable to remain unfertilised, and when that is the case it becomes advantageous to the species to be able to fertilise itself, and this has occurred, partially in many species, and completely in our bee-orchis.

I may remark here that the name "bee-orchis" is misleading, as the flower does not resemble any of our bees. But the very closely allied "spider orchises" resemble spiders much more closely. It occurs to me, therefore, that the general resemblance to bee or spider may occasionally prevent the flowers being eaten off by sheep or lambs, to whom even spiders on their noses or lips would be disagreeable.

Mr. Henry O. Forbes observed, in Sumatra, that many tropical orchids with showy flowers, which were perfectly adapted for insect-fertilisation, yet produced very few seed-capsules, and in many cases nona Yet the great abundance of seeds, as fine as dust, in a single capsule, together with the long life of most orchids, is quite sufficient, in most cases, to preserve the various species in considerable abundance. When, however, there is any danger of extinction the great variability of orchids, which at first enabled them to become so highly specialised for insect-fertilisation, also enables them (in some cases) to return to self-fertilisation as in our bee-orchis. Should this continuous self-fertilisation at length lead to a weak constitution, then, occasional variations serving to attract insects by nectar or in other ways, with minute alterations of structure may again lead to fertilisation by insects.

The other popular objection recently made to Darwin's views on the origin of the flowers is, that the colours and shapes of flowers are often such as to deter herbivorous animals from eatmg them, and that this is the main or the only reason why flowers are so conspicuous. The special case supposed to prove this is that some buttercups are not eaten by cattle because they are acrid or poisonous, and that the bright yellow colour is a warning of inedibility.

Even if these statements were wholly correct they would not in the least affect the general proposition that all conspicuous flowers attract insects which do actually cross-fertilise them. But, in the first place, there is much difference of opinion as to the inedibility of buttercups by cattle; and, in the second, our three most common yellow buttercups (Ranunculus acris, R. repens, and R. bulbosus) are so constructed that they can be cross-fertilised by a great variety of insects, and as a matter of fact are so fertilised. H. Miiller grouped these three species together, as the same insects visit them all, and he found that they were attractive to no less than sixty different species, including 23 flies, 11 beetles, 24 bees, -wasps, etc., and 5 butterflies.

Any readers who are not satisfied with Darwin's own statements on this subject should examine Miiller's Fertilisation of Flowers (translated by D'Arcy W. Thompson), in which details are given of the fertilisation of about 400 species of alpine plants by insects, while a General Retrospect gives a most valuable summary of the conclusions and teachings on the whole subject. As regards the general question of the uses and purposes of colour in nature the late Grant Allen's interesting and philosophical work on The Colour Sense should be studied. Any one who does so will be satisfied of the general truth of Darwin's doctrines though there are a few errors in the details. As an example of the fascinating style of the book I will quote the following paragraph comparing insectagency with that of man in modifying and beautifying the face of nature. After describing the great alterations man has made, and the large areas he has modified for his own purposes, the author thus proceeds:

But all these alterations are mere surface scratches compared with the immense revolution wrought in the features of nature by the unobtrusive insect. Half the flora of the earth has taken the imprint of his likes and his necessities. While man has only tilled a few level plains, a few great river-valleys, a few peninsular mountain slopes, leaving the vast mass of earth untouched by his hand, the insect has spread himself over every land in a thousand shapes, and has made the whole flowering creation subservient to his daily wants. His buttercup, his 'dandelion, and his meadow-sweet grow thick in every English field. His thyme clothes the hill-side; his heather purples the

bleak grey moorland. High up among the Alpine heights his gentian spreads itself in lakes of blue; amid the snows of the Himalayas his rhododendrons gleam with crimson light. The insect has thus turned the whole surface of the earth into a boundless flower-garden, which supplies him from year to year with pollen or honey, and itself in turn gains perpetuation by the baits it offers for his allurement,

Although I wholly agree with my lamented friend in attributing the origin and development of flowers to the visits of insects, and the consequent advantage of rendering many species of flowers conspicuous and unlike others flowering at the same time, thus avoiding the waste and injury of the frequent crossing of distinct species, yet I do not consider that the whole of the phenomena of colour in nature is thereby explained.

In my book on Tropical Nature I devoted two chapters to the Colours of Animals and Plants, and I opened the discussion with the following remarks, which indicate my present views on the subject. I will, therefore, give a few passages here:

There is probably no one quality of natural objects from which we derive so much pure intellectual enjoyment as from their colours. The heavenly blue of the firmament, the glowing tints of sunset, the exquisite purity of the snowy mountains, and the endless shades of green presented by the verdure-clad surface of the earth, are a never-failing source of pleasure to all who enjoy the inestimable gift of sight. Yet these constitute, as it were, but the frame and background of a marvellous and ever-changing picture. In contrast with these broad and soothing tints, we have presented to us, in the vegetable and animal worlds, an infinite variety of objects adorned with the most beautiful and the most varied hues. Flowers, insects, and birds are the organisms most generally ornamented in this way; and their symmetry of form, their variety of structure, and the lavish abundance with which they clothe and enliven the earth, cause them to be objects of universal admiration. The relation of this wealth of colour to our mental and moral nature is indisputable. The child and the savage alike admire the gay tints of flower, bird, and insect; while to many of us their contemplation brings a solace and enjoyment which is wholly beneficial. It can then hardly excite surprise that this relation was long thought to afford a sufficient explanation of the phenomena of colour in nature, and this received great support from the difficulty of conceiving any other use or meaning in the colours with which so many natural objects are adorned. Why should the homely gorse be clothed in golden raiment, and the prickly cactus be adorned with crimson bells? Why should our fields be gay with buttercups, and the heather-clad mountains be clad in purple robes? Why should every land produce its own peculiar floral gems, and the alpine rocks glow with beauty, if not for the contemplation and enjoyment of man? What could be the use to the butterfly of its gaily-painted wings, or to the humming-bird of its jewelled breast, except to add the final touches to a world-picture calculated at once to please and to refine mankind? And even now, with all our recently acquired knowledge of this subject, who shall say that these old-world 'views were not intrinsically and fundamentally sound; and that although we now know that colour has 'uses' in nature that we little dreamt of, yet the relations of those colours — or rather of the various rays of light — to our senses and emotions may not be another, and more important use which they subserve in the great system of the universe?

The above passage was written more than forty years ago, and I now feel more deeply than ever that the concluding paragraph expresses a great and fundamental truth. Although in the paragraph succeeding that which I have quoted from Grant Allen's book, he refers to my view (stated above) as being "a strangely gratuitous hypothesis," I now propose to give a few additional reasons for thinking it to be substantially correct.

The first thing to be noticed is, that the insects whose perceptions have led to the production of variously coloured flowers are so very widely removed from all the higher animals (birds and

mammals) in their entire organisation that we have no right to assume in them an identity, or even a similarity, of sensation with ourselves. That they see is certain, but that their sensation of sight is the same as our own, or even at all closely resembling it, is highly improbable. Still more improbable is it that their perception of colour is the same as ours, their organ of sight and their whole nervous system being so very different, and the exact nature of their senses being unknown. Even a considerable percentage of men and women are more or leas colour-blind, yet some diversity of colour is perceived in most cases. The purpose of colour in relation to insects is that they should distinguish between the colours of flowers which are otherwise alike and which have no perfume. It is not at all necessary that the colours we term blue, purple, red, yellow, etc., should be seen as we see them, or even that the sight of them should give them pleasure.

Again, the use of colour to us is by no means of the same nature as it is to insects. It gives us, no doubt, a greater facility of differentiating certain objects, but that could have been obtained in many other ways — by texture of surface, i by light and shade, by diversity of form, etc., and in some cases by greater acuteness of smell; and there are very few uses of colour to us which seem to be of "survival value "— that is, in which a greater or less acuteness of the perception would make any vital difference to us or would lengthen our lives. But if so, the exquisite perception of colour we normally possess could not have been developed in our ancestor? through natural selection; while what we call the "aesthetic sense," the sense of beauty, of harmony, of indescribable charm, which nature's forms and colouring so often gives us is still further removed from material uses. Another consideration is, that our ancestors, the Mammalia, derived whatever coloursense they possess almost wholly from the attractive colours of ripe fruits, hardly at all from the far more brilliant and varied colours of flowers, insects, and birds. But the colours of wild fruits, which have been almost entirely developed for the purpose of attracting birds to devour them and thus to disperse their seeds, are usually neither very brilliant nor very varied, and are by no means constant indications to us of what is edible. It might have been anticipated, therefore, that our perception of colour would have been inferior to that of birds and mammals generally, not, as is almost certainly the case, very much superior, and so bound up with some of our higher intellectual achievements, that the total absence of perception of colour would have checked, or perhapa wholly prevented, all those recent discoveries in spectroscopy which now form so powerful a means of acquiring an extended knowledge of the almost illimitable universe.

I venture to think, therefore, that we have good jeason to believe that our colour-perceptions have not been developed in us solely by their survival-value in the struggle for existence; which is all we could have acquired if the views of such thinkers as Grant Allen and Professor Haeckel represent the whole truth on this subject. They seem, on the other hand, to have been given us with our higher aesthetic and moral attributes, as a part of the needful equipment of a being whose spiritual nature is being developed, not merely to satisfy material needs, but to fit him for a higher and more enduring life of continued progress.

Colours of Fruits: a Suggestion as to Nuts

As flowers have been developed through insects, so have edible fruits been developed and coloured so that birds may assist in the dispersal of their seeds; while inedible fruits have acquired endlessly varied hooks or sticky exudations in order that they may attach themselves to the fur of quadrupeds or the feathers of birds, and thus obtain extensive dissemination. All this was clearly seen and briefly stated by Darwin, and has been somewhat fully developed by myself in the work already quoted: but there is one point on which I wish to make an additional suggestion.

In my Tropical Nature I referred to Grant Allen's view (in his Physiological ^Esthetics) that nuts were "not intended to be eaten"; and in my Darwinism (p. 305) I adopted this as being almost self-evident, because, though very largely edible, they are always protectively coloured, being green

when unripe and brown when they fall upon the ground among the decaying foliage. Moreover, their outer-coverings are often prickly, as in the sweet-chestnut, or bitter as in the walnut, while their seed-boxes are often very hard, as in the hazel-nut, or intensely eo, as in the Brazil-nut and many other tropical species.

But, on further consideration, I believe that this apparently obvious conclusion is not correct; and that nuts are, as a rule, intended to be eaten. I am not aware that this question has yet been discussed by botanists, and as it is one of much interest and exhibits one of the curious and indirect ways in which nature works for the preservation of species, both in the vegetable and animal world, I will briefly explain my views.

The first point for our consideration is, that most nuts are edible to some animals, and a large number are favourite foods even to ourselves. Then they are all produced on large trees or shrubs of considerable longevity, and the fruits (nuts, acorns, etc.) are produced in enormous quantities. If now we consider that in all countries which are undisturbed by man, the balance between forest and open country, and between one species and another, only changes very slowly as the country becomes modified by geographical or cosmical causes, we recognise that, as in the case of animals, the number of individuals of each species is approximately constant, and there is, broadly speaking, no room for another plant of any particular kind till a parent plant dies or is destroyed by fire or tempest. Imagine then the superfluity of production of seed in an oak, a beech, or a chestnut forest; or in the nutgroves that form their undergrowth in favourable situations. Countless millions of seeds are produced annually, and it is only at long intervals of time, when any of the various causes above referred to have left a space unoccupied, that a few seeds germinate, and the best fitted survives to grow into a tree which may replace its predecessor.

But when every year ten thousand millions of seeds fall and cannot produce a tree that comes to maturity, any cause which favoured their wider dispersal would be advantageous, even though accompanied by very great destruction of seeds, and such a cause is found when they serve as food to herbivorous mammals. For most of these go in herds, such as swine, peccaries, deer, cattle, horses, etc., and when such animals are startled while feeding and scamper away, two results, useful to the species whose fruit they are feeding upon, follow. As the acorns, chestnuts, etc., usually lie thickly on the ground, some will be driven or kicked along with the herd; and this being repeated many times during a season and year after year, a number of seeds are scattered beyond the limits of the parent trees. By this process seeds will often reach places they would not attain by ordinary means, and may thus be effective in extending the range of the species. It would also often happen that seeds would be trodden into soft or wet ground and thus be actually planted by the devouring animals; and being in this case placed out of sight till the herds had left the district would have a better chance of coming to maturity.

Now one such success in a year would more than compensate to the species for millions of seeds devoured, and it would therefore be beneficial to a species to produce nuts or seeds of large size and in great quantities in order to attract numbers of mammals to feed on them. This is quite in accordance with nature's methods in other cases, as Darwin has shown in the case of pollen. The very curious fact of the Brazil-nut having such a very hard shell to the triangular seeds and a still harder covering to the globular fruit, which falls from the very lofty trees without opening, and has to be broken open with an axe by the seed-collectors, is another example. This is said not to open naturally to let the seed escape for a year or more; and this fact, with its almost perfect globular form, would facilitate its being scattered to a considerable distance by the feet of tapirs, deer, or peccaries, and when at last the seeds fell out, perhaps aided by the teeth or feet of these animals, some of them would almost certainly be trodden into the ground, and this would be facilitated by their sub-angular shape. If this is the mode of dispersal it has proved very successful, for the species is widely scattered in moderate-sized groves over a considerable portion of the Amazonian

forests. The main facts and probabilities clearly point to the conclusion that the extensive group of nut-like fruits or seeds are intended to be eaten, not by birds while on the trees, but by ground-feeding animals — to be devoured wholesale, in order to disperse and save a few which may germinate and produce another generation of trees.

The Colours of Plants and Animals in relation to Man

The views of Haeckel and of the whole school of Moniste, as well as of most of the followers of Spencer and Darwin, are strongly antagonistic to the idea that in the various groups of phenomena we have so far touched upon there has been in any real sense a preparation of the earth for man; and those who advocate such a theory are usually treated with scorn as being unscientific, or with contempt as being priest-ridden. Darwin himself was quite distressed at my rejection of his own conclusion — that even man's highest qualities and powers had been developed out of those of the lower animals by natural or sexual selection. Several critics accused me of "appealing to first causes" in order to get over difficulties; of maintaining that "our brains are made by God and our lungs by natural selection "; and that, in point of fact, "man is God's domestic animal." This was when I published my Contributions to the Theory of Natural Selection, in 1870, its last chapter on The Limits of Natural Selection as applied to Man, being the special object of animadversion, because I pointed out that some of man's physical characters and many of his mental and moral faculties could not have been produced and developed to their actual perfection by the law of natural selection alone, because they are not of survival value in the struggle for existence.

In the present work I recur to the subject after forty years of further reflection, and I now uphold the doctrine that not man alone, but the whole World of Life, in almost all its varied manifestations, leads us to the same conclusion — that to afford any rational explanation of its phenomena, we require to poetulate the continuous action and guidance of higher intelligences; and further, that these have probably been working towards a single end, the development of intellectual, moral, and spiritual beings. I will now indicate briefly how the facts adduced in the present and preceding chapters tend to support this view.

Having shown in the last chapter that the phenomena of growth in the animal world, and especially as manifested in the feathers of birds and the transformations of the higher insects, are absolutely unintelligible and unthinkable in the absence of such intelligence, we must go a step further and assume, as in the highest degree probable, a purpose which this ever-present, directing, and organising intelligence has had always in view. We cannot help seeing that we ourselves are the highest outcome of the developmental process on the earth; that at the time of our first appearance, plants and animals in many diverging lines had approached their highest development; that all or almost all of these have furnished species which seem peculiarly adapted to our purposes, whether as food, as providing materials for our clothing and our varied arts, as, our humble servants and friends, or as gratifying our highest faculties by their beauty of form and colour; and as our occupation of the earth has already led to the extinction of many species, and seems likely ultimately to destroy many more except so far as we make special efforts to preserve them, we must, I think, assume that all these consequences of our development were foreseen, and that results which seem to be so carefully adapted to our wants during our growing civilisation were really prepared for us. If this be so, it follows that the much-despised anthropomorphic view of the whole development of the earth and of organic nature was, after all, the true one.

But if the view now advocated is not so wholly unscientific, so utterly contemptible as it has hitherto been declared to be by many of our great authorities, it is certainly advisable to show how various facts in nature bear upon it and are explained by it. I will therefore now add a few more considerations to those I have hitherto set forth.

On the question of the colour-sense I have already argued that though it may exist in birds and insects, it is hardly likely that it produces any such high aesthetic pleasure as it does in our own case. All that the evidence shows is, that they do perceive what are to us broad differences of colour, but we have no means whatever of knowing what they really perceive. It is a suggestive fact that colour-blind persons, though they do not see red and green as strongly contrasted as do those with normal vision, yet do perceive a difference between them. It is therefore quite possible that birds may see differences between one strongly marked colour and another without any sense of what we should term colour, and at all events without seeing " colours" exactly as we see them. It is now generally admitted that birds arose out of primitive reptiles, and from their very origin have been quite distinct from mammals, which latter probably diverged a little later from a different stock and in a somewhat different direction. The eyes of both were developed from the already existing reptilian eye, and their type of binocular vision may be very similar. But at that early period there were, it is believed, no coloured flowers or edible coloured fruits, and it is probable that the perception of colour arose at a much later period. It is therefore unlikely that a faculty separately developed in two such fundamentally different groups of organisms should be identical in degree or even in nature unless its use and purpose were identical. But birds are much more extensive fruit-eaters than are mammals, the latter, as we have seen, being feeders on nuts which are protectively tinted rather than on fruits, while their largely developed sense of smell would render very accurate perception of colour needless. It is suggestive that the orang-utan of Borneo feeds on the large, green spiny Durian fruit; and I have also seen them feeding on a green fruit which was repulsively bitter to myself. Our nearest relatives among existing quadrupeds do not therefore seem to have any need of

a refined colour-sense. Why then should it have heen so highly developed in us? It was one of the fundamental maxims of Darwin that natural selection could not produce absolute, but only relative perfection; and again, that no species could acquire any faculty beyond its needs.

The same arguments will apply even more strongly in the case of insects. They appear to recognise the colours, the forms, and the scents of flowers, but we can only vaguely guess at the nature and quality of their actual sensations. Their whole line of descent is so very far removed from that of the birds that it is in the highest degree improbable that there is any identity even in their lower mental faculties with those of birds. For the colour-sense is mental, not physical; it depends partly on the organ of vision, but more fundamentally on the nature of the nervous tissues which transform the effects of light-vibrations into the visual impressions which we recognise as colour, and ultimately on some purely mental faculty. But the colour-sense in insects may be quite other than the bird's or than our own, and may in most cases be combined with scent, and often with form to produce the recognition of certain objects, which is all they require.

Yet insects, birds, and the flowers and fruits which attract them, all exhibit to our vision nearly the same range of the colour-scheme, and a very similar intensity, brilliancy, and purity of colour in particular cases; which is highly remarkable if their respective needs were the only efficient causes in the production of these colours. Looking first at flowers, how very common and conspicuous are those of a yellow colour, yet far beyond the" average are the rich orange petals of the Escholtzia and the glistening splendour of some of our buttercups; red and purples are innumerable, yet in the Lobelia fulgens and some other flowers we reach an intensity of hue which seem to us unsurpassably beautiful; blues of the type of the campanulas or the various blue liliaceae are all in their way charming, but in the blue salvia (Salvia patens) the spring gentian (Gentiana verna), and a few others, we perceive a depth and a purity of hue which seem to have reached the limits of the possible. We may surely ask ourselves whether these exquisite refinements of mere colour as well as the infinity of graceful forms, and the indescribable delicacies of texture and of grouping, are all strictly utilitarian in regard to insect-visitors and to ourselves. To them the one thing needful seems

to be a sufficient amount of difference of any kind to enable them to distinguish among species which grow in the same locality and flower at the same time.

Special Cases of Bird-colouration

Coming now to birds, we find the colours with which they are decorated to be fully equal in variety and purity of tint to those of flowers, but extending still further in modifications of texture, and in occasionally rivalling minerals or gems in the brilliancy of their metallic lustre. The exquisite blues and vinous purples, reds and yellows of the chatterers and manakins, the glorious metallic sheen of the trogons, of many of the humming-birds, and of the long-tailed paradise-bird; the glistening cinnabar-red of the king-bird of paradise, appearing as if formed of spun-glass; the silky orange of the cock-of-the-rock and the exquisite green of the Malayan crested gaper, are only a few out of thousands of the extreme refinements of colour with which birds are adorned.

Add to these the marvellous ornaments with which the males are so frequently decorated, the crests varying from the feathery dome of the umbrella bird, to the large richly coloured crest of the royal flycatcher of Brazil, and the marvellous blue plumes from the head of the fern-bearing bird of paradise (Pteridophora Alberti), with a thousand others hardly inferior, and we shall more than ever feel the want of some general and fundamental cause of so much beauty.

All this wealth of colour, delicacy of texture and exuberance of ornament, has been explained hitherto as being utilitarian in two ways only: (1) that they are recognition-marks fuse to each species, more especially during its differentiation as a species; and (2) as influencing female choice of the most ornamental males, and therefore of use to each species in the struggle for existence. The former I have, I think, proved to be a true cause; the latter I reject for reasons given in my Darwinism. I there give an alternative solution of the problem which I still think to be fundamentally correct and which has been arrived at by Weismann and others from theoretical considerations to which I may advert later on.

Colouration of Insects

Passing now to the order of insects which perhaps exhibits the greatest range of colour-display in the whole of the organic world — especially in the order Lepidoptera, we find the difficulties in the way of a purely utilitarian solution still greater. Any one who is acquainted with this order of insects in its fullest development in the equatorial zone of the great continents, will recognise how impossible it is to give any adequate conception of its wealth of colour-decoration by a mere verbal description. Yet the attempt must be made in order to complete the argument I am founding upon a consideration of the whole of the facts of organic colouration.

Even in the temperate zones we have a rich display of colour and marking in our exquisite little blues, our silver-spotted fritillaries, our red-admiral, our peacock, and our orange-tip butterflies, and on the Continent, the two swallow-tails, the apollo butterflies, the fine Chaaxes Jason, and many others. But these are absolutely as nothing compared to the wealth of colour displayed in the eastern and western tropics, where the average size is from two to three times ours, and the numbers, both in species and individuals at least ten times as great. Not only is there every tint of red, yellow, blue and green, on ground-colours «f black or white and various shades of brown or buff, but we find the most vivid metallic blues or silky yellows covering a large portion of the wing-surface or displayed in a variety of patterns that is almost bewildering in its variety and beauty.

As a few examples, the Callithea sapphira of the Amazon is of a soft, celestial blue that the finest lobelia or gentian cannot surpass. The grand Oenithoptera Amphrisius, and its allies has the hind wings of an intense yellow with a silky lustre, while 0. Priamus and many allied species are richly

adored with metallic green, deep orange, or violet-blue. Papilio Ulysses of Amboyna equals in size and colour the splendid blue morphos of South America; while these latter not only present us with every shade of blue on insects of the largest size, but in Morpho cypris, and several allied species exhibit an intensity of colour and of metallic sheen that is equal to the highest efforts of nature in this direction on the caps or the gorgets of humming-birds, on the glittering shields of the Epimachidae of New Guinea, or on such precious gems as the emerald, the sapphire, the ruby, or the opal.

The exquisite combinations of brilliant colour and endless variety of pattern to be found among the small Lycaeniche and Erycinidae of both hemispheres must be passed over; as well as the somewhat larger Catagrammas whose diversified upper and under sides are a constant delight; while the vast groups of the Heliconidae and Danaidae, inedible to most birds and lizards, are often rendered conspicuous by bold contrasts of the purest white, yellow, or red, on a blue-black ground.

Some Extremes of Insect-Coloration

There are some examples of tropical butterflies in which nature may be said to have surpassed herself, and to have added a final touch to all the beauty of colour so lavishly displayed elsewhere. These are to be found in a few species only in both hemispheres, and are therefore the more remarkable. The largest butterfly to exhibit this form of colour is the Omithoptera magellanus, from the Philippines, whose golden-yellow wings, when viewed obliquely acquire the changing hues of polished opals, quite distinct from any of its numerous allies which possess the same colour but with what may be termed a silky gloss. In the same part of the world (the Bismarck Archipelago) there is a day-flying moth (Burgena chalybeata), one of the Agaristidse, whose wings change from black to blue and a fiery opalescent red. In tropical America there is a group of butterflies of the genus Papilio, which are very abundant both in species and individuals, whose velvet-black wings have a few bands or spots of blue or green on the upper pair, while the lower have a band of spots near the posterior margin of a brilliant crimson. Among perhaps a hundred species with this general style of coloration, there are a few (perhaps a dozen) in which the red of the hind wings, when viewed very obliquely from behind, changes into opalescent and then into a curious bluish phosphorescence of intense brilliancy.

I am informed by Dr. K. Jordan (of the-»Tring Zoological Museum) that in these insects the black ground of the wing changes also into metallic blue, which seems to spread over the red and to aid in the production of the phosphorescent effect. This is so marked that Mr. Bates gave to one of the new species he described, the name of Papilio phosphorus. One of the small Erycinidse (Euselasia prwclara) found in the Upper Amazon valley, is of a yellow buff colour, with a wonderful opalescent reflection which is said to be the most intense and brilliant in the whole order of Lepidoptera and probably the most brilliant colour known.

All metallic reflections in the animal world are what are called interference-colours, and are produced by excessively fine lines or rugosities on polished surfaces, or by equally thin transparent laminae. It is probable that in the remarkable changing glows now described, both these causes may come into play, producing, when viewed at certain angles, an intensity of hue resembling those of the finest opals, or sometimes imitating the most brilliant glow-worms or fireflies by means of reflected light. It seems probable that these rare hues may be of a protective nature, since a pursuing bird might be startled by the sudden flashing out of so brilliant a light and thus allow the insect to escape; but that does not render it more probable that the infinitely complex arrangements by which such structures are produced and transmitted unfailingly to offspring, should have been brought about for this purpose alone, when thousands of other species arrive at the same end by far simpler means.

Now if there was a difficulty in the view that all the wealth of colour and beauty in birds has been developed solely on account of its utility to themselves, that difficulty becomes greatly increased in the case of these insects. The described butterflies alone are already far more numerous than birds, and there are certainly more to be discovered of the former than of the latter. Bates well observed that the expanded wings of butterflies seemed to have been used by nature to write thereon the story of the origin of species. To this we may, I think, add that she has also used them, like the pages of some old illuminated missal, to exhibit all her powers in the production, on a miniature scale, of the utmost possibilities of colour-decoration, of colour-variety, and of colourbeauty; and has done this by a method which appears to us unnecessarily complex and supremely difficult, in order perhaps to lead us to recognise some guiding power, some supreme mind, directing and organising the blind forces of nature in the production of this marvellous development of life and loveliness.

It must always be remembered that what is produced on the flower, the insect, or the bird, is not colour, but a surface so constituted in its chemical nature or mechanical texture as to reflect light of certain wave-lengths while absorbing or neutralising all others. Colour is the effect produced on our consciousness by light of these special wave-lengths. To claim that the lower animals, especially the mammals, perceive all the .shades and intensities, the contrasts and the harmonies of colours as we perceive them, and that they are affected as we are with their unequalled beauty is a wholly unjustified hypothesis. The evidence that such sensations of colour exist in their case is wholly wanting. All we really know is, that they appear to perceive differences where we perceive colour, but it has not been proved how far this perception extends, since in the most intelligent of these, dogs and horses, the sense of smell is so highly developed as for many purposes to take the place of vision.

It is a very suggestive fact that the theory of the development of the colour-sense through its utility, receives least support from those animals which are nearest to us, and from which we have been corporeally developed — the mammals; rather more support from those which have had a widely different origin — the birds; and apparently most from those farthest removed from us — the insects, for whom it has been claimed that we owe them all the floral beauty of the vegetable kingdom, through their refined perception of differences of form and colour. This seems to me to be a kind of reductio ad absurdum, and to constitute a disproof of that whole argument as a final cause of the colour-sense. On the other hand, it gives the strongest support to the view that the refined perception and enjoyment of colour we possess has not, and could not have been developed in us by its survivalvalue in our early struggle for existence, but that these faculties are, as Huxley remarked in regard to his enjoyment of scenery and of music, "gratuitous gifts," and as such are powerful arguments for "a benevolent Author of the Universe."

Chapter XVI - THE VEGETABLE KINGDOM IN ITS SPECIAL BELATION TO MAN

It is obvious that, as animal life has from its very origin depended upon aud been developed in relation to plant life, the entire organisation of the former would, by the continuous action of variation and survival of the fittest, become so harmoniously adapted to the latter, that it would inevitably have every appearance of the plant having been formed and preordained for the express purpose of sustaining and benefiting the animal. This harmonious co-adaptation cannot therefore be adduced as, of itself, being any proof of design, but neither is it any proof against it. So with man himself, so far as his mere animal wants are concerned, his dependence on plants, either directly or indirectly, for his entire sustenance by food, and therefore for his very life, affords no grounds for supposing that either of the two kingdoms came into existence in order to render the earth a possible dwellingplace for him. But as regards those special qualities in which he rises so far above all other animals, and especially those on which the higher races found their claim to be "civilised," there seem to be ample grounds for such an argument, as I hope to be able to show.

Taking first the innumerable different kinds of wood, whose qualities of strength, lightness, ease of cutting and planing, smoothness of surface, beauty, and durability, are so exactly suited to the needs of civilised man that it is almost doubtful if he could have reached civilisation without them. The considerable range in their hardness, in their durability when exposed to the action of water or of the soil, in their weight and in their elasticity, render them serviceable to him in 8 thousand ways which are totally removed from any use made of them by the lower animals.

Few of these qualities seem essential to themselves as vegetable growths. They might have been much smaller, which would have greatly reduced their uses; or so much harder as to be almost unworkable; or so liable to fracture as to be dangerous; or subject to rapid decay by the action of air, or of water, or of sunshine, so as to be suitable for temporary purposes only. With any of these defects they might have served the purposes of the animal world quite as well as they do now; and their actual properties, all varying about a mean value, which serves the infinitely varied purposes to which we daily and hourly apply them, may certainly be adduced as an indication that they were endowed with such properties in view of the coming race which could alone utilise them, and to whose needs they minister in such an infinite variety of ways.

As one example of what such a different quality of timber as above indicated might mean let us remember that from before the dawn of history down to about the middle of the last century every ship in the world was built of wood. Had no -wood existed suitable for sea-going vessels, the whole course of history, and perhaps of civilisation, would have been different. Without ships the Mediterranean would have been almost as impassable as was the Atlantic . America would be still unknown, as well as Australia and possibly South Africa; and the whole world would be for us smaller than in the days before Columbus. And all this might have happened had the nature of vegetable growth, while differing little in external form and equally well adapted for unintelligent animal life, not possessed those special qualities which fitted it for ministering to the varied needs of intellectual, inventive, and ever advancing man.

But, even with the whole vegetable world in its outward aspect and mechanical properties exactly as it is now, there are still a thousand ways in which it ministers to the needs 6i our ever-growing civilisation, which have little or no relation to the animal world which grew up in dependence on it. Leaving out of consideration the vast number of fruits, and cereals, and vegetables which supply him with varieties of food, which may be of more importance to man in the future than, they are now, let us take first the innumerable drugs which enable bim to avoid some of the evils brought upon himself by his ignorance, his dissipations, or his wilful neglect. The pharmacopeias of every country and every age are crowded with the names of herbs and simples used with more or less success as remedies for the various diseases man was supposed to be heir to, and if many of these were altogether imaginary, very large numbers still hold their place as of real and often of inestimable value. To name only a few of the best known, we could hardly dispense with such common drugs as aloes, arnica, belladonna, calendula, cascara, gentian, jalap, ipecacuanha, nux vomica, opium, podopholin, quinine, rhubarb, sarsaparilla, and a host of others.

To these we may add the various "balsams" so much used in ancient surgery — balm of Qilead, friar's balsam, balsam of Peru, benzoin, camphor, etc.

Then there are the ordinary resins and gums so useful in the arts — copal, dammar, mastic, kauri, gum-arabic, tragacanth, asafoedita, gamboge, etc.

Among the numerous dyes are arnatto, Brazil-wood, logwood, camwood, fustic, indigo, madder, turmeric, and woad.

Vegetable oils, used for cooking, lighting, perfumes, medicines, etc., are very numerous. Such are candle-nut, castor oil, coco-nut oil, colza oil, olive oil, cotton seed, linseed, and rape-seed oils, cajeput oil, and innumerable others in every part of the world, known or yet to be discovered.

Perfumes and spices are also extremely abundant, such as caraways, cinnamon, cloves, mace, nutmegs, patchouli, peppermint, orris-root, sandal wood, sassafras, tonquinbeans, vanilla, and the many essential oils from highly perfumed fruits and flowers.

Of foods and drinks not used by the lower animals, are arrowroot, tapioca, sago, sugar, wine, beer, tea, coffee, and cocoa, the last six, when used in moderation, being among the choicest gifts of nature.

There remain a number of vegetable products invaluable for arts and manufactures — cotton and flax for clothing, hemp for cordage, rattan and bamboo for tropical furniture, boxwood for wood-engraving, gutta-percha for machine belts and a great variety of economic uses, and lastly india-rubber, one of the greatest essentials of our chemical and mechanical arts, without which neither the electric telegraph, the bicycle, nor the motor-car could have reached their present stage of perfection, while no doubt many equally important uses remain to be discovered.

It may be objected that so many of these varied products have been shown to be of use to the plants themselves as protections against injurious insects or from being devoured in their young state by herbivorous mammals, that their utility to man is only an accidental result, and of no real significance. But this objection can hardly be a valid one when we consider the enormous number of beneficial drugs, highly agreeable scents and spices, useful oils, and delicious foods or drinks, that are among the commonest of vegetable bye-products. There seems no direct connection between juices or volatile oils which are distasteful to insects, and drugs which are valuable medicines in the case of human diseases. The leaves or stems of seedling plants needed only a temporary protection, while the juices which effect it not only increase in quantity during the whole life of the plant, but are transformed into such as are of unmistakeable value to civilised man. It is almost inconceivable that the exquisite fragrance developed only by roasting the seed of the coffee shrub should be a chance result of the nature of the juices essential for the well-being of this particular species; or that the strange mechanical properties of india-rubber should be developed in a few only of the thousands of species having a protective milky sap.

Before leaving this branch of my subject, I must say a few words on the indications afforded by these varied products of plant-life, of the absolute necessity of a directive power and a mind of the highest organising intelligence for their production. Quite as clearly, perhaps even more clearly than for the development of the bird's feather or the insect's transformations, does the agency of such a supreme mind seem to be essential .

Let us consider first the extreme simplicity and uniformity of the conditions under which such marvellously diverse results are produced. A very large proportion of the vegetable products useful to man are obtained from the tropical forests, where the temperature is more uniform, the moisture more constant, and the trees less exposed to wind than anywhere else in the world. The whole organisation of the higher plants is, as compared with that of animals, extremely simple, 'and they are wonderfully similar in structure to each other, even in distinct genera and natural orders. The roots, the wood, the bark, the leaves, are substantially of the same type in thousands of species. All alike build up their structures out of the same elements, which they obtain from the water and the few substances it dissolves out of the soil, from the air and the carbonic acid and aqueous vapour it contains. Yet under these conditions what a seemingly impossible variety of products arise.

When the modern chemist attempts to bring about the same results as are effected by nature in the plant, he has to employ all the resources of his art. He has to apply great heat or great cold; he uses gas or electric fires and crucibles; he requires retorts for distillation, and air-tight vessels and tubes for the action of his reagents, or to preserve his liquid or gaseous products; but with all his work, carried out for more than a century by thousands of earnest students, he has only been able to reproduce in his laboratory a limited number of rganic substances, while the more important of the constituents of living organisms remain far beyond his powers of synthesis.

The conditions under which nature works in the vegetable kingdom are the very opposite of all this. Starting from the ripened seed, consisting essentially of a single fertilised cell and a surrounding mass of nutritive material, a root is sent out into the soil and a shoot into the atmosphere, from which the whole plant with all its tissues and vessels are formed, enabling it to rise up into the air so as to obtain exposure to light, to lift up tons weight of material in the form of limbs, branches, and foliage of forest trees, often to a hundred feet or more above the surface, by means of forces whose exact mode of operation is still a mystery; while by means of the very same tissues and vessels those recondite chemical processes are being carried on which result in the infinitely varied products already very briefly referred to.

The living plant not only builds up its own marvellous structure out of a few elements supplied to it either in a gaseous or liquid state, but it also manufactures all the appliances— cells, vessels, fibres, etc.— needful for its complex laboratory work in producing the innumerable bye-products possessing so many diverse properties useful to man, but which were mostly unneeded by the remainder of the animal world.

Usually botanists as well as zoologists are satisfied to describe the minute structure of the organs of plants or animals, and to trace out as far as possible the changes that occur during growth, without any reference to the unknown and unintelligible forces at work. As Weismann has stated, the fundamental question —" the causes and mechanism by which it comes about that they (the germicides or physiological units) are always in the right place and develop into cells at the right time"—is rarely or never touched upon.1 Modern theories of heredity take for granted the essential phenomena of life — nutrition, assimilation, and growth. * The Germ Plasm, p. 4.

I find, however that Professor Anton Kerner, in his great work on The Natural History of Plants, fully recognises this great fundamental problem, and even recurs to the much derided "vital force" as the only help to a solution of it. He says:

The phenomena observed in living protoplasm, as it grows and takes definite form, cannot in their entirety be explained by the assumption of a specific constitution of protoplasm for every distinct kind of plant, though this hypothesis may prove useful when we enquire into the origin of new species.

Again he says:

In former times a special force was adduced, the force of life. More recently, when many phenomena of plant-life had been successfully reduced to simple chemical and mechanical processes, this vital force was derided and effaced from the list of natural agencies. But by what name shall we now designate that force in nature which is liable to perish whilst the protoplasm suffers no physical alteration and in the absence of any extrinsic cause; and which yet, so long as it is not extinct, causes the protoplasm to move, to enclose itself, to assimilate certain kinds of fresh matter coming within the sphere of its activity and to reject others, and which when in full action makes the protoplasm adapt its movements under external stimulation to existing conditions in the manner which is most expedient?

This force in nature is not electricity nor magnetism; it is not identical with any other natural force; for it manifests a series of characteristic effects which differ from all other forms of energy. Therefore, I do not hesitate again to designate as 'vital force' this natural agency, not to be identified with any other, whose immediate instrument is the protoplasm, and whose peculiar effects we call life. The atoms and molecules of protoplasm only fulfil the functions which constitute life so long as they are swayed by this vital force. If its dominion ceases they yield to the operation of other forces. The recognition of a special natural force of this kind is not inconsistent with the fact that living bodies may at the same time be subject to other natural forces (p. 52).

And again, after discussing the various effects produced by that wonderful substance chlorophyll, he says:

We see the effective apparatus, we recognise the food-gases and food-salts collected for working up, we know that the sun's rays act as the motive force, and we also identify the products which appear completed in the chlorophyll granules. By careful comparison of various cells containing chlorophyll, having found by experience that under certain external conditions the whole apparatus becomes disintegrated and destroyed, it is indeed permissible to hazard a conclusion about the propelling forces. But what is altogether puzzling is, how the active forces work, how the sun's rays are able to bring it about that the atoms of the raw material abandon their previous grouping, become displaced, intermix one with another, and shortly reappear in stable combinations under a wholly different arrangement. It is the more difficult to gain a clear idea of these processes, because it is not a question of that displacement of the atoms called decomposition, but of that process which is known as combination or synthesis (p. 377).

I have made these quotations from one of the greatest German writers on botany in order to show that a professor of the science, with a most extensive knowledge of every aspect of plant-life, supports the conclusion I had already reached from a consideration of some of the broader phenomena of animal life and organisation. In the last paragraph quoted he even shows that phenomena occur during the growth of the plant, which are, as I suggested from other facts, comparable in complexity with those of the metamorphosis of the higher insects, and, therefore, equally requiring the agency of some high directive power for an adequate rational explanation of them.

I am quite aware that this view, of the earth and organic nature having been designed for the development of the human race, and further, that it has been so designed that in the course of its entire evolution, its detailed features and organisation have been such as not only to serve the purposes of the whole series of living things, but also in their final outcome, to serve the purposes and add to the enjoyments of man, is highly distasteful to a large proportion of scientific workers. They think, and some of them say, that it is a return to the old superstition of special creation, that science has nothing to do with first causes, whether in the form of spiritual or divine agencies, and that once we begin to call in the aid of such non-natural and altogether hypothetical powers we may as well give up science altogether. In my early life I should have adopted these same arguments as entirely valid, and should perhaps have thought of the advocates of my present views with the same contemptuous pity which they now bestow upon myself. But, I venture to urge, the cases are not fairly comparable, because both their point of view and my own are very different from those of our fellow-workers of the first half of the nineteenth century.

Let me recall the conditions that prevailed then as compared with those of to-day. Then the opposition was between science and religion, or, perhaps more correctly, between the enthusiastic students of the facts and theories of physical science in the full tide of its efforts to penetrate the inmost secrets of nature, and the more or less ignorant adherents of dogmatic theology. Now, the

case is wholly different. Speaking for myself I claim to be as whole-heartedly devoted to modern science as any of my critics. I am as fully imbued with the teachings of evolution as they can be; and I still uphold, as I have always done, the essential teachings of Darwinism.

Darwin always admitted, and even urged, that "Natural Selection has been the most important but not the exclusive means of modification." He always adduced the "laws of Growth with Reproduction," and of " Inheritance with Variability," as being fundamental facts of nature, without which Natural Selection would be powerless or even non-existent, and which, then as now, were and are wholly beyond explanation or even comprehension. He elaborated his theory of Panagenesis for the purpose of rendering the many strange facts of inheritance more intelligible, but even if it were proved to be an exact representation of the facts it would not be an explanation, because, as Weismann, Kerner, and many others admit, it would not account for the forces, the directive agency, and the organising power which are essential features of growth. This is felt so strongly by all the great workers in physiology, that even Haeckel has been driven to postulate "mind, soul, or volition," not only in every cell but in each organic molecule or physiological unit. And then, to save himself from the slur of being "unscientific," and of introducing the very organising power he had derided when suggested by others, he loudly proclaims that his "soulatom," though it has "will" is yet wholly "unconscious."

I again urge, therefore, that our greatest authorities admit the necessity of some mind — some organising and directive power — in nature; but they seem to contemplate merely some unknown forces or some innate rudimentary mind in cell or atom. Such vague and petty suppositions, however, do not meet the necessities of the problem. I admit that such forces and such rudimentary mind-power may and probably do exist, but I maintain that they are wholly inadequate, and that some vast intelligence, some pervading spirit is required to guide these lower forces in accordance with a pre-ordained system of evolution of the organic world.

If, however, we go as far as this, we must go farther. If there is a ruling and creative power to which the existence of our cosmos is due, and if we are its one and unique highest outcome, able to understand and to make use of the forces and products of nature in a way that no other animal has been able to do; and if, further, there is any reasonable probability of a continuous life for us to still further develop that higher spiritual nature which we possess, then we have a perfect right, on logical and scientific grounds, to see in all the infinitely varied products of the animal and vegetable kingdoms, which we alone can and do make use of, a preparation for ourselves, to assist in our mental development, and to fit us for a progressively higher state of existence as spiritual beings.

Chapter XVII - THE MYSTERY OF THE CELL

I have already given a short account of the chemical composition of protoplasm — the highly complex substance now held to be the physical basis of life, and by one school of biologists alleged to explain, as a result of that complexity, all the wondrous phenomena of growth and development. I now propose to give a very brief sketch of the physical characteristics of the Kving cell, of its internal structure, and of the extraordinary internal changes it undergoes during the growth or reproduction of all organisms.

One of the lowest or most rudimentary forms of life is the Amoeba, a living cell, just visible to the unaided eye as a little speck of floating jelly. This creature, being one of the most common of living microscopic objects, will have been seen by most of my readers. At first, under a low microscopic power, it appears structureless, as it was for some time described to be, but with increasing power and perfection of the microscope it is found to consist of three parts — a central body of a nearly globular shape slightly darker and more granular in texture, the outer jelly-like mass, and a small more transparent globular portion, which looks like an air-bubble, and is seen to

undergo a slow motion of contraction and expansion; this is termed the "contractile vacuole," which, when it has reached its full size, perhaps a quarter or a fifth of the whole diameter, suddenly disappears, and after a little "while reappears and gradually grows again to its maximum size. The shape of the Amoeba varies greatly. Sometimes it is globular and immovable, but most frequently it is very irregular with arm-like processes jutting out in various directions. By careful watching, these are seen to increase or diminish so as to change the whole shape in an hour or two. But more curious is its power of absorbing any particles of organic matter that come in contact with it by gradually enclosing them in its substance, where after a time they disappear. The Amoebae are found in stagnant water full of organic matter, and if they are transferred to pure water they soon diminish in size, proving that they require food and can digest it. The "contractile vacuole" is believed to have the function of expelling the carbonic acid gas and other waste products of assimilation.

This Amoeba is one of the simplest forms of the lowest branch of the animal kingdom, the one-celled animals or Protozoa; all other animals being classed as Metazoa, as they are entirely built up of separate cells, which in all the more complex forms are countless millions in number. Every part of our bodies, from blood to muscles and nerves, from bones to skin, hair, and nails, is alike constructed of variously modified cells.

It might be thought that animals consisting of single cells could not be very numerous or very differently organised. Tet they are grouped into five classes, the first, Khizopoda, comprising not only many kinds of Amoebse, but the beautiful Foraminifera, whose exquisite shells'>fcre such favourite microscopic objects. They are single amoeboid cells which yet have the power either of building up shells of small inorganic particles, or of secreting the more beautiful shells which seem to mimic the forms of those of the higher Mollusca. The fossils called Nummulites were Foraminifera with flat coiled shells, forming great masses of Eocene limestone. They are the largest of all, some equalling a half-crown in size. Radiolaria are rhizopods having a beautiful siliceous skeleton, and often living in colonies. Another class, the Mastigophora, have extremely varied shapes, often like sea-weed or flowers, having long, slender, whip-like processes. These and hundreds of other strange forms are still essentially single cells, though often grouped together for a time, and they all increase either by division or by giving off buds, which rapidly grow into the perfect form.

The remarkable thing in all these one-celled creatures is that they so much resemble higher animals without any of their organs. The writer of the article Cell in Chambers's Encyclopaedia says: "The absence of a circulating fluid, of digestive glands, nerves, sense-organs, lungs, kidneys, and the like, does not in any way restrict the vital functions of a 1 unicellular organism. All goes on as usual, only with greater chemical complexity, since all the different processes have but a unit-mass of protoplasm in which they occur. The physiology of independent cells, instead of being very simple, must be very complex, just because structure or differentiation is all but absent." All the one-celled animals and plants go through a series of changes forming the cycle of their lifehistory. Beginning as a nearly globular quiescent cell, they change in form, put forth growths of various kinds, then become quiescent again and give rise to new cells by subdivision or budding.

This fundamental fact, that all organic life-forms begin with a cell and are wholly built up either by outgrowths of that one cell or by its continued division into myriads of modified cells of which all the varied organs of living things are exclusively formed, was first established about the year 1840, and was declared by the eminent naturalist Louis Agassiz to be "the greatest discovery in the natural sciences in modern times." The cell is now defined as "a nucleated unit-mass of living protoplasm." It is not a mere particle of protoplasm, but is an organised structure. We are again compelled to ask, Organised by what? Huxley, as we have seen in Chapter XV., tells us that life is the organising power; Kerner termed it a vital force; Haeckel, a cell-soul, but unconscious, and he

postulated a similar soul in each organic molecule, and even in each atom of matter. But none of these verbal suggestions go to the root of the matter; none of them suppose more than some "force," and force is a cause of motion in matter, not a cause of organisation. What we must assume in this case is not merely a force, but some agency which can and does so apply, and direct, and guide, and coordinate a great variety of forces — mechanical, chemical, and vital — so as to build up that infinitely complex machine, the living organism, which is not only self-repairing during the normal period of existence, but self-renewing, self-multiplying, self-adapting to its ever-changing environment, so as to be, potentially, everlasting. To do all this, I submit, neither "life" nor " vital force" nor the unconscious "cell-soul" are adequate explanations. What we absolutely require and must postulate is, a Mind far higher, greater, more powerful than any of the fragmentary minds we see around us — a Mind not only adequate to direct and regulate all the forces at work in living organisms, but which is itself the source of all those forces and energies, as well as of the more fundamental forces of the whole material universe.

The necessity for some such far-reaching power and directive agency will be even more apparent when we consider the beautiful series of changes which occur in every germ-cell of the higher animals (Metazoa) at the commencement of growth into the perfect form, as detected by means of a long series of observations by many embryologists, with all the modern appliances of microscopic research, and summarised in Professor A. Weismann's interesting volume on The Germ-Plasm.

I will first quote a general description of such a cell from Professor Lloyd Morgan's Animal Life and Intelligence, and then give the further details as shown in the plate of diagrams from Weismann's book. (Fig. 110).

The external surface of a cell is (usually) bounded by a film or membrane. Within this membrane the substance of the cell is made up of a network of very delicate fibres (the plasmogen), enclosing a more fluid material (the plasm); and this network seems to be the essential living substance. In the midst of the cell is a small round or oval body, called the nucleus, which is surrounded by a very delicate membrane. In this nucleus there is also a network of delicate plasmogen fibres enclosing a more fluid plasm material. At certain times the network takes the form of a coiled filament or set of filaments, and these arrange themselves in the form of rosettes and stars. In the meshwork of the net, as in the coils of the filament, there may be one or more small bodies (nucleoli), which probably have some special significance in the life of the cell.

The accompanying series of diagrams from Professor Weismann's book already referred to are intended to show the essential features of what takes place in a cell previous to division, the detailed fibrous structure of the plasma being omitted for the sake of clearness. It must be understood, however, that much of what is described in the cells is quite invisible even in the highest powers of the best microscopes, owing to the fact that almost all the parts — the fibrous network and granules in the plasma, as well as the network in the nucleus — are transparent, and only become visible by the use of various chemical reagents and dyes, which stain some parts more than others and thus render them visible. The parts of the nucleus which are thus coloured and rendered visible are termed chromosomes or chromatin. I will now quote Weismann's description of what happens in such a cell. (Fig. 110, p. 370.)

When the nucleus is going to divide, the chromatin granules, which till then were scattered, become arranged in a line and form a long thread which extends through the nucleus in an irregular spiral (Fig. 110 A), and then divides into portions of fairly equal length (the chromosomes). These have at first the form of long bands or loops, but afterwards become shortened, thus giving rise to short loops (B), or else to straight rods or rounded granules. With certain exceptions the number of chromosomes which arise in this way is constant for each species of plant or animal, and also for successive series of cells.

By the time the process has reached this stage a special mechanism appears, which has till now remained concealed in the cell-substance. This serves to divide the chromatin elements into two equal parts, to separate the resulting halves from one another, and to arrange them in a regular manner. At the opposite poles of the longitudinal axis of the nucleus two clear bodies — the "centrosomes," each surrounded by a clear zone — the so-called "sphere of attraction"—now becomes visible (A to D, cs). Thej possess a great power of attraction over the vital particles of the cell, so that these become arranged around them in a series of rays. At a certain stage in the preparation for division, the soft protoplasmic substance of the cell-body as well as of the nucleus gives rise to delicate fibres or threads; these fibres are motile, and, after the disappearance of the nuclear membrane, seize the chromosomes— whether these have the form of loops, rods, or globular bodies — with wonderful certainty and regularity, and in such a way that each element is held on either side by several threads from either pole (B, C). The chromatin elements thus immediately become arranged in a fixed and regular manner, so that they all come to lie in the equatorial plane of the nucleus, which we may consider as a spherical body.

Now follows another and even more remarkable stage in the process, which is thus described:

The chromatin elements then split longitudinally, and thus become doubled (B), as Fleming first pointed out. It must be mentioned that this splitting is not caused by a pull from the pole threads (spindle threads), which attach themselves to the chromatin-rods on both sides; the division arises rather from forces acting in the rods themselves, as is proved by the fact that they are often ready to divide, or indeed have already done so, some time before their equatorial arrangement has taken place by means of these threads.

The splitting is completed by the two halves being gradually drawn further apart towards the opposite poles of the nuclear spindle, until they finally approach the centre of attraction or centrosome (D), which has now fulfilled its object for the present, and retires into the obscurity of the cell-substance, only to become active again at the next cell-division. Each separated half of the nucleus now constitutes a daughter-nucleus, in which it (the chromatin) immediately breaks up, and becomes scattered in the form of minute granules in the delicate nuclear network, so that finally a nucleus is formed of exactly the same structure as that with which we started.

Weismann then discusses and explains the meaning of this strange phenomenon. He says:

It is evident, as Wilhelm Roux was the first to point out, that the whole complex, but wonderfully exact, apparatus for the division of the nucleus exists for the purpose of dividing the chromatin substance in a fixed and regular manner, not merely quantitatively, but also in respect of the different qualities which must be contained in it. So complicated an apparatus would have been unnecessary for the quantitative division only. If, however, the chromatin substance is not uniform, but is made up of several or many different qualities, each of which has to be divided as nearly as possible into halves, or according to some definite rule, a better apparatus could not be devised for the purpose. On the strength of this argument we may, therefore, represent the hereditary substance as consisting of different qualities. . . . The statement that this substance is the hereditary substance can, therefore, hardly be considered as an hypothesis any longer.

After some further discussion of the views of other writers, he goes on to show that the chromatin substance is not only contained in the germ-cells, but also in all the cells of the entire organism in each phase of its development, which is effected by the constant division of the cells and their nuclei, the chromatin continuing to grow during the whole time. But in the body it enters on a long and complex process of growth, so as to build up the substance of all the varied organs and tissues, and also for the repair or renovation of these various tissues as they require it. He illustrates the

successive changes which he supposes the chromatin to bring about, and for which purpose it is so accurately divided and subdivided from the very beginning, in the following passage:

Even the two first daughter-cells (E) which result from the division of the egg-cell give rise in many animals to totally different parts. One of them, by continued cell-division, forms the outer germinal layer, and eventually all the organs which arise from it, e. g. the epidermis, central nervous system, and sensory cells; the other gives rise to the inner germinal layer and the organs derived from it — the alimentary system, certain glands, etc. The conclusion is inevitable that the chromatin determining these hereditary tendencies is different in the very first two daughter-cells.

Later on he shows in great detail how similar but even more complex changes take place in the newly fertilised germcell in which the male and female elements are combined, for the purpose of bringing about the accurate partition of these elements in all the cells which arise from them by subdivision, thus rendering possible the production, in all future generations, of males and females in nearly equal proportions. He also shows that there is a special provision for the production of slight variations in successive generations in a way too complex to be explained here. This, of course, is largely speculation, but it is based at every step on observed facts in the processes of fertilisation and cell-division.

In Professor J. Arthur Thomson's most valuable and illuminating work on Heredity, in which he impartially expounds the theories and discoveries of all the great physiological writers of the world, he gives a very high, if not the highest, place to those of Weismann. I will therefore quote from his volume Weismann's latest short statement of bis hypothesis as to the nature of the germ-plasm; and also Professor Thomson's very short summary of it, giving an explanation of Weismann's special terminology. Weismann's statement is as follows:

The germ-substance owes its marvellous power of development not only to its chemico-physical constitution, but to the fact that it consists of many different kinds of primary constituents, that is, of groups of vital units equipped with the forces of life, and capable of interposing actively and in a specific manner, but also capable of remaining latent in a passive state until they are affected by a liberating stimulus, and on this account able to interpose successfully in development. The germ-cell cannot be merely a simple organism; it must be a fabric made up of many different organisms or units — a microcosm.

And Professor J. A. Thomson's Summary of Weismann's mechanics of the germ-plasm is as follows:

The physical basis of inheritance — the germ-plasm — is in the chromatin of the nucleus of the germ-cell.

The chromatin takes the form of a definite number of chromosomes or idants (Fig. 110, B, C, D, id).

The chromosomes consist of ids, each of which contains a complete inheritance.

Each id consists of numerous primary constituents or determinants.

A determinant is usually a group of biophors, the minutest vital units.

The biophor is an integrate of numerous chemical molecules.

In the preceding Summary I have italicised the technical terms invented by Weismann for the different stages of what may be called the mechanical explanation of heredity by means of the successive changes observed in the growing and dividing germ-cells. But, as he himself admits, it explains nothing without taking for granted the essential phenomena of life — nutrition, assimilation, and growth; and these are admitted to be to this day quite unexplainable.

Division

A. Cell with nucleus (n) and centrosomes d-j) preparatory to division. The chromatin has become thickened so as to form a spiral thread (cfcr).

B. The nuclear membrane has disappeared. Delicate threads radiate from the chromosomes, and form the "nuclear spindle," and the equator of which eight chromosomes or nuclear loops (,cltr=Ji) are arranged; these have been formed by the spiral thread of chromatin in A becomir.
up.

C. The chromosomes have come split longitudinally into tiro, and are about to be drawn apart by means of the spindle threads. (For clearness four only of the eight chromasomes are shown.)

D. The daughter■loops pass towards the poles of the spindle.

E. The cell has divided, each new cell containing a centrosome and eight nuclear loops.

(From Weismann's Germ-Plasm, by permission of Walter Scott, Ltd.)

But the very first step of this process of growth — the division of the germ-cells, as described by Weismann himself and illustrated by his diagrams — is, as he himself almost admits, equally inexplicable. He speaks of a "complex, but wonderfully exact, apparatus for the division of the nucleus," of the purpose of that division being qualitative as well as quantitative, and of its evident adaptation to the building up of the future body, with all its marvellous complexities, coordinations, and powers. So that the farther we go in this bewildering labyrinth, as expounded in his works, in those of Professor Thomson, of Max Verworu, or in such general works as Parker and Haswell's Text-Book of Zoology, the more hopelessly inadequate do we find the claims of Haeckel, Verworu, and their school to having made any approach whatever to a solution of "the riddle of the universe," so far as regards its crowning problem, the origin and development of life.

The Plant Cell

So far I have taken the facts as to cell-division from the works of zoologists only; but almost exactly the same phenomena have been found to occur in plants, though they seem to have been rather more difficult to detect and unravel. In Professor A. Kerner's Natural History of Plants, already quoted, he gives the following short description of cell-division:

When a protoplast living in a cell-cavity is about to divide into two, the process resulting in division is as follows: — The nucleus places itself in the middle of its cell, and at first characteristic lines and streaks appear in its substance, making it look like a ball made up of little threads and rods pressed together. These threads gradually arrange themselves in positions corresponding to the meridian lines upon a globe; but at the place where on a globe the equator would lie, there then occurs suddenly a cleavage of the nucleus — a partition wall of cellulose is interposed in the gap, and from a single cell we have now produced a pair of cells" (vol. i. p. 48) .

But later on we have a much fuller description, illustrated by four diagrammatic figures of the dividing cell, which show that the process in plants is substantially identical with that described and figured already from Weismann (vol. L p. 581). This is most instructive, because it shows the absolute identity of the fundamental mechanics of life in the animal and vegetable kingdoms, though their ultimate developments are so wonderfully diverse.

Another interesting point is that, just as Weismann has stated, there is an identity in the number of certain elemente in the cell for each species. Kerner's statement is:

"For every species of plant the number, size, and shape of the bodies arising in the interior of a cell by division are quite definite, though they vary from species to species. In the cell-chambers of some species several thousand minute protoplasmic bodies arise. In others, again, the number is very limited. If the number is large the individual masses are exceedingly small, and can only be recognised when very greatly magnified. If the number is limited the divided portions are comparatively large. The shape of the structure is exceedingly various. Some are spherical, elliptical, or pear-shaped; others elongated, fusiform, filamentous, or spatulate; some are straight, others are spirally twisted, and many are drawn out into a thread; others are provided over the whole surface with short cilia; others, again, with a crown of cilia at a particular spot, or with only a single pair of long cilia. In the majority of cases the small bodies exhibit active movements; but sooner or later they come to rest, and then assume another shape or fuse with another protoplasmic body."

Referring to the theory that the structure of each plant is due to the specific constitution of the protoplasm of the species, Kerner says:

What it does not account for is the appropriate manner in which various functions are distributed among the protoplasts of a cell-community; nor does it explain the purposeful sequence of different operations in the same protoplasm without any change in the external stimuli; the thorough use made of external advantages; the resistance to injurious influences; the avoidance or encompassing of insuperable obstacles; the punctuality with which a'l the functions are performed; the periodicity which occurs with the greatest regularity under constant conditions of environment; nor, above all, the fact that the power of discharging all the operations requisite for growth, nutrition, renovation, and multiplication is liable to be lost. We call the loss of this power the death of the protoplasm (vol. i. p. 51).

Growth by Cell-Division: What it Implies

As the account now given of the-most recent discoveries as to what actually takes place in the living cell preparatory to its division and subdivision, which are the very first steps in the growth or building up of the highly complex and perfect animal or plant, is very technical, and will be perhaps unintelligible to some of my readers, I will now give a very short statement of the process with a few illustrations, and remarks as to what it all really means, and how alone, in my opinion, it can possibly be explained.

The egg is a single cell with a special central point or organ, called the nucleus, and it is this nucleus which makes the oell a germ-cell. That this is so has been proved in many ways,— in plants by grafting or budding, where the flower-bud which contains a germ<ell, when inserted in the bark of a different variety, and sometimes a different species of plant, reproduces the exact kind of flower or fruit that characterised the tree or bush the bud was taken from, not that of the plant of -which it now forms a part, and whose sap forms its nourishment.

Again, Professor Boveri deprived an egg of a species of sea-urchin (Echinus microtuberculatus) of its nucleus, and then fertilised the egg with the spermatozoa of another species (Sphcerechinus granularis). The egg so treated developed larvae with the true characters of the latter species only, so that the main substance of the egg provided nutriment for the offspring, but did not transmit to it any of its parental characters. A similar illustration, at a later period of life, is that of an infant which from birth is fed on cow's milk, yet, if it lives, possesses only human characteristics.

This nucleus, therefore, which, when fertilised, has such marvellous powers and properties, is the seat of heredity and development. What is it that gives it this power? What is the agency that sets in motion a whole series of mechanical, chemical, and vital forces, and guides them at every step to their destined end? Again, I urge, let us consider what we have to explain. The matter of the fertilised egg is the millionfold complex substance called protoplasm. It is also mainly living protoplasm. What power gave it life? It is also (in its essential part, the nucleus) already highly differentiated— it is organised protoplasm. What power organised it? It is a liquid or semi-liquid substance with slight cohesion; it gradually forms a cell, which divides and subdivides, till at a certain point the globular mass or layer of cells bends inward upon itself, forming a hollow sac with outer and inner walls. What power determines the cell-mass to take this or other well-defined shapes? Then, as cell-division and specialisation go on, the rudiments of muscle and bone are • formed with totally distinct properties — the one with immense contractility and tensile strength, the other with great hardness and rigidity. Who or what guides or determines the atoms of the protoplasmic molecules into these new combinations chemically, and new structures mechanically ? — combinations and structures which all the chemists and physicists of the world are powerless to produce even when they have the ready-formed protoplasm given them to start with? Then as the process goes on in an ever-increasing complexity which baffles the microscope of the observer to follow, never diverging at any one point from the precise mode of change which alone leads on to the completed living organism, we are asked to be satisfied with millions of "gemmules," "fundamental units," "determinants," etc., which actually do build up the living body of each organism in a prescribed and unchangeable sequence of events. But this orderly process is quite unintelligible without some directive organising power constantly at work in or upon every chemical atom or physical molecule of the whole structure, as one after another they are brought to their places, and built in, as it were, to the structure of every tissue of every organ as it takes form and substance in the fabric of the living, moving, and, in the case of animals, sensitive creation.

I will conclude this short sketch of cell-life and its mystery, with a picturesque account of one striking example in the animal world, from Professor Lloyd Morgan's illuminating volume.

There is, perhaps, no more wonderful instance of rapid and vigorous growth than the formation of the antlers of deer. These splendid weapons and adornments are shed every year. In the spring, when they are growing, they are covered over with a dark skin provided with short, fine, thick-set hair, and technically termed "the velvet." If you lay your hand on the growing antler, you will feel that it is hot with the nutrient blood that is coursing beneath it. It is, too, exceedingly sensitive and tender. An army of tens of thousands of busy living cells is at work beneath that velvet surface, building the bony antlers, preparing for the battles of autumn. Each minute cell knows its work, and does it for the general good — so perfectly is the body knit into an organic whole. It takes up

from the nutrient blood the special materials it requires; out of them it elaborates the crude bone-stuff, at first soft as wax, but ere#long to become as hard as stone; and then, having done its work, having added its special morsel to the fabric of the antler, it remains imbedded and immured, buried beneath the bone products o' its successors or descendants. No hive of bees is busier or more replete with active life than the antler of a stag as it grows beneath the soft warm * elvet. And thus are built up in the course of a few weeks those splendid "beams" with their "tynes" and "snags," which, in the case of the wapiti, even in the confinement of the Zoological Gardens, may reach a weight of thirty-two pounds, and which, in the freedom of the Rocky Mountains, may reach such a size that a man may walk without stooping through the archway made by setting up upon their points the shed antlers.

In the eastern European forests the horns of the red deer reach a weight of 74 pounds, while in the recently extinct Irish elk the large, broadly palmated horns sometimes reached an expanse of 11 feet . These remarkable weapons were developed both for combats between the males and as a means of protecting the females and young from enemies. As organic outgrowths they are extremely simple when compared with the feathers of the bird or the scales of a butterfly's wing; yet as exemplifying the need for some guiding power, exerted upon the individual cells which carry out the work with such wonderful precision every year, they are equally striking. The blood, we know, furnishes the materials for every tissue in the body; but here a large mass of bony matter, covered with a thin skin and dense hair, is rapidly built up, to a very definite form in each species; then the skin and hair cease growing and fall away, while the horns persist for nearly a year, when they, too, fall off and are again renewed.

Concluding Remarks on the Cell-Problem

The very short account I have now given of what is known of the essential nature, the complex structure, and the altogether incomprehensible energies of these minute unit-masses of living matter, the cells — so far as possible in the very words of some of the most recent authorities — must, I think, convince the reader that the persistent attempts made by Haeckel and Verworu to minimise their marvellous powers as mere results of their complex chemical constitution, are wholly unavailing. They are mere verbal assertions which prove nothing; while they afford no enlightenment whatever as to the actual cause* at work in the cells leading to nutrition, to growth, and to reproduction.

Very few of the workers who have made known to us the strange phenomena of cell-life in the Protozoa, and of celldivision in the higher animals and plants, seem to think anything about the hidden causes and forces at work. They are so intensely interested in their discoveries, and in following out the various changes in all their ramifications, that they have no time and little inclination to do more than add continually to their knowledge of the facts. And if one attempts to read through any good text-book such as Parker and Haswell's Zoology, or J. Arthur Thomson's Heredity, it is easy to understand this. The complexities of the lower forms of life are so overwhelming and their life-histories so mysterious, and yet they have so much in common, and so many cross-affinities among the innumerable new or rare species continually being discovered, that life is not long enough to investigate the structure of more than a very small number of the known forms. Hence very few of the writers of such books express any opinion on those fundamental problems which Haeckel and his followers declare to have been solved by them. All questions of antecedent purpose, of design in the course of development, or of any organising, directive, or creative mind as the ftmdamental cause of life and organisation, are altogether ignored, or, if referred to, are usually discussed as altogether unscientific and as showing a deplorable want of confidence in the powers of the human mind to solve all terrestrial problems.

If, as I have attempted to do here, we take a broad and comprehensive view of the vast world of life as it is spread out before us, and also of that earlier world which goes back, and ever further back, into the dim past among the relics of preceding forms of life, tracing all living things to more generalised and usually smaller forms; still going back, till one after another of existing families, orders, and even classes, of animals and plants either cease to appear or are represented only by rudimentary forms, often of types quite unknown to us; we meet with ever greater and greater difficulties in dispensing with a guiding purpose and an immanent creative power.

For we are necessarily led back at last to the beginnings of life — to that almost infinitely remote epoch myriads of years before the earliest forms of life we are acquainted with had left their fragmentary remains in the rocks. Then, at some definite epoch, the rudiments of life must have appeared. But whenever it began, whenever the first vegetable cell began its course of division and variation; and when, very soon after, the animal cell first appeared to feed upon it and be developed at its expense,— from that remote epoch, through all the ages till our own day, a continuous, never-ceasing, ever-varying process has been at work in the two great kingdoms, vegetal and animal, side by side, and always in close and perfect adaptation to each other.

Myriads of strange forms have appeared, have given birth to a variety of species, have reached a maximum of size, and have then dwindled and died out, giving way to higher and better-adapted creatures; but never has there been a complete break, never a total destruction, even of terrestrial forms of life; but ever and ever they became more numerous, more varied, more beautiful, and better adapted to the wants, the material progress, the higher enjoyments of mankind.

The whole vast series of species of plants and animals, with all their diversities of form and structure, began at the very dawn of life upon the cooling earth with a single cell (or with myriads of cells) such as those whose structure and properties we have here been considering; and every single individual of the myriads of millions which have ever lived upon the earth have each begun to be developed from a similar but not identical cell; and all the possibilities of all their organs, and structures, and secretions, and organic products have arisen out of such cells; and we are asked to believe that these cells and all their marvellous outcome are the result of the fortuitous clash of atoms with the help of "an unconscious cell-soul of the most primitive and rudimentary kind 1"

The Fallacy of Eternity as an Explanation of Evolution

It may perhaps not be out of place here to deal with what seems to me to be one of the common philosophical fallacies of the present day, the idea that you can get over the difficulty of requiring any supreme mind, any author of the cosmos, by assuming that it had no beginning — that it has existed, with all its forces, energies, and laws, from all eternity, and that it -will continue to exist for all eternity.

I have already quoted Haeckel and some others on this point. I will now give a similar statement by two writers of to-day. Dr. Saleeby in an article on The Life of the Universe, in The Academy (March 25, 1905), after discussing the theory of dissipation of energy, the infinity of the universe, the littleness of man, and other matters, with his usual clearness and vigour, concludes with this sentence: "Radiumclocks have been made that will go for a million years; but I believe that the Universe was never made and will go on for ever." This, of course, is vague, because, if the term "universe" is taken to mean "the all that exists," or rather, "all that exists, that ever has existed, or that ever will exist," it is a truism, because that includes all life and God. But "universe" is taken by Haeckel and his school to mean the material universe, and to definitely exclude spirit and god.

A great modern physicist, Professor Svante Arrhenius, in the preface to his recent work, Worlds in the Making, concludes thus:

My guiding principles in this exposition of cosmogonic problems has been the conviction that the Universe in its essence has always been what it is now. Matter, energy, and life have only varied as to shape and position in space.

This will be taken to mean, and I presume does mean, "matter" and "life" as we know them on the earth, and to exclude, as Haeckel does definitely, spirit and deity. The general conception of all these writers seems to be, that it is easier, simpler, more scientific, to assume that u matter, energy, and life" as we see them, have existed, the same in essence though in ever varying forms, from all eternity, and will continue to exist to all eternity, than to assume any intelligent power beyond what we see.

Now the idea, that positing eternity for matter and for organised life, and for all the forces of nature, overcomes difficulties or renders their existence at the stage they have now reached at all intelligible, is, I maintain, the very opposite of the truth, and arises from a want of real thought as to what "eternity" means. Take, first, "life" culminating in "man." It is admitted that there has been a continuous though not uniform progress from the first organic cell up to man. To arrive at that end it has admittedly occupied a very large portion of the duration of the habitability of the planet, and of the sun as a heat and life-giver. It is also assumed that, to ensure the persistence of life when suns cool and planets are unsuitable, either the germs of life must be carried through space (at the zero of temperature) from one solar system to another till they chance to alight upon one where the conditions of life are suitable, or they must have developed again out of dead matter. All this is overwhelmingly difficult,— but let us grant it all. Let us grant also that there are forces and energies capable of automatically building up progressively developing forms of sentient life, such as have been built up on the earth. Then, if these forces and energies have acted from all eternity, they must have resulted in an infinite lifedevelopment, that is, in beings inconceivably higher than we are. Now we, who, as they all tell us, are poor miserable creatures of a day, have yet got to know much of the universe, to apply its forces, and thus to modify nature — so, an eternity of progress at the same rate (and as there is progress there is no cause why it should stop) must necessarily have produced «n infinite result — that is, beings which as compared with us would be gods. And as you cannot diminish eternity, then long ages before the first rudiment of life appeared upon the earth, long before all the suns we see had become suns, the infinite development had been at work and must have produced gods of infinite degrees of power, any one of whom would presumably be quite capable of starting such a solar system as ours, or one immensely larger and better, and of so determining the material constitution of an "earth" as to initiate and guide a course of development which would have resulted in a far higher being than man. Once assume a mind-developing power from all eternity, and it must, now, and at all earlier periods of the past have resulted in beings of infinite power — what we should term — Gods!

It may, I think, be stated generally, that whatever has an inherent power of increase or decrease, of growth, development, or evolution, cannot possibly have existed from a past "eternity" unless the law of its evolution is an ever-recurrent identical cycle, in which case, of course, it may, conceivably, have existed from eternity and continue through an eternity of future cycles, all identical; and, therefore, such cycles could never produce anything that had not been produced an infinite number of times before. Is this a satisfactory outcome for an eternal self-existent universe? Is this easier, simpler, more rational, more scientific, more philosophical, than to posit one supreme Mind as self-existent and eternal, of which our universe and all universes are the manifestations? And yet the " infinity and eternity " men call themselves " monists," and claim to be the only logical and scientific thinkers. With them matter, ether, life — (surely three absolutely distinct things) — with all the wonderful laws, and forces, and directive agencies which they imply, and without which none of them could for a moment exist, all are to be accounted for and

explained by the one illogical assumption, their eternity; the one complete misnomer, monism; the one alleged fundamental law which explains nothing, the "law of substance."

It will be seen that this alleged explanation — the eternal material universe — does not touch the necessity, becoming more clear every day, not for blind laws and forces, but for immanent directive and organising Mindj acting on and in every living cell of every living organism, during every moment of its existence. I think I have sufficiently shown that without this, life, as we know it, is altogether unthinkable. No "eternal" existence of matter will make this in the remotest degree imaginable. It is this difficulty which the "monists" and the "eternalists" of the Haeckel and Verworu type absolutely shirk, putting us off with the wildest and most contradictory assertions as to what they have proved.

I venture to hope and to believe that such of my readers as have accompanied me so far through the present volume, and have had their memory refreshed as to the countless marvels of the world of life; culminating in the two great mysteries — that of the human intellect with all its powers and capacities as its outcome, that of the organic cell with all its complexity of structure and of hidden powers as its earliest traceable origin — will not accept the loud assertion, that everything exists because it is eternal as a sufficient or a convincing explanation. A critical examination of the subject demonstrates, as the greatest metaphysicians agree, that everything but the Absolute and Unconditioned must have had a beginning.

Chapter XVIII - THE ELEMENTS AND WATER, IN RELATION TO THE LIFE-WORLD

I Have already (in Chapter XVI.) given the statements of two continental physiologists as to great chemical complexity of the proteid molecule, involving as it does, in certain cases already studied, a combination of about two thousand chemical atoms. A more recent authority (Mr. W. Bate Hardy) is of opinion that this molecule really contains about thirty thousand atoms, while the most complex molecule known to the organic chemist is said to contain less than a hundred. One of the results of this extreme complexity is that almost all the products of the vegetable and animal kingdoms are what are termed hydro-carbons, that is, they consist of compounds of carbon, with hydrogen, oxygen, or nitrogen, or any or all of them, combined in an almost infinite variety of ways. Yet the compounds of these four elements already known are more numerous than those produced by all the other elements, more than seventy in number.

This abundance is largely due to the fact that the very same combination of carbon with the three gaseous constituents of the carbon-compounds often produces several substances very different in appearance and properties. Thus dextrine (or British gum), starch, and cellulose (the constituents of the fibres of plants) all consist of six atoms of carbon, ten of hydrogen, and five of oxygen; yet they have very different properties, cellulose being insoluble in water, alcohol, or ether; dextrine soluble in water but not in alcohol; while starch is only soluble in warm water. These differences are supposed to be due to the different arrangement of the atoms, and to their being combined and recombined in different ways; and as the more atoms are used, the possible complexity of these arrangements becomes greater, and the vast numbers and marvellous diversity of the organic compounds becomes to some extent intelligible. Professor Kerner, referring to the three substances just mentioned, gives the following suggestive illustration of their diverse properties, of which I have only mentioned a few. He says:

If six black, ten blue, and five red balls are placed close together in a frame, they can be grouped in the most diverse ways into beautiful symmetrical figures. They are always the same balls, they always take up the same space, and yet the effect of the figures produced by the different arrangements is wholly distinct. It may be imagined, similarly, that the appearance of the whole mass of a carbon-compound becomes different in consequence of the arrangement of the atoms, and that not only the appearance but even the physical properties undergo striking alterations.

Another and perhaps more interesting example, illustrated by a diagram, is given by Mr. W. Bate Hardy in his lecture already referred to. He says:

Here is a simple and startling case. The molecules of two chemical substances, benzonitrile and phenylisocyanide, are composed of seven atoms of carbon, five of hydrogen, and one of nitrogen:

N C

A A
A A

H—C [1 C—H H—€ f 1 C—H
H—C I I C—H H—C II C—H

0 C

A i

Benzonitrile. Phenylisocyanide.

The only difference in the arrangement of the atoms is that those of nitrogen and carbon are reversed. But the properties of these two substances are as unlike as possible. The first is a harmless fluid with an aromatic smell of bitter almonds. The second is very poisonous, and its odour most offensive."

Here only three elements are combined, and in identical proportions. We can imagine, therefore, what endless diversities arise when to these are added any of nine other elements, and these in varying proportions, as well as being grouped in every possible manner.

The fact of "isomerism," or of different substances, often with very different properties, having the very same chemical composition, is now so familiar to chemists as to excite comparatively little attention, yet it is really a marvel and a mystery almost equal to that of the organic cell itself. It is probably dependent upon the highly complex nature of the molecules of the elements, and also of the atoms of which these molecules are built up; while atoms themselves are now believed to be complex systems of electrons, which are held to be the units of electricity and of matter. It is these electrons and their mysterious forces that give to matter all its mechanical, physical, and chemical properties, including those which, in the highly complex protoplasm, have rendered possible that whole world of life we have been considering in the present volume.

Here, then, we find, as before, that the further back we go towards the innermost nature of matter, of life, or of mind, we meet with new complications, new forces, new agencies, all pointing in one direction towards the final outcome — the building up of a living sentient form, which should be the means of development of the enduring spirit of man.

Important and Unimportant Elements

If we look at the long list of between seventy and eighty elements now known we shall see that a comparatively small number of these (less than one-fourth) seem to play any important part either in the structure of the earth as a planet, or in the constitution of the organised beings that have been developed upon it. The most important of the elements is oxygen, which is not only an essential in the structure of all living things, but forms a large part of the air and the water which

are essential to their continued existence. It is also constituent of almost every mineral and rock, and is estimated to form about 47 per cent of the whole mass of the globe. The next most abundant elements are silicon, aluminium, and iron, which form 25, 8, and 7 per cent respectively of the earthmass. Then follow calcium, magnesium, sodium, and potassium, contributing from about 4 to 2 per cent of the whole; while no other element forms so much as one per cent, and the majority probably not more than one-fiftieth or one-hundredth of one per cent.

The gases, hydrogen and nitrogen, are, however, exceedingly important as forming with oxygen the atmosphere and the oceans of the globe, which by their purely physical action on climate, and in causing perpetual changes on the earth's surface, have rendered the development of the organic world possible. These ten elements appear to be all that were necessary to constitute the earth as a planet, and to bring about its varied surface of mountain and valley, rivers and seas, volcanoes and glaciers; but in order to develop life, and thus clothe the earth with ever-growing richness of vegetation and ever-changing forms of animals to be sustained by that vegetation, four other elements were required — carbon, sulphur, phosphorus, and chlorine — but these being either gaseous or of very small specific gravity, and thus existing (perhaps exclusively) near the earth's surface, comparatively little of them was needed.

List Of The More Important Elements

Elements in Protoplasm in Order of their Abundance (approximately)

1. Hydrogen

2. Carbon P

3. Oxygen

4. Nitrogen
6. Sulphur L~

6. Iron

7. Phosphorua L—

8. Chlorine t

9. Sodium

10. Potassium

11. Calcium

12. Magnesium

Elements in the Earth in Order of their
Quantity (approximately).

per cent

1. Oxygen 47

2. Silicon j£. 25

3. .4 (uminium 8

4. Iron 7

5. Calcium 4

6. Magnesium 3

7. Sodium 2.5

8. Potassium 2.5

9. Hydrogen (T) 0.1

10. Nitrogen (!) 0.1

All others (!) 9.8

100

The two elements in italics — Silicon and Aluminium — although forming a large proportion of the earth's substance, are not essential constituents of protoplasm, although occasionally forming part of it.

In the list of the more important elements here given, I have arranged them in two series, the first showing the essential constituents of protoplasm; the second showing the ten which are the most important constituents of the earth's mass as known to geologists and physicists. The four which are italicised in the first list do not appear in the second, and cannot, therefore, be considered as forming an essential portion of the rock-structure of the earth, although without them it seems fairly certain that the life-world could not have existed.

The Elements in relation to Man

So far as we can see, therefore, the fourteen elements in these two lists would have sufficed to bring about all the essential features of our earth as we now find it. All the others (more than sixty) seem to be surplusage, many exceedingly rare, and none forming more than a minute fraction of the mass of the earth or its atmosphere. All except seven of these are metals, including (with iron) the seven metals known to the ancients and even to some prehistoric races. The seven ancient metals are gold, silver, copper, iron, tin, lead, and mercury. All of these are widely distributed in the rocks. . They are most of them found occasionally in a pure state, and are also obtained from their ores without much difficulty, which has led to their being utilised from very early times. But though these metals (except iron) appear to serve no important purpose either in the earth itself or in the vegetable or animal kingdoms, they have yet been of very great importance in the history of man and the development of civilisation. From very remote times gold and silver have been prized for their extreme beauty and comparative rarity; the search after them has led to the intercourse between various races and peoples, and to the establishment of a world-wide commerce; while the facility with which they could be worked and polished called forth the highest powers of the artist and craftsman in the making of ornaments, coins, drinking-vessels, etc., many of which have come down to us from early times, sometimes showing a beauty of design which has never been

surpassed. Our own earliest rudiments of civilisation were probably acquired from the Phoenicians, who regularly came to Cornwall and our southern coasts to purchase tin.

Each of the seven metals (and a few others now in common use) has very special qualities which renders it useful for certain purposes, and these have so entered into our daily life that it is difficult to conceive how we should do without them. Without iron and copper an effective steam-engine could not have been constructed, our whole vast system of machinery could never have come into existence, and a totally distinct form of civilisation would have developed — perhaps more on the lines of that of China and Japan. Is it, we may ask, a pure accident that these metals, with their special physical qualities which render them so useful to us, should have existed on the earth for so many millions of years for no apparent or possible use; but becoming so supremely useful when Man appeared and began to rise towards civilisation?

But an even more striking case is that of the substances which in certain combinations produce glass. Sir Henry Roscoe states that silicates of the alkali metals, sodium and potassium, are soluble in water and are non-crystalline; those of the alkaline earths, calcium, etc., are soluble in acid and are crystalline; but by combining these silicates of sodium and calcium, or of potassium and calcium, the result is a substance which is not soluble either in water or acids, and which, when fused forms glass, a perfectly transparent solid, not crystallised but easily cut and polished, elastic within limits, and when softened by heat capable of being moulded or twisted into an endless variety of forms. It can also be coloured in an infinite variety of tints, while hardly diminishing its transparency.

The value of cheap glass for windows in cold or changeable climates cannot be over-estimated. Without its use in bottles, tubes, etc., chemistry could hardly exist; while astronomy could not have advanced beyond the stage to which it had been brought by Copernicus, Tycho Brahe, and Kepler. It rendered possible the microscope, the telescope, and the spectroscope, three instruments without which neither the starry heavens nor the myriads of life-forms would have had their inner mysteries laid open to us.

One more example of a recent discovery of one of the rarest substances in nature — radium — and its extraordinary effects, points in the same direction. So far as known at present, this substance may or may not be in any way important either to the earth as a planet or for the development of life upon it; but the most obvious result of its discovery seems to be the new light it throws on the nature of matter, on the constitution of the atom, and perhaps also on the mysterious ether. It has come at the close of a century of wonderful advance in our knowledge of matter and the mysteries of the atom. Many other rare elements or their compounds are now being found to be useful to man in the arts, in medicine, or by the light they throw on chemical, electrical, or ethereal forces.

If now we take the occurrence of all these apparently useless substances in the earth's crust; the existence in tolerable abundance, or very widely spread, of the seven metals known to man during his early advances towards civilisation, and the many ways in which they helped to further that civilisation; and, lastly, the existence of a few elements which, when specially combined, produce a substance without which modern science in almost all its branches would have been impossible, - we are brought face to face with a body of facts which are wholly unintelligible on any other theory than that the earth (and the universe of which it forms a part) was constituted as it is in order to supply us, when the proper time came, with the means of exploring and studying the inner mechanism of the world in which we live — of enabling us to appreciate its overwhelming complexity, and thus to form a more adequate conception of its author, and of its ultimate cause and purpose.

While this chapter is being written I see it announced that two of the rarest of the elements, lanthanium and neodynium, have been found to provide (through some of their compounds) light-filters, which increase the efficiency of the spectroscope in the study of the planetary atmospheres, and may thus be the means of still further extending our knowledge of the universe.

I have already shown that the postulate of a past eternal existence is no explanation, and leads to insuperable difficulties. A beginning in time for all finite things is thus demonstrable; but a beginning implies an antecedent cause, and it is impossible to conceive of that cause as other than an all-pervading mind.

The Mystery of Carbon: the Basis of Organised Matter and of Life

It is universally admitted that carbon is the one element which is essential to all terrestrial life. It will be interesting, therefore, to give a brief statement of what is known about this very important substance. Although it is so familiar to us in its solid form as charcoal, or in a more mineralised form as black-lead or graphite, it is doubtful whether it exists uncombined on the earth except as a product of vegetation. Though graphite (plumbago) is found in some of the earliest rocks, yet it is believed that some forms of vegetation existed much earlier. Graphite has also occurred (rarely) in meteorites, but I am informed by my friend, Professor Meldola, that it cannot be decided whether this is derived from carbondioxide gas or from gaseous carbon. Sir William Huggins was also doubtful as to the state in which it exists in the sun and comets, whether as carbon-vapour or a hydrocarbon. But the most interesting point for us is that it exists as a constituent of our atmosphere, of which carbon-dioxide forms about rfrcth part, equal to about jfafh part by weight of solid carbon; and it is from this that the whole of the vegetable kingdom is built up. The leaves of plants contain a green substance named chlorophyll, which by the aid of sunlight can extract the carbon from the gas, and there is no other means known by which this can be done at ordinary temperatures. The chemist has to use the electric spark, or very high temperatures, to perform what is done by the green leaves at the ordinary temperatures in which we live.

The reverse operation of combining carbon with other elements is equally difficult. In Chambers's Encyclopaedia we find the following statement: "At ordinary temperatures all the varieties of carbon are extremely unalterable; so much so that it is customary to burn the ends of piles of wood which are to be driven into the ground, so that the coating of nondecaying carbon may preserve the inner wood. Wood-charcoal, however, burns very easily, animal charcoal less so; then follow in order of difficulty of combustion coke, anthracite, blacklead, and the diamond." The two latter withstand all tem-, peratures, except the very highest obtainable. These various states of carbon differ in other respects. Ordinary carbon is a good conductor of electricity; the diamond is a non-conductor.

Carbon unites chemically with almost all the other elements, either directly or by the intervention of some of the gases. It also possesses, as Sir Henry Roscoe says:

Fundamental and distinctive quality. This consists in the power which this element possesses, in a much higher degree than any of the others, of uniting with itself to form complicated compounds, containing an aggregation of carbon-atoms united with either oxygen, hydrogen, nitrogen, or several of these, bound together to form a distinct chemical whole.

Carbon is also the one element that is never absent from any part or product of the vegetable or animal kingdoms; and its more special property is that, when combined with hydrogen, nitrogen, and oxygen, together with a small quantity (about 1 per cent) of sulphur, it forms the whole group of substances called albuminoids (of which white of egg is the type), and which, much diluted,

forms the essential part of the blood, from which all the solids and fluids of organisms are secreted. It was on these special features of carbon that Haeckel founded his celebrated carbon-theory of life, which he has thus stated: "The peculiar chemico-physical properties of carbon'—'especially the fluidity and the facility of decomposition of the most elaborate albuminoid compounds of carbon — are the sole and the mechanical causes of the specific phenomena of movement, which distinguish organic from inorganic substances, and which are called life, in the usual sense of the word." And he adds: "Although this 'carbon-theory' is warmly disputed in some quarters, no better monistic theory has yet appeared to replace it."

What a wonderfully easy way of explaining a mystery! Carbon forms a constituent of the bodies and of the products of all living things; therefore carbon is the cause of life and all its phenomena!

But besides the carbon in the atmosphere an immense quantity exists in the various limestone rocks, consisting of carbonate of lime (CaC03). It is quite possible, however, that these are all results of animal secretions as in coral-reefs; or of the debris of the hard parts of marine animals, as in the Globigerina-ooze. Limestones exist among the oldest rocks, but as we know that marine life was very much older, this is no objection. All water holds in solution a large quantity of carbonic acid gas, so that both air and water are the source of the most essential elements for building up the bodies of plants and animals.

The ocean also holds a large amount of carbonate of lime in solution, and this is kept permanently dissolved by the large amount of carbonic acid gas always present, which is sufficient to dissolve five times the amount of carbonate of lime which actually exists. Deposits of inorganic limestone are, therefore, now never formed except by long-continued evaporation in isolated bodies of salt water. This renders it more probable that all pure limestone rocks are really very ancient coral-reefs consolidated and crystallised by heat and pressure under masses of superincumbent strata.

The altogether remarkable and exceptional properties of carbon are fully recognised by modern chemists, as well shown by Professor H. E. Armstrong's statements in his Presidential Address to the British Association in 1909:

The central luminary of our system, let me insist, is the element carbon. The constancy of this element, the firmness of its affections and affinities, distinguishes it from all others. It is only when its attributes are understood that it is possible to frame any proper picture of the possibilities which he before us of the place of our science in the cosmos.

And a little further on he says:

Our present conception is, that the carbon atom has tetrahedral properties in the sense that it has four affinities which operate practically in the direction of four radii proceeding from the centre towards the four solid angles of a regular tetrahedron. . . . The completeness with which the fundamental properties of the carbon atom are symbolised by a regular tetrahedron being altogether astounding.

And again:

It would seem that carbon has properties which are altogether Bpecial; the influence which it exerts upon other elements in depriving them of their activity is so remarkable.

We see, therefore, that carbon is perhaps the most unique, in its physical and chemical properties, of the whole series of the elements, and so far as the evidence points, it seems to exist for the one purpose of rendering the development of organised life a possibility. It further appears that its

unique chemical properties, in combination with those of the other elements which constitute protoplasm, have enabled the various forms of life to produce that almost infinite variety of substances adapted for man's use and enjoyment, and especially to serve the purposes of his ever-advancing research into the secrets of the universe.

Water: its relations to Life and to Man

The compound water is as essential for building up living organisms as is carbon, and it exhibits peculiarities almost as striking as those of that element. Its more obvious qualities are singularly unlike those of its components, oxygen and hydrogen: oxygen supports combustion, water checks or destroys it; hydrogen burns readily, water is incombustible. Water is wonderfully stable at ordinary temperatures, hence it is the most innocuous of fluids; it is also an almost universal solvent, hence its great value in cookery, in the arts, and for cleansing purposes. Besides being absolutely essential for vegetable and animal life it has qualities which render it serviceable to civilised man, both in his pleasures and his scientific discoveries. Absolutely pure water is a non-conductor of electricity; but as all natural waters contain gases or salts in solution, it then becomes a conductor, and is partly decomposed, or becomes an electrolyte. The various curious facts connected with water are so puzzling, that in April 1910 the Faraday Society held a general discussion in order to arrive at some solution of what is termed in the Electrical Review "the most complex of problems." One of the facts that seem to be now generally accepted is, that water is not the simple compound, H20, it is usually held to be, but is really a compound of three hydrols, H20 being gaseous water, (H20)8 being ice, while liquid water is a mixture of these or (H20).

Professor H. E. Armstrong put forward this view in 1908, and in the Address already quoted he says:

Although it is generally admitted that water is not a uniform substance but a mixture of units of different degrees of molecular complexity, the degree of complexity and the variety of forms is probably under-estimated, and little or no attention has been paid to the extent to which alterations produced by dissolving substances in it may be the outcome and expression of changes in the water itself.

And again:

As water is altogether peculiar in its activity as a solvent, and is a solvent which gives rise to conducting solutions, an explanation of its efficiency must be sought in ite own special and peculiar properties.

Here again we find that the most common and familiar of the objects around us, and which we are accustomed to look upon as the most simple, may yet really be full of marvel and mystery.

The strange chemical properties of water are probably the cause of the singular but most important fact that water reaches its greatest density at 4°C. (= about 7° F.) above the freezing-point. If this curious anomaly did not exist the coldest water would always be at the bottom, and would freeze there; and thus many lakes and rivers during a hard winter would become solid ice, which the succeeding summer might not be able to melt. Sir Henry Eoscoe says:

If it were not for this apparently unimportant property our climate would be perfectly Arctic, and Europe would in all probability be as uninhabitable as Melville Island.

The very remarkable and highly complex relations between the quantity of water in our oceans, seas, and lakes, and the earth's habitability have been fully discussed in chapters xii. and xiii. of my volume on Man's Place in the Universe. I will only mention here, that in those chapters I have

pointed out the probable origin of the great oceanic basins; the proofs of their •permanence .throughout all geological time; the probable causes of that permanence; the necessity of such permanence to preserve the continuity of life-development, not only on the earth as a whole, but on each of the great continents; and, lastly, how all these phenomena have combined to secure that general uniformity of climatic conditions throughout the whole period of the existence of terrestrial life which was essential to its full and continuous development. There is, I believe, no more curious and important series of phenomena connected with the possibilities of life upon the earth than those described in the chapters above referred to.

Water as Preparing the Earth for Man

There remain yet some further relations of water to life which may be here briefly noticed. Among the various agencies that have modelled and remodelled the earth's surface, water has played the most important part. It is to water that we owe its infinite variety, its grandeur, its picturesqueness, its adaptability to a highly varied vegetable and animal life; and this work has been carried out through its manifold physical and chemical properties. It is in its three states, solid, liquid, and gaseous, that water exerts its most continuous and effective powers; and it is enabled to do this because, though each of these has its own limited range of temperature, they yet overlap, as it were, and can therefore act in unison. Thus within the narrow limits of temperature adapted to organic life we have both ice and water-vapour as well as liquid water, in almost continuous action. Through dew, mist, and rain, water penetrates every fissure of the rocks; through the carbonic acid gas dissolved in it, the rocks are slowly decomposed; by the expansion of water between 39° and 32° F. it freezes in the upper parts of the fissures, and when the temperature continues to fall the further expansion during ice-crystallisation forces the rocks asunder. The most massive rocks at high altitudes are first cracked and fissured by expansion and contraction due to alternations of temperature caused by sun-heat, then decomposed by rain, then fractured by the irresistible force of iceformation. On a large scale in polar regions, and everywhere at great altitudes, snowfields and permanent glaciers are formed, which not only carry down enormous quantities of debris on their surfaces or embedded in their substance, but with the help of that which is carried along the valley-floors they rest on, and by the enormous weight of the ice itself often miles in thickness, grind out deep valleys and lake-basins before cosmic or other agencies cause them to melt away.

This continuous water-action goes on perpetually in every continent, and is the great agent in producing that infinite variety of contour of the land surface — level plains, gentle slopes, beautifully rounded downs, wave-like undulations, valleys in every possible variety, basin-shaped, trough-shaped, "bounded by smooth slopes or rugged precipices, straight or -winding, and often leading us up into the very heart of grand mountain scenery, with their domes and ridges and rocky peaks, their swift-flowing streams, rushing torrents, dark ravines, and glorious cascades, in endless variety, beauty, and grandeur.

And all this we owe to what are termed the "properties of water," that extremely simple and unappreciated element, -which still abounds in mysteries that puzzle the men of science. Without water in all its various forms and with its many useful but very familiar properties, not only would life on the earth be impossible, but unless it had existed in the vast profusion of our ocean depths, and been endowed with its less familiar powers and forces, the whole world, instead of being a constantly varying scene of beauty — a very garden of delights for the delectation of all the higher faculties of man,— would have been for the most part a scene of horror, perhaps the sport of volcanic agencies of disruption and upheaval only modified by the disintegrating effects of sun and wind-action.

Our earth might thus have been in a state not very dissimilar from that in which the moon appears to be; not perhaps without a considerable amount of life, but with little of its variety, and with hardly any of that exquisite charm of contour and vegetation which we are now only beginning to appreciate and to enjoy.

Chapter XIX - IS NATURE CRUEL? THE PURPOSE AND LIMITATIONS OF PAIN

A very large number of persons of many shades of opinion, and various degrees of knowledge are disturbed by the contemplation of the vast destruction of life ever going on in the world. This disturbance has become greater, has become a mystery, almost a nightmare of horror, since organic evolution through the survival of the fittest has been accepted as a law of nature. The working out of the details of the Darwinian theory has forced public attention to this destruction, to its universality, to its vast amount, to its being the essential means of progress, to its very necessity as affording the materials for that constant adaptation to changes in the environment which has been essential for the development of the whole organic world.

The knowledge of this startling fact has come to us at a time when there is a great deal of humanity in the world, when to vast numbers of persons every kind of cruelty is abhorrent, bloodshed of every kind is repugnant, and deliberate killing of a fellow-man the greatest of all crimes. The idea, therefore, that the whole system of nature from the remotest eons of the past — from the very first appearance of life upon the earth — has been founded upon destruction of life, on the daily and hourly slaughter of myriads of innocent and often beautiful living things, in order to support the lives of other creatures, which others are specially adapted to destroy them, and are endowed with all kinds of weapons in order that they may the more certainly capture and devour their victims,— all this is so utterly abhorrent to us that we cannot reconcile it with an author of the universe who is at once all-wise, all-powerful, and all-good. The consideration of these facts has been a mystery to the religious, and has undoubtedly aided in the production of that widespread pessimism which exists to-day; while it lias confirmed the materialist, and great numbers of students of science, in the rejection of any supreme intelligence as having created or designed a universe which, being founded on cruelty and destruction, they believe to be immoral.

I am not aware that Darwin dealt with this question at all, except in the concluding words of his Origin of Species, where he says:

Thus, from the war of nature, from famine and death, the most exalted object we are capable of conceiving, namely, the production of the higher animals, directly follows.

This admits the facts as generally conceived; and, without palliating them, sets on the other side the great compensating result.

Much more to the point is the concluding sentence of his chapter on the Struggle for Existence:

When we reflect on this struggle, we may console ourselves with the full belief, that the war of nature is not incessant, that no fear is felt, that death is generally prompt, and that the vigorous, the healthy, and the happy survive and multiply.

These statements are, I believe, strictly true, but they do not comprise all that can be said on the question. Before dealing with the whole subject from the standpoint of evolution, I will quote the opinions of two eminent biologists, as showing how the matter has impressed even thoughtful and instructed writers. Professor J. Arthur Thomson (of Aberdeen University), when reviewing my Darwinism in The Theological Review, said:

Tone it down as you will, the fact remains that Darwinism regards animals as going upstairs, in a struggle for individual ends, often on the corpses of their fellows, often by a blood-and-iron competition, often by a strange mixture of blood and cunning, in which each looks out for himself and extinction besets the hindmost. We are not interested in any philosophical justification of this natural or unnatural method until we are sure that it is a fact.

These words do not, I hope, represent the Professor's view to-day; and I believe I shall be able to show that they by no means give an accurate impression of what the facts really are. About the same period the late Professor Huxley used terms still more erroneous and misleading. He spoke of the myriads of generations of herbivorous animals which "have been tormented and devoured by carnivores "; of the carnivores and herbivores alike as being "subject to all the miseries incidental to old age, disease, and over-multiplication "; and of tho "more or less enduring suffering" which is u the meed of both vanquished and victor "; and he concludes that, since thousands of times a minute, were our ears sharp enough, we should hear sighs and groans of pain like those heard by Dante at the gate of Hell, the world cannot be governed by what we call benevolence.1 Such a strong opinion, from such an authority, must have influenced thousands of readers; but I shall be able to show that these statements are not supported by facts, and that they are, moreover, not in accordance with the principles of that Darwinian evolution of which Huxley was so able and staunch a defender.

It is the influence of such statements as these, repeated and even exaggerated in newspaper articles and reviews all over the country, that has led so many persons to fall back upon the teaching of Haeckel — that the universe had no designer or creator, but has always existed; and that the life-pageant, with all its pain and horror, has been repeated cycle after cycle from eternity in the past, and will be repeated in similar cycles for ever. We have" here presented to us one of the strangest phenomena of the human mind — that numbers of intelligent men are more attracted by a belief which makes the amount of pain which they think does exist on the earth last for all eternity in successive worlds without any permanent and good result whatever, than by another belief, which admits the same amount of pain into one earth only, and for a limited period, while whatever pain there is only exists for the grand purpose of developing a race of spiritual beings, who may thereafter live without physical pain — also for all eternity! To put it shortly — they prefer the conception of a universe in which pain exists perpetually and uselessly, to one in which the pain is strictly limited, while its beneficial results are eternal!

None of these writers, however, nor, so far as I know, any evolutionist, has ever gone to the root of the problem, by considering the very existence of pain as being one of the essential factors in evolution; as having been developed in the animal world for a purpose; as being strictly subordinated to the law of utility; and therefore never developed beyond what was strictly needed for the preservation of life. It is from this point of view that I shall now discuss the question, and it will be found that it leads us to some very important conclusions. In order to do this, we must consider what were the conditions of the problem when life first appeared upon the earth.

The general facts as to the rate of increase of animals and plants have been given in Chapter VII. of this work; but even these facts, remarkable as they are, seem altogether insignificant when compared with those of the lowest forms of life. The most startling calculation of the kind I have seen was given last year in a Royal Institution lecture on The Physical Basis of life, by W. B. Hardy, F.R.S. (a Cambridge tutor), as to one of the infusoria (Paramecium) much used for experiment and observation on account of its comparatively large size (about y^th inch long) and its being very easily procured. This species multiplies by division about twice in three days, and has been kept under observation thus multiplying for more than 100 generations. Now it is not very difficult to calculate what quantity of Paramecia would be produced in any given number of generations, and what space they would occupy. No non-mathematical person can imagine or will believe the result.

It is, that if the conditions were such (as regards space, food, etc.) that the Paramecium could go on increasing for 350 generations, that is to say, for about two years, the produce would be sufficient in bulk to occupy a sphere larger than the known universe!

Now taking this as a type of the Protozoa — the one-celled animals and plants that still exist in thousands of varied forms — we see in imagination the beginnings of the vast world of life; and we also see the absolute necessity — if it was to continue and develop as it has done, filling the earth with infinite variety, and beauty, and the joy of life — for higher and higher forms to come successively into being, and for these forms to exist upon the food provided by the bodies of the lower. It follows that almost simultaneously with the first plant-cells which had the power of extracting carbon from the carbonic acid gas in the air and water and converting it into protoplasm, the first animal cells must also have arisen; and both must very rapidly have diverged into varied forms in order to avoid the whole of the water from being monopolised by some one form of each, and thus checking, if not altogether preventing, the development of higher and more varied forms. Variation and selection were thus necessary from the very first — were even far more necessary than at any later period, in order to avoid the possibility of the whole available space being occupied by some very low form to the exclusion of all others. Some writers have thought that, owing to the very uniform conditions in the primeval ocean, the development of new forms of life would then proceed more slowly than now. But a consideration of the enormously rapid increase of primitive life leads, to the conclusion that the reverse was the case. It seems more probable that evolution proceeded as much more rapidly than now, as the rate of increase of the lower animals is more rapid than that of the highest animals. This view is supported by the fact, observed long ago in the Foraminifera, that their variability was immensely greater than in any other animals; and this will serve to shorten the time required for the development of the life of the Cambrian period from the earliest onecelled animals.

We find, then, that the whole system of life-development is that of the lower providing food for the higher in ever-expanding circles of organic existence. That system has succeeded marvellously, even gloriously, inasmuch as it has produced, as its final outcome, Man, the one being who can appreciate the infinite variety and beauty of the life-world, the one being who can utilise in any adequate manner the myriad products of its mechanics and its chemistry. Now, whatever view we may take of the universe of matter, of life, and of mind, this successful outcome is a proof that it is the only practicable method, the only method that could succeed. For if we assume (with the monists) that it has been throughout the outcome of the blind forces of nature — of " the rush of atoms and the clash of worlds "— then, as they themselves admit, being the outcome of a past eternity of trial and error, it could not have been otherwise. If, on the other hand, it is, as I urge, the foreordained method of a supreme mind, then it must with equal certainty be the best, and almost certainly the only method, that could have subsisted through the immeasurable ages and could have then produced a being capable, in some degree, of comprehending and appreciating it. For that is surely the glory and distinction of man — that he is continually and steadily advancing in the knowledge of the vastness and mystery of the universe in which he lives; and how any student of any part of that universe can declare, as so many do, that there is only a difference of degree between himself and the rest of the animal-world,— that, in Haeckel's forcible words, " Our own human nature sinks to the level of a placental mammal, which has no more value for the universe at large than the ant, the fly of a summer's day, the microscopic infusorium, or the smallest bacillus,"—is altogether beyond my comprehension.

The Evolution of Pain

Taking it then as certain that the whole world-process is as it is, because it is the only method that could have succeeded, or that if there were alternative methods this was the best, let us ascertain what conclusions necessarily follow from it. And, first, we see that the whole cosmic process is

based upon fundamental existences, properties, and forces, the visible results of which we term the " laws of nature," and that, in the organic world at all events, these laws bring about continuous development, on the whole progressive. One of the subsidiary results of this mode of development is, that no organ, no sensation, no faculty arises before it is needed, or in a greater degree than it is needed. This is the essence of Darwinism. Hence we may be sure that all the earlier forms of life possessed the minimum of sensation required for the purposes of their short existence; that anything approaching to what we term " pain" was unknown to them. They had certain functions to fulfil which they carried out almost automatically, though there was no doubt a difference of sensation just enough to cause them to act in one way rather than another. And as the whole purpose of their existence and rapid increase was that they should provide food for other somewhat higher forms — in fact, to be eaten — there was no reason whatever why that kind of death should have been painful to them. They could not avoid it, and were not intended to avoid it. It may even have been not only absolutely painless but slightly pleasurable — a sensation of warmth, a quiet loss of the little consciousness they had, and nothing more —" a sleep and a forgetting."

People will not keep always in mind that pain exists in the world for a purpose, and a most beneficent purpose — that of aiding in the preservation of a sufficiency of the higher and more perfectly organised forms, till they have reproduced their Tcind. This being the case, it is almost as certain as anything not personally known can be, that all animals which breed very rapidly, which exist in vast numbers, and which are necessarily kept down to their average population by the agency of those that feed upon them, have little sensitiveness, perhaps only a Blight discomfort under the most severe injuries, and that they probably suffer nothing at all when being devoured. For why should they? They exist to be devoured; their enormous powers of increase are for this end; they are subject to no dangerous bodily injury until the time comes to be devoured, and therefore they need no guarding against it through the agency of pain. In this category, of painless, or almost painless animals, I think we may place almost all aquatic animals up to fishes, all the vast hordes of insects, probably all Mollusca and -worms; thus reducing the sphere of pain to a minimum throughout all the earlier geological ages, and very largely even now.

When we see the sharp row3 of teeth in the earlier birds and flying reptiles, we immediately think of the pain suffered by their prey; but the teeth were in all probability necessary for seizing the smooth-scaled fishes or smaller land-reptiles, which were swallowed a moment afterwards; and as no useful purpose would be served by the devoured suffering pain in the process, there is no reason to believe that they did so suffer.

The same reasoning will apply to most of the smaller birds and mammals. These are all so wonderfully adjusted to their environments, that, in a state of nature, they can hardly suffer at all from what we term accidents. Birds, mice, squirrels, and the like, do not get limbs broken by falls, as we do. They learn so quickly and certainly not to go beyond their powers in climbing, jumping, or flying, that they are probably never injured except by rare natural causes, such as lightning, hail, forest-fires, etc., or by fighting among themselves; and those who are injured without being killed by these various causes form such a minute fraction of the whole as to be reasonably negligible. The wounds received in fighting seem to be rarely serious, and the rapidity with which such wounds heal in a state of nature shows that whatever pain exists is not longcontinued.

It is only the large, heavy, slow-moving mammals which can be subject to much accidental injury in a state of nature from such causes as rock-falls, avalanches, volcanic eruptions, or falling trees; and in these cases by far the larger portion would either escape unhurt or would be killed outright, so that the amount of pain suffered would, in any circumstances, be small; and as pain has been developed for the necessary purpose of safe-guarding the body from often-recurring dangers, not from those of rare occurrence, it need not be very acute. Perhaps self-mutilation, or fighting to the death, are the greatest dangers which most wild animals have to be guarded against; and no very

extreme amount of pain would be needed for this purpose, and therefore would not have been produced.

But it is undoubtedly not these lesser evils that have led to the outcry against the cruelty of nature, but almost wholly what is held to be the widespread existence of elaborate contrivances for shedding blood or causing pain that are seen throughout nature — the vicious-looking teeth and claws of the cat-tribe, the hooked beak and prehensile talons of birds of prey, the poison fangs of serpents, the stings of wasps, and many others. The idea that all these weapons exist for the purpose of shedding blood or giving pain is wholly illusory. As a matter of fact, their effect is wholly beneficent even to the sufferers, inasmuch as they tend to the diminution of pain. Their actual purpose is always to prevent the escape of captured food — of a wounded animal, which would then, indeed, suffer useless pain, since it would certainly very soon be captured again and be devoured. The canine teeth and retractile claws hold the prey securely; the serpent's fangs paralyse it; and the wasp's sting benumbs the living food stored up for its young, or serves as a protection against being devoured itself by insect-eating birds; which latter, probably, only feel enough pain to warn them against such food in future. The evidence that animals which are devoured by lion or puma, by wolf or wild cat, suffer very little, is, I think, conclusive. The suddenness and violence of the seizure, the blow of the paw, the simultaneous deep wounds by teeth and claws, either cause death at once, or so paralyse the nervous system that no pain is felt till death very rapidly follows. It must be remembered that in a state of nature the Carnivora hunt and kill to satisfy hunger, not for amusement; and all conclusions derived from the house-fed cat and mouse are fallacious. Even in the case of man, with his highly sensitive nervous system, which has been developed on account of his unprotected skin and excessive liability to accidental injury, seizure by a lion or tiger is hardly painful or mentally distressing, as testified by those who have been thus seized and have escaped.

Our whole tendency to transfer our sensations of pain to all other animals is grossly misleading. The probability is, that there is as great a gap between man and the lower animals in sensitiveness to pain as there is in their intellectual and moral faculties; and as a concomitant of those higher faculties. We require to be more sensitive to pain because of our bare skin with no protective armour or thick pads of hair to ward off blows, or to guard against scratches and wounds from the many spiny or prickly plants that abound in every part of the world; and especially on account of our long infancy and childhood. And here I think I see the solution of a problem which has long puzzled me — why man lost his hairy covering, especially from his back, where it would be so useful in carrying off rain. He may have lost it, gradually, from the time when he first became Man — the spiritual being, the "living soul" in a corporeal body, in order to render him more sensitive. From that moment he was destined to the intellectual advance which we term civilisation. He was to be exposed to a thousand selfcreated dangers totally unknown to the rest of the animal world. His very earliest advance towards civilisation — the use of fire — became thenceforth a daily and hourly danger to him, to be guarded against only by sudden and acute pain; and as he advanced onwards and his life became more complex; as he surrounded himself with dwellings, and made clothing and adopted cookery as a daily practice, he became more and more exposed to loss, to injury, and to death from fire, and thus would be subject to the law of selection by which those less sensitive to fire, and therefore more careless in the use of it, became eliminated.

His tools continually becoming more and more dangerous, and his weapons becoming more and more destructive, were alike a danger to him. The scythe and the sickle caused accidental wounds, as did the needle and the knife. The club and the axe, the spear and the arrow, the sword and the dagger, caused wounds which, if not avoided, led quickly to death. Hence beneficent pain increased with him as a warning of danger, impelling him to the avoidance of wounds by skill and dexterity, by the use of padded clothing or of flexible armour; while nature's remedies were sought out to heal the less deadly injuries, and thus avoid long suffering or permanent disablement. And

ever as civilisation went on, such dangers increased. Explosives caused a new kind of wound from musket or pistol, and later from bombs and mines. Boats and ships were built and the ocean traversed. Endless forms of machinery were invented, at first hand-worked, and not dangerous to the worker, but soon driven by steam with such force that if carelessly entangled in it the worker's limbs might be torn from his body. And all this went on increasing till at last a large proportion of the human race laboured daily in peril of life or limb, or of painful wounds, or worse diseases. Against this vast ever-present network of dangers, together with the everpresent danger of consuming fire, man is warned and protected by an ever-increasing sensibility to pain, a horror at the very sight of wounds and blood; and it is this specially developed sensibility that we, most illogically, transfer to the animal-world in our wholly exaggerated and often quite mistaken views as to the cruelty of nature!

As a proof of the increased sensibility of the civilised as compared with the more savage races, we have the well-known facts of the natives of many parts of the world enduring what to us would be dreadful torments without exhibiting any signs of pain. Examples of this are to be found in almost every book of travels. I will here only mention one. Among most of the Australian tribes there is a regular scale of punishment for various offences. When a man entices away another man's wife (or in some other offence of an allied nature) the allotted punishment is, that the complainant and his nearest relatives, often eight or ten in number or even more, are to be allowed to thrust a spear of a certain size into the offender's leg between ankle and knee. The criminal appears before the chiefs of the tribe, he holds out his leg, and one after another the members of the offended family walk up in turn, each sticks in his spear, draws it out, and retires. When all have done so, the leg is a mass of torn flesh and skin and blood; the sufferer has stood still without shrinking during the whole operation. He then goes to his hut with his wife, lies down, and she covers the leg with dust — probably fine wood ashes. For a few days he is fed with a thin gruel only, then gets up, and is very soon as well as ever, except for a badly scarred leg. Of course we cannot tell what he actually suffered, but certainly the average European could not have endured such pain unmoved.

This, however, is only an illustration. It is not essential to the argument, which is founded wholly on the principles of Darwinian evolution. One of these principles, much insisted on by Darwin, is, that no organ, faculty, or sensation can have arisen in animals except through its utility to the species. The sensation of pain has been thus developed, and must therefore be proportionate in each species to its needs, not heyond those needs. In the lowest animals, whose numbers are enormous, whose powers of increase are excessive, whose individual lives are measured by hours or days, and which exist to be devoured, pain would be almost or quite useless, and would therefore not exist. Only as the organism increased in complexity, in duration of life, and in exposure to danger which might possibly lead to its death before it could either leave | offspring or serve as food to some higher form — only then could pain have any use or meaning.

I have now endeavoured, very roughly, to follow out this principle to its logical results, which are, that only in the higher and larger members of the highest vertebrates — mammals and birds, do the conditions exist which render acute sensations of pain necessary, or even serviceable. Only in the most highly organised, such as dogs and horses, cattle, antelopes, and deer, does there appear to be any need for acute sensations of pain, and these are almost certainly, for reasons already given, very much less than ours. The logical conclusion is, therefore, that they only suffer a very moderate amount of pain from such bodily injuries as they are subject to in a state of nature.

I have already shown that in most cases, even from our much higher standard, their death would be rapid and almost painless; whence it follows, that the widespread idea of the cruelty of nature is almost wholly imaginary. It rests on the false assumption that the sensations of the lower animals are necessarily equal to our own, and takes no account whatever of these fundamental principles of evolution which almost all the critics profess to accept.

There is, of course, a large body of facts which indicate that whole classes of animals, though very highly organised, suffer nothing which can be called pain, as in the insects; and similar facts show us that even the highest warm-blooded animals suffer very much less than we do. But my argument here does not depend upon any such evidence, but on the universally accepted doctrine of evolution through adaptation. According to that theory, it is only life-preserving variations, qualities, or faculties that have survival value: pain is one of the most important of these for us, but it is by no means so important to any other animal. No other animal needs the pain-sensations that we need; it is therefore absolutely certain that no other possesses such sensations in more than a fractional degree of ours. What that fraction is we can only roughly estimate by carefully considering the circumstances of each case. These show that it is certainly almost infinitesimal in by far the larger part of the animal kingdom, very small in all invertebrates, moderately small in fishes and reptiles, as well as in all the smaller birds and mammals. In the larger of these two classes it is probably considerable, but still far below that of even the lowest races of man.

A Possible Misconception

It may be said — I fear it will be said — that this idea of the lower animals suffering less pain than we suffer will be taken as an argument in favour of vivisection. No doubt it will; but that does not in the least affect the actual truth of the matter, which is, I believe, as I have stated. The moral argument against vivisection remains, whether the animals suffer as much as we do or only half as much. The bad effect on the operator and on the students and spectators remains; the undoubted fact that the practice tends to produce a callousness and a passion for experiment, which leads to unauthorised experiments in hospitals on unprotected patients, remains; the horrible callousness of binding the sufferers in the operating trough, so that they cannot express their pain by sound or motion, remains; their treatment, after the experiment, by careless attendants, brutalised by custom, remains; the argument of the uselessness of a large proportion of the experiments, repeated again and again on scores and hundreds of animals, to confirm or refute the work of other vivisectors, remains; and, finally, the iniquity of its use to demonstrate already-established facts to physiological students in hundreds of colleges and schools all over the world, remains. I myself am thankful to be able to believe that even the highest animals below ourselves do not feel so acutely as we do; but that fact does not in any way remove my fundamental disgust at vivisection as being brutalising and. immoral. A Recent Illustration of the Necessity of Pain.

Within the last few years we have had remarkable proofs of the beneficence of pain as a life-saver by the sad results of its absence. The recently discovered X-rays, so much used now for localising internal injuries, and of bullets or other foreign objects in any part of the body, have the property also of setting up a special internal disorganisation unaccompanied at the time by pain. The result has been loss of limbs or loss of life to some of the earlier investigators, and perhaps some injury even to the patients for whose benefit it has been applied. It seems probable, therefore, that if these rays had been associated in any perceptible degree with the heat and light we receive from the sun, either the course of evolution would have been very different from what it has been, or the development of life have been rendered impossible. Pain has not accompanied the incidence of these rays on the body, because living organisms have never hitherto been exposed to their injurious effects.

Microbes and Parasites: their Purpose in the Life-World

Much light is thrown on the analogous problem of those human diseases which are supposed to be caused by germs, microbes, or parasites, by the application of the more extended views of evolution I have advocated in the present volume. The medical profession appear to hold the view that pathogenic or disease-producing microbes exist for the purpose of causing disease in otherwise

healthy bodies to which they gain access — that they are, in fact, wholly evil. It is also claimed that the only safeguard against them is some kind of "anti-toxin" with which every one must be inoculated to be saved from the danger of attack by some or all of the large number of such diseases which affect almost every organ and function of the body. This view seems to me to be fundamentally wrong, because it does not show us any use for such microbes in the scheme of life, and also because it does not recognise that a condition of health is the one and only protection we require against all kinds of disease; and that to put any product of disease whatever into the blood of a really healthy person is to create a danger far greater than the disease itself.

On the general principles of the present argument there can be nothing in nature which is not useful, and, in a broad sense, essential to the whole scheme of the life-world. On this principle the purpose and use of all parasitic diseases, including those caused by pathogenic germs, is to seize upon the less adapted and less healthy individuals — those which are slowly dying and no longer of value in the preservation of the species, and therefore to a certain extent injurious to the race by requiring food and occupying space needed by the more fit. Their life is thus shortened, and a lingering and un enjoy able existence more speedily terminated. One recent writer seems to hold this view, as shown by the following passage:

Before it was perceived that disease is an undisputable battlefield of the true Darwinian struggle for existence, the tremendous part which it takes in ridding the earth of weaklings and causing the survival of health, was all credited to the environment and its dead physical forces.

But in this interesting article the writer elsewhere uses language implying that even the healthy require rendering "immune" against all zymotic diseases. It is that idea which I protest against as a libel on nature and on the Euler of the Universe; and in its practice as constituting a crime of equal gravity with vivisection itself.

It will be said that quite healthy persons die of these diseases, but that cannot be proved; and the absolutely universal fact that it is among those living under unhealthy conditions in our towns, and cities, and villages, that suffer most from these diseases is strongly against the truth of the statement. No doubt savage races often suffer dreadfully from these diseases; hut savages are no more universally healthy than the more civilised, though it Ib usually a different kind of unhealthiness. The only doctrine on this matter worthy of an evolutionist, or of a believer in God, is that health of body and of mind are the only natural safeguards against disease; and that securing the conditions for such health for every individual is the one and only test of a true civilisation.

A few words in conclusion on the main question of pain in the animal world. In my treatment of the subject I believe I have given unnecessary weight to those appearances by which alone we judge of pain in the lower animals. I feel sure that those appearances are often deceptive, and that the only true guide to the evolutionist is a full and careful consideration of the amount of necessity there exists in each group for painsensation to have been developed in order to preserve the young from common dangers to life and limb before they have reached full maturity. It is exactly the same argument as I have made use of in discussing the question of how much colour-sense can have been developed in mammals or in butterflies. In both cases it depends fundamentally on utilities of life-saving value as required for the continuance of the race. Hitherto the problem has never been considered from this point of view, the only one for the evolutionist to adopt. Hence the ludicrously exaggerated view adopted by men of such eminence and usually of such calm judgment as Huxley — a view almost as far removed from fact or science as the purely imaginary and humanitarian dogma of the poet:

The poor beetle, that we tread upon,
In corporal sufferance feels a pang as great

As when a giant dies.

Whatever the giant may feel, if the theory of evolution is true, the "poor beetle" certainly feels an almost irreducible minimum of pain, probably none at all.

Chapter XX - INFINITE VARIETY THE LAW OF THE UNIVERSE (CONCLUSION)

Throughout the present work I have had occasion to call attention to the endless diversity that characterises both organic and inorganic nature. In a previous work, Man's Place in the Universe, I was impressed by the diversity which the new astronomy had shown to exist throughout the stellar universe. Since that book was written such remarkable advance has been made in relation to the nature of matter itself, as to constitute almost a new science. It seems desirable, therefore, to say a few words here upon the whole question of the variety and complexity of every part of the material universe in its relation to man as an intellectual and moral being, thus summarising the whole aim and tendency of the present work.

It will, I think, be most instructive to follow the same order as I have adopted in the present volume, of showing how each kind of variety and complexity that presents itself to us can be traced back as dependent upon a preceding complexity, usually less obvious and more recently brought to light. Thus, the most obvious of all the diversities in nature is that of the various forms (or kinds) of animals and plants; whereas the diversities of inorganic nature — stones, rocks, etc., are far less obvious, and were discovered at a much later period.

The Causes of the Diversity of Life-forms

Modern research shows us that the immense diversity of lifeforms we now find upon the earth is due to two kinds of causes, the one immediate, the other remote. The immediate cause is (as I have endeavoured to sho\~ here), the slow but continuous changes of the earth's surface as regards contour, altitude, climate, and distribution of land and water, which successively open new and unoccupied places in nature, to fill which some I previously existing forms become adapted through variation and natural selection. I have sufficiently shown how this process has worked throughout the geological ages, the world's surface ever becoming more complex through the action of the lowering and elevating causes on a crust which at each successive epoch has itself become more complex. This has always resulted in a more varied and generally higher type of vegetation, and through this a more varied and higher type of animal life.

The remote but more fundamental cause, which has been comparatively little attended to, is the existence of a special group of elements possessing such exceptional and altogether extraordinary properties as to render possible the existence of vegetable and animal life-forms. These elements correspond roughly to the fuel, the iron, and the water which render a steam-engine possible; but the powers, the complexities, and the results are millions of times greater in the former, and we may presume that the Mind which first caused these elements to exist, and then built them up into such marvellous living, moving, self-supporting, and self-reproducing structures, must be many millions times greater than those which conceived and executed the modern steam-engine.

Variety of Inorganic Substances

The recognised elements are now about eighty in number, and half of these have been discovered during the past century; while twenty of them, or one-fourth of the whole, have been added during the last fifty years. These last are all very rare, but among those discovered in the preceding fifty years are such now familiar and important elements as aluminium, bromine, silicon, iodine, fluorine, and chlorine. So far as the elements are concerned, our earth has doubled in apparent complexity of structure during the last century. But if we take account of the advance of chemical

science, the knowledge that elements, the wonderfully complex laws of their combinations, and the immense variety of their known compounds, our everincreasing knowledge of the complexity of matter will be very much greater.

During the early part of the nineteenth century, the old idea of atoms as being indivisible, incompressible, and indestructible particles, almost universally prevailed. They were usually supposed to be spherical in form, and to be the seat of both attractive and repulsive forces, leading to cohesion and chemical combination. Those of the different elements were supposed to differ slightly in size, and energy, which led to their differences of weight and other properties. The whole conception, though we now see it to be totally inadequate, was comparatively simple, and with the help of the mysterious electric and magnetic forces seemed capable of explaining much.

But, decade after decade, fresh discoveries were made; chemical theory became more and more complex; electricity, the more it was known the less intelligible it became; while a host of new discoveries in the radiant forces of the ether seemed to show that this mysterious substance was really the seat of all the forces of the universe, and that the various basic forms of matter which we term elements were nothing more than the special manifestation of those forces. It thus became evident that all our progress in physical science rendered the world of matter far more wonderful, and at the same time less intelligible than it had ever seemed to us before.

The progress of modern chemistry well shows this increasing complexity with increasing knowledge. The fact of carbon existing in three distinct forms — charcoal, graphite, and diamond, each with its own special physical and chemical characters — has already been referred to. But it is found that many other elements have similar properties, especially silicon, phosphorus, arsenic, antimony, sulphur, oxygen, and several others. This curious property is termed allotropy; and it seems somewhat analogous to that property of many compound substances termed isomerism, of which two striking examples were given at the beginning of the last chapter. Another modern branch of chemistry is the study of the relation of crystallised substances to polarised light, which reveals many new and strange properties of identical compounds, and is termed Stereo-chemistry.

Returning now to the different forms under which matter exists in that portion of the earth which we can examine, we find them to be very limited as compared with those of the organic world. The crust of the earth, and presumably the interior also, consists mainly of what are called minerals, which is the term used for all chemical compounds of the elements which have been produced under natural law9 and forces, and constitute the materials of the whole planet. They comprise, besides the elements themselves, the various salts, alkalis, earths, metallic ores, precious stones, and crystals, which have a definite chemical constitution, a permanent form, and definite characters; forming what are termed mineral species. These, when disintegrated by natural forces, intermingled in various ways, and solidified in various degrees, make up the whole mass of rocks and surface material of the earth. The total number of mineral-species now known, almost the whole of which are to be found in the fine mineralogical gallery of the British Museum, is almost exactly a thousand. Many of these are very rare or local, the great bulk of the rocks being made up of a few score, or at most of a few hundreds of them.

The generally accepted idea being that the whole earth was once a molten mass, the crust may be supposed to give a fair sample of the whole; and the additional fact that, during all geological time, matter from the interior has been brought to ????????

These various properties of the atoms and molecules of matter have so complicated their relations, that the attempt to unravel them has led to a system of equations, of diagrams, and of formulse, which are almost as difficult for the general reader to follow in detail, as is the working out of some abstruse mathematical investigation. As an example of this complexity in chemical

nomenclature I may refer to a recent paper by Sir William Crookes, on the rare metal scandium (discovered in 1879). Near the end of this paper (in the Proc. Roy. Soc., series A, vol. 84, p. 84), the author says:

By the kindness of Dr. Silberrad, I have had an opportunity of experimenting with octamethyltetraminodihydroxyparadixunthylbezonetetracarboxilic acid.

He then adds: "Previous experiments would lead one to expect the scandium salt of this acid to have the composition C44HMOuN,Scr The only scandium salt I could form with this acid has the composition CMHJ,0»N,Scll.

The surface by volcanoes and hot springs, renders it probable that very few either of the elements or compounds remain unknown.

The skill of the chemist, however, has led to the production of a much greater number of stable chemical compounds than occur in nature. These are used in medicine or in the various arts, and their numbers are very great. They are usually divided into two classes, the inorganic and the organic; the former being of the same nature as those of the great bulk of the mineral species, while the latter, called also carbon-compounds, resemble the products of living organisms of which carbon is an essential part.

A recent estimate of the known inorganic compounds, natural and artificial, by a French chemist is 8000; but Mr. I. Fletcher, of the British Museum, informs me that this number must only be taken as an "irreducible minimum." As to organic compounds, I am told by Professor H. E. Armstrong, that they have recently been estimated at about 100, 000; but he states that the possibilities of forming such compounds are infinite, that chemists can make them by thousand if required, and that they now limit themselves to those which have some special interest. The approximate figures for the various kinds of stable chemical compounds now known, will therefore form an easily remembered series: —

Mineral species 1,000
Inorganic compounds (artificial) 10,000
Organic compounds (artificial) 100,000
Possible organic compounds Infinite!

What a wonderful conception this affords us of the possibilities of the elements (or rather of about one-fifth of them) to produce the almost endless variety of natural products in the vegetable and animal kingdoms. These possibilities must depend upon the "properties" of the elements; not only their actual properties as elements, but their latent properties through which they not only combine with each other in a great variety of ways, but, by each combination create, as it were, a new substance, possessing properties and powers different from those of any other substances whatever. These almost infinitely various properties of chemical combinations, together with a host of other problems with which the organic chemist has to deal, have led some of them to almost exactly the same conclusion to which I have been led by a more superficial view of the marvels of "growth" and cell-division in living organisms. In the Address already quoted, Sir H. E. Armstrong says, after referring to some of the complex and extraordinary chemical transformations produced by living plants:

The general impression produced by facts such as these is, that directive influences are the paramount influences at work in building up living tissues.

And again more explicitly:

It would seem that control is exercised and stability secured in several ways; not only is the form laid down in advance but certain chosen materials are alone available, and the builders can only unite particular materials in particular ways.

It is very satisfactory to find that both chemists and physiologists recognise the absolute need of some controlling and directive power in elaborating the special products or building up the complex tissues of plants and animals.

The Cause and Purpose of this Variety

The general conclusion to which the whole argument of this volume tends, is, that the infinite variety we see in nature can be traced back step by step to the almost infinite complexity of the cells by means of which they live and grow; of the protoplasm which is the substance of the cells; of the elements of which protoplasm consists; of the molecules of those elements; and finally of the atoms whose combination forms the separate and totally distinct elementary molecules. And at each step farther back we are as far off as ever from comprehending how it is possible for such infinite diversity to be brought about. And now that we are led to believe that the atom itself is highly complex—that it ia a system of revolving electrons or corpuscles, held together T)y tremendous forces — the mystery becomes deeper still, and we find it quite hopeless to realise what is the nature of the controlling power and mind, which out of such unimaginable entities has built up the vast material universe of suns and systems of which our earth forms a fractional part, together with that even more complex world of life of which we ourselves are the outcome.

The overwhelming complexity and diversity of this vast cosmos in its every part and detail, is the great fundamental characteristic which our highest science has brought prominently to our notice; but neither science nor religion has given us the slightest clue as to why it should be so. Science says: "It is so. Ours not to reason why; but only to find out what is." Religion says: "God made it so "; and sometimes adds, "it was God's will; it is impious to seek any other reason." In the present work I have endeavoured to suggest a reason which appeals to me as both a sufficient and an intelligible one: it is that this earth with its infinitude of life and beauty and mystery, and the universe in the midst of which we are placed, with its overwhelming immensities of suns and nebulfe, of light and motion, are as they are, firstly, for the development of life culminating in man; secondly, as a vast schoolhouse for the higher education of the human race in preparation for the enduring spiritual life to which it is destined.

I have endeavoured to show that some portion at least of what seems a superfluity of elements in our earth-structure has served the purpose of aiding the gradual progress of man from barbarism to material civilisation; while another portion has furnished him with materials which have alone enabled him to penetrate into the two unknown worlds with which he was encompassed — those of the almost infinitely great and of the almost infinitely little; but both alike attractive and grand in their revelations; both offering ever-fresh vistas of unfathomed mysteries; both impressing upon him the existence of immanent forces and controlling mind-power as their only possible cause.

I suggest, further, that these deeper and deeper mysteries which confront us everywhere as we advance farther in our knowledge of this universe, are now serving, and will serve in the future so long as man exists upon the earth, to give him more and more adequate conceptions of the power, and perhaps to some extent of the nature, of the author of that universe; will furnish him with the materials for a religion founded on knowledge, in the place of all existing religions, based largely on the wholly inadequate conceptions and beliefs of by-gone ages.

A Suggestion as to the Origin of Life

As it may be expected that I should state what is my own conception of the power which I claim to be proved to exist, and to be the fundamental cause of the life-world as well as of the material universe, I will here make a few suggestions as to what seems to me to be the least improbable, the least difficult, of all attempts to deal with what Herbert Spencer held to be "unknowable," but the non-existence of which he held to be unthinkable. In the Chapter on Religion, in Darwin's Life and Letters, he also seems to have rested in the one conclusion, that the universe could not have existed without an intelligent cause, but that any adequate conception of the nature of that cause was beyond the powers of the human mind to form. With these views I am in complete sympathy; but I yet think that we can form some conceptions of the powers at work in nature which help us to overcome the insuperable difficulty as to the nature of the infinite and absolute creator, not only of our world and our universe, but of all that exists or can exist in infinite space. Here, as everywhere in science, we must not attempt to deal with the ultimate problem without studying or comprehending the steps by which it may be approached.

I venture to hope that in the present volume, and especially in the last six chapters, I have satisfied most of my readers that the vast life-world, with its myriad forms, each one originating in a single cell, yet growing, by cell-division, into such marvels of variety, of use, and of beauty, does absolutely require some non-mechanical mind and power as its efficient cause. To such only my further argument will be directed.

My first point is, that the organising mind which actually carries out the development of the life-world need not be infinite in any of its attributes — need not be what is usually meant by the terms God or Deity. The main cause of the antagonism between religion and science seems to me to be the assumption by both that there are no existenpes capable of taking part in the work of creation other than blind forces on the one hand, and the infinite, eternal, omnipotent God on the other. The apparently gratuitous creation by theologians of a hierarchy of angels and archangels, with no defined duties but that of attendants and messengers of the Deity, perhaps increases this antagonism, but it seems to me that both ideas are irrational. If, as I contend, we are forced to the assumption of an infinite God by the fact that our earth has developed life, and mind, and ourselves, it seems only logical to assume that the vast, the infinite chasm between ourselves and the Deity is to some extent occupied by an almost infinite series of grades of beings, each successive grade having higher and higher powers in regard to the origination, the development, and the control of the universe.

If, as I here suggest, the whole purport of the material universe (our universe) is the development of spiritual beings who, in the infinite variety of their natures — what we term their characters,— shall to some extent reflect that infinite variety of the whole inorganic and organic worlds through which they have been developed; and if we further suppose (as we must suppose if we owe our existence to Deity) that such variety of character could have been produced in no other way; then we may reasonably suppose that there may have been a vast system of co-operation of such grades of being, from a very high grade of power and intelligence down to those unconscious or almost unconscious "cell-souls" posited by Haeckel, and which, I quite admit, seem to be essential coadjutors in the process of life-development.

Now granting all this, and granting, further, that each grade of being would be, for such a purpose as this, supreme over, all beings of lower grade, who would carry out their orders or ideas with the most delighted and intelligent obedience; I can imagine the supreme, the Infinite being, foreseeing and determining the broad outlines of a universe which would, in due course and with efficient guidance, produce the required result . He might, for instance, impress a sufficient number of his highest angels to create by their will-power the primal universe of ether, with all those inherent properties and forces necessary for what was to follow. Using this as a vehicle the next subordinate

association of angels would so act upon the ether as to develop from it, in suitable masses and at suitable distances, the various elements of matter, which, under the influence of such laws and forces as gravitation, heat, and electricity, would thenceforth begin to form those vast systems of nebulae and suns which constitute our stellar universe.

Then we may imagine these hosts of angels, to whom a thousand years are as one day, watching the development of this vast system of suns and planets until some one or more of them combined in itself all those conditions of size, of elementary constitution, of atmosphere, of mass of water and requisite distance from its source of heat, as to ensure a stability of constitution and uniformity of temperature for a given minimum of millions of years or of ages, as would be required for the full development of a life-world from Amoeba to Man, with a surplus of a few hundred millions for his adequate development.

Thought-transference as an agent in Creation

In my Man's Place in the Universe I have pointed out the very narrow range of the quantitative and qualitative conditions which such a world must possess; and the next step in the process of what may be well termed "creation" would be the initiation of life by the same or a subordinate body of spirit-workers, whose duty would be, when the waters of the cooling earth had reached a proper temperature and were sufficiently saturated with gases and carbon-compounds, to infuse into it suitable life-centres to begin the process of organisation, which, as Huxley acknowledged, implies life as its cause. How this was done it is impossible for us to know, and useless to speculate; but there are certain guides. Erom Haeckel's concession of "cell-souls" possessing volition, but a minimum of sensation, we have one conceivable startingpoint. From Weismann's vivid description of cell-growth and cell-division, with its complex apparatus, its purposive motions so evidently adapted to bring about a definite result, and its invariable onward march to that result, we as surely imply an intelligence and power far beyond anything we know or can clearly conceive.

We are led, therefore, to postulate a body of what we may term organising spirits, who would be charged with the duty of so influencing the myriads of cell-souls as to carry out their part of the work with accuracy and certainty. In the power of "thought-transference" or mental impression, now generally admitted to be a vera causa, possessed by many, perhaps by all of us, we can understand how the higher intelligences are able to so act upon the lower and that the work of the latter soon becomes automatic. The work of the organisers is then directed to keeping up the supply of life-material to enable the cell-souls to perform their duties while the cells are rapidly increasing.

At successive stages of development of the life-world, more and perhaps higher intelligences might be required to direct the main lines of variation in definite directions in accordance with the general design to be worked out, and to guard against a break in the particular line which alone could lead ultimately to the production of the human form. Some such conception as this — of delegated powers to beings of a very high, and to others of a very low grade of life and intellect — seems to me less grossly improbable than that the infinite Deity not only designed the whole of the cosmos, but that himself alone is the consciously acting power in every cell of every living thing that is or ever has been upon the earth.

What I should imagine the highest intelligence engaged in the work (and this not the Infinite) to have done would be Bo to constitute the substance of our universe that it would afford the materials and the best conditions for the development of life; and also, under the simple laws of variation, increase, and survival, would automatically lead to the maximum of variety, beauty, and use for man, when the time came for his appearance; and that all this should take place with the minimum lof guidance beyond that necessary for the actual working of the life-machinery of all the

organisms that were produced under these laws. Some such conception seems to me to be in harmony with the universal teaching of nature — everywhere an almost infinite variety, not as a detailed design (as when it was supposed that God made every valley and mountain, every insect and every serpent), but as a foreseen result of the constitution of the universe. The vast whole is therefore a manifestation of his power — perhaps of his very self — but by the agency of his ministering angels through many descending grades of intelligence and power.

Diversity of Human Character

Many people are disturbed by the now well-established fact that the effects of use, of training, or of education, are not inherited; and that though innate mental as well as bodily characters vary much through inheritance these can only be developed in special directions by some form of selection. There being very little if any effective selection of character among civilised people, they therefore fear that there can be no continued advance of the race. Quite recently I have discussed this question from two points of view. By a general glance over the early history of civilised man I have shown that there is little if any evidence of advance in character or in intellect from the earliest times of which we have any record.1 I had already, twenty years ago, shown in some detail how, under a rational system of society, in which all the present soul-degrading influences of individualistic wealth and poverty would be abolished, (especially as leading to unholy marriages) a progressive advance in character would necessarily arise through elimination of the worst and most degraded by an effective and truly natural selection.2 The following passage towards the end of the former article will briefly indicate the nature of the argument in both these essays:

The great lesson taught us by this brief exposition of the phenomena of character in relation to the known laws of organic evolution is this: that our imperfect human nature, with its almost infinite possibilities of good and evil, can only make a systematic advance through the thoroughly sympathetic and ethical training of every child from infancy upwards, combined with that perfect freedom of choice in marriage which will only be possible when all are economically equal, and no question of social rank or material advantage can have the slightest influence in determining that choice.

It now only remains to show, very briefly, how the views here sketched out are in perfect harmony with the entire scheme of the life-world. That scheme is shown to be the production of an almost infinite diversity in forms of life, beautifully coordinated for the common good, and for the ultimate development and education of an almost equally varied humanity. That variety has been assured and increased by the rapid development of man — from the epoch when he became a hving soul conscious of good and evil — so far above the beasts which perish that there was little actual selection except to ensure health and vigour, and the gradual advance towards civilisation. All types of character had a fairly equal chance of survival and of leaving offspring, and thus the continued unchecked action of the universal law of variation led to an amount of diversity of human nature far above that of any of the lower animals. We see this diversity manifested through all the ages, from the lowest depths of a Nero, a Borgia, or a De Retz, to the glorious heights of a Confucius or a Buddha, a Socrates or a Newton.

But if it had been a law of nature that the effects of education should be inherited, then men would have been continually moulded to certain patterns; originality would have been bred out by the widespread influences of mediocrity in power, and that ever-present variety in art, in science, in intellect, in ethics, and in the higher and purer aspirations of humanity, would have been certainly diminished. And if it be said that the very bad would have been made better if educational influences had been inherited, even this may be doubted; for in times which permitted so much that was bad, education often tended to increase rather than diminish the evil. On the

other hand, we are more and more coming to see that none were all bad, and that their worst excesses were due in large part to the influence of their environment and the fierce temp tations to which they were, and still are, so unnecessarily exposed.

But it is when we look upon man as being here for the very purpose of developing diversity and individuality, to be further advanced in a future life, that we see more clearly the whole object of our earth-life as a preparation for it. In this world we have the maximum of diversity produced, with a potential capacity for individual educability, and inasmuch a* every spirit has been derived from the Deity, only limited by the time at the disposal of each of us. In the spirit-world death will not cut short the period of educational advancement. The best conditions and opportunities will be afforded for continuous progress to a higher status, while all the diversities produced here will lead to an infinite variety, charm, and use, that could probably have been brought about in no other way.

This is also the teaching of modern spiritualism, and by this teaching its existence is justified and its truth upheld. Such teaching pervades all its best literature, of which Poe's Farewell to Earth, given through the trance speaker Miss Lizzie Doten, in 1863, is one of the most remarkable.1 He tells us of the educational value of much that we term pain and evil in the following lines:

Gifted with a sense of seeing, Far beyond my earthly being, I can feel I have not suffered, loved, and hoped, and feared in vain; Every earthly sin and sorrow I can only count as gain, I can chant a grand ' Te Deum' o'er the record of my pain.

Again, he shows us that struggle and effort are essential for progress there as here:

Human passion, mad ambition, bound me to this lower Earth, Even in my changed condition, even in my higher birth. But by earnest, firm endeavour, I have gained a height sublime; And I ne'er again — no, never! shall be bound to space or time; I have conquered 1 and for ever 1 Let the bells in triumph chime! 'Come up higher'! cry the Angels. 'Come up to the Royal Arch! Come and join the Past Grand Masters, in the Soul's progressive march, O thou neophyte of Wisdom! Come up to the Royal Arch!

iOf the more serious books dealing with the ethics and philosophy of spiritualism, I will only direct the reader's attention to two: Spirit Teachings, by W. Stainton Moses, M.A.; and Psychic Philosophy, as the Foundation of a Religion of Natural Law, by V. C. Desertes. To such of my readers who wish to obtain some knowledge of the higher aspects of modern spiritualism, I strongly recommend these two works.

In the preceding verse, however, he has given us the keynote to the future life, which he speaks of as —

The land of Light and Beauty, where no bud of promise dies;

and then continues —

There, through all the vast Empyrean, Wafted, as on gales Hesperian, Comes the stirring cry of ' Progress I' telling of the yet to be.
Tuneful as a seraph's lyre,
'Come up higher! Come up higher!'
Cry the hosts of holy angels: 'learn the heavenly Masonry:
Life is one eternal progress: enter then the Third Degree; —
Ye who long for light and wisdom seek the Inner Mystery.'

Conclusion

In accordance with the views expounded in a former work, Man's Place in the Universe, I have fully discussed the evidences in plant and animal life indicating a prevision and definite preparation of the earth for Man — an old doctrine, supposed to be exploded, but which, to all who accept the view that the universe is not a chance product, will, I hope, no longer seem to be outside the realm of scientific inquiry.

Still more important is the argument, set forth in some detail, showing the absolute necessity of a creative and directive power and mind as exemplified in the wonderful phenomena of growth, of organisation, and fundamentally of cell-structure and of life itself. This view is strengthened by a consideration of the nature of the elements which alone render lifedevelopment possible.

Herbert Spencer enforced the idea of "variously conditioned modes of the universal immanent force" as the cause of all material and mental phenomena, and as the " Unknown Reality which underlies both Spirit and Matter." I have here expressed the same views in a more concrete, and intelligible manner. This " Unknown Reality " is necessarily infinite and eternal as well as all-knowing, but not necessarily what we may ignorantly mean by "omnipotent" or "benevolent" in our misinterpretation of what we see around us. I have, I hope, cleared away one of these misinterpretations and misjudgments in my chapter Is Nature Cruel?

But to claim the Infinite and Eternal Being as the one and only direct agent in every detail of the universe seems, to me, absurd. If there is such an Infinite Being, and if (as our own existence should teach us) his will and purpose is the increase of conscious beings, then we can hardly be the first result of this purpose. We conclude, therefore, that there are now in the universe infinite grades of power, infinite grades of knowledge and wisdom, infinite grades of influence of higher beings upon lower. Holding this opinion, I have suggested that this vast and wonderful universe, with its almost infinite variety of forms, motions, and reactions of part upon part, from suns and systems up to plant-life, animal life, and the human living soul, has ever required and still requires the continuous co-ordinated agency of myriads of such intelligences.

This speculative suggestion, I venture to hope, will appeal to some of my readers as the best approximation we are now able to formulate as to the deeper, the more fundamental causes of matter and force, of life and consciousness, and of Man himself; at his best, already "a little lower than the angels," and, like them, destined to a permanent progressive existence in a World of Spirit.

1916
Elder Charles H. Hart, First Council of Seventy
Reasoning from Nature to Nature’s God
Conference Address, October 1916, Second Meeting Outdoors., p.126

For the most part, in the scriptures, there is little reasoning from nature up to nature's God. The existence of Deity is either assumed or directly asserted, without much by way of reasoning from creature to Creator. We have, however, some beautiful illustrations. For instance, the Psalmist exclaims, "The heavens declare the glory of God, and the firmament showeth his handywork. Day unto day uttereth speech, and night unto night sheweth knowledge. There is no speech nor language, where their voice is not heard."

In the 104th Psalm, after an enumeration of the works of the Lord, the Psalmist exclaims, "O Lord, how manifold are thy works! In wisdom hast thou made them all: the earth is full of thy riches."

There is a sublime passage from Job along the same line. "Lo, these are parts of his ways; but how little a portion is heard of him? but the thunder of his power who can understand?"

Naturalists of high standing have reasoned in the same way, and we have the scientist and philosopher, Spencer, declaring, "One truth must ever grow clearer, the truth that there is an inscrutable existence everywhere manifested, to which we can neither find nor conceive beginning or end." And again, "Amid the mysteries which become the more mysterious, the more they are thought about, there will remain this. one absolute certainty, that we are ever in the presence of an infinite energy from which all things proceed."

But while this line of reasoning is valuable, reasoning from nature up to nature's God, it requires a revelation to know God in all his attributes.

September 1925
Joy in An Appreciation of God's Handiwork
Improvement Era, September, 1925

I. The Heavens.
a. The heavens declare the glory of God and the firmament showeth his handiwork, Psalms 19-1.
b. The immensity of space.
c. The wonders of the firmament.

II. The Earth.
a. The glory of the everlasting hills.
b. The beauty of the fields and flowers.
c. The wonders of the bird and the animal kingdom.

III. Man.
a. "What is man, that thou art mindful of him? and the son of man, that thou visitest him? For thou hast made him a little lower than the angels, and hast crowned him with glory and honor. Thou madest him to have dominion over the works of thy hands; thou hast put all things under his feet." Psalms 8:4-6.
b. "As man is, God once was; and as God is, man may become."
c. His mind, his body, his spirit.

1928
Elder Joseph Fielding Smith, Council of the Twelve
Authority As a Universal Principle
Improvement Era Article

The heavens declare the glory of God; and the firmament sheweth his handiwork.
Day unto day uttereth speech, and night unto night sheweth knowledge.
There is no speech nor language where their voice is not heard.-Psalms 19:1-3.

Authority is an eternal principle operative throughout the universe. To the "utmost bounds" of space all things are governed by law emanating from the Lord our God. On Kolob and other giant governing stars and in the tiny electron, infinitesimally small, and of which all things are composed, divine authority is manifest in the form of immutable law. All space is filled with matter and that matter is controlled and directed by an All-Wise and Omniscient Creator who "Comprehendeth all

things, and all things are before him, and all things are round about him; and he is above all things, and in all things, and is through all things, and is round about all things; and all things are by him, and of him, even God, forever and ever. And again, verily I say unto you, he hath given a law unto all things, by which they move in their times and their seasons." Doc. and Cov. 88:41-42.

To Moses the Lord said: "And worlds without number have I created; and I also created them for mine own purpose; and by the Son I created them, which is mine Only Begotten. * * But only an account of this earth and the inhabitants thereof, give I unto you, for, behold, there are many worlds that have passed away by the word of my power. And there are many that now stand, and innumerable are they unto man, but all things are numbered unto me, for they are mine and I know them. * * And as one earth shall pass away, and the heavens thereof, even so shall another come; and there is no end to my works, neither to my words."

The Lord showed the stars to Abraham through the aid of Urim and Thummim, and Abraham wrote of them: "And I saw the stars, that they were very great, and that one of them was nearest unto the throne of God; and there were many great ones which were near unto it; and the Lord said unto me; These are the governing ones."

From these scriptural references we learn that the controlling authority in the universe is vested in God; that his authority is manifest in all things both great and small. In a revelation to Joseph Smith the Lord said: "All kingdoms have a law given, and there are many kingdoms; for there is no space in the which there is no kingdom; and there is no kingdom in which there is no space, either a greater or a lesser kingdom." The significance of this expression we could not understand before the very recent discoveries in the field of science pertaining to the atom, electrons, protons, and the ether of the universe. The probabilities are that we do not understand it now; except in small degree, and that future revelations will add to the lustre of this wonderful truth in relation to the composition of the universe and the controlling laws by which it is governed.

On this point, one of the world's greatest scientists has said:

"The vast interplanetary and interstellar regions will no longer be regarded as waste places in the universe. * * We shall find them to be already full of this wonderful medium (ether); so full that no human power can remove it from the smallest portion of space, or produce the slightest flaw in its infinite continuity."-Clerk Maxwell.

Sir Oliver Lodge, in his valuable little work, Ether and Reality, speaking of the composition of matter, says:

"That is one of the first things to realize about matter: there are great gaps between its particles."

You may say, That is all very well for the sky and the stars and planets; but what about the earth? What about a piece of rock, or furniture, or any solid subject? Do you mean to say that the particles of a body like that are widely separated, with great spaces between them in proportion to their size, and that a straight line might penetrate them deeply without encountering a particle?

Yes I do: * * * No microscope, however powerful, can show us an atom, still less can it show us how an atom is composed and how far apart its ultimate particles are: we know this otherwise and indirectly. It is, however, common knowledge, now, that matter is built up of minute electric charges, both negative and positive, which are called electrons and protons. It is also known that these electric units are so extremely minute that they are separated from one another like the planets in the solar system. The greater part of the atom is empty space, just like the sky on a small scale."

I quote these sayings merely to point out the fact that the scientist today is confirming what the Lord said to Joseph Smith in relation to the universe: "All kingdoms have a law given; and there are many kingdoms; for there is no space in the which there is no kingdom; and there is no kingdom in which there is no space, either a greater or a lesser kingdom." How wonderfully this is confirmed by the astronomer who studies and charts the stars of the universe; and how equally wonderful it is confirmed by the scientist who divides and examines the substance of the atom. All is subject to the direction and control of the Eternal Father.

January 1932
B. H. Roberts
Protest Against the Science-thought of "A Dying Universe" and No Immortality for Man: The Mission of the Church of the New Dispensation
Salt Lake Tabernacle January 23, 1932. (Taken from Discourses of B. H. Roberts

My dear brethren and sisters, you will perhaps understand better the emotions with which I undertake the task of addressing you if I remind you that it has been over ten months since I had the privilege of standing here to address a congregation of Latter-day Saints in this building. Since that time I have passed through trying experiences and great suffering, but I have been brought through it all, as I believe, by the grace and blessing of God, by the skill of surgeons and nurses, the generous prayers and kindness of my fellow servants in the Church, and also through the good wishes and kindly interests of many of the people.

Lord Lytton, in his great character of Richelieu, sets forth the thought that for justice every place is a temple, and all seasons summer. So I feel in relation to gratitude; for expressions of it, every place a temple, and all seasons summer. So I am returning to this post of duty in a spirit of profound gratitude to all these sources that have contributed to bring me back from the shadows in which I lingered to once more resume my labors among you.

If there has been any purpose in bringing me back to activity, any remnant of duty or any thing that I can do for the cause of God before passing on, I announce myself as being very willing to undertake it if God will lead me to it; for I confess before you all that without him man can do nothing. We are utterly dependent upon him and the presence of his Spirit to achieve the things he would have men do. That is where I begin this afternoon. If there is any unfinished business in my life that I can attend to, beginning now, I declare that I am most willing to undertake it.

Recently I made a visit to California for a few weeks and happened to be there at the time when the present intellectuals of our country and from some foreign countries gathered at Pasadena to resume investigations in scientific fields, and especially in the field of astronomy, at the Wilson Observatory. I saw the royal welcome that those men of learning extended to Dr. Einstein on his return from Germany. I remembered his appearance a year ago in the same place, when he came to display the theories and knowledge that he had developed concerning the great universe now unfolding before the visions of men. He came now to check up on some of his assistants and helpers, who, during the summer, had been pursuing investigations it was hoped would sustain the theories that he had advanced. It was a great gathering, and the interest was profound.

I wish to make some reference to that circumstance and also to call your attention to the revolution that has been going on in the world's knowledge during the past thirty years, by which the whole face of the universe may be said to have changed in the minds of learned men. They are calling to our attention things that go far to upset the doctrines in which scientists, especially physicists and astronomers and philosophers, were fairly well established; but through discoveries

that have been made in recent time, beginning about 1900, the whole human conception of the universe is revolutionized. I would like to investigate a little some of the changes that have occurred in our knowledge concerning these matters.

There was a time when learned men felt reasonably secure, for instance, in the thought that matter was indestructible. Also that energy was indestructible; that while these existences might change forms, it was but a change of form, the substance of the things was perpetuated, and the universe was secure as an enduring thing. But the new knowledge, recently developed in the years I indicate, has changed all that, and men are saying today that matter is being destroyed; that energy is radiated away, and that the whole universe is eminently in danger, with the lapse of time, of absolute annihilation!

You perhaps remember that it was about thirty or thirty-five years ago that radium was discovered, and it was found that radium radiated itself away, giving off particles that must end in its destruction. From that discovery the thought leaped upward to the blazing suns of the universe, and led scientists to conclude that they too were radiating away, and the time must come when they would disappear and the visible universe be annihilated....

That is the announcement of our modern science, and while there may be some exceptions to agreeing to such a conclusion, I announce, and deliberately, that such is the trend of modern science--the destruction of the universe, and of course, the killing of any hope of immortality....

Of course the chorus of voices among the scientists is not unbroken. There are others who entertain different views. For example, in about 1900 Ernest Haeckel published his Key to the Universe. He held that while these disintegrating forces were undoubtedly imminent in the world, nevertheless, in other quarters of the universe integrating forces were active; and while the destruction went on in one place, reconstruction went on in another, "and the eternal drama," as he phrased it--"the eternal drama begins afresh," and the universe was held to be permanent and enduring (Riddle of the Universe, pp. 240-43)....

To me the lamentable conditions that obtain in this "new knowledge" of the scientists the trend of which is to proclaim the end of the universe, the destruction of matter and energy, and its being resolved into that state described...as a mist of more than two hundred and fifty degrees below zero destroys all hope that man can entertain of immortality and eternal life! If that is to be the sum total of the discoveries of modern science, how hopeless it all is!

One of the achievements of this modern knowledge has been the expansion of man's knowledge of the extent and greatness of the universe. It was only a few years ago, I remember, when astronomers spoke tentatively of the

fixed stars as consisting of a hundred thousand or of five hundred thousand, perhaps with, and perhaps not with, planetary systems moving about them, as we know planets move about our own sun.

But today that knowledge is very greatly extended. The term universe once meant all the space there is, and all the things within the space, but today we have a different use of the term....It is often used in the plural. Not only one universe but many are now spoken of. What we called our "universe" is now called our "galaxy," and one out of many such. We call it ours because our solar system has a place in it, near the center of it; but out and beyond this great galaxy, or universe, of which we constitute a part out in the nebulae of the space depths, other universes are being revealed to the vision of man, and they may be as large, for all we know, as the one universe with which we are somewhat acquainted, and that now is described as being made up of a "billion

blazing suns!" Whether those suns, like our own, are encircled by planetary systems, science cannot say. Whether, if there are such planets, they are inhabited--as we know our own earth to be inhabited--science can give no information upon that subject.

I will ask you to bear with me while I develop suggestions that will enable you to think of the greatness of the expansion of knowledge among scientists concerning the universe. I do this because I have a motive in it and propose to use it presently in a more local way than we can use this knowledge I am now presenting to you, or reminding you of, for I am persuaded that you are not ignorant of this great enlargement of the knowledge of our modern world relating to the universe.

It is said that light travels at the speed of 186,000 miles per second! If you want to know how far it travels in a minute you, of course, multiply that number by sixty and it gives you the distance light moves in sixty seconds. If you would know how far it would travel in one hour, of course, you multiply your result by sixty and it gives you the distance light will travel in an hour. If you want to know how far it will travel in a day, you multiply your greatly increasing result by twenty-four and that will give you the distance light will travel in a day. If that increased result is multiplied by three hundred and sixty-five it will give you the distance light travels in one year, called a light year; and that has become the great measuring wand of scientists in computing the distances in space. This galaxy, or universe, of which I have spoken is measured by this light year. You will find, if you are careful in your calculations, that the distance light will travel in a light year amounts to nearly six thousand billions of miles, about 5,859,000,000,000, to be more exact. Of course, we don't understand how far that is, but we know it is a great distance.

This galaxy is suspended in space, in oblong fashion. Now, take light, traveling at the rate of nearly six thousand billions of miles per year, it would require three hundred thousand light years for light to pass over its longest distance and would require thirty thousand light years for it to pass through its width. That is how large this universe of ours is esteemed to be by scientists.

Now, we used to speak of this group of stars as one universe, but today, out in the space depths beyond it, there may be thousands or even millions of such groups of creations. Very naturally, of course, as you find the frontiers of space driven back and this great expansion of the knowledge of man opened up to him, you would expect that reverence for the greatness and majesty of all these creations would lead men to humility and also to acknowledgment of the great power that has brought these creations forth and has maintained them up to the present time. But instead of that you are astonished to find that men of science are not moved to reverence for God, but proclaim the death of the universe and have no hope for the immortality of man.

David, as a shepherd lad in the hills of Judea, watched the stars at night and gathered up spiritual life and power from their splendor. He doubtless was acquainted with some of the star groups because Job had named some of them. He had asked the question:

"Canst thou bind the sweet influence of Pleiades, or loose the bands of Orion?" [Job 38:31.]

He saw, perhaps, the great cluster of stars we now call the Scorpion; doubtless he had observed the North Star with Ursus Major revolving about it. He was greatly impressed by what he saw and he cried aloud--

The heavens declare the glory of God; and the firmament sheweth his handiwork.
Day unto day uttereth speech, and night unto night sheweth knowledge.
There is no speech nor language, where their voice is not heard.

Their line is gone out through all the earth, and their words to the end of the world. In them hath he set a tabernacle for the sun.
Which is as a bridegroom coming out of his chamber, and rejoiceth as a strong man to run a race.
His going forth is from the end of the heaven, and his circuit unto the ends of it; and there is nothing hid from the heat thereof. [Psalms 19:1-6.]

From the contemplation of this universal book he turned to the written law of God, and combined the two together for the comfort and the enrichment of human life, leading up to his beautiful prayer, wherein he said:

"Let the words of my mouth, and the meditation of my heart, be acceptable in thy sight. O Lord, my strength and my redeemer--" [Psalms 19:14] reverence for God!

But now come these men of science today with their larger views of the universe--its illimitable extent--and they give us to understand that the universe has outgrown God; there is none sufficiently grand to preside over and control it. Do you think that is an extravagant statement? Then listen! Langdon-Davies speaking:

"The truth is," he says, "that nobody has yet been able to imagine a God splendid enough or glorious enough aesthetically or ethically to capture the imagination of man, once it has become alive to what modern science can show it lying about its feet or hanging over its head."

And Dr. Einstein, supposed to be the prince of modern scientists, says:

I cannot imagine a God who rewards and punishes the objects of his creation whose purposes are modeled after our own--a God in short, who is but a reflection of human frailties.

Neither can 1 believe that the individual survives the death of his body, although feeble souls harbor such thoughts through fear or ridiculous egotism (The Forum, October, 1930).

The above in substance has been many times repeated in the works of modern scientists, so that the trend of our modern knowledge is away from God and to deny the continuance of the universe, and with that, of course, falls all hope of immortality and eternal life, promised in the revelations of God.

I fancy I hear you say, some of you, at least: "What has all this to do with us?" "What practical use can we make of these speculations and these conclusions of learned men, How does it affect our work of this new dispensation of the gospel?"

[Here Elder Roberts said: "I am going to ask the choir to favor us with a number while 1 gather a little strength to conclude this, I think, the noblest part of the thought I am trying to develop for you." The Choir then sang, "The Heavens Are Telling," after which Elder Roberts continued]:

It has always been a matter of pride with me, in my more than fifty years of ministry in The Church of Jesus Christ of Latter-day Saints, that it was no trivial thing which called this church of the new dispensation into existence. It was not founded upon the idea that men differed in relation to how baptism should be administered, whether by sprinkling or pouring or immersion; or whether it was for the remission of sins or because sins had been forgiven. I always rejoice that it had a broader foundation than whether the form of church government and administration should be Episcopal or Congregational, or the Presbyterian form of government, or any other minor difference of theologians. It went to the heart of things and astonished the world and at the same time, of course, aroused its opposition.

When the Prophet of the new dispensation asked God for wisdom, and which of the many

churches about him he should join, he was told to join none of them, for they were all wrong; their creeds were false; they drew near to the Lord with their lips, but their hearts were far removed from him; they had a form of godliness but denied the power thereof; that the Christian world, especially, had, in fulfillment of Isaiah's prophecy, transgressed the laws, changed the ordinances, and had broken the everlasting covenant (Isaiah 24), of which the blood of the Christ was the blood of that everlasting covenant. He promised the incoming of a new dispensation of the gospel of Christ, which would link together and unite all former dispensations, from Adam down to the present time, the great stream of events speeding on towards an immense ocean of truth in which it would be united with all truth. It was a world movement. To lay the foundations of a greater faith, it brought forth the American volume of scripture, the Book of Mormon. In time the authority of God, the holy priesthood, was restored--the minor phase of it, through John the Baptist; and later Peter, James and John, who held the keys of the kingdom of heaven, bestowed upon them by the Christ, appeared to the Prophet Joseph and Oliver Cowdery, and the divine and supreme authority from God was conferred upon them. By this authority and under the power of it they organized The Church of Jesus Christ of Latter-day Saints, outlined its doctrines, and established it firmly in the earth.

That is how the new dispensation began--not whether baptism should be by immersion, or for the forgiveness of sins. The rubbish of accumulated ages was swept aside, the rocks made bare, and the foundations relaid. I gather an inspiration from such a movement as that, and I rejoice in it. May it never become a merely tolerated sect--merely one of many!

Now to show you what an immense field is laid before us here and also how we connect up with these scientists and the development of our modern knowledge, I read to you an admonition to the early elders of the Church, who were assembled in Ohio for the purpose of being instructed and prepared for the work of the ministry unto which God had called them.

The Prophet brought this to them from God:

And I give unto you a commandment that you shall teach one another the doctrine of the kingdom.

Teach ye diligently and my grace shall attend you, that you may be instructed more perfectly in theory, in principle, in doctrine, in the law of the gospel, in all things that pertain unto the kingdom of God, that are expedient for you to understand;

Of things both in heaven and in the earth, and under the earth; things which have been, things which are, things which must shortly come to pass; things which are at home, things which are abroad; the wars and the perplexities of the nations, and the judgments which are on the land; and a knowledge also of countries and of kingdoms--[D&C 88:77-79].

I never can read that without exclaiming: What a field of knowledge there is laid before the elders of the Church, and which they are bidden to enter and reap abundantly! People have talked about the ignorant ministry of the Mormon Church. All the while here is our curriculum of studies marked out for us, a curriculum that we are to follow. And for what purpose? Listen to the next paragraph: "That ye may be prepared in all things when I shall send you again to magnify the calling whereunto I have called you, and the mission with which I have commissioned you." [D&C 88:80.]

God has no use for an ignorant ministry in his church. This is our law of instruction and our guide, to prepare us for the work of the ministry. Therefore we want to learn and become acquainted with

the trend of modern science as well as ancient science. We want to know something of what these men--who scan the heavens and reduce the elements, by analysis, to more or less true proportions-know; we want to know something about that, and it is our mission to find out; hence the connection.

Later on in this same revelation came this admonition, and I ask you to mark it. The Lord says, in continuation of this pursuit of knowledge, "And as all have not faith, seek ye diligently and teach one another words of wisdom; yea, seek ye out of the best books words of wisdom; seek learning, even by study and also by faith." [D&C 88:118.]

Knowledge by faith! What a thought--knowledge by faith! But let no one suppose that knowledge by faith is to be obtained by an easy road or method. It will demand effort and strenuous life and the exaltation of life itself to obtain knowledge by faith. It was the means by which Daniel of old found knowledge. By it he learned the secret of Nebuchadnezzar's vision, and by it he learned the interpretation thereof and gave God all honor and glory and high praise in an exalting exclamation to the God of knowledge and of wisdom, who had blessed him above the sorcerers of the king of Babylon with knowledge by faith.

Joseph Smith obtained his knowledge also by faith, but not in any easy fashion. I remember that David Whitmer, one of the witnesses to the truth of the Book of Mormon, said in one of his passages printed on the subject: "Joseph Smith was a good man when I knew him. He had to be, or he could not go on with his work."

And he [Whitmer] cites a circumstance in his book, addressed to all "Believers in Christ." Something unpleasant had arisen among the group living at the home of the Whitmers, while and where the Book of Mormon was being translated. The Prophet had some misunderstanding with his wife, Emma; she was not always satisfied with her lot and was sorely tried. So after this disagreement had taken place in the household, he came up to the translating room, where David Whitmer and Oliver Cowdery were waiting for his coming. He took up the divine instrument, the Urim and Thummim, tried to translate, but utterly failed. Things remained dark to his vision, David Whitmer tells how Joseph left the translating room and went to the woodslot on the Whitmer farm and there corrected himself, brought himself into a state of humiliation and of exaltation at the same time. He went back to the house, became reconciled to Emma, his wife, came up to the translating room, and again the visions were given and the translation went on. But he could translate only as he was in a state of exaltation of mind and in accord with the Spirit of God, which leads to the source of hidden treasures of knowledge.

You perhaps remember in our Word of Wisdom that it is said if the saints will observe that Word of Wisdom and keep the commandments of God, they shall have access to hidden treasures of knowledge by reason of faith. Knowledge by faith requires exalted living.

When Oliver Cowdery himself tried to translate and failed, God said to him in substance: You thought it was all sufficient if you asked me and I gave you the knowledge, but I say unto you that you must strive for it, you must think it out in your mind and the testimony shall be given of the truth which is revealed to you, your heart shall burn within you, and thus you will obtain wisdom and knowledge by faith. [See D&C 8, 9.]

But it is no lazy man's task this getting knowledge by faith. It requires the bending of the whole soul, the calling up of the depths of the human mind, and linking them with God-the right connection must be formed. Then comes knowledge by faith.

The Prophet of the new dispensation is perhaps the best illustration of how men can acquire a knowledge by faith, for under such a system he laid the foundations of this work and brought it into existence for the final triumph of God's purposes in the world.

It goes further than we have come, this knowledge by faith. After the Prophet had translated the Book of Mormon, he began to receive the revelations which today make up the Book of Moses (in the Pearl of Great Price), the translation of which began to be published about six months after the Book of Mormon had been translated. I read to you one or two passages from that, to show you how wonderful it is, and it leads directly up to the consideration of these matters that are contemplated by our learned scientists of modern days. Listen to it. The Lord revealed to Joseph Smith the revelation that he had given to Moses, from which Moses constructed his portion of the Bible, and the part I am reading is as follows: "And it came to pass, as the voice was still speaking,

Moses cast his eyes and beheld the earth, yea, even all of it; and there was not a particle of it which he did not behold, discerning it by the Spirit of God." [Moses 1:27.]

Hence he could write so beautifully and so truly of God's works, of creation in our Bible, because he had this vision.

And he [Moses] beheld also the inhabitants thereof, and there was not a soul which he beheld not; and he discerned them by the Spirit of God, and their numbers were great, even numberless as the sand upon the seashore.

And he beheld many lands; and each land was called earth, and there were inhabitants on the face thereof. [Moses 1:28, 29.]

That goes somewhat beyond the deductions of our scientists who have led out in the conception of this immense universe, as a billion blazing suns to our own universe alone. But whether they are encircled, as our own sun is, by opaque planets, or inhabited--as we happen to know our earth is inhabited, by intelligences, the sons of God--they cannot say and properly refrain from saying it until they have some assurance about it. This man Moses, however, teaching knowledge by faith, tells us that he beheld these numberless worlds and that they were inhabited also.

The Lord continued to say to Moses:

And worlds without number have I created; and I also created them for mine own purpose; and by the Son I created them, which is mine Only Begotten....

And the Lord God spake unto Moses, saying: The heavens they are many, and they cannot be numbered unto man, but they are numbered unto me, for they are mine. [Moses 1:33, 37.]

Later in this same book (chapter 7) it is revealed that if this earth were resolved into particles they would not begin to number the creations of God; and still further it says in substance that if millions of earths like this were so resolved into particles, they would not begin to number the creations of God. "And thy curtains are stretched out still." [Moses 7:30.]

Now let the scientists in Pasadena, California, and in all the world, with the one hundred inch telescope and the two hundred inch telescope that is in course of construction, go on and on and extend their vision farther and farther, but they will not succeed in numbering the creations of God or the extent of this universe beyond the information that was brought forth one hundred years before they spoke, that is, June, 1830! For this book I am reading from is one hundred years old, and God revealed this expanded universe through faith to his Prophet.

Again the correlation of space and matter was set forth in a revelation given two years later called the "Olive Leaf" [D&C 88] and sent to the saints settling in Missouri. "There are many kingdoms; for there is no space in the which there is no kingdom; and there is no kingdom in which there is no space, either a greater or a lesser kingdom." [D&C 88:37.]

I know of no language which better sets forth the existence and better states the correlation of space and matter than this. And then is added the tremendous fact that all this is under the domain of law!

Referring again to the Book of Moses: "The heavens, they are many, and they cannot be numbered unto man; but they are numbered unto me, for they are mine." [Moses 1:37.]

Now observe this: "As one earth shall pass away, and the heavens thereof even so shall another come; and there is no end to my works, neither to my words.

"For behold, this is my work and my glory, to bring to pass the immortality and eternal life of man." [Moses 1:38, 39.]

Let our scientists weigh that! That is knowledge through faith given to God. It far outstrips the halting footsteps of science both as to the extent of the universe and all that men have discovered in relation to it.

I admire the achievements of the men of science and hold them in honor. Especially am I an admirer of Professor Millikan and am thrilled by his discovery and his setting forth of the cosmic ray. But what am I to think of the Prophet of God, who, speaking a hundred years before him and speaking by the knowledge that comes by faith, revealed the same truth namely, that as one earth shall pass away, so shall another come, and there is no end to God's work? This gives to the Church of the new dispensation the right to voice her protest against a dying universe--its death blows to the immortality of man.

Oh, ye elders of Israel, this is our mission, to withstand their theory of a dying universe and this destruction of the idea of the immortality and eternal life of man. We have this knowledge revealed of God, and it is for us to maintain the perpetuity of the universe and the immortal life of man. Such was the mission of the Christ, such is ours. This testimony the elders of the first century of the new dispensation have set forth to the world in such strength as the Lord has given them. And now some of us, from falling hands, "fling to you the torch." Be yours to hold it high, nor let its flame diminish. If you break faith with God and with us who die--your responsibility will be very great.

October 1932
Elder Brigham H. Roberts, First Council of Seventy
Science, I Am Happy To Note, After Long Research Is Bringing Back The Conception Of The Existence Of Mind In The Universe
Conference Report, October 1932

Science, I am happy to note, after long research is bringing back the conception of the existence of mind in the universe. Sir James Jeans, whose name I before referred to, presents the universe as "God's great thought." An Intelligence is operating within it, destroying the notion that the universe is merely mechanical, which prevailed up to some forty years ago.

This is splendid to have science working along that line; bringing to light that testimony is worth while. I rejoice in the light and understanding that seems to be coming into the conception of these leading scientists of the world in relation to intelligence, mind, thought, being connected with the universe, whose extent and grandeur and glory are constantly increasing. So far increasing, indeed, that it is held that the universe is outgrowing any possible conception of God being connected with it.

One man who contributes a very thoughtful and splendid paper to this symposium said:

"Who that is alive to the questions that can be asked can dare to pretend that science has destroyed the splendor of the heavens, or the glory of the universe? The truth is that nobody has yet been able to imagine a God splendid enough or glorious enough, aesthetically or ethically, to capture the imagination of man, once it has become alive to what modern science can show it lying about its feet or hanging over its beady

So that the splendor and grandeur of the universe, in this man's thought, is that it exalts itself even above any possible conception of God, quite contrary to the conclusions of the inspired psalmist of Israel, who saw that "the heavens declare the glory of God, and the firmament showeth his handiwork." So that science, in this man's estimation, leads away from any reasonable conception of God, for such a universe as science has revealed.

1935
Dr. John A. Widtsoe, Council of the Twelve Apostles
THE External Universe Likewise Bears Witness To The Existence Of God
The Articles of Faith
Improvement Era 1935-1

II. the Foundation of the Gospel

(Read the First Article of Faith)
BELIEF in the existence of a Supreme, creative, directing Being, God, from whom issue the life and phenomena of the universe, is the foundation of faith in the Gospel restored by the Prophet Joseph Smith. Indeed, the first event in the latter-day restoration of the Gospel-the appearance to Joseph Smith of God the Father and His Son Jesus Christ-was a witness to the reality of these personages. Interest in the Gospel may be awakened in various ways, by temple work, the Word of Wisdom, social life within the Church, or the philosophy of the plan of salvation, but the truth of the Gospel can be known only through the certain knowledge of God's existence and a reasonable understanding of His nature. Upon the ocean of unbelief or of incorrect knowledge of God, many a soul has been stormswept and shipwrecked.

The evidences for the existence of God are so many and powerful that belief in a Supreme Being has always been well-nigh universal. Small groups, great in their own conceit, or blinded by false teachings, have at times declared themselves unbelievers in God's existence; but such atheists, usually quibblers over words and definitions, have harbored in their hearts the realization of the existence of an intelligent overruling Power. Voltaire, who with consummate skill of logic and rhetoric flaunted the existence of the Lord, crept back in his old age to his estate and built there a church dedicated to the unknown God. He is a true type of the atheist. Such fearing fumblings for the truth have recurred in all ages. They tie as a rule into scientific theories and mechanical human welfare, as for example the so-called Humanism of our day, with no provision for supplying the deep spiritual needs of man. They are ever on uncertain, changing ground, requiring manifesto after manifesto of varying opinion.

Deeply bedded in the very nature of man is the feeling that there is a great Power, a Being from whom he has come and under whose guidance he "lives and moves and has his being." So universal is this feeling, so insistent and continuous, that it compels men to believe in the reality of God. With his ears man may sense the universe of sound, with his eyes explore the visible world, and with his feelings learn of the unseen world of living beings. We have been too much inclined to limit man's knowledge of the universe to the truths gathered by eyes and ears. The other gifts and senses of men must be recognized to be of equal power in penetrating the veil that hangs before the seeker after truth. The deep consciousness in all men of the existence of God is the first indisputable evidence for his reality.

THE external universe likewise bears witness to the existence of God. The psalmist sang long ago, "The heavens declare the glory of God," and modern man, peering into space, filled with stars and electrons, has come to the same conclusion. The orderliness or "reign of law" under which nature operates must be the product of intelligence, for nowhere in our experience is order separate from intelligent direction. The man in Millersville was right: The seventeen parts of a meat chopper would never be assembled except under the direction of an intelligent mind, nor would the innumerable elements of earth and stars have been set upon courses of order except through an intelligent mind. The intelligence that maintains order in the universe is God. Similarly, natural phenomena are a series of causes and effects. As far as we know our every experience is the effect of some cause, often poorly understood. By that token every cause is itself an effect of some higher cause. Ultimately, then, there must be a first or ultimate cause of all things, a cause of causes, which is God. Nature in her every mood proclaims the existence and majesty of God.

March 1935
The Sober Student Of Nature Now Stands Humbly, Wishfully, Before The Mystery Of Existence; Every New Fact Is To Him The Shadow Of An Eternal, Intelligent Reality
Articles Of Faith Of The Church Of Jesus Christ Of Latter-Day Saints
Improvement Era 1935-1

1. We believe in God, the Eternal Father, and in His Son, Jesus Christ, and in the Holy Ghost.
2. We believe that men will be punished for their own sins, and not for Adam's transgression.
3. We believe that, through the atonement of Christ, all mankind may be saved, by obedience to the laws and ordinances of the Gospel.
4. We believe that the first principles and ordinances of the Gospel are: First, Faith in the Lord Jesus Christ; second, Repentance; third, Baptism by immersion for the remission of sins; fourth, laying on of Hands for the Gift of the Holy Ghost.
5. We believe that a man must be called of God, by "prophecy, and by the laying on of hands," by those who are in authority to preach the Gospel and administer in the ordinances thereof.
6. We believe in the same organization that existed in the primitive church, namely, apostles, prophets, pastors, teachers, evangelists, etc.
7. We believe in the gift of tongues, prophecy, revelation, visions, healing, interpretation of tongues, etc.
8. We believe the Bible to be the word of God, as far as it is translated correctly; we also believe the Book of Mormon to be the word of God.
9. We believe all that God has revealed, all that He does now reveal, and we believe that He will yet reveal many great and important things pertaining to the Kingdom of God.
10. We believe in the literal gathering of Israel and in the restoration of the Ten Tribes. That Zion will be built upon this continent. That Christ will reign personally upon the earth, and that the earth will be renewed and receive its paradisiacal glory.

11. We claim the privilege of worshiping Almighty God according to the dictates of our conscience, and allow all men the same privilege, let them worship how, where or what they may.
12. We believe in being subject to kings, presidents, rulers and magistrates, in obeying, honoring and sustaining the law.
13. We believe in being honest, true, chaste, benevolent, virtuous, and in doing good to all men; indeed we may say that we follow the admonition of Paul: "We believe all things, we hope all things," we have endured many things, and hope to be able to endure all things. If there is anything virtuous, lovely, or of good report or praiseworthy, we seek after these things.-Joseph Smith.

It is true that within the memory of living men, the age of materialism reached its height. Drunken with an overwhelming accession of new knowledge, men dreamed of themselves as the masters of a mechanical universe reducible to the interaction of non-living matter and unintelligent force. In such a universe there was no need of God. Today the folly of materialism has crumbled before increasing knowledge. The sober student of nature now stands humbly, wishfully, before the mystery of existence; every new fact is to him the shadow of an eternal, intelligent reality. The conception of the universe as a machine has collapsed. For example, Sir James Jeans, illustrious modern scientist, says:

"Thirty years ago, we thought, or assumed, that we were heading towards an ultimate reality of a mechanical kind. It (the universe) seemed to consist of a fortuitous jumble of atoms, which was destined to perform meaningless dances for a time under the action of blind purposeless forces, and then fall back to form a dead world. Into this wholly mechanical world, through the play of the same blind forces, life had stumbled by accident. ... Today there is a wide measure of agreement, which on the physical side of science approaches almost to unanimity, that the stream of knowledge is heading towards a non-mechanical reality; the universe begins to look more like a great thought than a great machine. ... If the universe is a universe of thought, then its creation must have been an act of thought." (The Mysterious Universe (1930), pp. 144, 148.)

Within the last few months an equally eminent scientist, Sir William Bragg, awed by the vast mystery of nature, bears similar testimony:

"We must think of the physical world around us as the footprints of something which exists in other dimensions as well, which has other qualities which are not physical and which no physical apparatus, however delicate, can measure." (Science, March 16, 1934.)

And within the last few weeks come the last words of Michael Pupin, scientist of world-wide service and fame:

"Wherever science has explored the universe, it has found it to be a manifestation of a coordinating principle which leads from chaos to cosmos. I choose to believe in this coordinating principle as a divine intelligence rather than that the cosmos is the result of haphazard happenings. We can place utmost faith in this divine intelligence. There is dependability, continuity everywhere present in the universe." (New York Times, March 14, 1935.)

SUCH statements implying an intelligent power in and behind universal phenomena from competent investigators and thinkers, which might be greatly multiplied, indicate the current of modern thought compelled by the vast discoveries of recent days.

Evidence of God's existence may be gained also from the experience and testimony of other men. The recorded history of mankind includes many accounts of the direct, personal revelation of God to man. Adam, the first man, walked and talked with God; Abraham, Moses, Elijah, John the Baptist, Joseph Smith and others, have also testified to such manifestations. The lives of these

witnesses were such as to make it improper for us to discredit their testimonies. We may not all visit China, yet we may learn of its existence, people and customs from those who have traveled in the Orient. We have not been at the North Pole, yet do not refuse to believe Admiral Peary's report. That which we ourselves have not seen or heard but have learned from others forms most of our knowledge. It would be unwise, indeed foolish, to reject such knowledge. We need only to examine such knowledge with care to assure ourselves of its genuineness. The historical evidence of revelation confirms the existence of God.

THERE is yet another method, personal, convincing, never-failing, which confirms all other evidences and leads to the certain knowledge that God lives. Whoever in absolute desire to know the truth places himself in harmony with divine forces and approaches God in humble prayer, with full surrender of inherited or acquired prejudices, will learn to his complete satisfaction that there is a God in Heaven, whose loving will is operative on earth. Just as the turning of the dial of the radio enables us to hear the messages of distant broadcasting stations, so we may tune ourselves in prayer for truth to hear the messages that come from heavenly places. Man is more than a machine; he can so purify himself, establish earnest desire, and forget his selfish needs, as to receive through prayer the final assurance of the existence of the Lord of Heaven and Earth. This method or test is within the reach of all, humble or great, rich or poor. Happy is the man who thus enters into the abundant knowledge of divine things.

The existence of God is made evident to man because, first, all men have an inner consciousness of a higher power; second, nature is orderly, betokening the operation of an intelligent master mind; third, every experience is the effect of a cause, itself an effect of a higher cause, leading to a great first cause-God; fourth, men have received personal revelations of God; and fifth, every man by prayer may know that God lives. It is doubtful if the truth of any other fact of human experience is or can be so well attested.

GOD, whose existence is proclaimed by every human experience, is personal in his nature. Only confusion of thought follows the conception of the Supreme Ruler as a universal mind filling all space. He would be then nothing more than a force within the universe, to which personal, organized man could not intelligently, willingly, bend his knee. The rational mind demands that the Master of the Universe be a personal being, however infinite may be his attributes; and conceives for him the fitting form of man, the highest creature among living beings. Painters, sculptors and poets have of necessity pictured him in personal form to make him comprehensible to the human mind. The roaring sea, tempests, earthquakes, lightning and thunder have been but manifestations of his power. Those who have attempted to identify the Lord with the forces of nature have been as twin brothers of the materialists. The human mind finds understanding and the human heart finds living peace only in a God who is a person. Moreover, those to whom the Lord has revealed himself have unanimously testified that he is in personal form, like unto a man, but glorious beyond the powers of man to describe, in the words of Joseph Smith, "whose brightness and glory defy all description." Joseph Smith and Oliver Cowdery in the great vision in the Kirtland Temple attempted to describe what they saw. "We saw the Lord standing upon the breastwork of the pulpit, before us, and under his feet was a paved work of pure gold in color like amber. His eyes were as a flame of fire, the hair of his head was white like the pure snow, his countenance shone above the brightness of the sun, and his voice was as the rushing of great waters." (Doc. and Cov. 110:2, 3.) God is personal, and in form like unto man.

The personal nature of God does not in any manner limit the extent of his power. From the presence of the Lord issues an influence known as the Holy Spirit, filling all existence and all space. By means of the Holy Spirit God is present everywhere, and may know the needs of all men and communicate comfort and strength to them. By the agency of the Holy Spirit, all manifestations of the physical universe are made evident. All the operations of life and motion, of all existence,

proceed from the Lord through the omnipresent Holy Spirit. This doctrine is readily understood in our day when words broadcasted into space may everywhere be picked up by those possessing the right instrument, or when great aeroplanes in the air or ships on the sea may be directed in their motions by the far distant radio operator. Long before radio was born, the Lord, revealing this truth to the latter-day prophet, declared, the "light proceedeth forth from the presence of God to fill the immensity of space-the light which is in all things, which giveth life to all things, which is the law by which all things are governed, even the power of God who sitteth upon his throne, who is in the bosom of eternity, who is in the midst of all things." (Doc. and Cov. 88:12, 13.)

GOD is also our Eternal Father. That is, he is more than a creator, an organizer of men. There is a kinship of family, descent, relationship between him and man. Indeed, man is the very child of God, begotten spiritually in the life before our earth existence. Man is therefore of a divine nature, in every power and attribute like unto his spiritual Father, though in an immeasurably smaller degree. Man is like God even in form, "And I, God, said unto mine Only Begotten, which was with me from the beginning, Let us make man in our image, after our likeness, and it was so." (Moses 2:26.) The Father, concerned with the welfare of his children, has placed them on earth for further education and preparation for their progressive, high destiny. The relation between God and man, that of actual father and son, explains the deep mystery of human existence. When we pray to God we do not approach a distant, strange Being, but we speak out of our hearts to our Father, of whose very substance we are. We do not plead with him as subject to ruler, as slave to master, but as child to parent, for such indeed are all men in their relationship to God.

There is no greater necessity in human life than a knowledge of the existence of God and a correct understanding of his plan for the salvation of mankind. It is the beginning of wisdom. Every intelligent man may win such certain knowledge for himself by following a simple formula, divinely ordained: First, he must fervently desire such knowledge, with a desire that burns into the soul. Then he must earnestly pray to God for help, nothing doubting, that is, he must place himself in full harmony with the forces he desires to know. At the same time he must learn by study that which already has been revealed concerning God, so that his mind may support him in his search. Lastly, he must try with all his might to live and practice the precepts of God, his actions must support his desire. If a man do this he cannot fail to find God and his truth. Such search is always greatly rewarded.

A fine, highly trained lover of truth once said in a hurried moment: "In science, every experience of one worker may be repeated by another to prove its truth. I cannot repeat Joseph Smith's first vision, therefore I find it difficult to accept it, for it seems at least unscientific." The conclusion was erroneous. The message received by Joseph Smith in the First Vision was that God is a real living Personage concerned with the welfare of the children of men. Any man who will seek with desire, prayer, study and practice, who will do as Joseph Smith did, will receive the same certain knowledge of God's existence. The Father and the Son may not appear in person to every seeker, but the message will be as convincing. A chemist may mix his chemicals in vessels of porcelain, gold or platinum, in dishes, round, square or oblong-the final reaction is the same and that is the vital matter. Without seeing God in person, but by the power that issues from him, one may know that he lives and that the latter-day restoration of the Gospel is divinely true. Every Latter-day Saint may and should have his own great vision of God to guide him through life.

1941
The Heavens Declare the Glory of God
Improvement Era Article

"The heavens declare the glory of God; and the firmament sheweth his handywork."-PSALM 19, VERSE 1.

What shall be said of the new star? "The heavens declare the glory of God," the Psalmist spoke for us all. The "bright and morning star" is the designation of Christ by the Revelator John. In a superb sense stars are truly forever representative of God in open testimony across the face of the sky that He is there in His heavens. The spirit of truth moved Joseph Smith to declare, "He that hath seen any or the least of these has seen God moving in all His majesty and glory." His creative power to form worlds without number was thus symbolized at His birth.

Yet, while we admit that sin is universal and repentance imposed in all seriousness on all men, we may nevertheless remember that there were periods of joy in the life of Jesus. Without considering the happy days of innocent childhood, of which we have only faint traditions, we may recall the marriage feast at Cana, the hours passed in the house of Lazarus conversing with him and his sisters, the day He fed so many people with only a small store of loaves and fishes, and His entry into Jerusalem, when the people acclaimed Him. Those were moments of joy and exultation for Jesus, and every man who tries to emulate Him in loving his fellow men and doing such acts of love and kindness as he has opportunity to do, will also experience such moments when his whole being overflows with thanksgiving and the joy of being alive, the joy of partaking of the happiness of others, the joy of watching innocent children at play, the joy of feeling the beauty of this world, of watching the clouds and the colors of sunrise and sunset, the flowers and the stately forests of earth, the placid rivers, the turbulent waterfalls, or even the bare austerity of the desert. All the world tells us of beauty if we look for it, and we may say with the Psalmist, "The heavens declare the glory of God and the firmament sheweth his handiwork."

1941
Winifred Heath
The Story of the Telescope
Improvement Era Article

EVER since the dawn days of man's life on the earth he has scanned the heavens above him and wondered, awed by their beauty, scarcely dreaming of their immeasurable distances and depth. David, dreaming on the hills of Palestine, put into wonderful words the things that all humble students of the skies have felt. The story of the telescope is the record of man's unceasing longing to learn more of God's great handiwork in the heavens-the sun, the moon, the brightly shining stars. And as with most of man's greatest inventions, the telescope had a very humble beginning.

Back in the thirteenth century a gentleman of the fine city of Florence in Italy invented spectacles. They were mentioned in an old manuscript, as follows: "Those glasses they call spectacles, lately invented, to the great advantage of poor old men when their sight grows weak."

It was these spectacles which made the telescope possible. About a century after the invention of glasses a certain young apprentice who worked in the optical shop of the good Dutchman, Jan Lippershey, happened to pick up two lenses intended for some "poor old gentleman with weak eyes." For some reason he put one on top of the other, a concave lens over a convex, and the result was so amazing that he nearly dropped them. He could actually see the town church with its steeple, weather-vane, and cock, but they had all moved close to him, and stranger still, they were all upside down. The boy was much too busy to hear the door open or see his master.

"So you waste my valuable time, as usual."

But the lad was too excited to be scared.

"Master, Master, a miracle has happened. Please, please look through these two glasses!"

Jan Lippershey looked and was just as startled as his young apprentice.

"Master, why is everything upside down?"

Jan got out of that awkward moment by bidding the lad get back to work. But Jan set to work to find out, and he finally succeeded in producing the world's first telescope.

He submitted his paper tube with the two lenses to the States General, who approved of it highly, for they felt it would help them to keep an eye on the armies of Spain who were trying hard to enslave brave Holland. Lippershey wanted a patent, but other would-be inventors appeared and said they had known about the telescope all along. The authorities compromised by giving Lippershey a good income for life with the strict understanding that the telescope idea was to be kept in Holland. Even when the King of France wanted a telescope, he had to do much persuasive talking and pay a very high price to the Dutch Parliament.

The Dutch government had another very good idea-it wanted the same kind of instrument for both eyes, and so the world got the convenient binoculars.

News of the telescope, however, could not be kept in Holland, and soon they were being made in France and in Britain, where they were known by the quaint name of "Dutch Trunks."

The world's first known picture of a man using a telescope appeared in 1609, and the owner was Simon Marius. There were people in those days who regarded the telescope as a sinful thing since it seemed to show a lack of gratitude to God for our own good eyes. Perhaps that is why the artist who painted the picture of Simon Marius gave him a rather sinister, sour expression.

AT FIRST the telescope was more or less a plaything. The first man to glimpse the wonderful possibilities that lay in this instrument was the great Italian Galileo, who all his life regarded the heavens even as the Psalmist David, with reverence and awe, rejoicing in the glory of God's work.

Galileo was away from his native Padua in the city of Venice when he first heard of this strange invention for "viewing afar" (the name "telescope," taken from two Greek words, means just that). He rushed back to Padua and visited every optical store to find the very best lenses. But none of them proved satisfactory, and so he ground his own-which was anything but a simple process in those days when there were no tools such as we have now.

After many experiments Galileo produced the world's finest telescope and presented it to the Doge and other high officials of Venice, a very great republic in those days. These gentlemen were amazed when, looking through that first simple tube, they saw, as if close by, the wonderful bell tower of the great Cathedral of Saint Mark.

This first real telescope seems very crude beside the great instruments of today, but through it Galileo was able to see much more of the heavens than his generation thought possible. He glimpsed the wonder of a lunar sunset, craters on the moon, the bright satellites of Jupiter, and set down these striking words: "The number of small stars is quite beyond determination." It is a wise man who will acknowledge his own limitations, and the true student of the stars, the honest astronomer, has always been humble in spite of great achievements. He has also been endowed with an immense patience and persistence.

Galileo, like many other great men, was ahead of his time and incurred the wrath of certain important people who were convinced that our earth was the center of all God's universe. One hundred years before the invention of the telescope, a wise man of Poland, Copernicus, had put forth the humbler theory that our earth was but a small part of the starry world and by no means the center.

In those days one had to agree with the important people or go to jail, or perhaps even lose one's life. Galileo suffered imprisonment and torture, but we know that he never really gave up the truth which he believed he had discovered, and which has since been proved.

The next great astronomer was John Kepler, whose three great laws governing the known planets and other heavenly matters still stand undisputed. After Kepler there seems to have been a lull in things telescopic and then another enterprising Dutchman comes on the scene. This was Christian Huygens, to whom the telescope was "the noblest thing that ever came out of Holland." He realized that about the most important part of the telescope was the lens, so he and his good brother set to work and managed to produce finer ones than had ever been made before.

On March 5, 1655, Christian Huygens, looking through one of their own telescopes saw, so far as is recorded for the first time in history, the rings which surround the planet Saturn, nine hundred million miles away from the earth-a distance which the human mind can scarcely grasp.

This new celestial discovery swept through the world like wildfire and everybody wanted a telescope. For some reason people got the idea that the longer the tube, the better the view, and so the instruments grew longer and longer. Johannes Hevelius made one 150 feet long and this so excited the scientists of Britain that one of them produced a giant 600 feet in length. These "bean poles" had to be operated with rope and pulley and Hevelius wistfully dreamed of some wealthy nobleman who would build a permanent home for these unwieldy instruments so that they would not have to be taken down and put up. His dream was to come true some hundreds of years hence in the shape of marvelous laboratories built to house such instruments as Christian and his brother had never dreamed of. UP TO this time there had been only one kind of telescope, the refractor with two lenses, convex and concave. With these there was always an annoying blur and color fringe around the object viewed. It was an Englishman, John Hadley, who found a way to improve on the bean pole and to get rid of the colored fringe. He also invented the modern sextant which took the place of the astrolabe and other ancient mariner's guides.

1943
John A. Widtsoe, Quorm of the Twelve Apostles
To What Extent Should the Doctrine of Evolution be Accepted?
Evidences and Reconciliations (Book)

The answer to the above question depends on the meaning assigned to the word evolution. Among people generally, as well as lay a group of scientists who should know better, the word is used with unpardonable looseness. Especially should the difference between the law of evolution and the theory or theories of evolution be stressed whenever the word is used.

In its widest meaning evolution refers to the unceasing changes within our universe. Nothing is static; all things change. Stars explode in space; mountains rise and are worn down; men are not the same today as yesterday. Even the regularities of nature, such as the succession of the seasons or of night and day, cause continuous changes upon earth. Everywhere, a process of upbuilding or degradation is in evidence. The face of nature has been achieved by continuous small and slow

degrees. This has been observed by man from the beginning, and must be accepted by all thinking people. Darwin knew it no better than the peoples of antiquity. The law of change, an undeniable fact of human experience, is the essence of the law of evolution (H. F. Osborn, From the Greeks to Darwin).

The great champion and amplifier of the doctrine of evolution, the philosopher Herbert Spencer, defined the law of evolution by saying, in substance, that whatever moves from the indefinite to the definite, is evolving; while that which moves from the definite to the indefinite, is dissolution or the opposite of evolution. Nebulae passing into stars are evolving; stars broken into cosmic dust are dissolving (Herbert Spencer, First Principles). When simple units are used to build up more complex structures we have evolution. When any structure is broken down into constituent elements, we have its opposite, dissolution. Evolution in this sense is the same as progression or growth.

From this point of view the law of evolution, representing eternal change upward, becomes a basic, universal law, by which nature in her many moods may in part be explained.
Indeed, it has been one of the most useful means of interpreting the phenomena of the universe. The first and most notable deduction from the law of evolution is that, in the words of Spencer, "We can no longer contemplate the visible creation as having a definite beginning or end, or as being isolated" (Herbert Spencer, First Principles). That is, existence is eternal.

The noisy babble about evolution, often disgraceful to both sides since Darwin wrote Origin of Species, has been confined almost wholly to speculations or guesses concerning the cause, methods and consequences of the law of evolution. The law itself has not been challenged. It is so with every well-established, natural phenomenon. Inferences are set up to explain observed facts. Such hypotheses or theories, which are often helpful, become dangerous when confused with the facts themselves. There are now many theories of evolution, all subject to the normal scrutiny to which all theories should be subjected; and until their probability is demonstrated, it is well to remain wary of them.

The foremost and best-known theory of evolution is that all living things on earth, whether fish, insect, bird, beast, or man, are of the same pedigree. All creation, it declares, has come from a common stock, from a cell formed in the distant past. Man and beast have the same ancestry. In support of this theory numerous well-established observations are presented. These may be grouped into five classes:

First, the fossil remains of prehistoric life on earth show that in the oldest rocks are remains of the simplest forms of life; and as the rocks become younger, more complex or more advanced life forms seem to appear. The scale of life appears to ascend from amoeba to man, as the age of the particular part of the earth's crust diminishes.

Second, each group of living things has much the same bodily organization. In the case of mammals, all, including man, have similar skeletons, muscular arrangements, nervous systems, sense organizations, etc. In some species the organs are merely rudimentary -- but they are there.

Third, the embryos of man and higher animals, in the earlier stages, are identical, as far as the microscope can reveal. This is held to mean that embryonic development summarizes or recapitulates the stages of man's development through the ages of the past.

Fourth, all organic creatures may be so grouped, according to structure and chemical nature, as to show gradually increasing relationships from the lowest to the highest forms of life. Similarities in

blood composition are held to indicate nearness of kinship. The blood of the great apes is very similar to the blood of man.
Fifth, it has been possible, within historic times, to domesticate many animals, often with real changes in bodily form, as the various breeds of cattle, sheep, or dogs. Besides, isolated animals, as on the islands of the sea, have become unique forms differing from those on connected continents.

These facts, so claim the proponents of the theory of evolution, all point to the common origin, and an advancing existence, of all animal forms on earth. To many minds these observations, upon which in the main the theory of evolution rests, are sufficient proof of the correctness of the theory of evolution. It is indeed an easy way of explaining the endless variety of life. All life has grown out of a common root. The ease of explaining the origins and differences among life forms has won much support for the theory of evolution (Sir Arthur Keith, Concerning Man's Origin, and Darwinism and What It Implies; H. H. Newman, Evolution Yesterday and Today).

Yet, at the best the doctrine of the common origin of all life is only an inference of science. After these many years of searching, its truth has not been demonstrated. To many competent minds it is but a working hypothesis of temporary value.

Many weaknesses in the theory of evolution are recognized by its adherents. Two are especially notable.
First, many reported similarities are far-fetched and not well enough established to be acceptable as the foundation of a world-sweeping theory. It is surprising how many such cases have been found. (Douglas Dewar, Man a Special Creation; Sir Ambrose Fleming, Evolution or Creation; E. C. Wren, Evolution, Fact or Fiction) Moreover, many actual similarities may be interpreted in more than one way. The theory of a common origin is only one of several possible explanations of the mass of biological facts.

Second the theory fails utterly to explain the emotional, reasoning, and religious nature of man which distinguishes him so completely from the lower animals. One defender of the theory declares that the brains of man and monkey are identical anatomically, but that the larger size of the human brain accounts for the higher intelligence of man. This suggestion falls to the ground in face of well-known facts such as that the ant shows greater intelligence than the cow. Many notable advocates of the theory, such as Darwin and Huxley, have stood helpless before the mental emotional, and moral supremacy of man over the ape, the animal most like man in body. Conscience is peculiar to man. Evil, sin, goodness, truth, love, sacrifice, hope, and religion separate man from the highest animal by a gulf not yet bridged by any scientific theory.

The doctrine of the common origin of life on earth is but a scientific theory, and should be viewed as such. Clear thinkers will distinguish between the general law of change or evolution accepted by all, and the special theories of evolution which, like all scientific theories, are subject to variation with the increase of knowledge. Honest thinkers will not attempt to confuse law and theory in the minds of laymen. The man, learned or unlearned, who declares the doctrine of the common origin of life on earth to be demonstrated beyond doubt, has yet to master the philosophy of science. The failure to differentiate between facts and inferences is the most grievous and the most common sin of scientists.

This is the trend of thought in the best scientific circles. In the words of Professor Punnett of Cambridge University, scientists "still hold by the theory of evolution, regarding the world of living things as dynamic, and not a static concern." But the interpretation of Darwinism has changed greatly. The theory of evolution "is released today from the necessity of finding a use for everything merely because it exists." More interesting, the glib talk about changing species is subdued. "Species are once more sharply marked off things with hard outlines, and we are faced once more

with the problem of their origin as such. The idea of yesterday has become the illusion of today; today's idea may become the illusion of tomorrow" (Punnett, "Forty Years of Evolution Theory," in Background to Modern Science). That is the spirit of science. By slow degrees, among many changes, accepting, rejecting, striving, it may in the distant future reach the correct understanding of final causes.

The majority of the advocates of the theory that all life came from one stock believe that the primeval cell originated by the chance assembling under favorable conditions of the constituent elements of cellular substance. That means that life is only an accidental intruder into the universe. The immediate logical weakness of this view is that if life on earth began by the fortuitous assembling of inorganic materials in a slimy, primitive pool, other equally favorable pools for the generation of life may have existed, thus providing more than one origin of life.

Those who insist that all life on earth has come from one source are almost obliged to rule God out of the picture; for, if a Supreme Being is allowed to create a living cell in the beginning, He may at will create other life at different periods of time. Even believers in God who accept the theory of evolution as a final explanation of the origin of life forms, are inclined to insist that the theory represents Gods only method of creation. Nearly always, those who so believe refuse to admit that any other process may also be in operation. They would limit God to one method of operation. Fettering God, or unbelief in Him, or making Him merely a universal super-force, have been usual companions of the theory of evolution (W. W. Keen, I Believe in God and Evolution).

Latter-day Saints accept every scientific fact, but rate theories based upon the facts as human explanations of the facts, likely to change as new facts appear. They do not deny that an evolutionary process, a reflection of the gospel law of progression, may be one of the methods of the Lord's labor in the universe. That does not mean, however, that the Almighty cannot perform other acts of will for the promotion of His plan, as, for example, the special creation of man. God is a purposeful Being; whatever is on earth or in heaven has been designed for the accomplishment of the divine purpose -- the welfare of man. The spirit of man, itself intelligent, purposeful, is an eternal pre-existent being. He reaches beyond the confines of earth. He was with God before the earth was made. The theory of evolution does not explain the external man.

Any theory that leaves out God as a personal, purposeful Being, and accepts chance as a first cause cannot be accepted by Latter-day Saints. The evidence for God is yet greater than for the chance creation of the earth and its inhabitants. Mind and thought shape a work of art from the marble block. More marvelous than any human work of art is man. However he may have risen to his present high estate, it has been by the operation of mind and thought. That man and the whole of creation came by chance is unthinkable. It is equally unthinkable that if man came into being by the will and power of God, the divine creative power is limited to one process dimly sensed by mortal man. The great law of evolution may have many forms of expression, far beyond man's present comprehension.

In fact, the whole squabble about evolution centers upon two questions. Did life on earth come by chance or by divine will? If by divine will, is God limited to one process? These questions are as old as history. The ancients asked them; and those who come after us will ask them.

Here, then, is the answer to the question at the head of this chapter: The law of evolution or change may be accepted fully. It is an established fact so far as human power can determine. It is nothing more or less than the gospel law of progression or its opposite. Joseph Smith taught that men could rise towards Godhood only "by going from one small degree to another, and from a small capacity to a great one; from grace to grace; from exaltation to exaltation." Modern revelation also says, "For I, the Lord God, created all things of which I have spoken, spiritually, before they

were naturally upon the face of the earth" (Pearl of Great Price, Moses 3:5), and further that each creation "remaineth in the sphere in which I, God created it" (Pearl of Great Price, Moses 3:9) This last statement suggests limitations placed upon development under the general law of progressive change. The theory of evolution which may contain partial truth, should be looked upon as one of the changing hypotheses of science, man's explanation of a multitude of observed facts. It would be folly to make it the foundation of a life's philosophy. Latter-day Saints build upon something more secure -- the operation of God's will, free and untrammelled, among the realities of the Universe.

October 1944
Elder Joseph B. Wirthlin
Through Creation of Worlds The Power of God is Made Manifest
Conference Address

The power of God is manifested by and through the priesthood. It was through the power of God that worlds were created, providing a tangible evidence of God's power. The power of God is evidenced and keenly felt in righteous words, honest deeds, sincere emotions, and clean thoughts of men. The power of God is creative, both in a spiritual and temporal sense, for all things were created, first, spiritually and then temporally. By his power the earth was formed; by his power light and darkness were separated; by his power the land and water were separated; by his power the vegetation, fowls of the air, the fish of the sea, and all earthly creatures were brought into being; but the most important of all these was the creation of man in the exact image of his Creator. The finite mind cannot comprehend or understand the full significance of the creation nor of the principles and the powers involved therein, but we do know that the creation was a great and stupendous work accomplished by actual, spiritual, mental, nd, who knows but what some physical effort was necessary on the part of our Heavenly Father. There must have been an element of work, of effort, in it, or else why the declaration found recorded in Genesis 2:2, "And on the seventh day God ended his work which he had made; and he rested on the seventh day from all his work which he had made," an indication of the necessity for rest after such a tremendous accomplishment.

October 1952
Elder Richard L. Evans, Quorum of the Twelve Apostles
Everywhere Evidence of Unhurried Intelligent Continuous Creation
Choir Broadcast at General Conference

There seems to be little evidence that the Creator of the universe was ever in a hurry. Everywhere, on this bounteous and beautiful earth, and to the farthest reaches of the firmament, there is evidence of patient purpose and planning and working and waiting. Perhaps this is a point to remember when we become too impatient with our own personal problems, or with the great unanswered questions that are in the minds of most of us. And when our troubles trouble us too much, it may be well to take a long look-perhaps a billion light years away, which is presently possible-across "worlds" that can't be counted-in sight of "suns" that can't be numbered-into space that can't be contemplated by the mortal mind of man. "And any man who hath seen any or the least of these hath seen God moving in his majesty and power." (D. & C. 88:47.) Everywhere there is evidence of a long, unhurried plan and pattern and purpose, of intelligence and continuous creation, and of the Creator-which makes one ask in all earnstness: "What is man, that thou art mindful of him?" (Psalm 8:4.) He must be important in the infinite plan and purpose or he wouldn't have the intelligence and the opportunities he has. And yet here on this pin-point planet, where in some ways we serve one another and in some ways we do our best to annihilate one another, the

most penetrating mind among us has profound reason to feel small and humble and repentant-for with all our brilliance and accomplishment (and stupidity) we are only children on the sands of the shore of an eternal sea. There is infinitely much that we must leave to time-including some of our troubles and some of our sorrows, some of our unsolved problems, and some of our unsatisfied questions. And a long look at the endless, orderly plan and purpose of the Father of us all may make some of the petty and passing things appear not so important as they have sometimes seemed. And when we find ourselves in conflict and confusion, we can well learn to wait a while for all the evidence ad all the answers that now evade us. Thank God for a glorious and interesting world, for truth, and for "infinity" and "eternity" in which to find it-and for faith in the limitless future.

1954
Dr. Henry Eyring, Sr., Dean, Graduate School, University Of Utah
Communication.
Improvement Era 1954

WHEN a person receives intelligence from the Lord and is willing to communicate that for the benefit of the people, he will receive addition to that intelligence." (Lorenzo Snow, Journal of Discourses 5:64.)

Human beings are born into the world with great potentialities but no learning. The knowledge which makes the difference between civilized man and the untutored savage flows to us from others in an unending stream from birth until death. All of us are involved in this process of communication, and the well-being of society measures directly how well the job is being done.

The industrial world we live in would fall apart without the intense inter-communication of information through advertising. Thus, the American standard of living exceeds the most extravagant dreams of our pioneer forefathers. Power machinery provides each of us with the work of forty slaves. Mass production, made possible by the advertising which promotes mass consumption, has created this magic world where the American laborer lives better than did ancient kings.

The gospel, in all its beauty and perfection, is effective, also, only as it is communicated. In each generation, the gospel needs people like the Apostle Paul to proclaim it for all to read and to hear. His epistles have brought faith and hope to millions. They fairly vibrate with the faith and ardor of this great Apostle. Not all of our great religious leaders, however, have been blessed with this gift of communication. How many of us, like Moses, when commissioned to lead Israel from bondage, say, "It is too difficult-for I am slow of speech"? (See Ex. 4:10.) Exemplifying, in a superlative degree, the overcoming of this barrier to communication, is Miss Helen Keller.

A short time ago, Life magazine carried a picture of the seventy-three-year-old, smiling Miss Keller with her hand pressed against President Eisenhower's face, following his reactions by touch. She has been without sight and hearing for seventy years. One can scarcely imagine more complete isolation. Yet, with the help of her teacher, Ann Sullivan, and others like her, Miss Keller did the impossible and learned to communicate her thoughts better than many who have no special handicap.

Communication of information involves both a sender and a receiver. The gospel flows out from the Creator of the world who sees the end from the beginning. It flows out to all who are able to receive it. Too many of those who are blind and deaf to this flow of information foolishly deny the

existence of the Creator. How much wiser they would be if like Helen Keller, they could overcome blindness and deafness and reach out and touch him.
Written in the many languages of the world are all sorts of messages which escape us completely because we don't speak that particular language. We have not found the appropriate Rosetta Stone. The Creator of the universe has implanted a message in every created thing.

Tennyson expressed the idea of the inter-relationship of things beautifully in the following words:

> Flower in the crannied wall,
> I pluck you out of the crannies.
> I hold you here, root and all, in my hand,
> Little flower-but if I could understand
> What you are, root and all, and all in all,
> I should know what God and man is.
> -"Flower in the Crannied Wall"

Geologists search for the meaning to be read into the piled-up strata of the earth much as a historian might turn the pages of an ancient, damaged manuscript. The astronomer seeks the answer to his questions in the depths of space. Still other men concentrate on the scriptures alone. The wise man searches all these and other sources, knowing that all are communications from the same divine source and certain that if followed far enough, all will guide him back to the divine Presence.

The scriptures give us a clear understanding of the concern of the eternal Father for his children. In both ancient and modern scriptures man has received divine communications which establish the religious pattern for those who heed it. When one contemplates the immensity of space, one cannot help marveling at the wonderful methods of communication still remaining to be discovered. Thus, the wisest physicists know no method of transferring messages faster than the speed of light. In fact, built into the theory of relativity is the idea that matter and energy, as we know them, never travel faster than light.

Consider now that the universe is so large that the best reflecting telescopes enable us to see stars by light which started journeying toward us so long ago. The subsequent history of these stars is completely unknown. They may long since have ceased to exist. There seems no reasonable alternative to the conclusion that the Creator has methods of communication which travel by other means and at speeds unknown and perhaps unknowable to mortal man. Somehow, the universe is co-ordinated and regulated by influences which transcend the known laws of physics. Nor should this seem strange if one remembers that such marvels as radar, radio, and the telegraph were unimaginable a century and a half ago.

What wonders can we not hope to unravel in the endless eternity ahead? It is interesting to note that Orson Pratt raised this same question regarding divine communication and answered it in much the same way about a century ago. Though our knowledge of the universe is always expanding, the fundamentals of the gospel endure unchanged.

1955
Pierre Teilhard De Chardin
The Phenomenon Of Man
Perennial Book - An imprint of HarperCollins Publishers

Originally published in French as La Phénomene Humain, copyright 1955 by Editions du Seuil, Paris.

First published in English in 1959 by Wm. Collins Sons & Co., Ltd., London, and Harper & Row, Publishers, Incorporated, New York. A revised translation was first published in 1965.

Book One - Before Life Came

Chapter One - The Stuff Of The Universe

To PUSH anything back into the past is equivalent to reducing it to its simplest elements. Traced as far as possible in the direction of their origins, the last fibres of the human aggregate are lost to view and are merged in our eyes with the very stuff of the universe.

As for the stuff of the universe—the ultimate residue of the ever more advanced analyses of science—I have not cultivated that direct and familiar contact with it which would enable me to do it justice, that contact which comes from experiment and not from reading and makes all the difference. Besides, I know the danger of trying to construct a lasting edifice with hypotheses which are only expected to last for a day, even in the minds of those who originate them.

To a considerable extent, the representation of the atom accepted at this moment is nothing more than a simple means, graphic even while subject to revision, enabling the scientist to put together and to show the non-contradiction of the ever more various ' effects' manifested by matter—many of which, moreover, have still no recognisable prolongation in man.

As I am a naturalist rather than a physicist, obviously I shall avoid dealing at length with or placing undue reliance upon these complicated and fragile edifices.

On the other hand, among the variety of overlapping theories, a certain number of characteristics emerge which are inevitable in any suggested explanation of the universe. It is of these' imposed' factors that it is not unbecoming for a naturalist to speak when engaged on a general study of the phenomenon of man. In fact, inasmuch as they express the conditions belonging to all natural change, even biological, he is bound to take them as his point of departure.

I. Elemental Matter

Observed from this special angle, and considered at the outset in its elemental state (by which I mean at any moment, at any point, and in any volume), the stuff of tangible things reveals itself with increasing insistence as radically particulate yet essentially related, and lastly, prodigiously active.

Plurality, unity, energy: the three faces of matter.

A. Plurality

The profoundly atomic character of the universe is visible in everyday experience, in raindrops and grains of sand, in the hosts of the living, and the multitude of stars; even in the ashes of the dead. Man has needed neither microscope nor electronic analysis in order to suspect that he lives surrounded by and resting on dust. But to count the grains and describe them, all the patient craft of modern science was necessary. The atoms of Epicurus were inert and indivisible. And the infinitesimal worlds of Pascal could still possess their animalcules. Today we have gone far beyond such instinctive or inspired guesswork both in certainty and precision. The scaling down is unlimited. Like the tiny diatom shells whose markings, however magnified, change almost indefinitely into new patterns, so each particle of matter, ever smaller and smaller, under the physicist's analysis tends to reduce itself into something yet more finely granulated. And at each new step in this progressive approach to the infinitely small the whole configuration of the world is for a moment blurred and then renewed.

When we probe beyond a certain degree of depth and dilution, the familiar properties of our bodies—light, colour, warmth, impenetrability, etc —lose their meaning.

Indeed our sensory experience turns out to be a floating condensation on a swarm of the undefinable. Bewildering in its multiplicity and its minuteness, the substratum of the tangible universe is in an unending state of disintegration as it goes downward.

B. Unity
On the other hand the more we split and pulverise matter artificially, the more insistently it proclaims its fundamental unity.

In its most imperfect form, but the simplest to imagine, this unity reveals itself in the astonishing similarity of the elements met with. Molecules, atoms, electrons--whatever the name, whatever the scale—these minute units (at any rate when viewed from our distance) manifest a perfect identity of mass and of behaviour. In their dimensions and actions they seem astonishingly calibrated—and monotonous. It is almost as if all that surface play which charms our lives tends to disappear at deeper levels. It is almost as if the stuff of which all stuff is made were reducible in the end to some simple and unique kind of substance.

Thus the unity of homogeneity. To the cosmic corpuscles we should find it natural to attribute an individual radius of action as limited as their dimensions. We find, on the contrary, that each of them can only be defined by virtue of its influence on all around it. Whatever space we suppose it to be in, each cosmic element radiates in it and entirely fills it. However narrowly the ' heart' ofan atom may be circumscribed, its realm is co-extensive, at least potentially, with that of every other atom. This strange property we will come across again, even in the human molecule.

We add: collective unity. The innumerable foci which share a given volume of matter are not therefore independent of each other. Something holds them together. Far from behaving as a mere inert receptacle, the space filled by their multitude operates upon it like an active centre of direction and transmission in which their plurality is organised. We do not get what we call matter as a result of the simple aggregation and juxtaposition of atoms. For that, a mysterious identity must absorb and cement them, an influence at which our mind rebels in bewilderment at first but which in the end it must perforce accept.

We mean the sphere above the centres and enveloping them.

Throughout these pages, in each new phase of anthropogenesis, we shall find ourselves faced by the unimaginable reality of collective bonds, and we shall have to struggle with them without ceasing until we succeed in recognising and defining their true nature. Here in the beginning it is sufficient to include them all under the empirical name given by science to their common initial principle, namely energy.

c. Energy
Under this name, which conveys the experience of effort with which we are familiar in ourselves, physics has introduced the precise formulation of a capacity for action or, more exactly, for interaction. Energy is the measure of that which passes from one atom to another in the course of their transformations. A unifying power, then, but also, because the atom appears to become enriched or exhausted in the course of the exchange, the expression f structure.

From the aspect of energy, renewed by radio-active phenomena, material corpuscles may now be treated as transient reservoirs of concentrated power. Though never found in a state of purity, but

always more or less granulated (even in light) energy nowadays represents for science the most primitive form of universal stuff. Hence we find our minds instinctively tending to represent energy as a kind of homogeneous, primordial flux in which all that has shape in the world is but a series of fleeting ' vortices '. From this point of view, the universe would find its stability and final unity at the end of its decomposition. It would be held together from below.

Let us keep the discoveries and indisputable measurements of physics. But let us not become bound and fettered to the perspective of final equilibrium that they seem to suggest. A more complete study of the movements of the world will oblige us, little by little, to turn it upside down; in other words, to discover that if things hold and hold together, it is only by reason of complexity, from above.

2. Total Matter

Up to now we have been looking at matter as such, that is to say according to its qualities and in any given volume—as though it were permissible for us to break off a fragment and study this sample apart from the rest. It is time to point out that this procedure is merely an intellectual dodge. Considered in its physical, concrete reality, the stuff of the universe cannot divide itself but, as a kind of gigantic atom ', it forms in its totality (apart from thought on which it is centred and concentrated at the other end) the only real indivisible. The history of consciousness and its place in the world remain incomprehensible to anyone who has not seen first of all that the cosmos in which man finds himself caught up constitutes, by reason of the unimpeachable wholeness of its whole, a system, a totum and a quantum: a system by its plurality, a totum by its unity, a quantum by its energy; all three within a boundless contour.

Let us try to make this clear.

A. The System

The existence of ' system ' in the world is at once obvious to every observer of nature, no matter whom.

The arrangement of the parts of the universe has always been tom is no longer the microscopic, closed world we may have imagined to ourselves. It is the infinitesimal centre of the world itself.

Now, on the other hand, let us turn our attention to the entirety of the infinitesimal centres which share the universal sphere among themselves. Indefinite though their number may be, they constitute in their multitude a group which has precise effects. For the whole, became it exists, must express itself in a global capacity for action of which we find the partial resultant in each one of us. Thus we find ourselves led on to envisage and conceive a dynamic standard of the world.

True the world has apparently limitless contours. To use varying metaphors: it behaves to our senses, either as a progressively attenuated environment which vanishes without a limital surface in an infinitely decreasing gradation, or as a curved and dosed space within which all the lines of our experience turn back upon themselves, in which case matter only appears boundless to us because we cannot emerge from it.

This is no reason for refusing it a quantum of energy, which the physicists, incidentally, already think they are in a position to measure.

But this quantum only takes on its full significance when we try to define it with regard to a concrete natural movement—that is to say, in duration.

3. The Evolution Of Matter.

Physics was born, in the last century, under the double sign of fixity and geometry. Its ideal, in its youth, was to find a mathematical explanation of a world imagined as a system of stable elements in a dosed equilibrium. Then, following all science of the real, it was inevitably drawn by its own progress into becoming a history. Today, positive knowledge of things is identified with the study of their development. Farther on, in the chapter on Thought, we shall have to describe and interpret the vital revolution in human consciousness brought about by the quite modern discovery of duration. Here we need only ask ourselves how our views about matter are enlarged by the introduction of this new dimension.

In essence, the change wrought in our experience by the appearance of what we shall soon call space-time is this, that everything that up to then we regarded and treated as points in our cosmological constructions became instantaneous sections of indefinite temporal fibres. To our opened eyes each element of things is henceforth extended backwards (and tends to be continued forwards) as far as the eye can see in such a way that the entire spatial immensity is no more than a section' at the time C of a trunk whose roots plunge down into the abyss of an unfathomable past, and whose branches rise up somewhere to a future that, at first sight, has no limit. In this new perspective the world appears like a mass in process of transformation. The universal totum and quantum tend to express and define themselves in cosmogenesis. What at this moment are the appearance (qualitative) assumed from the point of view of the physicists and the rules followed (quantitative) by this evolution of matter?

A. The Appearance

As seen in its central portion, which is the most distinct, the evolution of matter, in current theory, comes back to the gradual building up by growing complication of the various elements recognised by physical chemistry. To begin with, at the very bottom there is a still unresolved simplicity, luminous in nature and not to be defined in terms of figures. Then, suddenly(?) came a swarming of elementary corpuscles, both positive and negative (protons, neutrons, electrons, photons): the list increases incessantly. Then the harmonic series of simple bodies, strung out from hydrogen to uranium on the notes of the atomic scale. Next follows the immense variety of compound bodies in which the molecular weights go on increasing up to a certain critical value above which, as we shall see, we pass on to life. There is not one term in this long series but must be regarded, from sound experimental proofs, as being composed of nuclei and electrons. This fundamental discovery that all bodies owe their origin to arrangements of a single initial corpuscular type is the beacon that lights the history of the universe to our eyes. In its own way, matter has obeyed from the beginning that great law of biology to which we shall have to recur time and time again, the law of ' complexification '.

I say in its own way because, at the stage of the atom, we are still ignorant of many points in the history of the world.

First of all, must all the elements mount each successive rung of the ladder from the most simple to the most complicated by a kind of onto- or phylo-genesis in order to raise themselves in the series of simple bodies? Or do the atomic numbers only represent a rhythmic series of states of equilibrium, sets of pigeon-holes, as it were, into which nuclei and electrons fall in rough assemblages? Moreover, in the one Stance as in the other, must we regard the various combinations of nuclei as being equally possible at any one time? Or, on the other hand, must we suppose that on the whole, statistically, the heavy atoms only appear in a determinate order, after the lighter ones?

It does not appear that science is at present able to give definitive answers to these questions, or to others like them. At the present time we are less well informed about the ascending evolution of atoms (I do not say the disintegration ') than we are about the pre-living and living molecules. It is none the less true, and this is the only point of real importance that concerns us here, that from its

most distant formulations matter reveals itself to us in a state of genesis or becoming—this genesis allowing us to distinguish two of the aspects most characteristic of it in its subsequent stages. First of all, to begin with a critical phase, that of granulation, which abruptly and once and for all gave birth to the constituents of the atom and perhaps to the atom itself. Next, at least from the molecular level, of going on additively by a process of growing complexity.

Everything does not happen continuously at any one moment in the universe. Neither does everything happen everywhere in it.

So we may summarise in a few lines the ideas about the transformations of matter accepted by science today: but only by considering the latter in their temporal succession, and without as yet putting them anywhere within the cosmic expanse. Historically, the stuff of the universe goes on becoming concentrated into ever more organised forms of matter. But where, then, do these metamorphoses take place, beginning, let us say, with the framework of molecules? Is it indifferently at any point in space? Not at all, as we all know, but only in the heart and on the surface of the stars. From having considered the infinitely small elements we are abruptly compelled to raise our eyes to infinitely great sidereal masses.

The sidereal masses... Our science is at the same time troubled and fascinated by these colossal unities, which in some ways behave like atoms, but whose constitution baffles us by its enormous and—in appearance only?—irregular complexity. Perhaps the day will come when some arrangement or periodicity will become apparent in the stellar distribution both as regards their composition and their position. Do not a ' stratigraphy ' and a ' chemistry' of the heavens inevitably extend the story of the atoms?

We have not to entangle ourselves in these still misty perspectives. No matter how fascinating they may be, they surround man rather than lead up to him. On the other hand, because of its consequences even up to the genesis of the intellect, we must notice and record the definite connection which, genetically, associates the atom with the star. For a long time yet physics may hesitate over the structure to be assigned to the astral immensities. In the meantime one thing is certain and is enough to guide our steps along the ways of anthropogenesis. That is that the making of greater material complexes can only take place under cover of a previous concentration of the stuff of the universe in nebulae and suns. Whatever the overall figure of the worlds may be, the chemical function of each one of them already has a definable meaning for us. The stars are laboratories in which the evolution of matter proceeds in the direction of large molecules, and that according to determinate quantitative rules which we must now discuss.

B. The Numerical Laws

What ancient thought half perceived and imagined as a natural harmony of numbers, modem science has grasped and realised in the precision of formulae dependent on measurement. Indeed, we owe our knowledge of the macro-structure and microstructure of the universe far more to increasingly accurate measurements than to direct observations. And, again, it is ever bolder measurements that have revealed to us the calculable conditions to which every transformation of matter is subject according to the force it calls into play.

This is not the place for me to embark on a critical discussion of the laws of energy. That part of them that is indispensable and accessible to every world-historian may be simply summarised. Considered from this biological aspect, broadly speaking, they may be reduced to the two following principles:

First Principle. During changes of a physico-chemical type we do not detect any measurable emergence of new energy.

Every synthesis costs something. That is a fundamental condition of things which persists, as we know, even into the spiritual zones of being. In every domain, the achievement of progress requires an excess of effort and therefore of force. Now whence does this increase come?

In the abstract, one might assume an internal growth of the world's resources, an absolute increase in mechanical wealth corresponding to the expanding needs of evolution; but, in fact, things seem to happen otherwise. In no case does the energy required for synthesis appear to be provided by an influx of fresh capital, but by expenditure. What is gained on one side is lost on the other. Nothing is constructed except at the price of an equivalent destruction.

Experimentally and at first sight, when we consider the universe in its mechanical functions, it does not reveal itself to us as an open quantum capable of containing an ever greater reality within its embrace, but as a closed quantum, within which nothing progresses except by exchange of that which was given in the beginning.

That is a first appearance.

Second Principle. In every physico-chemical change, adds thermodynamics, a fraction of the available energy is irrecoverably entropised lost, that is to say, in the form of heat. Doubtless it is possible to retain this degraded fraction symbolically in equations, so as to express that in the operations of matter nothing is lost any more than anything is created, but that is merely a mathematicaltrick. As a matter of fact, from the real evolutionary standpoint, something is finally burned in the course of every synthesis in order to pay for that synthesis. The more the energy-quantum of the world comes into play, the more it is consumed. Within the scope of our experience, the material concrete universe seems to be unable to continue on its way indefinitely in a closed cycle, but traces out irreversibly a curve of obviously limited development. And thus it is that this universe differentiates itself from purely abstract magnitudes and places itself among the realities which are born, which grow, and which die. From time it passes into duration; and finally escapes from geometry dramatically to become, in its totality as in its parts, an object of history.'

Let us translate into images the natural significance of these two principles of the Conservation and Dissipation of Energy.

We said above that qualitatively the evolution of matter reveals itself to us, hie et nunc, as a process during which the constituents of the atom are inter-combined and ultra-condensed. Quantitatively, this transformation now appears to us as a definite, but costly, operation in which an original impetus slowly becomes exhausted. Laboriously, step by step, the atomic and molecular structures become higher and more complex, but the upward force is lost on the way. Moreover, the same wearing away that is gradually consuming the cosmos in its totality is at work within the terms of the synthesis, and the higher the terms the quicker this action takes place. Little by little, the improbable combinations that they represent become broken down again into more simple components, which fall back and are disaggregated in the shapelessness of probable distributions.

A rocket rising in the wake of time's arrow, that only bursts to be extinguished; an eddy rising on the bosom of a descending current—such then must be our picture of the world.

So says science: and I believe in science: but up to now has science ever troubled to look at the world other than from

without?

Chapter Two - The Within Of Things

ON THE scientific plane, the quarrel between materialists and the upholders of a spiritual interpretation, between finalists and determinists, still endures. After a century of disputation each side remains in its original position and gives its adversaries solid reasons for remaining there.

So far as I understand the struggle, in which I have found myself involved, it seems to me that its prolongation depends less on the difficulty that the human mind finds in reconciling certain apparent contradictions in nature—such as mechanism and liberty, or death and immortality—as in the difficulty experienced by two schools of thought in finding a common ground. On the one hand the materialists insist on talking about objects as though they only consisted of external actions in transient relationships. On the other hand the upholders of a spiritual interpretation are obstinately determined not to go outside a kind of solitary introspection in which things are only looked upon as being shut in upon themselves in their immanent workings. Both fight on different planes and do not meet; each only sees half the problem.

I am convinced that the two points of view require to be brought into union, and that they soon will unite in a kind of phenomenology or generalised physic in which the internal aspect of things as well as the external aspect of the world will be taken into account. Otherwise, so it seems to me, it is impossible to cover the totality of the cosmic phenomenon by one coherent explanation such as science must try to construct.

which have to be solved by the same method, namely, to discover the universal hidden beneath the exceptional?

Latterly we have experienced it too often to admit of any further doubt: an irregularity in nature is only the sharp exacerbation, to the point of perceptible disclosure, of a property of things diffused throughout the universe, in a state which eludes our recognition of its presence. Properly observed, even if only in one spot, a phenomenon necessarily has an omnipresent value and roots by reason of the fundamental unity of the world. Whither does this rule lead us if we apply it to the instance of human ' self-knowledge '?

Consciousness is completely evident only in man' we are tempted to say, ' therefore it is an isolated instance of no interest to science.'

Consciousness is evident in man,' we must continue, correcting ourselves, ' therefore, half-seen in this one flash of light, it has a cosmic extension, and as such is surrounded by an aura of indefinite spatial and temporal extensions.'

The conclusion is pregnant with consequences, and yet I cannot see how, by sound analogy with all the rest of science, we can escape from it.

It is impossible to deny that, deep within ourselves, an ' interior' appears at the heart of beings, as it were seen through a rent. This is enough to ensure that, in one degree or another, this ' interior ' should obtrude itself as existing everywhere in nature from all time. Since the stuff of the universe has an inner aspect at one point of itself, there is necessarily a double aspect to its structure, that is to say in every region of space and time—in the same way, for instance, as it is granular: co-extensive with their Without, there is a Within to things.

The consequent picture of the world daunts our imagination, but it is in fact the only one acceptable to our reason. Taken at its lowest point, exactly where we put ourselves at the

beginning of these pages, primitive matter is something more than the particulate swarming so marvellously analysed by modem physics. Beneath this mechanical layer we must think of a ' biological layer that is attenuated to the uttermost, but yet is absolutely necessary to explain the cosmos in succeeding ages. The within, consciousness' and then spontaneity—three expressions for the same thing. It is no more legitimate for us experimentally to fix an absolute beginning to these three expressions of one and the same thing than to any other lines of the universe.

In a coherent perspective of the world: life inevitably assumes a ' pre-life' for as far back before it as the eye can see.

In that case—and the objection will come from materialists and upholders of spirituality alike—if everything in nature is basically living, or at least pre-living, how is it possible for a mechanistic science of matter to be built up and to triumph?

Determinate without, and ' free' within—would the two aspects of things be irreducible and incommensurable? If so, where is your solution?

The answer to this difficulty is already implicit in what we have said above about the diversity of spheres of experience' superposed in the interior of the world. It will appear more clearly when we have discerned the qualitative laws that govern in their growth and variation the manifestations of what we have just called the within of things.

2. The Qualitative Laws Of Growth

To harmonise objects in time and space, without presuming to determine the conditions that can rule their deepest being: to establish an experimental chain of succession in nature, not a union of ` ontological' carnality; to see, in other words, and not to explain—this, let it not be forgotten, is the sole aim of the present study.

From this phenomenal point of view (which is the scientific point of view) can one go beyond the position where our analysis of the stuff of the universe has just stopped? In this last we have recognised the existence of a conscious inner face that everywhere duplicates the' material external face, which alone is commonly considered by science. Can we go further and define the rules according to which this second face, for the most part entirely hidden, suddenly shows itself, and then as suddenly bursts through into certain other regions of our experience?

Yes, so it seems, and even quite easily, provided there are placed one after the other three observations that each one of us could have made, but which do not take on their true value until we think of linking them together.

A. First Observation

Considered in its pre-vital state, the within of things, whose reality even in the nascent forms of matter we have just admitted, must not be thought of as forming a continuous film, but as assuming the same granulation as matter itself.

Soon we shall have to return to this essential point. As far back as we began to descry them, the first living things reveal themselves to our experience as kinds of ` mega-' or ' ultra-' molecules, both in size and in number: a bewildering multitude of microscopic nuclei. Which means that for reasons of homogeneity and continuity, the pre-living can be divined, below the horizon, as an object sharing in the corpuscular structure and properties of the world. Looked at from within, as well as observed from without, the stuff of the universe thus tends likewise to be resolved backwardly into a dust of particles that are (i) perfectly alike among themselves (at least if they are observed from a great distance); (ii) each co-extensive with the whole of the cosmic realm; (iii)

mysteriously connected among themselves, finally, by a global energy. In these depths the world's two aspects, external and internal, correspond point by point. So much is this so that one may pass from the one to the other on the sole condition that ` mechanical interaction' in the definition of the partial centres of the universe given above is replaced by ' consciousness '.

Atomicity is a common property of the Within and the Without of things.

B. Second Observation
Virtually homogeneous among themselves in the beginning, the elements of consciousness, exactly as the elements of matter which they subtend, complicate and differentiate their nature, little by little, with the passage of duration. From this point of view and considered solely from the experimental aspect, consciousness reveals itself as a cosmic property of variable size subject to a global transformation. Taken on the ascent, this huge phenomenon that we shall have to follow all along the development of life right up to the appearance of thought, has ended by appearing commonplace. Followed in the opposite direction, it leads us, as we have already seen, to the less familiar idea of inferior states that are ever less well defined and, as it were, distended.

Refracted rearwards along the course of evolution, consciousness displays itself qualitatively as a spectrum of shifting shades whose lower terms are lost in the night.

c. Third Observation
Finally, let us take from two different regions of this spectrum two particles of consciousness that are at unlike stages of evolution. As we have seen, there corresponds to each of them, by construction, a certain definite material grouping of which they form the within. Let us compare these two external groupings the one with the other and ask ourselves how they are arranged with regard to each other and with regard to the portion of consciousness that each of them encloses.

The answer comes at once.

Whatever instance we may think of, we may be sure that every time a richer and better organised structure will correspond to the more developed consciousness.

The simplest form of protoplasm is already a substance of unheard-of complexity. This complexity increases in geometrical progression as we pass from the protozoon higher and higher up the scale of the metazoa. And so it is for all the rest always and everywhere. Here again, the phenomenon is so obvious that we have long since ceased to be astonished by it. Yet its importance is decisive. For thanks to it we possess a tangible parameter' allowing us to connect both the internal and the external films of the world, not only in their position (point by point), but also, as we shall verify later on, in their motion.

The degree of concentration of a consciousness varies in inverse ratio to the simplicity of the material compound lined by it. Or again: a consciousness is that much more perfected according as it lines a richer and better organised material edifice.

Spiritual perfection (or conscious centreity ') and material synthesis (or complexity) are but the two aspects or connected parts of one and the same phenomenon.'

And now we have arrived, ipso facto, at the solution of the problem posed for us. We are seeking a qualitative law of development that from sphere to sphere should be capable of explaining, first of all the invisibility, then the appearance, and then the gradual dominance of the within in comparison to the 'without of things. This law reveals itself once the universe is,thought of as passing from State A, characterised by a very large number of very simple material elements (that

is to say, with a very poor within), to State B defined by a smaller number of Very complex groupings (that is to say, with a much richer within).

In State A, the centres of consciousness, because they are tremely numerous and extremely loose at the same time, only reveal themselves by overall effects which are subject to the laws f statistics. Collectively, that is, they obey the laws of mathetics. This is the proper field of physico-chemistry.

In State B, on the other hand, these less numerous' and at Vibe same time more highly individualised elements gradually escape from the slavery of large numbers. They allow their basic non-measurable spontaneity to break through and reveal itself. We can begin to see them and follow them one by one, and in so doing we have access to the world of biology.

In sum, all the rest of this essay will be nothing but the story the struggle in the universe between the unified multiple and unorganised multitude: the application throughout of the eat Law of complexity and consciousness: a law that itself implies psychically convergent structure and curvature of the world.

But we must not go too quickly, and since we are still concerned with pre-life let us only keep in mind that, from the qualitative viewpoint, there is no kind of contradiction involved in admitting that a universe of mechanistic appearance may be built up of ' liberties '—provided that the liberties are therein contained in a sufficiently fine state of division and imperfection.

3. Spiritual Energy

There is no concept more familiar to us than that of spiritual energy, yet there is none that is more opaque scientifically. On the one hand the objective reality of psychical effort and work is so well established that the whole of ethics rests on it and, on the other hand, the nature of this inner power is so intangible that the whole description of the universe in mechanical terms has had no need to take account of it, but has been successfully completed in deliberate disregard of its reality.

The difficulties we still encounter in trying to hold together spirit and matter in a reasonable perspective are nowhere more harshly revealed. Nowhere either is the need more urgent of building a bridge between the two banks of our existence—the physical and the moral—if we wish the material and spiritual sides of our activities to be mutually enlivened.

To connect the two energies, of the body and the soul, in a coherent manner: science has provisionally decided to ignore the question, and it would be very convenient for us to do the same. Unfortunately, or fortunately, caught up as we are here in the logic of a system where the within of things has just as much or even more value than their without, we collide with the difficulty head on. It is impossible to avoid the clash: we must advance.

Naturally the following considerations do not pretend to be a truly satisfactory solution of the problem of spiritual energy. Their aim is merely to show by means of one example what, in my opinion, an integral science of nature should adopt as its line of research and the kind of interpretation it should follow.

A. The Problem of the Two Energies

The inner face of the world is manifest deep within our Inman consciousness, and there reflects upon itself; it would esteem that we have only got to look at ourselves in order to understand the dynamic relationships existing between the within pd the without of things at a given point in the universe.

In fact so to do is one of the most difficult of all things.

We are perfectly well aware in our concrete actions that the opposite forces combine. The motor works, but we cannot figure out the method, which seems to be contradictory. What remains the crux—and an irritating one at that—of the problem of spiritual energy for our reason is the heightened sense that we see without ceasing in ourselves that our action seems at one `depend on, and yet to be independent of, material forces.

First of all, the dependence. This is depressingly and magnificently obvious. ' To think, we must eat.' That blunt statement buttresses a whole economy, and reveals, according to the way we look at it, either the tyranny of matter or its spiritual power.

The loftiest speculation, the most burning love are, as we know only too well, accompanied and paid for by an expenditure of ysical energy. Sometimes we need bread, sometimes wine, sometimes a drug or a hormone injection, sometimes the stimulation of a colour, sometimes the magic of a sound which goes in t our ears as a vibration and reaches our brains in the form of respiration.

Without the slightest doubt there is something through which material and spiritual energy hold together and are complementary. In last analysis, somehow or other, there must be a single energy operating in the world. And the first idea that occurs to s is that the' soul ' must be as it were a focal point of transformation at which, from all the points of nature, the forces of bodies converge, to become interiorised and sublimated in beauty and nth.

Yet, seductive though it be, the idea of the direct transformation of one of these two energies into the other is no sooner glimpsed than it has to be abandoned. As soon as we try to couple them together, their mutual independence becomes as clear as their interrelation.

Once again: To think, we must eat.' But what a variety of thoughts we get out of one slice of bread! Like the letters of the alphabet, which can equally well be assembled into nonsense as into the most beautiful poem, the same calories seem as indifferent as they are necessary to the spiritual values they nourish.

The two energies—of mind and matter—spread respectively through the two layers of the world (the within and the without) have, taken as a whole, much the same demeanour. They are constantly associated and in some way pass into each other. But it seems impossible to establish a simple correspondence between their curves. On the one hand, only a minute fraction of ' physical' energy is used up in the highest exercise of spiritual energy; on the other, this minute fraction, once absorbed, results on the internal scale in the most extraordinary oscillations.

A quantitative disproportion of this kind is enough to make us reject the naïve notion of ' change of form' (or direct transformation)—and hence all hope of discovering a ' mechanical equivalent' for will or thought. Between the within and the without of things, the interdependence of energy is incontestable. But it can in all probability only be expressed by a complex symbolism in which terms of a different order are employed.

B. A Line of Solution

To avoid a fundamental dualism, at once impossible and antiscientific, and at the same time to safeguard the natural complexity of the stuff of the universe, I accordingly propose the following as a basis for all that is to emerge later.

We shall assume that, essentially, all energy is psychic in nature; but add that in each particular element this fundamental energy is divided into two distinct components: a tangential energy which links the element with all others of the same order (that is to say, of the same complexity and the same centricity) as itself in the universe; and a radial energy which draws it towards ever greater complexity and centricity—in other words forwards?

From this initial state, and supposing that it disposes of a certain free tangential energy, the particle thus constituted must obviously be in a position to increase its internal complexity in association with neighbouring particles, and thereupon (since its centricity is automatically increased) to augment its radial energy. The latter will then be able to react in its turn in the form of a new arrangement in the tangential field. And so on.

In this view, whereby tangential energy represents' energy' as such, as generally understood by science, the only difficulty is to explain the interplay of tangential arrangements in terms of the laws of thermodynamics. As regards this we may remark the following:

a. First of all, since the variation of radial energy in function of tangential energy is effected, according to our hypothesis, by the intervention of an arrangement, it follows that as much as you like of the first may be linked with as little as you like of the second - for a highly perfected arrangement may only require an extremely [mall amount of work. This fits in with the facts noted in section above.

Moreover, in the system here proposed, we are paradoxically led to admit that cosmic energy is constantly increasing, not only in its radial form, but—which is much more serious—in its tangential one (for the tension between elements increases with their centricity itself). This would seem to be in direct contradiction with the law of conservation of energy. It must be noted, however, that this increase of the tangential of the second kind (the only one troublesome for physics) only becomes appreciable with very high radial values (as in man, for instance, and social tensions). Below this level, and for an approximately constant number of initial particles in the universe, the sum of the cosmic tangential energies remains practically and statistically invariable in the course of transformations. And this is all that science requires.

c. Lastly, since according to our reading, the entire edifice of the universe is constantly supported at every phase of its progressive centration ' by its primary arrangements, it is plain that its achievement will be conditioned up to the highest stages by a certain primordial quantum of free tangential energy, which will gradually exhaust itself, following the principle of entropy.

Looked at as a whole, this picture satisfies the requirements of reality.

Three questions remain still unanswered, however:

- By virtue of what special energy does the universe propagate itself along its main axis in the less probable direction of the higher forms of complexity and centricity?

- Is there a definite limit and end to the ' elemental' value and to the sum total of the radial energies developed in the course of transformation?

- Is this final and resultant form of radial energies, supposing it exists, subject to reversal? Is it destined one day to start disintegrating so as to satisfy the principle of entropy, and fall back indefinitely into pre-living and still lower centres, by the exhaustion and gradual levelling-down of the free tangential energy contained in the successive envelopes of the universe from which it has emerged?

To be answered satisfactorily, these three questions must await a much later chapter, when the study of man will have led us to the concept of a superior pole to the world—the omega point.

Book Four - Survival

Chapter Three - The Ultimate Earth

WE HAVE seen that without the involution of matter upon itself, that is to say, without the dosed chemistry of molecules, cells and phyletic branches, there would never have been either biosphere or noosphere. In their advent and their development, life and thought are not only accidentally, but also structurally, bound up with the contours and destiny of the terrestrial mass.

But, on the other hand, we now see ahead of us a psychical centre of universal drift, transcending time and space and thus essentially extra-planetary, to sustain and equilibrate the surge of consciousnesses.

The idea is that of noogenesis ascending irreversibly towards Omega through the strictly limited cycle of a geogenesis. At a given moment in the future, under some influence exerted by one or the other of these curves or of both together, it is inevitable that the two branches should separate. However convergent it be, evolution cannot attain to fulfilment on earth except through a point of dissociation.

With this we are introduced to a fantastic and inevitable event which now begins to take shape in our perspective, the event which comes nearer with every day that passes: the earl of all life on our globe, the death of the planet, the ultimate phase of the phenomenon of man.

No one would dare to picture to himself what the noosphere will be like in its final guise, no one, that is, who has glimpsed however faintly the incredible potential of unexpectedness accumulated in the spirit of the earth. The end of the world defies imagination. But if it would be absurd to try to describe it, we may none the less—by making use of the lines of approach already laid down—to some extent foresee the significance and circumscribe the forms.

What the ultimate earth cannot be in a universe of conscious substance; how will it take shape; and what it will probably be —those are the questions I want to raise, coldly and logically, in no way apocalyptically, not so much for the sake of affirming anything as to give food for thought.

1. Prognostics To Be Set Aside

When the end of the world is mentioned, the idea that leaps into our minds is always one of catastrophe.

Generally we think of a sidereal cataclysm. There are so many stars hurtling around and brushing past; there are those exploding worlds on the horizon; so, surely, by the implacable laws of chance, our turn will come sooner or later and we shall be stricken and killed; or, at the least, we shall have to face a slow death in our prison.

Since physics has discovered that all energy runs down, we seem to feel the world getting a shade chillier every day. That cooling-off to which we were condemned has been partially compensated for by another discovery, that of radio-activity, which has happily intervened to compensate and delay the imminent cooling. The astronomers are now in a position to guarantee that, if all goes as

it should, we have at any rate several hundred million years ahead of us. So we can breathe again. Yet, though the settlement is postponed, the shadow grows longer.

And will mankind still be there to watch the evening fall? In the interim, apart from the cosmic mishaps that lie in wait for us, what will happen in the living layer of the earth? With age and increasing complication, we are ever more threatened by internal dangers at the core of both the biosphere and the noosphere. Onslaughts of microbes, organic counter-evolutions, sterility, war, revolution—there are so many ways of coming to an end. Yet perhaps anything would be better than a long-drawn-out senility.

We are well aware of these different eventualities. We have turned them over in our minds. We have read descriptions of them in the novels of the Goncourts, Benson and Wells, or in scientific works signed by famous names. Each one of them is perfectly feasible. We could very well, and at any moment, be crushed by a gigantic comet. And, equally true, tomorrow the earth might quake and collapse under our feet. Taken individually, each human will can repudiate the task of ascending higher towards union. And yet, on the strength of all we learn from past evolution, I feel entitled to say that we have nothing whatever to fear from these manifold disasters in so far as they imply the idea of premature accident or failure. However possible they may be in theory, we have higher reasons for being sure that they will not happen.

All pessimistic representations of the earth's last days—whether in terms of cosmic catastrophe, biological disruptions or simply arrested growth or senility—have this in common: that they take the characteristics and conditions of our individual and elemental ends and extend them without correction to life as a whole. Accident, disease and decrepitude spell the death of men; and therefore the same applies to mankind.

But have we any right to generalise in this simple way? When an individual disappears, even prematurely, another is always there to replace him. His loss is not irreparable from the point of view of the continuation of life. But what about mankind? In one of his books the great palaeontologist Matthew has suggested that if the human branch disappeared, another thinking branch would soon take its place. But he does not tell us where this mysterious shoot could be expected to appear on the tree of life as we know it, and doubtless he would be hard put to it to do so.

If we take the whole of history into consideration, the biological situation seems to me to be quite otherwise.

Once and once only in the course of its planetary existence has the earth been able to envelop itself with life. Similarly once and once only has life succeeded in crossing the threshold of reflection. For thought as for life there has been just one season. And we must not forget that since the birth of thought man has been the leading shoot of the tree of life. That king so, the hopes for the future of the noosphere (that is to say, of biogenesis, which in the end is the same as cosmogenesis) are concentrated exclusively upon him as such. How then could he come to an end before his time, or stop, or deteriorate, unless the universe committed abortion upon itself, which we have already decided to be absurd?

In its present state, the world would be unintelligible and the presence in it of reflection would be incomprehensible, unless we supposed there to be a secret complicity between the infinite and the infinitesimal to warm, nourish and sustain to the very end—by dint of chance, contingencies and the exercise of free choice—the consciousness that has emerged between the two. It is upon this complicity that we must depend. Man is irreplaceable. Therefore, however improbable it might seem, he must reach the goal, not necessarily, doubtless, but infallibly.

What we should expect is not a halt in any shape or form, but an ultimate progress coming at its biologically appointed hour; a maturation and a paroxysm leading ever higher into the Improbable from which we have sprung. It is in this direction that we must extrapolate man and hominisation if we want to get a forward glimpse of the end of the world.

2. The Approaches

Without going beyond the limits of scientific probability, we can say that life still has before it long periods of geological time in which to develop. Moreover, in its thinking form, it still shows every sign of an energy in full expansion. On the one hand, compared with the zoological layers which preceded it whose average duration is at least in the order of eighty million years, mankind is so young that it could almost be called newborn. On the other hand, to judge from the rapid developments of thought in the short period of a few dozen centuries, this youth bears within it the indications and the promises of an entirely new biological cycle. Thus in all probability, between our modem earth and the ultimate earth, there stretches an immense period, characterised not by a slowing-down but a speeding up and by the definitive florescence of the forces of evolution along the line of the human shoot.

Assuming success—which is the only acceptable assumption —under what form and along what lines can we imagine progress developing during this period?

In the first place, in a collective and spiritual form. We have noticed that, since man's advent, there has been a certain slowing down of the passive and somatic transformations of the organism in favour of the conscious and active metamorphoses of the individual absorbed in society. We find the artificial carrying on the work of the natural; and the transmission of an oral or written culture being superimposed on genetic forms of heredity (chromosomes). Without denying the possibility or even probability of a certain prolongation in our limbs, and still more in our nervous system, of the orthogenetic processes of the past,' I am inclined to think that their influence, hardly appreciable since the emergence of Homo sapiens, is destined to dwindle still further. As thought regulated by a sort of quantum law, the energies of life seem unable to spread in one region or take on a new form except at the expense of a lowering elsewhere. Since man's arrival, the evolutionary pressure seems to have dropped in all the non-human branches of the tree of life. And now that man has become an adult and has opened up for himself the field of mental and social transformations, bodies no longer change appreciably; they no longer need to in the human branch; or if they still change, it will only be under our industrious control. It may well be that in its individual capacities and penetration our brain has reached its organic limits. But the movement does not stop there. From west to east, evolution is henceforth occupied elsewhere, in a richer and more complex domain, constructing, with all minds joined together, mind. Beyond all nations and races, the inevitable taking-as-a-whole of mankind has already begun.

With that said we have now to ask: along what lines of advance, among others—judging from the present condition of the noosphere—are we destined to proceed from the planetary level of psychic totalisation and evolutionary upsurge we are now approaching?

I can distinguish three principal ones in which we see again the predictions to which we were already led by our analysis of the ideas of science and humanity. They are: the organisation of research, the concentration of research upon the subject of man, and the conjunction of science and religion. These are three natural terms of one and the same progression.

A. The Organisation of Research

We are given to boasting of our age being an age of science. And if we are thinking merely of the dawn compared to the darkness that went before, up to a point we are justified. Something

enormous has been born in the universe with our discoveries and our methods of research. Something has been started which, I am convinced, will now never stop. Yet though we may exalt research and derive enormous benefit from it, with what pettiness of spirit, poverty of means and general haphazardness do we pursue truth in the world today! Have we ever given serious thought to the predicament we are in.

Like art—indeed we might almost say like thought itself—science was born with every sign of superfluity and fantasy. It was born of the exuberance of an internal activity that had outstripped the material needs of life; it was born of the curiosity of dreamers and idlers. Gradually it became important; its effectiveness gave it the freedom of the city. Living in a world which it can justly be said to have revolutionised, it has acquired a social status; sometimes it is even worshipped. Yet we still leave it to grow as best it can, hardly tending it, like those wild plants whose fruits are plucked by primitive peoples in their forests. Everything is subordinated to the increase in industrial production, and to armaments. The scientist and the laboratories which multiply our powers still receive nothing, or next to nothing. We behave as though we expected discoveries to fall ready-made from the sky, like rain or sunshine, while men concentrate on the serious business of killing each other and eating. Let us stop to think for a moment of the proportion of human energy devoted, here and now, to the pursuit of truth. Or, in still more concrete terms, let us glance at the percentage of a nations revenue allotted in its budget for the investigation of clearly-defined problems whose solution would be of vital consequence for the world. If we did we should be staggered. Less is provided annually for all the pure research all over the world than for one capital ship. Surely our great-grandsons will not be wrong if they think of us as barbarians?

The truth is that, as children of a transition period, we are neither fully conscious of, nor in full control of, the new powers that have been unleashed. Clinging to outworn habit, we still see in science only a new means of providing more easily the same old things. We put Pegasus between the traces. And Pegasus languishes—unless he bolts with the waggon! But the moment will come—it is bound to—when man will be forced by disparity of the equipage to admit that science is not an accessory occupation for him but an essential activity, a natural derivative of the overspill of energy constantly liberated by mechanisation.

We can envisage a world whose constantly increasing ' leisure ' and heightened interest would find their vital issue in fathoming everything, trying everything, extending everything; a world in which giant telescopes and atom smashers would absorb more money and excite more spontaneous admiration than all the bombs and cannons put together; a world in which, not only for the restricted band of paid research-workers, but also for the man in the street, the day's ideal would be the wresting of another secret or another force from corpuscles, stars, or organised matter; a world in which, as happens already, one gives one's life to be and to know, rather than to possess. That, on an estimate of the forces engaged,' is what is being relentlessly prepared around us.

In some of the lower organisms the retina is, as it were, spread over the whole surface of the body. In somewhat the same way human vision is still diffuse in its operation, mixed up with industrial activity and war. Biologically it needs to individualise itself independently, with its own distinct organs. It will not be long now before the noosphere finds its eyes.

B. The Discovery of the Human Object

When mankind has once realised that its first function is to penetrate, intellectually unify, and harness the energies which surround it, in order still further to understand and master them, there will no longer be any danger of running into an upper limit of its florescence. A commercial market can reach saturation point. One day, though substitutes may be found, we shall have exhausted our mines and oil-wells. But to all appearances nothing on earth will ever saturate our desire for knowledge or exhaust our power for invention. For of each may be said: *crescit mundo.*

That does not mean that science should propagate itself indifferently in any and every direction at the same time like a ripple in an isotropic medium. The more one looks, the more one sees. And the more one sees, the better one knows where to look. If life has been able to advance, it is became, by ceaseless groping, it has successively found the points of least resistance at which reality yielded to its thrust. Similarly, if research is to progress tomorrow, it will be largely by localising the central zones, the sensitive zones which are alive ', whose conquest will afford us an easy mastery of all the rest.

From this point of view, if we are going towards a human era of science, it will be eminently an era of human science. Man, the knowing subject, will perceive at last that man, ' the object of knowledge ', is the key to the whole science of nature.

Carrel referred to man as 'the unknown '. But man, we should add, is the solution of everything that we can know.

Up to the present, whether from prejudice or fear, science has been reluctant to look man in the face but has constantly circled round the human object without daring to tackle it. Materially our bodies seem insignificant, accidental, transitory and fragile; why bother about them? Psychologically, our souls are incredibly subtle and complex: how can one fit them into a world of laws and formulas?

Yet the more persistently we try to avoid man in our theories, the more tightly drawn become the circles we describe around him, as though we were caught up in his vortex. As I said in my Preface, at the end of its analyses, physics is no longer sure whether what is left in its hands is pure energy or, on the contrary, thought. At the end of its constructions, biology, if it takes its discoveries to their logical conclusion, finds itself forced to acknowledge the assemblage of thinking beings as the present terminal form of evolution. We find man at the bottom, man at the top, and, above all, man at the centre—man who lives and struggles desperately in us and around us. We shall have to come to grips with him sooner or later.

Man is, if I have not gone astray in these pages, an object of study of unique value to science for two reasons. (i) He represents, individually and socially, the most synthesised state under which the stuff of the universe is available to us.

Correlatively, he is at present the most mobile point of the stuff in course of transformation.

For these two reasons, to decipher man is essentially to try to find out how the world was made and how it ought to go on making itself. The science of man is the practical and theoretical science of hominisation. It means profound study of the past and of origins. But still more, it means constructive experiment pursued on a continually renewed object. The programme is immense and its only end or aim is that of the future.

What is involved, firstly, is the care and improvement of the human body, the health and strength of the organism. So long as its phase of immersion in the tangential' lasts, thought can only be built up on this material basis. And now, in the tumult of ideas that accompany the awakening of the mind, are we not undergoing physical degeneration? It has been said that we might well blush comparing our own mankind, so full of misshapen subjects, with those animal societies in which, in a hundred thousand individuals, not one will be found lacking in a single antenna. In itself that geometrical perfection is not in the line of our evolution whose bent is towards suppleness and freedom. All the same, suitably subordinated to other values, it may well appear as an indication and a lesson. So far we have certainly allowed our race to develop at random, and we have given

too little thought to the question of what medical and moral factors must replace the crude forces of natural selection should we suppress them. In the course of the coming centuries it is indispensable that a nobly human form of eugenics, on a standard worthy of our personalities, should be discovered and developed.

Eugenics applied to individuals leads to eugenics applied to society. It would be more convenient, and we would incline to think it safe, to leave the contours of that great body made of all our bodies to take shape on their own, influenced only by the automatic play of individual urges and whims. ' Better not interfere with the forces of the world! ' Once more we are no against the mirage of instinct, the so-called infallibility of nature. But is it not precisely the world itself which, culminating in thought, expects us to think out again the instinctive impulses of nature so as to perfect them? Reflective substance requires reflective treatment. If there is a future for mankind, it can only be imagined in terms of a harmonious conciliation of what is free with what is planned and totalised. Points involved are: the distribution of the resources of the globe; the control of the trek towards unpopulated areas; the optimum use of the powers set free by mechanisation; the physiology of nations and races; geo-economy, geo-politics, geo-demography; the organisation of research developing into a reasoned organisation of the earth. Whether we like it or not, all the signs and all our needs converge in the same direction. We need and are irresistibly being led to create, by means of and beyond all physics, all biology and all psychology, a science of human energetics.

It is in the course of that creation, already obscurely begun, that science, by being led to concentrate on man, will find itself increasingly face to face with religion.

c. The Conjunction of Science and Religion

To outward appearance, the modem world was born of an anti-religious movement: man becoming self-sufficient and reason supplanting belief. Our generation and the two that preceded it have heard little but talk of the conflict between science and faith; indeed it seemed at one moment a foregone conclusion that the former was destined to take the place of the latter.

But, as the tension is prolonged, the conflict visibly seems to need to be resolved in terms of an entirely different form of equilibrium—not in elimination, nor duality, but in synthesis. After close on two centuries of passionate struggles, neither science nor faith has succeeded in discrediting its adversary. On the contrary, it becomes obvious that neither can develop normally without the other. And the reason is simple: the

same life animates both. Neither in its impetus nor its achievements can science go to its limits without becoming tinged with mysticism and charged with faith.

Firstly in its impetus. We touched on this point when dealing with the problem of action. Man will only continue to work and to research so long as he is prompted by a passionate interest. Now this interest is entirely dependent on the conviction, strictly undemonstrable to science, that the universe has a direction and that it could—indeed, if we are faithful, it should—result in some sort of irreversible perfection. Hence comes belief in progress.

Secondly in its construction. Scientifically we can envisage an almost indefinite improvement in the human organism and human society. But as soon as we try to put our dreams into practice, we realise that the problem remains indeterminate or even insoluble unless, with some partially super-rational intuition, we admit the convergent properties of the world we belong to. Hence belief in unity.

Furthermore, if we decide, under the pressure of facts, in favour of an optimism of unification, we run into the technical necessity of discovering—in addition to the impetus required to push us forward and in addition to the particular objective which should determine our route—the special binder or cement which will associate our lives together, vitally, without diminishing or distorting them. Hence, belief in a supremely attractive centre which has personality.

In short, as soon as science outgrows the analytic investigations which constitute its lower and preliminary stages, and passes on to synthesis—synthesis which naturally culminates in the realisation of some superior state of humanity—it is at once led to foresee and place its stakes on the future and on the all. And with that it out-distances itself and emerges in terms of option and adoration.

Thus Renan and the nineteenth century were not wrong to speak of a Religion of Science. Their mistake was not to see that their cult of humanity implied the re-integration, in a re newed form, of those very spiritual forces they claimed to be getting rid of.

When, in the universe in movement to which we have just awakened, we look at the temporal and spatial series diverging and amplifying themselves around and behind us like the laminae of a cone, we are perhaps engaging in pure science. But when we turn towards the summit, towards the totality and the figure, we cannot help engaging in religion.

Religion and science are the two conjugated faces or phases of one and the same complete act of knowledge—the only one which can embrace the past and future of evolution so as to contemplate, measure and fulfil them.

In the mutual reinforcement of these two still opposed powers, in the conjunction of reason and mysticism, the human spirit is destined, by the very nature of its development, to find the uttermost degree of its penetration with the maximum of its vital force.

3. The Ultimate

Always pushing forward in the three directions we have just indicated, and taking advantage of the immense duration it has still to live, mankind has enormous possibilities before it.

Until the coming of man, life was quickly arrested and hemmed in by the specialisation into which it was forced to mould itself so as to act, and became fixed, then dispersed, at each forward bound. Since the threshold of reflection, we have entered into an entirely new field of evolution—thanks to the astonishing properties of 'artifice' which separate the instrument from the organ and enable one and the same creature to intensify and vary the modalities of its action indefinitely without losing anything of its freedom; and thanks to the prodigious power of thought to bring together and combine in a single conscious effort all the human particles. In fact, though the study of the past may give us some idea of the resources of organised matter

in its dispersed state, we have as yet no idea of the possible magnitude of noospheric ' effects. We are confronted with human vibrations resounding by the million—a whole layer of consciousness exerting simultaneous pressure upon the future and the collected and hoarded produce of a million years of thought. Have we ever tried to form an idea of what such magnitudes represent.

In this direction, the most unexpected is perhaps what we should most expect. Under the increasing tension of the mind on the surface of the globe, we may begin by asking seriously whether life will not perhaps one day succeed in ingeniously forcing the bars of its earthly prison, either by finding the means to invade other inhabited planets or (a still more giddy perspective) by getting into psychical touch with other focal points of consciousness across the abysses of space. The meeting

and mutual fecundation of two noospheres is a supposition which may seem at first sight crazy, but which after all is merely extending to psychical phenomena a scope no-one would think of denying to material phenomena. Consciousness would thus finally construct itself by a synthesis of planetary units. Why not, in a universe whose astral unit is the galaxy?

Without in any way wishing to discourage such hypotheses —whose realisation, though enormously enlarging the dimensions, would leave unchanged both the convergent form and hence the final duration of noogenesis—I consider their probability too remote for them to be worth dwelling on.

The human organism is so extraordinarily complicated and sensitive, and so closely adapted to terrestrial conditions, that it is difficult to see how man could acclimatise himself to another planet, even if he were capable of navigating through interplanetary space. The sidereal durations are so immense that it is difficult to see how in two different regions of the heavens, two thought systems could co-exist and coincide at comparable stages of their development. For these two reasons among others I adopt the supposition that our noosphere is destined to close in upon itself in isolation, and that it is in a psychical rather than a spatial direction that it will find an outlet, without need to leave or overflow the earth. Hence, quite naturally, the notion of change of state recurs.

Noogenesis rises upwards in us and through us unceasingly. We have pointed to the principal characteristics of that movement: the closer association of the grains of thought; the synthesis of individuals and of nations or races; the need of an autonomous and supreme personal focus to bind elementary personalities together, without deforming them, in an atmosphere of active sympathy. And, once again: all this results from the combined action of two curvatures—the roundness of the earth and the cosmic convergence of mind—in conformity with the law of complexity and consciousness.

Now when sufficient elements have sufficiently agglomerated, this essentially convergent movement will attain such intensity and such quality that mankind, taken as a whole, will be obliged—as happened to the individual forces of instinct—to reflect upon itself at a single point;1 that is to say, in this case, to abandon its organo-planetary foothold so as to shift its centre on to the transcendent centre of its increasing concentration. This will be the end and the fulfilment of the spirit of the earth.

The end of the world: the wholesale internal introversion upon itself of the noosphere, which has simultaneously reached the uttermost limit of its complexity and its centrality.

The end of the world: the overthrow of equilibrium, detaching the mind, fulfilled at last, from its material matrix, so that it will henceforth rest with all its weight on God-Omega.

The end of the world: critical point simultaneously of emergence and emersion, of maturation and escape. '

We can entertain two almost contradictory suppositions about the physical and psychical state our planet will be in as it approaches maturation.' According to the first hypothesis which expresses the hopes towards which we ought in any case to turn our efforts as to an ideal, evil on the earth at its final stage will be reduced to a minimum. Disease and hunger will be conquered by science and we will no longer need to fear them in any acute form. And, conquered by the sense of the earth and human sense, hatred and internecine struggles will have disappeared in the ever-warmer radiance of Omega. Some sort of unanimity will reign over the entire mass of the noosphere. The final convergence will take place in peace.' Such an outcome would of course conform most harmoniously with our theory.

But there is another possibility. Obeying a law from which nothing in the past has ever been exempt, evil may go on growing alongside good, and it too may attain its paroxysm at the end in some specifically new form.

There are no summits without abysses.
Enormous powers will be liberated in mankind by the inner play of its cohesion: though it may be that this energy will still be employed discordantly tomorrow, as today and in the past. Are we to foresee a mechanising synergy under brute force, or a synergy of sympathy? Are we to foresee man seeking to fulfil himself collectively upon himself, or personally on a greater than himself? Refusal or acceptance of Omega? A conflict may supervene. In that case the noosphere, in the course of and by virtue of the process which draws it together, will, when it has reached its point of unification, split into two zones each attracted to an opposite pole of adoration. Thought has never completely united upon itself here below. Universal love would only vivify and detach finally a fraction of the noosphere so as to consummate it—the part which decided to ' cross the threshold ', to get outside itself into the other. Ramification once again, for the last time.

In this second hypothesis, which is more in conformity with traditional apocalyptic thinking, we may perhaps discern three curves around us rising up at one and the same time into the future: an inevitable education in the organic possibilities of the earth, an internal schism of consciousness ever increasingly divided on two opposite ideals of evolution, and positive attraction of the centre of centres at the heart of those who turn towards it. And the earth would finish at the triple point at which, by a coincidence altogether in keeping with the ways of life, these three curves would meet and attain their maximum at the very same moment.

The death of the materially exhausted planet; the split of the noosphere, divided on the form to be given to its unity; and simultaneously (endowing the event with all its significance and with all its value) the liberation of that percentage of the universe which, across time, space and evil, will have succeeded in laboriously synthesising itself to the very end.

Not an indefinite progress, which is an hypothesis contradicted by the convergent nature of noogenesis, but an ecstasy transcending the dimensions and the framework of the visible universe.

Ecstasy in concord; or discord; but in either case by excess of interior tension: the only biological outcome proper to or conceivable for the phenomenon of man.

Among those who have attempted to read this book to the end, many will close it, dissatisfied and thoughtful, wondering whether I have been leading them through facts, through metaphysics or through dreams.

But have those who still hesitate in this way really understood the rigorous and salutary conditions imposed on our reason by the coherence of the universe, now admitted by all? A mark appearing on a film; an electroscope discharging abnormally; that is enough to force physics to accept fantastic powers in the atom. Similarly, if we try to bring man, body and soul, within the framework of what is experimental, man obliges us to readjust completely to his measure the layers of time and space.

To make room for thought in the world, I have needed to ' interiorise matter: to imagine an energetics of the mind; to conceive a noogenesis rising upstream against the flow of entropy; to provide evolution with a direction, a line of advance and critical points; and finally to make all things double back upon someone.

In this arrangement of values I may have gone astray at many points. It is up to others to try to do better. My one hope is that I have made the reader feel both the reality, difficulty, and urgency of the problem and, at the same time, the scale and the form which the solution cannot escape.

The only universe capable of containing the human person is an irreversibly' personalising universe.

Epilogue - The Christian Phenomenon

NEITHER in the play of its elemental activities, which can only be set in motion by the hope of an imperishable'; nor in the play of its collective affinities, which require for their coalescence the action of a conquering love, can reflective life continue to function and to progress unless, above it, there is a pole which is supreme in attraction and consistence. By its very structure the noosphere could not close itself either individually or socially in any way save under the influence of the centre we have called Omega.

That is the postulate to which we have been led logically by the integral application to man of the experimental laws of evolution. The possible, or even the probable, repercussion of this conclusion, however theoretical in the first approximation, upon experience will now be obvious.

If Omega were only a remote and ideal focus destined to emerge at the end of time from the convergence of terrestrial consciousnesses, nothing could make it known to us but this convergence. At the present time no other energy of a personal nature could be detected on earth save that represented by the sum of human persons.

If, on the other hand, Omega is, as we have admitted, already in existence and operative at the very core of the thinking mass, then it would seem inevitable that its existence should be manifested to us here and now through some traces. To animate evolution in its lower stages, the conscious pole of the world could of course only act in an impersonal form and under the veil of biology. Upon the thinking entity that we have become by hominisation, it is now possible for it to radiate from the one centre to all centres—personally. Would it seem likely that it should not do so?

Either the whole construction of the world presented here is vain ideology or, somewhere around us, in one form or another, some excess of personal, extra-human energy should be perceptible to us if we look carefully, and should reveal to us the great Presence. It is at this point that we see the importance for science of the Christian phenomenon.

At the conclusion of a study of the human phenomenon I have not chosen those words haphazardly, nor for the sake of mere verbal symmetry. They are meant to define without ambiguity the spirit in which I want to speak.

As I am living at the heart of the Christian world, I might be suspected of wanting to introduce an apologia by artifice. But, here again, so far as it is possible for a man to separate in himself the various planes of knowledge, it is not the convinced believer but the naturalist who is asking for a hearing.

The Christian fact stands before us. It has its place among the other realities of the world.

I would like to show how it seems to me to bring to the perspectives of a universe dominated by energies of a personal nature the crucial confirmation we are in need of, firstly by the substance of its creed, next, by its existence-value, and finally by its extraordinary power of growth.

Axes Of Belief

To those who only know it outwardly, Christianity seems desperately intricate. In reality, taken in its main lines, it contains an extremely simple and astonishingly bold solution of the world.

In the centre, so glaring as to be disconcerting, is the uncompromising affirmation of a personal God: God as providence, directing the universe with loving, watchful care; and God the revealer, communicating himself to man on the level of and through the ways of intelligence. It will be easy for me, after all I have said, to demonstrate the value and actuality of this tenacious personalism, not long since condemned as obsolete. The important thing to point out here is the way in which such an attitude in the hearts of the faithful leaves the door open to, and is easily allied to, everything that is great and healthy in the universal.

In its Judaic phase, Christianity might well have considered itself the particular religion of one people. Later on, coming under the general conditions of human knowledge, it came to think that the world around it was much too small. However that may be, it was hardly constituted before it was ceaselessly trying to englobe in its constructions and conquests the totality of the system that it managed to picture to itself.

Personalism and universalism: in what form have these two characters been able to unite in its theology?

For reasons of practical convenience and perhaps also of intellectual timidity, the City of God is too often described in pious works in conventional and purely moral terms. God and the world he governs are seen as a vast association, essentially legalistic in its nature, conceived in terms of a family or government. The fundamental root from which the sap of Christianity has risen from the beginning and is nourished, is quite otherwise. Led astray by a false evangelism, people often think they are honouring Christianity when they reduce it to a sort of gentle philanthropism. Those who fail to see in it the most realistic and at the same time the most cosmic of beliefs and hopes, completely fail to understand its ' mysteries Is the Kingdom of God a big family? Yes, in a sense it is. But in another sense it is a prodigious biological operation—that of the Redeeming Incarnation.

As early as in St. Paul and St. John we read that to create, to fulfil and to purify the world is, for God, to unify it by uniting it organically with himself.' How does he unify it? By partially immersing himself in things, by becoming' element ', and then, from this point of vantage in the heart of matter, assuming the control and leadership of what we now all evolution. Christ, principle of universal vitality because sprung up as man among men, put himself in the position (maintained ever since) to subdue under himself, to purify, to direct and superanimate the general ascent of consciousnesses into which he inserted himself. By a perennial act of communion and sublimation, he aggregates to himself the total psychism of the earth. And when he has gathered everything together and transformed everything, he will close in upon himself and his conquests, thereby rejoining, in a final gesture, the divine focus he has never left. Then, as St. Paul tells us, God shall be all in all. This is indeed a superior form of ' pantheism 's without trace of the poison of adulteration or annihilation: the expectation of perfect unity, steeped in which each element will reach its consummation at the same time as the universe.

The universe fulfilling itself in a synthesis of centres in perfect conformity with the laws of union. God, the Centre of centres. In that final vision the Christian dogma culminates. And so exactly, so perfectly does this coincide with the Omega Point that doubtless I should never have ventured to envisage the latter or formulate the hypothesis rationally if, in my consciousness as a believer I had not found not only its speculative model but also its living reality.

2. Existence Value

It is relatively easy to build up a theory of the world. But it is beyond the powers of an individual to provoke artificially the

1 Following Greek thought—following all thought in fact—are not' to be' and 'to be one' identical?

'En pis, pante.

Then: birth of a religion. Plato, Spinoza and Hegel were able to elaborate views which compete in amplitude with the perspectives of the Incarnation. Yet none of these metaphysical systems advanced beyond the limits of an ideology. Each in turn has perhaps brought light to men's minds, but without ever succeeding in begetting life. What to the eyes of a' naturalist' comprises the importance and the enigma of the Christian phenomenon is its existence-value and reality-value.

Christianity is in the first place real by virtue of the spontaneous amplitude of the movement it has managed to create in mankind. It addresses itself to every man and to every class of man, and from the start it took its place as one of the most vigorous and fruitful currents the noosphere has ever known. Whether we adhere to it or break off from it, we are surely obliged to admit that its stamp and its enduring influence are apparent in every corner of the earth today.

It is doubtless a quantitative value of life if measured by its radius of action; but it is still more a qualitative value which expresses itself—like all biological progress—by the appearance of a specifically new state of consciousness.

I am thinking here of Christian love.

Christian love is incomprehensible to those who have not experienced it. That the infinite and the intangible can be lovable, or that the human heart can beat with genuine charity for a fellow-being, seems impossible to many people I know —in fact almost monstrous. But whether it be founded on an illusion or not, how can we doubt that such a sentiment exists, and even in great intensity? We have only to note crudely the results it produces unceasingly all round us. Is it not a positive fact that thousands of mystics, for twenty centuries, have drawn from its flame a passionate fervour that outstrips by far in brightness and purity the urge and devotion of any human love? is it not also a fact that, having once experienced it, further thousands of men and women are daily renouncing every other ambition and every other joy save that of abandoning themselves to it and labouring within it more and more completely?

Lastly, is it not a fact, as I can warrant, that if the love of God were extinguished in the souls of the faithful, the enormous edifice of rites, of hierarchy and of doctrines that comprise the Church would instantly revert to the dust from which it rose?

It is a phenomenon of capital importance for the science of man that, over an appreciable region of the earth, a zone of thought has appeared and grown in which a genuine universal love has not only been conceived and preached, but has also been shown to be psychologically possible and operative in practice. It is all the more capital inasmuch as, far from decreasing, the movement seems to wish to gain still greater speed and intensity.

3. Power Of Growth

For almost all the ancient religions, the renewal of cosmic outlook characterising ' the modem mind' has occasioned a crisis of such severity that, if they have not yet been killed by it, it is plain they will never recover. Narrowly bound to untenable myths, or steeped in a pessimistic and passive mysticism, they can adjust themselves neither to the precise immensities, nor to the constructive requirements, of space-time. They are out of step both with our science and with our activity.

But under the shock which is rapidly causing its rivals to disappear, Christianity, which might at first have been thought to be shaken too, is showing, on the contrary, every sign of forging ahead. For, by the very fact of the new dimensions assumed by the universe as we see it today, it reveals itself both as inherently more vigorous in itself and as more necessary to the world than it has ever been before.

More vigorous. To live and develop the Christian outlook needs an atmosphere of greatness and of coherence. The bigger the world becomes and the more organic become its internal connections, the more will the perspectives of the Incarnation triumph. That is what believers are beginning, much to their surprise, to find out. Though frightened for a moment by evolution, the Christian now perceives that what it offers him is nothing but a magnificent means of feeling more at one with God and of giving himself more to him. In a pluralistic and static Nature, the universal domination of Christ could, strictly speaking, still be regarded as an extrinsic and super-imposed power. In a spiritually converging world this' Christie' energy acquires an urgency and intensity of another order altogether. If the world is convergent and if Christ occupies its centre, then the Christogenesis of St. Paul and St. John is nothing else and nothing less than the extension, both awaited and unhoped for, of that noogenesis in which cosmogenesis—as regards our experience—culminates. Christ invests himself organically with the very majesty of his creation. And it is in no way metaphorical to say that man finds himself capable of experiencing and discovering his God in the whole length, breadth and depth of the world in movement. To be able to say literally to God that one loves him, not only with all one's body, all one's heart and all one's soul, but with every fibre of the unifying universe—that is a prayer that can only be made in space-time.

More necessary. To say of Christianity that, despite appearances to the contrary, it is acclimatising itself and expanding in a world enormously enlarged by science, is to point to no more than one half of the picture. Evolution has come to infuse new blood, so to speak, into the perspectives and aspirations of Christianity. In return, is not the Christian faith destined, is it not preparing, to save and even to take the place of evolution?

I have tried to show that we can hope for no progress on earth without the primacy and triumph of the personal at the summit of mind. And at the present moment Christianity is the unique current of thought, on the entire surface of the noosphere, which is sufficiently audacious and sufficiently progressive to lay hold of the world, at the level of effectual practice, in an embrace, at once already complete, yet capable of indefinite perfection, where faith and hope reach their fulfilment in love. Alone, unconditionally alone, in the world today, Christianity shows itself able to reconcile, in a single living act, the All and the Person. Alone, it can bend our hearts not only to the service of that tremendous movement of the world which bears us along, but beyond, to embrace that movement in love.

In other words can we not say that Christianity fulfils all the conditions we are entitled to expect from a religion of the future; and that hence, through it, the principal axis of evolution truly passes, as it maintains?

Now let us sum up the situation:

i. Considered objectively asa phenomenon, the Christian movement, through its rootedness in the past and ceaseless developments, exhibits the characteristics of a phylum.

ii. Reset in an evolution interpreted as an ascent of consciousness, this phylum, in its trend towards a synthesis based on love, progresses precisely in the direction presumed for the leading-shoot of biogenesis.

iii. In the impetus which guides and sustains its advance, this rising shoot implies essentially the consciousness of being in actual relationship with a spiritual and transcendent pole of universal convergence.

To confirm the presence at the summit of the world of what we have called the Omega Point,' do we not find here the very cross-check we were waiting for? Here surely is the ray of sunshine striking through the clouds, the reflection onto what is ascending of that which is already on high, the rupture of our solitude. The palpable influence on our world of an other and supreme Someone ... Is not the Christian phenomenon, which rises upwards at the heart of the social phenomenon, precisely that?

In the presence of such perfection in coincidence, even if I were not a Christian but only a man of science, I think I would ask myself this question.

Peking, June 1938-June 1940

October 1960
Elder Mark E. Petersen
The great minds of the world today now teach there is a God; He does live; They teach that he is a great mathematician
Conference Report, October 1960

Is there any real reason to disbelieve in God? There are some who say, "Well, I learned in school that there is no God. I have learned that there are other reasons for creation." I was very interested the other day to read a speech by one of the great scientists of the world. He, with many others of his intellectual attainment, have reached the conclusion that all of the arguments in times past to the effect that science has abolished God are false. One of the great writers of America has said that rather than science abolishing God, science is now virtually abolishing atheism.

The present day attitude of top scientists was expressed recently by Dr. Joseph W. Barker, president and chairman of the Research Corporation of America, and formerly Dean of the Engineering School at Columbia University. He explained that scientists of the nineteenth century were misled by certain of their observations, and as a result came to conclusions which were definitely atheistic. "But now," said Dr. Barker, "even the most pragmatic materialist in the face of present day scientific knowledge is led to the inevitable conclusion that the heavens declare the glory of God and the firmament shows of his handiwork."

Dr. Barker's concluding remarks on that occasion were these: "As the children of Israel foreswore the worship of the golden calf and returned to the faith of Jehovah, so we have foresworn the crass mechanistic materialism and returned to the faith in God of which the Psalmist of old sang, "The earth is the Lord's and all that therein is.'"

The day is past, my young brethren, when we have to be shaken in our faith by the pseudo teachings of certain men. The day is past when we need to doubt that God lives. The great minds of the world today now teach there is a God. He does live. They teach that he is a great mathematician. They teach that he is the Creator of the universe, and they say that this great Deity who made the universe must be a person because they see purpose in all creation, and you cannot have purpose without a person. Therefore, they say, God, the Creator, is a person.

April 1961
Elder Legrand Richards
By unwavering mathematical law, we can prove that our universe was designed and executed by a great engineering intelligence
Conference Report, April 1961

In thinking of what I might say today, I want to make reference to a statement I read in an article in the Reader's Digest about six months ago that gave seven reasons why a scientist believed in God. This was by A. Cressy Morrison, former president of the New York Academy of Sciences. I am not going to take time to read the article, but I want to read these statements.

For the first reason, he said: "By unwavering mathematical law, we can prove that our universe was designed and executed by a great engineering intelligence." And then after he had given the seven reasons why he believed there was a God. he made this statement: "It is apparent from these and a host of other examples that there is not one chance in billions that life on our planet is an accident," and then he concluded with these words: "It is scientifically, as well as imaginatively true, as the Psalmist said, 'The heavens declare the glory of God; and the firmament sheweth his handwork.' " (Psalm 19:1.)

This is the thought I had as I read that article, which I appreciated so much, as I did a talk that Brother Clark gave to seminary and institute teachers called, "Man, God's Greatest Miracle." The scientists and this scientist give wonderful reasons why there was an intelligence-a major intelligence-that brought forth this universe, but the scientists cannot go beyond that. They cannot tell us why it was brought forth, and wherever you see an intelligent organization, you know that there was a reason for it. This building did not just happen here. You do not go into the wilderness and find a forty-story office building. Everything in this world that shows intelligence back of it had a reason for its coming into existence.

So, when he says it is apparent from these and a host of other examples that there is not one chance in billions that life on our planet is an accident, I could just as well believe that my watch made itself as to believe that we made ourselves or that this universe made itself. There is a master intelligence back of it.

Then the question is, if the scientists cannot tell us why this organization where do we go to get this information? Then I remind you of the words of the Prophet Amos when he said:

"Surely the Lord God will do nothing, but he revealeth his secret unto his servants the prophets." (Amos 3:7.)
So we have to turn to the prophets to find the secret of why the Lord created this earth, why we are here and all the marvelous things that evidence the fact that he does exist.

I like the statement in the first chapter of John:

"In the beginning was the Word, and the Word was with God, and the Word was God. . . .
"All things were made by him; and without him was not any thing made that was made." (John 1:1, 3.)
Then it goes on to say that the Word ". . . was the true light, which lighteth every man that cometh into the world." (Ibid., 1:9.)

And then it adds that

". . . the Word was made flesh, and dwelt among us, (and we beheld his glory, the glory as of the only begotten of the Father,) full of grace and truth." (Ibid., 1:14.)

No wonder we love to testify of the divinity of the Son of God when we realize that he was the instrument in the hands of the Lord in bringing about all this marvelous creation, and this scientist said, "there is not one chance in billions that life on our planet is an accident." And you know in the Pearl of Great Price, we read where the Lord said to Moses that he had created worlds without number,

". . . but all things are numbered unto me, for they are mine . . . (Moses 1:35.) "And by the word of my power, have I created them, which is mine Only Begotten Son. . . ." (Ibid., 1:32.)

April 1961
Elder Bernard P. Brockbank
God created the universe with all of its profound greatness and blessings
Conference Address

God created the heavens and the earth and all plant and animal life upon the earth. God created the universe with all of its profound greatness and blessings. The greatest of all miracles is Gods creation of man in his own image and likeness; eyes that can see, ears that can hear, minds that can reason were created within our mortal mothers. We know that our mortal mothers do not know how to make eyes that can see and ears that can hear and mortal minds that can reason. God said that he created man in his own image and likeness. Our creation and mortal birth is evidence of divine power. All that we have that is good for this life and eternal life comes from God. We owe our full respect, dedication, allegiance, and love to him.

October 1965
Elder Alma Sonne,
Testimony Of Nature Strong & Convincing Regarding Existence Of Overruling Providence
Conference Report, October 1965

I quote from Psalm nineteen:

"The heavens declare the glory of God; and the firmament sheweth his handy work.
"Day unto day uttereth speech, and night unto night sheweth knowledge.
"There is no speech nor language, where their voice is not heard." (Psalm 19:1-3.)

An Overruling Providence
The testimony of nature is strong and convincing regarding the existence of an overruling Providence. One need but look into the sky and see the sun, the moon, and the stars and observe their regularity as they glide through space. I have always been impressed with the majesty of the universe. We see enough of it to be profoundly touched by its grandeur and vastness.

There is no confusion in nature. Every one of its manifestations is a solemn declaration of a supreme power, a supreme knowledge, and a supreme design. It is not the result of chance, for the Creator is the source of intelligence and order. And intelligence is his glory, and it operates perfectly and is in harmony with established law. I see all this, and I am sustained by an "unfaltering trust."

God's Handiwork
I look around me, and I see the green fields, the flowers, the trees, and the shrubbery, and in the autumn I see the earth illuminated with red and gold before nature goes to rest. I witness God's handiwork. It bears the mark of a superior intelligence which is beyond my meager comprehension. I can conscientiously conclude that there is a divine plan which provides for man's future when and where mortality ends. I can join with the prophets and seers in the revelations from God and accept them as God's commandments. I am not a stranger wandering aimlessly without purpose. I am a child of God, and I see evidences of his existence all around me. In other words, I believe in God. I do not serve and worship him blindly. I trust him. He hears and answers my prayers. He sustains me in emergencies and comes to my rescue in times of need.

I realize that a mastermind has planned and made tangible all these things. They are gifts from him to his children. The Lord has given them freely regardless of their obedience. It is a manifestation of his love for his sons and daughters.

How are the gifts received? Some receive them with thanksgiving, some with scorn, and some deny the existence of the giver. Others fail to recognize and identify this giver. They "knew him not" (John 1:10), for they are absorbed in materialistic aspirations so characteristic of our day.

I read St. John's testimony regarding this giver and creator of all things.

"In the beginning was the Word and the Word was with God, and the Word was God.

"All things were made by him; and without him was not any thing made that was made.

"And the Word was made flesh and dwelt among us, (and we beheld his glory, the glory as of the only begotten of the Father,) full of grace and truth." (Ibid., 1:1, 3, 14.)

The above quotation answers the question: Who is the Creator? Paul the Apostle is even more explicit in his letter to the Colossians. In speaking of Jesus, he says: "For by him were all things created, that are in heaven and that are in earth, visible and invisible, whether they be thrones, or dominions, or principalities, or powers: all things were created by him, . . ." (Col. 1:16.)

October 1967
Elder Marion G. Romney
First Proof: Orderliness Of Universe
Conference Report, October 1967, Afternoon Meeting, p.134

The three types of proof to which I refer are first, the orderliness of the universe; second, the testimony of eyewitnesses; third, the witness of the Holy Spirit.

The orderliness of the universe
As to the orderliness of the universe and its probative evidence, the Psalmist exclaimed: "The heavens declare the glory of God; and the firmament sheweth his handywork." (Ps. 19:1.) In 1887 the English physicist, Lord Kelvin, wrote: "If you think strongly enough you will be forced by science to the belief in God."

Countless scientists have confirmed this judgment.

Dr. Henry Eyring, our own world-renowned scientist, has said that the two most famous modern mathematicians, Sir Isaac Newton, the Englishman, and Carl Friederick Gauss, the German, were both believers "in an all-wise Creator of the universe. . . . (Henry Eyring, The Faith of a Scientist, p. 74.)

He has further said that "in the autumn of 1957, in Houston, Texas, the Welch Foundation invited the top nuclear physicists and chemists from all over the world to a symposium. At a dinner, twelve of the most distinguished were seated at a table. . . . Mr. Malone, a trustee of the foundation, said, `Dr. Eyring, how many of these gentlemen believe in a Supreme Being?' I answered, `I don't know but I'll ask.'

". . . twelve people were asked and every one said, `I believe." All of these students of the exact sciences-two of them Nobel Prize winners-saw in the universal order about them evidence for a Supreme Being." (Ibid., p. 147.)

Dr. Thomas J. Parmley, another of our own eminent scientists, has eloquently written:

"The moon and stars in the night sky, one hundred million suns with their attendant planets, space, oceans, earth and nature, the flight of a bird, the wonder of a flower, the intricate design and unbelievable coordination of the human body, all of these and countless other creations proclaim the handiwork of God." ("Proclaim the Handiwork of God," The Instructor, July 1967, p. 272.)

The Lord gave his own personal witness that the orderliness of the universe is probative evidence of his existence, in these words:

"The earth rolls upon her wings, and the sun giveth his light by day, and the moon giveth her light by night, and the stars also give their light, as they roll upon their wings in their glory, in the midst of the power of God.

"Behold, all these are kingdoms, and any man who hath seen any or the least of these hath seen God moving in his majesty and power." (D&C 88:45, 47.)

Myriads of people are persuaded by the universal order about them that there is a divine power, a God, presiding over and controlling the universe. This conclusion is correct and comforting as far as it goes, but it is not enough. The honest, believing, inquiring soul wants to know about the nature and personality of God. This vital information God has provided in the testimony of the prophets, to whom he has revealed himself.

October 1968
Elder Mark E. Petersen, Quorum of the Twelve Apostles
Can a man who thinks that life came about by chance on a globe that was made by accident have any overlying purpose to guide him?
Conference Report, October 1968

Mankind drifting aimlessly
True purpose of life
If man understood his true purpose in life as it is revealed in the gospel, and if he knew the secret of his origin, he could begin to free himself from the shackles of this ignorance.

Who are we?

What is the purpose of our existence? Can a man who thinks that life came about by chance on a globe that was made by accident have any overlying purpose to guide him?

Can a man who thinks he evolved from the lowest forms of life have any lofty aspirations?

Does the idea that we are descendants of ape-like ancestors inspire us to any great heights of achievement?

The importance of having purpose in life cannot be overstated.

The discovery of an obvious purpose in creation is what now begins to open the eyes of our greatest scientists to the acts of our existence. They are learning that creation could not possibly exist, nor could it have come into being initially, without a definite purpose. These scientists now say they are convinced that creation came by the act of a supreme Intelligence, that he had a purpose in creation, and since he has purpose he therefore must be a person. Furthermore, they tell us that this Creator also had a definite purpose in creating man to be like himself.

Statements of scientists
Listen to some of them.

Dr. Arthur H. Compton, Nobel Prize winner, writing in the Los Angeles Times, said:

> Where there is plan, there is intelligence, and an orderly unfolding universe testifies to the truth of the most majestic statement ever uttered-`In the beginning, God.

In a volume entitled The Freedom of Man, published by Yale University Press, Sir John Arthur Thomson says:

> We feel compelled-and it is a glad compulsion-to say with the most philosophical of the disciples, `In the beginning was Mind, and the Mind was with God, and the Mind was God.'

Alfred G. Fisk, in his book The Search for Life's Meaning, says:

> Just as the ordered structure of the universe implies a creative Intelligence, Architect or Orderer, so a belief in the objectivity or purpose in the universe leads to a belief in a Purposer or Divine Agent who is the source and spring of purpose in the Universe.

Sir Ambrose Flemming, in his Origin of Mankind, wrote:

> The ultimate cause of things and events is a self-conscious and personal living Being. . . . Life can only proceed from already living matter. It cannot be derived spontaneously from non-living matter. We can obtain energy only from some source or body already possessing it. It cannot arise spontaneously from nothing. . . . Accordingly we can infer that the Cause which gave rise to our self-consciousness and powers of thought, must have been itself self-conscious and intelligent, or a Thinker. Hence we may infer that the thought of the Intelligent First Cause was not identical with ours, and therefore this separateness constitutes that First Cause a Person.

Dr. Compton, writing for This Week magazine, said:

> Few scientific men today defend the atheistic attitude. Design in the Universe presumes an intelligence. Evidence points to a Beginner, a Creator of the Universe. A physicist's studies

> lead him to believe this Creator to be an Intelligent Being. The intelligent God has an interest in and relation to man, and it is reasonable to assume that He would be interested in creating a being intelligent like himself.

Albert Einstein, in his book The World as I See It, says on pages 267-68:

> The harmony of natural law reveals an Intelligence of such superiority that compared with it, all the scientific thinking and acting of human beings is an utterly insignificant reflection.

October 1968
Elder Howard W. Hunter, Quorum of the Twelve Apostles
Evidence for God
Conference Address

Evidence of a creator
I, too, know that God lives. There is ample evidence of this fact, but concrete proof is not necessary to those who have faith. All nature portrays the existence of a supreme being. In this material world, we have learned that every building has a builder and everything that is made has a maker. As we look at this Tabernacle, the great organ that has been played for us, the clock on the wall, the camera that carries the image to the world, the lights, the microphones before me, we realize that each of these had its maker. Outside those things made by man, all of nature whispers to my reasoning that there was a creator. I know this to be God.

"In the beginning God created the heaven and the earth." (Gen. 1:1.) There was a divine plan. For every plan there must have been a planner, and for every creation there must have been a creator. Could the perfect universe emerge without a divine plan? Could it have come about by some mechanical chance? Such thoughts are against the stronger reasoning. Such belief could not be supported in view of the tangible evidence which portrays that there is a supreme being, one who had a divine plan, one who was the Creator and the builder of the universe.

Creation of man
Not only did God plan and create the heavens and the earth, but the plan also included the creation of man. "So God created man in his own image, in the image of God created he him; male and female created he them." (Gen. 1:27.) Thus we are his creation; we are literally his children, in his image and likeness. This would necessarily include the intellect, which distinguishes man from all other animal life. We are creatures of the flesh as well as the spirit, and the great striving in life is to develop the spirit as well as the physical body. True growth is dependent upon our conscious effort in lifting our awareness above and beyond those things which are physical.

As children of God, we learn in our young years to know our Heavenly Father in a childlike way, and if we follow the right course, the time comes when we understand the larger meaning of this relationship to our Heavenly Parent. We realize that we are made in his spiritual image as well as his physical image. In our more spiritual maturity, a whole new vista of reality opens to as; and we commence to understand the statement of Paul, who said, "The Spirit itself beareth witness with our spirit, that we are the children of God." (Rom. 8:16.)

April 1970
Elder Howard W. Hunter, Quorum of the Twelve Apostles
The Reality of God

Conference Address

What a glorious thing is life, surrounded by the beauties of the world in which we live. There is beauty in the mountains, the woods, and the lakes. There is beauty in the sea with its never-ceasing tides; beauty in the skies filled with fleecy clouds, in the sunshine and in the rain; beauty in the morning, the day, and the night. As the seasons come and go, we find beauty in the freshness of spring bringing new life to all nature, and beauty in the glory of the summer. Autumn ushers in an array of color before the silent winter brings its blanket of white. There is beauty everywhere if we look for the beautiful.

Order in Universe

There is an exactness of order in the universe of which we become conscious. The days come and the nights follow. The tides rise and fall with regularity, the recurring lunar cycle of the moon is exact; the seasons come and go in the sequence of nature. The stars in the sky follow exact repeated orders; the planets and their satellites perform precisely in their relation to their suns. The biologist sees the wonders and the beauty of plant and animal life, and the chemist discovers the mysteries of the elements of the earth; but with or without scientific training, every person becomes aware of a vast universe in which there is intricate exactness in all nature.

When we observe the phenomena of the heavens and the earth, we can come to only one conclusion: these are the effects of some great cause. There can be no design without a designer and nothing built without a builder. For every effect there is a cause. There must be a guiding hand to regulate the universe in its precise order. Are we compelled to admit the reality of a Supreme Being? Millions of people in the world have this deep and abiding conviction.

Finding God As a Reality

Is God a creation of man's mind, or is man a creation of God? Men struggle with many fundamental questions, but the question as to whether or not God is a reality should take precedence. The approach to the solution of this query differs from that given to scientific research. We are not dealing with a subject of the material realm, but rather of the spiritual.

In order to find God as a reality, we must follow the course which he pointed out for the quest. The path is one that leads upward; it takes faith and effort, and is not the easy course. For this reason many men will not devote themselves to the arduous task of proving to themselves the reality of God. On the contrary, some take the easy path and deny his existence or merely follow the doubter's course of uncertainty. These are the atheists infidels, free thinkers, skeptics, and agnostics.

Research of History

The approach to the study of most subjects consists of the research of its history and all of the known facts. If we start with history and turn to the commencement of the best known of the ancient records, we read these words: "In the beginning God created the heaven and the earth." (Gen. 1:1.) This statement forms the basis of the Hebrew belief in the creation, that earth did not come about by chance; neither was it created by accident. It is the intentional creation of a Supreme Being for a definite and meaningful purpose.

Must we accept blindly this statement of creation? The writer of these words in the Pentateuch did not witness the Creator at work but had the same conviction of faith as expressed at a later time by the writer of the Epistle to the Hebrews in these words: "Now faith is the substance of things hoped for, the evidence of things not seen." (Heb. 11:1.) Sometimes faith means believing a thing to be true where the evidence is not sufficient to establish knowledge. We must continue the probe and

follow the admonition: "Ask, and it shall be given you; seek, and ye shall find; knock, and it shall be opened unto you:

"For every one that asketh receiveth; and he that seeketh findeth; and to him that knocketh it shall be opened." (Matt. 7:7-8.)

Communication With God

After announcing that God created the heaven and the earth, the Old Testament relates that God conversed with our first parents, Adam and Eve, in the Garden of Eden. He gave them commandments and he conversed with them. No doubt Adam instructed his descendants, through eight generations to the father of Noah, in the things he had received from God by direct manifestations. Noah had direct communication with God and taught ten generations of his descendants. God appeared personally to Abraham, who followed, as well as to Isaac and Jacob. Moses became the leader of their descendants, and we remember the direct communion between God and
Moses, the record of which has been preserved for all following generations.

The New Testament also has recorded appearances of God. At the baptism of Jesus by John, there was a manifestation; "And lo a voice from heaven, saying, This is my beloved Son, in whom I am well pleased." (Matt. 3:17.) And again at the transfiguration on the high mountain: . . . a bright cloud overshadowed them: and behold a voice out of the cloud, which said, This is my beloved Son, in whom I am well pleased; hear ye him.
"And when the disciples heard it, they fell on their face, and were sore afraid." (Matt. 17:5-6.)

These are only a few instances of the many appearances of God to his children as recorded in the Old and the New Testament. The scriptures of the western hemisphere also record communications of God. History amply documents the reality of God by his personal dealings with men from generation to generation from the beginning.

Reason Gives Evidence

We need not rely upon history alone for evidence of the existence of a Supreme Being; reasoning will also give us such evidence. One of the ancient arguments of the marketplace, put in syllogistic form, is this: Everything that is created has a creator. The earth was created; therefore, the earth has a creator. Referring again to the Epistle to the Hebrews, the writer states in these words that God is the creator of the earth: "For every house is builded by some man; but he that built all things is God." (Heb. 3:4.) The moving universe and all of its beauties and wonders are trying to teach us of the existence of God as the great creator.

Truth-Seeker Seeks Cause

A scholar has said, ". . . though science has done all these things for man it cannot do for him what he only can do for himself. Science can teach but the individual only can learn, that is, learning is an individual process that a person must apply to himself, no one can do it for him. No person can learn for another. Science generally teaches there is a God, does it not? but to discover him is a problem for the individual to solve. The declaration of the atheist that there is no God proves nothing. He may sincerely believe we have no Father in Heaven, but certainly cannot prove there is none. Yes, we know that he does not know because there are individuals who positively testify they do know." (Joseph F. Merrill, The Truth-Seeker and Mormonism, pp. 104-105.)

It has been said that God cannot be found with the instruments of science or in modern-day electronics. The truth-seeker, however, cannot overlook an underlying power so overwhelming to the conscience that the existence of a Supreme Being becomes evident if he seeks for the cause of the effect.

Innate Urge to Worship
Man has an innate urge to worship. In early times God spoke to Israel: "I am the Lord thy God, which have brought thee out of the land of Egypt, out of the house of bondage. Thou shalt have no other gods before me." (Exod. 20:2-3.) There is profound truth in the doctrine that runs all the way through sacred history that no man can worship more than one God. To worship one God is to have one supreme loyalty in one's life. If we had a consciousness of one God, the Eternal Father, we would have a consciousness of one world and one mankind under God, all being brothers.

What causes people to have the urge to worship? There seems to be something inborn into the soul of man that causes him to seek communion with God. In the Book of Job it is put this way: "But there is a spirit in man: and the inspiration of the Almighty giveth them understanding." (Job 32:8.) This statement appears to be an allusion to man's creation. By this spirit he becomes capable of understanding and reason, and consequently of discerning divine truth. By this spirit he comes to know God.

December 1971
Elder Bernard P. Brockbank
God created the universe with all of its profound greatness and blessings Conference Address
Ensign (CR), December 1971

Every child should be taught by his parents that he is a child of God and in the image and likeness of God. The world is hungry for this truth.

God also said that he created man from the dust of the ground. Mans mortal creation and birth are living evidence of divine power, and man is left without excuse. The Lord personally gave commandments that would help mankind to grow and develop his Godlike attributes.

God created the heavens and the earth and all plant and animal life upon the earth. God created the universe with all of its profound greatness and blessings. The greatest of all miracles is Gods creation of man in his own image and likeness; eyes that can see, ears that can hear, minds that can reason were created within our mortal mothers. We know that our mortal mothers do not know how to make eyes that can see and ears that can hear and mortal minds that can reason. God said that he created man in his own image and likeness. Our creation and mortal birth is evidence of divine power. All that we have that is good for this life and eternal life comes from God. We owe our full respect, dedication, allegiance, and love to him.

1976
Frank B. Salisbury, Ph.D. LDS Scientist
Creation
Book (Introduction by Henry Eyring Sr., LDS Scientist)

Foreword

A book on the creation that tries to present all points of view fairly and sympathetically, written by a person who himself has strong commitments, is inherently interesting. Dr. Salisbury is a

distinguished scientist and a devout Latter-day Saint who faces problems squarely and provides many intriguing answers. I found the book engrossing enough that I read it through in one day.

Those not scientifically trained should find the book especially informative for the insights it gives into astronomy, geology, physics, biology, and biochemistry. The author's treatment is readable and instructive in all these areas. The same can be said for his presentation of the theological record of creation. Here too he assembles the pertinent information carefully. Many apparent difficulties disappear if the purpose of the theological and scientific records are taken into account. Science is chiefly concerned with how the physical world works. Religion, in addition to this concern, provides insights into what life is all about. "Whither goest thou?"

I came to the end of this book with the feeling that I have after returning from a very pleasant journey with a thoughtful friend. Thanks for the companionship. It is nice we have so much in common.

Henry Eyring

Prologue

I love this old world! Its beauty is sublime. I thrill when I contemplate its hills and vales, its oceans, lakes, and streams, or its rolling grassy plains, wooded hills, blazing deserts, stark and frozen tundras-even its farm-lands, towns, and cities-but most of all, I love its soaring alpine peaks. I marvel at the plants that cover its face and fill its waters, and I stand in awe of the role they play in its operations, trapping the rays from the sun to make food for themselves and for us and to purify our air. I feel a kinship to the creatures that crawl and run and swim and fly on my planet's surface. Their intricate activities fascinate, amuse, and astound me. And the stars in the heavens enchant my soul and fill it with wondering.

Sometimes when I contemplate this marvelous planet, I am overwhelmed with deep gratitude to God for providing this gift for all of us to love and enjoy and to use as the stage upon which we can work out our eternal salvation. This is his world, his creation! It declares his glory.

I have felt that way about as long as I can remember. I think of riding as a small boy in the back of the Chevrolet sedan as my parents went to see springtime at Fish Lake or the summer on Wolf Creek Pass or the fall in Provo or Hobble Creek canyons. On those outings, I could sense their love of the beauty of this earth and of the God who created it. Not long after, I discovered that one could earn a living by learning about creation-by being a scientist, that is. Although I had to settle on one field of science (botany, actually plant physiology), I enjoyed all my science classes almost equally. I seemed to be learning about God's creation in all of them.

But I didn't learn much about God in those classes. Because of the (certainly proper) separation of church and state in our public schools, it is against the rules to discuss purely religious matters. In Sunday School, priesthood, seminary, and institute of religion, I learned much about God but not much about how he creates or about his creation. This is not surprising, because few of my teachers were trained in the sciences. Unfortunately, I have had the impression that some religious teachers actually resist scientific knowledge.

The questions that forced themselves upon me during those school years often demanded coordinated answers from the fields of both science and religion. At first it bothered me that the bishop or high councilor, to whom I would put the question, would be unable to provide a satisfying scientific-religious answer. Many of these marvelous men did contribute much by clarifying important points of doctrine, but they could seldom come up with the specifics that I wanted. (It

amazes and amuses me to remember my high expectations for those men-and how close they came to meeting them.)

I haven't been bothered much for the last three decades about the inability of many people in the Church to tell me about creation. Perhaps in late high school or early college I discovered the scriptures. It was apparent to me, upon examining the Pearl of Great Price, that compared to science, God hadn't given us many words about creation, but what he did say was profound, significant, true, and terribly exciting. It was quite obvious that the messages of creation given by him, though brief, were worthy of a lifetime's study. I am still trying to fathom those few words.

So, that's what this book is about. I would like, between one set of covers, to do what is seldom done in any science class or in any religion class: to consider the creation from both standpoints. First, we will examine how man discovers truth by reason and by revelation. Then we will search the scriptures to discover their testimony of creation and the Creator and to seek from this testimony the understanding that can help us to gain eternal life. The discussions of God and revelation, as well as those of creation, are based mostly on the restored scriptures of The Church of Jesus Christ of Latter-Day Saints. Hence the book is written for my fellow Mormons.

Then we will examine what science has learned about creation. Section Three is a sort of minicourse in the sciences. Within the rather severe space limitations, I have tried to summarize some of the exciting discoveries in astronomy, geology, and biology, especially those that relate to the creation. It was enjoyable preparing these discussions for the nonscientist, being able to diverge now and again to consider how some scientific point might relate to God and his creative activities. Incidentally, if I have failed in my attempt to communicate science to someone not in this field (perhaps this is an impossible task for me), don't hesitate to pick and choose and skip around a bit in the third section. I would rather have you do that than not read the book at all!

Finally, in Section Four, the goal is to reconcile a bit when that is possible, and at least to outline the present state of the problems when it is not. The idea is to think of revealed and scientific knowledge simultaneously in an effort to better understand and appreciate the creation.

There is another compelling reason for writing the book: Clearly the world-civilization as we know it-is in deep trouble. There must be many reasons for the headlong decay in moral values, but certainly one of the most important of these reasons, and perhaps the central one, is the conflict between science and religion. Beginning with the Renaissance, science began to conflict with the teachings of religion (an apostate Christianity, we recognize). The earth wasn't the center of the universe after all. Then Charles Darwin, in 1858, provided mankind with a proposed mechanism that seemed to account for creation without a Creator. Not long after this, Sigmund Freud convinced most of the intelligentsia that man has no soul. The arguments of Darwin and Freud were embellished by a myriad of others who followed in their footsteps. These arguments have become intricate and involved, and relatively few people really understand them. But their implications are easy to understand: There is no God, and man has no immortal soul! And since they are presented by scientists and others who seem to be extremely intelligent, it is not difficult for many people to simply accept them on faith-and then to adjust their lives and their morality to match them.

Thus an important purpose of this book is to present the arguments for intelligence in creation as best I can. Hopefully, it will become apparent that faith is involved on both sides; that is, that the atheistic scientist-philosopher can no more prove the things he advocates than the religious person can objectively and conclusively prove the existence of God. Having looked at these matters myself for many years, it remains my fervent testimony that faith in Christ as the Son of God and the Creator and the Redeemer of the earth is not really incompatible with the study of science nor with its attempts to study truth about the universe. There are conflicts all right, plenty of them. Much

faith is still required to live one's religion, and as long as the earth in this phase of its creation is fulfilling its ordained purposes, faith will be required. But it is my testimony that the discoveries of science (especially biology) can contribute far more to an understanding of creation than they can detract from it. Thus part of this book deals with controversy. This can't be helped, and indeed I must admit that I relish it a bit. But I truly hope that the book is mostly about the sublime beauty of creation.

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Section 1:
The Ground Rules

"And I, God, called the dry land Earth; and the gathering together of the waters, called I the Sea; and I, God, saw that all things which I had made were good."

Moses 2:10

1
Revelation

As the Apollo 8 spacecraft was approaching the moon before that most memorable Christmas of 1968, astronaut James Lovell looked back at the earth and described it as "a grand oasis in the big vastness of space." There it was, our mother planet. By careful deductive studies extended over three centuries, we knew what it would look like from space. But there it was, shining with an almost incomprehensible glory that was accentuated by the bleak and dead satellite that human beings were about to approach for the first time in recorded history.

Where did this sparkling blue and white oasis in the vast void of space originate? How did it come into being? Why? Can the mind of man find answers to these questions? The human brain had dreamed dreams and schemed schemes until a spacecraft had taken form and was now drifting in its accurately calculated lunar trajectory. But could that brain discover its own origin and the origin of the earth that was its home?

Conceivably, there are two ways to gain answers to the questions of creation. First, if the earth was the product of another creatively intelligent mind or minds, a God or gods, we might find out from

the Creator himself how and why it was done. A mind that could create an earth could certainly communicate with other minds dwelling on that earth. Such communication is called revelation; it is one logical way for us to find out about this creation-if God exists.

Second, we might use our brains to find out about the earth's origin and our place on the planet. Indeed, by processes not unlike those that built the lunar spaceships, men and women have learned much about their planet. The scientist looks, describes, formulates ideas, and then tests these ideas in many ways. They broaden finally into concepts about how nature works. This is science. Is it not reasonable for man to take this approach in trying to find out about the creation of his earth?

The Believer and the Scientist

Both approaches are accepted and applied in this book. The discussions are based on the beliefs that God lives and has spoken and does speak to man, and that man can discover truth by the application of his own intelligence.

There are many who reject one or the other of these ideas. Some do not believe that there is a God nor that such a Being has spoken to man. Others are highly suspicious of science, accepting the technological achievements that speak for themselves, but believing that scientific philosophers tend to be unrealistic, wishful thinkers whose theories have blinded them to the commonsense truths so evident to a reasonable person. This book can have little meaning for the atheist or for the antiscience fundamentalist.

The man who rejects God can't understand when we are discussing God's word. He shouldn't even try to understand until he has pursued the question of God's existence and communication to man. Paul said: "But the natural man receiveth not the things of the Spirit of God: for they are foolishness unto him: neither can he know them, because they are spiritually discerned." (1 Corinthians 2:14.)

On the other hand, this book will have little meaning for the fundamentalist who rejects science, believing that all scientists (especially evolutionists) are Satan's henchmen. Scientists certainly do not have a clear monopoly on all truth. They have been wrong, and sometimes they have been disastrously wrong. But few are willfully bad. Most have developed an attribute that is one of God's prime characteristics: a love of truth. A true scientist is a person consumed by a desire to understand things as they are. All else in life may be secondary to this goal. But knowing truth is not easy, so this same scientist may be steeped in untruth, even falsehood that could lead one away from God. Yet his motives cannot be impugned. If he could be shown the truth to his complete satisfaction, he would embrace it.

The believer must realize that he also peers through a glass darkly. He, too, knows only in part. He may use gospel words confidently and even smugly, without really knowing what they mean. What is meant by celestial or intelligence or spirit or paradise or Urim and Thummim or a God of flesh and bone? Who among us could explain these terms with scientific precision?

Faith

Belief in a God who created the universe is an act of faith. But what is faith? Is it a bit of magic by which, if one just thinks hard enough that something is so, it becomes so? Not according to Alma: ". . . faith is not to have a perfect knowledge of things; therefore if ye have faith ye hope for things which are not seen, which are true." (Alma 32:21.)

Here is the paradox and the beauty-and the clue to understanding. If something is not seen, how can we know that it is true? We don't, but we hope! That is, we hope for truth. It is not a matter of

believing strongly because one hopes, and then expecting God to make something true to satisfy that hope. We hope that what we believe is true, but since we aren't positive, we continue to seek.

But isn't this still a blind faith? And isn't blind faith something abhorrent to science, a matter of accepting an idea without evidence? Not if we are only hoping for things that are true. This kind of hope means that we must base our faith upon something. It is a matter of believing in something we cannot know or understand based upon something we do know and understand. Accepting the principles of the gospel does not require blind faith. One studies the principles and is impressed by their logic. One investigates in ways not unlike those applied by the scientist in his search for truth. Eventually one concludes that certain gospel principles simply must be true-all the evidence supports this idea. Then one is able to make the intellectual leap of accepting on faith something else that he cannot thoroughly know and understand, something that goes beyond.

We should note that faith is ultimately a gift of God, given to those who seek and who obey. (See John 7:17; Romans 12:3; 1 Corinthians 12:9; D&C 46:12-13.) Surely God would not give the gift of blind faith. He would bestow faith in things that are true.

To me the evidence is clear (does not require the application of blind faith) that God lives and speaks to prophets. This forms the foundation for my faith in what I cannot always comprehend. I do not completely understand God's story of creation. Nevertheless, since I am convinced that the story is God's word, I can accept it as being fundamentally true whether I understand it or not. Furthermore, I accept God's promise that I will understand it at some future date, here or in eternity.

The Word of God

The logic of revelation is crystal clear: If God exists, it is reasonable to accept that he could tell us about creation. Furthermore, it is reasonable to expect that he might want to tell us. Indeed, it is difficult for some to understand why, if he exists, he does not tell each and every one of us. Of course, he could have his reasons-perhaps our ultimate progression depends upon our working out our own salvation as we walk by faith. But if God exists, he could tell at least some of us (the prophets) about creation. If God exists. That is the primary consideration.

Numerous evidences have been cited for the existence of God. Philosophers have examined the question for centuries. The arguments of father Lehi provide an excellent example:

"For it must needs be, that there is an opposition in all things. . . .

"And if ye shall say there is no law, ye shall also say there is no sin. If ye shall say there is no sin, ye shall also say there is no righteousness. And if there be no righteousness there be no happiness. And if there be no righteousness nor happiness there be no punishment nor misery. And if these things are not there is no God. And if there is no God we are not, neither the earth; for there could have been no creation of things, neither to act nor to be acted upon; wherefore, all things must have vanished away.

"And now, my sons, I speak unto you these things for your profit and learning; for there is a God, and he hath created all things, both the heavens and the earth, and all things that in them are, both things to act and things to be acted upon." (2 Nephi 2:11, 13-14.)

Lehi seems to be saying that the existence of good and evil, happiness and misery, argues for purpose in man's existence, which in turn argues for the existence of God. Indeed, the earth itself argues for God's existence: without God there could have been no earth, Lehi says. Alma stated this even more clearly: ". . . all things denote there is a God; yea, even the earth, and all things that

are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator." (Alma 30:44; see also Psalm 139:14-16; D&C 88:46-47; Moses 6:63.) Much of this book is devoted to an examination of the argument for God based upon order and design in nature. It is a powerful argument, but it is being challenged by many in the world today who believe that order and design can be accounted for without God.

Other evidences include some of the sublime attributes of man himself, such as the love he can feel toward another human being, the existence of hope in moments of despair, the welling up of joy within him as he reacts to beauty, the mercy and compassion he can feel toward one less fortunate than himself, and even the humor that often makes his existence seem more worthwhile. Could man possess such divine attributes if he were not the creative product, the very offspring, of a divine Father in heaven?

Surely my intuitive conviction that such human attributes have a divine origin contributes to my testimony that God lives. As I try to analyze this testimony, however, these arguments seem somewhat less important, perhaps, than four others. The "arguments" discussed below are more a matter of personal experience than logical polemics, but each has some logical validity.

1. The testimony of witnesses: the prophets.
In science we are often dependent upon the testimony of a witness. We like to think that we can always check his testimony by repeating the experiment or observation ourselves. Sometimes, however, this is not possible. It is virtually never possible for the historical scientist, who must try to understand past events based upon what someone has said about them. For centuries, research in astronomy was dependent upon the written testimonies of observers who measured the often unique positions and velocities of celestial bodies. Astronomical science made profound advances in spite of this limitation. Now photography and other recording procedures make the record somewhat more permanent, but an astronomer might be visually observing a planet, for example, and be the only human on earth so observing. If he sees some brief event (e.g., the brilliant flares on Mars seen several times this century), other astronomers will have only his word for it.

When we are dealing with witnesses instead of the objective data upon which much of science is based, we could be dealing with liars. Thus conclusions based upon the testimonies of witnesses have this limitation, but science has often made vast strides in spite of it, simply because men do not tend to be liars when they are bearing solemn testimony.

There are and have been men who have borne and do bear personal testimonies of experiences with God. Some claim to have communicated directly with God, to have heard his actual voice, to have witnessed his form and substance, and to have felt the influence of his Spirit upon their own. Some have claimed that they have received a commission from God to communicate the knowledge they receive to the rest of the human race. These are the prophets.

Their claims are worth investigating. If they are not true, if the men are liars, we might at least learn something about the operation of human nature and be able to protect ourselves in the future from such deceivers. On the other hand, if they are telling the truth, the information they might be able to communicate to us could be more important than any other knowledge.

But how can we discern whether a man is lying or telling the truth? Particularly if the man lived in a completely different culture some 2,000 to 6,000 years ago? Probably the task is impossible if the conclusion must be absolute and scientifically valid. It is possible, however, to apply a host of scholastic and scientific criteria. If all who testify claim to have spoken with the same God, for example, we can investigate the content of the reported messages to see if it is internally consistent. Occasionally (rarely) it is possible to compare what these prophets claim to be truth

with information gained through application of the scientific method. It is nearly always possible to examine a prophet's testimony in the light of the life he led. The motives of known liars (often a simple desire to obtain worldly goods or renown) have sometimes become apparent when their lives have been examined.

In my personal evaluation of the prophets of the Bible, the Book of Mormon, and the restored church, I see the marks of honest men and not the motives of the hoaxer. The detailed examination of this statement would be a worthy way to fill one or more volumes. Yet the final conclusions would still remain personal, because formal proof is probably not to be had. Consider the extent of the record available for study:

There are the several ancient prophets, including Abraham and Moses. They lived so long ago that we cannot evaluate them as witnesses in much detail, and secondary sources such as the writings of Josephus are limited. Other Old Testament records are somewhat more extensive. Consider the majestic testimony of Isaiah (e.g., Isaiah 6), the miracles of Elijah (e.g., 1 Kings 18:17-40), the marvelous story of Ezekiel about the strange vehicle that brought the "likeness of the glory of the Lord" to call Ezekiel to be a prophet to the Israelites in their captivity (Ezekiel 1 to 3), or all the minor prophets with their major messages. These are men telling the world that God himself has spoken to them. If only we knew more of their lives and could better understand their times!

The New Testament prophets are closer to our time, and their writings strike a more responsive chord. A number of them write as personal witnesses of divine manifestations, while a few are secondary witnesses. Of the authors of the four Gospels, Matthew and John personally witnessed the miraculous events they record, including particularly the resurrection of Jesus Christ, while Mark and Luke were friends of the apostles but not firsthand witnesses. Much of what Mark writes is similar to Matthew's account, although it may have been written first. Luke was a physician, and his account bears the marks of the inquiring scientific mind. He may have interviewed a number of the witnesses, including perhaps Mary, the mother of Jesus.

Luke tells us of the conversion of Paul, and Paul makes specific reference in his own writings to the miraculous events described by Luke. (See Acts 9:1-21; 22:6-21; 26:12-23; 1 Corinthians 15:8.) Peter's story is also told by the Gospel writers, and Peter then bears personal testimony. Consider his reference to the events that took place with the Savior on the Mount of Transfiguration (Matthew 17:1-6):

"For we have not followed cunningly devised fables, when we made known unto you the power and coming of our Lord Jesus Christ, but were eyewitnesses of his majesty.

"For he received from God the Father honour and glory, when there came such a voice to him from the excellent glory, This is my beloved Son, in whom I am well pleased.

"And this voice which came from heaven we heard, when we were with him in the holy mount.

"We have also a more sure word of prophecy. . . ." (2 Peter 1:16-19.)

John's personal witness is also impressive. (1 John 1:3, 5; Rev. 1:9-19.)

Much of the discussion in this book is based upon revelations received by Joseph Smith, especially the restored writings of Moses and Abraham. Joseph Smith is a modern prophet by whom we have volumes of personal written testimony and whose life can be examined in intricate detail. No better possibility exists to examine the prophetic claims. Sometimes the liberal atheist condescendingly tells us that a prophet, though personally sincere, was nevertheless mentally

deluded in some way. He may have thought that he had a communication with God, but really it was just a dream or hallucination. It is difficult to apply this interpretation to the writings of any of the prophets, but it is especially difficult with Joseph Smith. Either he is telling the truth or he has fabricated an elaborate and intricate set of lies, which he maintained in a consistent form throughout his lifetime, finally sealing his testimony with his life. The following statement of Joseph Smith does not sound like that of a self-deluded man: "I saw two Personages, whose brightness and glory defy all description, standing above me in the air. One of them spake unto me, calling me by name and said, pointing to the other-This is My Beloved Son. Hear Him!" (Joseph Smith 2:17.)

With Oliver Cowdery he declared: "The veil was taken from our minds, and the eyes of our understanding were opened. We saw the Lord standing upon the breastwork of the pulpit, before us." (D&C 110:1-2.)

And with Sidney Rigdon he wrote: "And now, after the many testimonies which have been given of him, this is the testimony, last of all, which we give of him: That he lives! For we saw him, even on the right hand of God; and we heard the voice bearing record that he is the Only Begotten of the Father-That by him, and through him, and of him, the worlds are and were created, and the inhabitants thereof are begotten sons and daughters unto God." (D&C 76:22-24.)

Here were witnessed events that occurred in the presence of others. Was it all some evil conspiracy designed to achieve a secret diabolical end? The record tells of a movement, a church, having righteous goals and being pushed forward by good and righteous men. The movement is still growing, and some of the literal and spiritual descendants of these men are my personal friends. I cannot believe that the basic goodness of those now leading The Church of Jesus Christ of Latterday Saints could be the result of a scheme that was originally a fraud. Furthermore, the president, apostles, and patriarch leading the Church today are sustained as prophets to receive revelations for the Church. They are our contemporaries, and their teachings and their lives can be evaluated. My evaluation has led to a personal acceptance of their divine callings. For these and other reasons, I can accept as prophets of God Joseph Smith and the men who have since occupied his position.

2. The coherence of scripture.
Numerous men have claimed divine communication and miraculous experiences. Sometimes the communications received by some are quite contrary to those received by others. It is conceivable not only that some men might be liars, but also that supernatural beings other than God might communicate with man. If a God of righteousness exists, it is conceivable that there is also a Satan, a supernatural being opposed to God's plan, who might communicate with man, sometimes even fraudulently claiming to be God. These possibilities do complicate the picture.

A scholarly approach to a study of the communications purported to have come from God might serve two purposes: If the communications collected together under the claimed inspiration of God and accepted by a people as scripture prove to be internally consistent, then we will have a more or less objective argument in favor of their divinity. In my studies, I have found this consistency.

On the other hand, when purported communications do not agree with this body of scriptural doctrine, we might be suspicious that they are either fraudulent or from some supernatural source other than God. Indeed, the Lord declared to Moses and the Israelites that the test of consistency was more important than that of miraculous works: "If there arise among you a prophet, or a dreamer of dreams, and giveth thee a sign or a wonder, And the sign or the wonder come to pass, whereof he spake unto thee, saying, Let us go after other gods, which thou hast not known, and let us serve them; Thou shalt not hearken unto the words of that prophet, or that dreamer of dreams. . . ." (Deuteronomy 13:1-3.)

3. The beauty and spirit of scripture and doctrine.
In my own attempts to study the scriptures, it soon became apparent that my reactions were both objective and subjective. It is possible to consider the consistency of some theological doctrine objectively, such as the nature of God as taught by the prophets from the beginning of recorded history, but in the process one is almost certain to be subjectively overwhelmed by the beauty of certain scriptural statements, and this feeling may be strongly augmented by the Spirit. Although unscientific, the intuitive impact upon our final conclusions may be considerable and ultimately more important than the results of our scholarly study.

As I thumbed through the scriptures, making a list of my favorites that illustrate this point, it soon became apparent that there are far too many excellent examples for any kind of detailed analysis here. Let us consider just one example from the Doctrine and Covenants. This was the scripture that first deeply impressed me with such an approach to testimony. I was staying for a few days in a distant town in the home of a former bishop under whom I had served in a bishopric. He and his family had just left, and I was alone for an hour or so before driving to the airport. I felt slightly depressed for reasons that were difficult to pinpoint or understand. I had been traveling some and had thus been exposed to some of the materialistic, technological aspects of our world. Furthermore, I had been studying the almost surrealistic advances being made in modern biology, and I was troubled by their possible effects upon our society. All this had led to some vague uneasiness-not exactly a weakening of testimony, but a nebulous feeling of insecurity.

In this mood, I remembered a scripture I had heard in a sacrament meeting talk a few weeks before. I went to my friend's bedroom and found the Doctrine and Covenants on his nightstand. I found the last two verses of section 121 and was immediately overcome by their beauty and by the manner in which they summarized, in so few words, the gospel requirements and the divine promises. My entire being was suffused with the conviction that these words were simply too sublime to be the creation of the mind of Joseph Smith. For centuries men had discussed these things, but never before (as the Spirit bore witness to me at that moment) had they done it so well. These had to be the words of God. I read the two verses four times, the tears welling up in my eyes in response to their beauty. Then I had them memorized, and I repeated them several times on my way to the airport.

Of course, the skeptic could not react to these verses as I did. This was a moment of truth, a special communion between God and me. But let me try to recall my feelings, as I read from those words (D&C 121:45-46):

"Let thy bowels also be full of charity towards all men, and to the household of faith." Here is the supreme commandment. This is what a life patterned after that of Christ is all about. This is the divine love called charity that Christ was able to feel toward all his fellow beings and that we, if we are to become perfect, must also experience. (See Ether 12:34 and Moroni 7:45-48.) Yes, we must feel this charity deeply within us toward all men, but we are nevertheless justified in loving our brothers and sisters in the gospel, "the household of faith," with a little extra measure of this divine Christian love.

". . . and let virtue garnish thy thoughts unceasingly." Here is the other part of the formula that will lead to exaltation: thinking proper thoughts. Yet we are not admonished to cloister ourselves in some monastery, forcing ourselves to speak the word virtue for hours on end. Rather, as we go about our business, anxiously engaged in good causes, virtue is to garnish our thoughts as the vegetables garnish a fine meal. Here, then, in just a few words is the way to a successful life in Christ: charity or love, and controlled virtuous thinking.

Then come the marvelous promises of the rewards developing out of such a life. First the immediate rewards: "then shall thy confidence wax strong in the presence of God; and the doctrine of the priesthood shall distil upon thy soul as the dews from heaven. The Holy Ghost shall be thy constant companion." No greater blessings could be promised to mankind. More than anything at that moment, I needed a renewal of my confidence in the presence of God-and it came as I was immersed in the beauty of this scripture. Who could ask for anything more than a reception of God's priestly doctrines by revelation? And how could one's joy be more full than in companionship with the Holy Ghost?

But the ultimate promises were even more marvelous to contemplate: ". . . and thy scepter an unchanging scepter of righteousness and truth; and thy dominion shall be an everlasting dominion, and without compulsory means it shall flow unto thee forever and ever." Here are allusions to the ultimate state of a perfected man or woman. Charity and virtue can make us kings and priests, queens and priestesses, even gods. (D&C 76:56-58; 132:20.) Yet if we reach this perfected state we shall rule only on the basis of truth and righteousness. On such a basis, we shall not need to obtain our dominion by force; rather, it shall flow unto us throughout all eternity as a natural consequence of righteous actions. Surely only God himself could express such a simple yet perfect formula for eternal progression and such supreme rewards.

4. The inner conviction arising as personal testimony.
We are told that the seeker after truth will eventually be confirmed in his convictions by a personal witness from God himself, administered through the power of the Holy Ghost. This and my response to scriptural beauty are the least scientific of the four aspects of my testimony. Witnesses have their scientific counterparts, and a scholastic study of scripture does also. Yet science does not operate without intuition. Any study of scientific discovery reveals numerous examples. Typically, the formal logic supporting the scientific discovery must be devised after the truth of the discovery has become intuitively apparent. Religious testimony is analogous, although certainly not identical. Intuition is one thing, but the gift of the Holy Ghost is another.

James tells us that we must "ask in faith, nothing wavering" (James 1:6), but the most complete explanation of what this means is given by Moroni near the end of the Book of Mormon. This is appropriate, since the reader of the book must either reject its truth or accept it on faith. If the book is really true, then rejection means giving up blessings for all eternity; acceptance could mean returning to the Father's presence. So the stakes are high. But how can one know of its truth? Moroni explains:

". . . when ye shall read these things . . . remember how merciful the Lord hath been unto the children of men . . . and ponder it in your hearts.

"And when ye shall receive these things, I would exhort you that ye would ask God, the Eternal Father, in the name of Christ, if these things are not true; and if ye shall ask with a sincere heart, with real intent, having faith in Christ, he will manifest the truth of it unto you, by the power of the Holy Ghost.

"And by the power of the Holy Ghost ye may know the truth of all things. . . .

"And ye may know that he is, by the power of the Holy Ghost. . . ." (Moroni 10:3-5, 7.)

This marvelous scripture deserves careful reading and analysis. First we must receive the word of the Lord, read it, and ponder it in our hearts, along with a realization of God's other manifestations (mercy) to the children of men. It is not enough just to be casually curious. We must pay the price of study and deep thought. We must be obedient to the principles in which we are gaining faith.

Then, when we are prepared, we are admonished to ask in prayer if the words are true, according to the form set by Christ: addressing the Eternal Father, God, in the name of his Son, Jesus Christ. But this is not to be a cavalier prayer, one motivated only by curiosity; it must be totally sincere and guided by real intent. A man once said: "I prayed to see if the Book of Mormon were true, just like it said to do. I didn't get an answer. But I wasn't surprised; I knew I wouldn't!" Furthermore, when one asks God, one must have faith in Christ. That is, one must already have examined the evidence and decided that the case is a good one. The study and the pondering have led to a faith in Christ, if not the Book of Mormon. Then, if all the conditions have been properly met, God will manifest the truth unto the seeker by the power of the Holy Ghost. That is, God will show the seeker that the book is true. Thousands testify that this promise has been fulfilled in their behalf.

But that isn't all. The procedure is a general one. One may know the truth of all things, including the very existence of God, by the power of the Holy Ghost. Presumably the formula of study, meditation, proper prayer, sincerity, real intent, and faith in Christ must also be followed when one wants to know the truth of things besides the Book of Mormon.

Yet experiences in which one's testimony has been confirmed by the Holy Ghost are not easy for a person to tell. He knows of their reality, but he also knows that one who has not had such an experience will never really be able to understand. He knows that the skeptic will think he understands-think that the one who bears the testimony was simply gullible or a dreamer. Thus such experiences are passed mostly by word of mouth between good friends, brothers and sisters in the gospel.

I have presented such a story in telling of my reactions to the last two verses of section 121 in the Doctrine and Covenants. It is easy to see how a skeptic might reject my account; for example, he could speak of my subconscious wish fulfillment. But let it be clear that, while he would be theorizing, it was, after all, my experience. Should I be expected to let someone who may not have known the presence of the Holy Ghost explain my experience to me?

Testing Religious Truths

How can one test for himself the validity of statements purported to have been received by revelation? One can and one should approach such statements in the same manner that he might approach any scientific statement. This will be discussed in Chapter 3. He should see if the statement agrees with other knowledge, including scientific fact and theory. It is foolish, however, to depend upon this approach exclusively. Many religious statements simply cannot be tested in this way-suitable facts and data are not available.

Sometimes the approach can be applied to prophecies. If a prophecy does not come to pass, then it was not a statement from God, as was explained to us long ago by Moses. (Deuteronomy 18:21-22.) Moses also implied that what the prophet says must be in agreement with what other prophets have said. (Deuteronomy 13:1-3.) A fulfilled prophecy could be luck or insight into developing trends. This test is especially easy to apply in our day when we have so much scripture. When a man claims to be speaking in the name of God but tells us something contrary to existing scripture (telling us to "go after other gods"), we should be extremely wary.

Ultimately the only valid test is to ask God himself in the manner prescribed by the prophets. This includes pondering the problem, prayer, faith in Christ, sincerity and real intent, and obedience to principles. Sometimes these are the only approaches-objective science just won't work. As we seek to know the word of God about the broad, general things constituting testimony, so we seek to know the truth of his word in all applicable cases, regardless of how minor. As Peter told us, scriptures came through the inspiration of the Holy Ghost and must be interpreted and understood in the same way. (2 Peter 1:20-21.)

Footnotes
1. I have expanded this discussion somewhat in my book Truth: by Reason and by Revelation (Deseret Book Co., 1965).

2
Counter Arguments

In the spring of 1969, Student Life, the student newspaper at Utah State University, ran a series of articles entitled "Are Religious Systems Necessary?" These were written mostly by faculty members, and while a few defended religious systems, most concluded that such systems were unnecessary. Many of these negative articles were written by persons who claimed to be atheists or who were presently inactive Latter-day Saints. Many of these writers were also outstanding scholars and scientists, for whom I had a great deal of respect.

I waited eagerly for the appearance of each article, because here was a chance to see the foundations of belief of persons who rejected the existence of God. What compelling logical arguments would cause one to give up his church or to deny the testimonies of the prophets? What glaring weaknesses were there in the foundations of my own faith? The articles should provide answers.

No really new ideas were forthcoming. The reasons these writers didn't believe in God were familiar arguments that I had heard and considered most of my life. When all the articles had been published, it was apparent that belief or disbelief in God was a highly personal matter; those persons were not convinced by my arguments nor I by theirs. There were no totally persuasive reasons for their disbelief-which is not to say that their arguments were obviously foolish. Indeed, they can be highly instructive. I have combined and condensed them into five principal ideas.

Man Created God
1. Man created God in his mind as an explanation for the universe, especially for events that he could not otherwise comprehend, including various natural phenomena (e.g., the creation), injustices in society, and death. This interesting argument is mentioned in one form or another by virtually all philosopher-agnostics or atheists. It is easy to marshal evidence for the idea, since men have from time immemorial created in their minds a god or gods with many and varied attributes. Volumes have been written to document this process. Yet because there are false gods, we cannot logically conclude that all gods are false-that there is no true and living God. If one does not want to believe in God (or in witches, hobgoblins, ESP, or flying saucers), one can always cite the negative cases. But these become meaningless if there is a single positive case.

I believe in God not in spite of the negative cases but because God has revealed himself. Numerous men, the prophets, claim to have communicated directly with God. The scriptures don't argue philosophically, saying: "There must be a God because-." Rather, they say: "Thus saith the Lord . . .," "I am the Lord, and there is none else . . .," "The word of the Lord came unto me, saying . . .," or "The words of the Lord, which he spake . . . ." Let it be clear that we believe in God not because he provides explanations for otherwise inexplicable phenomena. Often (as we shall see in relation to the creation) the phenomena remain inexplicable in spite of God's word-he reveals nothing about them. Rather, we believe in God because he has revealed himself-to witnesses, by the beauty of his word, and to many of us personally. What could be simpler?

Science Triumphs over Religion
2. Religion has lost every argument with science. What arguments? Of course, apostate Christianity lost many arguments relating to the operation of nature, arguments into which they had no business

entering in the first place. The approach was to deduce unjustified conclusions from scripture, such as the idea that the earth was flat or was the center of the universe. These were uninspired men arguing philosophically but in the name of religion.

But has science won an argument about how to lead a life that will return one to God's presence? In general, science knows enough not to become involved in the great arguments of religion relating to the salvation of men's souls. Science does not have the data to consider such problems and is well aware of this.

Actually, science hasn't even done a very outstanding job of telling us how we can best live with one another. This might well be a valid area for scientific inquiry. One assembles objective data about the interactions of human society, and then one draws conclusions about how we might best act. But this is an extremely complex process, and it has yet to be very successful. One problem is that social scientists often assume that what is average or normal (indulged in by the most people) is also desirable. God, speaking through prophets, has never taken this approach. Often the true way of life leading to happiness and salvation, as revealed by God, may be ignored by an entire people, and the prophets' admonitions are directed against all of them. It remains to be seen who will win this argument, but following God's word is certainly a logical approach.

We shall see that God has told us little about how the universe functions, the domain of science, but much about the nature of mankind. Yet when God does speak of physical things (e.g., the Word of Wisdom, the creation), his word is far ahead of science.

God's Omnipotence and An Imperfect World

3. A perfect God of love, as claimed by the religionists, and capable of accomplishing all things merely by the word of his power, would never create an imperfect world, one including injustice and evil men and women. This is one of the most persuasive arguments facing people of the world today. Many have been taught that God is a God of unlimited justice, mercy, and power; then they experience in the world around them acts of extreme injustice and cruelty. They remember the cold-blooded murder of five to six million Jews in Nazi Germany or the atrocities committed in Viet Nam. They see evil men and women who will sell their integrity, their bodies, or their souls for material wealth, or they witness a child struck down by a drunken driver. If God lived, some argue, he with his mercy and love would never permit these things. Yet they do occur; the world is evil, unjust, and imperfect. Hence there must be no God.

The argument appears to be foolproof, and much of mankind is presently so evil that one can only sympathize with today's youth or anyone else whose atheistic convictions are based upon it. Yet the argument is not logically conclusive, and since there are positive evidences for God's existence, we are entitled to be skeptical of it. The argument has the following form: A certain set of God's attributes is stated. But a God having such attributes is incompatible with the facts of contemporary life. Consequently, such a God cannot exist-does not exist. The logic is infallible. But what about a God having attributes other than those stated in the initial set?

The scriptures tell us about the purposes of creation: "Satan . . . came before me, saying-Behold, here am I, send me, I will be thy son, and I will redeem all mankind, that one soul shall not be lost, and surely I will do it; wherefore give me thine honor." (Moses 4:1.) Lucifer apparently proposed to do the very thing that those who present this argument assume that God would do: create a perfect world and redeem everyone. "But, behold, my Beloved Son, which was my Beloved and Chosen from the beginning, said unto me-Father, thy will be done, and the glory be thine forever." (Moses 4:2.) The Son apparently recognized that Satan's idea might not be a feasible one. He did not suggest an alternate plan but merely said: "Father, thy will be done."

"Wherefore, because that Satan rebelled against me, and sought to destroy the agency of man, which I, the Lord God, had given him, and also, that I should give unto him mine own power; by the power of mine Only Begotten, I caused that he should be cast down." (Moses 1:3.) One issue, then, hinged upon agency. God had provided the preexistent spirits of mankind with agency, an ability to choose for themselves. Satan thought that he could create a perfect earth for all the spirits of mankind, allowing them finally to be redeemed in the presence of God, but, in the process, destroying the very agency that God their Father had given them.

Probably we can deduce from this record that Satan's idea was rejected because it was an impossible idea. God is omnipotent in the sense that he can do all things that are possible, anything that he wants to do-but in his own omniscience, his perfect knowledge, he will only want to do what is possible. (Abraham 3:17.) We can apparently conclude that it was not possible for the spirits of men to be saved in the presence of God without the agency that he had given them.

In speaking of these same events in the preexistence, the Lord told Abraham: "And there stood one among them that was like unto God, and he said unto those who were with him: We will go down . . . and we will make an earth whereon these may dwell; And we will prove them herewith, to see if they will do all things whatsoever the Lord their God shall command them. . . ." (Abraham 3:24-25.) Obviously, if man is to keep commandments, he must have the agency to accept or to reject these commandments.

This is the real world in which we live. It is not a world where there can be no evil, as Lucifer apparently proposed. Rather, it is a world where men progress toward godhood by exercising their agency. According to the eternal scheme of things (not arbitrary laws established by God but natural laws that have always existed), man can become godlike in no other way. He must be tested or proven if his soul is to develop. This being the law of development, then individuals will make mistakes. Unfortunately, some make terrible mistakes, committing the atrocities mentioned above. Others build one small mistake upon another until virtually all their values have been warped; they are no longer in the way that leads back to their Father's presence.

Yet God is just and merciful. Some souls, as many as possible, will use his plan to become like he is. He has established patterns of repentance and the atoning sacrifice of his Son, so that all who really desire may become like him in spite of their mistakes. In his mercy and wisdom, he has even provided that the very worst of us (except those who deny the Holy Ghost) may achieve a glory that "surpasses all understanding." (D&C 76:89.) But in this mortal phase of eternal progression, we can expect evil in the world, and indeed, today, in the dispensation of the fulness of times, we can expect the world to be mostly evil. (See Joseph Smith 1:30, 41-42; Moses 7:60.) The parable of the wheat and the tares tells us clearly that the wicked shall coexist with the righteous until the end of this world. (Matthew 13:24-43.)

There are several arguments against God that have the same logical format as this one. The pattern is to assume certain attributes about God, compare them with the observed facts, and, when the two prove to be incompatible, conclude that there is no God. Again, let us be perfectly clear about the logic. The god described by the assumptions surely does not exist. He is a dead god. But what about the real God not so described?

Charles Darwin apparently began to lose faith in God as a creator by such an argument. He, in common with many other naturalists of his time, assumed that God would create all species individually and immutably, each one perfectly adapted for its location. On the voyage of the Beagle, Darwin compared the flora and fauna of two similar but widely separated volcanic islands: "It is possible that the islands of the Cape de Verd group resemble, in all their physical conditions, far more closely the Galapagos Islands, than these latter physically resemble the coast of [nearby

South] America, yet the aboriginal inhabitants of the two groups are totally unlike; those of the Cape de Verd Islands bearing the impress of [nearby] Africa, as the inhabitants of the Galapagos Archipelago are stamped with that of America." He asks why the Galapagos organisms were "created on American types of organization." Instead of revising his assumptions about God's means of creation, Darwin questioned the existence of God as a creator, although it would be many years before he would say: "I gradually came to disbelieve in Christianity as a divine revelation."

Today the biochemical evolutionist points to a close similarity in molecular structures of the proteins of apes and men. He asks, "If God had created men and apes, why should these similarities exist?" He is assuming that he knows how God would create things without similarities, and he is implying that since things are not this way, there must be no creator God.

What foolishness! What conceit! The arguer is brash enough to believe that he can discern the motives and the methods of God! A more logical approach would be to investigate God's existence by studying the direct evidences: revelation and the prophets. Becoming convinced that God exists, one might then study biology, not to discover the trivial apparent discrepancies, but to behold the manifestations of nature that testify of God's creative attributes.

Obviously, God did not create the species as rigidly as was assumed by eighteenth and nineteenth century naturalists. Nor, as we shall see, do the scriptural accounts of creation ever say that he did. We have been learning about some of the adaptibility and flexibility in God's organic creations and thereby gaining a little more insight into his attributes as creator. Why shouldn't we learn about God this way?

Naturalism

4. The universe can be explained in atheistic terms. In some ways this is the most common and most powerful argument presented by the scientific atheist. The implication is that science has done such a good job of explaining all natural phenomena that God is simply not necessary-as if we believed in God only to complete our philosophies. Although this argument is similar to the idea that men created God out of need, it deserves to be mentioned in this form.

It should be apparent to nearly anyone familiar with science that this is an argument based upon faith. What the argument really should say is: "Science has done a good job of explaining natural phenomena, and probably it will do such a good job in the future, that the concept of God will not be necessary." The one who expresses this argument is expressing his faith in the future of science. Surely science has not explained all phenomena at the moment. The revelations and personal experiences referred to in Chapter 1 are examples. Miracles of healing provide other examples. We shall see in later chapters that even creation, thought to be so well explained, certainly is not.

Besides, when one argues by alternative explanations, one must show that the facts fit one alternative better than the other. If both fit equally well, no decision can be made. It is not enough to show that the universe can be explained without God. It would be necessary to show that the universe cannot be explained with God.

Evil Christians

5. Some Christians are evil. Often the atheist will, after citing some version of the above arguments, state that he could never be a Christian (or Buddhist, Muhammadan, etc.) anyway, because Christians he has known are often hypocrites who profess one thing but do something else.

Such an argument apparently implies that, if Christ were the Son of God and perfect, anyone who professes to believe this should be perfect also. This is an illogical and unfair argument. The Christian doesn't expect the scientist to be a perfect scientist just because he believes in science.

Nor is there anything in the Christian's religion, in the revelations claimed to be from God, that says that mere profession of belief makes one perfect. As we have seen above, revelation teaches that man has his agency but is far from perfect in his use of it. The Christian is hoping for perfection. He is working toward it. But often he is far from it-and sometimes he may even lose sight of it as a goal, although others still think he is a Christian.

Actually, the argument, if softened a bit, is a valid one. If God has revealed a way of life that will make men happier, leading them toward perfection, then we might expect that those who accept this way of life will, on the average at least, be happier and more perfect: "Wherefore by their fruits ye shall know them." (Matthew 7:20.) ". . . that they also may be one in us: that the world may believe that thou has sent me." (John 17:21. See also Matthew 5:14-16.) There have been periods during the earth's history when "Christians" were among the most evil of all people. Rather than implying that Christ was not the Son of God, this only implies that they were not living his teachings. On the other hand, there have been periods when groups of people have truly applied the revealed teachings of God and, as a result, have become far happier and more perfect than mankind as a whole. (For example, the City of Enoch or the early Christians: Moses 7:16-21; 4 Nephi; Acts 2:44-47.) Of course, this is a rather subjective statement, but let me add another one: Really converted Christians are good people. Indeed, they are the best that I have ever known. Those who live according to gospel principles are known by their fruits. Frequently, investigators join the Church because of what they have seen in the lives of some of its members.

The arguments against God are, then, all inconclusive. We can predict that this would have to be so by realizing that there could be a God in the universe who could create a universe that appeared not to need him, and who might be powerful enough to control the minds of his children so that they could never find him. Perhaps such a pernicious God would not be worth seeking in the first place, but the point is that attempts to disprove God's existence must always be doomed to failure. On the other hand, God is proven for us if he reveals himself to us.

It is frightening to think of the importance such negative arguments could have in the minds of those who accept them. They could keep a person from searching for God or from trying to live according to his precepts as part of the search. Indeed, they might keep one out of the celestial kingdom. Could it be that they are presented sometimes less as sincere philosophical arguments against God than as excuses, offered so that one can avoid following God's laws? (See Matthew 13:15.)

After study and prayer and based upon the ideas discussed in these first two chapters, I can accept God's existence and his word. Hence, in attempting to understand the universe, God's word must come first. This is the first premise or ground rule of this book. How could it logically be otherwise if God lives and speaks through prophets? If God and science conflict, I will have to wait for more knowledge in science. After all, if God created the earth-which I fully believe-then he is the one who should know.

Yet his word on creation is extremely limited. As we shall see, there is much that he has not told us, particularly in relation to the mechanisms of creation. That is, there are limitations from the source of knowledge. Furthermore, much of what he has told us is difficult to comprehend, requiring much expenditure of effort, much seeking for the Holy Ghost. That is, there are limitations of interpretation. These statements of limitation may be thought of as the second and third ground rules.

Footnotes

1. Charles Darwin, The Voyage of the Beagle, second ed. (London: John Murray, 1845). (Reprinted in several editions, including paperback.)

2. Nora Barlow, ed., The Autobiography of Charles Darwin (1809-1882), with Original Omissions Restored (New York: Harcourt Brace). Darwin also lost faith in God because of the misery he saw in the world, including the "brute force" of the natural world (letter of Charles Darwin to Asa Gray, May 22, 1860, quoted in Francis Darwin, ed., The Life and Letters of Charles Darwin Including an Autobiographical Chapter, vol. 2 [New York: Appleton, 1896], p. 105.)

Chapter **3 - Science**

We are exploring on the campus of a great university. We cautiously enter a door labeled "Laboratory of Biochemistry." A man in a white jacket is busy at the dials and knobs of a complex piece of machinery, a spectrophotometer. As he adjusts the knobs and inserts and removes small square vials of colored liquid, he reads figures from a meter, and an assistant records them. The laboratory is crammed with glassware and expensive equipment. By a rack of test tubes placed on a towel, we see several pipettes plus reagent bottles and flasks. A unit about the size of a washing machine is humming loudly in one corner; it is marked "refrigerated centrifuge." In a small attached room, colored lights are flashing in sequence on a shiny big box labeled "scintillation counter." There are balances, vacuum pumps, chromatography cabinets, a gel electrophoresis apparatus, and on one bench an apparatus that is recognizable to us all: a food blender.

What is going on? Is the man in the white jacket some modern wizard who is developing a diabolical new terror to be loosed on mankind? Are his black arts and secret rites incomprehensible to ordinary mortals? Or is he a super brain with a mind full of complex equations that will save mankind from its ills?

The essence of what our biochemist is doing is much simpler: he is asking questions. The questions are addressed to nature, and they arise from the answers obtained from previous questions. The process is experimentation, and while it is part of science and specialized in many ways, in principle it is identical to the way in which we all go about learning things; it is the method of experience and logic.

You and I may wonder if a certain adjustment will improve the color on our TV screen; we try it to see what happens. Our biochemist wonders how a certain chemical known to be present in smoked meat, say, will affect a certain enzyme, a protein, that interests him; he tries it to find out. The enzyme is purified and prepared, the substrate (substance acted upon by the enzyme) is added at time zero, and the reaction controlled by the enzyme is stopped with a protein denaturant after five minutes.

The preparation is then centrifuged to get rid of the precipitated enzyme, chemicals are added that combine with the product of the reaction to form a colored substance, and the intensity of this color is measured in the spectrophotometer. All this is done with and without the compound from the smoked meat. Logic tells us that if the color is less intense in the reaction tubes containing the meat compound, the chemical must inhibit the action of the enzyme. A question has been asked and an answer obtained.

Perhaps this sounds complicated. In a way it is. It often takes some doing to ask nature sophisticated questions. Yet in principle it is as simple as our own learning by experience and logic. And it is clearly not magic, nor only for super brains. Any normal person willing to spend the time and effort could understand exactly what is going on. Anyone.

Much of our biochemist's preparation for his experiment involved being taught, as when one person is taught by another, or when a prophet is taught by God through revelation. That is how the

biochemist learned about the enzyme in the first place. We don't learn everything by experience. In science, the answers to the questions are published so the work of one scientist can build upon that of another.

Knowledge By Experience and Logic
Teaching and revelation both come from the outside: Another intelligence, the teacher or God, communicates with the mind of the learner. Our experiences also come from the outside through our senses, but the logic is from within. This is where the individual has an opportunity to exercise his own mental talents.

James E. Talmage says that "not a truth has ever been made the property of humankind except through the power of that great Spirit [the Holy Ghost] who exists to do the bidding of the Father and the Son." The Book of Mormon emphasizes that all good things, including the good actions of men, come ultimately from God. (See Omni 25; Alma 5:40; Ether 4:12; Moroni 7:12-13; 10:6.) For our purposes, however, we can think of experience and logic as an internally complete approach to truth. Insofar as the experiences and the steps of reason are complete and lead to a consistent picture, they become independent. It is not necessary for us to take anyone's word, even God's, for the idea that two objects added to two others make a total of four. We are, as the scriptures tell us (e.g., D&C 88:11-13), dependent upon God for our ability to think in the first place; for our abilities to conceive of twoness and fourness. Granted these abilities, however, the conclusion is independent and internally complete. Much faith must be applied in scientific endeavors (faith in one's abilities, in the scientific method, etc.), but in the sense that a logical conclusion based upon valid experience is internally complete and consistent, it is the opposite of faith. Once the conclusion has been clearly demonstrated, there is no longer a need for faith; belief has become knowledge.

What Is Science?
Science is an especially refined and formalized application of learning by experience and reason, just as in daily life data are accumulated by experience and then logic is applied to these data to arrive at conclusions. There are many pitfalls, so science has formalized the approach to restrict or at least to minimize or account for its limitations. To begin with, the data obtained by experience must be objective. That is, the data must not be colored in any way by the thought processes of the one who obtains them. It follows that if the data are truly objective, they will be the same regardless of who obtains them. Science is, then, first of all impersonal and based upon objective data.

1. The equipment of science: making measurements. Much of the appearance of science is concerned with the paraphernalia that have been devised to obtain objective data. The pieces of equipment in our biochemist's laboratory are examples. Their purpose is to make measurements, producing the objective data to which logical processes may then be applied. With a ruler, anyone should be able to measure the length of an object within a certain range of error determined by his ability to resolve the markings on the ruler. If this range of error is too great for the logical processes to be applied to the measurements, then more refined methods must be devised. Magnifying devices may be employed, temperatures must be controlled (to account for expansion and contraction), and ultimately the object may be measured in relation to a specific wavelength of light (e.g., from a sodium vapor lamp).

To obtain more detailed objective data, the scientist has devised the telescope, light and electron microscopes, infrared camera, gas chromatograph, pH meter, electronic recorders, cathode ray tube, and an almost infinite array of other special devices. Equally important are his special techniques. The science of statistics is primarily concerned with mathematical statements about the extent to which data are objective. Mathematics is a highly formalized way of applying logic to

objective data. Indeed, the everyday steps of logic used by us all can be stated precisely with mathematical symbolism.

2. The logic of science. Though science in the popular mind may often be equivalent to the paraphernalia devised to make measurements, the logic of science is at least equally important. Neither phase can get along by itself. The logic of science was well worked out by the ancient Greeks, particularly by Aristotle, who lived from 384 to 322 B.C. Yet emphasis was not on making measurements, so it was not possible to take full advantage of the logic. Now measurements may be emphasized, leading sometimes to sterile data. For science to amount to much, it must combine objective data obtained by the most advanced techniques of measurement with valid and truly creative logic.

Syllogisms of logic can be valid or invalid, and the truth of a conclusion is in a sense independent of the validity of the logic. For example, a conclusion may be valid but not true if the premises are not true. On the other hand, a conclusion may be true but not valid if it is not implied by the premises. Consider, for example, a valid deduction:

1. All bodies in the universe having mass obey the law of gravity.
2. The earth and moon are bodies having mass in the universe.
3. Therefore, earth and moon obey the law of gravity.

This is a valid conclusion, because the minor (second) premise is included in the major premise. Since we feel confident that the major premise is true and we know by our definitions that the minor premise is true, we believe that the conclusion is also true. Since we have not tested all bodies in the universe as to their obeying the law of gravity, however, we cannot be certain about the truth of the major premise; hence the syllogism does not prove the truth of the conclusion, although direct tests do. In any case, this is a good example of an Aristotlean syllogism, illustrating the process of deductive logic in which specific conclusions are deduced from general statements.

A more common procedure in scientific work is that of induction. Actually, when the inductive process is set up as a syllogism, it is seen to be an invalid one. Nevertheless, it is an extremely important tool in science. Consider the following:

1. The earth and moon are bodies in the universe having mass.
2. The earth and moon obey the law of gravity.
3. Therefore, all bodies in the universe having mass obey the law of gravity.

By our definitions, the earth and the moon are bodies in the universe. By observation, both are seen to obey the law of gravity. Thus both premises are true. Yet the conclusion is clearly not valid, since all bodies in the universe were not observed. We have only taken a sample of the bodies in the universe and induced from this sample a generalization about all bodies. We may intuitively feel that the conclusion must be true, but we have certainly not demonstrated it. In induction, we derive general conclusions from particular premises. Consider another example:

1. A green alga, a moss, a fern, an elm, a pine, a geranium, and a host of other plants have chloroplasts containing chlorophyll.
2. These same plants photosynthesize.
3. Therefore, all plants having chloroplasts with chlorophyll photosynthesize.

Obviously this is invalid for the same reason that the first example was. Not all plants were examined. Furthermore, the major premise is not always true. Chloroplasts do not develop in plants grown in total darkness, for example. And, in addition, no real relationship was shown between the

chloroplasts and photosynthesis; only a correlation is indicated. Perhaps plants use their nuclei to photosynthesize, and it was only a coincidence that all plants examined had chloroplasts. Actually, we know, based on much other information, that photosynthesis occurs in the chloroplasts. Hence, the conclusion is essentially true-but we do know of a few plants that have nonfunctional chloroplasts and that therefore do not photosynthesize.

All this illustrates the complexities and the pitfalls encountered in the application of logic to objective data. We must be especially careful to avoid drawing positive conclusions based upon correlations that do not really indicate cause and effect. We shall encounter examples in subsequent chapters.

Unfortunately, many so-called scientists are preoccupied with the techniques required to obtain the data, tending perhaps to overlook the importance of the logic. Only a small minority of scientists at the doctoral level have ever had a course in logic. In spite of its importance, they learn most of it by on-the-job training rather than formal classroom exposure.

As it turns out, some branches of science, such as nuclear physics and molecular biology, have been much more successful at applying logical principles than others; hence they have been much more productive. Their workers may not have had a class in logic, but a strong tradition has developed among them so that they are able to concentrate intently upon the business of recognizing significant questions and devising powerful and elegant ways to ask them of nature (set-up experiments). A useful approach is to devise hypotheses (suggested explanations for some phenomenon) that can be conclusively eliminated by a suitable experiment. Often it is much easier to disprove a hypothesis than it is to prove one. The hypothesis that is not disproven gains in probability of being true. Such a powerful and highly successful approach in science has been called strong inference.

3. The scientific process. Science, then, is experience, or objective data, plus logic. It is much like learning by experience and logic in everyday life, but there are some important differences. In both cases the first step is the collection of objective data; we have experiences. In science, data collection may be somewhat more purposeful and organized than in everyday life, but the principle is the same. From these data, problems or questions are recognized. This process may be formalized or almost subconscious in either science or everyday life. A hypothesis is established to solve the problems or answer the question in terms of the data. The hypothesis must then be tested. Logical statements may be set up to do this, and usually they imply a collection of more data. Again the procedure is quite similar in science and in everyday life. When we think we have an answer to something, we check our answer by gaining more information. Of course, in science the gaining of information may be much more formalized and exact than in everyday life. This is where the paraphernalia and the techniques come in. In either case, the testing may result in the recognition of another question. That is, rather than a clear acceptance or rejection, the hypothesis may be modified in terms of the new data; and to test the modified hypothesis, further logic must be used and further data must be obtained. Thus, science and learning in everyday life are circular processes going from questions to hypotheses to data and back to questions.

In one way, the scientific process differs rather markedly from learning in everyday life: The results are published. Science would not be science if it were not for publication. The circular steps of the scientific method must be allowed to continue over intervals of time exceeding the lifetime of an individual scientist, and the process must expand from one scientist to another. Without publication, science might be fun for the individual, but it would not be profitable for mankind. The statement "publish or perish" might imply a lack of appreciation by university administrators for good teachers, but a person cannot truly be a scientist unless his or her experimental results are published. Without publishing, a person perishes as a scientist.

Creativity in Science

Perhaps the above discussion implies that science is a cut-and-dried mechanical process. One simply plays the game according to the rules (collects data, applies logic, etc.), and the results automatically appear. Measurements are poured into the scientific machine, the crank is turned, and great discoveries emerge.

This is not the case at all. At several points in the scientific process, creativity is essential to real progress. This is true for recognition of the problem in the first place. Often data have been available for decades or longer before anyone manages to formulate a suitable question from them. In some ways, this is even encouraged in our schools by the manner in which they train scientists. It is easy to teach specific facts but extremely difficult to teach creativity. The student may get the idea that the field of science he is studying is complete, with nothing more to learn.

Creativity is also essential to the formulation of hypotheses. Often this becomes an intuitive thing in which the scientist, utilizing processes closely similar to those used by artists, writers, and other creative members of our society, formulates an explanation or hypothesis or accomplishes some other creative scientific act without the slightest understanding of the logical thought processes involved. There are numerous examples, such as Kekule's discovery while dozing on a streetcar and dreaming of snakes grabbing their tails in their mouths of the molecular structure of benzene as a ring of carbon atoms. This, of course, is where the Spirit of God or the Holy Ghost might well "quickeneth your understandings." (D&C 88:11.) Nevertheless, once the creative acts have been accomplished and the scientific method carried through to completion, it is usually possible to outline the procedures and logic in a manner that is quite internally consistent and not dependent upon intuitive insights.

There are other steps in the scientific method where creativity can be extremely important. Devising the technical procedures to make certain measurements may require considerable inventive creativity. Often this is where the breakthrough comes. Knowing what tests to perform may also be a highly creative accomplishment. Even publication may involve considerable creativity. If the results are presented poorly, they may not gain attention until someone comes along who is simply a better writer. Sometimes the discovery must be made anew by the second worker.

The importance of publication and presentation of results is well illustrated by Leonardo da Vinci. His diaries show that he was centuries ahead of his colleagues in many of his insights, inventions, and scientific discoveries, yet the information never got beyond the diary and consequently was worthless to the rest of the world.

Models and Absolute Truth

Fundamentally, science is model-building. The scientist seldom hopes to discover absolute reality. He builds mental models that describe the objective data, and these models hopefully will be increasingly accurate descriptions of reality. He has discovered that measurements can always be made to a higher level of exactness, so in that sense, his models may never be absolute truth-or he may at least be unable to know for certain that they represent absolute truth.

There are two kinds of models. In one case, an actual model could be built, or some physical situation can at least be imagined. For example, we can think of matter as consisting of atoms combined to form molecules, each having several described features. This is itself a model, but we can think of the molecules as being like perfectly elastic balls, and on this basis we can better understand such phenomena as temperature, diffusion, pressure of gas, evaporation, etc. The more sophisticated models consist of only mathematical equations. There are equations that describe the

characteristics of perfectly elastic balls, for example, and these equations help us to better understand matter (temperature, etc.). Sir Isaac Newton's equations for gravitational forces were developed into a mathematical model of the solar system. Albert Einstein's equations for relativity formed another model that in some highly detailed ways accounted somewhat better for our observations of the solar system. So it goes.

Revelation, unlike our models, may present absolute truth. If God says man can be saved only by baptism in water by one having suitable authority, then that is a law of God and is absolute reality. Science never claims this kind of absolute truth. Nevertheless, since God has been silent about most of the natural universe, science is the only way we can even approach an understanding of reality in those areas.

What Science Is Not

We should be quite clear about what science isn't. Science is never an attempt to explain the universe subjectively (without objective data), nor is it ever an attempt to explain the universe by illogical procedures. Even though the logically invalid procedure of induction must be used, its limitations are carefully defined in a logical way. Attempts to explain the universe subjectively are mysticism, superstition, a belief in magic-and often the efforts of religions not based upon revelation. Philosophy in general is an attempt to explain the universe by subjective means and thus fits in this category.

The statement that the only road to truth is through true science (objective data and logic) is the basic doctrine of logical positivism. Interestingly enough, logical positivism is itself a philosophy based upon a statement of faith (that only science works), and therefore there is no way to know that it is true. Furthermore, logical positivism usually rejects all religions as well as all philosophies besides itself. Obviously, to do so, it must show that the religion does not come from God. This it does not formally do, although it also accepts this conclusion on faith.

In modern scholarship, one may encounter invention and mysticism based upon subjective explanations of the universe. Premises are drawn subjectively (that is, by assumption), and then logical procedures are applied to these premises. The higher criticism of the Bible provides an excellent example. It is assumed that prophecy is not possible; who could know the future? It is assumed that the writing style of a prophet will be the same throughout his life regardless of circumstances or the topic about which he is writing. Other assumptions are also made. It is then concluded, for example, that several authors wrote the books of Genesis or Isaiah. The conclusions may seem highly reasonable, depending, of course, upon how reasonable the initial assumptions seem. It should be clear, however, that this is not an objective scientific procedure, but one more closely akin to that of the ancient Greek philosophers who tried to derive an understanding of the universe from "self-evident" principles. In studying creation, we shall encounter examples of subjective explanations.

Incidentally, Dr. L. Lamar Adams, an Old Testament scholar at the Brigham Young University, directed a computer study of the book of Isaiah. "Several hundred language variables were analyzed by more than 35 researchers, consultants, and their assistants, using 300 computer programs and more than 100 computer tapes." Literary styles were compared for the complete book of Isaiah and portions of eleven other Old Testament books. The computer analysis was completely objective, although it is conceivable that some subjectivity entered into the programming. "The parts of Isaiah most often claimed to have been written by different authors [chapters 1-39 and 40-66] were found in the computerized studies to be more similar in style than those of any other Old Testament books examined." For example, key phrases are repeated frequently in all sections of Isaiah. The study tends to confirm the single authorship of Isaiah.

There are two excellent examples of subjective scholarship in modern theological literature. Rudolph Bultmann of Marburg, Germany, would "demythologize" the scriptures. That is, he would remove from them anything that is miraculous or unscientific-specifically, anything that does not happen to agree with his theologian's understanding of early twentieth century science. Hugh J. Schonfield has written two books, The Passover Plot and Those Incredible Christians. The thesis is that the resurrection was a carefully planned plot. These books provide marvelous examples of how extensive and involved conclusions can be drawn from a few subjective assumptions. That is what science is not!

Testing By the Scientific Method

Having examined the scientific process, let us now look at a question comparable to the one considered at the end of Chapter 2: How can one test the truth of a statement made about the operation of the universe? One could ask God, as admonished by Moroni, but God wants us to expend our own efforts first. (See D&C 9:7-9.) Besides, if a man learns by inspiration that a statement is true or false, the information is valid for him, but he could never publish it in a scientific journal.

One begins testing the validity of a newly encountered scientific statement by examining it in the context of other scientific information: the facts, theories, and hypotheses already at hand. Much scientific information has been tested and proven so many times and in so many ways that we can hardly doubt its validity. If a new statement tends, for example, to contradict the principle of universal gravitation, then we are certainly entitled to be wary of it. Of course, we can only be much less confident about many other scientific statements.

If this approach is inadequate, then the scientific method must be applied-and indeed, this is what is happening in working scientific laboratories all over the world. Questions are formulated, and inductions and deductions are made that suggest ways of testing by searching for more objective data and by applying logic to these data. Here we are talking about research projects that can occupy months, years, or a lifetime. In this book, it will be necessary to restrict ourselves in our testing of scientific ideas to comparison of these ideas with other concepts, either religious or scientific, that have a high probability of being true. Sometimes this approach is necessarily tentative and limited, but it is nearly always rewarding.

Footnotes

1. The Articles of Faith, pp. 164-65.
2. John R. Platt, "Strong Inference," Science, vol. 164 (1964): 347-52.
3. L. Lamar Adams, and Alvin C. Rencher, "A Computer Analysis of the Isaiah Authorship Problem," BYU Studies 15:95-102.
4. Larry L. Adams, "Printout on Isaiah," Ensign 3 (December 1973): 58-59.
5. New York: Bantam Books, 1966. Also published by Bernard Geis, New York.
6. New York: Bantam Books, 1968.

4
Counter Arguments to Science

At first glance it might appear ludicrous for anyone to argue with science in this day and age. After all, science has given us longer lives, rapid transportation, and exciting insight into the nature of things. One can't argue with success-or can one? Some people believe that science has been too successful, believe that it has transformed our world from one of ancient, down-to-earth values to one with such mushrooming materialism that we are likely to suffocate in our own garbage. Furthermore, as I look at the anti-religion arguments of chapter 2, I can see parallel arguments that have been raised, often in an opposite sense, against science. Some of these have been suggested

by the philosophers, but most frequently they appear in the statements of religious writers. The first five presented below parallel those against God and religion in chapter 2, and the sixth touches upon some valid limitations of the scientific approach.

Science Destroys Concepts of God

1. Science tries to account for all things without God. It should be clear from our discussions that science per se does no such thing. Science collects objective data and applies logic to these data. And truly objective data relating to God are difficult (impossible?) to obtain, so science can seldom if ever deal with the question.

Many scientists acting as individuals and extending their philosophies beyond valid application of the scientific method do think the universe can be accounted for atheistically. In doing so, they are no longer functioning as scientists but are exercising faith in their own religion. As we have seen, this religion is a philosophy called logical positivism. It has as its basic tenet that all philosophies and all religions are incapable of arriving at truth and that only scientific truth has any logical validity. All arguments for God are rejected as part of the basic tenet of faith. Again, as we have seen, since this philosophy rejects all religions and philosophies, it thereby rejects itself. Its basic assumption cannot be demonstrated any more convincingly (many of us think far less so) than can the belief that God exists and speaks to prophets. Atheism is an assumption and no more. It must be accepted on faith. There is no other way.

Unfortunately, many scientist-professors not only accept this religion but teach it as though it were "gospel truth." Indeed, many of them accept the philosophy without even understanding that it is a philosophy. They absorbed and assimilated it when they were students, never doubting (or even wondering) that it was genuine scientific information. This is certainly one of the tragedies of our modern educational system. It subtly robs students of their freedom. As long as there are no truly objective data about God-data completely independent of all observers and all theories-science, in the truest sense of the word, can only be neutral about God. These are the rules of the game. The scientist can personally accept subjective data as I accept the testimony of God's witnesses, the prophets. He can have faith in logical positivism. It is tragic when he fails to realize that his beliefs are based only upon faith.

Religion and Science

2. Science disagrees with God's revealed word. Science makes no claim whatsoever to being in possession of ultimate truth; it is only striving to construct models that continually approach reality more closely. On the other hand, while science is trying to find out how the universe works, God already knows. Anything he might reveal to us that proves to be in conflict with the statements of science will thus have to take precedence over these statements. This is our first ground rule.

As we shall have much occasion to see, however, when dealing with the kinds of things that science can study, it is seldom easy to know exactly what God's word is. He has revealed much about how we can return to his presence but little about physical creation, and what he has revealed is difficult to comprehend in the terms used by science. Thus we are seldom called upon to make such a harsh decision between science and revelation. Of course, if a scientist says that creation happened by chance, while revelation says it was the product of divine intelligence, then we might have a real conflict-but does science really say that? Or is this only an interpretation of the logical positivists?

Science's Lack of Compassion Causes An Imperfect World

3. Science is inhuman. Some say that science is bad because it is not concerned with our deep emotions: love, hate, fear, longing, etc. Certainly it is true that science as a method cannot be concerned with these things except as natural phenomena worthy of scientific investigation. This is

simply according to the rules: only objective data can be used in science. This should hardly be surprising or disturbing. Science is only a tool to seek truth. The argument is like saying that a power saw is fundamentally evil because it has no compassion for its operator and may slice off his finger. Likewise, science has no compassion and could destroy man with its atomic bombs or pollutants, but the evil is neither in science nor the power saw. The evil arises within those who make use of scientific findings-or of power saws.

Perhaps many scientists give little thought to compassion; they are working on problems that may have little obvious relationship to man's well-being. But other scientists have more than their share of human compassion. Many of the great men of medicine have amply demonstrated their dedication to mankind, sometimes by giving their own lives for others. Many agricultural scientists are equally dedicated to the compassionate goal of producing food for mankind. Scientists from various fields have banded together to protest the inhumane application of scientific developments such as the atomic bomb or polluting technologies. These are individuals, however, not the tool-for-seeking-truth called science. That mechanism quite logically has no feelings of its own.

Theism

4. The universe cannot be explained by science-only by God. As things stand now, this is a true statement: Science has not yet explained the universe; God could explain it, but he hasn't chosen to do so. But if the statement applies to the future (i.e., that science never will explain the universe), then like its counterpart (that science will someday explain the universe without God), it is a statement based only on faith. It is conceivable that, given time, science will totally explain the universe, even in terms of a divine Creator. We haven't enough objective data or logical conclusions to make any arbitrary statements about what science (or religion, for that matter) can or cannot achieve. The question of what cannot be explained by science is irrelevant anyway. The important thing about science is what can be explained: what it can tell us about the universe, and how it can truly improve our lives.

Evil Scientists

5. Some scientists are evil persons. Well, yes, this must be true; some scientists probably are evil. But this has nothing to do with science as a tool for seeking truth any more than does the fact that some scientists are very good. Actually, the criterion of a good scientist is how well he or she can obtain objective data and apply logic to these data. It is quite conceivable that a scientist might be highly expert at this and still have personal philosophies far removed from the revealed tenets of God. He may hate his fellowmen, live in adultery, and be actively engaged in the search for super weapons capable of obliterating the world, yet still be an excellent scientist-highly proficient in the art of obtaining and dealing with objective data.

As a matter of fact, it is conceivable that a scientist might even have strong religious convictions and live a most exemplary, God-directed life, and, in spite of all this, still be a good scientist. There are outstanding scientists in the Church who are accepted by their fellow scientists in spite of their religious convictions.

Incidentally, of the dozens and perhaps hundreds of scientists with whom I am personally acquainted throughout the world, I don't know a single one whom I would consider an evil person. Most of these people know nothing about the restored gospel, nor do they live its tenets in every respect. Most do not live the Word of Wisdom, and only a few attend church or take part in any of the rituals connected with religion. Of those whom I know personally, however, all seem to be fundamentally good persons. Typically, they exhibit an exemplary love for their families, and they are clearly on the side of human justice and world brotherhood. Often, after a few hours spent working or communicating socially with these persons, I have felt a thrill of brotherhood quite

comparable to that experienced with my fellow members of the Church. Certainly most scientists are not evil. There is something uplifting about the pursuit of truth.

Imperfect Science

6. Science has made mistakes. I have on too many occasions found myself becoming disturbed by statements in Church literature that seem to imply that since science has made mistakes in the past, we should avoid it like the plague. Of course, the men who make these statements do not really mean them that way. I am probably a bit touchy on the subject, but consider this:

"Scarcely a century has passed but they have introduced new theories of science and of philosophy that supersede the old traditions and the old faith and the old doctrines entertained by philosophers and scientists."

"The Church . . . holds to the definite authority of divine revelation which must be the standard; and that, as so-called "science" has changed from age to age in its deductions, and as divine revelation is truth, and must abide forever, views as to the lesser should conform to the positive statements of the greater. . . .

"A good motto for young people to adopt, who are determined to delve into philosophic theories, is to search all things, but be careful to hold on only to that which is true. The truth persists, but the theories of philosophers change and are overthrown. What men use today as a scaffolding for scientific purposes from which to reach out into the unknown for truth, may be torn down tomorrow, having served its purpose; but faith is an eternal principle through which the humble believer may secure everlasting solace."

Certainly the statements are true. Science has changed many times. That is how science works. That is its secret of success. In its attempt to approach reality ever more closely, science sometimes may come very close, as in our understanding of the mechanics of the solar system, for example. In other cases, science may presently be as far from the mark as it was a thousand years ago when it said the earth stood still. If this is an argument that good Latter-day Saints should avoid science, then somebody is missing the boat. The important thing is that science now understands the solar system, and that much more will be learned as we continue to disprove hypotheses and improve our models. To repeat a refrain: There are many things about the universe that science can teach us but that have never been mentioned by the Lord.

On the other hand, if the statements are made (as above) to warn the youth and other Church members not to put too much faith in science at the expense of faith in revelation, then the arguments are well taken. It is extremely important for us to understand the nature of the scientific method and not to make irreversible decisions contrary to God's word based upon scientific models that may well prove to be poor representations of reality. If I were not totally convinced of this, I would not be writing this book.

Science recognizes in a scientific way that science makes mistakes. An important phase of science is the study of its own inherent errors. The subscience of statistics is devoted largely to this problem, and philosophers of scientific method are quite taken with it. Let's summarize the limitations on obtaining relevant objective data and applying relevant and valid logic to these data.

1. Human errors are always important. The ability to read instruments or to perform some other necessary technique might be an important limitation, but the really important boundaries set by human nature are in the area of human creativity. We have already discussed this in some detail. The scientist must know what to look for, think of the suitable hypothesis, or recognize the important relationship.

Errors of method are also important. Instruments may limit the search for truth. Due to the length of light waves, a light microscope cannot resolve objects smaller than about 2,500 Angstroms in diameter. This limitation arises from the nature of light rather than the ability of technicians to build microscopes. The electron microscope, on the other hand, is presently limited by the ability of technicians to construct magnetic lenses for focusing the electron beam. It can now resolve objects about as small as two to eight Angstroms in diameter. In the future, it or its technological descendants may resolve even smaller objects.

2. There are inherent statistical variabilities that often limit scientific studies. The biologist speaks of "biological variability," implying frustrating differences between individuals within a species. And sometimes the objective data essential to certain conclusions simply aren't available. It may be that we can never know the history of the earth by applying science, since the relevant data may by now have been obliterated. At the moment, we cannot study the nature of man's spirit or the nature of God because suitable objective data cannot be obtained. Sometimes these limitations of method may be permanent (as when the data are gone forever), or in other cases they may be only temporary (as in the construction of electron microscopes).

3. There are logical errors that also occur in the application of scientific method. We have mentioned that induction proper (reasoning from a few facts to a general conclusion) is a logically invalid procedure. Sometimes this can be overcome by invoking the principle of the uniformity of nature. If we have reason to believe that the sample is truly representative of the whole, then our inductions may be valid, but it is not always clear when we can safely extrapolate from a few facts to a general conclusion. There are times when the theory is, by its very nature, extremely difficult to prove or to disprove. The theory of evolution is an excellent example. Many of the fossil data required to test it may have long since been destroyed. Furthermore, it is an intrinsically difficult theory to test. Almost every feature of any plant or animal can be interpreted as adapting that plant or animal to its environment, just as the theory predicts. But this is exactly what we would also expect if plants and animals had been carefully designed by a supremely intelligent Creator. So how does one devise tests to distinguish between the theories? A theory that can't be tested is not a good theory.

The Ground Rules
To recapitulate, then, the ground rules presented at the end of the second chapter are:

1. God's word must come first.
2. There are limitations from the source of knowledge; i.e., many things have not been revealed.
3. We are limited by our abilities to interpret God's word.

The ground rules for our use of science are:

4. Science works whenever valid logic can be applied to the objective data.
5. Science is limited by human errors and by the limitations on human creativity.
6. Science is limited by errors of method and by technical achievements or by what can be technically achieved.
7. Science is limited by errors of logic and by the rules of logic.

Let's also recapitulate the three ways in which one may test religious and scientific truths:

1. Compare the new doctrine, idea, or data with other available knowledge: scripture, prophecy, history, theory, etc. Such an approach may not be conclusive, but it is nearly always an appropriate

first step. It is not always easy (who can know everything?), but it can be applied to revealed or scientific information, and it is virtually the only approach that can be taken in a book such as this.

2. Ask God in the prescribed manner: ponder the problem, pray with faith in Christ and with real intent, and obey the principles of righteousness that one has already accepted and in which one has faith. Moroni tells us that this test can be applied to any purported truth; yet we will be most inclined to use it with religious concepts. This is a highly personal approach that each of us must take on our own.

3. Apply the scientific method: formulate lucid questions, make valid deductions and appropriate inductions to establish hypotheses and to find ways to test these, and share the results through publication. In principle, anyone can take this approach, but in today's world, scientific research has reached a level of high sophistication, requiring much training and many capital resources.

Footnotes
1. Joseph F. Smith, Conference Report, April 1911, pp. 7-8.
2. Joseph F. Smith, "Theory and Divine Revelation," Improvement Era 14 (April 1911): 549, 551.

Section 2:
The Scriptural Accounts of Creation

"And out of the ground made I, the Lord God, to grow every tree, naturally, that is pleasant to the sight of man; and man could behold it. And it became also a living soul"

Moses 3:9

5 The Book of Moses

For many centuries, the first five books of the Old Testament were accepted by Jewish and Christian peoples as accounts written by Moses. The creation narrative of the first two chapters of Genesis was accepted as a factual though brief account of how our world came into being. Beginning a little over a century ago, the Genesis stories began to be questioned, not only by scholars, but also by Christian ministers and by a significant number of laymen. Even Joseph Smith wrote in the Articles of Faith: "We believe the Bible to be the word of God as far as it is translated correctly." Soon after organization of the Church, he was directed by the Lord to prepare an inspired translation (revision) of the biblical scriptures. One of his first targets was the creation narrative in Genesis.

By now, the "higher criticism" has questioned and finally rejected Moses as the author of Genesis, and scientists have developed theories of the earth's origin sharply contrasting to the Genesis story. The developing Genesis problems must have contributed much to the growing lack of faith in the scriptures as the word of God and consequently must share a certain responsibility for the problems of our disturbed generation.

The Problems of Genesis
To be more specific: scholars have decided that the five books of Moses (the Pentateuch) were a construction from four other basic documents written by four separate authors. Two writers are said to have written two creation stories in Genesis, stories that differ in highly significant ways. The first account is recorded in Genesis 1:1-31 and 2:1-3, and the second is in Genesis 2:4-25. The first account is ascribed to an author designated P, signifying the priestly code; the second to an author designated J for the Judean narratives. The two accounts differ most obviously in the order of creation. The first narrates the seven days of creation, but the second has man created first, and

no days are mentioned. They also differ in the names used for Deity. In the first account, the Creator is referred to as Elohim, translated in English Bibles as God. The second account uses the word Jehovah or Yahweh, translated as Lord God or Lord. (Only the consonants were written, and the word was almost never spoken by ancient Jews; hence its exact pronunciation has been lost.)

The two accounts of creation have caused considerable trouble. For example, Mary Baker Eddy, the founder of Christian Science, commented that the first account was dictated by God, whereas the second had to be a product of the devil. William Jennings Bryan at the famous Scopes monkey trial was trapped by his opponent Clarence Darrow on this point. Bryan, who was prosecuting Scopes for teaching evolution in a Tennessee school, was himself placed on the witness stand by Darrow. He replied in the affirmative when asked if he accepted every word in the Bible as the word of God. Darrow then asked him how he could reconcile the two accounts of creation. He had no answer.

During the first part of the nineteenth century, several individuals independently arrived at a theory for the origin of the earth's living organisms based upon a process of evolution. In 1859 Charles Darwin published his detailed theory of natural selection. Especially in its modern form, the theory attempts to account for the earth's living organisms in terms of chance-directed, purely atheistic events. The Creator God of Genesis was no longer needed.

Once thinkers began to doubt that the Genesis stories were irrefutable words of God, many specific questions appeared: Just how old is the earth and its creations? Scientific methods of dating seem to imply an age of about 4.5 billion years. So what was a day in the creation story of the first chapter of Genesis? What about the fossils of plants and animals found embedded in rocks "obviously" of ancient age? As to specific details of the creation stories, how could it be possible for plants to exist on the earth before the days, months, and years were established? Or how could whales be placed in the sea before mammals were placed on the land, if (as the evolutionist was deciding) whales and other marine mammals evolved from land mammals?

Even if the Genesis accounts were accepted as divinely inspired, a number of thorny problems remained. Was creation an act of God singular or Gods plural? Most of the account speaks of God or the Lord God in the singular, but Genesis 1:26 says: "And God said, Let us make man in our image, after our likeness. . . ." (Actually, the Hebrew word Elohim is a plural noun.) Whence came man's spirit? In Genesis 2:7, it is implied that God placed a spirit in man, but nothing is said of its origin. What is the significance of the curious story of the creation of Eve from Adam's rib? What is the significance of Adam's assignment to name the animals? And what about those two accounts of creation? In the first, man is the crowning and final product of creation; in the second, man was formed and became a living soul before other living organisms were placed on earth. Why should God give us two conflicting accounts?

And some troubling philosophical questions are not answered by the narratives: Just how did creation come about? Did God speak, and the very elements obeyed by some kind of magic? Or did God create as a modern engineer creates-by applying natural principles? Did God create or place each species on earth individually (special creation), or did God control an organic evolution similar to that postulated by Darwin? Whether creation was by magic or by the application of natural law, did it have any purpose or reason behind it?

We search the first two chapters of Genesis in vain for satisfying answers to these questions. Oh, it is possible to find supporting evidence for one viewpoint or another, but real answers are not to be found. If they were, neither the scientific nor the religious questions would still bother people today as they do.

If God chose to restore the gospel through Joseph Smith, then it seems reasonable that he might provide at least a few answers to the questions of creation brought up by Genesis 1 and 2. Here is a test, one of many, that we can apply in an evaluation of the restoration. We have no reason to believe that Joseph Smith was even aware of the scholarly problems of Genesis. Surely he was not aware of the scientific ones, since his contributions predated Darwin by twenty to thirty years. Did he answer the problems of Genesis?

Moses and Abraham

The restoration of the gospel did indeed produce information about the questions of creation. In June and December of 1830, Joseph Smith received from the Lord by revelation an account of dealings between Moses and God, followed by a creation narrative that closely parallels Genesis 1 and 2 and that continues to the time of the flood. Sometime later a number of ancient Egyptian papyri fell into the hands of the Prophet and the young church. One of these, Joseph translated by the power of God. It purports to be an account written by the hand of Abraham and includes a narrative of creation paralleling Genesis 1 and 2 but differing in significant ways from the account revealed to Moses. These I accept as the words of God.

No real effort will be made at this point to reconcile the creation accounts with scientific findings, although I am unable to avoid the temptation to interject a few comments. First, we shall consider the origin of the book of Moses. Then in chapter 6, the first three chapters of that book will be presented with my comments interjected. It is the scriptures themselves that really count. Yet reading them always gives rise to independent thoughts and interpretations. My commentary will sometimes be a simple restatement of something in the scriptures, or it might be a summary of opinion: someone else's (with suitable reference) or my own. My opinions are, naturally, what I consider at this moment most likely to be true. I believe these things after careful study, much thought, and prayer. Yet they are opinions. Perhaps if I were absolutely convinced that they were the last word, I would give up studying, thinking, and praying! In chapters 7 and 8, the same approach will be taken with the book of Abraham, and some attempt will be made to summarize and relate the two newly revealed accounts of creation. Yet I will continue to refrain from attempting scientific reconciliations. This is saved for the final chapters.

The Origins of the Book of Moses

In 1830 the Church had just been organized and the Book of Mormon published in its first edition. There is much talk in the revelations received during that period (D&C 3 to 37) of ancient scriptures, including the Book of Mormon, that were to be revealed anew at the beginning of this last dispensation. In Doctrine and Covenants 6:27-28, Oliver Cowdery is given power to translate, as Joseph Smith had been given this power, and told that he should "assist in bringing to light, with your gift, those parts of my scriptures which have been hidden because of iniquity. And now, behold, I give unto you, and also unto my servant Joseph, the keys of this gift, which shall bring to light this ministry; and in the mouth of two or three witnesses shall every word be established." This gift of translation of ancient scriptures is referred to in several later revelations (e.g., D&C 35:18; 64:5) as the "keys of the mysteries of the kingdom."

Joseph was commanded to make a new "translation" of the Bible. (See D&C 93:53.) As far as we know, this was not a translation in the usual sense that Joseph had ancient documents in Hebrew, Greek, Latin, etc., from which he made a scholarly translation. Rather, he studied the King James Version and revised it by inspiration. Apparently, he was not given complete sentences to replace those already in the scriptures. Rather, he was to "study it out in [his] mind," as he had studied the inscriptions on the gold plates, and when the translation came into his mind, he would know it was correct by experiencing a burning sensation in his bosom; if it was incorrect, he would "have a stupor of thought that shall cause [him] to forget the thing which is wrong." (D&C 9:8-9: instructions given to Oliver Cowdrey as he attempted to translate the Book of Mormon.)

The Lord was anxious to have Joseph Smith continue this revision of the holy scriptures and often admonished him to do so, as in the following case: "And, verily I say unto you, that it is my will that you should hasten to translate my scriptures, and to obtain a knowledge of history, and of countries, and of kingdoms, of laws of God and man, and all this for the salvation of Zion." (D&C 93:53.)

The book of Moses in the Pearl of Great Price is one of the most important results of Joseph Smith's inspired revisions of the Bible. Joseph never completed the revisions of the Old and New Testaments, although what he did accomplish has been published by the Reorganized Church of Jesus Christ of Latter Day Saints. The only parts of this inspired biblical revision presently accepted as scripture by The Church of Jesus Christ of Latter-day Saints are the book of Moses and Joseph Smith, chapter one, which is an inspired revision of chapter 24 of Matthew. Both are found in the Pearl of Great Price.

Unfortunately, little information is available concerning the circumstances surrounding the writing of the book of Moses. The first chapter was received by Joseph Smith as direct revelation from God sometime in June 1830. The Church had only been organized a little over two months, and the Book of Mormon had just been published. Joseph's comments preceeding the revelation as recorded in the History of the Church (volume 1, page 98) tell us almost nothing about the circumstances that led to it:

"I will say, however, that amid all the trials and tribulations we had to wade through, the Lord, who well knew our infantile and delicate situation, vouchsafed for us a supply of strength, and granted us line upon line of knowledge-here a little and there a little, of which the following was a precious morsel."

The remainder of the book of Moses was received by revelation some six months later, in December 1830. Again, however, the Prophet doesn't tell us much about the circumstances. What he does tell us indicates that the revelation was part of the restoration of lost records coming through the "translations" of the scriptures, which had begun:

"It may be well to observe here, that the Lord greatly encouraged and strengthened the faith of His little flock, which had embraced the fulness of the everlasting Gospel, as revealed to them in the Book of Mormon, by giving some more extended information upon the Scriptures, a translation of which had already commenced. Much conjecture and conversation frequently occurred among the Saints, concerning the books mentioned, and referred to, in various places in the Old and New Testaments, which were now nowhere to be found. The common remark was, 'They are lost books;' but it seems the Apostolic Church had some of these writings, as Jude mentions or quotes the Prophecy of Enoch, the seventh from Adam. To the joy of the little flock, which in all, from Colesville to Canandaigua, New York, numbered about seventy members, did the Lord reveal the following doings of olden times, from the prophecy of Enoch." (History of the Church, 1:131-33.)

Then follows what is now Moses 6:43 to the end of Moses 7. Chapters 2 to 5, most of chapter 6, and chapter 8 do not appear. They were published in the Times and Seasons and the Evening and Morning Star at intervals from 1832 until 1844, and then in 1851 in England, when Franklin D. Richards compiled the Pearl of Great Price. Yet there is good evidence that they were also received in December 1830. For one thing, an article appeared on January 18, 1831, in the Painesville Telegraph of Ohio, in which it is mentioned that a young gentleman by the name of Whitmer had a number of new revelations from God to Joseph Smith in which there was "a more particular description of the creation of the world, and a history of Adam and his family, and other sketches of the antediluvian world, which Moses neglected to record.

The Book of Moses

Chapter 1 of the book of Moses is clearly a new revelation rather than a revision of existing scriptures, since it has no counterpart in any other writing available to us. It consists of "The words of God, which he spake unto Moses at a time when Moses was caught up into an exeedingly high mountain." (Moses 1:1.) It closes with the parenthetical statement that "these words were spoken unto Moses in the mount. . . . And now they are spoken unto you. Show them not unto any except them that believe. Even so. Amen." (Moses 1:42.) Chapters 2 and 3 correspond to chapters 1 and 2 of Genesis in the Old Testament (the creation story).

It is quite possible and even seems apparent that chapters 2 and 3, as well as the remaining chapters of Moses, were received by revelation as Joseph Smith carefully studied their Genesis counterparts. This was part of his early attempts to translate the Bible, as the Lord had commanded. It has been suggested that the revision was not complete to Joseph's satisfaction at the time of his death. Indeed, the words "without form, and void" in Moses 2:2 run contrary to other statements made by the Prophet. Nevertheless, chapters 2, 3, and 4, which include the story of the fall as well as that of creation, include many statements with no counterparts in Genesis 1, 2, and 3, and they close with the words: "And these are the words which I spake unto my servant Moses, and they are true even as I will; and I have spoken them unto you. See thou show them unto no man, until I command you, except to them that believe, Amen." (Moses 4:32.)

While it seems plausible that the Prophet may have been studying the Genesis accounts during the reception of this revelation, so that a word here and there may have slipped through without being suitably corrected, we must assume from Moses 4:32 that additions are the words of God himself. Indeed, the emphatic statement that "they are true even as I will" should stand as a warning against trying to rationalize away statements in these accounts that we find difficult to reconcile with other scriptures or with our own preconceived ideas. The fact that chapters 2 to 4 were rather belatedly published (1844) may reflect Joseph Smith's response to the admonition to show them only to believers-until commanded.

God does not speak to man through his prophets unless he has something important to say. His words are not to be trifled with. The very statements that seem surprising and difficult to reconcile with preconceived ideas may well provide the most intriguing and exciting clues to an understanding of what went on during creation.

Footnotes

1. Robert J. Matthews, Joseph Smith's Translation of the Bible-A History and Commentary (Provo, Utah: Brigham Young University Press, 1975).

2. James R. Clark, The Story of the Pearl of Great Price, (Salt Lake City: Bookcraft, 1955), pp. 9-17, quoting from Francis A. Kirkham, A New Witness for Christ in America, enlarged ed., pp. 436-37.
3. Discussed in chapter 6, footnote 1.

6
Moses and Spiritual Creation

Imagine all the people who have lived. Imagine how many of them have wondered about creation, wondered how it all came about, if there was a reason for it all, what it meant. Some have studied the rocks and the things alive on the earth, trying to deduce and to induce how it all happened-and have found some answers. But a very few have lived such lives of righteousness and devotion that they were actually able to speak with God about creation: Enoch, Abraham, Moses, and probably a few others (Adam, the brother of Jared, Joseph Smith?).

What was it like to converse with God? To speak with him "face to face," as one man speaks with another? To ask questions and to receive answers? In June 1830, the Lord told Joseph Smith what it was like:

The First Chapter of Moses: the Visions of Moses
"The words of God, which he spake unto Moses at a time when Moses was caught up into an exceedingly high mountain,

"And he saw God face to face, and he talked with him, and the glory of God was upon Moses; therefore Moses could endure his presence.

"And God spake unto Moses, saying: Behold, I am the Lord God Almighty, and Endless is my name; for I am without beginning of days or end of years; and is not this endless?

"And, behold, thou art my son; wherefore look, and I will show thee the workmanship of mine hands; but not all, for my works are without end, and also my words, for they never cease.

"Wherefore, no man can behold all my works, except he behold all my glory; and no man can behold all my glory, and afterwards remain in the flesh on the earth." (Moses 1:1-5.)

Moses spoke with God face to face, being protected ("transfigured . . . strengthened") in some way from God's glory. Unprotected, he would have "withered and died" in God's presence (see verses 11 and 14, below), which no man can see "in the flesh, except quickened by the Spirit of God." (D&C 67:10-12.) God dwells with the angels "on a globe like a sea of glass and fire" (D&C 130:7); his "brightness and glory defy all description" (Joseph Smith 2:17). Apparently God's divine metabolism is such that tremendous quantities of energy emanate from him. Is there some kind of controlled nuclear reaction serving as the source of his energy? Does he release powerful ionizing radiations? That is, is he radioactive? Or does he "merely" emanate visible light at such an intensity that any unprotected thing in his vicinity is raised to the combustion temperature, as when the rays of the sun are focused by a lens? Of course, we know nothing about the nature of God's glory, but the precedents we are learning in our scientific endeavors help us conceptualize this reality.

"And I have a work for thee, Moses, my son; and thou art in the similitude of mine Only Begotten; and mine Only Begotten is and shall be the Savior, for he is full of grace and truth; but there is no God beside me, and all things are present with me, for I know them all." (Moses 1:6.)

Moses is called to the ministry and told that he is in the image of the Son of God-as he would later be told that all men are created in the image of God. The words are the words of God the Father, who knows all things and whose history and dominion have no equal, although he has given the Son a fulness of his glory. (See D&C 93:11-17.) Though the words are clearly spoken in the first person, with God the Father as the speaker, we have been told by our prophets that they were transmitted to Joseph Smith via Jesus Christ, and that the Father only speaks to inhabitants of this earth to introduce the Son.

"And now, behold, this one thing I show unto thee, Moses, my son; for thou art in the world, and now I show it unto thee.

"And it came to pass that Moses looked, and beheld the world upon which he was created; and Moses beheld the world and the ends thereof, and all the children of men which are, and which were created; of the same he greatly marveled and wondered.

"And the presence of God withdrew from Moses, that his glory was not upon Moses; and Moses was left unto himself. And as he was left unto himself, he fell unto the earth.

"And it came to pass that it was for the space of many hours before Moses did again receive his natural strength like unto man; and he said unto himself: Now, for this cause I know that man is nothing, which thing I never had supposed.

"But now mine own eyes have beheld God; but not my natural, but my spiritual eyes, for my natural eyes could not have beheld; for I should have withered and died in his presence; but his glory was upon me; and I beheld his face, for I was transfigured before him." (Moses 1:7-11.)

The vision shown to Moses of the earth and all its inhabitants must have been a truly unique experience. Thanks to motion pictures and television we can begin to imagine how God could provide a vision of some remote event such as creation, but the vision shown to Moses must have been a spectacular production indeed. It surely humbled Moses! He never had supposed that man was nothing.

"And it came to pass that when Moses had said these words, behold, Satan came tempting him, saying: Moses, son of man, worship me.

"And it came to pass that Moses looked upon Satan and said: Who art thou? For behold, I am a son of God, in the similitude of his Only Begotten; and where is thy glory, that I should worship thee?

"For behold, I could not look upon God, except his glory should come upon me, and I were strengthened before him. But I can look upon thee in the natural man. Is it not so, surely?

"Blessed be the name of my God, for his Spirit hath not altogether withdrawn from me, or else where is thy glory, for it is darkness unto me? And I can judge between thee and God; for God said unto me: Worship God, for him only shalt thou serve.

"Get thee hence, Satan; deceive me not; for God said unto me: Thou art after the similitude of mine Only Begotten.

"And he also gave me commandments when he called upon me out of the burning bush, saying: Call upon God in the name of mine Only Begotten, and worship me.

"And again Moses said: I will not cease to call upon God, I have other things to inquire of him: for his glory has been upon me, wherefore I can judge between him and thee. Depart hence, Satan.

"And now, when Moses had said these words, Satan cried with a loud voice, and rent upon the earth, and commanded, saying: I am the Only Begotten, worship me.

"And it came to pass that Moses began to fear exceedingly; and as he began to fear, he saw the bitterness of hell. Nevertheless, calling upon God, he received strength, and he commanded, saying: Depart from me, Satan, for this one God only will I worship, which is the God of glory.

"And now Satan began to tremble, and the earth shook; and Moses received strength, and called upon God, saying: in the name of the Only Begotten, depart hence, Satan.

"And it came to pass that Satan cried with a loud voice, with weeping, and wailing, and gnashing of teeth, and he departed hence, even from the presence of Moses, that he beheld him not.

"And now of this thing Moses bore record; but because of wickedness it is not had among the children of men." (Moses 1:12-23.)

In a sense, then, even this first chapter is a part of the inspired translation or revision of the Bible. Here is something that had been in the original scriptures but was lost.

It is interesting that Satan is sometimes permitted to tempt and otherwise struggle with the individuals to whom God is about to speak. Joseph Smith's vivid account of his struggles with the powers of darkness just before his first vision in the sacred grove is familiar to us all. (Joseph Smith 2:15-16.)

In Moses' words, there are some important insights into Satan's nature. At the council in heaven, he had desired to have God's glory. (Moses 4:1.) Though he was denied this, he continued to seek it whenever possible. He claimed to be the Only Begotten and demanded that Moses worship him. In our day, there has been a revival of Satan worship, but for the most part, Satan must achieve his goals by subtle means, even the denial of his own existence-so common among all the intelligent, educated people of the world (and in fulfillment of Nephi's ancient prophecy: 2 Nephi 28:22).

"And it came to pass that when Satan had departed from the presence of Moses, that Moses lifted up his eyes unto heaven, being filled with the Holy Ghost, which beareth record of the Father and the Son:

"And calling upon the name of God, he beheld his glory again, for it was upon him; and he heard a voice, saying: Blessed art thou, Moses, for I, the Almighty, have chosen thee, and thou shalt be made stronger than many waters; for they shall obey thy command as if thou wert God.

"And lo, I am with thee, even unto the end of thy days; for thou shalt deliver my people from bondage, even Israel my chosen." (Moses 1:24-26.)

Here is the detailed call to Moses. He will deliver the children of Israel from bondage, and he will have power over the waters, even the Red Sea and the water that flowed out from the rock at his command. (Exodus 14:23-31; 17:6.)

"And it came to pass, as the voice was still speaking, Moses cast his eyes and beheld the earth, yea, even all of it; and there was not a particle of it which he did not behold, discerning it by the spirit of God.

"And he beheld also the inhabitants thereof, and there was not a soul which he beheld not; and he discerned them by the Spirit of God; and their numbers were great, even numberless as the sand upon the sea shore.

"And he beheld many lands; and each land was called earth, and there were inhabitants on the face thereof." (Moses 1:27-29.)

Here Moses must have been shown more than a mere movie spectacular. This is not just God's ability to produce a comprehensive vision, but an ability to change Moses so that he could comprehend it. We know that God hears and answers all our prayers-even though many hundreds or thousands of us may be praying at once. God is continually aware of each part of the universe. This is something marvelous to contemplate, especially for those of us who find it difficult to read the paper and listen to our wives at the same time! In some way, Moses must have received a portion of God's power to comprehend all things at once.

"And it came to pass that Moses called upon God, saying: Tell me, I pray thee, why these things are so, and by what thou madest them?

"And behold, the glory of the Lord was upon Moses, so that Moses stood in the presence of God, and talked with him face to face. And the Lord God said unto Moses: For mine own purpose have I made these things. Here is wisdom and it remaineth in me.

"And by the word of my power, have I created them, which is mine Only Begotten Son, who is full of grace and truth.

"And worlds without number have I created; and I also created them for mine own purpose; and by the Son I created them, which is mine Only Begotten." (Moses 1:30-33.)

Here is the beginning of the sublime revelations that give us a momentary glimpse into the extent of God's creations-the immensity of the universe-and the role played by Jesus Christ in these creations. (See D&C 76:24; 93:9-10; John 1:3; Ephesians 3:9; Hebrews 1:2.) We might deduce that the worlds were created by the power of the priesthood, since we are told that they were created by the word of God's power, which is the Only Begotten Son. Originally the priesthood was called the Holy Priesthood, after the Order of the Son of God. (D&C 107:3.)

"And the first man of all men have I called Adam, which is many." (Moses 1:34.)

Because of the syntax, this statement is a trifle confusing. Is Adam the first of all men on all worlds created by God? Are there many Adams? Or are there many men? Perhaps a logical explanation, considering the verses before and after, which discuss the many worlds created by God, is that each of these worlds has an Adam who is the first man for that world, and that there are many worlds and hence many Adams.

"But only an account of this earth, and the inhabitants thereof, give I unto you. For behold, there are many worlds that have passed away by the word of my power. And there are many that now stand, and innumerable are they unto man; but all things are numbered unto me, for they are mine and I know them.

"And it came to pass that Moses spake unto the Lord, saying: Be merciful unto thy servant, O God, and tell me concerning this earth, and the inhabitants thereof, and also the heavens, and then thy servant will be content.

"And the Lord God spake unto Moses, saying: The heavens, they are many, and they cannot be numbered unto man; but they are numbered unto me, for they are mine.

"And as one earth shall pass away, and the heavens thereof even so shall another come; and there is no end to my works, neither to my words.

"For behold, this is my work and my glory-to bring to pass the immortality and eternal life of man." (Moses 1:35-39.)

Creation is continuous. By the word of God's power, worlds come into being and pass away. The number of worlds that now exist is innumerable unto man. We are learning the truth of this statement. With the 200-inch telescope, we may be able to see (given enough time to study all the sky) one to four billion galaxies. Within our own galaxy, which we see in the sky as the Milky Way, there are clusters of stars, each containing 10,000 to 100,000 stars. These plus those not in the clusters make a total of perhaps 200 billion stars. Counting these would be a hopeless task, and

indeed, vast numbers of them must occur behind clouds of interstellar material, or on the other side of our galaxy where they are so densely packed together on our photographic images that we cannot distinguish one from another. Truly the worlds God has created are innumerable unto man.

Actually, we don't even see the worlds-only the suns (stars) that give light to their orbiting planets. Nevertheless, in spite of these numbers, all are known to God, and the worlds that have inhabitants (one or more planets around each star or only a small percentage of the planets that exist?) are continuously in God's awareness. His works are endless in both time and space, and the knowledge that emanates from him-his words-is equally infinite.

And what is it all about? Some of God's purposes remain in him (Moses 1:31), but the guiding, directing, sublime reason for it all is made clear when God tells us that his work, his occupation, his continuous creative activity, is to bring to pass the immortality and eternal life of man. This guiding of the eternal progression of all the spirits who are God's children, this bringing of these spirits to the status of godhood in God's presence, this supreme and divine effort is the source of God's glory. It is an inspired and holy concept, such a divine mystery as to testify of the divinity of the restoration of the gospel in the last dispensation.

"And now, Moses, my son, I will speak unto thee concerning this earth upon which thou standest; and thou shalt write the things which I shall speak.

"And in a day when the children of men shall esteem my words as naught and take many of them from the book which thou shalt write, behold, I will raise up another like unto thee; and they shall be had again among the children of men-among as many as shall believe.

"(These words were spoken unto Moses in the mount, the name of which shall not be known among the children of men. And now they are spoken unto you. Show them not unto any except them that believe. Even so. Amen.)" (Moses 1:40-42.)

After the view of the eternal worlds sprinkled through space, the Lord then introduces his account of the creation, implying again the restriction that this account will concern only our world. Does this mean that creation on other worlds followed a different course? Very possibly. There is certainly a tremendous potential variety of other worlds.

The admonition to show this revelation to no one except believers may have been because the Church was very young at that time and such doctrines as continual creation for the immortality and eternal life of man carried out by God the Father through the power of his Only Begotten Son, in whose image Moses was created, would have provided powerful fuel for the critics of the Church. The admonition must have eventually been lifted, because the revelation has been published. Yet we should probably take it as a warning for our day as well as for when it was received. In learning about the gospel, one must first be given the milk before one can handle the meat. (1 Corinthians 3:2.) While the Pearl of Great Price has been published, few nonmembers of the Church are aware of it, and fewer still would have any interest in reading it (only the fanatic anti-Mormon who searches through any Church publication for ammunition). But it is not appropriate to argue with a confirmed evolutionist by quoting from the Pearl of Great Price!

The Second Chapter of Moses: the Writings of Moses

"And it came to pass that the Lord spake unto Moses, saying: Behold, I reveal unto you concerning this heaven, and this earth; write the words which I speak. I am the Beginning and the End, the Almighty God; by mine Only Begotten I created these things; yea, in the beginning I created the heaven, and the earth upon which thou standest.

"And the earth was without form, and void; and I caused darkness to come up upon the face of the deep; and my Spirit moved upon the face of the water; for I am God.

"And I, God, said: Let there be light; and there was light.

"And I, God, saw the light; and that light was good. And I, God, divided the light from the darkness.

"And I, God, called the light Day; and the darkness, I called Night; and this I did by the word of my power, and it was done as I spake; and the evening and the morning were the first day." (Moses 2:1-5.)

Moses was commanded to write the words spoken by the Lord, so these chapters are entitled "The Writings of Moses." The first verses expand on the Genesis account. In the beginning the earth was created by the Only Begotten. Was this beginning sometime in the far distant past well before the other events described here?

On one occasion, Joseph Smith stated that the term "without form and void," as it appears in the King James translation, should read "empty and desolate," as in Abraham 4:2. After all, a void earth without form would be no earth at all. Yet in the account in the book of Moses, it remains as it is in the King James Version. Does this imply that Joseph Smith might not have completed his revision of these scriptures? Perhaps, but it is a slim clue and hardly an excuse for us to argue with those scriptures.

It is interesting that God caused darkness to come upon the face of the earth. We might imagine that darkness would already be present. And the statement that God's spirit moved upon the face of the waters has always intrigued me. Is this the spirit that emanates from God to fill the universe? What did it accomplish by moving upon the face of the waters? The division of light from darkness may not have been the division of day and night due to the rotation of the earth, since this is implied as taking place on the fourth day.

"And again, I, God, said: Let there be a firmament in the midst of the water, and it was so, even as I spake; and I said: Let it divide the waters from the waters; and it was done;

"And I, God, made the firmament and divided the waters, yea, the great waters under the firmament from the waters which were above the firmament, and it was so even as I spake.

"And I, God, called the firmament Heaven; and the evening and the morning were the second day." (Moses 2:6-8.)

We now think of the firmament as being the atmosphere. What were the waters above the firmament? Was this excess water accumulated at the time the earth was formed but later lost as the atmosphere developed? Or was it simply clouds or mist in the upper atmosphere? Interestingly enough, the words describing these events do not make it impossible for an ancient Israelite to go on believing in a great transparent dome above the earth, appearing blue because of the water on the other side. Seldom, if ever, does the Lord in his revelations correct our scientific concepts.

"And I, God, said: Let the waters under the heaven be gathered together unto one place, and it was so; and I, God, said: Let there be dry land; and it was so.

"And I, God, called the dry land Earth; and the gathering together of the waters, called I the Sea; and I, God, saw that all things which I had made were good.

"And I, God, said: Let the earth bring forth grass, the herb yielding seed, the fruit tree yielding fruit, after his kind, and the tree yielding fruit, whose seed should be in itself upon the earth, and it was so even as I spake.

"And the earth brought forth grass, every herb yielding seed after his kind, and the tree yielding fruit, whose seed should be in itself, after his kind; and I, God, saw that all things which I had made were good;

"And the evening and the morning were the third day." (Moses 2:9-13.)

At the beginning of things, the earth was apparently completely covered with water; then the dry land appeared. The water was gathered all "unto one place," leaving a single continent. At this time, according to this account, the earth was commanded to produce plant life, and the laws of procreation and genetics are presented, stating that living things can reproduce themselves, their offspring always being of the same kind as the parents.

"And I, God, said: Let there be lights in the firmament of the heaven, to divide the day from the night, and let them be for signs, and for seasons, and for days, and for years;

"And let them be for lights in the firmament of the heaven to give light upon the earth; and it was so.

"And I, God, made two great lights; the greater light to rule the day, and the lesser light to rule the night, and the greater light was the sun, and the lesser light was the moon; and the stars also were made even according to my word.

"And I, God, set them in the firmament of the heaven to give light upon the earth,

"And the sun to rule over the day, and the moon to rule over the night, and to divide the light from the darkness; and I, God, saw that all things which I had made were good;

"And the evening and the morning were the fourth day." (Moses 2:14-19.)

Here again the language is clearly such that an ancient Israelite could maintain his concepts about the universe. He could imagine these great lights, which we know to be objects of about the same size as the earth (i.e., the moon and the planets) or much larger (i.e., the sun and the stars), to be attached to that great dome above the earth. Yet we see no denial of the solar system as it actually exists.

The sixteenth verse might imply that the sun and the moon were created at about the same time but that the stars were created at a different time ("the stars also were made"). Scientific thought would have it that the earth was made at the same time as the sun and moon. If this proves to be true, then perhaps the events of the third day refer to the sun, moon, and stars becoming visible through the atmosphere. Before this time, the atmosphere may have been so full of water vapor and perhaps particulate matter (as is the atmosphere of Venus now) that these great lights could not be seen through it. Enough light would penetrate so that night and day could be distinguished ("divided") as apparently occurred on the first day, and plant life could (but probably didn't-see below) exist as we know it today.

"And I, God, said: Let the waters bring forth abundantly the moving creature that hath life, and fowl which may fly above the earth in the open firmament of heaven.

"And I, God, created great whales, and every living creature that moveth, which the waters brought forth abundantly, after their kind, and every winged fowl after his kind; and I, God, saw that all things which I had created were good.

"And I, God, blessed them, saying: Be fruitful, and multiply, and fill the waters in the sea; and let fowl multiply in the earth;

"And the evening and the morning were the fifth day." (Moses 2:20-23.)

The idea that fish and fowl came into being during the same period but before the other land animals is certainly contrary to the evolutionary account taught by science, although science would accept the idea that animals appeared in the waters before they did on the land. Note that fowl fly in the firmament, implying that ancient Hebrews understood the term firmament not only as the dome above the earth but also as the air beneath it. These animals were also provided with procreative abilities and commanded to fill the sea and the earth.

"And I, God, said: Let the earth bring forth the living creature after his kind, cattle, and creeping things, and beasts of the earth after their kind, and it was so;

"And I, God, made the beasts of the earth after their kind, and cattle after their kind, and everything which creepeth upon the earth after his kind; and I, God, saw that all these things were good.

"And I, God, said unto mine Only Begotten, which was with me from the beginning: Let us make man in our image, after our likeness; and it was so. And I, God, said: Let them have dominion over the fishes of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth.

"And I, God, created man in mine own image, in the image of mine Only Begotten created I him; male and female created I them.

"And I, God, blessed them, and said unto them: Be fruitful, and multiply, and replenish the earth, and subdue it, and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth.

"And I, God, said unto man: Behold, I have given you every herb bearing seed, which is upon the face of all the earth, and every tree in the which shall be the fruit of a tree yielding seed; to you it shall be for meat.

"And to every beast of the earth, and to every fowl of the air, and to everything that creepeth upon the earth, wherein I grant life, there shall be given every clean herb for meat; and it was so, even as I spake.

"And I, God, saw everything that I had made, and, behold, all things which I had made were very good; and the evening and the morning were the sixth day." (Moses 2:24-31.)

Land animals, excluding fowl but including insects, were created on the sixth day, and man was created in the image of God. Does the fact that animals were created "after their kind" imply that their prototypes already existed on other worlds? Man was commanded to be fruitful and multiply and replenish the earth and subdue it, he was given dominion over all the other creatures, and he was given the products of plants for food. All the animals, including fowl, were also given plants for food. There is no indication that man or the other animals were to consume flesh; all could have

been vegetarians. Finally, God placed his seal of approval upon all the creations that he had carried out through the Only Begotten Son.

Note that in Moses, as revealed to Joseph Smith, the Lord gives animals "every clean herb for meat," whereas in Genesis (and Abraham) the words are "every green herb." "Clean" in the ancient Hebrew sense of "allowed" or "permitted" makes better sense. Not all edible plants ("herbs") are green (e.g., mushrooms), but many green plants are poisonous or otherwise unsuited for certain animals.

Note also that the words "let the earth bring forth" or "let the waters bring forth" might allow an ancient Israelite to keep his belief in spontaneous generation: the idea that mud directly produces frogs, meat produces maggots, etc. Science has thoroughly disproven this venerable concept. Yet a careful reading of the narrative shows that the Lord was not really talking about spontaneous generation as his modus operandi of creation: "I, God, made the beasts of the earth," and "Let us make man in our image. . . ."

The Third Chapter of Moses
"Thus the heaven and the earth were finished, and all the host of them.

"And on the seventh day I, God, ended my work, and all things which I had made; and I rested on the seventh day from all my work, and all things which I had made were finished, and I, God, saw that they were good;

"And I, God, blessed the seventh day, and sanctified it; because that in it I had rested from all my work which I, God, had created and made." (Moses 3:1-3.)

This last of the seven periods of creation as described so far seems to be merely a sanctified resting period, one used for contemplation. Yet there is more of the story to come. Scholars believe that the next verses begin the "second" account of creation. But the next verses may just as well tell us that the first six of the seven periods just presented are to be understood in a rather special, even unexpected way. The concept is critical, so let's read the version in Genesis first:

"These are the generations of the heavens and of the earth when they were created, in the day that the Lord God made the earth and the heavens,

"And every plant of the field before it was in the earth, and every herb of the field before it grew: for the Lord God had not caused it to rain upon the earth, and there was not a man to till the ground.

"But there went up a mist from the earth, and watered the whole face of the ground." (Genesis 2:4-6.)

Now in Moses:

"And now, behold, I say unto you, that these are the generations of the heaven and of the earth, when they were created, in the day that I, the Lord God, made the heaven and the earth;

"And every plant of the field before it was in the earth, and every herb of the field before it grew. For I, the Lord God, created all things, of which I have spoken, spiritually, before they were naturally upon the face of the earth. For I, the Lord God, had not caused it to rain upon the face of the earth. And I, the Lord God, had created all the children of men; and not yet a man to till the

ground; for in heaven created I them; and there was not yet flesh upon the earth, neither in the water, neither in the air;

"But I, the Lord God, spake, and there went up a mist from the earth, and watered the whole face of the ground." (Moses 3:4-6.)

These are the key verses if one is to understand Moses' account of creation. The remnants remain in Genesis, but without the restoration through Joseph Smith, we would never understand the abbreviated "before it was in the earth." The Lord tells us that the six generations of the heaven and the earth just presented refer to a spiritual creation. All organisms had been created "spiritually, before they were naturally upon the face of the earth." No plants or animals or men were on the earth up to that point, for it had not rained on the face of the earth from the beginning of this phase of creation (the creation of the earth as we know it now). If the six periods refer to a spiritual creation, we should have no difficulty in trying to reconcile these periods with scientific findings. Science knows nothing about spirit, let alone its creation! So this is how Moses reconciles the "two accounts of creation."

"And I, the Lord God, formed man from the dust of the ground, and breathed into his nostrils the breath of life; and man became a living soul, the first flesh upon the earth, the first man also; nevertheless, all things were before created; but spiritually were they created and made according to my word." (Moses 3:7.)

The words following "living soul" do not occur in Genesis. Yet they confirm beyond reasonable doubt the interpretation of the previous verse. Although man was created in the image of God during the sixth period, in this verse we are again told that no man yet existed on earth; men had been created spiritually in heaven. Now, during this seventh period, God forms man from the dust of the ground, and man becomes the first flesh upon the earth. Could this mean other animals were present but aren't considered flesh? The wording seems to eliminate this possibility by saying that man becomes not only the first flesh but also the first man.

Note that this verse refers only to the man Adam-not to mankind. Eve was not created until later. We know from the Doctrine and Covenants (27:11; 107:54; 128:21) that Adam was Michael before he came to earth and received a body, and Brigham Young tells us that as Michael he was one of the gods taking part in creation. Why did he become the first flesh on the earth? Possibly because he was assigned to help in the ensuing biological creation. He was immortal, and he may have retained his memory of his premortal existence and the council in heaven. It is conceivable that with his new immortal body he continued as a god with complete memory of the six spiritual periods of creation, and that he continued to take part in the creation of plants and animals on the earth. Perhaps this is the significance of the statement that he named the animals. (Moses 3:19.)

"And I, the Lord God, planted a garden eastward in Eden, and there I put the man whom I had formed.

"And out of the ground made I, the Lord God, to grow every tree, naturally, that is pleasant to the sight of man; and man could behold it. And it became also a living soul. For it was spiritual in the day that I created it; for it remaineth in the sphere in which I, God, created it, yea, even all things which I prepared for the use of man; and man saw that it was good for food. And I, the Lord God, planted the tree of life also in the midst of the garden, and also the tree of knowledge of good and evil." (Moses 3:8-9.)

A garden is planted. That is, plants are now placed upon the earth. There is none of the detail apparent in the discussion of the spiritual creation of plants on the third day. Presumably, the laws

of procreation and genetics stated at that time also apply here. The idea of planting implies that creation may have been carried out by bringing seeds and spores from other planets, and indeed, this was suggested by a number of the early leaders of the Church. In these verses the Lord further makes it clear that plants also have spirits and thus are living souls. The soul is defined as the spirit combined with the body. (D&C 88:15.)

"And I, the Lord God, caused a river to go out of Eden to water the garden; and from thence it was parted, and became into four heads.

"And I, the Lord God, called the name of the first Pison, and it compasseth the whole land of Havilah, where I, the Lord God, created much gold;

"And the gold of that land was good, and there was bdellium and the onyx stone.

"And the name of the second river was called Gihon; the same that compasseth the whole land of Ethiopia.

"And the name of the third river was Hiddekel; that which goeth toward the east of Assyria. And the fourth river was the Euphrates." (Moses 3:10-14.)

It would be nice if we could relate these geographical features with those of present earth. It is possible, however, that following the flood some of the geographical names familiar to Noah and those with him before the flood were applied to new features.

"And I, the Lord God, took the man, and put him into the Garden of Eden, to dress it, and to keep it.

"And I, the Lord God, commanded the man, saying: Of every tree of the garden thou mayest freely eat,

"But of the tree of the knowledge of good and evil, thou shalt not eat of it, nevertheless, thou mayest choose for thyself, for it is given unto thee; but, remember that I forbid it, for in the day thou eatest thereof thou shalt surely die." (Moses 3:15-17.)

Adam is given a commandment, but according to the account in Moses (but not Genesis) he is told that he has his agency to choose for himself. A wrong decision will bring dire consequences.

"And I, the Lord God, said unto mine Only Begotten, that it was not good that the man should be alone; wherefore, I will make an help meet for him.

"And out of the ground I, the Lord God, formed every beast of the field, and every fowl of the air; and commanded that they should come unto Adam, to see what he would call them; and they were also living souls; for I, God, breathed into them the breath of life, and commanded that whatsoever Adam called every living creature, that should be the name thereof.

"And Adam gave names to all cattle, and to the fowl of the air, and to every beast of the field; but as for Adam, there was not found an help meet for him." (Moses 3:18-20.)

Here, animal life is created physically, from the dust of the earth, as was man. Animals also are living souls. Further, this is the passage that might imply participation by Adam in biological creation, since the animals were brought to him to receive names.

There is an interesting point about the language. It appeared in verse 4 that the speaker changed. During the seven periods the account is written in the first person with God (Elohim) as the speaker. Beginning with biological creation (Moses 3:4), it is written in the first person with the Lord God (Jehovah) as the speaker. Elohim is the Father and Jehovah the Son. In the Moses account (3:18), however, the Lord God speaks unto the Only Begotten. This confuses the issue nicely and indicates that we can draw no conclusions about who is speaking based upon "God" or "Lord God." Apparently, it is the Father speaking throughout the entire account.

"And I, the Lord God, caused a deep sleep to fall upon Adam; and he slept, and I took one of his ribs and closed up the flesh in the stead thereof;

"And the rib which I, the Lord God, had taken from man, made I a woman, and brought her unto the man.

"And Adam said: This I know now is bone of my bones, and flesh of my flesh; she shall be called Woman, because she was taken out of man.

"Therefore shall a man leave his father and his mother, and shall cleave unto his wife; and they shall be one flesh.

"And they were both naked, the man and his wife, and were not ashamed." (Moses 3:21-25.)

Here is the story of Eve's creation. We shall have more to say about it in our discussion of Abraham's account and especially in chapter 16. The interesting play on words (woman because she was taken out of man) is meaningful in ancient Hebrew and in English but in few if any other languages. (Hebrew: man = ish; woman = isha.)

The Fourth Chapter of Moses
"And I, the Lord God, spake unto Moses, saying: That Satan, whom thou hast commanded in the name of mine Only Begotten, is the same which was from the beginning, and he came before me, saying-Behold, here am I, send me, I will be thy son, and I will redeem all mankind, that one soul shall not be lost, and surely I will do it; wherefore give me thine honor.

"But, behold, my Beloved Son, which was my Beloved and Chosen from the beginning, said unto me-Father, thy will be done, and the glory be thine forever.

"Wherefore, because that Satan rebelled against me, and sought to destroy the agency of man, which I, the Lord God, had given him, and also, that I should give unto him mine own power; by the power of mine Only Begotten, I caused that he should be cast down;

"And he became Satan, yea, even the devil, the father of all lies, to deceive and to blind men, and to lead them captive at his will, even as many as would not hearken unto my voice." (Moses 4:1-4.)

Here is a flashback given to Moses to inform him about the council of premortal spirits. This took place in the beginning, at a time not specified here, but according to Abraham (3:22-28) before the creation of the earth in its present form.

Satan's idea must have been an intriguing one. He was willing to redeem all mankind without losing a single soul, this by removing man's free agency. The Only Begotten Son did not present a plan but suggested that the Father's plan should be followed. Satan's plan was rejected for two reasons: First, he wanted the glory of God, to which he was not entitled. Second, he intended to take from mankind the agency received as a gift from God. As discussed in chapter 2, Satan's plan was

enticing (wouldn't it be nice to have salvation guaranteed?), but it must have been an impossible plan. Salvation in God's presence requires agency.

The remainder of Moses 4 is the story of the fall. Creation was not complete until this event had been consummated. There are several highly instructive points in this story, enough to merit a careful reading, although to save space we shall not present it all here.

Satan, speaking through the serpent, knew not the mind of God (which is a comforting thought) but sought to destroy the world by beguiling Eve. He mixed a lie (that she would not die) with the truth (that her eyes would be opened so that she would know good and evil). She gave the fruit to Adam, and their eyes were indeed opened so that they recognized their nakedness. They were questioned by God (who in his omniscience surely knew what had transpired) and admitted their transgression. The serpent was cursed and told by the Lord: ". . . I will put enmity between thee and the woman, between thy seed and her seed; and he shall bruise thy head, and thou shalt bruise his heel." (Moses 4:21; Genesis 3:15.) This is of symbolic significance. Satan would bruise the heel of mankind, but Jesus Christ, the Son of God and seed of woman, would bruise his head.

Eve was cursed so that her sorrow was multiplied in her conception, and her husband would rule over her. The ground was cursed for Adam's sake: he would eat bread by the sweat of his face, and he would return to the dust of which he was taken. Adam called his wife Eve, "because she was the mother of all living; for thus have I, the Lord God, called the first of all women, which are many." (Moses 4:26.) In Hebrew, the word for Eve (Chavah) means living. This statement is reminiscent of the Lord's statement that Adam was "the first man of all men . . . which is many." (Moses 1:34.) The Lord made coats of skins for Adam and Eve and drove them out of the garden, guarding the way with cherubim and flaming sword.

This revelation to Joseph Smith of the writings of Moses about creation ends with the words:

"(And these are the words which I spake unto my servant Moses, and they are true even as I will; and I have spoken them unto you. See thou show them unto no man, until I command you, except to them that believe. Amen.)" (Moses 4:32. Parentheses in original.)

Father Lehi spoke of the fall to his son Jacob. He discussed the importance of opposition in all things, that "man could not act for himself save it should be that he was enticed by the one or the other." Man's state is one of probation:

". . . if Adam had not transgressed he would not have fallen, but he would have remained in the garden of Eden. And all things which were created must have remained in the same state in which they were after they were created; and they must have remained forever, and had no end.

"And they would have had no children; wherefore they would have remained in a state of innocence, having no joy, for they knew no misery; doing no good, for they knew no sin.

"But behold, all things have been done in the wisdom of him who knoweth all things.

"Adam fell that men might be; and men are, that they might have joy.

"And the Messiah cometh in the fulness of time, that he may redeem the children of men from the fall. And because that they are redeemed from the fall they have become free forever, knowing good from evil; to act for themselves. . . .

". . . and all things are given unto them which are expedient unto man. And they are free to choose liberty and eternal life, . . . or to choose captivity and death, according to the captivity and power of the devil; for he seeketh that all men might be miserable like unto himself." (2 Nephi 2:22-27.)

Here in relation to the creation story is one of the most sublime scriptures ever received by man. Life is a probationary state in which we are enticed by evil and by good. The decision is difficult, because evil is indeed enticing. Yet man is that he might have joy. If he will stay true to the faith, joy may be his through the redemption of the Son, who was sent by the Father to redeem mankind from the consequences of Adam's fall. It was all part of the plan. Adam truly transgressed, but this was foreseen, and indeed, everything would otherwise have remained in a state of innocence, having no joy, knowing no misery, doing no good, knowing no sin. But all things were done in the wisdom of him who knoweth all things.

The statement that "all things which were created must have remained in the same state in which they were after they were created" (2 Nephi 2:22) has been interpreted to mean that plants and animals were immortal before the fall; i.e., that there was no death. (The scriptures are clear as to Adam and Eve's immortality.) Such an interpretation essentially eliminates any "scientific" understanding of the creation scriptures. For one thing, no death equals no fossils. For another, science knows no ecosystem without death. What would animals eat? Even grass that is eaten fails to survive the process! What would decay organisms consume? Thus we are entitled to wonder about the terms "same state." The next verse describes a "state of innocence" for Adam and Eve. Was this state a perfectly balanced ecosystem, an ideal paradise-but one in which both birth and death played their normal functions as we know them?

Footnotes

1. Joseph Fielding Smith, Doctrines of Salvation (Salt Lake City: Bookcraft, 1954), 1:27: James E. Talmage, Jesus the Christ (Salt Lake City: Deseret Book Co., 1951), p. 39.
2. Joseph Fielding Smith, comp., Teachings of the Prophet Joseph Smith (Salt Lake City: Deseret Book Co., 1976), p. 181. See also Joseph Smith Papers, 1839-1841, Church Historian's Library, Salt Lake City, and Hyrum L. Andrus, God, Man and the Universe (Salt Lake City: Bookcraft, 1965), p. 335.
3. For example: Journal of Discourses, 1:51 and 3:319.
4. W. Cleon Skousen, The First 2,000 Years (Salt Lake City: Bookcraft, 1953), p. 136.
5. James E. Talmage, Jesus the Christ, p. 43.
6. For example, Orson Pratt in Journal of Discourses, 21:197-206. Also, Joseph Fielding Smith, Man: His Origin and Destiny (Salt Lake City: Deseret Book Co., 1973), pp. 389-96.

7
The Book of Abraham

Why the book of Abraham? When I was a young lad first getting interested in the scriptural accounts of creation, I encountered the creation story in the book of Abraham and noticed that it seemed to be closely similar to its counterpart in the book of Moses. Oh, there were obviously some differences in wording (Moses is written in the first person: "And I, God, said"; while Abraham is in the third person plural: "And they, that is, the Gods, said"), but why should the Lord go to all the trouble of getting the book of Abraham translated just for these minor differences in wording? After all, God has not spoken to man on very many occasions, considering the number of persons who have lived over the ages. When he speaks, his words might be expected to be of real significance.

One can apply such a test to the revelations of God as was suggested by LeGrand Richards: If a revelation is really from God, it should contain new information previously unavailable or at least unclear to mankind, or it might confirm some previous commandment in need of validation. For

example, Doctrine and Covenants 42 is called "the law of the Church," and in it the Lord confirms several of the Ten Commandments.

Upon more careful study of the book of Abraham, it became increasingly apparent to me why the book was restored to mankind. There is valuable historical information in the first two chapters, and chapter 3 is a marvelous view of the insight held by some of the ancients into the workings of the universe, the realities of the God who created it, and his special abode in it. The creation story itself proves to be a unique and marvelous view of creation. It is probably the greatest insight available to man today into the nature of God's creative power. Creation is portrayed not as an act of magic but as the application of a supreme intelligence-truly a divine engineering. There was planning and preparation. Councils were held. Nothing like this is apparent from the Genesis or the Moses accounts. And nothing could be more important for modern man to understand.

The Origin of the Book of Abraham

The rediscovery of some of the papyrus fragments from which the book of Abraham was translated has sparked an eruption of historical research into the events surrounding translation of the book. Several articles and books are available, and so this topic will not be examined here. As indicated before, I have taken the steps in my own mind to ascertain the divinity of the work, and my interest now is centered more on its content than on its origin. If I accept Joseph Smith as a prophet of God-and I do-then the book of Abraham is one of his inspired and most important products.

Nevertheless, without going into the details of historical research presently under way, we can briefly summarize the origin of the book of Abraham as follows: Eleven Egyptian mummies were exhumed from their tomb near Thebes in Egypt about 1818 by Antonio Lebolo. After Lebolo's death in Trieste in 1823, they were shipped to Ireland and then New York, addressed to Michael Chandler, a nephew of Lebolo. One of the mummies included a roll of papyrus beneath the wrappings covering the breast. These scrolls were in a state of excellent preservation and contained writings in black and a few in red. Chandler heard of Joseph Smith's reputation as a translator, first in the customs house of New York, where he retrieved the mummies, and again on several occasions as he exhibited them throughout the eastern United States. Finally, the mummies and the papyrus were brought to Kirtland, Ohio, and to Joseph Smith on July 3, 1835. Chandler asked him for a translation of the hieroglyphics on the papyrus. The Prophet produced this, and it agreed in detail with suggestions Chandler had received from Egyptologists in the eastern United States. Chandler prepared a certificate attesting to this.

Recent research has produced not only fragments of the papyrus (including especially the illustration of Abraham on the altar) but changes in the dates for Lebolo's discovery and death originally given by Chandler to Joseph Smith. In addition, seven or eight of the original mummies have been located, and several details have come to light, such as the likely fact that Benjamin Bullock III may have been the individual who finally brought Chandler to Kirtland and Joseph Smith.

A number of the residents of Kirtland (apparently not members of the Church) purchased four of the mummies along with the scrolls and presented them to Joseph Smith. With the help of Oliver Cowdrey and others, including W. W. Phelps, Joseph worked intermittently on a translation of the scrolls from 1835 until the time of his death, and ascertained them to be writings from Abraham and Joseph. Only the writings of Abraham up to and including the creation story were ever published. Little is known about the procedures followed during translation. A number of manuscripts in the Church Historical Department contain parts of the book of Abraham along with Egyptian characters, but these were apparently uninspired attempts by W. W. Phelps, Oliver Cowdery, W. Parrish, and others to translate some of the papyrus characters. Abraham states: "I have given you the fashion of them in the figures at the beginning, which manner of the figures is

called by the Chaldeans Rahleenos, which signifies hieroglyphics." (Abraham 1:14.) The implication is that the text of Abraham's book was written in some fashion other than hieroglyphics. It has been suggested that the writing was in an even more ancient language, possibly Adamic.

The book of Abraham was published in two installments in March and May of 1842 in the Times and Seasons at Nauvoo, Illinois. It was subsequently included in the Pearl of Great Price, published by Franklin D. Richards in Liverpool, England, in 1851. This version of the Pearl of Great Price included a number of revelations from the Doctrine and Covenants as well as the material presently included. There were also the words to the song "Oh Say What Is Truth." The first American edition of the Pearl of Great Price was in 1878 in Salt Lake City. Utah. By vote of the Church in 1880 and 1902, this new scripture was accepted as binding upon the Church and as a part of its standard works. Thus these ancient writings of Abraham, the father of the faithful (and Moses, as already discussed), became available as modern-day scripture.

Abraham's Story

Abraham 1:1-4. The first two chapters of the book of Abraham review some of Abraham's history. While they are not directly related to the story of creation, they provide insight into the man who was given this story by God. They are well worth reading, but our summary must be brief.

Writing in the first person, Abraham tells us that he was living in the land of the Chaldeans with his father, and that he was a follower of righteousness, receiving his priesthood through the fathers. In D&C 84:14 we read: "Abraham received the priesthood from Melchizedek, who received it through the lineage of his fathers, even till Noah." Incidentally, it is important to keep in mind that Abraham lived in about 2000 B.C., or about 4,000 years ago. This was about 1,350 years before Moses.

1:5-20. Abraham's fathers had turned to idolatry, offering human sacrifices of men, women, and children. The priest of Pharaoh "laid violence upon" Abraham, binding him to the altar and attempting to offer him as sacrifice. Abraham describes the altar and even presents a picture, the only illustrated event in all scripture. (This illustration is part of what was found in the Metropolitan Museum in New York.) Abraham called upon God, who sent an angel to loosen his hands. Abraham was told that the Lord's name is Jehovah, and that he was going to take Abraham into a strange land. Through Abraham's ministry, Jehovah's name would be known in the earth forever. The Lord then destroyed the altar and "smote" the priest to death.

1:21-28. Abraham digresses to recount some of the history of the founding of Egypt. The Pharaoh was a descendant of Ham and thus carried the blood of the Canaanites. When Egypt was discovered by a daughter of Ham and Egyptus, it was under water, possibly one of the frequent floods of the Nile. The grandson of Ham, called Pharaoh, established the first government of Egypt. He was a righteous man and was blessed with the blessings of the earth and of wisdom but cursed as pertaining to the priesthood. Nevertheless, his descendants claimed the priesthood through Noah, and Abraham's father was led away by their idolatry.

1:29-31. Returning to the story, Abraham stated that a severe famine came into the land of Chaldea, and that his father was so tormented that he repented. Abraham had the record of the patriarchs, in which was a knowledge of the beginning of creation and of the planets and of the stars.

2:1-5. The famine became so severe that Abraham's brother Haran died, although his father, Terah, lived. Abraham married his niece Sarai, daughter of Haran. Then he went to Canaan, taking Sarai and also Lot, his brother's son. His father followed, apparently at a distance, but when the famine abated, Terah again became idolatrous.

2:6-11. Abraham and Lot prayed to the Lord, who appeared unto them. He stated his power (he controls the sea, the wind, the fire, the mountains) and again identified himself as Jehovah, who knows the ends and the beginnings. He promised to make Abraham a great nation and told him that the priesthood and the gospel should be carried to all nations and families of the earth through his seed. He would bless those who blessed Abraham and curse those who cursed him. This covenant between God and Abraham is a key gospel concept.

2:12-21. Abraham expressed his gratefulness, saying: ". . . thy servant has sought thee earnestly; now I have found thee." Following the Lord's instructions, Abraham took Lot and all their possessions and departed. He was sixty-two years old. They dwelt in tents in Canaan with eternity as their coverings. Abraham built altars and made offerings, praying that the famine would abate, but they continued on toward Egypt because the famine was still very grievous.

2:22-25. The Lord warned Abraham that when the Egyptians saw Sarai, who was very beautiful, they would kill Abraham to get her. Abraham was to tell the Egyptians that Sarai was his sister rather than his wife. Presumably, if Pharaoh thought she was his sister, he would have hopes of getting her with Abraham's permission, but if she was Abraham's wife, the only way to get her would be to kill Abraham! This is an interesting little story. Sarai was not only Abraham's sister in the gospel, but may have been a literal half-sister, since his father may have taken Haran's wife to raise children, as was the custom. (Genesis 20:12.) In any case, Abraham, to preserve his life, did not explain these details to the Pharaoh. It seems that such is justified in matters of life and death. (See also 1 Nephi 4:10-18; D&C 134:11.)

Abraham's Astronomy Lesson
With the beginning of chapter 3, we enter the part of the book of Abraham that has the most direct bearing on the creation. Abraham was given a generalized picture of the universe, and some of the information is of great interest and importance. We shall present the remainder of the book of Abraham verbatim, making comments here and there where they seem appropriate.

3:1-4. "And I, Abraham, had the Urim and Thummim, which the Lord my God had given unto me, in Ur of the Chaldees;

"And I saw the stars, that they were very great, and that one of them was nearest unto the throne of God; and there were many great ones which were near unto it;

"And the Lord said unto me: These are the governing ones; and the name of the great one is Kolob, because it is near unto me, for I am the Lord thy God: I have set this one to govern all those which belong to the same order as that upon which thou standest.

"And the Lord said unto me, by the Urim and Thummim, that Kolob was after the manner of the Lord, according to its times and seasons in the revolutions thereof; that one revolution was a day unto the Lord, after his manner of reckoning, it being one thousand years according to the time appointed unto that whereon thou standest. This is the reckoning of the Lord's time, according to the reckoning of Kolob."

Through the Urim and Thummim Abraham received the sublime truth that God's throne (the planet on which he dwells?) is near to, but not identical with, a great star called Kolob, which star is itself associated with other great ruling stars (those of our galaxy or some more local group?). God keeps time according to the "revolutions" of this great star, which completes one "revolution" in one thousand of our years. Probably this means that Kolob rotates once on its axis in one thousand years, as the earth rotates once each day. But the term revolution refers to movement of a

celestial body in its orbit. Did Joseph Smith choose the wrong technical term or does Kolob revolve around "God's throne"?

The Lord told Joseph Smith: "The place where God resides is a great Urim and Thummim. This earth, in its sanctified and immortal state, will be made like unto crystal and will be a Urim and Thummim to the inhabitants who dwell thereon, whereby all things pertaining to an inferior kingdom, or all kingdoms of a lower order, will be manifest to those who dwell on it; and this earth will be Christ's." (D&C 130:8-9.) Thus the Urim and Thummim must be a powerful instrument of divine engineering, designed for information storage and retrieval and for communication. Was the Urim and Thummim that is God's abode transmitting to Abraham's Urim and Thummim to give him this mighty vision?

3:5-13. "And the Lord said unto me: The planet which is the lesser light, lesser than that which is to rule the day, even the night, is above or greater than that upon which thou standest in point of reckoning, for it moveth in order more slow; this is in order because it standeth above the earth upon which thou standest, therefore the reckoning of its time is not so many as to its number of days, and of months, and of years.

"And the Lord said unto me: Now, Abraham, these two facts exist, behold thine eyes see it; it is given unto thee to know the times of reckoning, and the set time, yea, the set time of the earth upon which thou standest, and the set time of the greater light which is set to rule the day, and the set time of the lesser light which is set to rule the night.

"Now the set time of the lesser light is a longer time as to its reckoning than the reckoning of the time of the earth upon which thou standest.

"And where these two facts exist, there shall be another fact above them, that is, there shall be another planet whose reckoning of time shall be longer still;

"And thus there shall be the reckoning of the time of one planet above another, until thou come nigh unto Kolob, which Kolob is after the reckoning of the Lord's time; which Kolob is set nigh unto the throne of God, to govern all those planets which belong to the same order as that upon which thou standest.

"And it is given unto thee to know the set time of all the stars that are set to give light, until thou come near unto the throne of God.

"Thus I, Abraham, talked with the Lord, face to face, as one man talketh with another; and he told me of the works which his hands had made;

"And he said unto me: My son, my son (and his hand was stretched out), behold I will show you all these. And he put his hand upon mine eyes, and I saw those things which his hands had made, which were many; and they multiplied before mine eyes, and I could not see the end thereof.

"And he said unto me: This is Shinehah, which is the sun. And he said unto me: Kokob, which is star. And he said unto me: Olea, which is the moon. And he said unto me: Kokaubeam, which signifies stars, or all the great lights, which were in the firmament of heaven."

Abraham was given a vision of the universe, and it proves to be similar to the picture developing in modern astronomy. Astronomers have recognized that our solar system is in one arm of the Milky Way galaxy, the entire galaxy rotating about a center. The day of the "planet" moon, as was pointed out to Abraham, is longer than that of the earth-about 29 days. The planets beyond the

earth have yearly periods that are also much longer than that of the earth. The sun with its planets is revolving in the galaxy with a period of about 200 million years. The galaxy seems to be associated with a number of other galaxies, and they could all be revolving about a center and exhibiting extremely long periods. Thus the picture given to Abraham and translated by Joseph Smith is being substantiated by research in astronomy. Although the concepts had been suggested, there was no evidence in Joseph Smith's day (nor probably Abraham's day) for a solar system rotating within a galaxy.

I have stated that God tells man little about the physical universe via revelation. This idea remains pretty much intact, even after an examination of Abraham's astronomy lesson. We know that the governing force between the planets is gravity. Knowledge of the inverse square law of gravitational attraction is absolutely essential to any understanding of how the planets and stars relate to each other in the universe. This law was well known before Joseph Smith's day, but if it was given to Abraham, it is not mentioned in his writings. Although Abraham knew the set times of the earth, moon, sun, and perhaps the planets, these are not stated in his book. The implication might be that Abraham was arbitrarily given these times without any understanding of the force that controlled them.

It is even possible that the astronomy of his day was able to measure them. Certainly, there was much interest among Abraham's contemporaries relating to the times of movements of the planets (see chapter 9), since they were applied in casting astrological horoscopes. Abraham may have been given highly accurate figures for these times, but contemporary astrologers could always take issue with these based upon their own observations.

When the Lord gives us knowledge relating to the workings of the physical universe, we can usually talk our way out of it if we want to. Even the broad picture of star and planetary motions given to Abraham is so general that it means little without the findings of astronomy. For example, since the moon is a satellite of earth, it is hardly valid to compare the motions of the moon with those of other planets or stars except in the very general manner of Abraham's vision. Our search for God is seldom, if ever, fortified by "hard" scientific evidence. In seeking him, we must examine his precepts for correct living, his revelations about himself and the plan of salvation, and base our decisions on these data.

God's Supremacy: the Point of the Astronomy Lesson

3:14-19. "And it was in the night time when the Lord spake these words unto me: I will multiply thee, and thy seed after thee, like unto these; and if thou canst count the number of sands, so shall be the number of thy seeds.

"And the Lord said unto me: Abraham, I show these things unto thee before ye go into Egypt, that ye may declare all these words.

"If two things exist, and there be one above the other, there shall be greater things above them; therefore Kolob is the greatest of all the Kokaubeam that thou hast seen, because it is nearest unto me.

"Now, if there be two things, one above the other, and the moon be above the earth, then it may be that a planet or a star may exist above it; and there is nothing that the Lord thy God shall take in his heart to do but what he will do it.

"Howbeit that he made the greater star; as, also, if there be two spirits, and one shall be more intelligent than the other, yet these two spirits, notwithstanding one is more intelligent than the

other, have no beginning; they existed before, they shall have no end, they shall exist after, for they are gnolaum, or eternal.

"And the Lord said unto me: These two facts do exist, that there are two spirits, one being more intelligent than the other; there shall be another more intelligent than they; I am the Lord thy God, I am more intelligent than they all."

Here is the real reason for Abraham's astronomy lesson. He was not given this information so he could argue with the astrologers of his day-although he was commanded to declare the words. However, these words concerned not the nature of the universe, but the nature of God. As one planet or star was above another in the order of things, so one spirit was above another in order of intelligence. As Kolob was the great, superior, governing star, so God was the greatest and most intelligent of all spirits; this is what makes him God. Here was a radically new theological doctrine-and one that the scientists of neither Abraham's day nor our own would have been likely to elucidate by their researches. In Abraham's day people worshipped many gods. Abraham's message to them was that there was only one truly superior God, and this great Being is more intelligent than all other spirits.

Part of the lesson was also concerned with the covenant made between Abraham and the Lord. As the stars and planets filled the universe and as the sands multiplied along the shores of the seas, so would Abraham's seed multiply after him.

Abraham was also given in detail the doctrine of the eternal nature of spirits: they have no beginning, neither will they have an end. Thus they were not originally created by God (intelligence cannot be created-D&C 93:29), but they were organized to higher levels by God's intelligence. In heaven, they were created as spirits in God's image (Moses 2:26; 3:5), they became God's spirit children (D&C 76:24), and they received from God the gift of free agency (Moses 4:3).

These verses also contain one of the most marvelous statements of God's omnipotence to be found anywhere in scripture. Over the centuries theologians have argued about the nature of God's total power. If God can do anything, can he trisect an angle using only a square and a compass, as mathematicians have proven to be impossible? Or could he build a rock so large he couldn't lift it? Or much more pertinent to our modern day, could he build an earth where his children could live in perfect peace, justice, and harmony with no misery or woe-ultimately returning to become gods in the Father's presence?

If no restrictions are placed upon God's power, then these questions seem valid. But placing restrictions on God's power seems to be a presumptuous act of sacrilegious man, so we seem to be faced with a hopeless dilemma. Yet it was solved beautifully in the statement to Abraham that "there is nothing that the Lord thy God shall take in his heart to do but what he will do it." (Abraham 3:17.) God is indeed powerful enough to accomplish anything that he wants to accomplish. It is not a matter of what he can do, but what he wants to do. Surely with his omniscience, he will not want to do something that is impossible. He is all wise. He is certainly aware of the mathematical impossibility of trisecting an angle and consequently has no desire to do so; he would not be bothered with the trivialities of constructing rocks too large to lift; and most important of all, he knows that man cannot be saved in ignorance (D&C 131:6) but can only return to his presence by learning to use his mighty gift of agency, the power that can lead to salvation (D&C 58:28).

Footnotes

1. LeGrand Richards, A Marvelous Work and a Wonder (Salt Lake City: Deseret Book Co., revised and enlarged, 1976), p. 5.

2. For example, see Klaus Baer, "The Breathing Permit of Hor-A Translation of the Apparent Source of the Book of Abraham," Dialogue 3 (Autumn 1968): 109-34; Hugh Nibley, "Prolegomena to Any Study of the Book of Abraham," BYU Studies 8 (Winter 1968): 171-94; Hugh Nibley, "What Is 'The Book of Breathings'?" BYU Studies 11 (Winter 1971): 153-87; Jay M. Todd, The Saga of the Book of Abraham (Salt Lake City: Deseret Book Co., 1969); and various articles in the Improvement Era, Ensign, and New Era. An excellent discussion is found in Hugh Nibley, The Message of the Joseph Smith Papyri: An Egyptian Endowment (Salt Lake City: Deseret Book Co., 1975). In this definitive treatise, Professor Nibley places the papyrus fragments in their proper perspective. They are clearly not the source of the book of Abraham, which was produced from other papyri by direct revelation from the Lord. Although only the drawings on the papyri, reproduced as facsimiles, bear any relation to our present book of Abraham, authenticity of the book has been strongly supported by reference to other ancient documents relating to the Abraham story. Professor Nibley and others have been showing this for years. The papyri represent the "Book of Breathings," or "The Breathing Permit of Hor," as it has been called. It proves to be a rich source of information about the ancient ordinances of the Egyptians. As Abraham tells us, "Pharaoh, being a righteous man," was ever "seeking earnestly to imitate that order established by the fathers in the first generations," for he "would fain claim [the priesthood]." (Abraham 1:26-27.) Judging by the Book of Breathings, Pharaoh's imitations were most impressive. In some respects they resemble the modern LDS temple ceremony, known as the endowment.
3. Hugh Nibley, "The Meaning of the Kirtland Egyptian Papers," BYU Studies 11 (Summer 1971): 350-99.
4. Some of the material is reviewed in James R. Clark, The Story of the Pearl of Great Price (Salt Lake City: Bookcraft, 1955); James R. Clark, "Joseph Smith and the Lebolo Egyptian Papyri," BYU Studies 8 (1968): 195-203; and James R. Clark, Our Pearl of Great Price, Ensign 6 (August 1976): 13-17.
5. Thomas W. Mackay, "Abraham in Egypt: A Collation of Evidence for the Case of the Missing Wife," BYU Studies 10 (1970): 429-51.

8
Abraham and Physical Creation

Abraham's visions of the nighttime, given through the Urim and Thummim, must have greatly exceeded in beauty and glory anything we can possibly imagine. The culmination of this sublime vision was the story of our earth's creation, but the Lord had much to teach Abraham (and through him, us) before this story was told. We have seen that Abraham was taught the basic structure of the universe, and this was used as an analogy of the gradation of spirits and the supremacy of God's power and intelligence.

When God taught Moses about creation, he also set the narrative in the context of his other creations (Moses 1), speaking of the continuous creation of earths, for there is no end to God's works or his words. Why? The work and glory of God is "to bring to pass the immortality and eternal life of man." (Moses 1:39.) In the same manner, centuries before, the Lord told Abraham the purposes of creation before telling of creation itself. Notice how the scenario moves with no perceptible break from Kolob (already discussed, Abraham 3:1-19) through God's supremacy and purposes in creation, the council in heaven, to creation itself.

The Purposes of Creation
3:20-23. "The Lord thy God sent his angel to deliver thee from the hands of the priest of Elkenah.

"I dwell in the midst of them all; I now, therefore, have come down unto thee to deliver unto thee the works which my hands have made, wherein my wisdom excelleth them all, for I rule in the heavens above, and in the earth beneath, in all wisdom and prudence, over all the intelligences

thine eyes have seen from the beginning; I came down in the beginning in the midst of all the intelligences thou hast seen.

"Now the Lord had shown unto me, Abraham, the intelligences that were organized before the world was; and among all these there were many of the noble and great ones;

"And God saw these souls that they were good, and he stood in the midst of them, and he said: These I will make my rulers; for he stood among those that were spirits, and he saw that they were good; and he said unto me: Abraham, thou art one of them; thou wast chosen before thou wast born."

God's omniscience is stated in these passages. Here he tells us that he is indeed all wise, confirming the idea that he will not want to do the impossible.

In theology, we refer to the status of man before he became a spirit child of God as being an intelligence. This term depends almost exclusively upon these passages in the book of Abraham. Thus it is interesting to note that the terms intelligences, souls, and spirits are all used in an apparently synonymous way in verse 23. Yet we are justified in thinking of the "intelligence" as the most primeval state of being, because that is what we were "in the beginning," when God came down among us. That must have been when God became God of the intelligences shown to Abraham: when he came down in the beginning among them. Furthermore, as clearly implied by the astronomy lesson and its analogy with the spirits (chapter 7), not all intelligences are equal. Some are noble and great, and these future leaders, including Abraham, were chosen by God before they were born on the earth.

3:24-28. "And there stood one among them that was like unto God, and he said unto those who were with him: We will go down, for there is space there, and we will take of these materials, and we will make an earth whereon these may dwell;

"And we will prove them herewith, to see if they will do all things whatsoever the Lord their God shall command them;

"And they who keep their first estate shall be added upon; and they who keep not their first estate shall not have glory in the same kingdom with those who keep their first estate; and they who keep their second estate shall have glory added upon their heads for ever and ever.

"And the Lord said: Whom shall I send? And one answered like unto the Son of Man: Here am I, send me. And another answered and said: Here am I, send me. And the Lord said: I will send the first.

"And the second was angry, and kept not his first estate; and, at that day, many followed after him."

Here, in a few simple words, is one of the great statements of scripture relating to the purpose of life. An earth was to be created-not out of nothing, but from preexisting materials-and this was to test the intelligences-spirits-souls to see if they would do all things whatsoever the Lord, their God, should command them. If those who were spirits would "keep" their first estate (their status as God's spirit children), they would be added upon by progressing to a second estate, mortality, and if they met the responsibilities of that condition, then they would have glory added upon their heads forever and ever. That is, they would return to the presence of God and become even as he is. (D&C 76:50-70; 132:20.) Lucifer's plan to be the redeemer and to save everyone by taking away their agency (Moses 4:1-3) was discussed in chapter 6. Satan desired to have God's glory, but his

anger led to loss of the first estate. Yet he was convincing enough to take many others with him, a third of the hosts of heaven, we are told. (D&C 29:36.)

The Six Preparatory Periods of Creation

The general outline of creation follows that in Genesis and Moses. Again we have the problem of the "two accounts" (the seven periods plus the "man-from-the-dust" story). Abraham's solution is completely different from that of Moses, although not incompatible with it. The six times of creation (as Abraham calls them) were times of preparation and planning when the Gods plural, who carried out creation, planned and took counsel among themselves. In each period they also performed some preparatory creative act, readying the earth for the later placement of life. Man was created from the dust of the earth during the seventh time, and during this seventh time plants and animals were also placed upon the earth. There is nothing in Abraham's account to indicate that organisms were placed on earth before that time, although the earth was prepared for them. In the account of Moses, plants, animals, and mankind were created before the seventh day, but they were formed in heaven, and there was not a man to till the ground until man was placed on the earth, becoming the first flesh and the first man also. (Moses 3:5.) Let us examine Abraham's account:

4:1-2. "And then the Lord said: Let us go down. And they went down at the beginning, and they, that is the Gods, organized and formed the heavens and the earth.

"And the earth, after it was formed, was empty and desolate, because they had not formed anything but the earth; and darkness reigned upon the face of the deep, and the Spirit of the Gods was brooding upon the face of the waters."

The Lord, who had identified himself as Jehovah, went down with other gods to organize and form the heavens and the earth from preexisting material. (Abraham 3:24.) Who were the other gods? Michael, who was to become Adam, was one of them, we have been told by our prophets. Michael and Jehovah would make two, accounting for the plural term "the Gods," but others may have been present. Was it the spirit of the Holy Ghost that was brooding upon the face of the waters?

Abraham's description of the primeval earth uses the terms "empty and desolate" rather than "without form and void." As indicated previously, Joseph Smith stated that these words were a far more descriptive translation of the Hebrew. (See footnote 1, chapter 6.)

4:4-5. "And they (the Gods) comprehended the light, for it was bright; and they divided the light, or caused it to be divided, from the darkness.

"And the Gods called the light Day, and the darkness they called Night. And it came to pass that from the evening until morning they called night; and from the morning until the evening they called day; and this was the first, or the beginning, of that which they called day and night."

Perhaps we are to imply from this that the Gods ignited the sun at this time. Astrophysics suggests that a sun becomes a sun when it gathers enough matter to raise its temperature by gravitational compression to a point capable of supporting thermonuclear reactions. According to the accretion hypothesis for the origin of the solar system, matter from an interstellar cloud of material (which is indeed almost "without form and void") might have begun to condense, forming simultaneously the empty and desolate earth, the other planets, and the sun. Accretion of matter into the sun may not have been sufficient to ignite its thermonuclear fires until after most of the earth had been formed.

4:6-8. "And the Gods also said: Let there be an expanse in the midst of the waters, and it shall divide the waters from the waters.

"And the Gods ordered the expanse, so that it divided the waters which were under the expanse from the waters which were above the expanse; and it was so, even as they ordered.

"And the Gods called the expanse, Heaven. And it came to pass that it was from evening until morning that they called night, and it came to pass that it was from morning until evening that they called day, and this was the second time that they called night and day."

Current accretion theories hold that immense quantities of hydrogen, helium, and the lighter elements are present in the clouds of interstellar matter from which a solar system condenses. As the planet heats up by its own accretion processes, many molecules of these lighter gases, including water vapor, may attain such thermal velocities that they cannot be held by the planet's gravity. Perhaps here the Lord is speaking of this period, when some water is cooling and condensing onto the earth's surface (perhaps covering it entirely), while other water-possibly vast quantities-is being lost from the earth's gravity, and an atmosphere is forming above the waters on the earth's surface and below the waters that are escaping to space. Nothing is stated about the composition of this atmosphere called heaven. Modern theories suggest that it consisted primarily of such gases as hydrogen, methane, ammonia, water vapor, etc. There is no reason to believe that free molecular oxygen or probably even nitrogen were present.

4:9-13. "And the Gods ordered, saying: Let the waters under the heaven be gathered together unto one place, and let the earth come up dry; and it was so as they ordered;

"And the Gods pronounced the dry land, earth; and the gathering together of the waters, pronounced they, great waters; and the Gods saw that they were obeyed.

"And the Gods said: Let us prepare the earth to bring forth grass; the herb yielding seed; the fruit tree yielding fruit, after his kind, whose seed in itself yieldeth its own likeness upon the earth; and it was so, even as they ordered.

"And the Gods organized the earth to bring forth grass from its own seed, and the herb to bring forth herb from its own seed, yielding seed after his kind; and the earth to bring forth the tree from its own seed, yielding fruit, whose seed could only bring forth the same in itself, after his kind; and the Gods saw that they were obeyed.

"And it came to pass that they numbered the days; from the evening until the morning they called night; and it came to pass, from the morning until the evening they called day; and it was the third time."

Apparently there is dry land on earth because part of the earth's crust is lighter and tends to "float" on the heavier rock below (see chapter 11). These balances in the crustal rocks may not have been achieved until after the earth had been in existence for an interval of time, before which the earth might have been completely covered with water.

Soon after the earth came up dry, the Gods made plans for the plant life that would live on it, discussing the laws of plant genetics. They also decided to prepare and organize the dry land in anticipation of the time when plants would grow upon it. After making these decisions, they actually did prepare and organize the land for plant life, but it is not stated that plants were placed upon it at that time.

4:14-19. "And the Gods organized the lights in the expanse of the heaven, and caused them to divide the day from the night; and organized them to be for signs and for seasons, and for days and for years;

"And organized them to be for lights in the expanse of the heaven to give light upon the earth; and it was so.

"And the Gods organized the two great lights, the greater light to rule the day, and the lesser light to rule the night; with the lesser light they set the stars also;

"And the Gods set them in the expanse of the heavens, to give light upon the earth, and to rule over the day and over the night, and to cause to divide the light from the darkness.

"And the Gods watched those things which they had ordered until they obeyed.

"And it came to pass that it was from evening until morning that it was night; and it came to pass that it was from morning until evening that it was day; and it was the fourth time."

As suggested in chapter 6, the primeval earth might have been covered with dense materials, possibly clouds of dust and vapor. By the fourth time, these clouds may have cleared by condensation and settling to the point where the heavenly bodies could be seen from the earth's surface. It is also possible that the moon didn't come into orbit around the earth until this fourth time, and it is even conceivable that the earth might have come into its permanent orbit around the sun at this time. Yet to receive the light mentioned on the second time, it must have been close to the sun or perhaps some other luminous body.

A number of the early brethren stated that the earth was created in the vicinity of Kolob and that it "fell" away from Kolob at the time of the fall, when Adam and Eve partook of the forbidden fruit. It is difficult to think of an object falling away from a gravitation source such as Kolob must be. To fall is to move toward a center of gravity. The vast interstellar distances also make the concept a difficult one. In any case, if the earth did move from Kolob at the time of Adam and Eve's fall, it must have taken the sun and the moon with it, because these were present and apparent in the fourth creative period.

4:20-23. "And the Gods said: Let us prepare the waters to bring forth abundantly the moving creatures that have life; and the fowl, that they may fly above the earth in the open expanse of heaven.

"And the Gods prepared the waters that they might bring forth great whales, and every living creature that moveth, which the waters were to bring forth abundantly after their kind; and every winged fowl after their kind. And the Gods saw that they would be obeyed, and that their plan was good.

"And the Gods said: We will bless them, and cause them to be fruitful and multiply, and fill the waters in the seas or great waters; and cause the fowl to multiply in the earth.

"And it came to pass that it was from evening until morning that they called night; and it came to pass that it was from morning until evening that they called day; and it was the fifth time."

During this period the Gods prepared the earth for fishes and fowl. They planned carefully, saw that their plan was good, and saw that they would be obeyed-that is, that their plan would work.

Again, there is no statement that fish or fowl were actually placed in the waters and in the atmosphere of the earth at that time.

4:24-31. "And the Gods prepared the earth to bring forth the living creature after his kind, cattle and creeping things, and beasts of the earth after their kind; and it was so, as they had said.

"And the Gods organized the earth to bring forth the beasts after their kind, and cattle after their kind, and every thing that creepeth upon the earth after its kind; and the Gods saw they would obey.

"And the Gods took counsel among themselves and said: Let us go down and form man in our image, after our likeness; and we will give them dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth.

"So the Gods went down to organize man in their own image, in the image of the Gods to form they him, male and female to form they them.

"And the Gods said: We will bless them. And the Gods said: We will cause them to be fruitful and multiply, and replenish the earth, and subdue it, and to have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth.

"And the Gods said: Behold, we will give them every herb bearing seed that shall come upon the face of all the earth, and every tree which shall have fruit upon it; yea, the fruit of the tree yielding seed to them we will give it; it shall be for their meat.

"And to every beast of the earth, and to every fowl of the air, and to every thing that creepeth upon the earth, behold, we will give them life, and also we will give to them every green herb for meat, and all these things shall be thus organized.

"And the Gods said: We will do everything that we have said, and organize them; and behold, they shall be very obedient. And it came to pass that it was from evening until morning they called night; and it came to pass that it was from morning until evening that they called day; and they numbered the sixth time."

Again, the Gods prepared the earth for future life, this time for land animals. Again, there was much counseling and planning, much description of the ecological balances that would exist, both man and beast being given every herb and the fruit of trees for food, for meat. As in Moses' account, there is no indication that some animals would be carnivorous.

Animals were to be given the gift of life. And the Gods planned to go down and organize man and to cause him to be fruitful and to multiply, having dominion over the other organisms on the earth. They reiterate the soundness of their plan, knowing that it will function, that living things shall be obedient to the laws of life. Yet in all this planning and preparing, there is no statement that life was actually placed upon the earth, neither animal life nor man.

The Seventh Time: Biological Creation

The fifth chapter of Abraham is concerned exclusively with the seventh time of creation. All the preparations have been made; everything has been carefully planned. Councils have been held, and decisions have been arrived at. The divine engineering has been accomplished. The laws of biology-the laws of life-have been carefully worked out, based upon the laws of interacting atoms: physics

and chemistry. This has been done so carefully that the Gods know they will be obeyed, that their engineering will work. Now it is time to put these plans into operation.

5:1-5. "And thus we will finish the heavens and the earth, and all the hosts of them.

"And the Gods said among themselves: On the seventh time we will end our work, which we have counseled; and we will rest on the seventh time from all our work which we have counseled.

"And the Gods concluded upon the seventh time, because that on the seventh time they would rest from all their works which they (the Gods) counseled among themselves to form; and sanctified it. And thus were their decisions at the time that they counseled among themselves to form the heavens and the earth.

"And the Gods came down and formed these the generations of the heavens and of the earth, when they were formed in the day that the Gods formed the earth and the heavens,

"According to all that which they had said concerning every plant of the field before it was in the earth, and every herb of the field before it grew; for the Gods had not caused it to rain upon the earth when they counseled to do them, and had not formed a man to till the ground."

Now the Gods actually put into effect the plans and decisions they had previously made. They came down to earth to carry out their plans about the plants of the field. Here is Abraham's solution to the problem of the "two accounts." There is no mention of a previous spiritual creation, only a planning and preparation of the earth. Now, on the seventh time, the plans of creation are actually to be realized.

In both Moses and Abraham, there is a clear statement that it had not yet rained on the earth. This is a perplexing statement. Does it imply that temperatures had been too high up to this time to permit condensation? Or that the temperature profile of the atmosphere was inverted so that moist air could not rise to form clouds? A scientific understanding of this statement just might open the entire creation story to our comprehension.

5:6-7. "But there went up a mist from the earth, and watered the whole face of the ground.

"And the Gods formed man from the dust of the ground, and took his spirit (that is, the man's spirit), and put it into him; and breathed into his nostrils the breath of life, and man became a living soul."

Here was the creation of temporal man from the dust of the earth. Abraham does not emphasize that man was the first flesh, as does Moses, but man is mentioned first in the temporal creation of things. Again we must remember that this was the man Adam and not mankind. Eve is yet to come.

Note the emphasis upon man being created from the dust of the earth. The early brethren (especially Brigham Young) taught that Adam was brought here from another planet. This appears to be in conflict with the scriptural statement that Adam was "formed from the dust of the ground," but there may be some subtle way to reconcile the two ideas. Was Adam brought here in some embryonic form, using the substance of this earth to grow to maturity?

No clear-cut statement of man's spiritual creation is mentioned at this point in the account, but then that is hardly necessary, since Abraham 3 presents such a clear picture of man's preexistence as intelligence and in the first estate. It is simply mentioned that man's pre-existent spirit was placed into his earthly body.

5:8-10. "And the Gods planted a garden, eastward in Eden, and there they put the man, whose spirit they had put into the body which they had formed.

"And out of the ground made the Gods to grow every tree that is pleasant to the sight and good for food; the tree of life, also, in the midst of the garden, and the tree of knowledge of good and evil.

"There was a river running out of Eden, to water the garden, and from thence it was parted and became into four heads."

So plants were planted in the garden. As mentioned earlier, seeds may have been brought from other planets. In any case, the placing of plants on earth had been carefully planned as early as the third time of creation. Note that the rivers are not named as they are in the other account.

5:11-13. "And the Gods took the man and put him in the Garden of Eden, to dress it and to keep it.

"And the Gods commanded the man, saying: Of every tree of the garden thou mayest freely eat,

"But of the tree of knowledge of good and evil, thou shalt not eat of it; for in the time that thou eatest thereof, thou shalt surely die. Now I, Abraham, saw that it was after the Lord's time, which was after the time of Kolob; for as yet the Gods had not appointed unto Adam his reckoning."

Adam was told that if he partook of the tree of knowledge of good and evil, he would die, and it was made clear to Abraham that this was one of the Lord's times, presumably a "revolution" of Kolob and equal to a thousand years on earth. Adam did die at the age of 930.

Many literalist writers in the Church deduce from this statement that each of the times of creation was also equal to a thousand years, or one of the Lord's times. Certainly this is a logical conclusion. But if we are greatly troubled by the time element, we are probably not compelled to accept this conclusion. In the most literal sense, the statement of time refers only to Adam's dying in one of the Lord's times after he partook of the fruit. It is not explicitly stated that the times of creation were also each equal to the times of Kolob. On the other hand, in each of the times there is a specific reference to "from the evening until the morning" and "from the morning until the evening." Does this refer to the "revolutions" of Kolob?

5:14-19. "And the Gods said: Let us make an help meet for the man, for it is not good that the man should be alone, therefore we will form an help meet for him.

"And the Gods caused a deep sleep to fall upon Adam; and he slept, and they took one of his ribs, and closed up the flesh in the stead thereof;

"And of the rib which the Gods had taken from man, formed they a woman, and brought her unto the man.

"And Adam said: This was bone of my bones, and flesh of my flesh; now she shall be called Woman, because she was taken out of man;

"Therefore shall a man leave his father and his mother, and shall cleave unto his wife, and they shall be one flesh.

"And they were both naked, the man and his wife, and were not ashamed."

In this account, the creation of Eve is mentioned before the creation of the animals, although the situation is reversed in Moses. (There the order is justified by indicating that even though animals had been created, a suitable help meet for Adam was still not available-lions, horses, and elephants are all right as companions, but they can hardly take the place of a woman!) The fact that the order of things is reversed in the two accounts could mean that one account or the other is in error (which would open the door to speculation), or it may imply that except for man, creation of plants, animals, and Eve did not follow a sequential order but may have occurred simultaneously. Moses clearly states that the man Adam was first, but beyond this, perhaps there is no order to the creation of things: plants and animals were placed on earth, and sometime during all this, Eve was created.

5:20-21. "And out of the ground the Gods formed every beast of the field, and every fowl of the air, and brought them unto Adam to see what he would call them; and whatsoever Adam called every living creature, that should be the name thereof.

"And Adam gave names to all cattle, to the fowl of the air, to every beast of the field; and for Adam, there was found an help meet for him."

Here is the creation of animals, again out of the ground. What about Adam's naming of these animals? Does this mean that Adam was taking part in the formulation of language? Or is there a deeper meaning; namely, that Adam was a participant in creation? (See discussion in chapter 6.)

Some Implications of the Scriptural Accounts of Creation

The creation accounts of Moses and Abraham differ in several significant ways but are nevertheless not difficult to reconcile with each other. Moses describes six creation periods, stating that plants were created during the third period and animals and man during the fifth and sixth periods. Then we are told that every plant had been created before it grew and that all the children of men had been created in heaven, but that at the beginning of the seventh period there was not yet a man to till the ground, nor had it rained. Apparently, the reference to the creation of plants, animals, and man was a reference to their spiritual creation in heaven.

Abraham emphasizes a different aspect of the story; namely, the preparation of the earth for the ultimate reception of plants and animals and the planning or biological engineering that would be necessary to place these plants and animals on earth. Abraham tells us that on the seventh time, the Gods came to earth to carry out the remainder of their plan, creating man from the ground, placing plants in a garden, creating animals from the ground, and forming Eve from one of Adam's ribs. They also rested on this seventh time after completing their work, and they sanctified the seventh time. This concept of biological creation on the seventh time is born out by revelation to Joseph Smith as follows: "We are to understand that as God made the world in six days, and on the seventh day he finished his work, and sanctified it, and also formed man out of the dust of the earth, even so. . . ." (D&C 77:12.)

So there is no conflict between the accounts of Moses and Abraham. One describes a spiritual creation of life on the third, fifth, and sixth days; the other describes preparations and planning for biological creation, these occurring at the same times as their counterparts in spiritual creation.

This is fine, but two problems remain. First, it is extremely difficult to reconcile such a story with current theories of science, which have life originating early in the earth's history-certainly not in the last one-seventh of the earth's time (unless "life" means only multicellular organisms with true nuclei in their cells; these did appear only during the last one-seventh-plants and animals almost simultaneously). Up to this point, we have simply tried to look at the scriptural accounts as carefully as possible, not worrying much about potential conflicts with science. Soon, in Section III,

we shall examine some findings of science, finally returning in Section IV to a comparison of the creation accounts with what science has learned.

Second is the extent to which Latter-day Saint authors seem to disagree on what the creation accounts of Moses and Abraham actually say. Some take a literal approach to the stories, much as I have done (or even more so); others emphasize the discoveries of science and view the scriptural accounts as being mostly symbolic.

There is also a third problem: A creation story is presented as part of the temple ceremony. This cannot be considered outside the temple, but those familiar with the ceremony may be aware of certain conflicts, though the ceremony is often extremely illuminating. The conflicts mostly have to do with timing-but time sequences are not clear in the ceremony anyway.

The writings of other LDS authors sometimes trouble me in two ways: when they are too literal and when they are not literal enough. On the one hand, it is suggested (e.g., by Joseph Fielding Smith) that the statement that man was the first flesh (Moses 3:7) really means that man was the first mortal. For me, this is not being literal enough. I wish I could accept it, because it would lessen the conflicts with science. But as I read the words over and over and in their proper context (including D&C 77:12, which speaks of man being created on the seventh day), they just don't say to me that man was the first mortal. If that were the intent, it would have been simple for the Lord to make it clear (although he does speak to us "in parables"). I am also unimpressed by the suggestion that the statements relating to the events of the seventh day are really postscripts meant to apply to the sixth day. Again, the Lord could have said it that way, and again there is D&C 77:12.

On the other hand, authors are too literal for me when they consider every word that the early Church authorities said about creation to be true but seem to think that science has learned nothing of geology, paleontology, biology, cosmology, etc. They accept without question suggestions that Adam and Eve and plants and animals were brought from another planet, that the light bathing the earth on the second day emanated directly from God, that the earth fell from the vicinity of Kolob, and so on. I love to study these statements of the early brethren. They excite me and they expand my mind. They demonstrate the far-reaching, probing, inspired minds of those men. They show how much the early elders were influenced by some of the finest scientific minds of their day. But since they sometimes conflict with each other, with the scriptures perhaps, and certainly with a more modern science, I don't see why we should insist on being conservative about those liberal (in the best sense of the word) statements of earlier years, even though they may contain a great deal of truth.

It is up to the reader to decide what to do about this situation. I have tried merely to look as directly and literally as possible at the scriptural accounts, making an effort not to reinterpret what is stated-even though this may be virtually impossible and certainly poses some serious problems for a scientific reconciliation. At this stage of our ignorance, it seems reasonable to assume that if the revealed accounts diverge from the theories of science-or from the statements of General Authorities-then it is safest to stick with the revealed accounts. Perhaps for the moment we will simply have to admit that the answers are not available and that reconciliations cannot be made. Although various General Authorities have taken various stands, the official position of the Church has always been that we must not take an official position. For comfort, we can remember the Lord's promise that when he returns, he will reveal "things of the earth, by which it was made, and the purpose and the end thereof." (D&C 101:33.)

Footnotes

1. For example, Brigham Young in Journal of Discourses, 17:143 and 9:317, and John Taylor, The Mormon, August 29, 1857.

2. See Journal of Discourses, 7:285-86; 11:122.
3. Examples of these authors and their approaches include the following:
Melvin A. Cook and M. Garfield Cook, Science and Mormonism (Salt Lake City: Deseret Book Co., 1973). Two scientists who are strictly literalists; contains an excellent summary of what twenty-nine Mormon scientists and scholars and nine presidents of the Church have said about creation.
Henry Eyring, The Faith of a Scientist (Salt Lake City: Bookcraft, 1969). Accepts an ancient earth and other scientific findings.
Paul R. Green, comp., Science and Your Faith in God (Salt Lake City: Bookcraft, 1958). Includes statements by the following Latter-day Saint scientists who are not literalists: Henry Eyring, Carl J. Christensen, Harvey Fletcher, Joseph F. Merrill, Frederick J. Pack, John A. Widtsoe, Franklin S. Harris, Sr.
Milton R. Hunter, Pearl of Great Price Commentary (Salt Lake City: Bookcraft, 1965). A brief, literalist discussion; emphasizes that Abraham's record of the six days is concerned with planning.
Bruce R. McConkie, Mormon Doctrine (Salt Lake City: Bookcraft, 1966). A totally literalist approach; no reconciliation with science.
B. H. Roberts, The Gospel: An Exposition of Its First Principles and Man's Relationship to Deity (Salt Lake City: Deseret Book Co., 1965). Comments that indicate a subdued attempt to reconcile science and religion.
W. Cleon Skousen, The First 2,000 Years (Salt Lake City: Bookcraft, 1953). Quotes early brethren but emphasizes that much is not known.
Joseph Fielding Smith, Man, His Origin and Destiny (Salt Lake City: Deseret Book Co., 1954). The modern spokesman for the literalist-and against science.
4. James E. Talmage, The House of the Lord (Salt Lake City: Deseret Book Co., 1976), p. 83.

Section 3:
The Earth and the Universe

". . . I will show thee the workmanship of mine hands . . ."

Moses 1:4

9
The Solar System

Through Moses and Abraham, God gave us a glimpse of his creations. The worlds are innumerable unto man, yet numbered to God. As one earth with its heavens passes away by the word of his power, another comes into being, that man might have immortality and eternal life. Among the governing stars is Kolob, which governs our system and is closest to God's throne. The Lord God is more intelligent than all the spirits.

Yet beautiful as this awe-inspiring revealed message is, it is general in almost every way. No one could construct detailed pictures of the universe from these revealed concepts. However, a relatively detailed picture of the universe has become available to mankind, beginning with Copernicus and Galileo, and coming into especially sharp focus during the past half century-particularly during the past decade or so.

This is the dispensation of the fulness of times when all things are to be revealed to man. Must we believe that this knowledge will come only through the prophets? God has admonished us to study, to be anxiously engaged in a good cause, and to ponder in our hearts. (See D&C 58:27; 88:62, 78-80.) With this approach, men in and out of the Church have been discovering truths about the universe and about creation. God has told us that in the dispensation of the fulness of times nothing would be withheld, including the facts of astronomy: " . . . the sun, moon, or stars-All the times of

their revolutions . . . and all their glories, laws, and set times, shall be revealed. . . ." (See D&C 121:28-32.) Many of these things are now known, and new facts are being discovered at a dizzying pace. It seems apparent that God is revealing these scientific matters in the dispensation of the fulness of times via inspiration (seldom recognized as such) to scientists who are pursuing an almost passionate search for these truths.

In this and the next four chapters, we shall review some of the findings of science. We shall briefly examine the universe (astronomy), the earth (geology), some principles of life function (biology), and the modern theories of genetics and evolution that seem to have bearing on the problems of creation. Some general references to material on these subjects, mostly text-books, are included in the Bibliography.

In this chapter we shall examine the development of knowledge about the structure of the solar system. Such an examination shows that science has been going on at least since the ancient Greeks. (Although the method was formalized only in the 1600s by Galileo and especially by Francis Bacon, note the word science in the Bible: Daniel 1:4 and 1 Timothy 6:20.) This story also illustrates the scientific method and how science does what it claims to do: to continue to approach a more exact understanding of reality.

The Flat Earth under the Blue Dome

Imagine how early men must have wondered about the universe as they watched the sun move overhead during the day and the stars and the moon at night. The earth appeared vast, immobile, and quite flat. Above was a huge dome, apparently a sphere that rotated on its north-south axis, making a little more than one complete circuit around the earth each day.

This sphere was sprinkled with fixed stars forming patterns, the constellations. There were also seven lights that wandered among the fixed stars on a fairly narrow path, called the Zodiac, with its center tilted 23.5 degrees to the equator of the celestial sphere. The sun, the brightest of these seven lights, moved exactly along the center of this path, and its pathway was called the ecliptic. The year was defined as the time that the sun took to complete one full circuit among the stars and along the ecliptic. The moon made its complete circuit in about 29.5 days, and the five planets, Mercury, Venus, Mars, Jupiter, and Saturn, completed their circuits in various intervals of time, depending upon the planet. All these things, including the 23.5 degree tilt of an ecliptic to the equator, were observed by ancient man and could be observed by anyone today with no instruments except a protractor that divided the circle into 360 degrees.

But what did it all mean? Having the objective data, it was now up to ancient man to apply the logic. This he did, concluding that everything was just as it looked (certainly the simplest conclusion): The earth was huge, flat, and solid, and the stars were on some kind of huge crystal sphere called the firmament. Perhaps water on the other side of this crystal accounted for the daytime blue color. Seven of the lights on the firmament apparently moved on its surface, and the sun was such a bright light that it obscured the stars, although even ancient man realized that they must be present in the daytime sky.

Of course, ancient man, in addition to his logic, indulged in much creative invention and mysticism. One of his indulgences was astrology. He imagined that the celestial bodies influenced one's life. The position of the sun among the constellations at the time of birth was especially important, although the positions of the planets also somehow influenced the newborn in some way. Clearly, there were no objective data to support all this, but most people, during most of history, have never let this situation bother them much. In any case, astrology was extremely important to the developing science of astronomy, because it became important to predict the positions of the wandering planets. Astronomy was also furthered because of man's need to measure and

understand time, particularly as his agricultural practices (planting times) became more sophisticated.

A Round Earth Within a Celestial Sphere

The Greeks began to extend the objective data by making measurements. They also formalized the processes of logic, but they ended by putting too much emphasis on the logic and too little on the measurements.

From the earliest times, the Greeks understood that the earth was round. Aristotle, who lived from 384 to 322 B.C., summarized the arguments. Some were subjective and based upon mysticism, but the following three were logical and based upon objective data. First, Aristotle understood the phases of the moon and eclipses, as shown in Fig. 9-1. From this model, it was not difficult to imagine that the moon was a sphere and that its apparent shape was determined by the portion illuminated by sunlight. This implied a round earth at the center of the celestial sphere, and Aristotle's second evidence was that, during an eclipse of the moon, the earth's shadow on the moon was round. Third, as one moves north, the stars visible on the southern horizon drop out of sight. Since the surface of the celestial sphere is so far away, the earth must be round to account for this observation.

Aristotle rejected the idea that the earth moved around the sun. He reasoned that if the earth moved that much in the course of each year, surely it would cause the apparent positions of the stars to change throughout the year, as the positions of objects in a distant scene appear to change as the observer changes his position (a phenomenon known as parallax). Since there was no annual stellar parallax, the earth must be stationary in relation to the celestial sphere. Of course, it was possible that the stars were extremely far away, but this seemed unlikely. Yet Aristarchus of Samos (writing around 320 to 310 B.C.) decided that the earth did go around the sun and that the stars were indeed very far away. To him this model best accounted for the data. He also attempted to measure the relative distances to the moon and the sun in terms of the earth's diameter by observing their apparent sizes and the sizes of shadows during eclipses.

The Size of The Earth and Other Measurements

Eratosthenes of the Alexandrian school (276 to 195 or 196 B.C.) measured the size of the earth. He noted that at Syene in Egypt on the longest day of the year at noon, the sun fully illuminated the bottom of a deep well, and hence, it was exactly overhead. (Syene would thus be on the Tropic of Cancer, 23.5 degrees north of the earth's equator.) At the same time in Alexandria, 5,000 stadia north of Syene, the sun was not directly overhead but made an angle to the vertical of about 1/50th of a circle (7 degrees). If the sun's rays were parallel at Syene and Alexandria, then 5,000 stadia must be about 1/50th of the earth's circumference. If Eratosthenes used for his stadium one commonly used by the Greeks (equal to one-quarter of a mile-but we don't know for sure), then he came within 1 percent of the correct value for the earth's circumference. His approach is the principle upon which celestial navigation is based.

Hipparchus (160 to 127 B.C.) was one of the best of the Greek astronomers. He made numerous extremely careful measurements and invented or at least developed trigonometry. He measured the length of the year within six minutes. He was able to predict eclipses quite accurately. He determined that the sun appeared largest and thus came closest to the earth in winter, accounting for this by two models. In one, the sun went around the earth in a circular orbit, but the earth was not at the exact center of the circle. This model was called an eccentric. He also suggested that the sun was itself moving on a portable circle that had its center moving on a much larger circular orbit with the earth at its center. This model he called an epicycle. Either model accounted for the data equally well, but Hipparchus intuitively preferred the model of the eccentric, because it was simpler.

Ptolemy was the last great astronomer of Greek antiquity. He lived about 140 years after Christ, or 300 to 500 years after the Greek astronomers mentioned above. One of his notable achievements was to measure the distance from the earth to the moon by parallax or the change in angle of a line drawn from widely separate points on the earth's surface to a single point on the moon. This he did by measuring one line early in the evening and another several hours later after the earth (or the celestial sphere, as he thought) had turned a certain distance, and correcting for the moon's movement due to the daily rotation, as well as the moon's path on the ecliptic. Ptolemy deduced that the moon was 29.5 earth diameters from the surface of the earth. The true average value is about 30 earth diameters!

Retrograde Motion of the Superior Planets: the Ptolemic System

One of the main problems facing ancient astronomers concerned the so-called retrograde motion of the superior planets (those that did not stay relatively close to the sun: Mars, Jupiter, and Saturn). Most of the time, these planets move among the stars from west to east. Near the time of opposition, when a planet and the sun are on opposite sides of the earth, however, the planet appears for a while to move backwards; that is, from east to west. A sort of loop is formed in the sky if one plots the path of the planet among the fixed stars. How can we explain it?

Ptolemy constructed geometrically a model based upon Hipparchus' epicycles. If the planet moved on an epicycle, and the rate of movement of the epicycle were adjusted just right, then the planetary motion could be quite accurately predicted. To improve the accuracy of prediction, Ptolemy moved the earth slightly off center (on an eccentric). The planet did not move at a constant rate around the center of its circle but rather at a constant rate around another point opposite to the earth; that is, around another so-called equant (Fig. 9-2). With this complex geometry and the cumbersome Roman numerals (but not algebra), Ptolemy was able to predict the motions of the planets with a high degree of accuracy, making the astrologer's job that much easier.

Ptolemy recorded all this in the Almagast. Nowhere does he claim that his marvelously creative system of epicycles, eccentrics, and equants were a description of reality; rather, they simply provided an excellent model for prediction of planetary positions. Modern astronomers use algebraic equations in exactly the same way. During the Middle Ages, however, Ptolemy's models were accepted by the church as true descriptions of the universe. The scriptures were mingled with philosophy, and the church was thus set up to lose one of those arguments with science.

The Solar System: the Copernican System

From 1473 to 1543, Nicolas Copernicus lived in Poland. He did not make observations but was a mathematician who had the advantages of a good number system and algebra. In 1543, he published in De Revolutionibus his arguments for a universe in which the earth went around the sun. They were a triumph of creativity. His arguments, though perhaps not conclusive, were extremely disturbing to the scholars of his day. It had been argued, for example, that the earth must be stationary, or we would feel it moving around the sun. Copernicus showed that one wouldn't necessarily feel motion, and he argued that if the motion of the earth would tear it apart, the motion of the huge and much faster celestial sphere should certainly be catastrophic.

In his heliocentric system, he was able to account nicely for the retrograde motion of planets. He deduced that the planets nearest the sun must go faster than the ones farther away, and hence at opposition they tend to overtake the outer planets, causing them to appear to move backwards among the much more distant fixed stars (Fig. 9-2). He was also able to calculate the relative distances of the planets from the sun. This was simple for the inner (minor) planets and not too difficult for the outer (major) ones. It involved measuring the angular distances between the sun

and the planets at various times and applying a little trigonometry. (If you're interested, see the book by Abel in the Bibliography.)

Actually, Copernicus' system, based upon circular orbits for the planets around the sun, was not able to account for observed planetary motions as well as the Ptolemic system. To make it work as well, Copernicus incorporated the eccentrics and epicycles of Ptolemy!

Testing the Models: Tycho Brahe and Johannes Kepler
The Ptolemic or the Copernican models accounted equally well for the available observations. Tycho Brahe, usually called Tycho, provided the improved observational data required for further testing of the two hypotheses. Tycho was a Danish astronomer (1546-1601) who built an observatory in 1576 on the island of Hveen. For twenty years he made extremely accurate observations of planetary motions and other astronomical events. Although he did not have telescopes, his data were accurate within one minute of arc. (The full moon subtends an angle in the sky of about 1/2 degree or 30 minutes. One minute is about the limit of human vision.) Tycho determined the length of the year within one second.

In spite of these marvelous observations, he rejected the Copernican model. He was unable to measure any parallax of stars, although he thought he could measure some of their diameters as about two minutes of arc. (Actually this was only an illusion-all stars appear only as points of light, even in the largest telescopes; that is, they have no apparent diameter.) Tycho also interpreted certain biblical statements as refuting the idea of a moving earth. Toward the end of his life, he got in an argument with the Danish king and had to move to Prague, taking his observational data with him.

Johannes Kepler (1571-1630) was born in Germany and hired by Tycho at age twenty-nine, the year before Tycho's death. Kepler spent twenty-five years working with Tycho's data. He accepted the Copernican system and attempted to apply the data to it. He began with Mars, spending eight years examining one hypothesis after another to account for Mars' motion.

It was held by the church that only perpetual circular motion was worthy of God, but Kepler finally discarded this notion and tried an ellipse for the orbit of Mars. This worked extremely well. An important property of an ellipse is that from any point on the curve, the sum of the distances to two points inside the ellipse, called the foci of the ellipse, is the same. This is evident when one draws an ellipse by tying a string to two thumbtacks (the foci) and then pushing a pencil against the string.

Kepler found that if the sun was at one focus of the ellipse that described the orbit of Mars, then the speed of Mars around its orbit varied, being fastest when the planet was closest to the sun. He stated these observations as laws of planetary motion.

Actually, Kepler had tried earlier hypotheses that agreed with Tycho's data within about eight minutes of arc, but Kepler was convinced that Tycho's data were more accurate even than this. Kepler's laws accounted for Tycho's data on Mars within one minute of arc, the accuracy claimed by Tycho. Creative, extremely powerful logic and model-building had been applied to excellent objective data.

Further Testing of the Models: Galileo Galilei
Galileo Galilei (1564-1642), the Italian physicist, was the first really important scientist to emphasize observation over reasoning from basic postulates. Indeed, it is valid to date development of the modern scientific method from Galileo's experimental and creative approach to things. He formulated the law of inertia, which states that bodies tend to remain at rest or in

motion unless acted upon by an outside force. This could be applied to the planets in their orbits and to other cosmological questions. He performed numerous experiments on acceleration (by rolling balls down inclined planes) and on falling bodies. Aristotle had written that heavier bodies fall fastest. Galileo is said to have tested this from the Leaning Tower of Pisa and found it to be untrue. (Except for effects of wind resistance, bodies all fall at the same speed.)

In the 1590s Galileo accepted the Copernican hypothesis. It had been argued, for example, that objects would not remain on the earth if it were in motion. Galileo pointed out that when an object was dropped from the mast of a moving ship, it fell directly on the deck below because of its forward inertia. Hence, everything on earth would have the inertia of a moving earth and would not be swept off and left behind.

Galileo heard about telescopes and in 1609 developed the first one having practical astronomical value without ever having seen one. He finally constructed telescopes magnifying up to 30 diameters and used them to see the Copernican system in all its glory. In 1610 he published, in the Sidereal Messenger, five observations that were in close agreement with the Copernican solar system but not with the model of Ptolemy:

1. The Milky Way consisted of thousands of stars, each appearing as a point of light. This made it easier to accept the postulated tremendous distances of the fixed stars and the consequent lack of an annual stellar parallax.

2. Jupiter had four moons that moved with the planet and were not left behind, as opponents said would happen to our moon if the Copernican system were correct. And the very idea of a major planet having moons as the earth has a moon argued against the earth as the center of the universe.

3. Venus exhibited phases the same as those of the moon. When Venus was closest to earth, it was large and appeared as a crescent, exactly as predicted by the Copernican system. When it was farthest away from the earth, it appeared full and much smaller. According to the system of Ptolemy, Venus was always closer to the earth than the sun (Fig. 9-2), so it would always appear as a crescent. Here logic predicted a clear-cut test between the two systems, and the Copernican model was supported while the Ptolemic model failed completely.

4. Galileo saw craters, valleys, and mountains on the moon. Since the same kinds of features were known on the earth, he argued that the earth was a planet similar to the others, and not the center of the universe.

5. Galileo observed spots on the sun (the celestial body had "blemishes!") that moved as though the sun were a rotating sphere. He showed that the sun makes a complete revolution in a little over a month, an observation that again seemed more compatible with the Copernican system of celestial spheres rotating in their orbits.

Galileo wrote his Dialogue on the Great World Systems in Italian rather than in Latin. It was a magnificent and unanswerable argument for the Copernican system, meriting its placement on the Catholic index of prohibited books, where it remained until 1835. Galileo was forced to plead guilty to heresy and to deny his teachings. He was placed under house arrest for the last ten years of his life.

Newton's Laws: Refining the Model

Isaac Newton (1643-1727) was born in Lincolnshire, England, the year after Galileo's death. Perhaps Newton was the greatest genius who ever lived. He had worked out most of his understanding of

cosmology by age twenty-four, but principally for his own amusement. It was published twenty years later in 1687 at the urging of his friends under the title Philosophiae Naturalis Principia Mathematica. This is possibly the most important scientific document ever published, for it tied everything together. The Copernican system was a description of the solar system and not an explanation of what was happening. This Newton provided. As an initial basis for his mathematical explanation of the universe, Newton formulated the three laws of motion:

1. Inertia. Newton stated that the property of a body giving it inertia (as stated by Galileo) is its mass. By convention, mass is taken as being equal to weight at sea level on earth, although in space the weight is gone, but the mass remains. Bodies having inertia tend to remain at rest or in motion; that is, to resist change. The inertia of a body in motion is equal to its momentum, which Newton defined as being equal to the mass times the velocity. As Newton restated his first law: Momentum is conserved.

2. Force. If a force acts on a body, it produces a change in the momentum of the body in the direction of the applied force. The magnitude of the force determines the rate at which it produces a change in momentum, and this rate of change is called acceleration. The Force (F) is equal to the mass (m) times the acceleration (a): F = ma.

3. Reaction. All forces occur in pairs. Any force in one direction has an equal force in the opposite direction. This is the law upon which rocket propulsion operates. As force is exerted to expel a propellent from the nozzle of the rocket in one direction, an equal and opposite force propels the rocket in the opposite direction.

Newton (and others independently) derived a mathematical equation for centripetal force. Centripetal force causes the tension on a string that is whirling an object. The momentum of the whirling object tends to make it go in a straight line, but the centripetal force (tension on the string) holds it to the center so that it goes in a circle. What about the planetary orbits? Galileo had argued that the planets remain in motion because of their inertia, but he didn't worry about why their orbits are nearly circles instead of straight lines as inertia would suggest.

Newton discovered the answer to the question of planetary circular orbits in his law of universal gravitation. He wondered about the force on an apple pulling it toward the center of the earth. Is the apple also pulling on the earth? If this force extends to the moon (the earth and the moon pull on each other), then it might provide the centripetal force required to keep the moon in orbit. Newton formulated a simple mathematical statement of the law of universal gravitation. This says that the gravitational force (F) is proportional to the product of the masses of two mutually attracting objects (m1 and m2) and that it is inversely proportional to the square of the distance (d) between them. His equation also includes a proportionality constant (G) that depends upon the units of mass, distance, and force:

$F = G (m1m2/d2)$

One problem worried Newton. If all bodies mutually attract each other by the gravitational force, then each portion of the earth is pulling upon the apple, yet the apple falls toward the center. To solve the problem of the direction of force, combining all forces from all portions of the earth pulling on the apple, Newton invented the calculus. (This mathematical procedure was derived independently and simultaneously by Gottfried Wilhelm Leibniz in Germany.) By application of the calculus, Newton found that gravitation acted as if all the mass were concentrated at a point called the center of gravity, which in the case of the earth was the center of the earth.

To test the law of universal gravitation as it applied in the solar system, it was necessary to know the gravitational constant (G). Newton compared the effect of the earth's gravity on the apple with its effect on the moon. At the earth's surface, when the apple is dropped, it accelerates 32 ft/sec2. The law of gravitation predicts that because the moon is 60 times farther from the center of the earth than an apple on its surface, its acceleration should be 60 2 times less. It is relatively simple, using the equation for centripetal force, to calculate the acceleration of the earth on the moon required to provide the exact centripetal force necessary to maintain the moon's orbit. When this calculation is performed, the answer turns out exactly as predicted: It is 60 2 times less than the acceleration at the earth's surface. (At the moon it is 0.0089 ft/sec2.) This calculation was extended to the orbits of all of the planets and found to hold exactly in every case. Thus, the mathematical model of universal gravitation was upheld by observational data.

Newton was able to derive all of Kepler's laws of planetary motion from his general laws of motion, centripetal force, and universal gravitation. So by 1687 everything had fallen into place. The Copernican system, as corrected by Kepler (ellipses rather than circles and epicycles) and as accounted for by Newton's laws, fit the observational data of Tycho, Galileo, and others so well that no previous model could any longer be considered.

Recent Developments
It is amazing how little has been added to our picture of solar system mechanics since that time nearly three hundred years ago. Two modern advances in physics have been relativity and quantum mechanics, which apparently account for phenomena occurring at extremely high velocities and small distances (within the atom). Newton's laws hold in all the usual circumstances.

A few other evidences for a round, rotating earth have been presented, such as the cyclonic storms mentioned in a footnote above (the Coriolis effect) and the Foucault pendulum. You'll remember that the law of inertia states that objects in motion continue in motion unless acted upon by an outside force. So you can imagine that the plane of a pendulum swinging above the north or south pole would appear to rotate 360 degrees in 24 hours as the earth rotated once under the swinging pendulum. The time for a complete rotation of the pendulum plane will be more than 24 hours at latitudes below the poles, but times can be exactly calculated assuming a rotating earth; the observations exactly match the calculations. Foucalt pendulums can be seen in many museums of natural history.

Distances between the earth and planets (but not the moon) were known only in terms of the astronomical unit (the average distance between the earth and the sun). The next step was to measure this unit in the terms used to measure the earth's diameter; that is, miles or kilometers. One way was to measure the parallax of Mars at opposition. The principle is the same as determining the distance to the moon by measuring its parallax. Of course, accurate telescopes are required to measure planetary parallaxes. Since the distance to Mars was known in terms of the astronomical unit, determining its distance in miles or kilometers allows us to calculate the astronomical unit in these terms. There are other ways. Most recently the astronomical unit has been determined by radar measurements of the distances to Mars or Venus.

Newton's Principia were elaborated into the science of celestial mechanics. This applies the laws of motion and gravity to calculate the trajectories and orbits of the various bodies in the solar system (planets, satellites, asteroids, comets, etc.). Application of celestial mechanics led to the discoveries of Neptune and Pluto. Now it can be applied in sending probes to the moon and planets, where it works exactly, providing the proof of the pudding. The problem with rockets and artificial satellites is in building equipment precise enough to calculate (with computers) the necessary angles and velocities and then to achieve them. It is the technology that limits us, not the theory of

celestial mechanics. In any case, our present space explorations confirm in the minutest detail the solar system model as worked out by Newton and his predecessors.

Footnotes
1. It was later shown that objects near the equator have more forward inertia than objects closer to the poles, since the equator is moving faster. Hence, as an object moves northward from the equator, it tends to be thrown toward the east, accounting for the counterclockwise motion of cyclonic storms in the northern hemisphere. This is called the Coriolis effect.

10
The Universe

How far is really far? How big is really big? How long is a really long time? People living at the time of the Pharaohs, when the Lord stretched out his hand in the night-time to show Abraham his creations, must have thought the sky-globe around the earth, on which the stars were hung and the sun, moon, and planets wandered, was incomprehensively large and far away. After all, it would take a man a hundred days to walk a thousand miles if he walked ten miles a day, or almost seven years to circle the globe. Since that time, the universe has been getting larger. Now it is truly incomprehensible in size, distance, and age. But the earth gets smaller.

A jet airplane, traveling 600 miles per hour, can circle the earth in a little over 41 hours, but an artificial satellite covers approximately the same distance in about 90 minutes. A telephoned message, going through the wires at the speed of light, circuits the earth nearly seven and a half times in a second, yet it takes light a full 8 1/3 minutes to reach earth from the sun-and nearly 5 1/2 hours to get to Pluto, a planet in our own solar system that is probably far more distant than anything the ancients could imagine. Yet compared to the nearest star, Pluto is almost within touching distance. The nearest star is nearly 7,000 times as far away as Pluto; it takes light 4.27 years to get to us from Proxima Centauri. The diameter of the Milky Way galaxy is over 23,000 times that distance. But to reach one of the most distant galaxies, the Milky Way's diameter must be multiplied 80,000 times, which is 4,700 billion billion (4,700,000,000,000,000,000,000) times the thousand miles a man might walk in 100 days! That's really far and really big. And the light speeding to us from that distant galaxy, going 186,000 miles each second, left about 8 billion years ago-which is almost 30 billion times the hundred days, a really long time. And some estimates are that the most distant quasar (see below) is 13 billion light years away.

We have only been aware of these truly incomprehensible numbers for a little over half a century. We arrived at them by studying parallaxes and by applying logic to objective data in unanticipated ways. Their discovery is a fascinating story.

Astronomy's Tools: the Telescope Camera and Spectroscope
The modern story of the universe beyond the solar system is so fantastic as to be almost unbelievable. Thus it is important to know something about the foundations of this story. In spite of many new technological advances, most discoveries about the universe have been made with three rather traditional tools, sometimes improved with modern electronics.

The most basic tool remains the telescope. Its primary function is to gather light. Consider that 640,000 times as much light will pass through an aperture 200 inches in diameter as will enter a human eye through an iris diaphragm with an opening of one-fourth inch. The light gathered by the telescope is focused by suitable lenses, allowing us to see things better.

Interestingly enough, however, there are relatively few things in the universe to be seen in the usual sense of the word. The telescope gives us marvelous visual images of the sun, the moon, the

planets and satellites of the solar system, comets, interstellar clouds, and galaxies, but mostly, the sky is full of stars, which appear only as points of light. No telescope has yet been built large enough to focus the image of a star so that it appears as a disc (except for one: our sun), although electronic methods applied in 1974 allowed us to visualize details on the face of the giant red sun, Betelgeuse. The value of the telescope is that it allows us to pinpoint a star's position with an accuracy much greater than would otherwise be possible, and it collects light from individual stars for us to analyze.

The second important instrument aids in gathering light for analysis: the camera. Actually, photographic film is the important "instrument," since the telescope plus a holder for the film form the camera. Because time exposures are required to provide images as bright as those observed with the eye, our continually moving atmosphere distorts the image, and photographs of the planets, comets, etc., seldom show as much detail as the eye can detect. Yet for the same reason, photographs of the galaxies show much more than the eye can detect. With a truly precision instrument, movement of the telescope can exactly compensate for movement of the earth so that exposures can extend for literally hours. This allows the film to build up an image until an extremely faint object that could not be detected by the eye becomes visible.

The camera is at least as valuable in helping to pinpoint positions as it is in giving us visual images. When the pinpoints of light from the stars are recorded on the glass photographic plate, and the telescope position is accurately noted, the ultimate potential of the telescope as a position-measuring device can be realized. Slight changes in position of one star can be detected by superimposing photographic plates taken at different times and matching up the stars whose positions have not changed.

The telescope and the camera are used as light-collecting devices for the third important instrument: the spectroscope. The real revolution in astronomy came when we learned to break light into its component wavelengths by use of the spectroscope, using a prism (as Newton did) or more recently a diffraction grating. When a beam of white light is passed through either kinds of spectroscope, the result is a rainbow or spectrum. The complete instrument used to record the spectrum on film is called a spectrograph.

It was observed that light included wavelengths not visible to the human eye. Temperatures produced by the various colors or wavelengths of light in a spectrum were measured. When the thermometer was placed beyond the red (long-wavelength) part of the spectrum into an area that appeared dark to the human eye, it still increased in temperature, indicating that radiation invisible to the human eye but capable of producing heat was contained in the original beam of light. This was referred to as infrared (beyond the red) radiation. The same phenomenon occurred on the violet (short-wavelength) end of the spectrum, and this was called ultraviolet radiation. We now know that the spectrum extends over a vast range of wavelengths, beginning with the extremely short cosmic rays, passing through X rays, ultraviolet rays, visible rays, infrared rays, and finally the extremely long radio rays. Of course, the cosmic, X-ray and radio radiation are not detected using prisms, but other means have been developed to study and measure them.

Another important discovery made with the spectroscope was that the spectrum of light is strongly dependent upon its source and the medium or media through which it passes. First, the spectrum is a function of the temperature of the source. All objects above the absolute zero are emitting radiation. An object at room temperature emits radiation primarily in the far infrared part of the spectrum. As the temperature of an object increases, the peak of its emitted radiation shifts toward shorter and shorter wavelengths. At the temperature of the filament in a glowing light bulb, the peak of an object's radiation is in the near infrared part of the spectrum, with about 25 percent of the radiation in the visible portion of the spectrum. The rather orange sun emits radiation with a

peak of energy in the green part of the spectrum, and still hotter objects such as a blue-white star emit with the peak of their energy in the blue part of the spectrum. Using this principle, one can measure the temperatures of celestial objects.

Radiation is also emitted in a highly specific way that is characteristic of the atom giving off the radiation (as in a mercury vapor lamp or a fluorescent tube). Thus a given atom will emit radiation at a number of highly specific wavelengths, these appearing in the spectrum as a set of highly characteristic, bright spectral lines, a sort of fingerprint of the atom.

On the other hand, when a beam of white light consisting of a continuous spectrum (rather than individual lines), such as that emitted from a high-temperature body like the sun, is passed through some medium-a gas or some transparent, although perhaps colored, liquid or solid-portions of the spectrum are absorbed. As it turns out, if a given atom will produce certain lines in a spectrum when it is excited, it will absorb those same lines when a continuous spectrum is passed through it, so that a set of dark lines is produced in the continuous spectrum.

Thus an astronomer can gather the light from a star with his telescope, pass it into his spectrograph, and record the results on photographic film or electronically. By examining the bright and the dark lines, he can tell what elements were present in the star and what elements and compounds were present in the atmospheres or interstellar gases through which the light from the star has passed. He can do celestial chemistry.

Even this is just a beginning. Spectral analysis makes it possible to measure relative motions of celestial objects. The principle is called the Doppler effect. We have all noticed how a train whistle has a high pitch as the train is approaching and a lower pitch after the train has passed by. This principle works also with light. When the light source is approaching, the waves are pushed together so that they have a shorter wavelength or a higher frequency; they appear more blue. A receding source produces longer wavelengths (lower frequency) that appear more red.

How do we know where the wavelengths were to begin with? When several lines are found spaced at highly characteristic intervals along the spectral scale, then these lines are identified as being emitted by a specific element. The lines of hydrogen, for example, are present in the spectra of most stars, since all stars contain hydrogen. (Some are too hot to show the hydrogen lines.) Calcium, sodium, and other lines also can usually be identified. When these lines are shifted in relation to their normal position in the spectrum, we know that the object is moving in relation to the earth. Since light travels very fast (186,000 miles/sec), when the Doppler effect is observed, the relative velocities of the emitting object and the earth must be very great, on the order of several miles/sec. As it turns out, virtually all objects in the universe are moving toward or away from the earth at such great velocities. Furthermore, if a star is rotating, one edge will be moving toward the earth, while another edge is moving away, resulting in a broadening of the spectral lines. Their breadth is a measure of the rate of rotation.

Clearly, much can be learned by analyzing radiation from celestial bodies. Polarization of light is another property of light that can be measured to gain knowledge about the universe (e.g., the presence of magnetic fields). Radiotelescopes have extended the part of the spectrum that can be analyzed. Satellites and deep space probes have allowed us to carry our instruments beyond the limitations imposed by the earth's atmosphere and sometimes within a few thousand miles of another planet or onto its surface, as the Viking space-craft landed on Mars on July 20, 1976. Such are the tools of modern astronomy.

Measuring Astronomical Distances

Using these tools, the astronomer has made a number of measurements upon which he has constructed our present picture of the universe. Primary among these measurements is the measurement of distance.

You'll remember that a primary argument against the Copernican system was that the relative positions of the stars remain constant, and that this could only be true if they were at extremely great distances, since the distance the earth moved around the sun was itself great. Now, with powerful telescopes mounted on solid mounts and moved by precision mechanisms, we measure parallaxes by recording on film the position of a given star among its background of even more distant stars at one time and then compare this position six months later when the earth has moved halfway around its orbit.

Distances only to relatively close stars can be measured this way, but in 1912, Henrietta S. Leavitt, working with Harlow Shapley, made a most interesting correlation. To begin with, the brightness of a star depends upon its distance; the farther away, the dimmer it will be. So if we knew the absolute brightness of a star, we could measure its apparent brightness and calculate its distance by the inverse square law (brightness is inversely proportional to the square of the distance). Miss Leavitt was studying a distant cluster of stars-so distant that it was safe to assume that all the stars in the cluster were at virtually the same distance from the earth. She noticed that many of the stars in this cluster varied in intensity in about 1 to 100 days, depending on the star. These were the so-called Cepheid variables (named after their prototype, the star Delta Cephei). She further noticed that the longer the period of fluctuation in brightness (the time in days), the greater the intensity of the star at its maximum brightness. The problem then was to know the distance of the star cluster so that absolute brightness of any of the stars could be calculated. Using estimates that we won't discuss here, Harlow Shapley, in about 1914, was able to plot a fairly accurate graph of Cepheid variable absolute magnitude (brightness) as a function of the period length.

Once this correlation had been made, we could assume that it applied to all Cepheid variable stars in the universe. Then when a Cepheid variable was observed, its period could be measured, giving an indication of its absolute brightness (working backwards from Shapley's graph), and its absolute brightness could then be compared with its apparent brightness to calculate its distance. This marvelous relationship allowed the measurement of distances for many stars and even galaxies in the universe. (Shapley's original graph was corrected in 1952 in terms of data obtained with the 200-inch telescope, which became operational around 1950. The corrections in the graph meant that distant objects were twice as far away as we had thought. The universe-in our minds-suddenly doubled in size!)

It has also been found that another kind of variable star, with a period shorter than the Cepheids (less than one day), is also valuable for distance measurement. All stars of this type (RR Lyrae variables) have the same absolute magnitude. So when one of them is found, measurement of its apparent magnitude immediately allows calculation of its distance.

In 1929, Edwin Hubble made still another important correlation. He observed that distant objects such as the galaxies were all receding from the earth, as indicated by the Doppler shift toward the red part of the spectrum. Furthermore, the farther they were away from the earth (indicated by their Cepheid variables), the faster they were receding. It is as though the entire universe is expanding-just as the seeds in a watermelon all recede from each other as the watermelon grows. If this generalization is true, then when an object is so far away that no Cepheid variable stars can be observed, we can still measure its red shift and calculate its distance by assuming that the more rapidly it is receding, the farther away it must be. This is the only method available to us at the moment to estimate the distances of very distant galaxies.

Although there are other ways to measure stellar distance, much is based upon assumption. We assume that all Cepheid variable stars in the universe have the same characteristic relationship between period and absolute magnitude, for example. We assume that we can make valid estimates of the amount of material distributed in space between the star and us that might change the apparent magnitude of one of these stars. Have we overlooked anything? The measurements based on the red shift seem particularly vulnerable. They are based on the assumption that the universe is really expanding, which assumption is supported only by the red shift-a nice bit of circular logic.

Discovery of the Universe

From 1738 to 1871, William and John Herschel, a father and son, had observed and catalogued 5,079 stellar "clouds" or nebulae. These were interpreted as literal clouds of interstellar gases or dust. One, the Andromeda nebula, is bright enough to be faintly visible to the unaided eye. In 1924 Edwin Hubble used the 100-inch Mount Wilson telescope, which became operational in 1918, to discover that Andromeda and some other large nebulae were not a mass of gases or vapors but consisted of individual stars (Fig. 10-1). He identified some Cepheid variables and calculated their distance as 800,000 light years. This strongly supported an idea suggested by Immanual Kant in 1775 but abandoned by more modern astronomers-that the nebulae were "island universes" of stars.

The idea was also strongly supported by the then recent discovery that our own Milky Way forms just such an island universe or galaxy. Several globular clusters of stars had already been observed, but these were much brighter than the stars in Andromeda and hence were apparently much closer. From 1914 to 1917, Harlow Shapley plotted the positions of 93 of them, determining the distances of Cepheid variable stars in the clusters. He proposed that these clusters formed the "bony frame" of a great galaxy (similar to the Andromeda galaxy) and of which our own sun was a part. Even a good pair of binoculars shows that the Milky Way consists of countless stars. Shapley suggested that these were the members of this great Milky Way galaxy, with our sun located in one of its arms-and thus not at the center of even our island universe.

Many studies since those of Shapley have defined the characteristics of our galaxy in some detail. It appears to be disc-shaped, probably with a bulge at the center. Numerous other galaxies with this form (including the galaxy in Andromeda) are now known in the universe. The edges of the disc are probably made up of great spiral arms of stars radiating out from the center. The diameter of the disc is about 80,000 to 100,000 light- years. Our sun occurs in one of the spiral arms, about 32,600 light-years from the center. As we look toward the center, the stars appear to be so close to each other, or interstellar material becomes so predominant, that we cannot see to the center or to the galaxies on the other side. In the last two decades, however, we have learned to "see" into and through the clouds of material by observing in the X-ray, infrared, and radio parts of the spectrum.

Actually, individual stars as well as many of the clusters in our galaxy form a sphere rather than a flattened disc. These outer stars and clusters form the corona, with a diameter two or three times that of the more dense, flattened disc. At the galactic center, there is a concentration of stars having a thickness of perhaps 10,000 to 15,000 light-years. In a given space at the galaxy's center, there are a million times as many stars as in a comparable space in the vicinity of our sun. If we lived on a planet there, our night sky would have a million stars as bright as the brightest star (Sirius) in our present night sky, giving 200 times as much light as the full moon.

Doppler measurements show that the stars of the galaxy are rotating in relation to the clusters. Our sun is out near the edge of the galactic disc and is apparently moving around the disc along with its neighbors at a velocity of about 200 to 300 km/sec. At this rate the sun's galactic year (the time of one complete revolution) is about 200 million earth years. If we wait half that time, we'll see the other side of the universe!

All this nicely confirms Abraham's astronomy lesson, adding a fantastic amount of detail not reported by Abraham. The earth-moon and the solar systems are indeed prototypes for the galaxy itself, just as Abraham was told. Is Kolob located somewhere at the center of the galaxy, governing by its gravitational forces and energy emanations the countless stars in our island universe? We don't know and may not know until it is revealed to us.

The galactic center is a source of fantastic quantities of energy. In this respect it is similar to the nuclei of other galaxies that have been observed. Furthermore, large quantities of gas, mostly hydrogen, are streaming out from the center of the galaxy. Apparently there is a ring or spiral arm of the gas that is rotating along with the galaxy but also moving away from the center and toward us with a velocity of 53 kilometers per second. A second arm on the far side of the galactic center is moving away from us at 135 kilometers per second. It is as though these masses of gas were expelled by a gigantic explosion of an object 100,000 times the size of the sun, consuming all the mass of 10 suns and converting it to energy. Or they may have had some as yet undreamed of origin. Inside the hydrogen arms are clouds of molecules forming a ring around the galactic center: ammonia, water vapor, carbon monoxide, formaldehyde, and others (some yet to be discovered). There are stars being born near the galactic center that produce powerful radio waves (and other forms of radiation) from their hot, ionized gases. Near the center there are also powerful infrared ("heat waves") sources. These would occur if a bright sun were surrounded with such dense gas and dust that no light escapes, but the dust, being heated by the sun, emits the infrared energy. Freeman Dyson has suggested that a super civilization might devise a way to surround their sun with some super sphere that could capture and use all the light (energy) from its sun to power its technology, the sphere then becoming a dark but powerful source of infrared radiation. Is this one of the activities of the Gods?

We cannot count the stars that we cannot see near the galactic center; they are "innumerable . . . unto man." (Moses 1:35; Abraham 3:12.) That they are numbered unto God (Moses 1:35, 37) should provide some appreciation of his majesty and power. Yet each globular cluster (the "boney frame") may have from 10,000 to 100,000 stars, and the total number of stars in the galaxy may be around 200 billion.

The Galaxies

Huge telescopes such as the 200-inch instrument on Mt. Palomar are able, using long time exposures, to provide photographic images of the distant galaxies. It is painstaking work to examine the sky in this manner. Only a minute portion can be observed at any one time, and the times are limited by cloudy skies. It could take over a thousand years to examine all the sky for galaxies using the 200-inch telescope. Nevertheless, based upon the work completed so far, we can estimate that there may be four billion galaxies within the range of the 200-inch telescope.

The galaxies appear to occur in groups. Our Milky Way and the Andromeda galaxy are in a group with about 21 members called (with a touch of irony) the local group. The assemblage is some three million light years in diameter. We do not see galaxies beyond the center of our own because of its density, but with this exception, the groups of galaxies appear to be fairly evenly distributed throughout the universe. The galaxies occur in four general categories of shapes: ellipticals, spirals, barred spirals, and irregulars. The names are fairly descriptive.

The farthest galaxies presently observed are on the order of five billion light-years away, although some quasars (see below) may be 10 to 13 billion light-years distant from us. This is based on the assumption that the farther away an object is, the more rapidly it appears to be receding from the earth and the greater its red shift. If a galaxy were receding from earth with the velocity of light, then the shift would be so great that the light would not reach us at all. According to Hubble's

estimates, this would happen when an object was about 10 billion light-years away. In principle, this sets a boundary to our observable universe.

It is interesting to realize that the above description cannot apply to the universe at this instant in time. We can only know the present on earth. If a star in the galaxy is 40,000 light-years away, we can only know where it was 40,000 years ago. A galaxy located five billion light-years from earth can be known only as it was five billion years ago, which was about the time our sun was born, according to current theories.

How much of this is God's universe? Is Kolob at the center of our galaxy, or is it one of the other galaxies or located at another galactic center? Does Elohim govern all the galaxies, populating all their worlds with his spirit children? Or will those children become Gods of other stars or clusters or galaxies that are now lifeless? We haven't the faintest shred of information pertaining to these questions.

The Birth and Death of Stars

The Lord told Moses: "And as one earth shall pass away, and the heavens thereof even so shall another come; and there is no end to my works, neither to my words." (Moses 1:38.) During the past few decades, astronomers have been learning about the birth and death of stars and, presumably, the "earths" that accompany them. Early in this century absolute star magnitudes (an indication of star size) were plotted as a function of star colors (a measure of temperature). The majority of stars fell along a curved diagonal known as the main sequence, on which the largest stars have the bluest color, and the smaller ones tend to be more red. This makes good sense. The larger the star, the greater the gravitational forces compressing its matter at the center, and hence the greater the pressures and temperatures that are generated. Thus, the large stars are the hottest and the bluest. Our sun proves to be a rather ordinary star about half-way along the main sequence.

During the past two or three decades, it has been possible to develop models of stellar evolution. The laws of nature-motion, gravity, relativity, radiation, convection, the interactions of basic particles, etc.-are expressed mathematically and incorporated into the models, which are then fed into computers. It becomes possible to follow mathematically what might happen as a vast cloud of interstellar hydrogen and other material condenses to form a central star with its planets, the star then evolving toward its final death. The different stages generated by the computer-processed models can be compared with observed stars in the real universe, thereby testing the models.

The first steps involve a slow condensation from huge interstellar clouds of material consisting of hydrogen and a small percentage of other elements. As condensation occurs, the temperature increases; when a star has formed at the center of a condensing cloud and its temperature reaches about 30 million degrees Fahrenheit, its hydrogen fires become ignited-thermonuclear fires in which hydrogen is converted to helium, similar to the explosion of a hydrogen bomb.

If the star is about the size of our sun, it is relatively unstable for the first few million years but then settles down to about a ten-billion-year lifespan on the main sequence. Our sun appears to be about halfway through that stage. Finally, when its hydrogen reserves at the core become exhausted, the outer layers begin to be consumed, and the luminosity increases to about four times today's level. Then, during the next 600 million years, the red giant structure begins to emerge. The star expands, and its surface temperature drops. Our sun in its red giant stage would probably engulf the orbits of Mercury, Venus, and the earth. Heat transfer from the core is decreased, so its temperature rises. When it reaches about 100 million degrees, helium nuclei combine to form heavier elements such as carbon, and a maximum red giant size is reached. Our sun will be about 5,000 times as luminous as it is now on the main sequence. Matter may be puffed off in shells for 50,000 years, forming a huge circular cloud called a planetary nebula. As the last of the helium

burning is complete, the star cools and contracts. Finally, it collapses to a white dwarf, occupying a volume about the same as our present earth. Matter is so compressed that a cubic inch of material from the white dwarf would weigh about 10 tons on the earth's surface. In spite of its high temperature, no more nuclear reactions are initiated, and it gradually cools by radiating heat into space until it becomes a black dwarf: a cold, dark, lifeless hulk of super-dense material.

A star having only about a third the mass of our sun would go through essentially the same history, but because it was smaller, its temperatures would be lower, hydrogen would burn more slowly, and it would remain as a red dwarf on the main sequence for 50 to 100 billion years. In its last stages, it would also be a small red giant, a white dwarf, and finally a black dwarf.

The larger stars have the most violent histories. They heat to higher temperatures to begin with, so hydrogen burning occurs much more rapidly. They remain on the main sequence for only about 100 million years, depending upon their size. In this condition, such a star may be about ten times the diameter of the sun and 10,000 times as luminous. When helium burning finally begins, the outer layers balloon into a red super giant 500 times the sun's present diameter. The core heats up to an incredible 600 million degrees, at which temperature carbon-the end product of helium burning-is consumed by nuclear processes, forming magnesium and other heavier elements. When the carbon runs out, collapse again occurs, and temperatures increase even more. Now many of the heavier elements are formed, but when iron is formed, a critical point is reached. The formation of iron actually absorbs heat rather than generates it, so that the core suddenly, within only hours, begins to cool; all the available heat is swallowed in the sudden production of iron.

The core collapses catastrophically, but this fantastic collapse generates immense amounts of explosive energy, ejecting material at 5,000 miles per second. As the outer parts of the expanding shell are ignited to enormous temperatures, the exploding star shines with the light of a billion suns and could be seen from neighboring galaxies. This is a super nova. One is expected to occur in our galaxy every 50-100 years. Present theory holds that the heavy elements formed at the last are thrown into space where they subsequently become parts of other clouds of material and, thus, parts of new solar systems. The elements in our earth upon which we depend for our technologies and even for our very lives (our bodies consist of them) would thus have been formed in the core of a super-giant star and then released in the super-nova explosion. We are children of the stars.

After the super nova, the material that has not been irreversibly thrown out into space begins to collapse to the white-dwarf stage, but since there is more mass (the star was much larger to begin with), gravitational collapse doesn't stop there. When the atomic particles get close enough together, they begin to interact in new ways. Protons combine with electrons to form neutrons. The final result is a neutron star consisting of matter so densely packed that it is completely beyond our experience or our imagination. A neutron star may have the mass of 10 to 20 times that of our sun compressed into a ball only 10 to 20 miles in diameter-rotating sometimes 100 times in a second and giving off pulsations of intense X rays and other radiant energies. (When neutron stars were first discovered, they were called pulsars.) Each super-condensed spoonful of material from a neutron star would weigh tens of millions of tons on the earth's surface.

But if the original star had a mass more than about 20 times that of the sun, collapse does not stop when neutrons are formed but continues until the star becomes a black hole-an object with such colossal gravitational forces that nothing can escape, not even light. If the matter in the earth were condensed until it became a black hole, it would occupy a volume about equal to that of a Ping-Pong ball!

Black holes have been the objects of considerable study during the past few years (less than a decade). There is reason to believe that huge black holes occur near the center of galaxies. Minute

black holes may have been formed at the time of the formation of the galaxy; some think they may be common in the universe. Some mathematical theories suggest that black holes might even lead one into another realm of space and time. It might be possible to enter (in a spaceship, presumably) a black hole that was hundreds of millions of miles across, gradually enough that the individual so entering would not be torn apart by uneven gravitational forces. If the black hole were rotating and the astronaut navigates his ship at just the right angle, instead of being drawn to oblivion at the hole's center, he might be flung to another region of time and space. But we would never know if he were successful: it would be impossible for him to return. Could this be the "outer darkness" mentioned in some scriptures such as D&C 101:91?

Of course, the theories presented above are extremely new and may well change. I have found several different versions while preparing these paragraphs. Yet there is evidence that many of the postulated stages (e.g., main sequence stars, red giants, white dwarfs, super giants, neutron stars, even black holes) actually exist in the universe. Nevertheless, things not presently known or assumptions not properly included in the models could upset the above sequences. For one thing, the models do not adequately account for the initial condensation from the interstellar cloud. Several "uncomfortable" assumptions must be made. Here, I like to imagine that the Gods might be in control. It is at these initial stages that suitable interventions in the course of events might have the greatest impact on the organization of future worlds-and for the least expenditure of energy.

Theories of stellar evolution are based on the idea that stars have a finite amount of hydrogen. The explanation in Figure 5 of Facscimile 2 in the book of Abraham suggests that the Egyptians said that the sun "borrowed" its light from Kolob. Clearly, the sun is not reflecting light from Kolob, as our moon is reflecting light from the sun. If this were the case, we should be receiving much more light from Kolob than we do from the sun. Cook and Cook have suggested that the statement can be understood according to a theory of accretion. Matter (mostly hydrogen) may be continually expelled from Kolob and captured by the sun, refueling its atomic fires and contributing kinetic energy as it falls into the sun. It's an interesting idea, but what we actually observe seems to be contrary: The solar wind consists of protons (hydrogen nuclei) flowing away from the sun rather than toward it.

Quasars

In the 1950s, many powerful radio sources were observed in the sky. Some of these sources looked exactly like stars, yet their spectra were unusual. In 1963, the spectral lines were finally identified for two of these so-called quasi-stellar radio sources or quasars. The lines were shifted so far toward the red part of the spectrum that the two objects were apparently receding from us at velocities 14.5 and 30 percent of the speed of light. Hence their red shifts indicated that these objects were on the order of billions of light years away. By now, well over a hundred quasars have been identified, and in 1973 one was calculated to be 10 to 13 billion light years away (depending upon the exact model of the universe used in the calculation).

Immediately upon their discovery, profound paradoxes became apparent. They seemed to be extremely small, appearing only as points of light, yet if they are at the calculated distances, they are radiating energy at rates 100 to 10,000 times that of an entire galaxy! Some vary in intensity with periods of one day to a year or so. It is impossible to imagine that an object with a diameter larger than about one light day could pulsate with a period shorter than a day; hence, at the largest, they can't be much larger than about twice the diameter of our own solar system-a mere pinpoint compared to galaxy dimensions. Such small objects emitting such fantastic amounts of energy differ by orders of magnitude from anything else known in the universe. How can these paradoxes be resolved?

Either the objects must be much closer than the red shifts seem to indicate (implying that we fail to understand the red shifts), or there must be physical laws that we fail to understand, or both. An early suggestion was that the red shift is some kind of gravitational effect: that photons of light leaving points of extremely high gravity are somehow slowed or de-energized. Another possibility is that the objects are much closer (and hence much less energetic) but moving away from us at high velocity for some unknown reason. Many quasars seem to be quite close to galaxies; that is, they appear associated on photographs, although the quasars could be much farther away from us than the galaxies. Could the quasars have been ejected from their "associated" galaxies? At least one case is known in which a portion of a galaxy connected to a parent galaxy by a stream of stars and interstellar material is moving away from us at a velocity about twice that of the galaxy itself. But if this is the explanation, why should all quasars be moving away from us and none of them toward us, as might be expected if the ejection from galaxies occurred randomly in all directions? Or are the quasars the "other side" of black holes that exist in some other realm of space and time? Does matter fall into a black hole and end up in a quasar in another universe? How does God control these celestial events to achieve his goals?

His Many Mansions

Christ said: "In my Father's house are many mansions." (John 14:2.) Furthermore, Paul spoke of different bodies in the resurrection, some being compared with the glory of the stars, others with that of the moon, others with that of the sun. (I Corinthians 15:40-52.) In section 76 of the Doctrine and Covenants is recorded a small portion of a vision of Joseph Smith and Sidney Rigdon in which they were shown the final state of resurrected beings. Those with telestial bodies (comparable to the glory of the stars as seen from earth) were to dwell in a place where God or Christ never come (D&C 76:76-78, 86-88), presumably on a telestial sphere; those with terrestrial bodies on a terrestrial sphere comparable to the glory of the moon; and those with celestial bodies on a celestial sphere comparable to the glory of the sun. We are told that telestial or terrestrial bodies can never go to the celestial glory. Apparently they won't be able to tolerate conditions there. The earth itself is to be prepared for celestial glory. (D&C 88:18; 130:9.) The implication of all this (and much more) is that there are many kinds of suns and planets in God's universe.

The findings of modern astronomy provide ample precedent for the great variety of celestial bodies implied by the scriptures. The suns along the main sequence vary in size, intensity, temperature, and color. There are also the white dwarfs, the red giants, and the super giants, not to mention pulsars, black holes, and quasars. Furthermore, planets could vary as much as or more than stars. If a planet is as close to its sun as Mercury, it will be hot; if distant (Mars to Pluto), cold. If its axis is tipped as with the earth or Mars, it will have seasons. If its orbit is highly elliptical (Mars), its seasons will be influenced. If its rate of rotation is slow (Venus or Mercury), then the days and nights will be long and the temperature extremes between them will be great. If the planet is as small as Mercury, it will not hold an atmosphere; if large, its atmosphere may be as dense and oppressive as Jupiter's. In short, when the Gods said, ". . . we will take of these materials, and we will make an earth whereon these may dwell" (Abraham 3:24), they were speaking of their future activities in planetary engineering. When the Gods prepare dwelling places for resurrected beings, they will again face the challenges of planetary design and construction.

Lastly, God promises that those who return to his presence with celestialized bodies may themselves become kings and queens, priests and priestesses, even gods and goddesses, being blessed with the riches of eternity, including even an eternal increase. (D&C 38:39; 76:50-70; 132:19-21.) Modern astronomy helps us to understand that there is ample space and material in the universe for the Lord to make good on these promises.

In spite of our recent insights, numerous questions remain. How many stars have planets? How many of these planets support life? How common is intelligent life: the other children of God? Not a single planet beyond our solar system has yet been viewed by man.

Someday we shall have the answers. Consider again, this time in detail, the Lord's description of the dispensation of the fulness of times: He speaks of "a time to come in the which nothing shall be withheld, whether there be one God or many gods, they shall be. . .

". . . revealed and set forth upon all who have endured valiantly for the gospel of Jesus Christ.

"And also, if there be bounds set to the heavens or to the seas, or to the dry land, or to the sun, moon, or stars-

"All the times of their revolutions, all the appointed days, months, and years, and all the days of their days, months, and years, and all their glories, laws, and set times, shall be revealed in the days of the dispensation of the fulness of times-

"According to that which was ordained in the midst of the Council of the Eternal God of all other gods before this world was, that should be reserved unto the finishing and the end thereof, when every man shall enter into his eternal presence and into his immortal rest." (D&C 121:28-32.)

Perhaps the time will come when Christ will meet with righteous learned men of the world, holding symposia and revealing knowledge of the universe. Then we shall know about creation and its bounds. But must we wait until then to know these things? Perhaps, to know them all. But now is the dispensation of the fulness of times ". . . in the which I will gather together in one all things, both which are in heaven, and which are on earth." (D&C 27:13.) We have seen that many of the things the Lord promised to reveal have already been discovered by modern astronomers (". . . times of their revolutions . . . appointed days . . . glories . . . laws . . ."). Is it such a surprising thought that God, prior to his coming in glory, might reveal these things during our dispensation by inspiring modern astronomers? And what a blessing to live now when it is possible to take part in this accretion of knowledge-or at least to enjoy its fruits!

What does all this mean to you and to me personally? Should it have any impact on our daily lives? Of course it can provide us with the joy of new knowledge. God delights in wisdom, and as his offspring, so do we. I have enjoyed preparing these astronomy chapters, and hopefully you have enjoyed reading them. But can they really teach us something about life?

When we learn about God and the manner in which he interacts with us, we are learning about life-about how we should live. The message of these astronomy chapters is that God clearly wants us to ponder and to be engaged in good causes of our own free will-to be exercising the gift of agency that he gave us. He knows we are curious about how the universe works and what it all means; he made us that way. And he wants us to apply the talents he gave us to discover these things on our own. He may inspire and subtly direct, but he doesn't outwardly intervene in our search for truth when we can find it on our own. The astronomy lessons given to Moses and Abraham were parables to help them (and us) understand things about God that they (or we) could never discover without his help. But we can learn a fantastic amount about astronomy on our own.

Doesn't this also apply to our daily lives? Should we expect God to solve our problems when we can solve them ourselves? Won't our efforts to find solutions bless us with growth and satisfaction? Let's pray for the guidance of God's Spirit, but then let's attack our problems with all the enthusiasm, intense thought, and concerted action that Harlow Shapley or Edwin Hubble must have used to find understanding of the universe. That's the real lesson of modern astronomy.

Footnotes

1. "Starspots on Betelguese," Astronomy 3 (October 1975): 18-21.

2. For relatively close stars in our galaxy, for example, analysis of spectral lines leads to an estimate of absolute magnitude. Distances of galaxies can be estimated by comparing their apparent diameters with those of similar but closer galaxies of "known" distance. Or absolute magnitudes of galaxies can be estimated based on their resemblance to known types.
3. R. H. Sanders and G. T. Wilson, "The Center of the Galaxy," Scientific American 230 (4): 67-77.
4. See, for example: Ben Bova, "What Chariots of Which Gods?" Astronomy 2 (August 1974): 4-18; Robert Jastrow, Red Giants and White Dwarfs (New York: Signet Book, American Library, 1969); Philip C. Peters, "Black Holes: New Horizons in Gravitational Theory," American Scientist 62 (1974): 575-83; Daniel J. Willens and Raymond P. Villard, "Black Holes-Gateway or Grave?" Astronomy 3 (February 1975): 7-15; Gerret L. Verschuur, "From Dust to Dust," Astronomy 3 (June 1975): 6-23.
5. Melvin A. Cook and Melvin G. Cook, Science and Mormonism (Salt Lake City: Deseret Book Co., 1967), pp. 41-49.
6. Donald Goldsmith, "The Quasar Dilemma," Astronomy 3 (September 1975): 18-25.

11
The Earth

An Oklahoma farmer has just finished preparing his fields for seeding. The soil has been plowed and harrowed, and it now lies moist, exposed to the elements. Black clouds are forming on the horizon. Soon these billowy, cumulus giants have moved over the farm, and it is beginning to rain. Within minutes, the scattered gentle drops have turned into a torrential downpour. Vast quantities of water are falling onto the surface of the land. Nearly all is absorbed at first, but soon the soil is saturated, and the runoff begins. Little rivulets are collecting into medium and then moderate size streams, carrying the soil along. Before it is all over, a miniature Grand Canyon, complete with tributaries, dissects the farmer's field.

A meandering river follows its tortuous course across a valley bottom. The water has its greatest momentum and hence its most efficient scouring power on the outside of the curves. Its flow rate is relatively slow on the inside, so mud is being deposited there. Thus the graceful bends become even larger until finally, perhaps at flood time, overflow occurs, the channel is straighter, and a large bend remains as an oxbow lake.

On the West Coast, the spring rains have been unusually intense. The soil along the coastal bluffs has finally reached the saturation point. A large segment of highway slips away into the ocean.

In 1954, a severe earthquake occurred near Fallon, Nevada. The result was a twelve-foot vertical face of newly exposed soil running for some distance along the base of a mountain range, which is now several feet higher relative to the valley.

A glacier in Alaska has been studied for decades. It is in motion, traversing a distance of two or three hundred feet each year. Vast quantities of crushed rock and other debris are expelled from the moving ice mass. Clearly the glacier is widening and deepening the canyon that it fills, scouring out basins and building up mountains of material along its exposed sides and at its end.

To the great surprise of a farmer, a volcanic eruption begins in a field in Mexico in 1943. Gas, debris, and finally molten lava are expelled. A mountain called Paricutin forms where the farmer once grew corn.

By studying such events and many others, it is not difficult to deduce that such processes, continuing over an immense span of time, might account for many of the earth's surface features. Such a deduction, refined during the early part of the nineteenth century, became the theory of uniformitarianism. It states that the present is the key to the past: that events going on now are representative of those that, continued over vast spans of time (millions to billions of years), shaped and formed the present earth.

God has told us little about how the earth was created. There is the statement that "there is space there, and we will take of these materials, and we will make an earth whereon these may dwell. . . ." (Abraham 3:24.) So the earth was "organized and formed" from preexisting materials, and "the earth, after it was formed, was empty and desolate. . . ." (Abraham 4:1-2.) The Spirit of the Gods brooded upon the face of the waters, and the earth was prepared and organized to bring forth grass and living creatures.

Important as these concepts are, they don't inform us about the rivers and plains, oceans and mountains, and other structural features that we see on the face of the earth. How were they formed? Did God direct the current geologic processes in a kind of uniformitarian creation, or did he shape the earth's features by directly applying forces as a sculptor works with clay? Did it all happen in seven 24-hour days of creation, seven 1,000-year creation periods, or gradually over an immense span of time, perhaps as long as 4.5 billion years?

Judging by the paucity of scriptural comments relating to these questions, one must deduce that the Lord expects us to seek answers for ourselves. He has instructed us: "Teach ye diligently . . . all things that pertain unto the kingdom of God, that are expedient for you to understand; Of things both in heaven and in the earth, and under the earth. . . ." (D&C 88:78-79.) He has promised that when Christ returns, he will explain to us about "things of the earth, by which it was made . . .- Things most precious, things that are above, and things that are beneath, things that are in the earth, and upon the earth, and in heaven." (D&C 101:33-34.)

For about the last two centuries, men and women have been intensively applying the scientific method to a study of "things in the earth, and under the earth," and they have been speculating about "things of the earth, by which it was made." Geology is the broadest of the earth sciences, concerned with all the questions posed above. The objective data upon which the science is based come from studies of the earth's surface, its mountains, plains, oceans, and other features; from drilling cores brought up from deep oil wells; and from other data such as earthquake shocks. Paleontology is a subscience of geology, concerned with the study of fossils. It attempts to understand the organisms that have lived on the earth.

The problem of reconciling God's word about creation with the findings and theories of science is mostly a problem of understanding the time intervals involved. Like other problems of science and religion, this is an important modern question exactly because no completely satisfying answers are available. There are ways to reconcile what God has said with the findings of geologists, as we shall see in section 4, but no one knows which is best or exactly how it all fits together. The creationists, scientists many of whom believe that the Genesis account of seven 24-hour periods of creation is literally true, emphasize that catastrophes, such as the flood, could bring about profound changes in short time intervals. But traditional geologists accept the doctrine of uniformitarianism. I will resist (although not completely) the temptation to get into that argument here, saving the viewpoints of the creationists for chapter 14. For now, let's look objectively and sympathetically at traditional geology and uniformitarianism. There is much to learn!

The Origin of the Earth and of Life

The most popular current theory suggests that the earth and all the planets were formed simultaneously with the sun by condensation and accretion in a vast cloud of interstellar material consisting of gas (mostly hydrogen, with some helium and the lighter elements) and some solid material. The sun and the planets all revolve in the same direction, and their orbits are in about the same plane, as if the primeval cloud were rotating. As it slowly contracted by gravitational force (attraction of all its atoms and molecules for each other), it rotated faster and tended to become flattened into a disk. Most of the materials were drawn to the center of this rotating cloud where they became the sun. The rest first condensed into smaller units (called protoplanets) and then finally into the planets and asteroids as we know them now. The planets originally swept up large quantities of the primeval hydrogen, helium, water vapor, and other gases.

Based upon the accretion hypothesis, biologists, astronomers, and geologists go on to speculate about the origin of life. The game plan is to assume that everything happened by chance-directed natural processes; that is, that God had no part in these events.

When the earth first formed, it was extremely hot, but heat was slowly lost by radiation into space. The gases of the atmosphere were, for the most part, the original gases of the interstellar cloud: hydrogen and helium with some other gases. Still other gases were released from the molten rocks (as from modern volcanoes): carbon dioxide, ammonia, methane, water vapor, etc. Hydrogen and helium molecules and atoms are too light to be held by the earth's gravity and would gradually escape into space, but while they were present in excess quantities, the hydrogen would react chemically with everything exposed on the earth's surface as well as with the other atoms and molecules in the atmosphere. All would become reduced, which is a chemical condition opposite to that of being oxidized (the present condition of the earth's surface and atmosphere). As the earth cooled, water would condense in torrential rains to form oceans.

Thus the primeval earth may have been covered by an ocean under a reducing atmosphere. There were many energy sources. Volcanoes and the earth itself, still cooling from its fiery beginning, would produce heat. The sun's radiation was then, as now, an important energy source. The gases of the primeval atmosphere did not absorb ultraviolet light, so this highly energetic form of radiation from the sun could penetrate to the earth's surface at intensities much higher than can penetrate today. Violent electrical storms would have been common.

It was suggested in the late 1940s that large quantities of energy released in a reducing atmosphere of hydrogen, methane, ammonia, carbon dioxide, carbon monoxide, hydrogen sulfide, and water vapor would result in the formation of many complex organic molecules. This was tested in the laboratory. Gases were mixed in proportions that might have been present in the primeval atmosphere, and energy in the form of electrical discharges, ultraviolet light, heat, etc., was put into the system. After hours to days or weeks, the resulting system was analyzed, and organic molecules of all kinds were found to be present. Amino acids, sugars, nucleotides (see chapter 12), and even simple proteinlike molecules have been found in related experiments. In the most recent studies, these compounds have been generated more directly from cyanide. The conclusion is that the basic building blocks of life might have been formed by natural processes under primitive earth conditions. Such molecules have now also been discovered spectroscopically in clouds of interstellar material toward the center of our galaxy, suggesting that some might have been present on the earth from the very beginning.

From here on, the story is based much more strongly upon speculation. It is said that proteins and nucleic acids originated in those ancient soupy seas, and that some way, these became associated and surrounded by a membrane to produce a primitive cell. So-called coascervate droplets, which are said to resemble cells in some highly primitive ways, form in some of the laboratory mixtures. It is suggested that the primitive cells fed on the molecules present in the primeval seas, but as these

molecules began to run out, the cells gradually became capable of synthesizing the molecules for themselves from simpler substances. Eventually a green plant capable of photosynthesis (perhaps a single-celled alga) might have appeared.

Oxygen is a product of photosynthesis, and carbon dioxide is used. It is suggested that the oxygen released by plants gradually built up in the atmosphere, carbon dioxide was removed, hydrogen and helium escaped into space, and the atmosphere as we now know it was produced. Ozone forms from oxygen in the upper layers of the atmosphere. It absorbs ultraviolet light, and the lowered intensities of ultraviolet radiation at the earth's surface could have allowed life to move onto the land-or so the story goes.

Recent evidence (some rather dubious "fossils") seems to indicate that the most primitive cells appeared at an early stage in the earth's history-perhaps 3.5 billion years ago. Yet the oldest clearly identifiable fossil remains of many animals and some plants are dated at about 600 million years ago, when numerous organisms appear suddenly in the fossil record.

The Geologic Time Scale

The most recent 600 million years on the geologic time scale is divided into three main eras (Fig. 11-1). All the perhaps 4-billion-year time interval preceding this is referred to as the Precambrian. The most ancient of the three eras is the Paleozoic, which began about 600 million years ago and lasted 370 million years, over half the geologic time characterized by well-formed fossils. The second era is the Mesozoic, which continued for 165 million years until about 65 million years ago. The most recent era is the Cenozoic. It is divided into the Tertiary period, which continued up to about 3 million years ago, and the Quaternary, which has continued until the present.

What is the basis of this time scale involving millions and even billions of years? Our present concepts have their roots in the study of sedimentary rocks. Most of these rocks form in such bodies of water as lakes, large inland seas, and the oceans. Sediments are washed into these bodies of water, forming layers as conditions producing the sediments change with time and as the sedimentary particles are sorted according to size by the moving water. As deposition continues, the weight of the deposited material exerts pressure, and eventually the sediments are consolidated into rock. Glacial deposits or wind-blown material may also be consolidated into rock, as in the solidified sand dunes of Zion National Park in Utah.

The characteristic layering of sedimentary rocks can be recognized from many miles away. Think of the mountains of Glacier National Park or the pyramids and spires of the Grand Canyon. The layers are not always horizontal, however, since extensive tilting, and even bending and folding, occur during the processes of mountain building. Another characteristic is the presence of fossils (Fig. 11-2). These are the preserved bodies of once living organisms, their imprints, or their petrified castings. Most are marine animals, but plant remains are also abundant in some rocks. Coal, for example, consists almost exclusively of plant remains. The sediments containing only animals were probably formed on the bottom of relatively deep seas, while those containing plants must have formed in shallow, swampy areas.

Beginning in England about 1790, William Smith, an engineer, kept careful notes of the rocks and their fossils in England. These led to the first geologic map, published in 1815. It became apparent that certain strata (layers of sedimentary rock) could be characterized by the presence of certain fossils, and that the strata virtually always occurred in a certain order. For example, a stratum containing one kind of invertebrate animal would always be found below but never above another stratum containing a certain kind of bony fish. Fossils were the same below and above strata of coal in England, France, and Russia, for example. By 1833 enough was known about strata from all over the world that Charles Lyell (who became a close friend of Charles Darwin) proposed a standard

geologic column. This ordered the strata with the oldest (simplest fossils) on the bottom. The layers of rocks, though they often graded gradually into each other, were given distinct names. The familiar diagram had achieved its modern form by about 1905 (Figs. 11-1 and 11-2).

Typically, only a small portion of the geologic column exists at any given location, and often when this is compared with the same part of the column at some other location, it can be seen that portions are missing from one or the other. This is certainly what we might expect, because we wouldn't think that deposition would always be constant and continuous over the whole earth. For example, an area might be covered with a shallow sea for a few million years, finally drying up, only to be covered again at some later date. Nowhere do the sedimentary rock formations account for more than several thousand feet of thickness (perhaps at most 75,000 feet in the San Joaquin-Sacramento Basin). But if representative strata from all the geologic eras could be stacked in the proper sequence, the total thickness might reach 450,000 feet or about 80 miles.

It is reasonable to imagine that the deposition of such extensive sediment must have required long intervals of time, but estimating the exact intervals has not been an easy task. All methods of dating must apply the principle of uniformitarianism. Most fundamental (and questionable) are those in which one measures the present rate of sedimentation, divides it into the total thickness of the strata, and arrives at an estimate of age. Based on this approach, estimated time intervals have been applied to the strata in the standard geologic column shown in Figs. 11-1 and 11-2.

A method of dating that seems somewhat more reliable involves the radioactive decay of certain elements. We know that many environmental factors can speed up or slow down the rate of sediment deposition, but so far we have been unable to detect any physical forces (temperature, pressure, etc.) that significantly influence the rate of radioactive decay. A number of these "clocks" are now known. Uranium changes gradually into lead, rubidium to strontium, and potassium to argon, for example. A crystal can be taken from a rock that was once molten. The quantity of each isotope of uranium and of lead can be carefully measured. When one knows the exact rate at which a given isotope of uranium changes to a given isotope of lead, it is then possible to estimate with considerable accuracy how long it has been since the crystal formed from the molten rock.

A serious problem is that sediments cannot be directly dated by the radioactive clock. The particles from which they form may have crystallized eons before sedimentation and consolidation occurred. If, however, molten rock covers or intrudes into a crack of sedimentary rock, cools, and crystals form, these can be dated, and it is then possible to say that the sedimentary rock must be older than the intruded or overlain crystalline rock. But how much older is only a guess. The trouble is, such situations are relatively rare. Nevertheless, the few examples that are known support the ages assigned to the geologic column in Fig. 11-1.

The Grand Tetons: Earliest Events

In the northwest corner of Wyoming lies Yellowstone National Park, a high plateau consisting of volcanic rocks with many hot springs, geysers, and similar features. Just to the south lies the Teton Range, encompassed now in Grand Teton National Park. The granite peaks at the center of the range jut skyward to over 13,000 ft. above sea level (Fig. 11-3). They seem to rise vertically from the floor of the broad valley lying east of the range, called Jackson Hole by the early trappers. Jackson Lake fills a large glacial basin near the north end of the range, and Leigh Lake, String Lake, and Jenny Lake fill smaller basins south of Jackson Lake (Fig. 11-4). The central peaks of the Tetons stand well above their supporting cast of lesser mountains, forming some of the most impressive (although not the highest) mountains on the North American continent. To the west, they slope off somewhat more gradually into the Teton Valley of Idaho, a rich agricultural area. Let's weave the rest of our story of geology around this scenic region.

The most ancient rocks in the Tetons, those of the Precambrian era, are somewhat granular layered gneisses. These were probably once volcanic and sedimentary rocks that were then exposed to extreme pressures and temperatures-perhaps 1,000 degrees F., five to ten miles below the surface of the earth. Among these are some layers of marble, for example, that are thought to be the result of exposing limestone to such enormous pressures and high temperatures. Rocks subjected to such changes are called metamorphic rocks.

Why are they considered to be the oldest rocks? First, because they occur "below" all the other rocks in the Grand Teton Range. (Some have been elevated above others, but the strata on top of them match the lowest Paleozoic strata in the area.) Furthermore, the layered gneisses have been intruded by granites that are more than 2.5 billion years old on the radioactive clock. Thus the layered gneisses are among the oldest rocks in North America and record (albeit nebulously) the earliest events in the building of the North American continent.

The granites that intruded the layered gneisses form only the central part of the Tetons: the Grand Teton and its surrounding peaks (Fig. 11-3). Other peaks in the range consist mostly of the gneisses. Often these have cracked, and the cracks are filled with the 2.5 billion-year-old granites and so-called pegmatite dikes.

There is another kind of dike in the Tetons: black diabase dike. These rocks resemble basalt chemically, but they were intruded like the granites rather than being extruded on the surface as is the usual case with basalts. There is a spectacular black dike that extends from the top of Mt. Moran to its base (Fig. 11-5). It has been traced for seven miles westward toward Teton Valley. On Mt. Moran, it is 150 feet thick, narrowing to about 100 feet at its western extension. It cuts across all the other Precambrian rocks and hence is the youngest of these rocks. It does not, however, cut any of the oldest Paleozoic beds (the Cambrian beds). The dike has been dated by the radioactive clock at 1.3 billion years.

About the time that the black dikes were forming, sandstone was being deposited to the northwest of the present Teton Range. This was later compressed (metamorphosed) into quartzite. Later erosion carried vast quantities of this material into the valley of Jackson Hole, so that the valley is now filled with quartzite boulders.

After the dikes intruded, the Precambrian rocks were uplifted and eroded to an almost level plain. Perhaps about 700 million years were required for this to occur-more than all the time since then! Then about 600 million years ago, at the close of the Precambrian era, this plain began to settle and was covered by a shallow sea. The sea advanced and retreated at intervals over the next 500 million years.

The advance of the shallow sea marked the beginning of the Paleozoic era. Thousands of feet of sediment were deposited at intervals by this sea. Later, all was elevated and tipped so that the strata sloped to the west. Where the sediments were elevated the most, in the center of the Teton Range, they were subsequently almost completely eroded off, although a sandstone layer still caps a part of the peak of Mt. Moran. To the north and the south of the central peaks, the sediments were not elevated as high, and they are still plainly visible.

The Paleozoic and Mesozoic Seas

In Teton Village, about fifteen miles northwest of the town of Jackson, an aerial tramway runs to the top of the Teton Range. In winter this provides a variety of ski trails, traversing over 4,000 feet in vertical elevation-some of the most precipitous runs available anywhere. In summer, the view from the top of the tram is one of unexcelled alpine splendor, and looking southward, one can clearly see the sedimentary formations of the Paleozoic era (Fig. 11-6).

The lowest of these formations is the Gallatin Limestone. Nearly 600 million years ago, a shallow sea extended from California, northeastward across Nevada into Utah and Idaho. Mountains consisting of Precambrian rock probably existed to the east of this sea. They were being eroded and deposited into the sea. As this occurred, the land gradually dropped so that the seashore moved slowly eastward. Sand was deposited along the shore (as occurs today), and as the shore moved eastward, mud was deposited on top of the sand. Thus there are formations of sandstone and shale that occur beneath the Gallatin Limestone (at other locations besides the one shown in Fig. 11-6). Simple invertebrate marine organisms called brachiopods and trilobites occur as fossils in these ancient strata. When the shoreline of the shallow sea had moved far enough eastward so that most of Wyoming and Montana were covered, the water was about 100 to 200 feet deep in the Teton area, and the Gallatin Limestone was deposited. This is dated by traditional geologic means (not radioactivity) at about 510 to 520 million years ago. The sea continued to move eastward until it connected with another shallow sea that covered the eastern part of the United States. This story of early Paleozoic seas is based upon reconstruction from the sedimentary rocks (sandstones, shales, and limestones) of North America.

After the Gallatin Limestone was deposited, the seas retreated, and the Teton area was uplifted for perhaps 70 million years, only to sink again when a second shallow sea covered the area to deposit the Big Horn Dolomite (perhaps 430 to 450 million years ago). Fossil corals and other animals of clear warm seas occur in this rock formation. The sea retreated again for perhaps 60 million years and returned to deposit the Darby Formation (360-370 million years ago) on top of the Big Horn Dolomite. Rock in the Darby Formation indicates that the sea bottom was foul and the water turbid, but numerous brachiopods, corals, bryozoans, and even bony fishes occur as fossils. These animals were more advanced than those of the Big Horn Dolomite or the Gallatin Limestone, but some animals (e.g., brachiopods) from the earlier formations were still present. The sea left for another 50 million years but returned to deposit the Madison Limestone about 310 to 340 million years ago. Again the water was clear, and numerous beautiful marine organisms became fossilized. The testimony of the Gallatin Limestone, the Big Horn Dolomite, the Darby Formation, and the Madison Limestone is that seas came and went for 285 million years. The waters were present for perhaps 180 million years, and the rest of the time the land was elevated with some erosion occurring.

The Mesozoic era was also a time of marine sediment deposition, but there were transitional periods and times when the area was typically continental. Fossils are numerous and varied from marine mollusks to dinosaurs-far more advanced than the fossils of the Paleozoic. Still, the shallow seas came and went. For example, the Sundance Sea gradually moved down from Alaska until it covered all of Wyoming. It was warm and muddy with many marine mollusks. There were tropical humid flood plains. At other times, there were swamps with dinosaurs and extensive land vegetation. Finally, the area was covered with a cretaceous sea (the youngest of the Mesozoic seas), which retreated eastward 85 million years ago. There were extensive coal swamps. Numerous complex strata, too involved for detailed discussion here, testify of these events.

The Tertiary Upheavals

About 70 million years ago, during the so-called Laramide Revolution, the Rocky Mountains began to be elevated. The quartzite boulders in Jackson Hole testify that ranges existed west of the Tetons before that, but no trace of these mountains remains today. Near the end of the Mesozoic era, about 65 million years ago, the dinosaurs became extinct and the Tertiary era began. As the most recent era, it provides the most detailed evidence about its events. Furthermore, no region in the United States has a thicker or more complete nonmarine Tertiary record than that of the Teton area, where the record testifies of much crustal motion, erosion, faulting, and volcanism. Many of

these events were related to the Laramide Revolution, which reached its climax about 50 to 55 million years ago.

The fossils are far more complex than those of the earlier periods. There are snails and clams, plus beaver bones and teeth, aquatic mice, suckers, and other fossils typical of fresh water lakes. Indeed, Teewinot Lake covered much of the area during Tertiary time. Mammals became abundant, and there were numerous coal swamps. The climate was subtropical for a time and then temperate. Many of the plants and animals were similar to those presently living in the Teton area. There are fossil conifers and flowering plants, for example.

Near the close of the Tertiary era, about 9 million years ago, the Teton Range finally began to be elevated. With an age of a mere 9 million years, the Tetons are clearly the youngest range in North America. Their relative youth explains why they are so spectacular, with their steep slopes, jagged peaks, and precipitous cliffs.

Crustal Deformation and Mountain Building

What caused the Tetons to be elevated? The processes of mountain building have long intrigued geologists, and during recent years we have begun to approach an understanding. One key was the study of earthquakes. A quake occurs as rocks slip past each other along a fault. Apparently tension builds up until slippage occurs, releasing the stored energy in an earthquake.

Faulting can occur in many ways. In the San Andreas Fault in California, both sides of the fault remain horizontal, but the west (actually, southwest) side moves northward while the east side moves southward. The fault slipped as much as 16 to 21 feet along a 270-mile line in the earthquake that devastated San Francisco on April 18, 1906. The San Andreas Fault with its many tributary branches has been traced for 600 miles along the coastal region of California. During its history over millions of years, it has slipped at least tens of miles and possibly over 100 miles.

Probably a vertical displacement along a fault is more common than a horizontal slippage. One side may go up while the other side goes up or down, or one side may remain relatively stationary. The Yakutat Bay (Alaska) earthquake of 1899 resulted in a vertical displacement that lifted part of the coastal belt nearly 50 feet! Many mountain ranges, especially in western America, have been built this way. Displacements by faulting can be observed at present, and relatively fresh fault scarps (the newly exposed rock along the fault) can be observed at the base of many mountains, such as the one near Fallon, Nevada, mentioned earlier. The strata exposed on the mountain faces can often be found by drilling into adjacent valleys. Much crustal movement occurs well below the surface, so no scarps can be observed. Seismographs (delicate instruments designed to detect minute movements in the earth's crust) can usually pinpoint where the subsurface movement has taken place, since they record not only motion but also its exact direction.

The Tetons were apparently produced by faulting as the east face was raised in relation to Jackson Hole, the entire block being tilted as though it were hinged along its western edge. The eastern face is the remnant of the fault scarp, but erosion has carved numerous canyons and peaks from this uplifted block.

How well does the principle of uniformitarianism apply? Were the Grand Tetons elevated to their present height by slippage of a foot or so every two or three centuries during the past 9 million years? (This is the calculated rate.) Or were they elevated in one mighty cataclysmic event lasting from a few minutes to perhaps a few brief centuries? The uniformitarian view is strongly favored by secondary evidence such as the patterns of erosion that formed the canyons in these fault-block mountains. The formations in the Tetons indicate that several thousand feet of sediments once existed above the present Tetons. We can imagine that this could have been eroded away if the

Tetons were gradually raised over a 9-million-year period, but this seems much less likely if they had been raised cataclysmically. We seem to be dealing with an ancient earth.

We should note that a uniformitarian concept of mountain building is not incompatible with occasional cataclysms. The formation of the volcanic Paricutin mountain in the Mexican field was certainly a cataclysmic event! Indeed, earthquakes are cataclysms by human standards. Uniformitarianism merely says that such "minor" cataclysms extended over vast intervals of time could account for mountain building.

But what about cataclysms on a global scale? In 3 Nephi 8 and 9, we are told of the great upheavals that occurred at the time of the crucifixion of Christ and his visit to the American continents. Mountains were thrust up, cities submerged into the seas, etc. I do not know of geological deductions about specific cataclysmic events occurring nearly 2,000 years ago-but then I don't know much about geological deductions. Perhaps no one has bothered to look for the evidence of such events. Latter-day Saint geologists might well become involved in such a search.

The Interior of the Earth and Plate Tectonics

What are the forces that lead to mountain building? Apparently, they come from deep within the earth. But what is happening there? Two kinds of earthquake shocks or waves pass through the earth: those in which individual particles move forward and then back along a line parallel to the direction of the wave (compression waves) and those in which the particles move at right angles to this imaginary line (shear waves). The two kinds of waves move with different velocities, which depend upon the material through which the waves are passing. Only the compression waves move through liquid. In either case, the waves may be refracted (bent) as they pass through different kinds of material. Thus by studying the movement of earthquake waves through the earth, we can deduce much about its interior. And by applying sophisticated mathematics to data on artificial satellite orbits, we can measure the earth's moment of inertia-the distribution of mass within the earth's interior.

The evidence indicates that there is an inner solid dense core with a radius of about 860 miles surrounded by an outer molten core of iron and nickel about 1300 miles thick. This circulates and causes the earth's magnetic field, which has changed during geologic time as the circulation patterns have changed. Overlying the molten core is the solid mantle with a thickness of 1800 miles, and covering the mantle is the crust, varying from a few miles to about 40 miles thick. The crust is thickest under the continents, which are huge plates of granite, a relatively light rock, "floating" in the heavier basalt-like rocks that form the ocean floors. Under the tremendous pressures existing several miles below the earth's surface, rock, while it remains solid in a literal sense, is capable of gradually flowing. Thus as the mountains are worn off by erosion, they continue to rise as an iceberg rises when the sun melts the ice above the surface. Clearly there is more to the story, however. The Tetons have not always been in existence, their granite masses floating in the underlying basalt. We've seen that the area was repeatedly covered by inland seas.

During about the past decade, geologists have been enjoying a scientific revolution as profound and exciting as the one that has been revising our concepts of the cosmos. The roots of the revolution trace to the 1950s and before, but convincing data supporting the ideas began to be obtained first in 1964. Since then, geologists have developed a sequence of insights, explaining one geological mystery after another in terms of the new concepts.

The new theory, called plate tectonics, is based on an old suggestion, that of continental drift. In Genesis 10:25, in the genealogy of the descendants of Noah, it is stated: ". . . the name of one was Peleg; for in his days was the earth divided. . . ." For many years this statement has been interpreted by theologians to mean that the continents were separated from each other in Peleg's

days. (Or was it a political rather than a geological division of the earth?) It is easy to see that the west coasts of Europe and Africa fit into the east coasts of North and South America. One can fit all the continents (including their continental shelves) together as a jigsaw puzzle into a single vast continent called Pangaea. Geologists didn't take the idea of continental drift seriously until so much evidence had accumulated that it could no longer be ignored. Strata on the west coast of Africa closely match comparable strata on the east coast of South America, for example, and the distribution of plants and animals also agrees with the idea that the continents were all unified at one time and then separated. During the 1950s, and 1960s, continental drift was placed on a firm footing. It was estimated that the rate of separation of Europe and Africa from the Americas was about 10 kilometers/million years, beginning about 200 million years ago-well before the days of Peleg!

But what is causing the continental drift? Because of submarine warfare during World War II, the oceans were studied as never before. A striking discovery was that an undersea range of mountains runs along the center of the Atlantic and extends for 47,000 miles, forming a continuous, serpentine, underwater ridge system around the globe. This discovery led to the theory of plate tectonics. The earth was seen as a system of dynamic crustal plates spreading apart at the midocean ridges, where they were and even now are being manufactured by processes deep within the earth's interior. Material is welling up from below, forming the ocean ridges and pushing the plates asunder at rates of 1 to 7.5 cm (one-half to three inches) per year. Where the plates collide, one may slip under another, forming the deep ocean trenches, another fairly recent discovery. The average depth of the Pacific Ocean is just over 14,000 feet, but the Mariana Trench reaches a depth of 35,800 feet. The basalt that forms the ocean bottom seems to be plunging slowly into these trenches to depths of 400 miles, where it is destroyed as crust and becomes part of the mantle. Thus the plates grow at the mid-ocean ridges and are returned to the mantle in the trenches. Once the granite continents (including the continental shelves) form, they never disappear. They seem to float serenely above the plate turmoil below. But they do undergo many transformations.

Most earthquakes occur at the edges of the plates: the mid-ocean ridges and the deep trenches. The San Andreas Fault is where two plates are sliding by each other. When two plates butt their edges together with comparative gentle force, instead of forming a trench with one plate slipping deep into the mantle, they slowly deform and emerge above sea level as great folded mountain ranges such as the Alps. Thus buckling may occur at some distance from the plate edge, as is the case with the Rocky Mountains, which are still growing. This is how the Teton area could be covered with shallow seas for millions of years, only to be deformed by buckling and intrusions of molten granites (melted, perhaps, by the heat of radioactive decay trapped below).

Modern geologists have traced the movements of the plates during geologic time to account for the shallow seas, the elevation of specific mountain ranges, changes in ocean circulation patterns, the consequent changes in climate, and the effects of all this on the earth's plants and animals-including the extinction of the dinosaurs. Other long-standing problems that appear to be solved by the theories of plate tectonics include the formation of island chains (e.g., the Hawaiian Islands), and the mechanisms of mineral deposition (so-called hydrothermal alteration at spreading ridges and other locations). Thus plate tectonics is one of those marvelous theories that makes science so much fun. It successfully ties together many scattered and apparently unrelated facts, predicting phenomena that can then be tested by observation.

The Quaternary Glaciers in the Tetons

So, thanks to plate tectonics, we have gained some insight into how the Tetons came into being beginning about 9 million years ago. The Quaternary period includes the last 3 million years of the Tertiary era. It was during this time that most of the geologic processes responsible for the present

landscape were taking place. There continued to be much faulting and volcanic activity (especially to the north in Yellowstone Park). There were also numerous lakes, but perhaps the most significant geologic process of the late Quaternary period was glaciation. The rocks testify that there were three ice ages or periods of glaciation during this time:

The Buffalo Glaciation was the oldest. It began about 200 thousand years ago and was by far the most extensive glaciation in the Teton area. Huge ice sheets came from the Bear Tooth Mountains to the north and the Wind River Mountains to the south, filling Jackson Hole perhaps to a depth of 2,000 feet and moving gradually through the Snake River Canyon into Idaho.

The Bull Lake Glaciation occurred about 35 to 80 thousand years ago, being less than half as extensive as the Buffalo Glaciation. Deposits from the Bull Lake Glaciation are overlaid by deposits of loess, fine soil particles with sharp edges that apparently were blown in from Idaho to the west. Fossil shells deposited in this loess have been dated by carbon-14 at 13,000 to 19,000 years old, so the Bull Lake Glaciation was before then.

The Pinedale Glaciers were younger than the 13,000-year-old loess. This was the most recent and the least extensive glaciation to occur in the Teton region, but it added the final touches to the landscape and was more than any other geologic process responsible for the present features. The glaciers may have been extensive in the canyons of the Tetons as recently as 9,000 years ago, but there is evidence that a warm period occurred about 6,000 years ago, during which all the glaciers melted. The trend has been a cooling one during the most recent past, and small glaciers have again formed in the Tetons. In any case, the lakes of Jackson Hole were formed by the Pinedale Glaciers, as were the present conformations of the Teton canyons and the glacial moraines (piles of glacial debris) that stand up as timbered island hills in the sagebrush flats of the valley. It is easy to interpret the glacial features in the area, because it is possible to see such features being formed today in conjunction with glaciers in Canada, Alaska, Switzerland, and other locations.

What Does It All Mean

For many years, I have done a lot of wondering about what all this means and how it relates to the scriptural accounts of creation. It would be nice for scriptural interpretation if the geologists were all wrong, and the earth were only some 13,000 years old (6,000 since Adam plus seven 1,000-year periods of creation). I have listened to fundamentalist preachers argue with the findings of geologists. I have emphasized in my own mind the weaknesses of the uniformitarian doctrine. Why should the present be the key to the past? Perhaps the plates slid around much faster during the 7,000 years of divine engineering (or in Peleg's days) than they do now. I have examined the arguments of Melvin and Garfield Cook and others who try to place catastrophism on a scientific foundation. Now, having indulged in these exercises, I'm afraid I must conclude that the evidence still is in favor of an extremely ancient earth, one that is at least hundreds of millions, and probably billions, of years old.

Yes, I can imagine that much sediment might have been deposited during the flood. I can imagine that many plants and animals might have been trapped in these sediments. But the regularity of the stratigraphic column (the ordering of fossils with more complex forms nearly always occurring in the upper layers) is not easy to account for in a theory based on the flood.

Surely the rocks are trying to tell us something: that our planet has been around for a long, long time, and that there has been a continuous and orderly parade of life forms for at least 600 million years. Many species (perhaps 99 percent of all that have lived) have flourished in abundance for millions of years only to become extinct. Simple invertebrates began the story in the ocean as did highly simplified plants on land. As the earth progressed through time, spinning on and on around the sun, increasingly complex life forms made their appearance on its surface. For a few million

years, the dinosaurs reigned. Seed ferns, cycads, giant horsetails, and lycopods flourished in the swamps. Then the conifers covered the hillsides for eons before a flower appeared. Finally the flowering plants made their debut at about the same time that mammals were spreading on the face of the earth and dinosaurs were becoming extinct. How strongly can I question this story when the signs are nearly as clear as the glacial moraines of Jackson Hole?

Please note that "a parade of life forms" is not necessarily equivalent to an evolution of life forms. The fossils and the sediments seem to tell us that the life forms were there, for about how long, and the approximate order in which they appeared, but there is no way of knowing from the fossils alone that one life form evolved into another.

Does the Lord want us to doubt the ancient age of the earth with its parade of life? Perhaps, but I don't think so. Isn't it more reasonable that he wants us to weigh the evidence, both the scriptures and the story in the rocks? To study "things both in heaven and in the earth, and under the earth" (D&C 88:79)? We shall return to these questions.

Footnotes

1. One of the most vocal modern proponents of cataclysm in the earth's history is Immanuel Velikovsky (not a creationist). His book Worlds in Collision caused much negative reaction from the scientific community in 1950 when it was published. Ages in Chaos and Earth in Upheaval followed. His thesis involved Venus being ejected from Jupiter and coming close to the earth. Some vindications of Velikovsky's views were reviewed recently by Fred Warshofsky, "When the Sky Rained Fire: the Velikovsky Phenomenon," Readers Digest 107 (December 1975): 219-40.
2. Melvin Calvin, "Chemical Evolution," American Scientist 63 (1975): 169-77.
3. Dorsey Hagen, Practical Oil Geology (New York: McGraw-Hill, 6th ed., 1951), p. 99.
4. W. Lee Stokes, Essentials of Earth History (Englewood Cliffs, N. J.: Prentice Hall, Inc., 1966), p. 19.
5. J. D. Love and John C. Reed, Jr., Creation of the Teton Landscape (Moose, Wyo.: Grand Teton Natural History Association, 1st ed. rev., 1971).
6. For more details, see Tom Alexander, "A Revolution Called Plate Tectonics Has Given Us a Whole New Earth," Smithsonian 5 (10): 30-40; and "Plate Tectonics Has a Lot to Tell Us About the Present and Future Earth," Smithsonian 5 (10): 38-47.
7. Melvin A. Cook and M. Garfield Cook, Science and Mormonism, op. cit.
8. In this regard, it is interesting to note that the close associates of Joseph Smith were not dismayed by the idea of an extremely ancient earth, as indicated by the following excerpt from a letter of W. W. Phelps to William Smith (brother of Joseph), published in Times and Seasons 5 (January 1845): 758. "Well, now, Brother William, when the house of Israel begin to come into the glorious mysteries of the kingdom, and find that Jesus Christ, whose goings forth, as the prophets said, have been from of old, from eternity: and that eternity, agreeably to the records found in the catacombs of Egypt, has been going on in this system (not this world) almost two thousand five hundred and fifty five millions of years. . . ."

12
The Unity and Complexity of Life

This is a glorious time of year in Cache Valley, Utah. It is May, and I have brought my dictaphone into the foothills about three miles from my home. There are fields of dry-land wheat and alfalfa, but I'm on a strip of unplowed land between two high-tension power lines running along the lip of a bluff slightly too steep and rocky for convenient plowing. The soil is beginning to dry, and spring won't last much longer, but right now I am surrounded with large, yellow balsam root flowers, which are similar to sunflowers but close to the ground. There are pink phlox, the white death

camas, a lovely blue penstemon, a mostly white, but faintly blue forget-me-not, and many equally lovely but somewhat less showy mustards, grasses, geraniums, and others.

Along these shorelines of ancient Lake Bonneville and up and down the ridges of the mountains, I can see the yellow fields of balsam root. Living things are growing and developing just as their Creator planned. I tend to be preoccupied with the plants, but there is a beautiful butterfly, and our old black Labrador, Princess, panting from the walk up, reminds me that animals also grow and develop in the springtime, and that, strange as it might seem, they have many complexities in common with the planets. We've marveled at the galaxies and the plants, the structure of the earth; now let's briefly examine the unity and complexities of the living things God placed on this creation.

The Variety of Living Things

The fantastic diversity of organisms living on the earth's surface is most impressive. There are hundreds of thousands of plant species and probably millions of animals-mostly insects! Emphasis upon the diversity of life was at a peak in the mid-1700s when Carolus Linnaeus (Carl von Linne) in Sweden was classifying the world's plants and animals. The study of anatomy also tended to emphasize diversity. It got its start, perhaps, in 1628 when William Harvey demonstrated the circulation of the blood. Although we are surrounded by plants and animals, it is almost impossible to grasp the extent of this variety without formal, extended study. For one thing, many are invisible to us without a microscope. But imagine that you are going to study all the 700,000 known species of insects. You are wealthy and can command the help of the world's experts. The specimens are brought to you one by one, so you can spend exactly one minute looking at each. You do this eight hours a day, seven days a week, but it takes you four years and one day to look at all 700,000. Yet there may well be 3 million or more kinds of insects when all have been cataloged! But say that you want to examine all the species of plants: 10,500 species of bacteria and blue-green algae (both single-celled organisms without organized nuclei in their cells), the 100,000 fungi and 17,000 lichens (organisms that consist of both an alga and a fungus), the 25,000 species of other algae (including the browns, reds, golds, and greens, to mention a few), the 23,000 kinds of mosses and liverworts, the 21,000 ferns and their relatives, the 665 species of conifers, cycads, ginkgo tree (a single species with no close relatives) and all their relatives, and finally the 300,000 species of flowering plants, making a total of about half a million plant species. Then take a look at the million animal species (assuming only 700,000 insects): the 30,000 kinds of single-celled animals, the 13,800 species of sponges, jellyfish, corals, sea anemones and their relatives, the 30,000 kinds of worms (round, flat, and segmented) and other minor invertebrates, the 770,000 species of "jointed animals with external skeletons" (insects, spiders and mites, centipedes and millipedes, and crustaceans, including crabs and lobsters), the 100,000 clams, snails, squids, octopuses and their relatives, the 5,700 kinds of starfish and relatives, and finally the 45,000 animals that have a notochord (a structure associated with the spinal cord or its apparent precursor) at some time during their life cycle (the fishes, frogs and salamanders, snakes, lizards, turtles, birds, and mammals-plus some other minor groups). For this job, let's reduce your work load to a forty-hour week, fifty-two weeks per year. But you must still spend exactly one minute on each species. It will take you almost exactly 12 years to examine all 1.5 million known species. By then you should be well impressed with the variety of God's creations.

Yet the emphasis of this chapter is on unity. Although living things may look as different as an elephant and a yeast cell, or a mushroom and a tiger, all have much in common. All consist of cells, and the molecules and organelles that make up those cells are very much alike.

Discovering the Unity of Life

It is striking to realize that the unity of life has become apparent only rather recently. It all began a little over 300 years ago with the discovery of the microscope. This instrument first extended our

appreciation for the diversity of living things: the microscopic world of single-celled plants and animals; the algae, protozoa, and bacteria. Then in 1665, Robert Hooke, who built one of the first compound microscopes, sliced a thin section from a piece of cork and observed that it consisted of minute empty spaces that reminded him of the cubicles in a monastery. He called them cells and began to notice them in sections cut from living plant tissues, in which the cells were not empty but were filled with fluid and barely discernible particles. This was the beginning of our appreciation for the unity of life.

During the early 1800s, the sciences of organic and inorganic chemistry were developing, and their findings were being applied to an understanding of living things. By the 1830s, it was possible to formally state the cell theory: that all living things consist of cells. And the realization was developing that cells are minute chemical factories, functioning according to the laws of physics and chemistry. Back when the newly restored church of Jesus Christ was being organized and going through the tribulations of Ohio, Missouri, and Illinois, biologists were learning about cells and cell chemistry.

By 1947, one hundred years after the arrival of the pioneers in the Salt Lake Valley, we had accumulated a vast amount of information about plant and animal cells and about the chemical reactions that make them what they are. Then there was another knowledge explosion. Most of this came about in response to the development of some powerful and marvelous tools. The electron microscope, quite advanced by the end of the 1940s, could be used to examine cells during the 1950s, because extremely sharp knives made of glass or diamond were invented to cut exceedingly thin sections, and special stains (often utilizing the atoms of heavy metals) absorbed the electrons in the electron beam and made cellular structures visible in these thin sections.

The technique of chromatography was worked out for the accurate and complete separation of closely similar molecules. (The pigments mixed in a drop of liquid, as in many inks, placed on a piece of filter or blotter paper, will often separate as the liquid moves on the paper by capillarity-illustrating the principle of chromatography). The technique of X-ray diffraction, which had been used to visualize the arrangement of atoms in inorganic crystals, was extended to proteins and other important molecules of cells. Numerous other techniques contributed so that our understanding of cell structure and function has multipled several times from about 1950 until the present.

The revolution in biology has been quite comparable to the revolutions in astronomy and geology. A formidable body of fact and theory has accumulated about how organisms work, especially at the molecular level. In discussing the questions of creation, I want to base some of my arguments upon this new information, so in the following pages I will try to outline a few highlights and insights that have been discovered during the past two or three decades. Let's see what biologists have been learning about God's creations.

The Cell: Key to Understanding

We knew there were numerous particles in the cell, but thanks to the electron microscope, we now know how they are put together and what they do. We have probably learned as much in the past two decades as had been learned in the previous 300 years-and this doubling of knowledge could happen again during the next two decades.

Each cell is a unit factory in itself, usually with the potential to reproduce itself. A single-celled bacterium, alga, or protozoan performs all the necessary life functions, but some cells, in addition to performing the functions necessary to stay alive, are highly specialized. A nerve cell transmits nervous impulses, thyroid cells produce the thyroid hormone, muscle cells contract and relax, and a microspore mother cell in the anther of a flower produces pollen. So there is no such thing as a

perfectly typical cell, and in the following discussion where we are mostly talking about cells as though there were only one kind, we are not really telling things quite like they are. Nevertheless, most of the important features and structures of plant and animal cells are fairly well-represented in a leaf cell and a liver cell. Electron micrographs of a plant cell, along with two interpretive drawings of cells, are shown in Fig. 12-1.

Cell Membranes and Walls

Each cell is surrounded by a membrane, and many of the particles in the cell, such as the nucleus, chloroplasts, mitochondria, and others are also surrounded by membranes, although all these membranes are not exactly alike. Membranes are marvelous structures. They control the passage of substances in and out of the cell or the cell organelle. Sodium (in sodium chloride, common salt) is pumped out of most cells, for example, and potassium is pumped in. There are dozens of similar membrane functions, involving probably hundreds of dissolved substances.

In addition to the cell membrane, plant cells are surrounded by a cell wall consisting largely of cellulose but often including pectin, hemicellulose, lignin, protein, and other materials. Wood or cork consists mostly of the cell walls of once living cells that had contained membranes and all the other organelles. In living plant cells, the wall is capable of sustaining high pressures from within-pressures that would cause an animal cell to burst. (Incidentally, in newspapers, magazines, and the like, cell membranes of animal cells are often incorrectly called walls.)

The Nucleus: Genes and Nucleic Acids

One of the most notable organelles of the cell is the nucleus. Most of the cell organelles are nearly transparent, but nuclei readily absorb certain applied stains and become quite prominent. Discovery of this technique led to the discovery that most cells have nuclei and got biologists to thinking along the lines that led to the cell theory. Yet not all cells have nuclei. By the time human red blood cells and phloem cells in the bark of plants have matured, all traces of nuclei have vanished. More important, there are two large groups of microorganisms that never contain organized nuclei: the bacteria and the blue-green algae. Nuclear functions are carried out in these cells, however, because the important molecules we will be discussing shortly are present there, but these are not surrounded by a nuclear membrane as in all other organisms.

The important molecular material in the nucleus is the brightly staining chromatin. When the cell is dividing, the chromatin forms into elongate bodies called chromosomes, the shape and number of which are quite constant for a given species. There are 23 pairs of chromosomes in man, for example, making a total of 46.

Chromatin consists primarily of two kinds of molecules: protein and nucleic acid, but the nucleic acid is of special and immediate interest. It is the genetic material. The genes that control the inheritance of such features as blue or brown eyes, straight or curly hair, white or pigmented skin, and probably even musical ability and intelligence are really molecules of nucleic acid. These marvelous molecules must do two kinds of things: they must reproduce themselves whenever the cell reproduces, and the information they contain must be used to produce inherited features. Furthermore, the genes in a given cell must act only at the suitable time and place. The genes that produce brown eyes, for example, must be active only in the cells that constitute the iris of the eye.

We can imagine that there must be hundreds of thousands of genes, since there are certainly that many different inherited features. Of course we are not talking only about the things that make people (or petunias) different, such as eye color; we are talking about all the physical and perhaps mental things that make people people! Virtually every detail of bodily structure and function is controlled by the genes. And when the egg is fertilized by the sperm cell, all the genes that will

control all those features in a mature adult (be it plant or animal, including human) are present in that fertilized egg. Some will act at certain times and places, and others will act at other times and places, but the result will be the mature individual.

How do the genes work? In 1953, the molecular structure of nucleic acid was worked out, and this immediately suggested how molecules of nucleic acid might reproduce themselves. In the next ten to fifteen years, we learned how the information of a nucleic acid molecule might be transferred out into the cell where it can control function-at least in many cases, and probably the principle applies to all. We still do not know, however, why a gene (a molecule of nucleic acid) acts only at the suitable time and place. The discovery of that principle would equal in importance the discovery of the atomic bomb or any other discovery ever made in science. It could open to our understanding and control the very secrets of life itself.

There are two kinds of nucleic acid, designated DNA and RNA. It is the DNA that is the stuff of genes. Each kind of nucleic acid molecule is a long chain of smaller molecules. There are four kinds of links in each of these chains. Each link, called a nucleotide, consists of three other kinds of molecules: phosphoric acid (which gives the nucleic acids their acidic nature), a 5-carbon sugar, and a larger molecule consisting of carbon, nitrogen, hydrogen, and oxygen atoms. There is one kind of sugar molecule (deoxyribose) in DNA; another sugar (ribose) in RNA. There are four kinds of organic bases (the carbon-oxygen-nitrogen part of the molecule) in DNA, and three of these occur along with a fifth kind in RNA. For our discussion, it is not important to understand anything about the chemistry of these molecules except to know that a DNA molecule is a chain of four different kinds of nucleotides and that RNA also consists of four different kinds of nucleotides.

The way in which the nucleotides are put together was worked out by James D. Watson and Frances H. C. Crick in 1953. As it turned out, a molecule of DNA is a double helix, or spiral. That is, there are two chains of nucleotides twisting around each other. The links are held together through the sugar and the phosphate groups, and the organic base parts of the nucleotides protrude toward the center of the spiral. A nucleotide in one spiral is lined up with its counterpart in the other spiral.

The significant discovery was that only certain nucleotides fit together. We can designate the four nucleotides in DNA by the letters T, A, C, and G (standing for their chemical names). In the double helix, a T in one chain will always be opposite to an A in the other chain (and vice versa, of course). C in one chain always has a G as its counterpart in the other chain. This arrangement of T equals A and C equals G is known as complementary bonding. It makes possible the reproduction of a molecule of DNA. All that is necessary is that the two strands in the double helix separate, and that new nucleotides then form a second strand in conjunction with each of the first strands. Each half of the original double helix will act as a template for the formation of the second half of the new strand.

What is the "information" in a molecule of DNA? Apparently it is the sequence of nucleotides (links) in the DNA strand. It is easy to understand that information is contained in this sentence because of the sequence of letters and spaces. Of course the sentence could be translated to Morse code, in which the dots, dashes, and spaces more closely approximate the four kinds of units in the DNA code. The language of the gene, then, is in the arrangement of its nucleotides. But how does this work? We shall see next as we discuss proteins and enzymes.

Protein Synthesis

Certain minute round bodies, apparent in electron micrographs as black dots, are called ribosomes. Some cells have hundreds of thousands of these. Their role is to build proteins. Since the protein enzymes are the working machinery of the cell, it is important to know how proteins are made.

As nucleic acids consist of links of nucleotides, so proteins consist of long chains of amino acids. There are twenty kinds of amino acids, and all have in common two molecular structures, a carboxyl or acid group, and an amino, or basic group. We will not discuss the detailed chemistry of amino acids. In proteins, the amino acids are hooked together with the amino group of one amino acid attached to the carboxyl group of another.

Aside from the amino and carboxyl groups, each of the amino acids is different from the others in its molecular structure. Some have a considerable attraction for water molecules, and others are attracted by fatty molecules such as benzene or ether. Some of the amino acids also are acidic or basic, and under different conditions, they can have minute electrical charges that are either positive or negative. Thus you can imagine a protein as a long chain of amino acids with each link being highly specific in its solubility, electrical, and other chemical properties. The chain will be folded according to the nature of its amino acids, water-loving ones to the outside and fat-loving to the inside.

You might begin to suspect how the nucleic acids relate to the proteins. In both cases we are dealing with long chains of highly specific molecular links. But in the one case, the chain consists of only four kinds of links, and in the other case, twenty kinds are involved. The sequence of nucleotides in a molecule of DNA (a gene) might control the sequence of amino acids in protein. But since the two "languages" have a different number of "letters," some kind of translation is necessary, as when Morse code is translated into conventional English. The key to such translation is that several symbols in the Morse code are required to determine a single letter in English.

So it is in the synthesis of proteins. Three nucleotides in DNA determine a single amino acid in a protein. Actually, taking the four nucleotides three at a time, it is possible to have sixty-four combinations, so it would be possible for DNA to control sixty-four kinds of amino acids in protein. But in nature this doesn't happen, and as many as six of the possible three-nucleotide combinations (called codons) may determine the same amino acid. If I'm not careful, we'll soon be getting in deeper than we need to for this discussion, but the important point to remember is that a nucleic acid language consisting of four symbols (the nucleotides) can be translated into a protein language consisting of twenty symbols (the amino acids).

The translation occurs with the help of RNA and the ribosomes. When a gene is active in the nucleus, a strand of RNA with its four nucleotides is synthesized along the gene (DNA molecule), using it as a template much as occurs in the reproduction of a DNA molecule. Probably the DNA double helix unwinds a bit, and the RNA strand forms along one of the DNA strands. The RNA that is formed is called messenger-RNA (m-RNA), because it carries the message of nucleotide arrangement from DNA out into the cytoplasm of the cell, where the message is translated into the amino acid sequence of protein.

The messenger RNA attaches to a ribosome in the cytoplasm. In another series of complex steps, individual amino acids have become activated or energized and attach to another kind of small RNA molecule called transfer-RNA (t-RNA). The transfer RNA molecules line up along the messenger RNA strand in conjunction with the ribosome. This is where the actual translation occurs. Three nucleotides in the transfer-RNA molecule become complementarily bonded to three nucleotides along the messenger-RNA strand (i.e., to a codon). Obviously, this must begin at one end of the strand, and none can be missed or overlapped or the message is badly garbled. It is the enzymes that control all this. Finally, when transfer-RNA molecules with their attached activated amino acids are lined up next to each other along the RNA strand attached to a ribosome, then chemical bonds are formed between the amino acids (the amino group of one to the carboxyl group of another) to make the amino acid chain, which is a protein molecule. That's all there is to it!

If you have never encountered this story before, it will certainly sound complicated in spite of all my efforts to mention only the bare essentials and to simplify as much as possible. That is simply because the story is extremely complicated. The workings of living organisms are not simple, which is the whole point of this discussion. When we consider the theories proposed to account for the origin and evolution of life, we need to realize the fundamental complexity of living things.

Enzyme Molecules: the Cellular Machinery

Why are we so interested in proteins? Because the secret of life function is found in the enzymes, which are all protein molecules. Life is literally thousands of different chemical reactions going on in cells at any given moment. Complex molecules are being built up and broken down, and energy is being transferred in numerous ways. And this multitude of chemical reactions depends upon the enzymes. So the important question is: How do enzymes work?

A given enzyme catalyzes a single chemical reaction. That is, it causes it to go much faster than it would otherwise. As it turns out, enzymes do not make reactions happen that could not otherwise take place; enzymes merely speed up reactions. But often the acceleration amounts to thousands or millions of times, and the fact that numerous enzymes are present in a cell at any moment, catalyzing numerous reactions, means that the compounds entering into these reactions are present in the cell because of the enzymes. That is, a given reaction going on in a cell would probably not occur in nature, simply because the compounds that enter into the reaction would not be present at sufficient concentrations if it weren't for other enzymes.

Again, if we begin discussing the specific reactions that occur in cells, we will soon get lost in chemical details that are way beyond the point of this discussion. But you need to have some appreciation for the fantastic complexity of cellular metabolic processes, so let's wet our feet a bit in the vast ocean of biochemistry.

Consider the fate of a sugar molecule in a cell, a molecule that is about to be burned (combined with oxygen) to produce carbon dioxide, water, and energy in a form that can be used to power the functions of the cell. The process is called cellular respiration. The sugar molecule is first activated or prepared by having two molecules of phosphate attached to it. This requires special enzymes and the very compound, a molecule called ATP, that respiration is going to produce. The phosphorylated sugar molecule can then enter into one of two systems of biochemical reactions that occur in the cytoplasm part of the cell. One of these systems involves about nine enzymes, and the other about eight enzymes. The sugar molecule is changed in several ways, but no oxygen is used yet, and only one of the six carbons is given off as carbon dioxide in the second system. The first system produces some ATP and another energy compound called NADH; still another compound (NADPH) is formed in the second system. The molecular product of the first system (pyruvic acid) may be acted upon to form alcohol and carbon dioxide, lactic acid, or other molecules in a process known as fermentation, providing no oxygen is present. Or the pyruvic acid may go through a third series of reactions controlled by about nine more enzymes that are located in the mitochondria of cells. (Mitochondria are shown in Fig. 12-1.) To begin with, a carbon atom is lost as carbon dioxide from each molecule of pyruvic acid, and the remaining 2-carbon fragment is combined with a 4-carbon molecule to make a 6-carbon compound, citric acid. This is then cycled until two molecules of carbon dioxide have been given off, and the original 4-carbon molecule has been regenerated. Still no oxygen has been used. But at several steps in all three processes, energy has been transferred to NADH or NADPH, and these molecules are now acted upon by a fourth system of perhaps twenty or more enzymes, called the electron transport system. Hydrogen atoms that originally came from the sugar molecule are moved along the chain of enzymes that exists in the mitochondria, producing several molecules of ATP and finally combining the hydrogen with oxygen to produce water.

All together, about fifty enzymes are involved in cellular respiration, and at least a part of the system is organized on the membranes of the mitochondria. It is a marvelous system that allows a controlled burning in the water of the cell, with much of the released energy being trapped in molecules of ATP that can then be used directly for energy-requiring processes in the cell.

Does this all sound complex and confusing? Surely it does if you have never encountered it before. Yet it is a relatively simple system compared to what is now known about photosynthesis! Anyway, you certainly don't need to understand the details of cellular respiration or photosynthesis to grasp the important point that the cell is indeed a complex, yet beautifully ordered and designed chemical factory, and that it works because of its enzymes.

Each enzyme is a minute machine. A protein molecule is too small to see even with the electron microscope, except as a minute speck. With other powerful techniques developed during the past decade, however, it is possible to determine the structure of proteins. Each determination requires a great deal of laborious effort, first to learn the sequence of amino acids in the protein chain (by one set of techniques), and then to learn the complex manner in which this chain is folded upon itself (by another set of techniques, particularly X-ray diffraction). Although the procedure was developed in the late 1940s, only a few protein structures had been worked out by 1970. The process goes somewhat faster now. The marvelous thing is that by combining knowledge of the structure with knowledge of the reaction catalyzed by the enzyme, it is possible to understand what is going on.

The enzyme lysozyme, for example, breaks down a substrate chain of sugar-like molecules found in the cell walls of bacteria. Knowing the structure of lysozyme, we can visualize how the substrate chain fits exactly into a deep cleft along this globular protein and further how the protein flexes slightly, causing one of the bonds in the sugar chain to break. No other molecular chain will fit in the enzyme cleft. In another case, we know how a protein is digested when the end of its amino acid chain goes into a waterless hole in the digesting enzyme, where the cleavage becomes possible.

In each case so far studied, we can see how the structure of the protein-enzyme molecule is capable of catalyzing the observed reaction in a purely mechanical way. We can understand, for example, how the fat-loving amino acids are confined to the inside of an enzyme molecule away from the surrounding water molecules, where they are ideally suited to catalyzing some reaction of a fat-loving substrate. Again, we could soon go too far into the chemical details, but the important thing at this point is to visualize protein enzymes as minute bits of machinery that snip apart other molecular chains or that staple bits and pieces together to form other complex molecules.

Enzymes are even involved in the duplication of DNA, in the synthesis of a messenger RNA molecule on a DNA template, in the activation of amino acids, in the attaching of transfer RNA molecules to messenger RNA, and finally in the formation of bonds between amino acids to produce other protein molecules-which in turn may themselves act as enzymes. Enzymes are made to make enzymes-and to do all else in the cell that needs doing. It's a complex business, but its complexity is its beauty. The more we delve into these matters, the more we can appreciate the intricate engineering involved in life processes, and if we are of a proper mind to do so, we can appreciate the ingenious creativity of the God who engineered it all.

Footnotes

1. The fascinating story of this monumental discovery is documented by James D. Watson in The Double Helix (New York: Atheneum, 1968). Now available in paperback.

Evolution By Natural Selection

As we grow old enough to look around, pay attention to things, and begin to wonder what it's all about, we find ourselves living on a beautiful world. We soon appreciate that life forms on earth are characterized by a fantastic diversity, the thousands of species and varieties that make up the planet's ecosystems. If we really get down to the heart of things, going into the laboratory to study the cells with their enzymes and genes, we also appreciate that life on this planet is characterized by an intricate complexity and unity of structure and function.

How did it all come about? That's the question that all this has been leading up to. Two principal answers (each with many complex subdivisions) have been seriously considered: theism and atheism. Some have believed that our earth, with its life forms, was the creation of God, a divine, creative Intelligence-that it was thought out, ordered, planned, and then brought into being by divine engineering. Others have argued that God doesn't exist, but that matter and energy in the universe interacted in ways that eventually gave rise to our planet.

Theism and Atheism

In 1802 William Paley, in his book Natural Theology, spoke of someone finding a watch by a path. The finder examines its intricate design and structure. How did the watch come into being? There could be only one answer: It was engineered by a watchmaker. Paley argued that the earth, by comparison, was far more intricate and complex than the watch. His book was devoted to an examination of the complexity of living things to the extent possible in his time. Charles Darwin, as a young man, read Paley's book and was thrilled by it.

The argument that the complexities of creation imply the existence and intelligence of God had been around much longer than William Paley. The psalmist declared: "I will praise thee; for I am fearfully and wonderfully made: marvellous are thy works. . . . Thine eyes did see my substance . . . in thy book all my members were written . . . when as yet there was none of them." (Psalm 139:14, 16.) And again: "When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained. . . . O Lord our Lord, how excellent is thy name in all the earth!" (Psalm 8:3, 9.)

Alma presented the argument with eloquence to Korihor, the Anti-Christ: "Thou has had signs enough; . . . all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator." (Alma 30:44.)

The Lord told Enoch the same things: "And behold, all things have their likeness, and all things are created and made to bear record of me, both things which are temporal, and things which are spiritual; things which are in the heavens above, and things which are on the earth, and things which are in the earth, and things which are under the earth, both above and beneath: all things bear record of me." (Moses 6:63.)

Finally, the Lord summarized the argument in a revelation to Joseph Smith when, speaking of the earth, the moon, and the stars, he said: ". . . any man who hath seen any or the least of these hath seen God moving in his majesty and power." (D&C 88:47.)

The alternative to creation by intelligence is the concept of naturalism or logical positivism, which suggests that everything can be explained atheistically by natural law-whatever that is. Because of the astonishing successes of science during the first half of the nineteenth century, and perhaps because atheism is rather undemanding (sin becomes only relative), naturalism became highly appealing. Yet, until 1858 and 1859 when Charles Darwin constructed the bulwark of faith,

naturalism was on shaky ground. In this chapter I would like to present his argument with its later embellishments, these mostly from the science of genetics. Then in chapters 14 and 15, I would like to tell why I don't believe the argument to be conclusive; indeed, why I think it fails.

Charles Darwin

As everyone knows, Charles Darwin gets the credit for the theory of evolution. To state the case more accurately, he proposed the concept of natural selection, which provided a reasonable foundation for the idea of evolution, an idea that had been around for some time. Many authors, including Darwin's grandfather, Erasmus Darwin, talked about the evolution of one species from another, all species eventually originating from some simple, one-celled ancestor. It was all part of the philosophy of naturalism. Darwin suggested a model to account for this in rational terms. At least the terms seem rational to those who accept the idea.

Before Darwin's natural selection, about the only proposed mechanism of evolution was that of the inheritance of acquired characteristics, suggested by the great French biologist, Jean Baptiste LaMarck. This was the familiar idea that giraffes develop longer necks by stretching to reach higher leaves, and that because of this their offspring were then born with longer necks than the previous generation. By now this idea has been thoroughly discredited, and even Darwin referred to it as "that LaMarckian nonsense."

Charles Darwin is one of the truly fascinating personages of history. This is especially true because so much is known about the details of his life. He carried on voluminous correspondence with many people, he kept diaries and wrote a detailed autobiography, and he wrote several books and many papers that provide deep insight into his thought processes. Though he proposed a theory that may have done more to destroy belief in God than any other idea, I nevertheless find myself highly sympathetic toward Darwin. He was an honest seeker after truth. It is easy to feel compassion for him, considering the dilemmas he faced and how they led to his eventual loss of faith in God, in spite of his background and his deep and overwhelming reverence for the beauties of the earth and its organisms. He was a good man. I sincerely hope that he and his Emma have now accepted the gospel.

Darwin began his schooling in medicine, but because he could not bear to watch surgery on children without anesthetics, he entered theology in Cambridge. Yet his heart was not in it. Instead, he came under the wing of a devout and wonderful botany teacher, John Steven Henslow. He collected plants and beetles and was so thoroughly excited by these pursuits that when the opportunity came, he embarked on a scientific voyage on the H.M.S. Beagle. From 1832 to 1837, as the ship cruised around the world, Darwin collected avidly on the Cape Verde archipelago (off the coast of Africa), and then at many locations around South America, especially on the Galapagos Islands off the coast of Peru. As he left on the voyage, Henslow gave him a copy of Charles Lyell's new book on geology, which was the first really persuasive argument for uniformitarianism. Henslow advised Darwin to read it carefully, but not to believe a word of it! Darwin did read it carefully but became quite converted to the uniformitarian approach. He wondered how this might logically be applied to the evolution of species. What do we see in nature today that might tell us how species could evolve from one to another, given enough time?

Upon returning from the voyage, Darwin was a convinced evolutionist. He noted, for instance, that the birds on the Cape Verde archipelago resembled the birds on the nearby African landmass; birds on the Galapagos resembled those on the South American landmass. Since it seemed to him that a Creator should make island birds everywhere alike, the observation seemed incompatible with his concept of special creation. On the other hand, if the birds on the island got there from the mainland and then evolved into relatives that were similar yet definitely distinct, this would

account for the observation. Based on this and other observations, Darwin tended to reject God, a rejection that became complete many years later. See pp. 22-23.

Darwin took up bachelor quarters in London, where he read "heaps of books" on horticulture, agronomy, and other topics. He became thoroughly familiar with plant and animal breeding. Pigeons, for example, are selected for desired characteristics and then used to breed the next generation; those without the desirable characteristics are not allowed to reproduce. This was what we call artificial selection, and in the fall of 1838 it led Darwin, in a marvelous flash of insight (as he later described it), to the concept of natural selection.

At about the same time, he married his cousin, Emma Wedgewood. She and the rest of the relatives (the Darwins and the Wedgewoods) were extremely devout, and Darwin began to face the conflicts that would bedevil him for the rest of his life. He loved the quiet Victorian England in which he lived, yet he recognized that his developing ideas could destroy the foundations of faith.

Darwin didn't so much as write down his ideas. Apparently, he did not want to freeze into writing ideas that might otherwise grow and flower beyond their primordial state as they existed in the fall of 1838. He moved to a comfortable house in Down, where he was able to live and do his research with the support of family money. Eventually he prepared an outline of his ideas, and he indulged in a great deal of correspondence with a few trusted scientific colleagues. The first of these was Joseph Dalton Hooker, who was a few years Darwin's junior and who admired him greatly. Charles Lyell also became a close friend, and Hooker and Lyell were frequent visitors at Down. The developing theory was discussed at length, but it was not published.

Darwin spent some eight years studying barnacles. Was this discipline to make him a more thoroughly trained scientist? Or was it an escape from the publication and defense of his theory of natural selection? He was ill much of his life; indeed he was a notorious hypochondriac-who lived into his seventies. Were the tangible symptoms of his illness due to a tropical disease acquired on the voyage of the Beagle, or were they psychosomatic, developing within him in response to his internal conflicts about the faith of his beloved Victorian England and the impact his natural selection might have upon that faith? Possibly, they were a little of both.

Finally, things were brought to a head. Darwin received a letter from Alfred Russel Wallace, who described a theory identical to Darwin's own, even to the similarity of certain terms. Wallace had arrived at the idea independently but had inklings of Darwin's work. What was to be done? At the urging of Hooker and Lyell, Darwin prepared a joint paper with Wallace for presentation before the Linnean Society in the summer of 1858, twenty years after the marvelous flash of insight. The paper was presented by Hooker because Darwin was sick at home and Wallace was in South America. There was apparently little response to the paper itself, but the idea was soon being discussed all over England. In 1859 when Darwin published his "abstract" (actually a thick book entitled On the Origin of Species by Means of Natural Selection or the Preservation of Favored Races in the Struggle for Life), all of the first edition was sold out on the first day.

There is much more to the story, such as the famous debate between Bishop Samuel Wilberforce and Thomas Huxley, who defended Darwin. Soapy Sam, as he was called, waxed eloquent. Finally he stepped over the bounds of Victorian decency by asking whether Huxley descended from the apes on the maternal or the paternal side. Huxley devastated the Bishop and won the day with words to the effect that he would be hardpressed to decide whether he would rather have an ape as an ancestor or a man who would use his talents to ridicule the humble seeker after truth!

Natural Selection

But what was Darwin's theory of natural selection? The basic idea was that in nature, the struggle for existence took the place of the plant or animal breeder who does the selecting. Hence it is natural selection rather than artificial selection. Let's consider the various parts of the theory.

First, Darwin was impressed by the writings of Thomas Malthus. This eighteenth century cleric studied a population of oysters, recognizing that there was a tremendous potential for overproduction. If a population is going to remain stable, only two of the offspring of any average set of parents can themselves become parents. If, on the average, fewer than two become parents, the population will decrease; if more than two, it will increase. Yet all organisms are capable of producing far more than two offspring per set of parents (or only one offspring from a bisexual parent, such as most plants). Think of the thousands of acorns produced during the life of an oak tree, for example, or the number of eggs laid by a single female fish or insect. Even when we think of higher animals that produce a relatively limited number of offspring, the potential for extremely rapid growth of a population is nevertheless there.

The human population increased at an annual rate of about 2 percent during the 1960s. Compared to other examples, this is not a rapid rate of increase. It is achieved by each couple producing between three and four children in a lifetime. Yet at a 2 percent annual rate of increase, the population doubles after 35.1 years. After 35.1 years, 3.5 billion people become 7 billion. Beginning with only 100 people, the 7 billion mark is reached in 912.1 years. In another 502.2 years, that 7 billion will have increased to 148,400 billion people, which is one person for each square meter of the earth's land surface; only 62.2 more years cover the oceans also! About 2,389 years after the 100 people began their 2 percent annual increase, the mass of flesh will equal the volume of the earth; only 3,852 years after this beginning, the mass of flesh will fill a sphere with a radius equal to the distance from the earth to the sun! But, of course, such a geometric population increase cannot really happen, because an increasing population must draw on many resources, especially food. These resources are finite and eventually run out.

This led Darwin, and Malthus before him, to the second point: A continual overproduction of young inevitably leads to a struggle for existence. Malthus deduced that food supplies increase arithmetically, while populations increase geometrically. He was right in principle, at least in the sense that populations are theoretically capable of geometric increase extending to infinity, while the supply of resources, including food, shelter, and space, is finite. Malthus was wrong, however, in his specific predictions; food supplies and consequently the human population are now much larger than he ever thought possible. Ultimately there must be a limit, but Malthus did not know what the limit was, and we do not know today what it is, although many recent authors have made estimates. In any case, expanding populations of organisms do in our experience lead to a struggle for existence, although we find certain complications and exceptions. Often natural populations are limited by yet-to-be-understood decreases in the birth rate that seem to be characteristic of crowding. This is true for laboratory mice, black-tailed jack rabbits in northern Utah, and numerous other populations that have been studied.

Third, Darwin was impressed with the variety that he had observed in numerous populations of plants and animals. We are immediately aware of the variety in the human population. I'm told that a cowboy learns to recognize the individual steers in a herd. Variety is not only the spice of life, it is one of its most dependable characteristics. Its recognition was the key to Darwin's theory.

Fourth, Darwin recognized that if a struggle for existence was going on within a population of variable organisms, some would, on the average, be better able to cope with the struggle for existence than others. There would be a survival of the fittest. Any feature that helped an individual survive would tend to be preserved. Organisms that were least able to obtain food, escape from their predators, or find mates would be least likely to pass on these characteristics to

another generation. We now emphasize that the important thing was not so much survival of a given individual as production of offspring with the parental characteristics.

In Darwin's scheme, the survival of the fittest led to evolution. The principle was a statistical outcome of the overproduction of offspring and the struggle for existence in a population that included variety. The struggle for existence was selecting out features that made the population best suited to its environment, just as the plant or animal breeder selected the features that he wanted in his domestic plants or animals. Given a great deal of time, Darwin reasoned (and Lyell and the uniformitarians had provided him with the necessary immense span of time), and given some source of new variety continually coming into the population, populations of organisms might be expected to gradually change or evolve.

If a population were some way divided into two groups (e.g., by some natural disaster, by migration into a new area, etc.), then the two groups might be expected to gradually diverge from each other in response to different environmental factors in the different areas, and also in response to different chance variations in the features of the populations. Two species might thus evolve from a single ancestor species.

Carrying the process on over long enough periods of time, both in water and on land, couldn't we begin with a single, simple form of life, perhaps a single cell such as an amoeba (which seemed simple to Darwin, at least), and end with the immense diversity and complexity of life that we see on earth today? Darwin suggested that we could, and his book was an eloquent and detailed argument supporting this contention. It seemed that a way had been provided whereby Paley's watch by the path could indeed be created according to natural law and without the necessity of a God in the universe. Man, who made the watch and who is himself far more complex than the watch, had simply evolved by the statistical natural selection of minute differences in populations, beginning with some simple form of life several billion years ago.

Please note that the argument was really compelling. Please realize that the people who accepted it, and thereby rejected God, were not ignorant, stupid people. Certainly many people who accepted it were not evil. Most were honest, sincere seekers after truth. The arguments that raged were violent arguments, because the contenders on both sides were utterly convinced that they were right.

Yet the logic was not as totally incontrovertible as many nineteenth century proponents of evolution seemed to think. There was a weakness in Darwin's scheme. He was aware of it and discussed it at length, especially in the later editions of his book. The scheme depended completely upon some source of variety in the population that would produce changes rapidly enough and of the right type for evolution to work-for some amoeba-like ancestor to evolve into a man and into an oak tree. Darwin couldn't account for this source of variability. Finally, he retreated to the "LaMarckian nonsense" he had so thoroughly rejected originally. Surely this indicates the desperation of his position. He tried to imagine how the use of a part (a giraffe stretching its neck) could influence the future offspring. He decided that there must be something transmitted from the used part (the giraffe's neck) to the reproductive cells, changing them in some special way. The something he referred to as pangenes. But unknown to Darwin, in the 1860s an Austrian monk was making discoveries that would lead to formulation of another theory of how the variety originated, although the theory would not be recognized for two decades after Darwin's death in 1882.

Gregor Mendel

Mendel's story is almost as interesting as Darwin's, but contrasted to Darwin, we know virtually nothing about Mendel's life. He did not write down every thought and mood for the benefit of posterity. As a matter of fact, his spectacular insight, published in 1868, had virtually no impact

upon human thought. No one paid any attention until 1900, when three other scientists had duplicated his experiments and rediscovered his concepts, and then independently found his paper. (Two of the three men had rediscovered Mendel's laws; there is some question about the third.) The discoverers of Mendel's paper, as well as virtually all modern biologists, give Mendel the credit for discovering the laws of inheritance, upon which the science of genetics is based, and indeed he did discover these laws. Yet his discovery didn't really make any difference, because it was ignored until rediscovered.

Mendel was an Austrian monk who experimented with pea plants. His experiments were a model of scientific method. He was careful and thorough, doing much preliminary research with many varieties of peas before deciding on the ones that he wanted to use. Finally, he did something that was not common in the biology of his day: He applied simple mathematical principles to the results he had obtained.

Let's consider one of his experiments. Normally, pea flowers are self-fertilized; that is, the stamens that produce the pollen do not grow out of the flower, so the pollen falls upon the stigma in the same flower (Fig. 13-1). There it germinates, and a tube grows through the stigma to the ovary, where eventually the nucleus of the pollen combines with the nucleus of the egg cell. This is fertilization. Mendel would remove the stamens from a pea flower with a set of tweezers before they had begun to produce pollen. Then he would dust the pollen from a mature stamen onto the stigmas in the flowers from which he had removed the immature stamens. This way he could achieve cross-pollination (cross-fertilization), which is the normal situation in many flowers, where the pollen is taken from one flower to another by honeybees, wind, or other means.

When Mendel crossed plants producing red flowers with plants producing white flowers and then planted the resulting seeds, all the plants that grew from these seeds produced red flowers; there were no white flowers among the offspring! Mendel then allowed these red flowers (with red-and-white-flowered parents) to self pollinate in the normal way. He planted the seeds from the second cross and observed that the resulting plants had both red and white flowers; namely, 705 red and 224 white. Mendel recognized that there were about three times as many plants with red flowers as there were plants with white flowers (3.15 times as many red-flowered plants). He noticed the same three-to-one ratio in the six other characteristics that he studied. In each case, one of the two contrasting features appeared in the first generation, and the other didn't; in the second generation there were three times as many plants with the feature that appeared in the first generation as there were plants with the contrasting feature.

Mendel's Laws

Mendel explained his results by proposing two laws. From his work we can derive three general principles of heredity. The first of these, which has stood the test of time and stands as the basis of our present science of genetics, was the concept of unit inheritance. Mendel suggested that there was some unit (which we would now call a gene) that came from each parent and that influenced the appearance of a given character in the offspring. There was a unit for red flowers and a unit for white flowers, for example.

The second principle is that of dominance. Mendel suggested that one of these genes might dominate the other, so that if both were present, the observed feature in the offspring would be determined by only one of them. Thus the gene for red flowers dominated the gene for white flowers, round seed dominated wrinkled seed, etc. This was why only one of the two contrasting features appeared in the first generation. In that first generation, all the pollen from red-flowered plants, for example, would contain only the gene for red flowers; all the egg cells in white-flowered plants would contain only the gene for white flowers. Thus all the offspring would have a

gene for red flowers and a gene for white flowers, and the gene for red flowers would dominate, producing only red flowers.

The pair of genes in cells of adult plants separate when pollen or egg cells are formed. Hence, in the second generation, half the pollen grains from red flowers would have the gene for red flowers and half would have the gene for white flowers; half the egg cells would contain genes for red flowers and half for white flowers. So the gene for red flowers in a pollen grain might combine with a gene for red flowers in the egg cell, or with a gene for white flowers. And a gene for white flowers in a pollen grain might combine with a gene for red flowers or a gene for white flowers. There are four possibilities: One is to combine two genes for red flowers; two of the four possibilities combine one gene for red flowers with one gene for white flowers (producing red-flowered plants); and the final possibility combines two genes for white flowers. Thus three of the possible four combinations will produce red flowers, and one will produce white flowers-which is the ratio Mendel observed.

You should note from Table 13-1 that the numbers are not exact. We are dealing with chance processes, and so they are bound to be only approximate. You can obtain the same ratios by flipping two coins at a time for several hundred throws. Approximately one-fourth of the tosses will be double heads, one half will be a head and a tail, and the final fourth will be double tails.

OBSERVED CHARACTERISTICS FIRST GENERATION SECOND GENERATION F2 RATIO

(F1) (F2)

Round X Wrinkled seeds All Round 5474 Round: 2.96:1

1850 Wrinkled

Yellow X Green seeds All Yellow 6022 Yellow: 2001 3.01:1

Green

Red X White flowers All Red 705 Red: 224 White 3.15:1

Inflated X Constricted All Inflated 822 Inflated: 299 2.95:1

pods Constricted

Green X Yellow pods All Green 428 Green: 152 2.82:1

Yellow

Axial X Terminal flowers All Axial 651 Axial: 207 3.14:1

Terminal

Long X Short stems All Long 787 Long: 277 Short 2.84:1

Table 13-1 Mendel's results from crosses involving 7 single character differences.

One of Mendel's laws and our third principle is that of independent segregation. He studied various combinations of features in red and white flowers on tall and short plants, for example. In every

case, he found that the results of the crosses could be explained by assuming that the different characters acted quite independently of each other. After the science of genetics began to develop in the early 1900s, however, this was found in many cases not to be true. We now know that genes are located on the chromosomes that appear during cell division. If the genes are on separate chromosomes, they will segregate independently. As it turns out, there are only seven pairs of chromosomes in pea cells, and the gene for each of Mendel's seven characteristics occurs on a separate chromosome. This was certainly an amazing stroke of good luck. If two genes appear on the same chromosome, then they will not segregate in this independent way, although some separation occurs because chromosomes intertwine with each other and exchange segments in a process called crossing over.

Genetics and Evolution

So Mendel's laws developed into the science of genetics, which studies both heredity and the causes of variability in populations. Actually, a given feature may be controlled not just by two kinds of genes, but by many kinds (called alleles). Furthermore, a single character (tallness or skin color in man, for example) may be controlled by several sets of genes (several allele pairs). Variability is also caused by the many ways that genes are expressed. Mendel's law of dominance holds for only about half the genes that have been studied. In other cases dominance is incomplete. In snapdragons, for example, a cross between red and white flowers produces pink flowers. All this provided one answer for the source of variety in evolution: It is the recombination and expression of genes.

Many modern textbooks define evolution as a change in gene frequencies in a population in response to environmental selection pressures. A classical example, to which we shall return in chapter 15, is that of the peppered months of England. At the beginning of the Industrial Revolution, most individuals of the moth population were white with a speckling of black spots on their wings. During the day, on the bark of lichen-covered trees with the same light gray appearance, they were extremely well camouflaged. A few, however, had black wings with white spots and were rather easily spotted by their predators (several bird species). With the coming of the Industrial Revolution, pollutants in the atmosphere killed the lichens on the trees, and the bark became covered with black soot. Now the dark moths were much better camouflaged than the light ones. After only two or three decades, most of the peppered moths were of the dark variety. That is, the frequency of the gene or genes for blackness had increased in the population. (Say, for example, that at the beginning the gene frequency was 5 percent or 0.05 for the genes controlling blackness, and 95 percent or 0.95 for the genes controlling lightness. Gradually the gene frequency for blackness increased until it was about 95 percent and the gene for lightness was only 5 percent.)

But if, to make evolution work, we only had to change the frequencies of genes that already existed in a population, then we would be forced to imagine that the genes in the ancient amoeba were sufficient, after they had been properly recombined and their frequencies shifted, to account for all the organisms living today. Surely this couldn't be true, so there must be some other source of variety besides genetic recombination, if Darwin's selection is to work.

Around 1900 it was suggested by Hugo DeVries, a Dutch botanist (one of the discoverers of Mendel's paper), that this other source of variety was mutation. DeVries observed in his experimental plants that occasionally totally new features seemed to appear in the population from nowhere. He assumed that these features represented changes in the genes. As it turned out, DeVries was wrong about his specific features-they had already existed in his populations but had gone unobserved. His principle was correct, however, and other scientists soon discovered valid examples of mutations.

In the 1920s, Herman Mueller, a geneticist at the University of Indiana, discovered that he could induce mutations in organisms by irradiating them with X-rays or with ultraviolet light. We understand now that such radiations will slightly change the configuration of the DNA molecules, which are the genes. This in turn leads to configurational changes in the protein enzymes (that is, changes in amino acid sequences) controlled by these molecules, which presumably leads to changes in metabolic functions and structural features of the organism possessing the mutated gene. At last there seemed to be a source of variety sufficient to account for Darwin's natural selection. During the 1920s and 1930s, a number of geneticists (and others) took these new tools (the concepts of genetics, including mutations) and applied them to evolutionary theory.

The Modern Synthetic Theory of Evolution

The modern synthetic theory of evolution says that variety first enters a population by mutations. Genes change in totally random ways in response to the ultraviolet and ionizing radiations of nature (e.g., cosmic rays, radioactive decay) and also certain chemicals that are now known to cause mutational changes in the genetic material. It is immediately apparent that when we randomly change something as complex as a DNA molecule and the protein whose structure it controls, most changes are likely to be bad. Imagine making random changes in the structure of a watch! So the vast majority of mutations are either harmful or fatal.

Nevertheless, it is said by modern biologists, a mutation will occasionally be positive. Either it will make the organism better suited to its environment, or it will make it potentially better suited after many recombinations and perhaps environmental changes. Perhaps only one mutation in a thousand will be positive in this sense, it is often stated, but considering the mutation rate observed in nature, one good mutation in a thousand random gene changes ought to be plenty to account for evolution. Estimates have been made of the number of genes present in a given organism, the number of mutations required to produce them, and the available times. It seems to work out.

Evolutionary theory thus finally came of age. All the details seemed to fit. The impact on biology was profound. It gave direction to the science by providing a framework for conceptual thought in many diverse fields. Numerous positive discoveries trace their origins to the theory. Without it, for example, many biologists would flounder in their research. When they apply the concept to the natural populations they study and the classifications they devise, it works well.

Yet there are problems. From the standpoint of our philosophies about creation, the theory really does seem to do away with the need for God. The modern biology student is presented with a theory that seems to be even more compelling than Darwin's original concept of natural selection. Everything seems logical, and all is backed with the prestigious authority of famous scientists. Books have been written, learned treatises have been presented-how could it possibly not be true? And isn't the earth extremely ancient? What about the fossils? Don't taxonomy, embryology, and anatomy argue conclusively that evolution did happen, regardless of how? And don't the calculations of population geneticists, who have studied the recombinations of genes and the shifts in gene frequencies, finally once and for all prove the modern synthetic theory of evolution?

This view of the origin of biological diversity and complexity is now the foundation of faith, the catechism of belief, the great biological dogma, the prevailing and pervading doctrine. Who could doubt it? It is discussed in classes at one level or another from grade school to graduate school. Always it is presented as the inviolate truth. Yes, the details may be discussed and questioned, but the overall dogma is taught and accepted as fact. Anyone who would question it is clearly a heretic.

It was questioned by fundamentalists and creationists in the state of California until a law was put on the books that it must be taught only as theory and not as fact. There was an immediate hue

and cry from the world of biology. Editorials were written. Biologists felt they were witnessing a witch hunt as repulsive as the Catholic inquisition.

I can't agree. I believe that the modern synthetic theory of evolution is indeed a theory. It may work well with contemporary populations, but I don't believe that it has really solved Darwin's question of the origin of variability applied to his general theory: an amoeba to man. (One positive mutation in a thousand mutations seems hopelessly optimistic.) I believe that variability remains the Achilles' heel of the entire concept. Indeed, I believe that the findings of modern science during the past two decades have greatly increased the seriousness of the original problem, that the origin of variability and complexity is a greater mystery than ever. I believe, with William Paley, that the complexities of living things argue for their creation by divine intelligence. I believe, with Alma, that "all things denote there is a God; yea, even the earth, and all things that are upon the face of it. . . . "(Alma 30:44.) The reasons I believe these things form the topic of the next chapters.

Note: Since the type was set for this book, I heard in a sacrament meeting talk, in relation to Paley's story of the watch (page 99) that Voltaire (1694-1778) said, "If a clock proves the existence of a clockmaker, and the universe does not prove the existence of a Supreme Architect, I am content to be called a fool."

Section 4:
Evolution or Creation?

"And the earth, after it was formed, was empty and desolate . . ."
Abraham 4:2

14
Evidences From Rocks and Family Trees

Now it's time to get down to business. The general theory of evolution implies a creation directed only by chance events and "natural laws," while the scriptures tell of creation by divine intelligence. Hence we are entitled to ask: How conclusive are the scientific evidences for atheistic evolution? Does scientific knowledge support or conflict with a concept of creation by a God of intelligence? Can we reconcile what God has revealed and what science has discovered?

The answer to the last question is clearly no. Certainly we cannot reconcile science and revelation in a way that will satisfy everyone. If we could, books like this wouldn't be written. Yes, there are suggestions to make and possible interpretations to give. That is the point of this section. But few of the ideas can be considered conclusive. Often there are several alternatives that all seem equally likely. God hasn't told us the whole story, and science hasn't collected all the data. The facts simply aren't all in-in science or religion. My personal viewpoint has changed considerably during the past thirty years (even during the past few weeks). As new discoveries are made, and as new thoughts come to mind, I expect my viewpoint to continue to change.

So the conclusion of these chapters must be that there cannot yet be a real conclusion. The name of the game must be "wait and see." My appeal must be for you to remain objective, to realize that you can't know for sure at this stage exactly what the answers are. This is a difficult position to take. We have been taught that it is courageous to take a stand, to fight for what we believe. That's fine for broad philosophical principles such as a belief that God was the Author of creation. That viewpoint is fortified by his revelations to us through the prophets. But the best things you can learn now about how creation took place are the arguments on both sides of the question, why totally satisfying answers can't be obtained at this time, and that you must be reasonably tolerant

of all viewpoints that are based upon facts. It is already clear that there is much truth on both sides of the argument.

The Role of Faith

But if you do learn the lessons of these chapters-be objective, wait and see, don't expect a final answer now, and be tolerant of all views-you probably aren't going to be exactly comfortable in your discussions about evolution. Few people have learned these lessons. On both sides of the question, many are completely convinced that they are correct. Since, as we shall see, the evidence doesn't warrant such conviction, their beliefs must be based on faith.

The modern biologist often states his total devotion to the evolutionary dogma with intense religious zeal. Consider this statement of H. G. Wells: "One thing is certain. Not one fact has ever emerged, in a stupendous accumulation of facts, to throw a shadow of doubt on what is still called the 'Theory' of organic evolution. In spite of that violent lying and yapping of the pious, no rational mind can question the invincible nature of the evolutionary case." These are strong words and eloquently put, but similar statements couched in less eloquence can be found in almost any textbook of biology. Yet many straightforward facts are presented and assembled by highly rational minds that cast considerable doubt on the theory of evolution. If you mention these facts to most modern biologists, you will immediately be labeled a "fundamentalist" whose arguments come from "anti-evolutionary tracts." And on that basis, you will be ignored.

The general theory is taught in most schools as though it were proven fact. The extensions from this approach are naturalism, logical positivism, existentialism, and atheism. Furthermore, these philosophical doctrines are often subtly introduced, even by teachers who do not believe in them. As we have seen, naturalism is one of the rules of the scientific game that must be accepted by anyone who will do science, whether he accepts it as a universal philosophy or not. Even a devout scientist must play the atheistic game and assume that God will not interfere with his experiments. Hence the assumptions of naturalism are usually implicit in classroom discussions of evolution in particular or science in general, so that even a good Latter-day Saint biologist can strengthen the case for atheism (via naturalism) without even being aware of it.

On the other hand, teachers of religion with little training in science, especially biology, can make dogmatic statements about the wicked, evil, foolish scientist who rejects God. They have strong faith in the idea that nothing about evolution can be true. Acceptance of evolution is said to be tantamount to apostasy. I talked to one good brother who was totally baffled in trying to understand how anyone could accept the concept of evolution. In his mind the scriptural as well as the scientific evidences were so strong against evolution that it was incomprehensible to him how anyone could possibly be fooled into believing the doctrine. It is not incomprehensible to me.

In the standard biology class, several evidences for evolution are usually presented. It is instructive to consider these evidences from a somewhat more objective viewpoint than one usually encounters in such classes. As we'll see, some of the "best" evidences for evolution turn out to be equally good or even better evidences for creation by God. We'll examine these evidences from the standpoint of what might be predicted on the basis of atheistic-evolutionary or creation theories.

The Fossil Record

For me the fossil record was always the most compelling evidence for evolution. In chapter 11, we saw that one can tell a reasonably coherent story based upon the fossils and upon the assumption that evolution did occur. The stratigraphic sequence has been studied on a worldwide scale, and it seems to tell of a progression of increasingly complex life forms on this planet during about the past 600 million years. Such a progression is exactly what the theory of evolution would predict.

I've been reading some of the creationist literature, however, and I am becoming convinced that the fossil record is not such a compelling evidence after all. Indeed, a strong case can be made that two important predictions of evolutionary theory in relation to the fossils fail to work out. On the other hand, predictions based on a creationist theory fit rather well.

We have discussed what might be called the general theory of evolution, namely, that all organisms are related by descent from a common ancestor (some primordial cell), the increasing complexity being accounted for by a natural selection over an immense span of time of the best-adapted micromutations and new combinations of genes. A way to test a theory is to deduce what the theory predicts and then to observe nature to see if the predictions are substantiated. What does the general theory of evolution predict in relation to the fossil record? At least three things come to mind:

1. One would expect to find fossils of increasing complexity as younger strata (those higher in the sequence) are examined.

2. One would expect to find extremely simple fossil organisms in the most ancient strata, with a gradual increase in complexity as the strata are younger and a divergence in lines of similar organisms until all the major phyla and divisions of the animal and plant kingdoms have appeared. That is, we would expect to find fossil organisms representing the trunk and the many branches of the evolutionary tree of life.

3. Since evolution might proceed rapidly at some time (e.g., during times of climatic change), and since some organisms may not leave fossils (e.g., those that live in uplands where they are not likely to fall into the mud on the bottom of a shallow sea), it might not be surprising if the family tree has large sections not represented by fossils. But one would nevertheless expect to find several good examples in which a continuum of fossil forms makes it possible to account for the origins of modern genera, families, and orders. This is a necessary consequence of the accumulation of minor changes, which is central to the modern synthetic theory.

What would a theory based upon creation by God predict? This is a more difficult question, since the details of such a theory must depend heavily upon one's interpretation of the scriptures. If the theory is based upon the seven-period account in Genesis 1, for example, then it might predict that fossil plants should occur in strata more ancient than those containing the oldest animal fossils-if such a creation theory allowed the geologic strata to be formed at all during the periods of creation! But one might soon run into problems. If there were no death before the Fall, for example, then the fossils would have to be formed after the Fall, perhaps during the Flood. On the other hand, the fossils might have been formed during some period before the creation account given in the scriptures.

So to make any predictions, we must make certain assumptions. We shall build our creation theory on the accounts in Moses and Abraham. Remember that actual biological creation occurred only during the seventh period, when man was created and the Gods rested (Moses 3:5; Abraham 5; and D&C 77:12), and that there was no mention of the order in which biological creation took place, except that the man Adam (but not Eve) came first (Moses 3:7). Organisms were commanded to bring forth only after their own kind. How they were created is never mentioned, except that some were made from the dust of the earth. Since the record states that a garden was planted (Moses 3:8; Abraham 5:8), it is conceivable that seeds (in the broad sense, including spores or other reproductive structures) were brought to the earth, where they would use the "dust of the ground" to grow into mature plants-and in turn be consumed by animals that might have been brought to the earth from somewhere else (in embryonic form?). Based on these ideas, and assuming that the period of biological creation was long enough and conditions were such that fossils could be formed

during creation (an assumption with which many might not be comfortable), there are at least two things that a creation theory might predict with respect to the fossil record:

1. A great variety of highly complex forms might appear suddenly in the record.

2. Since variation is permitted only within a "kind," which could mean a species, genus, or even family in some cases, we might expect to find fossil evolutionary sequences of limited extent and closely related organisms, but we should not expect to find "missing links" that account for the evolution of one major group into another.

So what does the fossil record actually reveal after 200 years of careful study? Certainly, as we saw in chapter 11, the fossils are usually increasingly complex in the upper (younger) strata (Fig. 11-2) just as the general theory of evolution might predict. This is hammered into students from the first grade to graduate school, and it is no doubt the reason why I felt that the fossils were the strongest evidence for evolution. A moment's reflection, however, makes it clear that the fossils are only a good evidence for evolution if the other predictions are also met. Increasing complexity by itself means little, since a reasonable creation theory might well allow the same thing. The importance of increasing complexity in the fossil record depends upon many things, such as the time spans involved and how the fossils were formed.

As to the other two predictions of the two theories, Creation comes out ahead. There is no fossil record of gradual evolution of the phyla and divisions (Fig. 11-2). The most ancient fossils of multicellular organisms are found in the Cambrian strata, and virtually all the invertebrate phyla of animals are represented. These include many highly complex and varied organisms with extremely well developed structures. Remnants of such single-celled organisms as bacteria or algae apparently occur in Precambrian rocks, but where are all the intermediate stages leading to the several invertebrate phyla? They are simply not to be found; complex forms appear suddenly in the record!

And how about the transitions or continua in fossil types that allow us to see how genera, families, orders, and phyla come into being by evolutionary pathways? Such series simply do not appear in the record. Any book on either plant or animal paleontology makes this quite clear. The transitional forms just aren't there. Again and again the authors must state that the origin of some major group such as the insects, mollusks, rodents, birds, fungi, mosses, ferns, gymnosperms, or flowering plants must be deduced from contemporary anatomical evidence (and such deductions always remain tentative), because the fossil record is "silent" or "shrouded in mystery." For some reason, the reader always tends to imply (I always did) that some group or groups other than the one under immediate discussion does have clear-cut fossil ancestors. But the fact of the matter is, no major group has obvious fossil predecessors that inform us as to how the group came into being by evolution.

Could the modern synthetic theory be wrong? (Heaven forbid!) Perhaps, as the evolutionist (a geneticist) Richard B. Goldschmidt suggested, a lizard may lay an egg and a bird may hatch from it! That is, extensive changes may occur all at once (i.e., in one or a few generations) by some evolutionary mechanism not yet understood. This was the "hopeful monster" hypothesis. But all the evidence is against this suggestion, and it was rejected by Goldschmidt's contemporaries.

The biology teacher always points to the horse as the classical example of a gradual increase in complexity. The way the fossils are displayed in the American Museum of Natural History seems to show a gradual increase in size, loss of toes until a hoof developed, etc. Yet the professional in the field knows that the story is not as clear-cut as it appears to be in the museum display or on the textbook page. Each of the intermediates is completely distinct from others in the series and

appears suddenly in the record. There is no way of knowing that one of the so-called fossil horses gave rise by an evolutionary process to any other in the sequence, or even to be sure of the supposed dates assigned to these fossils.

Actually this is an extremely important weakness of the fossil record: it is impossible to find rigorous proof that any one fossil was the descendant of any other. The paleontologist, in his attempts to establish evolutionary sequences, assumes that morphological similarity implies relationship and descent. Similar form may well imply relationship and descent, but it certainly does not prove it. If it did, we would have to conclude that Fords and Chevrolets are genetically related and that 1976 Fords descended from 1975 Fords. But each automobile is the product of an act of special creation, and the designs evolve and descend only in a more figurative sense in the minds of automotive engineers.

A few fossils have been presented as missing links-not the hundreds of thousands that one might expect, but a few. These specimens seem to be transitional, having intermediate characteristics between those of two organisms postulated to be related by descent. Most are vertebrates, including intermediates between fishes and amphibia, amphibia and reptiles, reptiles and mammals, and reptiles and birds. But consider an example: A fossil called Archeopterix has both reptilian and avian (bird) characteristics. There are feathers, but the ends of the wings have claws, and there are teeth. Is this really a missing link? The creationist points out that Archeopterix was simply a bird with claws and teeth. Its feathers and other structures for flight were as well formed as those of any modern bird. Birds with claws are known in the jungles of South America today (the hoatzin), and other fossil birds have teeth.

Creationist Attacks on Uniformitarianism

The creationist says that fossils were probably not formed gradually as uniformitarian doctrine holds, but rather they were formed cataclysmically. We normally assume that plants or animals fell to the bottom of a swamp, or shallow sea, where they were gradually covered with sediments and fossilized. But organisms that fall to the bottom are usually eaten, or they decay. Why didn't the organsms that became fossils simply decay?

In many locations a cataclysmic origin of the fossils seems to be clearly indicated. There are whole beds, such as the "bone bed" at Agate Springs, Nebraska, containing thousands of bones of fossil mammals, for example, as though an entire population were suddenly trapped in a mud slide or some other cataclysm. The deposits in Lincoln County, Wyoming, contain vast numbers of fossil fish, palms, alligators, birds, mollusks, crustaceans, turtles, mammals, and insects, all jumbled together. The creationist usually suggests that the biblical flood was the cataclysm that produced such fossils.

One of the most striking examples of fossils that appear to be produced by catastrophe are the hairy mammoths of Siberia. These have been studied in detail and documented by many authors. There are areas where thousands of the beasts have been found, and the total number along the coast of Siberia reaching all the way to Alaska may be as high as 5 million. A few of the better specimens are so well preserved in the permafrost that the meat has been thawed out and fed to the dogs-or, in a few cases, to explorers! The stomachs of these well-preserved specimens contain the undigested remains of tropical plants. In a few examples, tropical food was actually found in the mouths of these frozen mammoths. Certainly a drop in temperature sharp enough to quick-freeze a hairy mammoth before he could finish swallowing his mouthful of tropical food ought to qualify as a catastrophe! In chapter 16, we shall consider one of the proposed explanations for this observation.

The creationists have zeroed in on the stratigraphic sequence. They point out that there is no place on earth where all the strata lie one on top of another, as the sequence appears in the geology textbooks (Fig. 11-1). Comparing the fossils in the strata that occur around the world, the stratigraphic sequence was constructed. Obviously this involved some assumptions. In particular it involved the assumption that evolution occurred, that organisms became increasingly complex through time. But isn't that what we were trying to prove in the first place? We have an excellent example of circular reasoning: To construct the stratigraphic sequence, we must assume that strata containing more complex fossils are younger than strata containing simpler fossils, because evolution happened. Then once the stratigraphic sequence has been constructed, we point to it with glee as the most convincing evidence that evolution occurred.

Furthermore, as the creationist is quick to point out, the stratigraphic sequence isn't all that well established anyway. Numerous examples are known in which simpler (and therefore presumably older) fossil beds occur on top of more complex ones. These are so completely against the assumptions of evolution and uniformitarianism that they have been serious problems. But a way has been conceived to accommodate these examples in uniformitarian theory: the concept of the overthrust. The idea is that, since the apparently older strata could not have formed on top of the younger ones, they must have been formed somewhere else and then moved to their present location.

Consider the Lewis overthrust. This is an elongated area running north and south for about 135 miles, crossing the border between Montana and Canada. It includes the spectacular portion of the northern Rockies where Glacier National Park is located. The area is about 15 miles wide, consisting of Precambrian limestone resting on top of cretaceous shalebeds. That is, limestone that is supposed to be 500 million to a billion years old rests on top of shale that is supposed to be only 20 million years old. How did it happen? The answer of uniformitarianism is that Precambrian limestones several thousand feet thick and along a line about 135 miles long were pushed 15 miles to the east until they rested on top of the cretaceous shales.

If thousands of feet of limestone along a line 135 miles long were pushed for fifteen miles over shalebeds, there really ought to be some sign of this gigantic movement at the interface between the limestone and the shale. In some areas the rocks do seem a bit broken, but certainly no more so than in many other areas where an overthrust is not postulated. Much more impressive is that the contact between the limestone and the shale appears at many locations to be quite typical of contacts between strata as they occur over most of the world, where no overthrusting is postulated. That is, there is simply a normal contact line with no evidence of extensive metamorphoses, breakage, faulting, etc. In any other situation, the geologist would simply interpret this as one stratum being deposited normally upon another. The concepts of plate tectonics (continental drift) might account for the forces that caused the movement, but where is the expected breakage and distortion? Such cases can be multiplied many times throughout the world.

The creationist cites other examples that are contrary to the establishment picture of fossil sequences. For example, footprints that appear human have been found with dinosaur footprints in a cretaceous limestone formation near Glenrose, Texas. This is completely unacceptable to uniformitarian geology, since the dinosaurs supposedly became extinct about 70 million years before man evolved. As a consequence, such observations must be ignored or explained away. It is usually suggested either that the fossil footprints were artificially made by someone wanting to perpetrate a hoax, or that they belong to some creature other than man who had a foot closely resembling man's. Yet if it were not for their position of occurrence, they would be accepted immediately as genuine. It is important to realize that if there are examples of strata or even single

fossils completely out of sequence (as the overthrusts and misplaced fossils might imply), then the whole story told by geologists is wrong. No compromise position is possible.

The Origin of Man

The difficulties with the fossil record reach their peak when it comes to fossil man. The story is complex and has a long history; indeed, there is far too much detail for presentation here. Table 14-1 summarizes the important findings (up to 1975) that have been interpreted as humans or ancestors of humans. There are not really many specimens that are thought to be prehuman, and many of these are only fragments, perhaps a piece of a jaw-bone or a few teeth.

Table 14-1 Some fossils postulated to be human ancestors or near relatives; summary of some members of the family Hominidae.

Name	**Discoverer - Place**	**Date**	**Age (years)**	**Brain Capacity**	**Comments**
Homo sapiens			10,000	1,200 to 1,600	Many races all interfertile; no sharp divisions. Cro-Magnon man appeared rather suddenly in Europe. Similar in virtually
Modern man					(3 to 30, depending upon the criteria)
Cro-Magnon man	(France) Many fossils	1888	40,000	cubic centimeters	

						all respects to modern man, especially Scandinav- ian and Anglo- Saxon types. Fairly advanced culture: art, sculpture, ritualistic burial, etc. Probably had counter- parts in the rest of the world.
Homo neanderthalensis	Johann Karl	1856	120,000	1,200 to	Short (5 to	

Neanderthal man (Germany); first recognized fossil man	Fuhlrott (ends 35,000 years ago)	1,600 receding forehead, eyebrow ridges, chin, but large brain. Many tools. Buried dead (religion?). Eliminated or absorbed by Cro-Magnon man. (Original fossils said to be pathologic modern men- Rudolf Virchow.)	5.5 feet),
Gibralter man (Gibralter; usually	1848		

overlooked.)

Homo

erectus Eugene 1894 750,000 775 Specimens

Erect man, Dubois (Java- (200,000 to from Java,

Java man, locked up his 1,000,000) 1,300 Asia,

Peking man, material until Africa,

etc. 1920s!) maybe

Europe

(Heidelberg).

Davidson 1927 Much variety

Black & (many names.)

Franz Primitive

Weidenreich facial

(Peking, features:

China) large jaw

and teeth,

almost no

chin,

receding

forehead,

bony

eyebrow

ridges,

broad

lowbridged

nose. Used

				tools and fire, maybe speech.
	Ralph von Koenig-swald (Java)	1930s		
	Louis S. B. Leakey and Mary Leakey (East Africa; Olduvai Gorge)	1960s		
Homo habilis	Mary Leakey (East Africa; Laetolil)	1975	3.35 to 3.75 million	Teeth and lower jaws from 11 individuals; potassium-argon dated. Oldest fossils of Homo, older than many of the Australop

			-ithecus noted below.		
	Richard Leakey (East Rudolf, Kenya)	1972	2.8 million		
Australo-pithecus sp. African ape man	Raymond Dart (South African Taung baby)	1924	500,000 to 2,500,000 (Pleisto-cene Geolo-gical Epoch)	450 to 750	Erect (bipedal), simple bone tools, large jaws, almost no forehead or chin. At least two species for the Taung baby.
Two species now gener-ally recognized: africanus robustus	Robert Broom (South Africa)	1933	3 million years-one was an herbivour (robus-tus).		

			but predator (afri- canus) would probably be the human ancestor. Also found in North Africa and in Java.
	Louis and Mary Leakey (East Africa)	1959	
	(Ethiopia)	1969	2-4 million
	Bryan	1971	4 million Arm bone
	Patterson (Kenya)		5.5 million (Pliocene) Jawbone
Rama- pithecus punjabicus (breviro- stris)	Leakeys	1960s	14 million (Late Miocene Teeth and jaw frag- ments only Roof of jaw is arched, 5-cusp molars.

			Possibly hominid ancestor, but little is known.
Proconsul (Dryopithecus)	Leakeys (Lake Victoria, Kenya)	1930s (Miocene)	20 million Part monkey, part ape-man. A diverging point. Perhaps went from the trees to the ground.
Oligopithecus	(Egypt; Fayum Depression)	1961 (Oligocene)	28 to 40 million Teeth with 4-cusp molars as in monkeys.
Propliopithecus	(Egypt; Fayum	1963 in Chimpanzee	350 to 450 Teeth with 5-cusp molars as in apes

and men.

Depression)

The story of man's postulated descent has been changing radically since Darwin published his book on the evolution of man about 100 years ago. The scheme I learned at the University of Utah around 1950 is not taught today. For one thing, one of the "fossil human ancestors" that I learned about (Piltdown man) proved to be a hoax. A human skull had been combined with a "doctored" monkey jawbone. But most of the changes have come about not because of the discovery of hoaxes, but because of additional fossil finds.

For the last century and a half, when a fossil of an alleged human ancestor was found, it was given a highly specific name. This was true even if the fossil was only a tooth. Trying to fit all these types into an evolutionary scheme was extremely difficult or impossible, although it was often tried. In recent years many of these fossils have been grouped together, and most texts outline the evolution of one group to another, much as they are shown in Table 14-1. Proconsul 20 million years ago was supposed to be the ancestor of Ramapithecus, which lived 10 to 14 million years ago and which gave rise to Australopithecus, which lived one to 5 million years ago. Australopithecus, which was very ape-like, gave rise to Homo erectus, which was also quite ape-like and which lived 200 thousand to 2 million years ago, giving rise to Neanderthal man (45 to 200 thousand years ago) and finally modern man (Homo sapiens).

This scheme seemed simple enough, and it seemed to greatly reduce the confusion. One could argue with many of the points of evidence used to support it, but it was nevertheless accepted by many biologists. In recent years this has been considerably upset by the researches of a husband and wife team of archeologists from East Africa: Mary and the late Louis S. B. Leakey, and now their son Richard. Richard in 1972 and Mary in 1975 have reported finding fossil jaws, teeth, leg bones, and a skull that appear much more modern (like Homo sapiens) than Homo erectus (Peking Man and Java Man) or even Australopithecus, but that lived from 2 to 3.75 million years ago. Four of the recent fossils, reported by Mary Leakey, were found imbedded in volcanic ash that was dated by the potassium-argon method at 3.35 to 3.75 million years. So again the scheme is upset. The modern form predates the ones that seemed to be its ancestors by at least 2 million years. Richard Leakey has said that "either we toss out this skull or we toss out our theories of early man." The surprisingly large braincase "leaves in ruins the notion that all early fossils can be arranged in an orderly sequence of evolutionary change. . . . It simply fits no previous models of human beginnings." And Leakey has no new model to supply in place of the old one.

It is worthwhile to examine a few of the details relating to the history of research on the origin of man. This history includes a form of science that is a far cry from the experimental and observational approach that has led to our present understanding of the cell, for example.

Java Man and Peking Man

Consider the story of Java Man. A Dutch physician named Eugene Dubois became convinced that the "missing link" would be found in Dutch Java. In 1891, along the bank of the Solo River, he found a skull cap with a low, sloping forehead and heavy brow ridges. About a year later and 50 feet from the original spot, he found a human thigh bone (femur) and two molar teeth. He found another tooth in 1898. The collection was called Pithecanthropus erectus (erect ape man) and was estimated to be 500,000 years old. Dubois concealed until 1922 the fact that he had found two human skulls at about the same level in nearby Wadjak. Many authorities identified the skull and the teeth as those of a gibbon or chimpanzee. The femur was clearly human. Why associate the femur and the skull cap found at different times and places? Only because of the need to find a

"missing link." Dubois, who was most aware of the circumstances of the find, changed his mind before his death and declared that his Java Man was nothing more than a large baboon. But anthropologists have elevated the skull cap, teeth, and femur to Homo erectus, or erect man.

Peking Man, now also called Homo erectus, is even more tenuous, although he is considered one of the strongest links in man's alleged evolution. Dr. Davidson Black, in the 1920s, found a single tooth and said it came from Sinanthropus pekinensis. Later, about 30 skulls, 11 lower jaws, and 147 teeth were found in unlayered debris in the side of a cliff, which was called a cave but hardly fits that description. Remains of modern man were also found somewhat higher up in what was allegedly an upper cave. All the fossils except two teeth disappeared sometime between 1941 and 1945, so now we have only the models, descriptions, and modern reconstructions. There is ample evidence that construction of the models involved much subjectivity and pre-conceived ideas. For one thing, they differ markedly from the early descriptions.

A most interesting observation is that the skulls were found with only a few other bones, these always occurring separately. No skull had an associated lower jaw, and all the skulls were damaged in much the same way, bashed in at the base. It is as though they had been brought to the site by a hunter who consumed the brains. This is a reasonable explanation, and it is accepted by most authorities. Who was the hunter? Believe it or not, the evolutionists have concluded that the hunter was Peking Man himself. Yet the best assessment of the site is that it was a stone quarry and not a cave in the usual sense. There is ample evidence of cut stone, and apparently the roof had collapsed, producing the unstratified rubble in which the skulls were found, including the human remains. Thus it is reasonable that True Man was the hunter, and that the ape-like skulls represent his prey. Why isn't this simple explanation accepted? Because Peking Man could hardly be the ancestor of True Man if they co-existed together.

The above two paragraphs summarize a rather extensive discussion by Duane T. Gish, associate director of the Institute of Creation Research. His discussion is based on several well-documented sources but relies heavily on a book by two evolutionists and another by a Catholic priest who was a creationist and who was in China while the excavations were being carried out (although he never visited the site personally). During the final revision of this manuscript, I have been reading a recently published book entitled Peking Man by Harry L. Shapiro, chairman of the Department of Anthropology at the American Museum of Natural History in New York. Although the tone of the discussion is very different (Shapiro harbors no doubts that man evolved), some of the facts mentioned in the above two paragraphs are indeed confirmed: human remains were found in the upper caves, the skulls had indeed all been damaged, and early workers had suggested that the damage was the result of cannibalistic feasts. But other ideas were not clearly confirmed, so after worrying for awhile, I telephoned Dr. Shapiro. Gish's discussion implies that we have only models and reconstructions of the original fossils. Shapiro assures me that the museum has actual castings, probably the first and best made from the molds, although they are not of as high quality as castings made with more modern materials. (Incidentally, to insure against the loss of the castings, the original plaster casts have recently been recast using modern materials.) Dr. Shapiro would not support the idea that the original caves were the result of quarrying, although he agrees that the peasants have quarried in the area intermittently during recent times. He says that the caves were really natural fissures in the limestone, and that the roofs did indeed collapse. He says that many of the fossils were found in the collapsed, unstratified material, but he thought (wasn't sure) that some were found in layered material below the rubble.

My present feeling is that proponents on both sides of the question have overemphasized and exaggerated points that seem to be in their favor. This is certainly not deliberate deception; it is virtually impossible to rise above one's biases or prejudices regardless of how one tries. Gish has certainly distorted the picture somewhat in his attempt to portray a recent stone quarry with

human hunters of ape-like creatures. But Shapiro has no doubts that the Peking skulls represent the remains of a community that flourished half a million years ago; he speculates and rationalizes until any evidence to the contrary becomes minimized in his thinking.

Subjective Science

The real problem with the story of the evolution of man is that it is the product of basically bad science. To begin with, only a small handful of scientists have actually studied the problem intensively, although a great many more are somewhat conversant with it. All the individuals involved have been completely convinced from the beginning (before they started their researches) that man did evolve. That was never the question at issue. There has been much argument about the placement of given fossils in man's evolutionary history, but for about the past century, no one in the halls of establishment science has seriously questioned the idea that man did evolve. Creationists have advanced many scientific arguments against the idea, but the establishment completely ignores these. (And it must be conceded that their arguments are not always all that scientific.)

In the context of the superficial science associated with the evolution of man, I tend to think of examples in which the scientific community has been totally convinced about an idea that has subsequently turned out to be wrong. In areas where the acquisition of data is extremely difficult, it is often possible to make highly convincing arguments for some viewpoint that later proves to be totally incorrect. Certainly evidence relating to the evolution of man is of this nature; it is fragmentary, highly incomplete, and subject to extremely broad and subjective interpretation.

Consider our ideas about conditions on Mars. These ideas were always based upon the best available scientific information, yet they changed radically over the years. Around the turn of the century it was possible to think of Mars as being rather similar to the earth, supporting life represented by the large markings that change color with the seasons. By the 1940s, the picture had completely changed. Mars was known to be much colder than had originally been thought, and the atmosphere was known to be extremely thin. In 1964, the first Mariner spacecraft to approach Mars sent back eighteen historic pictures that showed a surface resembling that of the moon, and our ideas about Mars again changed radically and rapidly. The subsequent Mariner spacecraft caused equally drastic modifications in our thinking. For example, the atmosphere of Mars proved to be at least ten times as thin as the thinnest earlier estimate, and nitrogen appeared to be completely absent. The 1976 Viking Lander detected nitrogen in the atmosphere after all, about 3 percent. As this book was going to press, Viking seemed to be reporting signs of life. The reason that the picture could change so rapidly and with such little stress in the scientific community is that either picture is quite acceptable emotionally. Indeed, the present picture of a virtually lifeless planet seems to fit rather nicely into the establishment atheistic universe. Questioning evolution, however, is another matter.

The Fossil Evidence: a Summary

Although I have presented some of the creationists' views about the fossil evidence, I would like to close this discussion by reemphasizing that the fossils continue to provide the evolutionist with one of his strongest arguments. True, the general theory of evolution does not predict a sudden appearance of major groups in the fossil record nor the lack of transitional forms. But the evolutionist can exercise a little faith and speak of a time when a little more information will solve these problems. In the meantime, the stratigraphic sequence fits well with the idea that the earth is very old and that a parade of life forms moved across its surface over eons of time. If we just knew why evolution occurred so rapidly sometimes (accounting for sudden appearance and lack of transitional forms), all would indeed be well.

Although the existence of the fossils does not prove or even strongly support the general theory of evolution, I must presently conclude that it is easier to account for the fossils in terms of an ancient earth, long populated by life, than it is to accept the creationists' suggestions that the fossils were all formed at the time of the Flood or during other relatively recent cataclysms. This suggestion doesn't seem to account for the generally valid progressive increase in complexity toward the upper strata (although the creationist speaks of the most complex organisms moving to mountaintops or swimming to the upper floodwaters). Furthermore, although I haven't made the calculations in detail, it seems that the vast amounts of coal, oil, and other fossils represent far more organic material than could exist as living organisms at one time on earth, to be destroyed in a single flood. Nor can I imagine how a flood could account for the fifty or more alternating layers of coal and sandstone or other rock that exist in some locations (although the creationists do have proposals). Limestone and diatomaceous earth are also of fossil origin but appear to have been laid down gradually over vast time intervals. So my present feeling is that the fossils testify of an ancient earth and a parade of life forms (whether part of this creation or not), although this is clearly not equivalent to the atheistic general theory of evolution. But keep an open mind, and read a few of the creationists' books if their ideas appeal to you.

Age of the Earth

The strictest interpretation of the Genesis creation account suggests that the earth is not really very old: about 6,000 years since the time of Adam, and perhaps seven 24-hour days, or seven 1,000-year periods of creation, preceding that. Evolutionary theory, on the other hand, requires that the earth be extremely old, on the order of hundreds of millions to billions of years. When uniformitarian geology developed, asserting that the earth was indeed extremely old, a naturalistic theory of evolution became possible. So what is the evidence for an ancient earth?

We have seen in chapter 11 that the evidences are uniformitarian in that they assume that the present is the key to the past. As indicated in the above paragraphs, existence of fossils (especially coal, oil, limestone, diatomaceous earth, etc.) argues rather strongly for an ancient earth. But of the several approaches to dating of the rocks, the radioactive clock is by far the most impressive. Again we could consider some of the suggestions made by the creationists. The importance of assumptions is emphasized, for example, especially the assumption that the element produced by radioactive decay was not present in the rock to begin with. After such a discussion I would personally conclude that the evidence for an extremely ancient earth remains strong. The arguments are indeed uniformitarian, however, and perhaps the present is not the key to the past in this case, any more than it is in some other cases. So again, I shall recommend that if you are interested in these arguments you might study some of the creationist literature.

Carbon-14 Dating

There is one line of reasoning that is worthy of our examination. It is concerned with the technique of dating with carbon-14 (14C). This radioactive atom decays (changes form) at a consistent rate. Given a certain amount of 14C, half will be gone in 5,730 years. This so-called half-life is too short for dating the strata, but radiocarbon could be of considerable value in measuring ages of objects that are younger than about 40,000 years. If the proportion of 14C compared to 12C has been constant in the atmosphere for the past 40,000 years, then as green plants photosynthesize, they would incorporate this proportion into their tissues. Animals eating the plants would incorporate the same proportion into their tissues. Then we could measure the ratio of 14C/12C in any ancient organic object and calculate its age.

Where does the 14C in the atmosphere come from? Neutrons produced by cosmic rays are absorbed by nitrogen atoms (14N) in the upper atmosphere to produce 14C with loss of a proton. If it were known that cosmic ray fluxes have been constant for the past 40,000 years, that the relative proportion of nitrogen to other gases (including water vapor) in the atmosphere has been constant

during this period, that the rate 14C becomes incorporated into or released from living matter has been constant throughout this period, and that the rate of radioactive decay has been constant, then the method should be valid for dating objects up to this age-providing also that the objects studied have not been contaminated with more recent or more ancient carbon!

How can we go about testing these assumptions? Beginning about 1946, Dr. Willard F. Libby attempted to obtain objects of known ages to measure their 14C/12C ratios, and to see if ages based upon these ratios agreed with the known ages. When Libby began he was astounded to learn that no objects are known with positive ages older than about 5,000 years (the first dynasty in Egypt). We continually encounter dates of 20,000 or more years in the archaeological literature, but these are all estimates based upon positions in sediments, etc. That is, they are uniformitarian guesses. Libby applied the method to many objects up to about 5,000 years old and found that it worked rather nicely. But what about things older than that? Here we are left only with the assumptions mentioned above (plus a few others).

As Melvin and M. Garfield Cook have pointed out, there is a problem with the 14C clock that was recognized originally by Libby but then ignored because "everybody knew the earth was ancient." If the quantity of 14C in the earth's atmosphere has remained constant for the past 40,000 years, then the rate at which 14C is formed should equal the rate at which it disappears by radioactive decay. Consider the bathtub analogy: If the level in a bathtub is to remain constant while the tap is on, then the rate at which water flows out the drain must equal the rate that it comes in through the tap. It turns out that the rate of formation of 14C in the atmosphere by cosmic rays can be rather accurately measured. The rate at which 14C disappears by radioactive decay is also known. As it turns out, these two rates are not equal to each other. Radiocarbon is appearing in the atmosphere more rapidly than it is disappearing.

In the bathtub analogy, this means that the water is coming in faster than it is draining out, so the level should be rising. We could measure the rate at which the level is changing in the tub and easily calculate back to the time when the tub was empty. If we can't actually measure the rate of change in level, we can calculate it by measuring the rate water is coming in and going out and by knowing the dimensions of the tub. This is what must be done in the case of 14C. We measure the rate of its formation and the rate of its decay. We consider the size of the atmosphere so we can calculate the present rate of change in 14C levels (a rate too slow to observe directly). Then we can calculate back to the time when there was no 14C in the atmosphere. According to Cook and Cook, this proves to be 6,000 to 10,000 years ago. Since their interpretation of scripture is that the beginning of creation was about 13,000 years ago, they see this as a highly satisfactory calculation.

If the calculation holds up, it would be an impressive evidence for significant changes in the earth's atmosphere during relatively recent times. It would also mean that there was less radiocarbon in the atmosphere several thousand years ago than there is now, and that objects dated by the radiocarbon method would therefore appear to be older than they really are (the less 14C compared to 12C, the older the object appears to be).

Although this would be strong evidence against accepted uniformitarian interpretations of the earth and would support the cataclysmic ideas of the creationists, we should realize that it is itself a uniformitarian argument. It assumes that processes have been constant during the past 10,000 years or so. Furthermore, radiocarbon dating has been refined and extended since Libby's first studies. Most impressive, perhaps, are the recent direct tests of the method. Tree rings from bristlecone pines have been dated in long, continuous sequences extending back over 7,400 years. Radiocarbon from these rings can be measured. Such studies, combined with studies of dated sediment in lakes, the oceans, and soils (sediments in which a single layer called a varve is laid down each year), show that rates of formation of radiocarbon in the atmosphere have indeed

changed during the past 7,400 years. There have been increases and decreases in the rates of formation. For example, wood dated by the radiocarbon method at about 5,000 B.C. would actually be 800 years older. But this is exactly opposite to the prediction of Cook and Cook. In spite of the creationists' arguments, the earth continues to appear very old.

Classification and Comparative Anatomy

The old standby of the evolutionist is the evidence of classification and anatomy. Surely evolution works, it is implied in the biology class, because plants and animals can be organized in a reasonable way that seems to indicate how it happened. This is what the general theory of evolution would predict. First there were single-celled protozoa, like the amoeba; then there were sponges, then jellyfish, and so on up the ladder of increasing complexity until we get to man. The early forms have stayed around without changing much, so it is possible to construct the evolutionary tree. Of course, there was much branching along the way, so the tree is complex and not like a simple ladder, but then that is what evolutionary theory would predict. Next to the fossils, this is probably the most convincing evidence for most students.

I find this evidence much less convincing. The picture seems reasonable in a beginning class, where only large groups are discussed in a general way, but when one looks at the details, a different picture emerges. As a matter of fact, except for one point, I personally consider classification and anatomy to be one of the strongest evidences against evolution.

To begin with, we should realize that classification could not be convincing even if everything were just as the general theory might predict. A creation theory might predict the same thing. An Intelligent Creator would certainly not be haphazard in his creations. Surely he would follow a plan, and most of the early taxonomists (scientists who specialize in classification) thought that they were discovering the details of this plan followed by God in creation.

The scheme followed by an Intelligent Creator would not necessarily be exactly like the phylogenetic trees one might predict on the basis of a theory of evolution, however. It could be the same, but God could do things not allowed by an evolutionary theory. The general theory predicts that there should be a rather continuous sequence of organisms from the simplest to the most complex-if not living today, at least represented in the fossil record, although we can accept some discontinuity due to rapid evolution and other factors. We have seen that discontinuity is the overwhelming rule and that a creation theory allows this.

The general theory of evolution also says that increases in complexity come about by chance mutations and recombinations of genetic material that are preserved by natural selection in the struggle for existence. Since there is a vast variety of potential genetic forms (chapters 12, 13, and 15), it is unlikely that a given feature would appear more than once during evolution. Thus if evolution really worked, so-called natural classification systems should not be too difficult to construct. The eye, for example, with its amazingly complex focusing lens, might be expected to appear only once. Thus all creatures that have eyes with a focusing lens should be related to each other through a direct line of descent.

Actually, classification based on similar features is virtually never clearcut as one might expect if evolution really worked. Indeed, the whole idea of evolution would be completely disproven if one insisted upon application of the principle exactly as stated above. But of course the evolutionist has a way out. He speaks of parallel evolution. The focusing eye apparently arose separately at least three times in the course of animal evolution: in the mollusks (octopus and squid), in the arthropods (spiders, crustaceans, etc.), and in the vertebrates (fish, lizards, mammals, etc.). The wing supposedly was developed independently in fish, insects, reptiles (fossils only), birds, and mammals (the bat). Natural classification schemes (based upon relationship through evolutionary

descent) are thoroughly riddled with such examples of parallel evolution. Indeed, these examples are a source of awe to the student of evolution. He marvels at how wonderful the natural selection of chance mutations and genetic recombinations can be, producing such beautiful examples of seemingly impossible accomplishments. The reverence men used to reserve for God is bestowed upon these chance-directed "processes of nature."

As a young student going through the basic classes in evolution, I managed to maintain my faith in a God of creation, but I felt for a long time that the case for atheistic evolution was so logically sound that it could not be refuted even if false. This is the spirit in which it was presented. But my faith in the invincibility of the evolutionary case began to crumble when I took a class in Advanced Taxonomy of the Angiosperms (flowering plants). Here at last it became evident that the classification of flowering plants faced problems that could only be surmounted by exercising much faith; that is, by frequently invoking the principle of parallel evolution, and then by making unprovable assumptions about which features came first.

The idea is not difficult to grasp. It is illustrated in Table 14-2 and Figure 14-1. The table lists a few representatives of the flowering plants, and the figure illustrates ways in which they can be classified based upon which assumptions one is willing to make. Actually, the two schemes shown in Fig. 14-1 have deep historical roots. One scheme was developed from 1897 to 1936 by Adolf Engler and K. Prantl, based upon a still earlier system. It was assumed that the uniting of the petals in the flower to form a tube was of fundamental importance. All plants having flowers with united petals were considered to be related by descent; those without united petals formed another important line. At about the same time (1897 to 1915), Charles A. Bessey at the University of Nebraska was developing another scheme that went back nearly 200 years in history. Bessey assumed that the position of the ovary in the flower was the most important feature. If the ovary was attached above the attachment points of other flower parts, it was called superior; if below, inferior (Fig. 14-2). Flowers having inferior ovaries were thought to be related by evolutionary descent, as were those having superior ovaries. But the problem is that flowers with inferior ovaries have both separate and united petals, as do flowers with superior ovaries. Thus, in the Bessey system, uniting of the petals was assumed to be an example of parallel evolution. In the Engler and Prantl system, the inferior position of the ovary was thought to be an example of parallel evolution.

There are numerous other features and examples of parallel evolution. In the Bessey system, for example, the petal tube is irregular with two lobes on top and three on the bottom in the two separate evolutionary lines (honeysuckles; snapdragons and mints). The cacti and the euphorbes are other classic examples. Both are closely similar in appearance (Fig. 14-3), but one has flowers with inferior ovaries and the other with superior; hence they are completely unrelated in the Bessian system. Consider the milkweeds and the orchids, which seem as unrelated as possible. In any system, they are in the two major separate groups of flowering plants: the monocots and the dicots. Yet they have two interesting features in common: The stamens are fused to the pistil, and the pollen grains are transported in a waxy mass called a pollinium. These features don't occur in any other group of flowering plants, but they are common to these otherwise highly dissimilar groups.

These examples of parallel evolution offer no difficulties whatsoever for a creation theory. Certainly it is logical that an intelligent God would be orderly in his creation of things, but if he wanted to include similar features in widely divergent groups, he could do so. It's like two different automobile manufacturers both adopting disc brakes.

Actually, modern insights in biology further weaken these arguments from comparative anatomy. The whole attempt to classify organisms into a natural evolutionary scheme based upon similar anatomical structures that have a common ancestor (called homologous structures) assumes that

these structures are controlled by the genes, and that the genes pass more or less unchanged through the generations of evolutionary history. Homologous structures in plants would be the spore-producing sporophylls in ferns, leaves of higher plants, and the various parts of a flower, for example. In animals, the bones in the fore-limb of a horse, bat, penguin, dog, manatee, and man would provide other examples. Yet, modern researches have clearly shown that homologous structures need not be controlled by identical or even related genes, and that characters that are controlled by identical genes may not be homologous.

These observations seem to destroy the very foundations upon which the general theory of evolution is constructed. If the anatomical features used in classification schemes do not owe their similarities to similar genes, then what is responsible for them? And how could a theory of common descent account for them? God's creative activities would, of course, not be bound by the restrictions placed upon the general theory of evolution.

Vestigial Organs

There is one observation from the field of classification and comparative anatomy that must be regarded as strong evidence for evolution. It is not proof positive, but strong evidence it certainly is. Someday this evidence may give us insight into the nature of God and his methods of creation. It is the evidence of vestigial organs.

During the early stages of development of the human embryo as well as embryos of other vertebrates, gill slits are clearly visible. As the embryo develops further, these eventually disappear in land animals (including man). The evolutionist says that the gill slits are a vestigial remnant from the ancestors of the vertebrates, these ancestors being fish. The human embryo also has a "tail" that disappears. The obvious evolutionary interpretation is that human ancestors had tails. Actually, it was thought that a developing embryo went through stages representing its ancestors in the course of evolutionary history. These stages (phylogeny) were recapitulated by the developing embryo (ontogeny), making possible the sophomoric statement that premedical students loved to quote to their non-science friends: ontogeny recapitulates phylogeny. Careful study in embryology has found numerous apparent exceptions to this generalization, although there are several examples such as the two mentioned above.

But vestigial organs are not restricted to the stages of embryonic development. The human appendix has often been cited as an example of a vestigial organ; it has some value in lower vertebrates but seemed to be quite worthless in humans where, the evolutionist says, it is a remnant that evolution never eliminated. But now it appears that the appendix is made of tissue similar to the tonsils, and that both are important in fighting disease. At one time the evolutionist listed 180 organs in the human body that were vestigial, but with increasing knowledge the list has shrunk until it approaches zero. Yet it would be difficult to argue that the gill slits and the tail of the human embryo served a purpose (and equally difficult to prove that they do not).

So granted the existence of vestigial organs, what are we to make of them? We must admit that they are exactly the kind of thing the general theory would predict. The reason that vestigial organs do not prove evolution is that God could have designed things that way if he wanted. But why would he? Did he want to confuse the modern-day biologist? I personally resist that kind of an explanation. Perhaps in the process of creation, vestigial organs were a natural result of the way things were created. As the Gods "counseled among themselves" (Abraham 5:3), perhaps they found it efficient to design the developmental program for one kind of organism (e.g., the vertebrates) and then simply to modify parts of this program to produce the different kinds (species?) representing this main type (e.g., fish, amphibians, reptiles, birds, mammals). If this is what the vestigial organs really mean, then they do indeed give us a great deal of insight into the means of creation-the planning and organizing and decision-making mentioned by Abraham.

Footnotes

1. The term "atheistic" is not meant to have any emotional impact in this book; it simply means "without God."
2. H. G. Wells. A Short History of the World (London: Watts and Company, 1956). The Thinker's Library, No. 6.
3. Books I have studied include Henry M. Morris and John C. Whitcomb, Jr., The Genesis Flood (Philadelphia: The Presbyterian and Reformed Publishing Co., 1964); Donald Wesley Patton, The Biblical Flood and the ice Epic (Seattle: Pacific Meridian Publishing Co., 1966); and Duane T. Gish, Evolution: the Fossils Say No (San Diego: ICR Publishing Co., 1973). See also the numerous publications of such groups as the Jehovah's Witnesses, the Seventh Day Adventists, the Creation Research Society, and the Ambassador College in Pasadena, Calfornia. These publications represent the thoughts of a growing band of individuals who call themselves creationists. These are deeply converted Christians (for the most part, not members of The Church of Jesus Christ of Latter-day Saints) who believe in God and accept the creation account in Genesis as an inspired document. Although some are amateurs, most are highly conversant in the sciences. Some have doctoral degrees in geology, biology, etc. As a starting point at least, some of them accept a story of creation based on seven 24-hour days. In general, their arguments are in favor of catastrophism and against uniformitarianism. Though a lawyer but not a creationist, the author of the following book presents an extremely penetrating examination of the logical position of modern evolutionary theory and finds it tenuous at best: Norman Macbeth, Darwin Retried (Boston: Gambit Inc., 1971).
4. R. B. Goldschmidt, "Evolution, as Viewed by One Geneticist," American Scientist 40 (1952): 84-98, 135; and The Material Basis of Evolution (New Haven: Yale University Press, 1940).
5. George Gaylord Simpson, "Evolutionary Determinism and the Fossil Record," Scientific Monthly 71 (1950): 265.
6. Richard E. Leakey, "Skull 1470," National Geographic 143 (1973): 819-29. Mary Leakey's find was reported in the news media in the fall of 1975. My information was obtained from "Hominid Bones: Old and Firm at 3.75 Million," Science News 108 (1975): 292.
7. Duane T. Gish, Evolution: the Fossils Say No (San Diego: ICR Publishing Co., 1973).
8. M. Boule and H. M. Vallois, Fossil Men (New York: The Dreyden Press, 1957, an English translation of Les Hommes Fossiles, published in 1952).
9. P. O'Connel, Science of Today and Problems of Genesis (Hawthorne, California: Christian Book Club of America, Book 1, 1969).
10. Harry L. Shapiro, Peking Man (New York: Simon and Schuster, 1974).
11. Science and Mormonism, pp. 165-71.
12. Elizabeth K. Ralph and Henry N. Michael, "Twenty-five Years of Radiocarbon Dating," American Scientist 62 (1974): 553-60.
13. Sir Gavin de Beer, Homology, an Unsolved Problem (London: Oxford University Press, Ely House, 1971).

15
Genetic and Molecular Evidences

We have been considering the traditional evidences for evolution: the fossils and classification schemes. We have found them impressive but not convincing. Indeed, some parts of these evidences favor a creation theory more than the general theory of evolution. But these evidences are all rather old-fashioned anyway, the biology teacher might imply. Wait until you hear the results of modern studies! Now we have powerful mathematical tools to use in studying the flow of genes through populations, and there are computers to handle vast quantities of data in these studies and in modern approaches to natural classification schemes (called numerical taxonomy). More than that, we have all the knowledge of biochemistry to testify of the validity of the general theory. Not only do we know about enzymes and genes-proteins and DNA molecules-but we can

actually map the sequences of amino acids in a protein and thereby many of the nucleotides in its controlling gene, finding just what the theory of evolution would predict. Computers and biochemistry seem especially impressive.

In many ways these modern evidences are impressive, as we shall see, but as in the case of the more traditional evidences, these turn out not to be proof positive after all. Often they are compatible with a creation theory, and as in the case of vestigial organs, when they seem to be almost incompatible, their real importance is that they may well tell us something about how creation took place-and hence about the nature of God. But most important, certain new insights from molecular biology are extremely difficult to reconcile with the modern synthetic theory of evolution. They stand as powerful evidences for intelligence in creation. It's a fascinating story and one I'm anxious to get on with.

Population Genetics

Although virtually all biologists consider that their research contributes to a better understanding of evolution (the "unifying theory" of modern biology), most research being done today with the specific aim of better understanding the evolutionary process is carried out in the field of population genetics, which provides the modern definition of evolution. It states, as we saw, that evolution is a shift in gene frequency within a population occurring in response to Darwinian selection.

Remember the British peppered moths (p. 212). Early in the nineteenth century, most specimens had light- colored wings; few had dark. The light moths were well camouflaged, but with the coming of the Industrial Revolution, soot soon filled the skies of England and covered the tree trunks. Now the light moths were most visible to their predators, and the dark ones were best camouflaged. Gene frequencies in the population began to shift, so that the number of genes for dark color increased, and the number of genes for light color decreased, providing our classical example of evolution.

The creationist cannot argue with this. Population geneticists have observed dozens, perhaps hundreds, of similar situations. Examples that come to mind are the DDT-resistant flies that build up in a population following the use of DDT, or the bacteria in hospitals that have become resistant to various antibiotics. The artificial selection discussed by Darwin (controlled breeding of domestic plants and animals) also proves the point, although this is no longer natural selection. The creationist must simply admit that if evolution is defined this way, then evolution works in nature. It would be well if those who defend creation would thoroughly realize this. There is no need for a seminary teacher, for example, to attempt a disproof of evolution if this is the idea under discussion.

But does it prove the general theory of evolution? Does the change in peppered moth gene frequencies really allow us to conclude that some primordial glob of protoplasm (the first cell) evolved in just a few billion years into a human being capable of contemplating this question? Most biology teachers apparently seem to think that it does.

But this is the invalid argument by extrapolation. This form of inductive reasoning often leads to the truth, but doesn't necessarily lead to the truth. When our first son was born, I had some fun with extrapolation. During the first two or three weeks he gained a pound a week. Since he weighed about 7 pounds at birth, this meant that he would weigh 59 pounds on his first birthday, 111 pounds on his second birthday, 527 pounds on his tenth birthday, and 5,207 pounds if he lived to be 100! Such are the dangers of extrapolation.

It is important to recognize that features can change in a population in response to selection pressures. Surely the Creator would design things this way. As conditions change, the population tends to adapt. But this is a far cry from producing new phyla, orders, families, and genera from some common ancestor. The evolutionist has great faith in the ability of these so-called micro changes to account for evolution on the macro scale, but his proof is limited to the micro scale.

Please note in the example of the peppered moths that no new genes appeared; there was simply a shift in the frequencies of genes already present. So this classical example of "evolution" includes only a portion of the modern synthetic theory; mutations play no role at all. In many other examples, such as the appearance of new bacterial strains resistant to an antibiotic, this also proves to be the case. In other cases it is more difficult to know whether new genes have appeared, and it may be impossible to prove that they have or have not. Certainly, new genes do appear in natural populations as they do in laboratory populations treated with X rays, etc. But can new genes with potential adaptive value appear rapidly enough in natural populations to account for evolution as proposed? No one knows. Certainly the usually quoted examples such as the peppered moths or the resistant bacteria don't prove that the mechanism would work.

The studies in population genetics have provided us with a vast body of fascinating biological information. We can understand, often in detailed mathematical terms, how populations can change in response to environmental selection pressures. The evolutionist is firmly convinced that all this proves his case. I am firmly convinced that it does not. It is an enormous intellectual leap of extrapolation and an induction of the most invalid kind to believe that the proven micro cases also prove the macro theory.

Molecular Biology

There are now a number of books that discuss the origin of life and the postulated role of molecules in evolution. (See Bibliography.) Many biologists feel that this area provides the strongest evidences for the modern synthetic theory. It seems that the theory surely must be true if we can apply it to explain the varieties of molecules in living organisms. Yet I feel that by far the most serious challenge to the modern synthetic theory comes from the field of molecular biology. Thanks to the development of knowledge about molecules and cells, we can now return to the old question of complexity, and do so at a much higher level of precision, where something can be said about the probabilities involved in producing structures (enzyme molecules) with a given degree of complexity. But before I present my argument about natural selection and gene complexity, let's look at the evidences in favor of evolution.

It has become fashionable in recent years to analyze molecules from various organisms to see if the observed structural differences seem to bear a relationship to the postulated evolutionary history of the organisms. This is probably most relevant when it is done with proteins. You'll remember from chapter 12 that an enzyme is a protein molecule consisting of a chain of amino acids hooked together through peptide bonds, the chain being twisted and folded in ways determined by the specific parts of amino acids (the so-called R groups) standing out along the chain. Those groups that are repelled by water push the chain toward the inside of the final folded molecule; those attracted to water stay on the outside. The end result is an extremely complex structure, a portion of which may be designated as the active site. In this region of the molecule, the enzyme exactly fits and combines with its substrate, interacting with it so that some highly specific chemical reaction is likely to occur. Each enzyme molecule is synthesized in response to "information" contained in a molecule of DNA, a gene; the sequence of nucleotides in the DNA molecule is translated according to the genetic code into the sequence of amino acids in the protein chain. Clearly, the relationships between structure of protein enzymes in different organisms could be highly interesting from the standpoint of evolution, since the genes (DNA) that control the enzymes are inherited from generation to generation. This is where evolution ought to occur.

Cytochrome C

Of the several examples we could discuss, that of cytochrome c is probably the best. You may remember that sugars and other molecules are broken down in all cells by a highly complex process called cellular respiration, involving in many cells about fifty enzymatically controlled steps. Hydrogen atoms with their electrons are removed at various points and moved along a chain of about twenty enzymes in the electron transport system. At the beginning of the chain, the proton part (nucleus) of the hydrogen atoms is released into the solution as a hydrogen ion, and only electrons are moved along the chain. Energy-rich molecules of ATP are synthesized, utilizing the energy originally carried by the electrons. Finally, at the end of the chain, the electrons are combined with the hydrogen nuclei (protons) and oxygen to produce water. Near the end of the chain the electrons are passed from cytochrome to cytochrome c, then to cytochrome c, and finally to cytochromes a and a3, where the water is formed. Cytochrome c, then, is an enzyme, third from the end in this chain. It has been widely studied because it is relatively easy to isolate, and it is quite small, consisting in most organisms of only 104 amino acids.

All organisms, plant and animal, contain cytochrome c molecules, and as far as we can tell, all these cytochrome c molecules act equally well. Yet they are not identical in structure. Sixty-nine of the 104 amino acids have been found to vary in different organisms. To determine this, the cytochromes c were extracted from 38 organisms, and the sequences of amino acids were determined for all these. There were mammals (man, chimpanzee, donkey, rabbit, etc.), other vertebrates (pigeon, peking duck, rattlesnake, bullfrog, tuna, etc.), insects, lower plants (two yeasts and a mold), and higher plants (wheat, sunflower, pumpkin, etc.).

Cytochrome c from man is identical to that from the chimpanzee, and the cytochromes c from chicken and turkey are identical, but each of the others differed from all the rest. Thirty-five of the amino acids were identical at a given position in all 38 organisms studied. At 23 locations in the chain, either of two related amino acids could be found; at twelve locations, either of three amino acids. There were 24 locations where a considerable variety of amino acids could be found, but if a water-repelling amino acid (for example) occurred in one organism at such a location, then a water-repelling amino acid would occur in the other 37 organisms at that same location. At five locations, apparently any of the twenty possible amino acids could occur.

The significance of all this is that the organisms could be related to each other in a kind of evolutionary tree with those having the greatest number of dissimilar amino acids being the farthest apart. (Fig. 15-1) The conclusion is that since man and the chimpanzee have identical sequences, they must be closely related, while man and higher plants must be distantly related, since they have the fewest sequences in common.

How does all this relate to the theory of evolution? It is not an example of evolutionary "progress," but it, nevertheless, seems to provide a powerful evidence for the general theory of evolution. It is not that the cytochromes c of higher organisms are better than those of lower organisms; rather, the differences are said to be tolerated ones. Of the random mutations that have been occurring during the millions of years of evolution, those that led to amino acid changes that had no effect upon the function of cytochrome c were not eliminated by selection and hence can be observed now. The longer it has been since two organisms diverged from a common ancestor, the more time there has been for random tolerated changes to occur, so the number of changes (different amino acids) ought to be greater. Apparently the most ancient ancestors of life already had highly functional cytochrome c molecules. The argument is similar to that of vestigial organs, with the unchanged amino acid patterns being vestigial.

This is indeed a compelling story and certainly one of the most impressive evidences that the evolutionist can produce. If it didn't really happen this way, how can we account for these patterns? Why would God design organisms in this way?

Why shouldn't he? Certainly God might have had his own good reasons, unfathomable to us, for designing organisms in this way. It is also possible that we may someday understand the amino acid sequences as we now understand some vestigial organs. Perhaps the different patterns do have meaning in terms of the metabolisms of the various organisms. That is, perhaps the changes are not just tolerated; perhaps they are actually adaptive to the organism. But at the moment there isn't the slightest shred of evidence for this idea.

There is another side to the cytochrome c story, however. Where did cytochrome c come from in the first place? The study with 38 different organisms allows us to say something in an objective, mathematical way about the complexity of the cytochrome c molecule. And the overwhelming conclusion is that any cytochrome c molecule is far too complex to be accounted for by the modern synthetic theory.

The Power Rule

To understand, you need to know about information theory and the "power rule." How many four-letter words are there? Let's perform a little mathematical exercise: How many one-letter words are there? Since there are 26 letters in the alphabet, it is obvious that there are 26 one-letter words. How many two-letter words? The letter A can be combined with another A, or with any of the other 25 letters in the alphabet; the same is true for the letters B, C, D, etc. Thus there are 26 x 26 = 676 possible two-letter words. How many four-letter words? 26 x 26 x 26 x 26 = 456,976. Five-letter words? 26 5 = 11,881,376. Clearly, when we keep multiplying by a number as large as 26, the result goes up very rapidly (a geometric progression). Of course it is obvious that not all the 456,976 four-letter words would have informational value in English, or for that matter in any other language. Most would consist only of consonants, for example, and would thus not be usable. In any case we have derived the power rule: The number of possible words of any length that can be constructed of an alphabet consisting of any given number of letters equals the number of letters in the alphabet raised to the power of the number of letters in the desired word (e.g., the number of possible four-letter words in an alphabet with 26 letters = 26 4).

The exact principle applies if we want to calculate the number of possible protein molecules of any given amino acid length that could be synthesized from the 20 possible amino acids. For example, the number of possible small peptides containing four amino acids equals 20 raised to the fourth power: 160,000. (Note what a difference the six extra letters make in our example above!) What is the number of possible protein molecules each containing 104 amino acids, the number in the usual cytochrome c molecule? Clearly, this will be 20 to the 104th power. Using a little algebra, this works out to 10 to the 135.5th (let's say 10 to the135th). This is the figure one followed by 135 zeroes! This is a totally incomprehensible number. I have tried to think of examples from nature that might help to provide some insight into the enormity of such numbers. It has been estimated, for example, that there are about 10 to the79th atoms in all the universe (a universe with 500 billion galaxies). It would take 10 to the 56th universes to account for 10 to the 135th atoms!

Let's think of a model universe. According to our present theories of cosmology (chapter 10), the universe is expanding, and the farther objects are away from each other, the more rapidly they are receding from each other. Objects farther than about 10 billion light years from the earth would be receding with a velocity exceeding the speed of light, so they could never be visible to us. Assume, then, that our universe is a cube (to make the calculation a trifle easier) that is 20 billion light years on each side. (Remember that a light year is the distance light travels in a year at its velocity of 186,000 miles = 300,000 kilometers per second.) We'll let our model universe include 5 billion

galaxies, each of which has 20 billion planets. It would occupy a volume of 8,000 billion billion billion (8 x 10 to the 30th) cubic light years. Consider the dimensions of such a model universe in Angstrom units, the smallest unit normally used by science. (One Angstrom equals 0.00000001 centimeters.) Our model universe would be 2 x 10 to the 36th Angstroms on each side of the cube, and its volume would be 8 x 10 to the 108th cubic Angstroms. To occupy a volume equal in cubic Angstroms to the number of possible protein molecules, each the size of cytochrome c, we would need a hundred million billion billion (10 26) universes the size of my model!

Let's have one more go at portraying the size of the number 10 to the 135th. Current theory postulates that at one time the oceans of the earth were filled with organic molecules, including proteins, and that in this organic soup life originated (chapter 11). Presumably some of the protein molecules had enzymatic activity, and eventually one appeared that had the activity of cytochrome c. With this greatly oversimplified background, let's do our next mathematical exercise-one that clearly points up some of the weaknesses in the theory.

Say that the primitive ocean covered all the earth to a depth of two kilometers. Say that it contained about 15 percent of its weight in protein molecules the size of cytochrome c (104 amino acids). There would be about 2.19 x 10 to the 44th molecules of protein-far fewer than the possible number of kinds. Let each protein molecule reproduce one million times each second, and (for ease of calculation) assume that each molecule changes each time it reproduces, and that no two protein molecules are ever alike. Let this process go on in our two kilometer ocean for five billion years, producing 10 to the 67th different kinds of molecules-still nowhere near the 10 to the 135th possible kinds. If we cover all the 10 to the 20th planets in the model universe with two kilometers of water, etc., and let the protein molecules multiply on all the planets for 5 billion years, we will produce 10 to the 87 different kinds-still nowhere near enough. If we are going to make all the possible 10 to the 135 kinds of protein molecules (each the size of cytochrome c), we will have to let the process continue on our 10 to the 20 planets for 10 to the 57 years-or if we are unwilling to wait so long, having only 5 billion years at our disposal, then we must let the process occur in 10 to the 48 of our model universes. Hopefully, you are beginning to see that 10 to the 135 is indeed a large number. Imagine the minute possibility that a human-type cytochrome c would be produced. In our model universe, there is only one chance in 10 to the 48 possibilities that the molecule would appear!

But, says the skeptic, you are assuming that only one of the 10 to the 135 possibilities will have cytochrome c activity. Yet we know that this is not the case-the cytochrome c molecules from the 38 organisms that were studied differed in many ways, showing that many different amino acid combinations can have the same enzymatic activity. It's exactly like the analogy of language. "This above all, to thine own self be true," is one way to convey a certain bit of information, but approximately the same information can be conveyed by other combinations of letters, such as "It is more important to be true to yourself," or "Dies uber alles: dir selbst treu sein."

That is the beauty of the situation relating to cytochrome c. We actually have some concrete information that allows us to make estimates about how specific a molecule must be if it is to have cytochrome c activity. Remember that 35 of the amino acids in the chain of 104 could apparently not change without loss in activity. According to the power rule, if amino acids are randomly hooked together, the chances that 35 of them will be absolutely specified at 35 previously specified positions are 1 in 20 35, which equals one chance in 10 to the 45.5. Twenty-three of the amino acids could be any one of two amino acids; the chances of this occurring are 10 to the 23. Seventeen of the amino acids can be any one of three; the chances of this occurring are about one in 7 to the 17 = 10 to the 14. Twenty-four of the amino acids can be any one of ten; the chances are 2 24 = 10 to the 7. A fundamental law of probability states that the chances of any two events occurring simultaneously are equal to the product of the chances of these events occurring

independently. Thus we multiply together the above list of probabilities (simply by adding their exponents). The result informs us that, based upon our present understanding of the structure and function of cytochrome c, the chances of a protein molecule with cytochrome c activity being produced by random combination of 104 amino acids are one chance in 10 to the 89.5 (say, 10 to the 89). This is an improvement over the idea that only one molecule in 10 to the 135 would have cytochrome c activity, but when you think about, it doesn't make much difference. To be certain that at least one molecule of active cytochrome c would be produced, we must use 100 of our model universes and the 5 billion years to produce 10 to the 89.5 different kinds of protein molecules, each having 104 amino acids in its chain!

Teleological Evolution

The evolutionist has his faith. He says: "We may not know how it happened, but the fact of the matter is, evolution did happen. So it must work. Besides, your argument has a fallacy. It makes the mistake of assuming that evolution is teleological, that it is being directed some way toward a goal. On the contrary: It is purely opportunistic, fortuitous. There is no Director. Who says there ever had to be a cytochrome c? Certainly, it is unlikely that cytochrome c would appear. It is also unlikely that any specified bridge hand will be dealt. Every bridge hand is unlikely! Yet all you have to do to get some set of four hands is to shuffle and deal. And the game then progresses based upon the hands that appear. So is evolution. If cytochrome c had not appeared, life today would be different-but it would still be life! Just because each and every enzyme is so totally unlikely, we can be certain that life on any other planet, evolved independently from our own, will be totally different from life as we know it. Each planet is its own bridge game."

This is a rather compelling argument. If true, it would indeed negate my probability calculations. But it is not true. The modern synthetic theory of evolution is not analogous to a bridge game (or other game of chance). There are numerous points where evolution must have been goal directed, in spite of what the evolutionist says about its opportunistic nature. It is as if the game could not be played unless certain hands were dealt out. It is true that most of the time the opportunistic argument seems to apply, but this may be due mostly to our ignorance. I am becoming aware of an increasing number of cases in which the goal would have been established by previous steps in evolution, and the process would ultimately have to stop if the goal were not reached. It is the goal that establishes the selection pressure, and only one goal is readily conceivable. Consider two examples:

Norman Horowitz suggested a scheme to account for the evolutionary origin of complex metabolic pathways. The idea has been widely accepted. It suggests that the "primeval soup" contained virtually all of the organic molecules now found in living cells. The first organisms merely incorporated these into their structures as they grew and multiplied, changing them little if at all. Eventually these organisms would fill the seas, and then one or more of the essential organic molecules in the "soup" would begin to run out. At that point, there would be a strong selection pressure in favor of any enzyme that could convert one of the molecules present in abundance into the one that had become limiting. That is, the whole business would have to grind to a halt unless an enzyme capable of one function appeared and were selected. Each time a molecule became limiting, there would be a teleological necessity for an enzyme that could produce it. Horowitz assumed that this went on until organisms like present green plants existed, having all the necessary enzymes to convert carbon dioxide, water, light energy, and a few minerals into living protoplasm. I believe the process would face impossible odds at each step where the environment (limited molecules) demanded the evolution of some new enzyme. The situation demands that in some relatively small number of trials a given hand must be dealt out-or the game stops. And each time the chances of getting the hand are vanishingly small. (Unless the complexity of the necessary enzyme were much lower than in the above examples-i.e., that the bridge hand included only three

cards, so that its appearance became quite likely-a possibility that at the moment hasn't a shred of evidence to support it.)

A new field is developing, called chemical ecology. It is concerned with the chemical interactions between organisms. For example, a shrub in the California soft chaparral releases volatile terpenes (e.g., camphor) that are adsorbed on nearby soil particles, preventing the germination of competitive species (gas warfare!). Or some plants contain special insect hormones that upset the insect's course of development when the plant is eaten. The point is that literally dozens of cases are now known in which one organism has apparently evolved a special set of enzymes in direct response to the chemistry of some other organism-which not infrequently seems to have returned the compliment. Here, again, is evolution to a goal. "As the defensive chemistry of the plants evolves, intensifies, and differentiates through time, the chemical adaptations of existing consumers of plants must evolve, if these consumers are not to become extinct." Evolution as proposed may indeed sometimes be teleological.

Creation or Chance?

Such arguments could be multiplied at length, but the crux of the matter is simple: The findings of molecular biology during the past few decades have given us a much deeper appreciation for the intricacy and complexity of life (although few scientists seem to have realized the implications of all this). The argument against the modern synthetic theory of evolution is the same as the argument originally put forth by many thinking people against Darwin's original theory. The principle of natural selection of variability in populations (this variability being produced by genetic recombinations and mutations, according to the modern theory) as a means of generating complexity falls far short when we contemplate the level of complexity that would have to be produced. Original opponents of Darwinism mentioned the wing and the eye as examples. They were unable to accept the idea that natural selection of small variations was really capable of producing such complexity. Yet they did not really know in any kind of mathematical way how complex a wing and an eye really are, nor do we know today. We do, however, know something that can be expressed mathematically about the complexity of protein and DNA molecules. We have the power rule and the concepts of information theory to help us along. We arrive at the exact point arrived at by the opponents of evolution 100 years ago: Natural selection is simply incapable of doing the job. Variety won't appear rapidly enough-not by tens of orders of magnitude.

A common creationist argument is that evolution breaks the second law of thermodynamics, which states that order can never spontaneously increase in the universe. Entropy, a measure of disorder, must always spontaneously increase. I haven't liked this argument much, because order can increase if energy is put into the system and if there is a controlling or guiding mechanism, as in the growth of a plant or animal from a fertilized egg cell. The evolutionist says that there was plenty of energy, and natural selection was the guiding mechanism. The above arguments show, however, that natural selection is an inadequate mechanism, because when we study the situation at the micro-level of mutations, we see that the proposed mechanism falls far short of providing sufficient variety for natural selection to function. The second law of thermodynamics is now being understood on the basis of the probabilities of events occurring at the micro-level. My argument and that based on the second law then reduce to a single basic idea.

One thing should be made quite clear in closing this chapter: The examples of complexity discussed here nowhere near approach the kinds of things that could be discussed. Cytochrome c is a relatively small protein, which is why it has been studied so intensively. Furthermore, it is one enzyme in a chain of twenty others making up the electron transport system, which is only part of the overall system of cellular respiration (with its fifty enzymes) that goes on in each cell. And respiration is only one of many functions. Photosynthesis is at least as ordered and complex (probably more so), and there are numerous other equally important metabolic pathways that must

be accounted for, such as the synthesis of the amino acids that go to make up the proteins, or the nucleotides that make up the DNA molecules, or the complex fatty substances that constitute the all-important membranes around and within all living cells. Some way, each of these many complex individual units must be accounted for if we are going to account for the origin and development of life in purely mechanistic, chance-directed, atheistic ways. And all the units must be integrated together. We must even account for how cells can divide, multiply, and specialize at exactly the right times and places to produce from a single fertilized egg cell a mature organism as complex as a thinking human being.

'"But," the skeptic says, "you solve the problem of complexity in living things by postulating an even more complex intelligent Creator. Where did God come from?" Of course we don't know. But perhaps it is some consolation to know that we have finally reached the most difficult dilemma, one that seems completely beyond human comprehension: When did time begin, when will it end- or where does space end? Since everything in our existence has a beginning, it is impossible to imagine a universe without a beginning, but it is equally impossible to imagine a universe with a beginning. We can no more think of something coming into existence where nothing (not even empty space) existed before than we can think of an end to space. Science has no answers, nor has God ever explained these things to man through the prophets.

Thus we arrive at a conclusion of logical positivism: that no philosphy can provide us with a true explanation of the universe-and a certainty that it is true. Yet we can know the truth of some things. We can know that God lives and that he was the Creator, not just because we can't explain the universe any other way (in which case God becomes a "God of the gaps"), but because he has revealed himself and this knowledge to us (to the prophets, and to each of us if we qualify ourselves). Believing and finally knowing this, we can then see God's hand in all things; we can see that the complexities of the universe, the solar system, the earth, and the creatures on it declare his glory and bear record of him.

Knowing that God lives and creates doesn't solve all the problems, but it certainly helps with some. Writing Shakespeare by letting monkeys pound typewriters isn't very promising; it is comparable in many ways to the problems of generating enzymes by chance as described above. But letting Shakespeare apply his intelligence to the task is perfectly reasonable. One can imagine the Gods counseling together to work out the intricate metabolic pathways or the fascinating chemical interactions between organisms. To me, the lessons of molecular biology and indeed all biology and science are that God verily spoke the truth when he said: " . . . all things are created and made to bear record of me. . . ." (Moses 6:63.)

Footnotes

1. F.B. Salisbury, Truth by Reason and Revelation (Salt Lake City: Deseret Book Co., 1965), Ch. 8, "Natural Selection and the Complexity of the Gene," Nature 224 (1969): 342-43; and "Doubts About the Modern Synthetic Theory of Evolution," The American Biology Teacher 33 (1971): 335-38.
2. 20 104 = 10x; 104 log20 = x log 10; 10 to the 4..1.302 = x. 1.00; x = 135.5.
3. N. H. Horowitz, "On the Evolution of Biochemical Syntheses," Proceedings of U. S. National Academy of Sciences 31 (1945): 153.
4. Robert H. Whittaker and P. P. Feeny, "Allelochemics: Chemical Interactions Between Species," Science 171 (1971): 757-70.
5. James A. Fay, Molecular Thermodynamics (Reading, Mass.: Addison Wesley, 1965). George N. Hatsopoulos and Joseph H. Keenan, Principles of General Thermodynamics (New York: John Wiley & Sons, 1965).

16
The Millennial Symposium: Scenarios of Creation

Let's use the literary device of moving ahead in time to the Millennium and then looking back in retrospect. There have been so many momentous events during recent times that it is virtually impossible to have any real feeling for just how long it has been since the beginning of the twenty-first century. On the one hand, events have followed one another in such machine-gun succession that it seems like only yesterday when we celebrated, in a world so full of turmoil that almost any celebration seemed falsely hollow, that New Year's Day that was also the first day of a new century. On the other hand, when I think of all that has happened, the fantastic changes that have occurred in the world, it would not be difficult to account for the passage of many decades. It is amazing that so much could have transpired in just one generation-but it did, just as the prophecies said. And now today is that day for which many of us have been waiting most of our lives.

There were false Christs and false prophets in the twentieth century. A few actually claimed to be Christ, but many others with outstanding qualities of leadership gave their messages to the world with prophetic force. There were gurus from India who could teach the most subtle arts of mental self-control and psychotherapists who taught the opulent life via scientific principles of the mind. There were religious leaders, many with radio and television programs, who seemed to return almost exactly to the church of God as it was established in the meridian of time. And there were great signs and wonders being shown forth among the people. Technology took man to the moon in the 1960s and produced computers that could simultaneously consider the hundreds of parameters of a tropical hurricance. But faith healers in the Philippines and in South America in the 1970s still performed bloodless operations with rusty knives or even their bare hands. Numerous individuals claimed to be in touch with visitors from outer space and sometimes could produce sings and wonders that seemed to support their claim, such as making gasoline by adding a little black powder to water, or quenching a roaring fire with a pinch of another powder.

The elect, according to the covenant, were gathered from the four corners of the earth to old Jerusalem and to the new Zion. All this gathering led to far-reaching political upheavals. During the last half of the nineteenth century and all of the twentieth century, there were wars and rumors of wars. There were also famines and pestilences, and terrible earthquakes were not uncommon. During much of the twentieth century, these events were known in all the world only moments after they happened, thanks to electronic communications systems, which themselves were great sings and wonders.

Yet in spite of the detailed fulfillment of prophecy, the love of many waxed cold. Millions decided that God was only a remote concept, and many actually denied his existence. Wickedness abounded in the earth; indeed, it was as in the days of Noah. Sins such as adultery and Sabbath breaking, which were once punished by death, were openly committed and justified in all the entertainment media and even by learned professors speaking before groups of young people. Lust replaced love. Yet the gospel of the kingdom had been restored, and it was being preached throughout much of the world during the last half of the twentieth century. Indeed, all these things were either fulfilled or well in the process of fulfillment by the 1970s.

Finally the preaching of the gospel was complete, standing as a witness to all nations. Then came the abomination of desolation, as prophesied originally by Daniel and repeated by the Savior when he was here. The terror of this abomination that made everything desolate remains vivid in the minds of those who witnessed it. Then came the great natural calamities. Many of the mountains were made low, and the valleys were raised up. The whole earth trembled and reeled to and fro as a drunken man. This geological commotion filled the atmosphere with dense dust, such that the very sun itself appeared to be darkened, and the moon appeared to be changed into blood. Part of the celestial body that came close to the earth and caused these convulsions shattered into billions

of small pieces that fell into the atmosphere as fiery meteorites, such that the stars themselves appeared to be falling from heaven. These fierce atmospheric upheavals produced tremendous electrical storms, with devastating hail. Flies and maggots multiplied upon the land, the flesh fell from many creatures, while others were devoured by beasts.

Suddenly there was a great sign in the heavens. In the midst of these turmoils, seemingly the ultimate of natural calamities, a supernatural event took place. Angels flew through the midst of heaven. Now that we have seen them and recognized them for what they are, we wonder how our forefathers could have gained such twisted impressions of reality as the winged beings portrayed by medieval artists.

The angels gathered the elect from the four corners of the earth-and even from the very ends of heaven itself. Many saints who had slept in their graves were resurrected and assembled. Then the angels, with powerful devices that made even the advanced electronic communications of our time seem inconsequential, announced the imminent return of Jesus Christ, the Savior of mankind. As the day progressed, these angels also recounted the deeds of mankind during the 6,000 years of history. Then Christ returned in the clouds of heaven, even in a pillar of fire. Everyone alive on earth at that time could see and hear him at once as he returned to the planet where he had made his atonement complete, dressed in a glorious red apparel that signified his trodding of the winepress alone, his bringing to pass the redemption of mankind by the shedding of his blood.

The great and abominable church was cast down, and naturalism collapsed! Christ and his accompanying angels were terrible to the nonbelievers who had constructed their atheistic, intellectually conceived universe. In great fear, those who had been the unquestioned voice of leadership stood off at a great distance, trembling.

But these mighty events, as you all know, were just a prelude to today. Now is the time for the Millennial Symposium. Now all will be told. At last Christ will "reveal all things-Things which have passed, and hidden things which no man knew, things of the earth, by which it was made, and the purpose and the end thereof-Things most precious, things that are above, and things that are beneath, things that are in the earth, and upon the earth, and in heaven." (D&C 101:32-34.)

The meeting hall has been prepared. It will seat the many thousands who have been assembled. Not only are we who lived through the terrible events preceding the Savior's return present here today, but many are here who in life were concerned with the topics to be discussed today. There on the podium are Aristotle, Hippocrates, Linnaeus, Charles Darwin, Gregor Mendel, and many others. Today is the day for the presentation of the creation story; other topics to be revealed will be presented on other days. We are now waiting with much anticipation to hear the proceedings in the Adamic tongue, which miraculously we can all understand.

The Creation Scenarios

That is as far as I dare go with the past tense approach, as though I really knew what were going to happen in that Millennial Symposium, if there really is such a symposium. But whatever the format, a time will come, after the collapse of naturalism, when the Savior will reveal "things of the earth, by which it was made, and the purpose and the end thereof." What will he reveal on that momentous occasion? Obviously, if I knew, there would be no need for him to reveal it. He is going to tell us "hidden things, which no man knew . . . things most precious. . . ." So we might just as well relax and realize that we are not going to foresee those things in advance. Nevertheless, when they are revealed, they are certainly going to agree with things that have already been revealed-the stories of creation, for example. It's just that we shall see those stories in a different perspective, one that we can't imagine now.

Thus for the moment we must train ourselves intensively in the careful art of not making a decision-when none is justified. It is as bad to arrive at an inflexible position regarding the detailed nature of creation based upon the scriptural accounts as to decide that there is no God and that all happened by chance-directed evolutionary processes.

To fortify this open-minded stance, I would like to present, in the format of the Millennial Symposium, the possible interpretations of creation of which I am aware. This means that they appear possible to me or to others in terms of the scriptural accounts and/or the findings of science. Although accepted by many, the first three conflict with either science or revelation or both (Table 16-1 summarizes a few of the things that are known or not known about creation). In my opinion, these three indicate what didn't happen. The remaining four may have elements of truth, although the last is an easy way out, and there are difficulties with each of the other three. My own feelings and prejudices have changed in the past and will probably change in the future, so use these scenarios only as springboards or talking points-and be suspicious if you find yourself becoming convinced that any of these approaches, or one of your own, really reflects the whole truth. For that, you'll have to wait for the real Millennial Symposium.

Table 16-1The Known and the Unknown About Creation

THE KNOWN	**THE UNKNOWN (No mention made)**
1. Creation was an act of intelligence, involving purpose.	1. Actual mechanisms of creation. 2. The nature of spirit. (What is the matter that is "more fine or pure?" D&C 131:7-8)
2. Creation was carried out by the Son, under direction of the Father (Gods plural).	
3. Creation had spiritual and temporal phases, divisible into seven periods. (Where the "times" each 1,000 years? Abraham 5:13)	3. The time element in creation.
4. Creation involved much planning and preparation before life was placed on Earth.	4. The nature of the Fall. (What is the physiochemical nature of a change to mortality? Were all things immortal before the Fall, as II Nephi 2:22 and several Mormon theologians seem **to imply?)**
5. The man (to be called Adam) was the first man and the first flesh on Earth.	
SCIENCE	**SCIENCE**

THE KNOWN (it is possible to contest some of these points if one insists upon doing so.)	THE UNKNOWN (This list could be almost infinite in length, depending on its level of detail.)
1. According to our experience, the law of cause and effect (effects have causes) always operates in the universe.	1. What is the origin of species? the modern synthetic theory of evolution (mutations, gene frequency shifts, etc.) account
2. The Earth is a planet orbiting the sun, which is a star in the Milky Way galaxy.	for the vast range of variety and complexity in the Earth's organisms?
3. The structure and dynamics of the Earth can be at least partially understood according to the laws of physics and chemistry.	2. How do organisms really function? For example, how can a fertilized egg develop into a a mature individual?
4. Most indications are that most rocks of the Earth are extremely old (millions to billions of years).	
5. Sedimentary rocks contain fossils and can be ordered according to the standard geologic column, indicating that the Earth has seen a parade of life forms during millions of years.	
6. Numerous organisms that have existed (been fossilized) are not here now.	
7. Organisms exist in a great variety,	

which can be organized only into

imperfect classification schemes.

8. Organisms are extremely complex

mechanical constructions that obey

the laws of physics and chemistry.

9. Gene frequencies change in

populations in response to Darwinian

selection pressures. (According to

this definition, evolution occurs

at present.)

Details (plus many points not summarized here) are discussed in Chapters 5 to 15. Some points, in both the scriptures and science, are known with much more certainty than others.

Let us return to my imaginary symposium. The participants fill the great hall. At the highest point on the podium is Jesus Christ, the Savior of the world. The radiance of this glorified being dominates and overwhelms the entire congregation, although many on the stand and in the congregation are resurrected beings. Some will speak today. Those who lived on the earth when the gospel was not here have now accepted Christ as their Savior and have had the ordinances performed for them vicariously. After the introductory revelations of Christ, who is now the uncontested God of this earth, many others will discuss the details of creation, and then one will summarize. What will the summary speaker say?

1. Creation By a God of Magic

The speaker is introduced. He could be any of a number of philosophers of antiquity, perhaps, or Saint Augustine of the early Christian era. Probably Bishop Samuel Wilberforce, who debated with Huxley, would also be appropriate to give this talk. He begins by paying homage to the god of creation, "a god whose majesty and power is derived from man's inability to comprehend him and who is incomprehensible not so much because he transcends our experiences, but because descriptions of him are fabricated from complex internal contradictions. He is a god without body, parts, or passions, yet a god of love and vengeance, who fills the universe but can dwell in the minute volume of one's heart. He is a great being who consists of three separate beings that are nevertheless one being.

"He is totally powerful in such a way that anything man or god might conceive of, he can accomplish. His power is not a power of controlling causes to produce effects; rather, it is a power in which totally inadequate causes are sufficient to produce effects. His whims are obeyed by the very inanimate elements. Indeed, he created these elements from nothing and he created time itself as a context for their existence. When he created light, for example, he simply said: 'Let there be light,' and there was light. Saying it was enough. There was no need to do anything, nor indeed to expect any other being to do anything in response to his command. Thus the creation of light was a supreme act of magic. The god of creation was and is a god of magic."

But wait a minute! Could this talk possibly be given at our Millennial Symposium? Certainly not, if the most fundamental conclusions of science have any meaning whatsoever. All the experiences gained by application of the scientific method argue against the existence of magic in the universe and for the cause-and-effect relationship. Furthermore, the scriptures themselves clearly portray a creation that was not by magic-at least the scriptures brought forth in the restoration of the gospel portray such a nonmagical creation. Yet the creation story in Genesis almost allows one to believe in a God of magic, as does the story in Moses: "And I, God, said: Let the waters under the heaven be gathered together unto one place, and it was so; and I, God, said: Let there be dry land; and it was so." (Moses 2:9.)

But for the most part, the modern scriptures include statements of cause and effect-positive action-not magic:

". . . by mine Only Begotten I created these things. . . . and I caused darkness to come up upon the face of the deep. . . . I, God, ended my work. . . ." (Moses 2:1-2; 3:2.) It is in Abraham that the verbs of cause and effect are most striking:

". . . the Gods, organized and formed the heavens and the earth. . . . And . . . they divided the light, or caused it to be divided, from the darkness. . . . And the Gods ordered the expanse. . . . And the Gods said: Let us prepare the earth. . . . And the Gods organized the earth to bring forth grass. . . . And the Gods watched those things which they had ordered until they obeyed. . . . And the Gods prepared the waters. . . . And the Gods prepared the earth. . . . And the Gods took counsel among themselves. . . . And the Gods said: We will cause them to be fruitful and multiply. . . . we will give them life, and also we will give to them every green herb for meat. . . ." (Abraham 4:1, 4, 7, 11-12, 18, 21, 24, 26, 28, 30.)

". . . And thus were their decisions at the time that they counseled among themselves to form the heavens and the earth. And the Gods came down and formed these the generations of the heavens and of the earth . . ., According to all that which they had said. . . . And the Gods planted a garden, . . . And out of the ground made the Gods to grow every tree. . . . And the Gods caused a deep sleep to fall upon Adam; and he slept, and they took one of his ribs, and they closed up the flesh in the stead thereof; And of the rib which the Gods had taken from man, formed they a woman, and brought her unto the man. . . . And out of the ground the Gods formed every beast. . . ." (Abraham 5:3-5, 8-9, 15-16, 20.)

Clearly "the gods" were not some collective immaterial god of magic. Creation was an act of power, a power derived from intelligence, which is God's glory. Surely this talk will not be given.

2. Evolution By Chance-Directed Natural Selection

The speaker is J. B. S. Haldane, although it could just as well be Julian Huxley, George Gaylord Simpson, George Wald, numerous other scientists who work in the field of evolution, or, for that matter, thousands of modern biology teachers. "You see," Professor Haldane begins, "the scientific process was finally vindicated. True, for a long time there were many unsolved questions, but by the year 2000, every serious objection had been overcome. It was possible to outline all the essential mechanisms in the evolutionary process. After the laws of physics and chemistry were really mastered, it was only necessary to apply these laws to a total understanding of the nature of life. Then it became possible to formulate a second modern synthetic theory of evolution, one against which no objections whatsoever could be raised. Random molecular interactions, operating within known laws and combined with the powerful processes of natural selection, were quite sufficient to account for the generation of organic complexity within the available 4.5 billion year time span. Obviously, no supernatural influence, no God of creation, was needed to understand the universe. Life itself was synthesized in the laboratory and under suitably controlled conditions

could be made to evolve in any direction environmental selection pressures might require. Thus the problem was solved. There may well be more advanced races in the universe, but man represents the supreme kind of creative intelligence. There is no God."

But wait a minute again! As we saw in the previous chapter, difficulties with the modern synthetic theory of evolution are not likely to be that easily set aside. Furthermore, our theological convictions tell us that this talk won't be given. If it could, there would clearly be no Millennial Symposium. If the universe contains no God of creation, then Christ will not return in the clouds of heaven to reveal all things. But order in the universe is the product of a God of creation. By him the worlds were and are created. How do we know? Not just because of the apparent order and design; our minds are not yet capable of excluding, or perhaps even considering, all the possible alternatives that might account for what we see around us. Far more important, God has revealed himself to us. This is how we know he exists. He has spoken to prophets and allowed some of them to see him. He has revealed his will and his work, and these seem in every way to be worthy of him. Most of all, he will speak by the Holy Ghost to each and every person who earnestly seeks after him and keeps his commandments.

3. Flying Saucers and Ancient Astronauts

This is a difficult scenario to develop, mostly because at this stage it could be any of several dozen scenarios, depending on who is talking. The approach may not be well known, but it will probably become better known in the years to come. This is because it seems to offer a logical way to reject the revealed God of the restoration but to take the scriptures at face value. It is a way to accept the miracles and the visions of scripture as events that really happened without accepting the theology, or even the existence of God as we know him. Most people who presently adhere to the flying saucer faiths do accept God and are fundamentally religious, but a few individuals take another approach, one that could become extremely important.

Before attempting a flying saucer scenario, let's establish the credibility of such an approach (to the extent possible) by summarizing the UFO story. Since 1947, thousands and perhaps millions of people have been seeing things in the skies and sometimes on the ground that they cannot understand and that could be interpreted as vehicles from some other world. Careful study of the reports makes it possible to identify many of these "unidentified flying objects" as some conventional phenomenon such as the planet Venus, some other planet or star, a special cloud formation, a weather balloon, ball lightning, a reflection from an airplane, a flock of birds, a satellite, a sun dog or other mirage, etc. After this preliminary screening, a small percentage (perhaps 2 to 8 percent) of the sightings remain unexplained. In actual numbers this still amounts to many tens of thousands of sightings.

Some of these residual sightings may be purely psychological phenomena, such as hallucinations or after-images, but few sightings really seem to fit this category, and psychology has been unable to provide an answer to the UFO enigma. A very few of the remaining sightings may be of secret machines being developed by the United States or some other government (a rocket shield used at the White Sands Proving Ground may be an example), but again, this hypothesis fails as an explanation for most unexplained sightings, since they go far back in history. For example, the Romans recorded that they saw flying shields in the skies. Some sightings are hoaxes. Either the hoaxer fools the witness by releasing some object into the sky (e.g., a plastic bag buoyed up by hot air from a candle), or the UFO story is simply a lie (sometimes supported by fraudulent photographs) told by the "witnesses." It is extremely difficult to believe that all good sightings are the result of hoax, although it is extremely difficult to prove conclusively that they are not.

After these explanations have been tried, we are still left with thousands of unexplained sightings. Typically, these have little in common with the explained ones. It's not just that we lack enough

information for an explanation; rather, the sightings involve such detail, multiple witnesses, ample time for observation, close encounters, etc., that they simply cannot be explained as the planet Venus, hallucinations, secret weapons, or hoaxes. A large object (e.g., 50 feet in diameter) with windows, flashing lights, antennae, and a spinning rim may be seen by several witnesses at close range for minutes to an hour or more.

It is barely conceivable that some physical or psychological explanation for these good sightings will yet be found, but this seems extremely unlikely. Thus it is possible that we are being visited by vehicles with technological capabilities completely beyond any presently found on earth. These could be coming from other solar systems; they could even be forerunners of the ten tribes or the city of Enoch. Alternatively, they could be signs and wonders concocted by Satan to deceive the very elect!

One part of the UFO story involves the so-called contactees: individuals who claim to have been contacted by the flying saucers, taken for rides to other planets, and instructed in the wisdom of the universe. If there is one thing these numerous stories have in common, it is that they tell of a universe that is totally foreign to modern science. Before our astronauts went to the moon, for example, George Adamski told of his trip there. He described the other side of the moon as being covered with lush forests, gem-like lakes nestled in the rolling hills, and spic-and-span towns with citizens walking to church, since all the inhabitants of the universe except for the wicked people of the earth are deeply religious beings. If George Adamski or one of his ilk were to present the talk in the Millennial Symposium, he would tell of a universe governed by God and peopled with benevolent and superior beings of high intelligence whose lives are spent in worshiping God. He would tell how these peoples move through the galaxy in mighty spaceships, visiting inhabited planets in their smaller scout craft. But this scenario of creation would not be much different from many others set in a religious context.

If the symposium talk were given by Erich von Daniken or Brinsley LePoer Trench, however, it might really be an alterative approach to the other six scenarios. Since they are alive, I don't think I had better speak for them, but H. G. Wells wrote The War of the Worlds and might be sympathetic with this approach. Let's let him give this talk:

"Now you all know that both science and religion were right all along. It was all in the interpretation placed upon the events recorded in scripture. There has almost always been intelligent life in the universe. Its origins go back so many billions of years that they have been totally lost, even to the gods. These gods were the ones who recently arrived in the clouds of heaven in their space vehicles, accompanying Jesus Christ, who was taken away in such a vehicle three days after his crucifixion and restored to life with medical technologies developed during the billions of years that the gods had been in existence. Of course these same technologies bestow immortality upon those who possess the knowledge. The science that could actually reconstruct or resurrect men goes so far beyond even the most advanced earth knowledge that it must seem like magic, but let me assure you that it is not. Anything that is possible in the universe has now been achieved by these supercivilizations of incomprehensible age. They are able to ignite or extinguish a star! They can capture all the energy output from such a luminary and use it to drive their supercivilizations. They can exceed the speed of light in their travels and their communications, using principles that never were discovered on the earth before this return of the gods. They can even read and control thoughts from great distances.

"As to creation and the elements of religious history: one faction of the gods, those you have called ancient astronauts, thought they would like to learn something of their origins (long lost to history) by doing an experiment in planetary ecology and sociology. The relatively unorganized solar system was chosen. The planet earth had supported various forms of plants and animals for eons; earlier

scientists among the gods had visited the planet at intervals and adjusted its biota by introductions, extinctions, controlled mutations, etc. Of course they scarcely left a trace, since an extremely small intervention was sufficient to cause far-reaching effects.

"Finally, two human beings who had been especially bred and raised on another planet were brought to the earth and placed in a specially prepared garden. Using appropriate communication technologies, they were instructed by the gods in various ways. They had been carefully protected from the elements of their own culture, and as a further precaution amnesia was induced when they were placed in the garden. They were given simple little tests to perform. For example, they were instructed not to partake of the fruit of a certain tree, but they were given other instructions that seemed to conflict with this. As punishment for partaking of this fruit, they were cast out of the garden. This and other stories are familiar to you.

"At intervals throughout ensuing history, the gods from space intervened in various ways. Sometimes these interventions were technologically relatively simple, as when the god in charge of the experiment visited Moses on the mountain top amidst an impressive display of light and sound. Other times the illusion took some real doing, as when the sun apparently stood still. This required a tremendous artificial light source and production of a huge cloud to eclipse the sun! The crossing of the Red Sea involved some of the more subtle technologies in which gravity is controlled. The antigravity beams were generated by equipment in the pillar of fire and cloud. When Elijah was taken into heaven in a chariot of fire, this was one of the more brilliantly illuminated small scout ships. The angels who often communicated with prophets and others were, of course, extraterrestrial beings taking part in the experiments: laboratory technicians, so to speak.

"So it was throughout history. The miracles of the New Testament were really illusions brought about by the intervention of the sky people-the gods. Even Joseph Smith in the Sacred Grove was fooled by the chief experimenter and his supervisor. The gods also communicated with people in other cultures such as India, China, and the Americas, sometimes giving them conflicting theologies. Some of the revealed stories that are now part of the Judeo-Christian scriptures were not really true; they were just part of the experiment. The creation narratives provide a good example. Yet it was not all really a farce. Much of what these brothers from space revealed to people on earth was true. The ethics of righteous living are the best conceivable formula for ultimate happiness. But deep down it was really all a kind of sham, because it was not really carried out for the benefit and progress of mankind."

It should be apparent that this kind of an argument, not yet really appreciated by most people, has all that might be essential to "deceive even the very elect." The astronaut gods have much in common with the God we worship, who has revealed himself in the scriptures. So if a person wants to believe in naturalism and to reject our concept of God, he can think of God merely as a supercivilized being who has achieved the ultimate in technology. What is the difference? The subtle but extremely important differences perhaps boil down to questions of motives (of the "experiment" versus "to bring to pass the immortality and eternal life of man"), to the role of the Holy Ghost in testimony, to priesthood as authority with power, and to the nature of the relationship between God and the prophets (e.g., a God who could not lie).

There is a younger group of scientists who in their writings are establishing the basis for such an "ancient astronaut" approach. Given a few more decades there may well be large segments of the population who accept a scheme not too different from that outlined above.

4. Initial Creation Then Natural Selection

Who but Charles Darwin could give this talk? Would he feel indisposed, as he did on most such occasions during his lifetime? If so, someone else would have to give the talk for him, and there are

numerous possibilities, including many well-educated religious people, some who are members of our church. But Darwin is in fine speaking condition. (After all, he is now a resurrected being.) He begins by saying:

"Although it may appear a bit immodest, I have been specifically requested to initiate my remarks today by reading the last paragraph from the sixth and last edition of my book on the origin of species:

" 'It is interesting to contemplate a tangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent upon each other in so complex a manner, have all been produced by laws acting around us. . . . Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed by the creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved.'

"Since I left the sphere of mortality, I have been instructed by members of the heavenly hosts as well as some of those who left mortality ahead of me, such as Carlos von Linneaus and Sir Isaac Newton. They have been explaining to me the details of my suggestion that I did not take very seriously myself, but included mostly in deference to my dear wife, Emma, whose faith in God was much deeper than my own. If I had but listened to her, I might have looked at things much differently, especially during those last, frustrating years of my life when I had lost all faith in God but felt convinced that my theory of natural selection must be valid in spite of the variety problem.

"It was really the physicists and the chemists who were pursuing the right spore toward an understanding of creation. The laws of creation were embodied in the elements all along. The simple laws of compound formation went infinitely farther than anyone had imagined during my time-or even during most of the twentieth century. Little did we realize the intricate engineering required of our Creator when he imbued these elements with these laws. The very complexity of a human brain was built into the atoms with their protons, neutrons, electrons, etc., so when the earth was established with a suitable mixture of these atoms and at the proper distance from the sun, the evolutionary development of man and all other living things was inevitable.

"Some of you may be surprised to learn that God did not intervene in creation after he had established the earth with its suitable environment. You may be especially surprised, because when you read the creation stories in Genesis (or in Moses, revealed to the Prophet Joseph Smith while I was still a medical student; or in Abraham, revealed at about the time I was formulating my theory of natural selection), you may get the idea that God was intervening at many steps during creation. But you must realize that the scriptural accounts were never meant to have any scientific value. They were originally given to ancient Hebrews and to other ancient peoples steeped in the superstitions of their times, peoples who had no concept whatsoever of atoms and molecules, let alone natural law. Any attempt to explain the real mechanisms of creation to these people would only have confused them and made them even more superstitious.

"The Hebrews could accept the idea that an all-powerful God might command the elements and be obeyed, just as the people obeyed Moses when he spoke with authority. The Egyptians, with their complex sociological systems of priests and rulers, could understand the planning and organizing that play such a role in the account Abraham received while he was among them. But what could either of these peoples think if God told them about mutations in DNA and about gene frequency

changes in populations in response to selection pressures? Why did later peoples with more sophistication try to take these creation stories so literally, when they were really only meant to say that God's intelligence was behind it all? Couldn't they see that the stories were given to ancient superstitious peoples?

"But enough of these philosophical introductory comments. What I and my colleagues intend to explain during the next several hours of this symposium will be the actual laws imbued by God into the elements, making an evolutionary creation possible. As you listen to our presentations, surely you will be overwhelmed with awe at the fantastic intelligence and ingenuity of your Creator. Let us begin by considering the primeval earth, with its atmosphere of hydrogen, methane, and ammonia, and the energy inputs via electrical discharges, radiation. . . ."

I personally doubt that this speech will be given. First, Mormon theology teaches that the "elements are eternal." (D&C 93:33.) Since specific elements are created in atomic reactions (e.g., in the stars), this must refer in a general way to the matter-energy stuff of which the universe consists. In any case the creation story says nothing of the creation of matter-energy and imbuing it with laws. The Gods said: " . . . we will take of these materials. . . ." (Abraham 3:24.) Second, the idea that God did not intervene during creation after he once got it started goes totally against the scriptural accounts. Yes, this argument can be circumvented by assuming that the scriptures are not to be taken literally but are only symbolic, and that they were meant not for us but only for ancient peoples. Yet as I see it, far more people are able to study the creation accounts now than could ever have done so in ancient times. There are far more people now than then, and the printing press brings the accounts into the hands of nearly everyone. Thus I firmly believe that the accounts were meant as much for us, with our scientific insights, as for anyone.

But then that's my opinion. You should realize that there are many brilliant and well-educated men in the Church who have deep and profound testimonies of the existence of God and the divinity of the restored church and who agree in principle with Darwin. They could be right. Until the facts are presented in the Millennial Symposium, we need open minds.

5. a Directed 4.5-Billion-Year Evolution

The next step beyond Darwin's suggestion is to assume that God was not only initially responsible for creation, but that he intervened at many, possibly even all, the steps along the way, even though these steps were basically the ones outlined by the evolutionists. Many great minds of the twentieth century have taken similar positions, although of course the scenarios of creation they have outlined in their writings vary considerably in detail. Well-known proponents of related or similar ideas are Teilhard de Chardin, LeCompt du Nuoy, and Edmund Sinnot. Several biologists in the Church are happy with this approach. Thus it is difficult to suggest who might be the speaker at the Millennial Symposium if this is the viewpoint that turns out to represent the truth. Whoever the speaker might be, parts of the talk might go like this:

" . . . so the scriptural accounts of creation were indeed mostly symbolic, not to be taken literally, and written for ancient peoples who had no concept of scientific principles. Nevertheless, even though these records omitted the details of creation, their message was quite clear: not only was God the initiator of creation; he was deeply involved with it all the time. As species evolved for several billion years, special genes were created whenever the need arose. Often this was done in ways that might appear perfectly natural to an outside observer; the cosmic ray that rearranged the atoms to produce a certain mutation appeared to be a random event in the functioning of the universe. Yet it was assuredly directed by God's intelligence. So when the scriptures state that man was created in the very image of God, the concept was meant to be taken most literally-although man's creation was clearly not a molding of clay and a magical conversion of this to human flesh. Rather, as the genes mutated and were selected, the ultimate goal-man in the image of God-was

always clearly present in the Creator's mind. When this goal had been achieved, a divine spirit was placed in man. The story of Adam and Eve was meant to convey this sublime truth."

This is an appealing idea to many scientifically trained religious people, both in and out of the Church. I am often drawn to this idea and could accept it readily if I could just reconcile it better with some scriptures (e.g., ". . . man became a living soul, the first flesh upon the earth, the first man also. . ."-Moses 3:7). Perhaps someday I will be able to make this reconciliation, at which time it would be easier to be a scientist in the modern world. And I would feel comfortable in having these important ideas in common with many of my fellow biologists in the Church.

6. Literally True Scriptural Accounts With a Few Serious Errors in Science
The speaker here could be any of many individuals both in and out of the Church. Any one of the creationists might be appropriate. Orson Pratt and Brigham H. Roberts discussed creation in terms similar to those in this section. Joseph Fielding Smith was also a strong proponent of this approach during most of his lifetime, although he was not in a position to evaluate the scientific aspects of the problem as well as Melvin Cook, for example, who has written extensively from the standpoint of a formidable scientific competence. Apostles John A. Widtsoe or Joseph F. Merrill might also be appropriate speakers, although they were perhaps somewhat less inclined to take the creation scriptures literally. This may also be true of Elder James E. Talmage, yet I believe he would be a highly appropriate speaker for the Millennial Symposium. Trained in geology and chemistry, he was considered one of the outstanding scientists of his time. He also had an unwavering faith in the restored gospel of Jesus Christ. He seemed to know without the faintest shadow of doubt that everything would work out in a perfectly reasonable, intellectually acceptable way if we would just be patient. With due credit to those mentioned above as well as to several others, let's let Elder Talmage occupy the podium:

"Although I failed to fully appreciate it during my lifetime, the scriptural key to an understanding of creation was Abraham's parenthetical statement, in which he remarks that the creation story 'was after the Lord's time, which was after the time of Kolob; for as yet the Gods had not appointed unto Adam his reckoning.' (Abraham 5:13.) The Lord had already explained his time scheme: '. . . Kolob was after the manner of the Lord, according to its times and seasons in the revolutions thereof; . . . one revolution was a day unto the Lord, after his manner of reckoning, it being one thousand years according to the time appointed unto that whereon thou standest. This is the reckoning of the Lord's time, according to the reckoning of Kolob.' (Abraham 3:4.) Thus the seven periods of creation each lasted a thousand years of earth time.

"This was a stumbling block to one such as I, who had been trained in geology, the science of the earth. As a student I had been thoroughly imbued with the concepts of uniformitarianism, which led inevitably to the conclusion that the earth was of ancient age. Yet the key to understanding had been present all along in a statement of the Prophet Joseph Smith: 'This earth was organized or formed out of other planets which were broken up and remodeled and made into one on which we live. The elements are eternal. . . .'

"Here was the answer to the problem! To reconcile the scriptural accounts of creation with what I had learned in the science of geology was not at all difficult. As a geologist, I had studied the remnants of earlier planets that were brought together to form this earth. Of course they were ancient! They had supported God's other creations for eons of time! Yet when they were assembled to create our planet, this new planet was at first 'empty and desolate,' as Abraham says. Yet in the sometimes twisted and distorted strata forming the tectonic plates that were transported through space by gravity control to form a mantle for our planet, there were deposits of coal, oil, natural gas, other fossils, gold, silver, and the many other resources that God's children would need during

their brief 6,000-year period of telestial history, with its final centuries of technology. These resources will even suffice for the coming 1,000 years of terrestrial peace.

"As the Gods, with Jehovah in immediate command under the direction of Elohim, began with the empty and desolate earth, much preparation was required. The first thousand-year time was used in exploring and comprehending this new earth ('the Spirit of the Gods was brooding upon the face of the waters'-Abraham 4:2), igniting the sun ('Let there be light; and there was light'-Abraham 4:3), and establishing the rotation period of the planet ('and they divided the light, or caused it to be divided, from the darkness'-Abraham 4:4).

"The second thousand years was used to form a suitable atmosphere, obviously a difficult and detailed job ('the expanse, so that it divided the waters which were under the expanse from the waters which were above the expanse . . . called the expanse, Heaven'-Abraham 4:7-8). This was mostly chemical engineering.

"During the third thousand years, an ocean was formed, as plate tectonics began to function, and the earth came up dry-obviously a most challenging and difficult feat of geological engineering, only possible with the tools and energy sources available to the Gods. During this period the earth was also prepared to bring forth plants when the time would come; that is, erosion patterns were established on the face of the earth, with mountains, valleys, plains, and other geographical features, and weathering was initiated to begin the physical aspects of soil formation. During this time, plant spirits were created back near Kolob ('in heaven').

"During the fourth thousand years, the Gods set cosmic forces into motion to bring the great lights of the universe into their present relationship-the sun, moon, planets, and stars as they appear in the sky. The earth's atmosphere cleared so these heavenly bodies could have been seen from the surface. The Gods watched the progress of things to see that their plans would be carried out ('obeyed').

"During the fifth thousand years, most of the planetary engineering involved the oceans and other waters on the earth's surface. These needed to have the proper concentrations of minerals, acids and bases, dissolved gases, etc. Thus they were prepared to 'bring forth great whales, and every living creature that moveth, which the waters were to bring forth abundantly after their kind.' (Abraham 4:21.) Preparations were also made for the 'winged fowl' that would eventually be placed upon the earth. Plans were made as to how these fish and fowl would 'be fruitful and multiply, and fill the waters in the seas or great waters.' (Abraham 4:22.) Much of this planning took place near Kolob, where the spirits of fish and fowl were being created.

"During the sixth thousand years, the Gods put the finishing touches on this planet, which they were readying for life. It was organized to support other animals, and at that time the Gods also took counsel among themselves to go down and form man, and to bestow upon him those familiar biological characteristics: his urges to reproduce and to subdue and replenish the earth, having dominion over all the plants and animals, and his appetites for herbs and fruits and the flesh of beasts. Man was to be given life itself! During this sixth period, as the Lord explained to Moses, the spirits that would become mankind were being created in God's abode; that is, they were being born to their heavenly parents, Elohim, the God whom they would learn to call Father in heaven.

"By the end of the sixth time, the earth was prepared and ready for life, ready for the Gods to carry out the plans they had formulated during the six thousand years. So the Gods were really busy during the seventh or last thousand years of creation; they ended their work as they had planned, and then they rested and sanctified the seventh time. First of all they formed a man. This had been carefully planned beforehand; the fantastically complex nucleotide sequences were brought from

the celestial sphere near Kolob. These were cultured using materials obtained from the earth's elements, so that Adam was literally created from the dust of the ground. He was given the breath of life and also a spirit: the spirit of Michael the archangel who had taken part in creation. As Adam, Michael's spirit was clothed in a body that was not subject to the processes of senescence that lead to aging and eventual death. Given his full level of intelligence, he was able to take an active part in the planting of the earth and in populating it with animal life. This he did from his headquarters in the garden called Eden.

"To plant the garden and the rest of the earth, the Gods brought seeds and spores from heaven and from other planets and planted them into the soil that had been prepared beginning about four thousand years previously. Each variety was planted in its appropriate location. While the earth was being covered with vegetation, a process requiring only a relatively short time under the intensive cultural practices applied by the Gods, animals were brought from other planets and distributed on the earth's surface.

"During these last phases of creation, the Gods had nearly completed all the things that they had planned, so the earth was nearly ready to begin its function as a testing grounds for the spirit children of Elohim. Then Adam was placed under anesthesia, a rib was removed, and cells from this rib were treated so that they divided miotically to become haploid and then divided without spindle formation to become diploid. A cell with a nucleus having two X chromosomes was chosen, and it grew and developed in simulated uteral conditions to become Eve, who also then received her preexistent spirit. At that time the memories of Adam's preexistence as one of the Gods of creation, and even the role played after receiving his physical body, were blocked, as were Eve's recollections of her preexistent life.

"Let me digress from this chronological account of events to tell you something that has given me great joy since I have had the opportunity of hearing this story from the Gods themselves. I had begun to sense this when I read in the eighth chapter of Proverbs, 30th verse and verses preceding, that wisdom, which was present with God before and during all Creation, 'was daily his delight, rejoicing always before him.' The application of wisdom, that special righteous blend of knowledge and intelligence, was a source of transcending joy to the Gods during the divine engineering of creation. This essential and highly rewarding step in bringing to pass the immortality and eternal life of God's children was and is God's work and his glory. All of you, being made in his image, can understand God's joy in creation; you know the personal joy of your own creations.

"Of course, the Gods did not start from scratch in their divine engineering. They did not create in a vacuum, building this earth and its biota from nothing and with no previous knowledge of temporal life. For you who have not yet passed through the veil, eternity is difficult to comprehend. You cannot imagine how the universe can continue without end-nor can you imagine how it could possibly have an end! It is even more difficult to imagine the beginnings. Knowing only the supreme God, it is difficult to imagine how he could have once been as man now is, paying homage to his supreme God. Yet such is the nature of eternity. As a God has always existed, so man has always existed somewhere in the universe as you exist now. And as there has always been man somewhere, so there have always been plants and animals: life in its numerous forms. Yet as a few calculations with the power rule may help you to realize, the possible forms of life are truly infinite, as are the ways in which they can be combined with each other on a planet's surface.

"So when the Gods created the earth and all thereon, they faced a truly stupendous challenge, one worthy of Elohim's intelligence and that of Jehovah and the others. Only now, in the time of this Millennial Symposium, has knowledge on the earth increased to the point where you can begin to comprehend this. Creation was not just the transplanting of a few plants and animals as a man might plant a garden (though the story almost makes it sound so simple!). Rather, several million

species had to be combined on an earth that had been prepared in intricate detail. Many of these species were new creations: new combinations of genes interacting in new ways. Consider the organisms of the tropical rainforest, the desert, or the tundra to appreciate the challenge!

"Clearly the details of creation were so beyond man's comprehension during nearly all his 6,000-year sojourn on the earth that there was no possible way God could tell man more than was told in the scriptural accounts. But during the last few centuries, science directed by the Holy Ghost has discovered virtually all that was required for a proper understanding of creation. Geology, astronomy, biology-even genetics and studies of 'evolution' (gene frequency changes)-all these things were part of the picture. What was needed was a correct context and viewpoint. That is the purpose of this Millennial Symposium.

"To return to the story, while the Gods rested during the later part of that sabbath of creation, enjoying the fruits of their labors on their sanctified terrestrial sphere, Adam and Eve lived an idyllic existence in the garden, where joy was the sum total of existence. As you all know, such a condition could not last long, because all of God's spirit children were waiting for their opportunity to face the tests of mortality. Thus Satan, who had been Lucifer in the preexistent worlds, was allowed to confront Eve in the form of a serpent, saying to her. . . ."

Clearly this presentation could vary in a number of important ways from the approach that I have caused Elder Talmage to follow. Perhaps Adam and Eve were transported to the earth from some other planet, as suggested by several of the early brethren. In this case, both the "dust of the earth" and the story of the rib must be only symbolic. (Of mankind's relationship to the mother planet and of woman's dependence on man?) Perhaps the geology of the earth is not to be understood only in terms of its having been assembled from the parts of earlier planets. Perhaps the parts were only dust particles-certainly no fossils. If that is the case and the earth is really young after all, then cataclysms including the flood must account for most of the geologic record. Volcanic action, glaciation, sedimentation, mountain-building, and numerous other processes might have taken place cataclysmically during the six thousand years of creation before life was actually placed on the earth. Or such cataclysms, including the flood, might even account for the fossils, the strata, etc., these cataclysms having happened at various points on the earth's surface after Adam and Eve were cast out of the garden, and at all times up to the rather recent past. Some of the creationists take this approach.

Consider the hypothesis presented by Donald Patton, one of the creationists. Remember the thousands of hairy mammoths frozen in Siberia with tropical food in their stomachs (p. 226)? Patton suggests that at the time of the flood a comet, consisting mostly of ice at the near absolute zero temperature reached by objects in outer space, approached the earth so closely that gravitation from the earth was stronger than the gravitational forces holding the comet together. (That is, it came within a distance that can be calculated and that is called the Roche limit.) Thus the comet shattered into relatively small and extremely cold ice particles. These went into orbit around the earth, forming a ring not unlike those of Saturn. Protons from the sun (in the solar wind) became attached to these particles. When sufficiently charged, they moved along the earth's magnetic lines of force, falling suddenly onto the earth's magnetic poles-and plunging the temperature so rapidly that a single breath froze the lungs of the mammoths before some of them even had a chance to swallow.

As the comet circled the earth before shattering, its gravity raised fantastic tides so that "all the fountains of the great deep [were] broken up." (Genesis 7:11.) And these gravitational forces acted on the land as well as the waters, breaking the earth's crust and suddenly raising a chain of mountains most of the way around the globe (in the single landmass before the continents moved apart). Much ice fell into the hot layers of the upper atmosphere, further heating by friction, and

melting to form the worldwide rain that raised the ark and lasted forty days and forty nights. "The windows of heaven were opened." This destroyed the "canopy" or inversion layer of the atmosphere, permanently changing the earth's climate. This canopy had until this time caused a nearly uniform, warm climate over all the earth and had prevented moist air from rising and condensing to form rain: " . . . the Lord God had not caused it to rain upon the earth. . . ." (Genesis 2:5.) Rather, plants were watered by dew that formed "in the cool of the day." (Genesis 3:8.) Destruction of the canopy also allowed small amounts of ozone, formed from oxygen in the upper atmosphere by ultraviolet light from the sun, to reach the earth's surface, greatly shortening the lifespans of people born after the time of Noah. The movements of land and water in the flood redistributed vast quantities of sand, silt, clay, and other sediments, trapping living plants and animals, which became the fossils. It's a rather impressive subscenario, and one worthy of our careful thought.

Although I personally find the idea that the fossils were left over from earlier creations to be a better answer than cataclysms, there are times when I find some variation on Patton's theme to be most acceptable. Basically, however, I am probably most attracted to the scheme that I have had Elder Talmage present. It might even make palatable the idea of no death before the fall. But there are certainly problems. How could science have missed the story so completely-found no evidence, for example, that the earth was "empty and desolate" as recently as 13,000 years ago, and that organisms were not here until about 7,000 years ago? The bristlecone pines reliably dated to 7,400 years ago (p. 238) would be among the first organisms on earth during this phase of creation! Of course, science has not really looked for such evidence, but wouldn't it be so striking that it could not be missed? When I get to thinking this way, I am not entirely happy with this scenario; then I am more impressed with the previous one, in which science tended to be about right all along, and the scriptures were mostly symbolic. A few relatively minor mistakes in science could indeed make this last scenario an acceptable one, but I think we should be careful not to accept it too glibly.

7. Both the Scriptures and Science Were Right All Along

For the life of me, I can't imagine who might present this talk at the Millennial Symposium or what they might say. I see no way in which both scientific teachings and literal interpretation of the scriptural accounts can be correct. Either the scriptures are highly symbolic, or science has made some rather important errors. The scenarios presented above solve the dilemma by amputating one or the other of its two horns.

Yet I will not be terribly surprised if a solution is ultimately found. Certainly this kind of thing has happened in the past: some new finding has completely upset our concepts of the universe. For example, near the end of the nineteenth century, physicists led by the great Lord W. T. Kelvin calculated with sophisticated principles of chemistry and the new thermodynamics that the sun could not be more than about 20 to 100 million years old. A chemical fire of that size could not last much longer. Yet when nuclear reactions were discovered, the entire picture changed. We had Einstein's equation to tell us that matter and energy were interconvertible. Suddenly a sun that could burn for 10 billion years was reasonable and easy to accept.

Will some similar discovery allow a total reconciliation of the scriptures with science? Probably we will have to wait for the Millennial Symposium to find out. In the meantime we can study science intensively, for it tells us many marvelous things about our universe and about how God acts. And we can strengthen our testimonies of God's existence and his speaking to prophets by studying his word, living his commandments, and enjoying the sublime blessings of feeling his divine Spirit inspire and communicate with our own spirits. We can fulfill the measure of our creation and find joy therein.

Footnotes

1. This summary of the last days represents my tentative interpretation of Joseph Smith 1 (the scripture that relates the order of events), embellished by several other scriptures, including as basic sources: Matthew 24; Mark 13; Luke 17:20-37; 21:5-38; D&C 45:15-75. Also: D&C 29:9-21; 34:7-9; 72:12; 88:92-116; 101:23-24; 121:28-32; 130:1; 133:17-56; 1 Nephi 12-14; 2 Nephi 26-32; Moses 7:65-67; and the book of Revelation.
2. Duane E. Jeffrey, in "Seers, Savants, and Evolution: The Uncomfortable Interface," Dialogue 8 (3/4): 41-71, has shown with careful documentation that the Church has never taken an official position on the details of creation, the role of evolution, etc.
3. I have written about this topic in (1) Truth by Reason and by Revelation (Salt Lake City: Deseret Book Co., 1965), pp. 247-51; (2) The Utah UFO Display (Old Greenwich, Conn.: Davin Adair, 1974); (3) "The Scientist and the UFO," Bioscience 17 (1967): 15-24; and (4) "Recent Developments in the Scientific Study of UFO's," Bioscience 25 (1975): 505-12.
4. Erich von Daniken, Chariots of the Gods (New York: Bantam Books, 1968), and Brinsley LePoer Trench, The Sky People (London: Neville Spearman, 1960).
5. Pierre Teilhard de Chardin, The Phenomenon of Man, trans., Bernard Wall (New York: Harper, 1959); Le Compt du Nouy, Human Destiny (New York: New American Library, 1947); Edward W. Sinnott, The Biology of the Spirit (New York: Viking Press, 1955).
6. For example, Bertrand F. Harrison, "The Relatedness of Living Things," Instructor, July 1965, pp. 272-76.
7. Orson Pratt, in Journal of Discourses, 21:197-206, and B. H. Roberts, The Gospel and Man's Relationship to Deity (Salt Lake City: Deseret Book Co., 1959). Roberts' ideas were perhaps best summarized in an unpublished manuscript briefly reviewed in the following article: Truman G. Madsen, "The Meaning of Christ-The Truth, the Way, the Life: An Analysis of B. H. Roberts' Unpublished Masterwork," BYU Studies 15(3): 259-92 (see esp. pp. 271-72).
8. James E. Talmage, "The Earth and Man," first published in the Deseret News Church Section in 1931 and subsequently reprinted as a pamphlet and in Instructor, December 1965, pp. 474-77, and January 1966, pp. 9-11 See also Duane E. Jeffrey, "Seers, Savants, and Evolution: The Uncomfortable Interface," Dialogue 8 (3/4): 41-75. This article includes numerous references to Church writers.
9. Alma P. Burton, Discourses of the Prophet Joseph Smith (Salt Lake City: Deseret Book Co., 3rd ed., 1965), p. 207.
10. In this respect, consider the following statement of the Prophet Joseph Smith, made in relation to John's visions of beasts recorded in Revelation 4 and 5: "I suppose John saw beings there of a thousand forms, that have been saved from ten thousand times ten thousand earths like this,- strange beasts of which we have no conception: all might be seen in heaven. The grand secret was to show John what there was in heaven. John learned that God glorified Himself by saving all that His hands had made, whether beasts, fowls, fishes, or men; and He will glorify Himself with them. Says one, 'I cannot believe in the salvation of beasts.' Any man who would tell you that this could not be, would tell you that the revelations are not true. John heard the words of the beasts giving glory to God, and understood them. God who made the beasts could understand every language spoken by them. The four beasts were four of the most noble animals that had filled the measure of their creation, and had been saved from other worlds, because they were perfect: they were like angels in their sphere. We are not told where they came from, and I do not know, but they were seen and heard by John praising and glorifying God." (Joseph Fielding Smith, comp., Teachings of the Prophet Joseph Smith [Salt Lake City: Deseret Book Co., 1976], pp. 291-92.)
11. Donald Wesley Patton, The Biblical Flood and the Ice Epoch (Seattle: Pacific Meridian Publishing Co., 1966).

Epilogue

There is so much more to the creation than the controversies between creationists and evolutionists. They force us to live with the insecurities of being indecisive: the knowledge that we

cannot know for certain how creation was really brought about. But let's not let contention and indecision be our final thoughts about creation. There is so much more!

Let's you and I each go alone to a mountaintop where we can properly meditate about creation and what it means to each of us. I think I'll go in summer to Mount Wolverine above Brighton in Big Cottonwood Canyon, east of Salt Lake City. The peak is flanked so that it is not easily seen from the valley floors, although it stands above all its neighbors. The rounded pile of boulders that forms its summit provides a view that is sublime. It is a fit place to approach God. Your trip is the important one, your personal experience, but I'll assume as I go with you in my mind's eye that it will be like my trip.

You start amid the willows that border Silver Lake. When you see the fish jump, you are aware of the complex ecosystem within that pond. Your legs work like pistons as they pull you up along the trail through the aspens, disdaining the ski lift that could save you some of this effort. You walk by Englemann spruce and alpine fir, noticing geranium, monkshood, columbine, arnica, nine-bark, huckleberry, and all the other wonderful plants that flourish here in the summer, slumbering during the winter under nine feet of snow. A lizard darts across a rock where the trail rounds a sunny ridge, and a chipmunk protests your coming with his high-pitched staccato. You're deep in thought, moving quietly, so when the buck with his ten-point antlers bounds through the brush off to your right, you are at first startled and then thrilled at the marvelous sight. The going gets easier along Twin Lakes as you work your way toward the head of the cirque. It is easy to imagine how this canyon was once filled with ice, a smaller glacier carving the rounded vales near the top and dumping its debris over the ledge of the hanging canyon onto the large glacier in the Brighton Valley below. The trees are getting few and far between as you work your way up the steep slope at the head of the canyon, but the meadow is green, moist, and filled with pungent-but-sweet alpine odors.

At last you have reached the pass, and the steepest part is behind you. You look over into Grizzly Gulch in Little Cottonwood Canyon, and your eyes follow the ridge to the south that will take you to the top of Mount Wolverine. The last mile will be a rocky, sometimes steep, sometimes nearly level climb. The going so far has taken its toll, and as your lungs work hard and rapidly to expel the carbon dioxide in exchange for the precious oxygen in the thin air, and your heart pounds to circulate the blood throughout your system, you become sharply aware of your physical body, that most priceless mortal possession created for you by God.

At last you have reached the summit. First you sit on a rock to catch your breath, and then you let your gaze follow the horizon from the Alta peaks to the southwest around to the mountains bordering the Salt Lake Valley, and finally to the distant Uintas shimmering in the haze far to the east. Clearly, it is a marvelous earth that God has made for you. You have felt the sun beat down on you during the late afternoon of the climb; now it is evening, and soon that fiery orb will settle into the red-orange, burnt sienna, and even the blue and purple of a desert sunset. Then, while you wait for the half-moon to rise after midnight, you see the stars with a brilliance never possible from a valley floor. The mighty Milky Way, stretching from pole to pole, and traversed by an occasional satellite, seems to follow the sun slowly to the west as the earth spins slowly to the east. The moment is now right. From the depths of your soul, you call mightily upon God to give you understanding and the spirit of truth, so you can comprehend and appreciate the meaning of creation.

Your thoughts drift back over what you have seen along the trail: not only the trail to the peak, but your trail through life, and even the pathway through the sixteen chapters of this book. There are things that you could observe with your senses, these senses sometimes being sharpened by the instruments of science and the careful observations of others. You have beheld a vast and mighty

universe structured of shining stars with their orbiting planets, billions of these, though separated by incomprehensible distances, yet organized to form the great galaxies. As you stand on this granite peak thrust up by the convulsions of the North American plate contending with the Pacific abyss, you are aware that your planet has intricate structure that provides a spacious stage for you and your several billion brothers and sisters to work out your salvation in fear and trembling.

Having dwelt upon these mighty physical works of God, you then contemplate the great assemblage of organisms, the plants, that draw their sustenance from this old earth or the animals that scurry on its surface. You imagine them absorbing the water and the gases, basking in the sunshine, or absorbing its photons to make energy-rich carbohydrates, fats, and proteins. The realization of the variety in these organic creations is almost overwhelming, but when you think of the intricacy and complexity of design in each of these bits of living machinery, it is nearly too much, and you can only fall to your knees and praise that God who is the Author of it all.

On the screen of your mind's eye, you see the cells with their nuclei. Inside are the chromatin strands that will form chromosomes when the cell puts on its most spectacular performance by dividing to form two cells. You see on the strands of chromatin the molecules of DNA, the genes, each with its hundreds to thousands of nucleotide links, telling the stories of life by their sequences. As you think about it, you can almost comprehend how the different genes are interacting with each other and with the other components in the cell, directing, like an advanced computer, the activities that we recognize as life. The messenger-RNA molecules are forming on the active genes, moving out of the nucleus to the ribosomes in the cytoplasm, assembling the transfer-RNA molecules each with its own activated amino acid, and putting these amino acids together to form a protein enzyme molecule. Then, finally, as your mind rambles through this submicroscopic machinery of the cell, you see the enzymes cutting and stapling, releasing and tying, constructing all the other cellular parts. You see the mitochondria making the energy currency, the ATP molecules, that allowed your muscle cells to contract and carry you to the top of Mount Wolverine. Now you are teleported into the cytoplasm of a green leaf cell where you see the chloroplasts absorbing light energy, separating charges across membranes, and combining water and carbon dioxide molecules to make carbohydrate. Through much of the night, while the universe wheels overhead, you meditate on the products of God's creation. You know with Mormon that creation was indeed a miracle. (Mormon 9:16-17.)

Then, as light begins to appear far to the east over the Uinta Mountains, his Holy Spirit begins to bring to your recall vivid knowledge of things that you cannot know by the senses. You can almost imagine Elohim in his glory somewhere near that mighty star called Kolob. Though glorious beyond comprehension, he is your Father, and it is this feeling of relatedness that is most powerful. You think of his Only Begotten Son in the flesh, the Creator of this world, your Redeemer, the Author of your salvation. You think of the other Gods of creation: Michael, the Holy Spirit, perhaps others. The voices of Moses and Abraham thunder in your mind, and all the scriptures you have read give you insight into the nature of God and his activities. Your confidence waxes strong in his presence.

This presence is the overwhelming fact in the universe of his creations that have been filling your mind during most of the night. Now with this realization, you are especially aware of that plan of salvation by which you can someday return to his presence. Now his glory, especially as exhibited through his creations, burns so strongly in your bosom that you know beyond doubt that he lives, that your spirit is his offspring, and that his Son is your Redeemer! Your testimony is a shining light within you and the only really important thing in the universe.

So, you ask: "Who am I? Am I a child of the universe?" Of course, but you are much more: You are a child of God! "Where have I been?" you ask. You have been with him. You always existed, but on the sixth day he created your spirit in his presence. "But what am I doing now? What is the real me?"

You have advanced to another of your Father's creations, but by doing so you have left his presence so that you can be tested. You are something very special. As his child, he knows you, every fiber, every chromosome within you. He loves you as only he can love. But he knows that he cannot by himself exalt you; you must do your part. The real you, deep within, wants more than anything else to achieve these things that your Father has made possible for you to achieve. "So where am I going?" If you prove valiant, you will return to his presence. You shall have glory added upon your head forever and ever. Your dominion shall be everlasting. Can you prove valiant? Are you awaiting Christ? Are you living for him? Can you imagine the glory of his millennial creation, when the lamb and the lion shall lie down together? Do you hunger and thirst for that thousand years of peace in his presence? Can you imagine the celestialized earth? Is your faith strong enough to appreciate such a world of glass and fire? Have you learned from studying the creation that the beauty of God's works lies in their information content, in the order, design, and purposes that characterize them above all else? Can you imagine that a world of glass and fire could be a creation with unsurpassed information content-order, design, and purpose-and thus a world of infinite beauty, incomprehensible to you now?

The sun is well above the horizon in the east. Your body is fatigued, but your soul has been renewed by its night of contemplations and communion with its Creator. Now it is time to wend your way down from the mountain, back into the world. But creation and the Creator have wrought their work upon you. You are going back into the world, but you won't be part of the world. You are resolved that your eye shall be single to God's glory, so that your whole body shall be filled with light, and there shall be no darkness in you; because that body which is filled with light comprehendeth all things. Therefore, you are resolved to sanctify yourself that your mind may become single to God, for "the days will come that you shall see him; for he will unveil his face unto you, and it shall be in his own time, and in his own way, and according to his own will." (D&C 88:67-68.)

Footnotes

1. It is certainly appropriate that an appreciation of creation should intensify our worship of the Creator. This is evident from many scriptures (in addition to the creation stories) that mention creation as one of the credentials of divine glory, usually of the Son. For example: "Behold, I am Jesus Christ, the Son of the living God, who created the heavens and the earth. . . ." (D&C 14:9. See also D&C 45:1; 76:24; 93:10.) "By these things we know that there is a God in heaven, who is infinite and eternal, . . . the framer of heaven and earth, and all things which are in them; And that he created man, male and female, after his own image. . . ." (D&C 20:17-18.) "Thou art worthy, O Lord, to receive glory and honour and power: for thou hast created all things, and for thy pleasure they are and were created." (Revelation 4:11. See also D&C 29:31; 39:3; 45:1; 76:6-7; 88:20; 93:9-10; 95:7; 104:14-17; 117:6-7; 1 Nephi 17:36; 2 Nephi 1:10; 2:14; 11:7; Jacob 4:9; Ether 3:15; Psalm 148:5; Isaiah 40:26, 28; John 1:1-3, 14; Ephesians 3:9; Colossians 1:16; Hebrews 11:3; Revelation 10:6.)

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May 1978
Elder Gordon B. Hinckley, Council of the Twelve
All of beauty in the earth bears the fingerprint of the Master Creator
Ensign Article

John says of the creation that “all things were made by him; and without him was not any thing made that was made.” (John 1:3.)

All of beauty in the earth bears the fingerprint of the Master Creator, of those hands which, after they took the form of mortality and then immortality, Thomas insisted on touching before he would believe.

1979
Freeman Dysan
Disturbing the Universe
Book

Chapter 23 - The Argument from Design
Professional scientists today live under a taboo against mixing science and religion. This was not always so. When Thomas Wright, the discoverer of galaxies, announced his discovery in 1750 in his book A n Original Theory or New Hypothesis of the Universe, he was not afraid to use a theological argument to support an astronomical theory:

> Since as the Creation is, so is the Creator also magnified, we may conclude in consequence of an infinity, and an infinite all-active power, that as the visible creation is supposed to be full of siderial systems and planetary worlds, so on, in like similar manner, the endless immensity is an unlimited plenum of creations not unlike the known universe. . . . That this in all probability may be the real case, is in some degree made evident by the many cloudy spots, just perceivable by us, as far without our starry Regions, in which tho' visibly luminous spaces, no one star or particular constituent body can possibly be distinguished; those in all likelyhood may be external creation, bordering upon the known one, too remote for even our telescopes to reach.

Thirty-five years later, Wright's speculations were confirmed by William Herschel's precise observations. Wright also computed the number of habitable worlds in our galaxy:

In all together then we may safely reckon 170,000,000, and yet be much within compass, exclusive of the comets which I judge to be by far the most numerous part of the creation.

His statement about the comets is also correct, although he does not tell us how he estimated their number. For him the existence of so many habitable worlds was not just a scientific hypothesis but a cause for moral reflection:

In this great celestial creation, the catastrophy of a world, such as ours, or even the total dissolution of a system of worlds, may possibly be no more to the great Author of Nature, than the most common accident in life with us, and in all probability such final and general Doomsdays may be as frequent there, as even Birthdays or mortality with us upon the earth. This idea has something so chearful in it, that I own I can never look upon the stars without wondering why the whole world does not become astronomers; and that men endowed with sense and reason should

neglect a science they are naturally so much interested in, and so capable of inlarging the understanding, as next to a demonstration must convince them of their immortality, and reconcile them to all those little difficulties incident to human nature, without the least anxiety.

All this the vast apparent provision in the starry mansions seem to promise: What ought we then not to do, to preserve our natural birthright to it and to merit such inheritance, which alas we think created all to gratify alone a race of vain-glorious gigantic beings, while they are confined to this world, chained like so many atoms to a grain of sand.

There speaks the eighteenth century. Now listen to the twentieth, speaking through the voices of the biologist Jacques Monod: "Any mingling of knowledge with values is unlawful, forbidden," and of the physicist Steven Weinberg: "The more the universe seems comprehensible, the more it also seems pointless."

If Monod and Weinberg are truly speaking for the twentieth century, then I prefer the eighteenth. But in fact Monod and Weinberg, both of them first-rate scientists and leaders of research in their specialties, are expressing a point of view which does not take into account the subtleties and ambiguities of twentieth-century physics. The roots of their philosophical attitudes lie in the nineteenth century, not in the twentieth. The taboo against mixing knowledge with values arose during the nineteenth century out of the great battle between the evolutionary biologists led by Thomas Huxley and the churchmen led by Bishop Wilberforce. Huxley won the battle, but a hundred years later Monod and Weinberg were still fighting the ghost of Bishop Wilberforce.

The nineteenth-century battle revolved around the validity of an old argument for the existence of God, the argument from design. The argument from design says simply that the existence of a watch implies the existence of a watchmaker. Thomas Wright accepted this argument as valid in the astronomical domain. Until the nineteenth century, churchmen and scientists agreed that it was also valid in the domain of biology. The penguin's flipper, the nest-building instinct of the swallow, the eye of the hawk, all declare, like the stars and the planets in Addison's eighteenth-century hymn, "The hand that made us is divine." Then came Darwin and Huxley, claiming that the penguin and the swallow and the hawk could be explained by the process of natural selection operating on random hereditary variations over long periods of time, If Darwin and Huxley were right, the argument from design was demolished. Bishop Wilberforce despised the biologists, regarding them as irresponsible destroyers of faith, and fought them with personal ridicule. In public debate he asked Huxley whether he was descended from a monkey on his grandfather's or on his grandmother's side. The biologists never forgave him and never forgot him. The battle left scars which are still not healed.

Looking back on the battle a century later, we can see that Darwin and Huxley were right. The discovery of the structure and function of DNA has made clear the nature of the hereditary variations upon which natural selection operates. The fact that DNA patterns remain stable for millions of years, but are still occasionally variable, is explained as a consequence of the laws of chemistry and physics. There is no reason why natural selection operating on these patterns, in a species of bird that has acquired a taste for eating fish, should not produce a penguin's flipper. Chance variations, selected by the perpetual struggle to survive, can do the work of the designer. So far as the biologists are concerned, the argument from design is dead. They won their battle. But unfortunately, in the bitterness of their victory over their clerical opponents, they have made the meaninglessness of the universe into a new dogma. Monod states this dogma with his customary sharpness:

> The cornerstone of the scientific method is the postulate that nature is objective. In other words, the systematic denial that true knowledge can be got at by interpreting phenomena in terms of final causes, that is to say, of purpose.

Here is a definition of the scientific method that would exclude Thomas Wright from science altogether. It would also exclude some of the most lively areas of modern physics and cosmology.

It is easy to understand how some modem molecular biologists have come to accept a narrow definition of scientific knowledge. Their tremendous successes were achieved by reducing the complex behavior of living creatures to the simpler behavior of the molecules out of which the creatures are built. Their whole field of science is based on the reduction of the complex to the simple, reduction of the apparently purposeful movements of an organism to purely mechanical movements of its constituent parts. To the molecular biologist, a cell is a chemical machine, and the protein and nucleic acid molecules that control its behavior are little bits of clockwork, existing in well-defined states and reacting to their environment by changing from one state to another. Every student of molecular biology learns his trade by playing with models built of plastic balls and pegs. These models are an indispensable tool for detailed study of the structure and function of nucleic acids and enzymes. They are, for practical purposes, a useful visualization of the molecules out of which we are built. But from the point of view of a physicist, the models belong to the nineteenth century. Every physicist knows that atoms are not really little hard balls. While the molecular biologists were using these mechanical models to make their spectacular discoveries, physics was moving in a quite different direction.

For the biologists, every step down in size was a step toward increasingly simple and mechanical behavior. A bacterium is more mechanical than a frog, and a DNA molecule is more mechanical than a bacterium. But twentieth-century physics has shown that further reductions in size have an opposite effect. If we divide a DNA molecule into its component atoms, the atoms behave less mechanically than the molecule. If we divide an atom into nucleus and electrons, the electrons are less mechanical than the atom. There is a famous experiment, originally suggested by Einstein, Podolsky and Rosen in 1935 as a thought experiment to illustrate the difficulties of quantum theory, which demonstrates that the notion of an electron existing in an objective state independent of the experimenter is untenable. The experiment has been done in various ways with various kinds of particles, and the results show clearly that the state of a particle has a meaning only when a precise procedure for observing the state is prescribed. Among physicists there are many different philosophical viewpoints, and many different ways of interpreting the role of the observer in the description of subatomic processes.

But all physicists agree with the experimental facts which make it hopeless to look for a description independent of the mode of observation. When we are dealing with things as small as atoms and electrons, the observer or experimenter cannot be excluded from the description of nature. In this domain, Monod's dogma, "The cornerstone of the scientific method is the postulate that nature is objective," turns out to be untrue.

If we deny Monod's postulate, this does not mean that we deny the achievements of molecular biology or support the doctrines of Bishop Wilberforce. We are not saying that chance and the mechanical rearrangement of molecules cannot turn ape into man. We are saying only that if as physicists we try to observe in the finest detail the behavior of a single molecule, the meaning of the words "chance" and "mechanical" will depend upon the way we make our observations. The laws of subatomic physics cannot even be formulated without some reference to the observer. "Chance" cannot be defined except as a measure of the observer's ignorance of the future. The laws leave a place for mind in the description of every molecule.

It is remarkable that mind enters into our awareness of nature on two separate levels. At the highest level, the level of human consciousness, our minds are somehow directly aware of the complicated flow of electrical and chemical patterns in our brains. At the lowest level, the level of single atoms and electrons, the mind of an observer is again involved in the description of events. Between lies the level of molecular biology, where mechanical models are adequate and mind appears to be irrelevant. But I, as a physicist, cannot help suspecting that there is a logical connection between the two ways in which mind appears in my universe. I cannot help thinking that our awareness of our own brains has something to do with the process which we call "observation" in atomic physics. That is to say, I think our consciousness is not just a passive epiphenomenon carried along by the chemical events in our brains, but is an active agent forcing the molecular complexes to make choices between one quantum state and another. In other words, mind is already inherent in every electron, and the processes of human consciousness differ only in degree but not in kind from the processes of choice between quantum states which we call "chance" when they are made by electrons.

Jacques Monod has a word for people who think as I do and for whom he reserves his deepest scorn. He calls us "animists," believers in spirits. "Animism," he says, "established a covenant between nature and man, a profound alliance outside of which seems to stretch only terrifying solitude. Must we break this tie because the postdate of objectivity requires it?" Monod answers yes: "The ancient covenant is in pieces; man knows at last that he is alone in the universe's unfeeling immensity, out of which he emerged only by chance." I answer no. I believe in the covenant. It is true that we emerged in the universe by chance, but the idea of chance is itself only a cover for our ignorance. I do not feel like an alien in this universe. The more I examine the universe and study the details of its architecture, the more evidence I find that the universe in some sense must have known that we were coming.

There are some striking examples in the laws of nuclear physics of numerical accidents that seem to conspire to make the universe habitable. The strength of the attractive nuclear forces is just sufficient to overcome the electrical repulsion between the positive charges in the nuclei of ordinary atoms such as oxygen or iron. But the nuclear forces are not quite strong enough to bind together two protons (hydrogen nuclei) into a bound system which would be called a diproton if it existed. If the nuclear forces had been slightly stronger than they are, the diproton would exist and almost all the hydrogen in the universe would have been combined into diprotons and heavier nuclei. Hydrogen would be a rare element, and stars like the sun, which live for a long time by the slow burning of hydrogen in their cores, could not exist. On the other hand, if the nuclear forces had been substantially weaker than they are, hydrogen could not burn at all and there would be no heavy elements. If, as seems likely, the evolution of life requires a star like the sun, supplying energy at a constant rate for billions of years, then the strength of nuclear forces had to lie within a rather narrow range to make life possible.

A similar but independent numerical accident appears in connection with the weak interaction by which hydrogen actually burns in the sun. The weak interaction is millions of times weaker than the nuclear force. It is just weak enough so that the hydrogen in the sun burns at a slow and steady rate. If the weak interaction were much stronger or much weaker, any forms of life dependent on sunlike stars would again be in difficulties.

The facts of astronomy include some other numerical accidents that work to our advantage. For example, the universe is built on such a scale that the average distance between stars in an average galaxy like ours is about twenty million million miles, an extravagantly large distance by human standards. If a scientist asserts that the stars at these immense distances have a decisive effect on the possibility of human existence, he will be suspected of being a believer in astrology. But it happens to be true that we could not have survived if the average distance between stars

were only two million million miles instead of twenty. If the distances had been smaller by a factor of ten, there would have been a high probability that another star, at some time during the four billion years that the earth has existed, would have passed by the sun close enough to disrupt with its gravitational field the orbits of the planets. To destroy life on earth, it would not be necessary to pull the earth out of the solar system. It would be sufficient to pull the earth into a moderately eccentric elliptical orbit.

All the rich diversity of organic chemistry depends on a delicate balance between electrical and quantum-mechanical forces. The balance exists only because the laws of physics include an "exclusion principle" which forbids two electrons to occupy the same state. If the laws were changed so that electrons no longer excluded each other, none of our essential chemistry would survive. There are many other lucky accidents in atomic physics. Without such accidents, water could not exist as a liquid, chains of carbon atoms could not form complex organic molecules, and hydrogen atoms could not form breakable bridges between molecules.

I conclude from the existence of these accidents of physics and astronomy that the universe is an unexpectedly hospitable place for living creatures to make their home in. Being a scientist, trained in the habits of thought and language of the twentieth century rather than the eighteenth, I do not claim that the architecture of the universe proves the existence of God. I claim only that the architecture of the universe is consistent with the hypothesis that mind plays an essential role in its functioning.

We had earlier found two levels on which mind manifests itself in the description of nature. On the level of subatomic physics, the observer is inextricably involved in the definition of the objects of his observations. On the level of direct human experience, we are aware of our own minds, and we find it convenient to believe that other human beings and animals have minds not altogether unlike our own. Now we have found a third level to add to these two. The peculiar harmony between the structure of the universe and the needs of life and intelligence is a third manifestation of the importance of mind in the scheme of things. This is as far as we can go as scientists. We have evidence that mind is important on three levels. We have no evidence for any deeper unifying hypothesis that would tie these three levels together. As individuals, some of us may be willing to go further. Some of us may be willing to entertain the hypothesis that there exists a universal mind or world soul which underlies the manifestations of mind that we observe. If we take this hypothesis seriously, we are, according to Monod's definition, animists. The existence of a world soul is a question that belongs to religion and not to science.

When my mother was past eighty-five, she could no longer walk as she once did. She was restricted to short outings close to her home. Her favorite walk in those years was to a nearby graveyard which commands a fine view of the ancient city of Winchester and the encircling hills. Here I often walked with her and listened to her talk cheerfully of her approaching death. Sometimes, contemplating the stupidities of mankind, she became rather fierce. "When I look at this world now," she said once, "it looks to me like an anthill with too many ants scurrying around. I think perhaps the best thing would be to do away with it altogether." I protested, and she laughed. No, she said, no matter how enraged she was with the ants, she would never be able to do away with the anthill. She found it far too interesting.

Sometimes we talked about the nature of the human soul and about the Cosmic Unity of all souls that I had believed in so firmly when I was fifteen years old. My mother did not like the phrase Cosmic Unity. It was too pretentious. She preferred to call it a world soul. She imagined that she was herself a piece of the world soul that had been given freedom to grow and develop independently so long as she was alive. After death, she expected to merge back into the world soul, losing her personal identity but preserving her memories and her intelligence. Whatever

knowledge and wisdom she had acquired during her life would add to the world soul's store of knowledge and wisdom. "But how do you know that the world soul will want you back?" I said. "Perhaps, after all these years, the world soul will find you too tough and indigestible and won't want to merge with you." "Don't worry about that," my mother replied. "It may take a little while, but I'll find my way back. The world soul can do with a bit more brains."

1983
Paul Davies
God and the new physics
Book, Simon & Schuster Paperbacks

Chapter 12 - Accident or design?

> 'Whence arises all that order and beauty we see in the world?'
> Isaac Newton
>
> 'Man at last knows that he is alone in the unfeeling immensity of the universe . . . Neither his destiny nor his duty have been written down.'
> Jacques Monod in Chance and Necessity

In his book Natural Theology William Paley (1743-1805) articulated one of the most powerful arguments for the existence of God:

> In crossing a heath, suppose I pitched my foot against a stone, and were asked how the stone came to be there: I might possibly answer, that, for anything I knew to the contrary, it had lain there for ever; nor would it, perhaps, be very easy to show the absurdity of this answer. But suppose I found a watch upon the ground, and it should be inquired how the watch happened to be in that place. I should hardly think of the answer I had given before — that, for anything I knew, the watch might always have been there. Yet why should not this answer serve for the watch as well as for the stone?'

The intricate and delicate organization of a watch, with its components dovetailing accurately, is overwhelming evidence for design. Someone who had never seen a watch before would conclude that this mechanism was devised by an intelligent person for a purpose.

Paley went on to argue that the universe resembles a watch in its organization and complexity — though on a vastly greater scale.

Surely, therefore, there must exist a cosmic designer who has arranged the world this way for a purpose: 'the contrivances of nature surpass the contrivances of art, in the complexity, subtlety and curiosity of the mechanism'.

The argument from design came to be associated with the concept of teleology: the idea that the universe has been programmed to evolve towards some final goal. In its broadest form the teleological argument encompassed both the order of simplicity and the order of complexity. It is an old idea. Aquinas wrote that 'an orderedness of actions to an end is observed in all bodies obeying natural laws, even when they lack awareness . . . which shows that they truly tend to a goal, and do not merely hit it by accident'. Though Aquinas knew nothing about the mathematical simplicity of the fundamental laws of physics, he spotted the striking fact of the compliance of material bodies with orderly laws and used that fact as evidence for a designer God.

The teleological argument was so savagely attacked that it is treated today with circumspection by theologians. Nevertheless it does have some modem proponents. 'The existence of order in the universe', writes Swinburne, 'increases significantly the probability that there is a God." But Swinburne bases his argument on the order of simplicity rather than the order of complexity. The idea that complex natural structures provide evidence for a cosmic designer seems to have fallen into disrepute.

The main objection to the argument from design involving complexity is that many systems which display complex order and structure can, in fact, be explained as the end result of perfectly ordinary natural processes. This does not, of course, prove that all ordered systems have arisen naturally, but it makes us cautious about inferring the existence of a designer purely on the rather superficial grounds that something looks too complicated to have arisen by chance. One must also have some understanding of the processes whereby complex order can develop.

The classic conflict between these opposing philosophies came with Charles Darwin's publication of The Origin of the Species. The exquisite organization of living creatures seems to offer the best possible demonstration of a supernatural designer, yet the evidence of biology and geology provide an adequate explanation for the extraordinary characteristics of biological organisms. Evolution of biological order by mutation and natural selection is now accepted virtually unanimously by scientists and theologians alike. Though Darwin's original theory is by no means established in its entirety, the basic principles, and mechanisms of evolution are no longer seriously in doubt.

The essential feature of Darwinian evolution is its accidental nature. Mutations occur by blind chance, and as a result of these purely random alterations in the characteristics of the organisms nature is provided with a wide range of options from which to select on the basis of suitability and advantage. In this way, complex organized structures can arise from the accumulation of vast numbers of small accidents. The corresponding increase in order (fall in entropy) occasioned by this trend is more than paid for by the much greater number of damaging mutations which are weeded out by natural selection. There is thus no conflict with the second law of thermodynamics. Today's beautifully fashioned creatures sit atop a family tree festooned with genetic disasters.

Whether one is prepared to accept that the Darwinian mechanism of evolution is the whole story, it cannot be denied that mutation and natural selection must be a major contributory factor in the development of biological order. The essential principle that physical systems can spontaneously organize themselves into intricate complexity is an empirical fact. In Chapter 5 we saw how many simpler examples of self-organization in the laboratory have been studied by physicists and chemists in recent years. Indeed, so important have these studies become that a new word — synergetics — has been coined to describe them. The conclusion must be that the presence of order in a system, however remarkable and complex it might be, is in itself no guarantee that a designer is necessary. Order can, and does, occur spontaneously.

These observations still, however, leave open a vital issue. Though the spontaneous appearance of order will not conflict with the second law of thermodynamics so long as compensatory disorder is generated elsewhere, it is clear that no order at all could exist unless the universe as a whole started out with a considerable stock of negative entropy. If total disorder always increases, in accordance with the second law, then the universe must, it seems, have been created in an orderly condition. Does this not provide strong evidence in favour of a creator-designer? After all, even if natural processes can generate localized order unaided, a fund of negative entropy is still needed to drive those processes in the first place. True, this could only constitute evidence of a designer-by-proxy, a creator who winds up the machine and then lets it crank out whatever structures it will, but even that strategy would involve supernatural dexterity of an astonishing degree, for the following reason.

Entropy, or disorder, is closely related to the concepts of probability and arrangement. A high-entropy, or disordered system, is one that can be achieved in a large variety of ways. Consider, for example, a box of gas in equilibrium at some uniform temperature and density; this is the condition of maximum possible entropy for the gas. Under these circumstances the molecules of gas could be rearranged in a huge variety of ways (for example, by being moved to different positions, or having their velocities altered) without affecting the large-scale properties of the gas. On the other hand, consider a very low entropy state, where all the molecules are moving on parallel trajectories, or another in which every molecule is crowded into one end of the box. These ordered configurations are exceedingly sensitive to any minute rearrangement of the molecules, and can only be achieved by a very limited fraction of the total available number of molecular arrangements. It follows that ordered (low-entropy) states are highly improbable and unstable. They require the careful cooperation of vast numbers of individual molecules. In disordered (high-entropy) states, all the molecules can move about randomly without regard for the others.

Now if you were asked to pick an arrangement of molecules at random, it is overwhelmingly likely that you would choose one that corresponds to maximum entropy, simply because there are vastly more possible disorderly arrangements than orderly ones. It is rather like the monkey who tinkers at random on a piano. The chances of his playing a well-known tune rather than a chaotic sequence of notes is minute. A mathematical investigation shows that order is exponentially sensitive to rearrangements. That is to say, the probability of a random choice leading to an ordered state declines exponentially with the degree of negative entropy. An exponential relation is characterized by its rapid rate of growth (or decline). For example, a population that grows exponentially doubles its size in a fixed interval of time: 1, 2, 4, 8, 16, 32 .. .

The exponential factor implies that the odds against randomly-generated order increase astronomically. For example, the probability of a litre of air rushing spontaneously to one end of a box is of the order 1010" to one, where the number 101020 stands for one followed by 100,000,000,000,000,000,000 zeros! Such figures indicate the extreme care with which low-entropy states must be selected from the vast array of possible states.

Translated into a cosmological context, the conundrum is this. If the universe is simply an accident, the odds against it containing any appreciable order are ludicrously small. If the big bang was just a random event, then the probability seems overwhelming (a colossal understatement) that the emerging cosmic material would be in thermodynamic equilibrium at maximum entropy with zero order. As this was dearly not the case, it appears hard to escape the conclusion that the actual state of the universe has been 'chosen' or selected somehow from the huge number of available states, all but an infinitesimal fraction of which are totally disordered. And if such an exceedingly improbable initial state was selected, there surely had to be a selector or designer to 'choose' it?

A useful image here is that of a creator equipped with a pin. Before him is a vast 'shopping list' of universes, each characterized by their initial state. If the creator picks a universe by sticking in a pin at random, there is an overwhelming probability that the choice will be a highly disordered cosmos with no appreciable structure or organization. Indeed, to find an ordered universe, the creator would have to scour a selection of 'models' that is so vast its number could not be written down on a sheet of paper as big as the entire observable universe.

The mystery of how the universe got into its low-entropy state has exercised the imagination of several generations of physicists and cosmologists, many of whom have been reluctant to appeal to divine selection. The pioneer of statistical thermodynamics, Ludwig Boltzmann, preferred to fall back on blind chance. He suggested that the cosmic order had arisen spontaneously as a result of a collaboration of unbelievably rare fluctuations from equilibrium. The basis of his argument is the

fact that, even in equilibrium, the molecules of a gas do not remain inert, but are continually rushing about in a random sort of way. From time to time, purely by chance, a few molecules will find themselves in unwitting cooperation, and a tiny enclave of order will arise, fleetingly, amid an ocean of chaos. Exponentiate the time scale and one can be persuaded that still larger regions of cooperation will eventually accidently occur. If the universe has enough time available then, sooner or later, one might suppose, whole stars, whole galaxies, will simply happen to form — accidentally. The fact that the time for such an absurdly improbable accident is inconceivably long (at least 101080 years) is, in principle, no problem if one is prepared to believe that the universe is of infinite age.

According to this view, the universe spends the overwhelming majority of its time in total chaos, with no organization whatever. But from time to time, after intervals of mind-numbing duration, there occurs a few billion years of accidental order. The reason that we — humanity — are present to witness one such occurrence of staggering improbability is simply because, in the absence of such a 'miracle, life could not exist. Because life feeds on negative entropy (see Chapter 5) conscious observers will only exist in the epochs of 'miraculous' fluctuations.

An interesting by-product of Boltzmann's reasoning is its assurance of a form of immortality. The continual molecular reshuffling which is responsible for the universe 'winding itself up' can be proved, mathematically, to possess the following curious property. As the molecules mill around, the universe visits state after state. Eventually, every possible state that can ever exist will be visited: anything at all that can happen, will happen, sooner or later. After this, the shuffling continues, and the universe starts revisiting states that have previously occurred. Eventually, every state will have been revisited, and so the process continues. This phenomenon of unlimited repetition and duplication is known as the Poincaré cycle, after the mathematical physicist Henri Poncaré who proved the result (at least, he proved it for an idealized model). Taken at face value, the Poincaré theorem implies that, in the fullness of time, planet Earth, long since disappeared, will be reconstituted, together with all its inhabitants! Moreover, this will happen infinitely often. But for every instance of more or less exact duplication there will be untold numbers of cases in which there are departures from the present arrangement. The closer the 'fit' the smaller the probability of reconstitution and the longer the wait.

Few physicists would take Boltzmann's explanation of cosmic order seriously. The basic mechanism of Poincaré recycling is not in doubt, however it is now known that the universe is not simply sitting there, shuffling away, but is in a state of global expansion. It is generally assumed that this expansion forces the universe to be of finite age. Its multi-billion-year lifetime is but an insignificant drop in the ocean of time needed to bring about all but a trifling decrease in entropy.

Boltzmann's argument does, however, bring out one vital feature of enduring value. The universe we perceive is, necessarily, selected by us, from the elementary requirement that life, and hence consciousness, can only develop under the appropriate physical conditions. By definition, we cannot observe an uninhabitable cosmos. This simple fact has, as we shall shortly see, been used to argue by some that the extraordinarily improbable, low-entropy universe that we observe has indeed been selected from a vast array of possible universes (nearly all of which are disordered); but the selection has been made by us, not by God.

Adopting, therefore, the big bang scenario, it would seem that we have little choice but to assume that the universe went bang in a remarkably orderly way, even though an accidental creation would, with a probability that is a virtual certainty, produce a totally disordered universe. This fundamental paradox of cosmology has stimulated several different responses:

1. So what?

Many scientists incline to the view that it is meaningless to discuss the concepts of probability, randomness and likelihood on an a posteriori basis. If you pick up a pebble on a beach at random, and carefully measure its size and shape you could correctly conclude it was wildly improbable that you had selected a pebble of those exact dimensions. But you would not be justified in proceeding to claim it must have therefore been a miracle that you made the choice you did, or that some supernatural or occult agency had been responsible for guiding your selection. Such arguments carry no conviction after the event. Amazement would have been justified had the pebble's dimensions been specified in advance, of course. In the same vein it could be argued that, given the existence of the universe, its particular structure need occasion no surprise: it simply is the way it is.

A related difficulty is that, at least according to one conception, probability is only defined in relation to a collection of trials. To say that, for example, the toss of a die will produce the result 'two' with a probability one-sixth is to say that, after many, many such tosses, roughly one-sixth of them will have produced a 'two'. The greater the number of trials the closer the proportion converges on the value one-sixth. At the very least, the subject to which our discussion of probability is directed must be a member of a collection or ensemble of similar things. The face of a die, for example, has five neighbours; the pebble on the beach had millions of neighbours. If, then, there is but one universe, what meaning can be attached to discussions of its likelihood?

This argument is not completely convincing though. If the selected pebble had turned out, for example, to be exactly spherical, surprise would indeed have been justified, even if its spherical nature had not been specified in advance. A sphere is a very special sort of shape with the property that it is mathematically highly regular. Even after the event the random selection of an exactly spherical pebble would be regarded as a remarkable circumstance deserving some sort of explanation. Likewise, a universe that is suitable for human habitation has a special significance for us that is absent for the vast majority of other possible universes: those that are uninhabitable.

At this point the 'so what' proponents reply that, had the universe not been arranged in the way it is, we should not be here to marvel at it. Indeed, any universe in which intelligent creatures can frame philosophical and mathematical questions is, by definition, a universe of the sort we observe, however remarkable that universe would otherwise have been a priori. In other words, they maintain, there is not, after all, anything very extraordinary or mysterious about the highly ordered universe we perceive, because we could not (obviously) perceive it otherwise.

This type of reasoning receives some support from the philosophy of logical positivism which argues, crudely speaking, that it is meaningless to talk about what can never be observed. What does it mean to discuss a universe that has no conscious observers within it? As such a universe could never be verified or refuted by observation, its existence would seem to have no meaning or significance for conscious individuals.

A related argument is that of the so-called strong anthropic principle, first articulated in detail by the astrophysicist Brandon Carter, and much discussed in recent years by physicists and astronomers. According to this principle 'The universe must be such as to admit conscious beings in it at some stage's (my italics). This amounts to saying that, far from being astonishingly unlikely, the universe had no choice about appearing with the appropriate degree of order required for life to appear.

These two positions — logical positivism and the strong anthropic principle - hinge on the paramountcy of human (or extraterrestrial) intelligent observers. The theologian could counter, however, that God is an observer, who moreover does not require special physical conditions for his existence. So universes that never produce life are still meaningful if observed by God.

2. The many-universes theory.
According to this point of view, there is an ensemble of universes of which ours is but one member. The universe we perceive is only one of a huge, perhaps infinite, collection of universes, each differing from the other members of the ensemble in some way. Somewhere among this collection is an example of every possible arrangement of matter and energy. Although the overwhelming majority of these universes are unsuitable for life, and lie very close to the totally chaotic conditions of maximum entropy (thermodynamic equilibrium), nevertheless there will be a minute fraction in which, accidentally, the conditions came out just right, and life develops. Obviously it is only,those accidental universes that will be perceived by living organisms, who will write books about how incredibly improbable their world is.

Boltzmann's hypothesis, mentioned above, is logically identical to the many-universes theory. His universes occur sequentially, but the organized phases are separated by such enormous chasms of time that they are all but physically independent. A modem variant of the sequential scenario is the oscillating universe theory. As we shall see (in 'Chapter 15) the present expansion of the universe might not continue indefinitely. If it does not, the universe will eventually begin to contract, falling back on itself in a gigantic cataclysm known as the 'big Crunch'. Some physicists have speculated that the highly compressed *SILOS, rather than imploding to oblivion at a spacetime singularity, *II 'bounce' at some enormous density, and thereafter embark on a new cycle of expansion and eventual contraction. In this scenario, then, the universe continues indefinitely in a cyclical fashion, oscillating between collapsed 'crunch-bangs' and distended, low-density states, like a balloon being successively inflated and deflated.

The oscillating universe suffers from the physical problems assodated with all infinitely old universes which were discussed briefly in Chapter 2. However, the uncertainties surrounding the physics of the extremely collapsed state widen the scope for speculation, and one suggestion, due to Wheeler, is that the 'crunch-bangs' have the effect of 'reprocessing' the cosmos. What this means is that each new cycle of expansion and contraction is a sort of 'new deal' in which the physical conditions are re-scrambled randomly. No attempt is made to explain how this might happen, but if it did it would clearly enable the universe to explore all possibilities open to it after a sufficient number of cycles — which would, of course, have to be astronomically large. Once again, only in those cycles where, by accident, the cosmos scrambler got it just right, would cosmologists evolve to speculate about it.

An alternative to assuming an ensemble of universes in time is to suppose that there is only one universe, which is infinite in spatial extent. Almost all of the cosmos would be close to equilibrium (no structure or organization) but, here and there, oases of order would appear spontaneously out of the chaos, by chance fluctuations. The distances between the oases would be inconceivably great, of course, but life and conscious observers could only form within an oasis, so all observers of this universe would necessarily perceive order.

Perhaps the most popular version of the many-universes idea comes, however, from Everett's interpretation of the quantum theory. In this theory all possible quantum worlds are actually realized, and coexist in parallel with each other. Thus, every time an electron faces two choices both alternatives occur, and the entire universe divides into two. Each universe is complete with inhabitants (whose brains and presumably minds have also bifurcated) each set of which believes that the electron has abruptly opted for one of the alternatives. The two universes are disconnected from each other in the sense that it is not possible to travel from one to the other through ordinary space or time. They exist 'side-by-side' or 'in parallel' in some abstract sense. And because there are as many universes as there are quantum choices, every possible arrangement of matter and energy will occur somewhere among the infinite array of parallel worlds.

This pattern of reasoning — that observers select a highly atypical universe from among a vast number of alternatives — is known as the weak anthropic principle. The idea has been attacked on a number of philosophical and physical grounds. First it is, in a sense, too successful. By allowing nature to realize all possibilities, anything at all might be 'explained'. Indeed, we might need no science at alL It is merely necessary to make a case that such-and-such a feature is indispensible to human existence and, hey presto, it is explained.

Another weakness of the anthropic argument is that it seems the very antithesis of Occam's razor, according to which the most plausible of a possible set of explanations is that which contains the simplest ideas and least number of assumptions. To invoke an infinity of other universes just to explain one is surely carrying excess baggage to cosmic extremes, not to mention the fact that all but a minute proportion of these other universes go unobserved (except by God perhaps). 'Not a bit of it,' counter the anthropic proponents. 'The Everett interpretation of the quantum theory may be expensive in universes but it is extremely cheap in epistemology. Consider the convoluted and implausible assumptions that are made in the alternative explanations of the quantum measurement problem. In the many-universes theory, the interpretation just drops out of the formalism with no additional metaphysical hypotheses.'

Nevertheless, the many-universe theorists concede that the 'other worlds' of their theory can never, even in principle, be inspected. Travel between quantum 'branches' is forbidden. Moreover, the ordered regions in the infinite or oscillating model universes are separated by such huge expanses of space or time that no observer can ever verify or refute empirically the existence of the many universes. It is hard to see how such a purely theoretical construct can ever be used as an explanation, in the scientific sense, of a feature of nature. Of course, one might find it easier to believe in an infinite array of universes than in an infinite Deity, but such a belief must rest on faith rather than observation.

The scientific basis of both the weak and strong anthropic principles has also been challenged. The appeal to the concept of probability, upon which the whole anthropic argument turns, has been used to argue against it. The issue concerns the relative likelihood of small versus large fluctuations. Imagine the chimpanzee on the piano again, tinkering randomly. After an exceptional wait we might reasonably expect to hear a three or four note sequence of a familiar tune. The wait for, say, a six note sequence would be immensely longer. The improbability rises sharply with the degree of order involved. To take another example, a shuffled pack of cards might well result in each of four players receiving an ace. Less likely is for each to receive an ace, two and three of the same suit. The odds against each player being dealt a whole suit are colossal. Small coincidences are relatively much more likely than big ones.

In the context of cosmology, a random accident which produces, say, one star, is exceedingly more probable (less improbable) than one which produces a whole galaxy. And the chances of billions of galaxies forming this way would be infinitesimal compared to the chances for a single galaxy. But, it has been reasoned, surely only one galaxy —perhaps only one star — would be sufficient for life to form and observers to arise? Why, then, do we observe an entire universe filled with orderly structure? In the many-universes theory for example, there would be untold billions of universes with just one galaxy for every universe which had two; when more galaxies are involved the proportional discrepancy escalates rapidly. If observers exist in all these universes, the overwhelming majority will, therefore, inhabit a one-galaxy as opposed to a many-galaxy cosmos. How, then, do we account for the existence of so many galaxies in our universe?

The only conceivable answer to his criticism is that, for some as yet unknown reason, the formation of a galaxy is somehow linked to the large scale structure of the universe. Perhaps galaxies can only

form when some special global condition is realized, and then when this is the case, they form everywhere. In other words, universes either have galaxies everywhere, or no galaxies. Linking principles of this type are known in physics but the mechanism of galaxy formation is still too obscure for a realistic evaluation of such a possibility. 3. Order out of chaos.

The third response to the mystery of the origin of cosmic order is an attempt to demonstrate that it has somehow arisen out of an initially chaotic state as a result of natural physical processes (not merely inconceivably rare fluctuations). (This idea has already been discussed in detail in Chapter 4; only a brief summary will be given here.) At first sight such an approach seems doomed to failure. Does the second law of thermodynamics not state that (fluctuations aside) order can give way to chaos but not vice versa?

It does indeed, but one has to look at the small print. Strictly stated, the second law is intended to apply only to completely isolated systems. Obviously any portion of the universe, however large, is not isolated, because it is in contact with the surrounding portions. More important, the entire universe is subject to the famous expansion, and this external disturbance can make all the difference.

A good analogy here is the humble piston and cylinder of the type found in ordinary petrol-driven engines. Imagine a gas confined in the cylinder beneath the piston. If the piston is at rest, the gas will be in equilibrium at a uniform temperature and pressure — a condition of maximum entropy. No further change can be expected: the gas is devoid of any ordered structure or organized activity. Suppose now that the piston is abruptly raised, allowing the gas to expand. Suddenly the gas is no longer uniform. The density is lower near the retreating piston where more available space is opening up. Turbulent motions occur as the gas flows forward into this space. If the piston should then reverse and return to its starting position the gas would eventually settle down again into a new state of thermodynamic equilibrium, but the entropy will have risen as a consequence of this disturbance. Temporarily the gas will have grown a structure and organization as the piston moved.

Have we found a loophole in the second law? No. The entropy of the gas still rises after a complete cycle of motion (it is hotter). The initial state of equilibrium was the maximum entropy state consistent with the external constraints on the system. When the piston moved, however, those constraints changed, allowing the gas to seek a still higher entropy state. In short, the initial state of equilibrium was only a relative, not an absolute maximum.

In the cosmological case the expansion of the universe plays a similar role to the piston as a changing external constraint. Cosmologists point out that, far from being in an orderly state, the primeval universe was close to thermodynamic equilibrium. None of the familiar structures we now observe — galaxies, stars, atoms — were present in the big bang. Indeed, before about one minute or so after the beginning, the temperature was too hot even for atomic nuclei to exist. Somehow the present orderly structure has arisen from the primeval chaos. How?

Most of the complex organization with which we are familiar on Earth, such as biosystems and weather patterns, are generated by sunlight, the vital source of negative entropy on which we all feed. The sun's store of negative entropy is its nuclear fuel (mainly hydrogen). The most relaxed, high-entropy form of nuclear matter consists of medium-mass elements, such as iron. The production of sunlight represents the entropy produced by the sun's attempt to convert hydrogen into iron through a succession of nuclear reactions. The secret of the sun's order (negative entropy), and that of most other stars, is to be found in the explanation for its hydrogen content About three-quarters of the mass of the universe is made of hydrogen, nearly all the rest consisting ofthe next lightest element, helium. Why is it not all made of iron?

The answer to this question was given in Chapter 4. The primeval universe was simply too hot for iron to exist, and its subsequent cooling was too rapid to allow significant nuclear transmutation to take place. The primeval material thus remained trapped in the form of low-entropy hydrogen, unable to achieve its goal of high-entropy iron until the stars appeared.

By appealing to an explanation along these lines, it is evidently unnecessary to suppose that the universe was created in a remarkably ordered state after all. The primeval material was actually in a condition of total disorder (maximum entropy). Such a state can be realized in the greatest number of ways, and the creator-with-the-pin would merely need to stab the 'shopping list' at random. The mystery of the origin of the cosmic order is solved.

Or is it?
The nuclear condition of the cosmic material is certainly a crucial factor in generating the observed structure and organization, but it is not the whole story. The larger structures — stars and galaxies — are shaped by gravity. Moreover, the crucial cosmic expansion is also controlled by gravity. What can be said about the gravitational organization of the cosmos? Do we live in a highly ordered, or a disordered universe, from the gravitational point of view? These questions will form the subject of the next chapter.

1983
Henry Eyring Sr.
Reflections of a Scientist
Book

The Age of the Earth
When President Joseph Fielding Smith's book Man, His Origin and Destiny was published, someone urged it as an institute course. One of the institute teachers came to me and said, "If we have to follow it exactly, we will lose some of the young people." I said, "I don't think you need to worry." I thought it was a good idea to get this problem out in public, so the next time I went to Sunday School General Board meeting, I got up and bore my testimony that the evidence was strongly in the direction that the world was four or five billion years old. That week, President Smith called and asked me to come see him. We talked for about an hour, and he explained his views to me. I said, "Brother Smith, I have read your books and know your point of view, and I understand that is how it looks to you. It just looks a little different to me." He said as we ended, "Well, Brother Eyring, I would like to have you come in and let me talk with you sometime when you are not quite so excited." As far as I could see, we parted on the best of terms.

I would say that I sustained President Smith as my Church leader one hundred percent. I think he was a great man. He had a different background and training on this issue. Maybe he was right. I think he was right on most things, and if you followed him, he would get you into the celestial kingdom.

The scriptures record God's dealing with his children back to a "beginning" some six thousand years ago, but dismiss the long prologue in a few short paragraphs. The scriptures tell us of six creative periods followed by a period of rest. During these periods the earth was organized and took essentially its present form. In the King James Version of the Bible, the phrase creative periods is rendered as "days." The use of this term has led to at least three interpretations. In the first, the "days" are construed to mean the usual day of twenty-four hours. In the second, the days of creation are interpreted as thousand-year periods following such statements as occur in 2 Pet. 3:8: "One day is with the Lord as a thousand years, and a thousand years as one day." The third

interpretation accepts "creative periods" as times of unspecified length and looks to a study of the earth itself to give added meaning to the exceedingly brief scriptural accounts.

In earlier times some variation of the first two interpretations was all but universally held by the Christian world. This is no longer true. In school and in secular publications, the third interpretation is the generally accepted one. Accordingly, whatever our own point of view may be, we need to know the viewpoint presented to our children if we are to be effective counselors to them.

The cumulative thickness of rocks laid down as sediment is about four hundred fifty thousand feet, or eighty miles. The rate of deposition varies enormously with the time and the place, but a not unreasonable average rate is one foot every 250 years. This leads to a very rough estimate of 112 million years for the time required to deposit all the known sediments.

Also, in my opinion, the orderly structure of these horizontally lying layers, with their fossils, argues strongly against the notion that the earth has been assembled, relatively recently, from the wreckage of earlier worlds.
A quantitative way of getting at the age of strata and other earth structures is by use of the radioactive decay of various elements. An analogy of how radioactive decay works may be helpful. If one should look at a fire and note that half the wood is burned the first hour and that an hour after that, half of what was left had burned, he could say the fire obeys the radioactive decay law. This law states that in a given length of time the same fraction of the fuel is burned, independent of the circumstances. Conversely, by measuring the fuel remaining at a fire and the amount of ashes already produced, one can deduce the fraction of the fuel consumed and so estimate how long the fire has been burning.

All the radioactive elements behave like our hypothetical fire in that, independent of the existing conditions, the same fraction of the radioactive elements is always transformed to another element in a given interval of time. The new element is the ashes of the radioactive fire; for example, half of the potassium (atomic weight forty) present to begin with changes into argon forty in a period of 1,300 million years, and half of what remains is changed in the next 1,300 million years, and so on. This period of 1,300 million years is called the half-life of potassium forty.

When a potassium-containing mineral crystallizes, it is ordinarily free of all gaseous argon. As time goes on, the potassium forty changes to argon forty at a rate determined by its half-life. If the crystal doesn't leak so that the liberated argon is retained inside the crystal, one can melt the crystal, measure the amount of potassium and the amount of argon, and so determine the age of the crystal.

If equal amounts of argon forty and potassium forty are found, the crystallization occurred 1,300 million years ago. If there is only one part potassium to three parts argon, 2,600 million years have elapsed since crystallization of the mineral occurred, and so on. Clearly, any potassium-containing mineral constitutes a built-in clock that we can use to read the time of the formation of the crystalline mineral.

Many complications may arise to make the clock give incorrect time. If some argon was entrapped in the crystal as it formed, the clock will read too long a time. If some of the argon has escaped since crystallization occurred, the indicated time will be too short. Nonetheless, by being careful to choose elements with appropriate half-lives and by careful selection of the crystal used and by using more than one kind of a "clock," a reasonably consistent time scale for the formation of the various strata in the world has been achieved.

The radioactive clocks, together with the orderly way many sediments containing fossils are laid down, result in agreement by most scientists on an age for the earth of about four-and-one-half billion years. On the other hand, the exact age of the earth is apparently of so little import religiously that the scriptures sketch earth history in only the briefest terms. The present heated religious controversies on the subject will undoubtedly be resolved in time and will then appear as quaint as the medieval arguments on the shape of the earth seem to us now.

In my judgment, anyone who denies the orderly deposition of sediments with their built-in radioactive clocks places himself in a scientifically untenable position. Actually, the antiquity of the earth was no problem for two of our greatest Latter-day Saint leaders and scientists, John A. Widtsoe and James E. Talmage. However, there are vast differences in the training and background of members of the Church. Therefore, I am completely content that there is room in the Church for people who think that the periods of creation were twenty-four hours, one thousand years, or millions of years. I think it is fine to discuss these questions and for each individual to try to convert others to what he thinks is right. It is only fair to warn parents and teachers that a young person is going to face a very substantial body of scientific evidence supporting the earth's age as millions of years, and that a young person might "throw the baby out with the bath" unless allowed to seek the truth, from whatever source, without prejudice.

The Lord made the world in some wonderful way that I can at best only dimly comprehend. It seems to me sacrilegious to presume that I can really understand him and know just how he did it. He can only tell me in figurative speech that I dimly understand, but that I expect to more completely comprehend in the eternities to come. He created the world, and my faith does not hinge on the detailed procedures he used.

Organic Evolution

When one of my grandsons was a small boy, just starting Primary, someone remarked to him, "So, now you are a Sunbeam." His face clouded, and he answered, "I am not a 'unbeam, I'm Henry Johnson Eyring!" I can understand how we sometimes object to being labeled. Some labels we accept. For instance, I'm content with "Mormon," "devout," "Christian," "chemist," "husband," "father," and so forth. Sometimes, however, a label is loaded with emotional baggage far beyond its usefulness or importance. For example, "organic evolutionist" or "creationist" are labels, either one of which I would reject, for myself, at least. They simply carry too much baggage and confusion for my taste.

Considering the difference in training of the members of the Church, I never cease to marvel at the degree of agreement found among believing Latter-day Saints. However, organic evolution is one topic upon which there is apt to be wide disagreement.

Such a topic becomes controversial partly because it is interesting to us, but it seems to be sufficiently nonessential to our salvation that the Creator has only briefly treated it in the scriptures. If you think about it, it makes almost no difference at all to the way we should live our lives and treat one another. Still, there are those who line up on both sides as if everything depended on the outcome of this year's "monkey trial."

Some people object to the slightest hint of being related to the rest of the animal kingdom, particularly the hairy apes. The idea is right next to the three "s's"-spiders, snakes, and sharks-on their list of things beyond the pale. I've never had that particular aversion. In fact, I've kind of enjoyed what little I've seen of them.

One time I was stuck most of a day in London and couldn't face the thought of sightseeing, so I went to the London Zoo. I was attracted by a crowd watching the great apes. One fellow in particular

was getting a lot of attention as he sat close to the front of the cage on a tree platform. As the zoo visitors moved closer, he suddenly spewed them with water he had in his mouth. Now, that was interesting! I found a bench across the path-out of range-and watched. The ape got down and went over to his water trough to reload. He then went about the cage awhile and finally repositioned himself on the platform. He waited-patiently. Finally a new group of humanoids, not aware of the danger, moved into range. Spray! Splat! Bullseye! The fellow practically chortled out loud as he made his trip to the trough. I spent the entire afternoon enjoying his enjoyment. Theoretically, he was there for our amusement, but quite clearly, he didn't understand that. He thought we were there for his. I have to admit I kind of admired the fellow. Animals seem pretty wonderful to me. I'd be content to discover that I share a common heritage with them, so long as God is at the controls.

I have always felt comfortable with the views of our trained scientists among the General Authorities. For example, James E. Talmage delivered a sermon entitled "The Earth and Man" from the Salt Lake Tabernacle on August 9, 1931, and John A. Widtsoe published "Science and the Gospel" in the Young Men's Mutual Improvement Association manual of 1908-9. Each of these brethren regarded the earth as having a very great age and were open to the testimony of science to uncover the truth on those questions.

What, then, is to prevent us from seeking to understand God's methods of creation by any and all means available to us? Many avoid seeking understanding from science because they believe that any theory in conflict with the Lord's revelations will finally be proven false. Of course, given those assumptions, the position is clearly correct, since I don't believe that God intentionally misleads his children.

We have a dilemma, however, because God has left messages all over in the physical world that scientists have learned to read. These messages are quite clear, well-understood, and accepted in science. That is, the theories that the earth is about four-and-one-half billion years old and that life evolved over the last billion years or so are as well established scientifically as many theories ever are. So, if the word of God found in the scriptures and the word of God found in the rocks are contradictory, must we choose between them, or is there some way they can be reconciled?

The scriptures state that Adam was the first man on the earth and that he was also the first flesh. Other scriptures teach that Adam was not subject to mortal and spiritual death before the fall, and that the fall brought these deaths into the world. Also, the scriptures say the earth is passing through seven periods ("days") of temporal existence, and that it was not temporal before the fall. Each of these ideas seems to be in conflict with the scientific views of organic evolution, but are they?

The fundamental principle that has guided my religious life is that I need believe only what is true. The gospel is the truth as learned or discovered by whatever means and tools I can lay my hand or mind on. I appreciate the scriptures for their insights into how to love God and my neighbor and how to learn obedience to the laws and ordinances of the gospel. These teachings are precious to all devoted Latter-day Saints. However, the brevity of the scriptures about God's methods of creation indicates that this may be a subject we will understand sometime but do not need to worry about for the time being: "Yea, verily I say unto you, in that day when the Lord shall come, he shall reveal all things- things which have passed, and hidden things which no man knew, things of the earth, by which it was made, and the purpose and the end thereof-things most precious, things that are above, and things that are beneath, things that are in the earth, and upon the earth, and in heaven." (D&C 101:32-34.)

In the meantime, I think it is perfectly appropriate for us to study and learn as much as we can about this wonderful place God has prepared for us.

We should keep in mind that scientists are as diligent and truthful as anyone else. Organic evolution is the honest result of capable people trying to explain the evidence to the best of their ability. From my limited study of the subject I would say that the physical evidence supporting the theory is considerable from a scientific viewpoint.

In my opinion it would be a very sad mistake if a parent or teacher were to belittle scientists as being wicked charlatans or else fools having been duped by half-baked ideas that gloss over inconsistencies. That isn't an accurate assessment of the situation, and our children or students will be able to see that when they begin their scientific studies.

"Now wait a minute," you say. "I thought you weren't an `evolutionist'!" I'm not. I'd be just as content to find out that God stirred up some dirt and water and out stepped Adam, ready to occupy the Garden of Eden. The only important thing is that God did it. I might say in that regard that in my mind the theory of evolution has to include a notion that the dice have been loaded from the beginning in favor of more complex life forms. That is, without intelligent design of the natural laws in such a way as to favor evolution from lower forms to higher forms of life, I don't think the theory holds water. I can't see randomly generated natural laws producing these remarkable results. So, in my mind, God is behind it all whether we evolved or not.

Probably one of the most difficult problems in reading the scriptures is to decide what is to be taken literally and what is figurative. In this connection, it seems to me that the Creator must operate with facts and with an understanding that goes entirely outside our understanding and our experience. Because of this, when someone builds up a system of logic, however careful and painstaking, that gives a positive answer to this difficult question, I can't help but wonder about it, particularly if it seems to run counter to the Creator's revelations written in the physical world. At least I would like to move slowly in such matters.

The really awful thing about me is that I really don't care one way or the other. Sometime, a billion years from now, it may come up in some heavenly science class and I'll be glad to know, but until then I'll be content.
Reflections of a Scientist

The Physical Worlds
My wife and I have a lot that is sixty feet across the front, one hundred feet deep, and extends straight up to the limits of space, so far as I know. Clearly, this qualifies me to speak on the broader aspects of the universe.

We live in a series of six worlds, from the infinitesimally small to the infinitely big. They can be represented by a point surrounded by five circles. This chapter deals with the five physical worlds of the nucleus, atom, living cell, everyday experience, and stars. The next chapter explores the sixth, the spiritual world.

The first, or central, world is the world of the atomic nucleus. The nucleus is where most of the weight of the atom is situated. One hundred thousand atomic nuclei touching each other in a line extend only across one atom, and it takes 100 million atoms to make one inch! Vibrations inside the nuclei of atoms are about a million times more frequent than the vibrations between atoms.

It is natural to wonder how anything as small as the nucleus can have structure, and even if it does, how we can find out about it. The procedure for finding out is to shoot electrically charged atoms or electrons at nuclei and see how they bounce. This tells us a great deal about the kinds of forces that are acting between the colliding particles.

When a particularly violent collision results in penetration into the nucleus and causes it to fragment, we can watch the tracks left by the fragments in a cloud chamber. In this way we find out that the nucleus is made up of positively charged protons and uncharged neutrons of virtually the same weight.

For twenty-five years scientists accepted parity, the principle that an atom does not know which end is up and has the same properties in all directions. However, an experiment suggested by Yang and Lee, for which they were given the Nobel Prize, showed otherwise. If we put radioactive cobalt sixty in a magnetic field, its nuclei line up with their south poles pointing toward the north pole of the earth. Every once in a while, one of the cobalt nuclei shoots out an electron. If the nuclei were indeed symmetrical, they would be equally likely to eject the electron through the north pole as through the south pole. However, a Geiger counter, similar to those used to prospect for uranium, reveals that the electrons are shot out preferentially through the nuclear south pole. Thus, the principle of parity must be given up.

Now the scientists have introduced quarks, fractional particles having a charge of one-third. When quarks were proposed in the early 1970s, they were conceived of as being undivided particles, although their charge was fractional. More recently observations have indicated the existence of one-dimensional conductors called solitons, which have fractional charge and fractional electron number.

By such experiments we come to understand something of the complexity and intricacy of this almost unimaginably tiny world of the nucleus. One hesitates to speculate whether we have even yet found the indivisible building blocks of the physical world.

The second world is the world of chemistry, made up of atoms and molecules. This, too, is a tiny world. It would take 100 million atoms placed side by side to make an inch. A molecule finishes one of its vibrations in about a ten million millionth of a second. We call this length of time a jiffy for lack of a better name. The quartz-crystal watch you wear on your wrist derives its great accuracy from such rapid vibrations.

An example of the exactness with which the universe works is found in the ammonia molecule. Ammonia consists of a nitrogen atom sitting on three hydrogen atoms. The startling fact is that this umbrella-like molecule turns wrong-side out almost twenty-four thousand million times a second. If you beam radar through a tube containing ammonia, the signal fades just when the radar frequency equals the inversion frequency of the molecules. In this way the ammonia molecules can be used as a clock to break time up into twenty-four thousand millionths of a second with unprecedented accuracy. It is interesting that this ammonia molecule turns wrong-side out just as often whether it is at room temperature or at the lowest temperature obtainable in the laboratory; whether in Soviet Russia or the United States; and whether this country is Democratic or Republican. Many things we think are important don't seem to affect the ammonia molecule much. The accuracy and order of the universe continue without regard to fashions in hairstyles, clothes, politics, science, or religion. What's true is true. What works, works.

When I went to Berkeley in 1925 to take my Ph.D., no one could explain more than a tenth of the attraction of two hydrogen atoms for each other. We knew that each hydrogen atom was uncharged, being made up of a positive nucleus whose charge was just neutralized by the charge on a negative electron. True, the atoms could distort each other and give about one-tenth of the observed binding energy, but the remaining part of the bond was a mystery.

The complete answer supplied by quantum mechanics was that the electron pair, by keeping out of the way of each other as they circulated around the two nuclei, could spend enough time between the two positive nuclei to glue them together to just the observed amount.

In order for the pair of bonded atoms to exchange partners with a similar pair, thus making a new compound, the pairs must approach each other closely. Accordingly, as two pairs of bonded atoms bump into each other, they can only approach and change partners if one or the other pair of electrons are pushed out of the way into an upper state. This collisional work that has to be done so a chemical reaction can take place is called the energy of activation.

Using this picture of the energy of activation accompanying a chemical reaction and building on the labors of my many able predecessors, it was possible for me, in 1935, to write down the general equation for the rate of all chemical reactions. This equation has become an integral part of chemistry, used universally.

The excitement of standing, in imagination, at a pass between two energy valleys representing the initial and final states in a chemical reaction and counting the activated complexes as they make their way over the pass in shattering collisions in which atoms are exchanged between the two colliding molecules is the thrill of a lifetime.

Further, to find that wave mechanics and thermodynamics, which have had so many other triumphs, are the same tools that enable us to quantitatively explain this all-pervading aspect of the material world in which we live brings a feeling of awe at the order and exactness of the universe that is never forgotten.

The third world in which we live is the world of the living cell, the world of biology. Cells vary in size, but typically they are about a micron across, that is, about one ten-thousandth of a centimeter. An active cell divides into two cells about every twenty minutes.

The word life itself conjures up animation, movement, excitement, and perhaps a little mystery. Discussions of the origin of life disturb some people. Some are particularly disturbed by scientists who "tamper with creation" and actually try to start life in a laboratory. It would disturb me more to find that life couldn't be started in a laboratory. If life can't be started somehow in this physical world, then how did I get here? You see, I think I'm alive, although some of you might observe me dozing at my desk and wonder.

The human cell has near its center a nucleus containing forty-six chromosomes. Twenty-three of these come from the father and twenty-three from the mother. The chromosomes are made up of about a million genes that constitute our inheritance. A gene controls the synthesis of essential molecules, such as enzymes, that build and regulate our unbelievably complicated bodies.

A colleague, Frank Johnson, and I once wrote a paper on evolution and rate theory, "The Critical Complex Theory of Biogenesis." This paper outlines a theory of prebiological evolution. One of the principal questions addressed is why living things are optically active.

The body is made up of many types of molecules, just as a large building may be made up of many types of brick. Many of these molecules are asymmetrical, and frequently one optical isomer is found to occur in living things to the virtual exclusion of its mirror image. We can understand this selective choice of building blocks if we recognize that the body is built up by molecules that are to be incorporated into the body from the food we eat. This selection is made by a process of fitting of the molecules to the enzyme much as a left hand selects a left-hand glove and rejects a righthand glove.

Muscles and enzymes are made by joining amino acids together into long chains called proteins. There are twenty different amino acids that are joined together in different proportions to form the links in the various types of protein chains. Of these twenty amino acids used by the body, all but one are asymmetric. Further, all the nineteen asymmetric amino acids used are like the left-hand glove and are called l-amino acids. In every living thing, the opposite optical isomers, which are called the d-amino acids, if present in the food, are rejected by the enzymes that build proteins, and are eliminated from the body. We therefore call this world we live in an l-amino acid world. The "l" comes from laevo, the Latin word for left; and "d" stands for dextro, or right.

Using absolute rate theory, Johnson and I arrived at a reasonable rate of appearance of these optically active templates, given assumed concentrations of certain chemicals in the primordial "soup."

The interesting thing is that from any given pot of "soup" it is as likely that a d- as an l-type world will start up. We can readily imagine a d-amino acid world. In fact, if we look into a large mirror, the world we see is a d-amino acid world, since every object, including the molecules, is the mirror image of those in the real world. Obviously, everything in the d-amino acid world would work exactly as well as everything in our real world, and it is a matter of no obvious consequence which world we happen to have. If there are other worlds that support life, there is no reason for supposing that they may not be d-amino acid worlds. If so, such worlds would be completely inhospitable to us, since we could not digest their foods, and marriages between people coming from d and l worlds would necessarily be sterile. On the other hand, there is, of course, no reason why people from two such worlds might not converse with each other with complete understanding, and one could not tell the two types of people apart by their appearance.

The fact that in our world every living thing, from the tiniest living cell to man, uses only the l-amino acids along with the d-sugars highlights the unity running through the living world. Everything that grows collects those particular optical isomers needed for food and rejects the opposite isomers. Here again, we catch a glimpse of the unity that everywhere characterizes the cosmic design.

The fourth world is the world of everyday. Here, we measure time in seconds or minutes, and distances in feet or miles. This is the world we know most about.

Sir Isaac Newton discovered the universal law of gravitation and developed the laws of mechanics so that his successors have been able to calculate the motion of the planets in their orbits to any desired degree of accuracy. Astronomers predict exactly when an eclipse will occur. Using this knowledge, men make great preparations, assemble expensive scientific equipment, and move to the ends of the earth when told that an eclipse is imminent. They get their cameras ready to take pictures and open the shutters at the right moment, and the eclipse begins at the predicted instant. If the eclipse were ever so little off schedule, it would make headline news around the world.

These same laws that enable astronomers to compute eclipses tell precisely, of course, how a satellite goes around in its orbit. A man who makes a good running broad jump only misses becoming an earth satellite by not running fast enough. Thus, if instead of running twenty miles an hour he ran twenty thousand miles an hour, he would find that as he jumped, the earth would curve away beneath him faster than he could fall toward it. Our jumper would settle into an elliptical orbit extending around the earth, except for one thing-the air resistance would slow his speed and set him on fire. To avoid air resistance, the satellite is shot above the atmosphere. This is the only reason for sending it up six hundred miles.

Satellites like Sputnik and the moon have a terrifically frustrating job. The moon has been falling toward the earth and overshooting the mark for billions of years and still has no prospect for a successful hit. Man has not succeeded in sending satellites up to such complete frustration yet. The reason is simple. Even at altitudes of six hundred or a thousand miles there is still a trace of hydrogen left. As the satellite circles the earth, it bumps into gas. When it has bumped into a weight of gas equal to its mass, its momentum is cut in half, except that by falling closer to the earth it picks up additional speed. Still, it is a remarkable human achievement to launch a satellite and in a small degree become a partner in creation.

All such achievements rely on the fundamental belief that the everyday world is exactly predictable. We may not yet know or completely understand the rules of when earthquakes occur, or what causes surprises for the weatherman, but we are sure that such events are not really capricious. The more we learn, the better we understand and the closer are our predictions.

If we look at the stars, we see the fifth world. Men have probably always looked up and wondered: How far away are the stars? What makes them shine? How long have they been there? Will they exist forever? Some have believed that the stars were gods who controlled their destiny. Others noticed the regularity in the grouping of stars and used their knowledge of stellar movement to help mark the passage of the seasons and fix the times of planting and harvesting. The early Greeks believed the stars were fixed like nails to the vault of the heavens. Aristotle maintained that celestial objects were permanent, immutable, and perfect. He so convinced the Greeks of this that when a new star appeared in 134 B.C. it was attributed by its discoverer to an omission by his predecessors.

In the Middle Ages, Copernicus showed that the earth was not the center of the solar system. But Aristotle's thinking continued to dominate astronomy until the 1500s when new stars were discovered and then in the seventeenth century when Galileo used his telescope to discover spots on the sun-demonstrating that the solar complexion was somewhat less than perfect-and to prove that the sky was filled with stars that could not be seen with the naked eye.

Just so you know how old I am, I can remember when astronomers, using ever-larger telescopes, discovered that some of the "stars" thought to be part of the Milky Way were actually other galaxies-each containing billions of stars and lying far beyond the Milky Way's outermost limits.

Even so today, as we look out at the universe, the first impression is one of stupendous size. By using such instruments as the huge 200-inch optical telescope on Mount Palomar and newer radio, X-ray, and gamma-ray telescopes, modern-day stargazers have pushed the frontiers of understanding ever closer to the edges of the universe and into the very cores of the stars. We can see out so far that the light reaching our eyes started on its journey toward us almost 12 billion years ago. You remember how fast light travels: 186,000 miles a second; it goes around the earth, a distance of 24,000 miles, seven and one-half times in a second. A light-year is the distance that light travels in a year-about 6 trillion miles. If you multiply 12 billion years by 6 trillion miles, you get a seven followed by twenty-two zeros for the number of miles you can see in any direction you care to look. The known radius of the universe in miles is even bigger than the national debt. It is a very long distance indeed.
When you walk outside on a clear moonless night, all the celestial objects you can see with the naked eye are either planets or stars, or, if you have superman vision, you might be able to see the Andromeda galaxy that looks like a fuzzy star. All the stars you see are part of our own Milky Way galaxy. The closest star, other than our own sun, is Proxima Centauri, four light-years away. At our present rates of space travel, this journey would require one hundred twenty thousand years. Consequently, we seem to be marooned in our solar system, at least for the time being. Present

missile travel, which proceeds at a speed about a thousand times as fast as man can run, will need to be speeded up by another factor of a thousand before we can undertake trips beyond our solar system.

Some scientists believe that the universe is the expanding remnant of a huge fireball created 20 billion years ago by a giant explosion. The stars and planets are the products of that cataclysmic blast and its aftereffects. In 1929 astronomer Edwin Hubble used shifts in the spectral lines of light coming from distant galaxies to calculate that these islands of stars are moving at tremendous speeds away from the earth-and from each other-like dots painted on the surface of an expanding balloon. Scientists at Bell Laboratories have even listened with their sensitive radio antenna to radiation interference, which amounts to the hissing echoes of creation: "In the beginning God created the heaven and the earth. And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters. And God said, Let there be light: and there was light." (Gen. 1:1-3.)

Most cosmologists-scientists who study the structure and evolution of the universe-agree that the biblical account of creation, in imagining an initial void, is uncannily close to the truth. I might add, it is as if the one who wrote those words was there, or at least had talked to Someone who was.

Are we the only worshipers in this great cathedral called the universe? Professor Harlow Shapley, emeritus professor of astronomy at Harvard University, has written an interesting book, Of Stars and Men (New York: Washington Square Press, Inc., 1960) in which he estimates that there are 100 million, million, million, million suns in space. Shapley has very conservatively estimated that at least one sun in a thousand should have acquired planets. Most of these satellites are at such distances from their suns that they are either too hot or too cold to support life as we know it. Still others lack life-giving water, while others lack the necessary oxygen. However, Shapley has estimated that of those suns with planets at least one in a thousand has a planet at the right distance for life.

Of those having a planet at the right distance, at least one in a thousand should have a planet large enough to hold an atmosphere, and, finally, that one in a thousand of those having a large enough planet at the right distance should have an atmosphere of the right composition to support life. Thus, he concludes that there should be at the very minimum 100 million planets that could support life, and the number is probably many times more. From the scientific point of view, it is hard to doubt that myriads of worlds are suitable for human habitation.

It is accordingly natural to conclude that the universe is filled with intelligent beings and, presumably, always has been. Any unfolding of intelligences on this earth only repeats what has happened previously elsewhere. Even if we believe beings on distant planets have progressed far beyond us, still the barrier to travel posed by interstellar distances seems quite sufficient to explain why mortal space travelers have not visited us.

So we envision a still-expanding universe that began almost 20 billion years ago, extends for 12 billion lightyears, and contains 10 billion galaxies-each one an island of hundreds of billions of stars. Actually, we also need to add the dimension of time. We see our nearby sun as it looked a little more than eight minutes ago. We see Proxima Centauri as it was about four years ago, and some of the farther galaxies as they looked billions of years ago. The farther out we look, the further we are looking back in time. Some objects we see may no longer exist.

With all that we do know, it is obvious to the serious student that there is a great deal more that we don't know. To the ultimate question-what existed before the big bang-most of modern science

is mute. It's as if it were against the rules to ask questions when there isn't any scientific way to approach the answers. It's still a nice question though, isn't it?

From nucleus to galaxies, the universe is complex, orderly, consistent, and very, very interesting. It is also full of energy and motion. There is something peculiar about that.

If you picked up a watch far from human habitation and found it running, you would ask not only "Who made this watch?" but "Who wound it up?" So it is with the universe. The universe is running down. It is a universe of change. People are born and pass from the earth, and stars, too, come into existence and pass away.

The sun is about half hydrogen; the rest of it is composed of other materials. The hydrogen bomb shows us what happens to hydrogen down in the center of the sun where the pressures and temperatures are enormous. Four hydrogen atoms come together to make helium, and, in the process, a little of their weight is changed into energy. This energy falls on the earth as sunlight and makes the plants grow.

Thus, the sun is a giant furnace with a supply of hydrogen for fuel-quite a good supply. But if the sun ever burns out, it is going to be very cold in Salt Lake City. You might like an estimate of the fuel supply on hand. I would say the supply should last at least five billion years, so we don't need to worry about it right away.

This picture of the sun as a furnace with a limited amount of fuel poses interesting problems. The second law of thermodynamics is a formal statement of the familiar fact that if energy is being obtained continuously from some source, then the supply of energy must run out sometime unless it is replenished from an outside source. As with any woodpile, if you keep burning up the hydrogen on the sun, it must ultimately be used up unless it is replenished. There is evidence that in the last billion years the sun's temperature has never varied by the small amount that would make the earth unfit for habitation.

It is a well-known fact of experience that if we set a pot of boiling water on a table in a cool room, the pot cools, and when once cooled it never returns to the boiling point without being reheated. In just the same way the sun is giving off its heat and very gradually growing colder. When the sun ceases to shine, all living things will die; all changes will cease, and the world will reach a deadly, monotonous uniformity. This state is called the heat death and is a consequence of nature always moving toward more probable states and never in the reverse direction toward less probable states.

An interesting calculation illustrates the complete improbability of a hot sun arising by chance. We suppose that in order to become hot again the sun must accumulate an amount of heat equal to that it gives off during its lifetime. This must be accumulated from its surroundings, which we shall assume in the heat death drops to a temperature of 700 degrees centigrade. Then, using the straightforward theory of chemical reactions, we find that a length of time in years equal to at least one with a hundred thousand, billion, billion, billion, billion, billion zeros must elapse before a hot sun has a 50-percent probability of occurring again by chance. This is almost no chance at all! A universe filled with hot suns is no more likely. It is evident that our hot sun, or this universe, did not arise by such a chance fluctuation.

In a very real sense, then, the universe is like a clock that has been wound up. If it is self-winding, it is unique in scientific experience. In a talk before the National Academy of Sciences, I raised the obvious question, "How did the universe get wound up?" No one chose to answer. After the talk, I repeated my question privately to three scientists. President Millikan of the California Institute of Technology said, "I, like you, am a religious man." Professor Van Vleck of the Harvard physics

department said, "Of course, one doesn't know." The third man said, "Don't you believe in your religion?" I answered, "Yes, but I wondered about yours."

November 1985
Don Lind, LDS Astronaut
The Heavens Declare the Glory of God,
Conference Address

I am sure the general image of space flight is one of impressive machines and billowing flames and the precision of high technology. That is not incorrect. But for me, there were also many special, personal, private feelings. Some of them were fun. Living in weightlessness is delightful. The Peter Pan ability to float to any corner of the laboratory and perch like a sparrow on the slightest protrusion made me feel as though I was living my little boy dreams.

Some of my personal feelings were very spiritual. To look down on the earth from space is absolutely incredible. I knew ahead of time just exactly what I was going to see. I was intellectually prepared, but I was not prepared emotionally for what I saw. The world is very large. I knew that. But to see this huge, magnificent sphere slowly rotating beneath me was overwhelming. I have no ability to describe what it was really like, and no photographic emulsion can even start to do it justice. The visibility, of course, was excellent. But I was amazed at the intensity of the colors. I estimated that there were twenty shades of intense blue as the earths atmosphere changes from the gray of the curved horizon into the incredible black void of space. And when you look at an archipelago of islands, there are hundreds of shades of blue and green and yellow tan that are just beyond description.

The first time I had a minute to stop and just look at the earth, the absolute beauty of the scene brought tears to my eyes. In weightlessness tears do not just quietly roll down your cheeks. They stay in front of your eyeballs and get bigger and bigger and in a few moments you feel like a guppy looking up through the surface of the aquarium.

Now, try to imagine what it was like for me to have that scene in front of me and then have the fragments of half a dozen scriptures pop into my mind. The heavens declare the glory of God. (Ps. 19:1.) If you have seen the heavens, you have seen God moving in his majesty and power. (D&C 88:47.) I am sure you can imagine the closeness I felt to my Father in Heaven as I looked down at one of His beautiful creations. I was really stirred by an increased awareness of what He did for us as the Creator of our earth. That was one of the most moving experiences of my life.

Another experience that is very close to me was to have the sacrament in orbit. We were in space for a full week, so of course, we were up there on a Sunday. Our bishop had given me permission to hold my own sacrament service. It was a little unusual. You priests in the audience might consider what it would be like to try to kneel down in weightlessnessyou keep drifting off. For privacy I held my sacrament service in my sleep stationsomething like a Pullman berth. I kneeled on what you would think of as the ceiling and braced my shoulders against my sleeping bag so I would not float away. It was a very special experience. I will remember that sacrament service and the renewing of my baptismal covenants high above the earth all my life. It had some of that special feeling that you usually have only when you go to the temple.

November 1986
Elder Ted E. Brewerton

Now another evidence of God: speaking of the planets and orbs, the Lord says, Any man who hath seen any or the least of these hath seen God moving in his majesty and power Conference Address

Now another evidence of God: speaking of the planets and orbs, the Lord says, Any man who hath seen any or the least of these hath seen God moving in his majesty and power (D&C 88:47). The heavens declare the glory of God; and the firmament sheweth his handywork (Ps. 19:1).

Mike, lets visualize three scenes together.

Scene 1. First of all, we see before us, Michael, our solar system: our sun, together with the earth and the eight other heavenly bodies that revolve around it. We see law, beauty, order, and perfection.

Scene 2. Now, Michael, in this next scene, we see this same solar system in its place in our galaxy, the Milky Way. We marvel at the order and arrangement. Our planets are so small they cant be detected here, but our sun and its nine planets appear as one of these shining orbs and are situated about two-thirds of the way from the center, about thirty thousand light years from the middle of the Milky Way. Our planets move about the sun; the sun itself moves in a circular path at a speed of 130 miles per second, yet even at that speed, Mike, a complete turn around the Milky Way takes two hundred billion years. This, our star system, has about two hundred billion blazing suns and is one hundred thousand light years wide.

Scene 3. Now in this next scene, Michael, we see our galaxy, the Milky Way, in space along with other galaxies. You know, Mike, it is conservatively estimated that there are ten billion star systems like these galaxies. Incomprehensible? I should say! We have soared out far beyond our imaginations.

What is a billion, Michael? One thousand million. thats right.

Whats a definition of a million, Michael? Thats good; you say a million is like your mother telling you to clean up your room 274 times every day for ten years.

How fast does light travel, Mike? Thats right: 186,000 miles per second. Hold up your left fist as if it represented the earth. Now whirl your right index finger around it. If your index finger spun around it about seven times in one second, you have shown how fast light would travel around the earth.

It takes about eight minutes for light to reach the earth, and just over one second for light to reach the moon from the earth. Imagine how far light could travel in one day of 86,400 seconds. Wow! Then in one year it is beyond our ability to understand.

The Lord said: And worlds without number have I created; and I also created them for mine own purpose; and by the Son I created them, which is mine Only Begotten.

And the Lord God spake unto Moses, saying: The heavens, they are many, and they cannot be numbered unto man; but they are numbered unto me, for they are mine (Moses 1:33, 37).

He further said:

And were it possible that man could number the particles of the earth, yea, millions of earths like this, it would not be a beginning to the number of thy creations (Moses 7:30).

Isnt that exciting, Mike?

From The Amazing Universe we read: As the sum of knowledge grows, the astronomer continues to seek answers to mans most profound questions: What is the grand design of the universe? How was it created? How did we get here? Are we alone? (p. 10).

We again read, It is impossible to any sensitive person to look at a star-filled sky without being stirred by thoughts of creation and eternity (The Amazing Universe, p. 166). A super-giant elliptical galaxy may contain more than ten trillion stars and measure 300,000 light-years across.

The sheer immensity of such systems suggest eternal qualities of stability and predictability (The Amazing Universe,, p. 134; italics added). See, Mike, the scientific world sees the evidence of a supreme being.

With all this massive, orderly creation, are you, Michael, a single human being, important? The scriptures state:
When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained;

What is man, that thou art mindful of him? and the son of man, that thou visitest him?
For thou hast made him a little lower than the angels, and hast crowned him with glory and honour.
Thou madest him to have dominion over the works of thy hands; thou hast put all things under his feet (Ps. 8:3-6).

Yes, you, Michael, are everything; you are why the heavens were created.

Mike, you must realize a truth: that God knows who you are and what you may become. He knows where you are and what he expects of you.

You, Michael, are Gods son, hence heir to all he has. His purpose and goal is to bring to pass your immortality and eternal life. You are the most important thing that existshis most important creation. So we must be master of our beings and control ourselves, and not be controlled by some habit or by someone else. We must be lifters and not leaners. Reach for the stars.

You, Mike, with the Lords help, have an unlimited potential. Lets follow the perfect example of the Master, our Savior. How easy it is to have hope: Hope is the strongest weapon in the spiritual arsenal of youth (Royal Bank Newsletter, vol. 66, no. 6).

The sun is our star, the only source of all light and energy for us. It makes life possible.

One star is a remarkable one. There are about two hundred billion blazing ones, or suns, in our star system alone, and over ten billion star systems; yet one sun is a remarkable one. You, Michael, are like a sun a remarkable one.Jesus, the Redeemer, had no office or public function, yet he shaped the worlds history. He wishes you to understand that you should be a remarkable one, for the power is in you to make things happen.

November 1987
Elder Neal A. Maxwell, Quorum of the Twelve Apostles
Yet Thou Art There
Conference Address

What John and Paul wrote about Gods creations and the plurality of worlds, the restored gospel grandly affirms, declaring that worlds without number have been created (Moses 1:33; see also John 1:3; Heb. 1:2; Heb. 11:3; D&C 93:10). These gospel truths are very significant assurances for us, situated as we are on this tiny speck of sand at the outer edge of a minor galaxy, the Milky Way. Without the gospels fulness, we would appear to be living during one tick of the geological clock and in the midst of unexplained vastness.

Nevertheless, our focus is to be on this planet, just as the Lord told Moses:

But only an account of this earth, and the inhabitants thereof, give I unto you. For behold, there are many worlds that have passed away. Innumerable are they unto man; but all things are numbered unto me, for they are mine and I know them (Moses 1:35).

Enoch, to whom the Lord revealed so much, praised God amid His vast creations, exclaiming reassuringly, Yet thou art there (Moses 7:30; see also Jer. 10:12).

This same special assurance can see each of us through all the seasons and circumstances of our lives. A universal God is actually involved with our small, individual universes of experience! In the midst of His vast dominions, yet He numbers us, knows us, and loves us perfectly (see Moses 1:35; John 10:14).

Along with knowing that God is there, it is equally vital to know what He is like, including His perfected attributes of justice and mercy. More mortals die in ignorance of Gods true character than die in actual defiance of Him. Belief in the goodness and power of God is greatly facilitated by understanding His plan of salvation with its crucial allowance for mankinds moral agency, real moral agencywith real mistakes and with real consequences! His plan includes real tests, real dilemmas, real anguish, and real joy.

Even though he knew he had been called personally by a personal God, Enoch wrestled with feelings of personal inadequacy (see Moses 6:31). Enoch also wept over the human condition, but he was told, Lift up your heart, and be glad; and look (Moses 7:44). If Enoch had not looked and been spiritually informed, he would have seen the human condition in isolation from the grand reality. If God were not there, Enochs Why? would have become an unanswered scream of despair!

At first, Enoch refused to be comforted (Moses 7:44). Finally, he saw Gods plan, the later coming of the Messiah in the meridian of time, and the eventual triumph of Gods purposes. Enoch saw how the throne of God features justice and mercy (see Moses 7:31).

Significantly, the consequences of misused human agency were explained to Enoch: mortals had been given a commandment to love one another, yet those then had become a people without affection who hate their own blood (Moses 7:33).

We, too, can refuse to be comforted. We can wrongly charge God with that large portion of human misery which is actually caused by mortals failure to keep His commandments. Or, like Enoch, we can be intellectually meek enough to look and to accept the truths about Gods being there and about His personality and plans.

Alas, when the Lord gives us line upon line and precept upon precept about Himself and His plans, many ignore these great gifts. Instead of lines, some demand paragraphs and even pages. When God provides here a little, and there a little (Isa. 28:10), some want a lotnow!

Even so, the pages of scripture rustle with reassurances, such as were tenderly given to Abraham:

And he said unto me: My son, my son (and his hand was stretched out), behold I will show you all these. And he put his hand upon mine eyes, and I saw those things which his hands had made, which were many; and they multiplied before mine eyes, and I could not see the end thereof (Abr. 3:12).

Whatever the scale of things, the Lord is there! Whether in speaking of how sun, moon, and stars show God moving in his majesty and power (D&C 88:47) or in describing the lilies of the field as being better arrayed than Solomon in all his finery, who is better qualified than the Creator to make such descriptions of the heaven and such comparisons between raiment and flowers (see Matt. 6:28-29)?

A solitary Samaritan woman was one of the very first to learn from His lips that Jesus was in fact the Messiah. She marveled how Jesus told me all things that ever I did (John 4:29). Jesus had been there in her life for a long time. To hasten recognition, the resurrected Jesus told Peter where to lower his fishing nets to harvest a particular school of fish (see John 21:6-8). Deity called Samuel, Mary Magdalene, Saul, and Joseph Smith by their first names (see 1 Sam. 3:4; John 20:16; Acts 9:4; JSH 1:17).

Macro-love with such micro-manifestations!

God is not only there in the mildest expressions of His presence, but also in those seemingly harsh expressions. For example, when truth cutteth to the very center (1 Ne. 16:2), this may signal that spiritual surgery is underway, painfully severing pride from the soul.

God is there also when true but hard words break open the chained door of a mind taken over by a single obsession. Sometimes, brothers and sisters, instead of the minds wrapping itself around an idea, an idea wraps itself tightly around the mindanother way in which pride compasseth about as [with] a chain (Ps. 73:6).

The Lord is truly there to chastise those whom He loves, including the spiritually preeminent. The Brother of Jared for too long had failed to pray (see Ether 2:14). Even the good can become careless without the Lords being there to chasten. Later, the chastened Brother of Jared saw Christ (see Ether 3:13-16)!

What we mortals encounter as the unforeseen, God has already seen, such as how the oil deposits of this earth would shape the latter-day conflicts among nations. Gods is the hand that is stretched out upon all the nations (Isa. 14:26). He likewise foresaw all the awful famines, some resulting from the unwise, unnecessary erosions of precious topsoil. He surely foresaw the terrible persecutions of the Jews. Having created the earth, He has anticipated the impact of continental drifts on the frequency and intensity of latter-day earthquakes. He who analogized that the wicked are like the troubled sea, when it cannot rest (Isa. 57:20) also knows where and when, in latter days, the seas tidal waves will heave themselves savagely beyond their bounds (D&C 88:90).

Without the revelations, however, the answers as to the why of our existence and the why of human suffering would elude even the best intellectual excursions:

Behold, great and marvelous are the works of the Lord. How unsearchable are the depths of the mysteries of him; and it is impossible that man should find out all his ways. And no man knoweth of his ways save it be revealed unto him; wherefore, brethren, despise not the revelations of God (Jacob 4:8).

The ultimate human questions are really the why questions! The gospel is positively brim with answers to the why queries concerning human purpose. Gospel truths are the vital integrating and ordering truths, not only telling us of things as they really are but also as they really will be (Jacob 4:13).

No wonder we should live in thanksgiving daily (Alma 34:38) because all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator (Alma 30:44).

Furthermore, all things which have been given of God from the beginning of the world, unto man, are the typifying of [Christ] (2 Ne. 11:4).

Providing adequate oxygen for us on this planet is a form of Gods lending [us] breath, as in King Benjamins litany (Mosiah 2:21). God keeps this planet habitable, preserving [us] from day to day (Mosiah 2:21). Given all He has done, no wonder we are, comparatively, unprofitable servants (Mosiah 2:21).

Even given our unprofitability, our Redeemer is still there. In fact, Jesus transcending service to us stretches back to premortal days. When God brought before us His plan of salvation, Jesus was there, volunteering meekly and humbly, Here am I, send me (Abr. 3:27), saying, Father, thy will be done, and the glory be thine forever (Moses 4:2). The Father, ever anxious that all be free to choose, gave Lucifer opportunity to campaign:

Behold, here am I, send me, I will be thy son, and I will redeem all mankind, that one soul shall not be lost, and surely I will do it; wherefore give me thine honor (Moses 4:1; see also Abr. 3:27; Isa. 6:8).

Note the ego dripping from only three lines: two mes and four Is. Those vertical pronouns are usually accompanied by unbending knees, because the proud, as in Jesus parable, trust in themselves that they [are] righteous, and [despise] others (Luke 18:9).

Long ago, it was also meek, loving, and redeeming Jesus who anticipated the need to take the gospel to those in the spirit prison, including the wicked of Noahs time when the chosen hath pled before [Gods] face (Moses 7:39). Jesus has been there as our long-suffering Shepherd for ages.

We need not be atop high mountains or in sacred groves for God to be there. God is also there even in the mildest expressions of His presence.

Conscience permits the Lord to be there, whether in early warnings or final warnings. He gives us a flash of insight or a twinge of remembrance, pulling us back from a precipice or prompting us to do good. Conscience can warn that we are only falling further behind by insisting on getting even. Conscience warns us not to sink our cleats too deeply in mortal turf, which is so dangerously artificial.

In a hundred ways, Deity will always be there, just as Enoch testified, including in our suffering.

Some among us, desperately ill, know the loneliness of a hospital room by night when loved ones have departed or are sleeping for sorrow (Luke 22:45), unable to watch another hour (Matt. 26:40). The night magnifies the stillness of the hospital corridors, as these individuals brush against the veil of death. Even so, whether or not appointed unto death (D&C 42:48), these faithful are in His hands. They can and do know of God, Yet thou art there!

Widows and widowers whose deprivation stretches into years, when the caress of dimmed memories is insufficient, sometimes sob to see purpose in it all. However, they will later know moments when the Lord shall wipe away tears from off all faces (Isa. 25:8). Meanwhile, they can truly testify, Yet thou art there!

Wives and husbands whose lives are shattered by the betrayal of a deserting spouse may feel forsaken or drenched by injustice. Yet they, too, can know, Thou art there, by responding to Jesus invitation, Come unto me, all ye that are heavy laden (Matt. 11:28).

Parents, striving to reach and to rescue the truculent teenager, experiencing disappointment after disappointment and wondering when it all will end, can be assured, Yet thou art there!

To those of you who so suffer and who, nevertheless, so endure and so testify by the eloquence of your examples, we salute you in Christ! Please forgive those of us who clumsily try to comfort you. We know from whence your true comfort comes. Gods bosom is there to be leaned upon.

Jesus promised peace is a special form of rest amid unrest. Even when other things are in commotion, His disciples can still stand (see D&C 45:26, 32). His disciples know the Lord is there in latter-days. I am he who led the children of Israel out of the land of Egypt; and my arm is stretched out in the last days, to save my people Israel (D&C 136:22).

We can confidently cast our cares upon the Lord because, through the agonizing events of Gethsemane and Calvary, atoning Jesus is already familiar with our sins, sicknesses, and sorrows (see 1 Pet. 5:7; 2 Ne. 9:21; Alma 7:11-12). He can carry them now because He has successfully carried them before (see 2 Ne. 9:8)!

Yes, Gods creations are stretched out, but so is his redeeming arm (see Ex. 6:6; Ps. 136:6)!

He who is ever there is perfect in His love. Moreover, eye hath not seen, nor ear heard, neither have entered into the heart of man, the things which God hath prepared for them that love him (1 Cor. 2:9; see also Isa. 64:4).

The Restoration is thus filled with such abundant assurances about God, about life, about the universe, and about us.

As you and I dash about the wonder-filled landscape of the Restoration, exclaiming and observing, it should not surprise us that our first impressions are less than definitive. Little wonder that some of us mistake a cluster of trees for the whole forest or that, in some of our joyful exclamations, there are some unintended exaggerations.

Roving amid the tall timber of truth, the pervasive scent of pine is inevitably upon us. Our pockets are bulging with souvenir rocks and cones. And we are filled with childish glee. There is no way to survey it allin one tour or several. Besides, further familiarization will only increase our wonder. After all, One not given to hyperbole used the word marvelous to describe the Restoration!

Further reconnoitering, in fact, produces a hushed expectancy because, one day, the faithful will have it all. The day cometh that all things shall be revealed unto the children of men which ever have been and which ever will be even unto the end of the earth (2 Ne. 27:11).

Like Moses, Nephi was atop exceedingly high mountains and beheld great things too great for man (2 Ne. 4:25). Like Enoch, Nephi cited the attributes of God, who is there amid worlds without number, declaring:

O how great the goodness of our God! (2 Ne. 9:10).
O the greatness of the mercy of our God! (2 Ne. 9:19).
O how great the plan of our God! (2 Ne. 9:13).

Gladly and firmly, I add my small voice of witness to these wonderful declarations of adoration, in the name of Jesus Christ, amen!

1988
Freeman Dyson, Physicist and Philosopher of Science
Infinite in All Directions
Harper and Rowe Book and Gifford Lectures in 1985

Chapter 4 - How Did Life Begin?

1 am concerned with the origin of life as a scientific problem, not as a philosophical or theological problem. The problem is to find out what happened. To understand what happened, it is not necessary to agree upon a verbal definition of life. So far as science is concerned, the problem is to find a plausible sequence of events by which a barren and lifeless planet becomes transformed into the planet we see around us today. The question, at which point along that sequence of events we draw the line between non-living and living, is not a scientific question. The line between living and non-living at the beginning of evolution is arbitrary, just as the line between human and non-human primates at the end of evolution is arbitrary. In both cases, we are free to draw the line according to our taste. In both cases, the task of science is not to define the exact position of the line but to understand how it came to be crossed.

A hundred years ago, Charles Darwin could write books discussing the central problems of biology in language which was scientifically precise and still accessible to the general public. In those days the subject matter of biology was plants and animals. The language of Darwin was intelligible to experts and non-experts alike. One did not need a degree in botany to understand the difference between a fern and a flower. Darwin could assume that his readers were familiar with the world of nature as he described it.

Today, unfortunately, the language of Darwin is no longer adequate to describe the main themes of science. The language of physics has moved steadily further into the domain of abstract mathematics. Instead of describing nature with mechanical models, physicists now describe it with infinite-dimensional spaces and other even more esoteric mathematical concepts. And the language of biology has become heavily encrusted with the jargon of chemistry. During the last fifty years, biologists have made enormous progress in understanding the basic processes of life. The basic processes are chemical reactions. The price of progress is a language in which "amino acid,' "nucleotide," ..protein," ..nucleic acid" are the common nouns, 'synthesize," "catalyze, '"polymerize" the common verbs. The chemistry of living cells is the essence of life. The beauty of their variegated architecture is inescapably tied to the ugliness of chemical terminology. The further we penetrate into the mysteries of their behavior, the longer and the uglier our words become.

Anyone who tries to explain modem science to the general public faces a choice, either to write an elementary textbook with technical terminology carefully defined, or to take refuge in metaphor. I

have chosen the latter course. In Chapter 1 1 used the metaphor of the rain forest to describe the proliferation of particles and of theoretical models in modem physics. The metaphor is impressionistic, but it is not altogether misleading. It may be more illuminating than an elementary description of the objects, quarks and leptons and hadrons and so forth, which the experts are exploring. If the reader would prefer an elementary textbook, there are plenty available, both in particle physics and in molecular biology. I do not need to write another. I shall use metaphor again to describe the chemical architecture of life. In this way I avoid the multitude of technical definitions which are needed if one names each brick in the structure by its proper name.

The metaphor of the computer represents in some crude fashion the chemistry of life. Nowadays one may assume that the average citizen of an industrialized country is at least as familiar with computers as with rain forests. The idea of using the computer as a metaphor is a natural one. A computer is a device for handling information according to a program which it is able to remember and execute. A living cell, to remain in control of its vital functions in a variable environment, must also possess a program of chemical reactions which it is able to remember and execute. The control system of the cell must be capable of storing and handling the large amount of information that is needed to keep a large number of complicated chemical reactions in balance.

Everyone who works with computers knows that two essential components are needed to make them useful. The components are hardware and software. Hardware is the computer itself, the box full of electronic circuits which carry out logical or mathematical operations. Software is the floppy disk on which instructions and information are written. You feed the software into the hardware in order to tell the hardware what to do. Likewise, every living cell has two dominant components, two kinds of large chemical molecules called proteins and nucleic acids. The discoveries of the last fifty years have revealed that proteins behave like hardware, acting as catalysts to make other chemicals react in highly specific ways. And nucleic acids act like software, organizing the proteins and telling them what to do. The decisive event which started the modem era in biology was an experiment done by Oswald Avery and his colleagues in New York in 1944. Avery took bacteria of one variety and fed them nucleic acid from another variety. The bacteria were transformed into the variety from which the nucleic acid came. If computers and floppy disks had existed in 1944, Avery might have said that the change of nucleic acid was affecting his bacteria just as a change of disk affects a computer.

The computer metaphor has been enormously fruitful as an aid to the understanding of living processes. Like the meta phor of the rain forest, it is not exact. It is only a metaphor. One should not push metaphors too far. One should not think that a molecule of nucleic acid is really an inert object like a floppy disk. In reality, a molecule of nucleic acid can do many other things besides serving as a passive container of information. Recent experiments have shown that under some conditions nucleic acids can act as catalysts just as proteins do. The separation between hardware and software in a living cell is not absolute. There is no law of nature which forbids proteins to carry information and forbids nucleic acids to process information. Nevertheless, the metaphor is a good one to describe the overall organization of a cell. Most of the time, proteins are busy chopping and splicing while nucleic acids are quietly telling them what to do.

The computer metaphor can be extended a little further. Living cells have two primary functions which are given the names "metabolism" and "replication." Metabolism means eating and digesting and excreting. Metabolism maintains the integrity of the cell by a continual reshuffling of chemical components, converting raw materials from outside the cell into the substances required for its continued existence. Replication means making exact copies of molecules so that a cell can reproduce itself. Replication allows the copying of hereditary information so that the characteristics of a cell can be precisely inherited by its offspring. The two functions of metabolism and replication are again well described by the metaphor of hardware and software. Metabolism is

the business of protein, replication is the business of nucleic acid. Metabolism is a hardware function because it requires constant activity. Replication is a software function because it requires stability and legibility. Nucleic acids, like floppy disks, are easily read and copied. Proteins, like computers, are made by following instructions and not by copying.

The metaphor of the computer will serve as a framework within which to examine the problem of origins. I approach the discussion of the origin of life by introducing a selection of people who have contributed to our thinking. I have six characters to introduce. I might have titled this chapter as Luigi Pirandello titled his play, Six Characters in Search of an Author. The first two characters are the physicist Erwin Schrodinger and the mathematician John von Neumann.

In 1943, the year before Avery discovered the transformation of cells by nucleic acids, Erwin Schrodinger gave a course of lectures on biology to a mixed audience at Trinity College, Dublin. Schrodinger did not then know about Avery's experiment. Schrodinger did not once mention nucleic acids in his lectures. This makes it all the more remarkable that he was able to guess correctly the general nature and properties of the generic apparatus in which nucleic acids play the dominant role.

The year 1943 was a bleak moment in the history of mankind. Ireland was then, as it had been in the days of St. Columba 1400 years earlier, a refuge for scholars and a nucleus of civilization beyond the reach of invading barbarians. It was one of the few places in Europe where peaceful scientific meditation was still possible. Schrodinger proudly remarks in the published version of his lectures that they were given "to an audience of about four hundred which did not substantially dwindle." The lectures were published in 1944, in a little book with the tide What Is Life? Schrodinger's book is less than a hundred pages long. It was widely read, and was influential in guiding the thoughts of the young people who created the new science of molecular biology in the following decade. It is clearly and simply written, with only five references to the technical literature and less than ten equations from beginning to end.

Schrodinger's book was seminal because he knew how to ask the right questions. The basic questions which he asked were the following: What is the physical structure of the molecules which are duplicated when cells divide? How is the process of duplication to be understood? How do these molecules retain their individuality from generation to generation? How do they succeed in controlling the metabolism of cells? And how do they create the organization that is visible in the structure and function of higher organisms? He did not answer these questions. But by asking them he set biology moving along the path which led to the epochmaking discoveries of the subsequent forty years, to the double helix, to the genetic code, to the precise analysis and wholesale synthesis of genes, to the quantitative measurement of evolutionary divergence of species.

Schrodinger showed wisdom not only in the questions which he asked but also in the questions he did not ask. He did not ask any questions about the origin of life. He understood that the time was ripe in 1943 for a fundamental understanding of the physical basis of life. He also understood that the time was not then ripe for any fundamental understanding of life's origin. Until the basic chemistry of living processes was clarified, one could not ask meaningful questions about the possibility of spontaneous generation of these processes in a pre-biotic environment. He wisely left the question of origins to a later generation.

Now, forty years later, the time is ripe to ask the questions which Schrodinger avoided. The questions of origin are now becoming experimentally accessible, just as the questions of structure were becoming experimentally accessible in the 1940s. Schrodinger asked the right questions about structure because his thoughts were based on the experimental discoveries of his friend Max Delbruck. We can hope to ask the right questions about origins today because our thoughts are

guided by the experimental discoveries of Manfred Eigen and Leslie Orgel. Delbruck became the chief explorer of the problems of structure in the 1930s and 1940s because he hit on the bacteriophage as the ideal experimental tool, a biological system stripped of inessential complications and reduced to an almost bare genetic apparatus. The phage is a virus specialized for living as a parasite inside a bacterium. The phage was for biology what the hydrogen atom was for physics. In a similar way, Eigen became the chief explorer of the problems of origin in the 1970s because he hit on RNA, one of the common varieties of nucleic acid, as the ideal experimental tool for but not to replicate. What does this mean? For a cell, to reproduce means simply to divide into two cells with the daughter cells inheriting approximately equal shares of the cellular constituents. For a molecule, to replicate means to construct a precise copy of itself by a chemically specific process. Cells can reproduce but only molecules can replicate. In modem times, reproduction of cells is always accompanied by replication of molecules, but this need not always have been so in the past. Conversely, even in modem cells, replication of molecules often occurs without reproduction of cells.

Only five years after Schrodinger gave his lectures in Dublin, the logical relations between replication and metabolism were clarified by the mathematician John von Neumann. In a lecture which he gave at Princeton in 1948, Von Neumann introduced the computer as a metaphor for a living cell. He described an analogy between the functioning of living organisms and the functioning of mechanical automata. His automata were an outgrowth of his thinking about computers. Out of his computers, Von Neumann built a grand conceptual scheme which he called "The General and Logical Theory of Automata" A Von Neumann automaton had two essential components which were later, when his ideas were taken over by the computer industry, given the names "hardware" and "software." Hardware processes information; software embodies information. In the old days, hardware was machinery and software was paper. Now hardware is silicon chips and software is floppy disks.

Von Neumann described precisely in abstract terms the logical connections between the components. For a complete self-reproducing automaton, both components are essential. But there is an important sense in which hardware comes logically prior to software. Pocket calculators existed before there were floppy disks. An automaton composed of hardware without software can exist and maintain its own metabolism. It can live independently for as long as it finds food to eat or numbers to crunch. An automaton composed of software without hardware must be an obligatory parasite. It can function only in a world already containing other automata whose hardware it can borrow. It can replicate itself only if it succeeds in finding a cooperative host automaton, just as a bacteriophage can replicate only if it succeeds in finding a cooperative bacterium.

Let me summarize the story up to this point. Our illustrious predecessor Erwin Schrodinger gave his book the title What If Life? but neglected to ask whether the two basic functions of life, metabolism and replication, are separable or inseparable. Our illustrious predecessor John von Neumann raised the question which Schrodinger had missed and gave it a provisional answer. Von Neumann observed that metabolism and replication, however intricately they may be linked in the biological world as it now exists, are logically separable. It is logically possible to postulate organisms composed of pure hardware, capable of metabolism but incapable of replication. It is possible to postulate organisms composed of pure software, capable of replication but incapable of metabolism. And if the functions of life are separated in this fashion, it is to be expected that the latter type of organism will become an obligatory parasite upon the former. This logical analysis of the functions of life helps to explain and to correct the bias toward replication which is evident in Schrodinger's thinking and in the whole history of molecular biology. Organisms specializing in replication tend to be parasites, and molecular biologists prefer parasites for experimental study because parasites are structurally simpler than their hosts and better suited to quantitative manipulation. In the balance of nature there must be an opposite bias. Hosts must exist before

there can be parasites. The survival of hosts is a precondition for the survival of parasites. Somebody must eat and grow to provide a home for those who only replicate. In the living world, as in the world of human society and economics, we cannot all he parasites.

When we begin to think about life's origins we meet again the question which Schrodinger did not ask, Is life one thing or two? And we meet again Von Neumann's answer, that life is two things, metabolism and replication, and that the two things are logically separable. There are accordingly two logical possibilities for life's origins. Either life began only once, with the functions of replication and metabolism already present in rudimentary form and linked together from the beginning. Or life began twice, with two separate kinds of creatures, one kind capable of metabolism without exact replication, the other kind capable of replication without metabolism. If life began twice, the first beginning must have been with proteins, the second beginning with nucleic acids. The first protein creatures might have existed independently for a long time, eating and growing and gradually evolving a more and more efficient metabolic apparatus. The nucleic acid creatures most have been obligatory parasites from the start, preying upon the protein creatures and using the products of protein metabolism to achieve their own replication.

The main theme of this and the next chapter will be a critical examination of the second possibility, the possibility that life began twice. I call this possibility the double-origin hypothesis. It is a hypothesis, not a theory. A theory of the origin of life should describe in some detail a postulated sequence of events. The hypothesis of dual origin is compatible with many theories. It may be useful to examine the consequences of the hypothesis without committing ourselves to any particular theory.

I do not claim that the double-origin hypothesis is true, or that it is supported by any experimental evidence. Indeed, my purpose is just the opposite. I would like to stimulate experimental chemists and biologists and paleontologists to find the evidence by which the hypothesis might be tested. If it can be tested and proved wrong, it will have served its purpose. We will then have a firmer foundation of fact on which to build theories of single origin. If the double-origin hypothesis can be tested and not proved wrong, we can proceed with greater confidence to build theories of double origin. The hypothesis is useful only insofar as it may suggest new experiments.

Lacking new experiments, we have no justification for believing strongly in either the single-origin or the double-origin hypothesis. I have to confess my own bias in favor of double origin. But my bias is based only on general philosophical preconceptions, and I am well aware that the history of science is strewn with the corpses of dead theories which were in their time supported by the prevailing philosophical viewpoints. For what it is worth, I may state my philosophical bias as follows. The most striking fact which we have learned about life as it now exists is the ubiquity of dual structure, the division of every organism into hardware and software components, into protein and nucleic acid. I consider dual structure to be prima facie evidence of dual origin. If we admit that the spontaneous emergence of protein structure and of nucleic acid structure out of molecular chaos are both unlikely, it is easier to imagine two unlikely events occurring separately over a long period of time than to imagine two unlikely events occurring simultaneously. Needless to say, vague arguments of this sort, invoking probabilities which we are unable to calculate quantitatively, cannot be conclusive.

The third and fourth on my list of illustrious predecessors are Manfred Eigen and Leslie Orgel. Unlike Schrodinger and Von Neumann, they are experimenters. They are the chief explorers of the experimental approaches to the problem of the origin of life. They are, after all, chemists, and this is a job for chemists. Eigen and his colleagues in Germany have done experiments which show us biological organization originating spontaneously and evolving in a test tube. Eigen won his Nobel Prize for work in the more conventional areas of physical chemistry. After winning the prize, he

switched to the less conventional area of molecular evolution. As a result, he has now become the leading guru in the international fraternity of people who think seriously about the origin of life.

The Eigen experiments begin with a supply of the building blocks which make up RNA when they are joined together by the right chemical bonds. The building blocks are called nucleotides. They come in four kinds. Eigen dissolved these four kinds of molecule in water and mixed them together with a protein which catalyzes the replication of RNA. The experiment was done first with a small quantity of RNA added to the test tube. Then the protein replicates the RNA by collecting nucleotides from the solution and linking them together. The amount of RNA in the solution can be measured as a function of time and is observed to double every two or three minutes. The process of replication is very quick and efficient, once there is some RNA in the rube to be replicated. The experiment was done using smaller and smaller quantities of RNA as the initial seed. It turned out that it works perfectly well with only a single molecule of RNA. A single RNA molecule will be replicated enough times in an hour or two to make 101' copies, at which point the supply of nucleotides begins to be exhausted. The replication of the RNA from one molecule to 10" is reproducible and predictable.

But then Eigen tried something new. He did the experiment with zero molecules of RNA in the tube. He gave the nucleotides nothing to copy. You would expect then that nothing would happen. But in fact a lot of interesting things happened. The main thing that happened was that RNA appeared in the robe. But it did not appear reproducibly. It took typically two or three hours for an RNA molecule to appear, but the time varied from experiment to experiment. Once the first RNA molecule was produced by some statistically random process, it would then be replicated as before. So the experiment beginning with zero RNA ended as before with 1014 molecules of RNA, only the time taken to reach 10t+ molecules was no longer predictable. Also, the sequence of nucleotides in the spontaneously generated RNA was not the same from tun to run. In some cases, Eigen observed mutations in his RNA. The first RNA to appear would be replaced later by a mutated RNA which replicated itself more efficiently.

Eigen's experiments show that a solution of nucleotides will under suitable conditions give rise spontaneously to a nucleic acid molecule which replicates and mutates and competes with its progeny for survival. From a certain point of view, one might claim that these experiments already achieved the spontaneous generation of life from non-life. They bring us at least to the point where we can ask and answer questions about the ability of nucleic acids to synthesize and organize themselves. Unfortunately, the conditions in Eigen's test roles are not really pre-biotic. To make his experiments work, Eigen put into the test tubes a protein catalyst extracted from a living bacteriophage. The synthesis and replication of the nucleic acid is dependent on the structural guidance provided by the protein. We are still far from an experimental demonstration of the appearance of biological order without the help of a biologically derived precursor. Nevertheless, Eigen has provided the tools with which we may begin to attack the problem of origins. He has brought the origin of life out of the domain of idle speculation and into the domain of experiment.

Leslie Orgel is, like Manfred Eigen, an experimental chemist. He taught me most of what I know about the chemical antecedents of life. He has done experiments complementary to those of Eigen. Eigen was able to make RNA grow out of nucleotides without providing any RNA for the nucleotides to copy, but with a protein catalyst to tell the nucleotides what to do. Orgel has done equally important experiments in the opposite direction, demonstrating that nucleotides will under certain conditions make RNA if they are given RNA molecules to copy, without any protein to guide them. Orgel found that zinc ions in the solution are a good catalyst for the RNA synthesis. It may not be entirely coincidental that many modem biological catalysts have zinc ions in their active sites. To summarize, Eigen made RNA using a protein but no RNA, and Orgel made RNA using a RNA but no protein. In living cells we make RNA using both RNA and protein. If we suppose that RNA was the

original living molecule, then to understand the origin of life we have to make RNA using neither RNA nor protein. Neither Eigen nor Orgel has come close to achieving this goal.

The experiments of Eigen and Orgel fit more naturally into the framework of a double-origin hypothesis. According to the double-origin hypothesis, RNA was not the original living molecule. The original living molecules in this hypothesis were proteins, and life of a sort was already established before RNA came into the picture. The Eigen and Orgel experiments are exploring the evolution of RNA under conditions appropriate to the second origin of life. They come close to describing a parasitic development of RNA life within an environment created by a pre-existing protein life. Concerning the first origin of life, the origin of protein life and of protein metabolism, they say nothing. The origin of metabolism is the next great virgin territory which is waiting for the experimental chemists to explore.

The fifth on my list of illustrious predecessors is Lynn Margolis. She is an ecologist, a first-rate scientist and writer. But she also performed another service to the popular understanding of science. She was Carl Sagan's first wife and taught him most of what he knows about biology. Although she is still very much alive and considerably younger than I an., she set the style in which I came to think about early evolution.

Lynn Margolis is one of the chief bridge builders in modem biology. She built a bridge between the facts of cellular anatomy and the facts of molecular genetics. Her bridge was the idea that parasitism and symbiosis were the driving forces in the evolution of cellular complexity. She did not invent this idea, but she was its most active promoter and systematizer. She collected the evidence to support her view that most of the internal structures of cells did not originate within the cells but are descended from independent living creatures which invaded the cells from outside like carriers of an infectious disease. Her book Symbiosis in Cell Evolution summarizes the evidence up to 1981. According to Margulis, the invading creatures and their hosts gradually evolved into a relationship of mutual dependence, so that the erstwhile disease organism became by degrees a chronic parasite, a symbiotic partner, and finally an indispensable pan of the substance of the host.

This Margolis picture of early cellular evolution now has incontrovertible experimental support. Some of the molecular structures within plant and animal cells are found to be related more closely to alien bacteria than to the cells in which they have been incorporated for I or 2 billion years. There are also reasons for believing that the Margolis picture will be valid even in cases where it cannot be experimentally demonstrated. A living cell, in order to survive, must be intensely conservative. It must have a finely tuned molecular organization and it must have efficient mechanisms for destroying promptly any molecules which depart from the overall plan. Any new structure arising within this environment must be an insult to the integrity of the cell. Almost by definition, a new structure will be a disease which the cell will do its best to resist. It is possible to imagine new structures arising internally within the cell and escaping its control, like a cancer growing in a higher organism. But it is easier to imagine new structures coming in from the outside like infectious bacteria, already prepared by the rigors of independent living to defend themselves against the cell's efforts to destroy them.

The main reason why I find the double-origin hypothesis congenial is that it firs well into the general picture of evolution portrayed by Margolis. According to Margolis, most of the big steps in cellular evolution were caused by parasites. The double-origin hypothesis implies that nucleic acids were the oldest and most successful cellular parasites. It extends the scope of the Margulis picture of evolution even further back into the pt. It proposes that the original living creatures were cells with a metabolic apparatus but with no genetic apparatus. Such cells would lack the capacity for exact replication but could grow and divide and reproduce themselves in an approximate statistical fashion. They might have continued to exist for millions of years, gradually diversifying and refining

their metabolic pathways- Amongst other things, they discovered how to synthesize ATP, adenosine triphosphate, the magic molecule which serves as the principal energy-carrying intermediate in all modem cells. Cells carrying ATP were able to function more efficiently and prevailed in the Darwinian struggle for existence. In time it happened that cells were full of ATP and other related molecules such as AMP, adenosine monophosphate, and so on.

Now we observe the strange fact that the two molecules ATP and AMP, having almost identical chemical structures, have totally different but equally essential functions in modem cells. ATP is hardware. AMP is software. ATP is the universal energy-carrier. AMP is one of the nucleotides which make up RNA and function as bits of information in the genetic apparatus. ATP is a compound composed of an adenine base, a sugar and three phosphate ions, joined together in a particular geometrical arrangement. AMP has the same pieces in the same arrangement except that two of the phosphate ions are missing. To get from ATP to AMP, all you have to do is replace a triple phosphate by a single phosphate.

I am proposing that the primitive cells had no genetic apparatus but were saturated with molecules like AMP as a result of the energy-carrying function of ATP. This was a dangerously explosive situation. In one cell which happened to be carrying an unusually rich supply of nucleotides, an accident occurred. The nucleotides began doing the Eigen experiment on RNA synthesis 3 billion years before it was done by Eigen. Within the cell, with some help from preexisting proteins, the nucleotides produced an RNA molecule which then continued to replicate itself. In this way RNA first appeared as a parasitic disease within the cell. The first cells in which the RNA disease occurred probably became sick and died. But then, according to the Margolis scheme, some of the infected cells learned how to survive the infection. The protein-based life learned to tolerate the RNA-based life. The parasite became a symbiont. And then, very slowly over millions of years, the protein-based life learned to make use of the capacity for exact replication which the chemical structure of RNA provided. The primal symbiosis of protein-based life and parasitic RNA grew gradually into a harmonious unity, the modem genetic apparatus.

This view of RNA as the oldest and most incurable of our parasitic diseases is only a poetic fancy, not yet a serious scientific theory. Still, it is attractive to me for several reasons. First, it is in accordance with our human experience that hardware should come before software. The modem cell is like a computer-controlled chemical factory in which the proteins are the hardware and the nucleic acids are the software. In the evolution of machines and computers, we always developed the hardware first before we began to think about software. I find it reasonable that natural evolution should have followed the same pattern. A second argument in favor of the parasite theory of RNA comes from chemistry. Because of the details of the chemistry, it is easier to imagine a pond on the pre-biotic Earth becoming a rich soup of amino acids than to imagine a pond becoming a rich soup of nucleotides. Nucleotides would have had a better chance to survive if they originated in biological processes inside already existing cells. My third reason for liking the parasite theory of RNA is that it may be experimentally testable. If the theory is true, living cells may have existed for a very long time before becoming infected with nucleic acids. There exist microfossils, traces of primitive cells, in rocks which are more than 3 billion years old. It is possible that some of these microfossils might come from cells older than the origin of RNA. It is possible that the microfossils may still carry evidence of the chemical nature of the ancient cells. For example, if the microfossils were found to preserve in their mineral constituents significant quantities of phosphorus, this would be strong evidence that the ancient cells already possessed something resembling a modem genetic apparatus. So far as I know, no such evidence has been found. I do not know whether the processes of fossilization would be likely to leave chemical traces of nucleic acids intact. So long as this possibility exists, we have the opportunity to test the hypothesis of a late origin of RNA by direct observation.

The last of the illustrious predecessors on my list is the geneticist Moron Kimura. Kimura lives in Japan and has a biological institute of his own out in the country between Tokyo and Kyoto, with a magnificent view of Mount Fujiyama. Kimura developed the mathematical basis for a statistical treatment of molecular evolution, and he has been the chief advocate of the neutral theory of evolution. The neutral theory says that, through the history of life from beginning to end, random statistical fluctuations have been more important than Darwinian selection in causing species to evolve. Evolution by random statistical fluctuation is called genetic drift. Kimura says that genetic drift drives evolution more powerfully than natural selection.

I am indebted to Kimura in two separate ways. First, I use Kimura's mathematics as a tool for calculating the behavior of molecular populations. The mathematics is correct and useful, whether you believe in the neutral theory of evolution or not. Second, I find the neutral theory helpful even though I do not accept it as dogma. In my opinion, Kimura has overstated his case, but still his picture of evolution may sometimes be right. Genetic drift and natural selection are both important, and there are times and places where one or the other may be dominant. In particular, I find it reasonable to suppose that genetic drift was dominant in the very earliest phase of biological evolution, before the mechanisms of heredity had become exact. Even if the neutral theory is not true in general, it may be a useful approximation to make in building models of pre-biotic evolution.

We know almost nothing about the origin of life. We do not even know whether the origin was gradual or sudden. It might have been a process of slow growth stretched out over millions of years, or it might have been a single molecular event that happened in a fraction of a second. As a rule, natural selection is more important over long periods of time and genetic drift is more important over short periods. If you think of the origin of life as slow, you must think of it as a Darwinian process driven by natural selection. If you think of it as quick, the Kimura picture of evolution by statistical fluctuation without selection is appropriate. In reality the origin of life must have been a complicated process, with incidents of rapid change separated by long periods of slow adaptation. A complete description needs to take into account both drift and selection. If one wishes to examine seriously the double-origin hypothesis, the hypothesis that life began and flourished without the benefit of exact replication, then it is natural to imagine that genetic drift remained strong and natural selection remained relatively weak during the early exploratory phases of evolution.

There are many other illustrious predecessors besides those whom I have mentioned. I chose to speak of these six—Schrodinger, Von Neumann, Eigen, Orgel, Margolis, and Kimura—because each of them is in some sense a philosopher as well as a scientist. Each of them brought to biology not just technical skills and knowledge but a personal philosophical viewpoint extending beyond biology over the whole of science. From all of them I have borrowed the ideas which fitted together to form my own viewpoint. The origin of life is one of the few scientific problems which are broad enough to make use of ideas from almost all scientific disciplines. Schrodinger brought to it ideas from physics, Von Neumann from mathematical logic, Eigen and Orgel from chemistry, Margolis from ecology, and Kimura from population biology. I will try in the next chapter to explore the connections, to see whether mathematical logic and population biology may have raised new questions which chemistry may be able to answer.

Chapter 5 - Why Is Life So Complicated?

The origin of life, however it happened, must have been the culminating event at the end of a long and complicated process of preparation. The process by which the planet Earth prepared itself for life is called pre-biotic evolution. The study of pre-biotic evolution divides itself into three main stages which one may label with the names "geophysical, "'chemical" and "biological." The geophysical stage concerns itself with the early history of the earth and especially with the nature

of the Earth's primitive atmosphere. The chemical stage concerns itself with the synthesis, by natural processes operating within plausible models of the primitive atmosphere and ocean, of the chemical building blocks of life. By building blocks we mean principally the amino acids and nucleotides out of which proteins and nucleic acids are built. The biological stage concerns itself with the appearance of biological organization, with the building of a coordinated population of proteins and nucleic acids and other large molecules out of a random assortment of building blocks.

The geophysical and chemical stages of pre-biotic evolution are reasonably well understood. These two stages are in the hands of competent experts, and I have nothing significant to add to what the experts have reported. Theories of the geophysical stage can be checked by abundant observations in the fields of geochemistry, meteoritic chemistry and radio astronomy. Theories of the chemical stage can be checked by experiments done by chemists in the laboratory. Many details remain to be elucidated, but the geophysical and chemical stages are no longer shrouded in mystery. I have therefore concentrated my attention on the biological stage. The problem of the origin of life is for me the biological stage, the problem of the appearance of biological organization out of molecular chaos. It is in this biological stage that mysteries still remain. The purpose of my own work has been to try to describe mathematically what we mean by the appearance of biological organization, and thereby to make the biological stage accessible to experimental study.

It is likely that there existed on the primitive Earth substantial quantities of simple organic molecules which would have either dissolved in the primitive oceans or formed an oily scum on their surface. Molecules of this sort are seen by radio astronomers in the sky and by geochemists in carbonaceous meteorites. The geophysical stage of pre-biotic evolution thus provides us with a wide choice of hydrogen-rich gases and liquids to serve as the input for the chemical stage.

The chemical stage of pre-biotic evolution was explored in the classic experiments of Stanley Miller in 1953, and in many later experiments. Miller took a plausible reducing atmosphere composed of methane, ammonia, molecular hydrogen and water, passed electric sparks through it, and collected the reaction products. He found a mixture of organic compounds containing a remarkably high fraction of amino acids. Other people have repeated the Miller experiments with many varia- lions, using ultraviolet light or ionizing radiation as the energy source instead of electric sparks. The results are consistent. The upshot of the Miller experiments is that we can rely on nature to provide an ample supply of amino acids on the primitive Earth. So long as there was a reducing atmosphere with plenty of ultraviolet light pouring in from the Sun, amino acids must have been made in large quantities. They would have descended from the atmosphere with rainfall and would have accumulated in land-locked lakes and seas where rainwater evaporates and leaves its dissolved chemicals behind. This is a familiar story, ending with a picture of a pond full of rich warm soup on the lifeless Earth. The pond contains a concentrated solution of amino acids and other organic molecules, waiting only for the breath of life to stir them into organized activity. So far as the geophysical and chemical stages are concerned, this story is probably a good approximation to the truth.

The pre-biotic synthesis of nucleotides, the pieces out of which nucleic acids are made, is a more difficult problem. Efforts to synthesize nucleotides directly from their elementary components in a Miller-style experiment have not been successful. A nucleotide is a wobblier and more delicate structure than an amino acid. The nucleotides on the primitive Earth would have been rare birds, difficult to synthesize and easy to dissociate. Nobody has yet discovered a way to make them out of their components rapidly enough so that they would have a reasonable chance of finding each other and combining into nucleic acids before they fall apart.

The results of thirty years of intensive chemical experimentation have shown that the pre-biotic synthesis of amino acids is easy to simulate but the pre-biotic synthesis of nucleotides is not. We

cannot say that the pre-biotic synthesis of nucleotides is impossible. We know only that if it happened, it happened by some process which none of our chemists has been clever enough to reproduce. This conclusion may be considered to favor the double-origin hypothesis and to argue against a single-origin hypothesis for the origin of life. A single-origin hypothesis requires both amino acids and nucleotides to be synthesized by natural processes before life began. The double-origin hypothesis requires only amino acids to be synthesized pre-biotically, the nucleotides being formed later as a by-product of protein metabolism. The evidence from chemical simulations does not disprove the single-origin hy pothesis, but makes at least a strong presumptive case against it.

We have experimental and observational evidence concerning things which happened before and after the origin of life. Before the origin of life, we had geophysical and chemical processes which left behind traces that can be observed in the Earth's rocks and in the ski. After the origin of life, we had evolutionary processes which can be observed in fossils. Concerning the origin of life itself, the watershed between chemistry and biology, the transition between lifeless organic soup and organized biological metabolism, we have no direct evidence at all. The crucial transition from disorder to order left behind no observable traces. When we try to understand the nature of this transition, we are forced to go Beyond experimental evidence and take refuge in theory.

There are three main groups of theories about the origin of life. I call them after the names of their most famous advocates, Oparin, Eigen, and CaimsSmith. I have not done the historical research that would be needed to find out who thought of them first. The Oparin theory was described in Alexander Oparin's book The Origin of Life in 1924, long before anything was known about the structure and chemical nature of genes. Oparin supposed that the order of events in the origin of life was cells first, proteins second, genes third. He observed that when a suitably oily liquid is mixed with water, it sometimes happens that the two liquids form a stable mixture called a coacervate, with the oily liquid dispersed into small droplets which remain suspended in the water. Coacervate droplets are easily formed by non-biological processes, and they have a certain superficial resemblance to living cells. Oparin proposed that life began by the successive accumulation of more and more complicated molecular populations within the droplets of a coacervate. The physical framework of the cell came first, provided by the naturally occurring droplet. The proteins came second, organizing the random population of molecules within the droplet into self-sustaining metabolic cycles. The genes came third, since Oparin had only a vague idea of their function and they appeared to him to belong to a higher level of biological organization than proteins.

The Oparin picture was generally accepted by biologists for half a century. It was popular, not because there was any evidence to support it, but rather because it seemed to be the only alternative to biblical creationism. Then, during the last twenty years, Manfred Eigen provided another alternative by turning the Oparin theory upside down. The Eigen theory reverses the order of events, placing genes first, proteins second, and cells third. It is now the most fashionable and generally accepted theory. It has become popular for two reasons. First. Avery's discovery that genes are nucleic acids made genes easier to study than proteins. Second, the experiments of Eigen and of Orgel use RNA as working material and make it plausible that the replication of RNA was the fundamental process around which the rest of biology developed. Once the mystery of the genetic code was understood, it became natural to think of the nucleic acids as primary and of the proteins as secondary structures. Eigen's theory has self-replicating RNA at the beginning, proteins appearing soon afterwards to build with the RNA a primitive form of the modem genetic apparatus, and cells appearing later to give the apparatus physical cohesion.

The third theory of the origin of life, the theory of Graham Cairns-Smith, is based upon the idea that naturally occurring microscopic crystals of the minerals contained in common clay might have served as the original genetic material before nucleic acids were invented. The microcrystals of clay consist of a regular lattice with a regular array of atomic sites, but with an irregular

distribution of metals such as magnesium and aluminum occupying the sites. The metal arms can be considered as carriers of information like the nucleotide bases in a molecule of RNA. A microcrystal of clay is usually a flat plate with two plane surfaces exposed to the surrounding medium. Suppose that a microcrystal is contained in a droplet of water • with a variety of organic molecules dissolved in the water. The metal atoms embedded in the plane surfaces form irregular patterns which can adsorb particular molecules to the surfaces and catalyze chemical reactions on the surfaces in ways dependent on the precise arrangement of the atoms.

In this fashion the information contained in the pattern of atoms might be transferred to chemical species dissolved in the water. The crystal might perform the same function as RNA in guiding the metabolism of amino acids and proteins. Moreover, it is conceivable that the clay microcrystal can also replicate the information contained in its atoms. When the crystal grows by accreting dissolved atoms from the surrounding water, the newly accreted layer will tend to carry the same pattern of metals as the layer below it. If the crystal is later cut) along the plane separating the old from the new material, we will have a new exposed surface replicating the original pattern. The clay crystal is thus capable in principle of performing both of the essential functions of a genetic material. It can replicate the information which it carries, and it can transfer the information to other molecules. It can do these things in principle. That is to say, it can do them with some undetermined efficiency which may be very low. There is no experimental evidence to support the statement that clay can act either as a catalyst or as a replicator with enough specificity to serve as a basis for life. Cairns-Smith asserts that the chemical specificity of clay is adequate for these purposes. The experiments to prove him right or wrong have not been done.

The Cairns-Smith theory of the origin of life has clay first, proteins second, cells third, and genes fourth. The beginning of life was a natural clay crystal directing the synthesis of protein molecules adsorbed to its surface, later, the clay and the proteins learned to make cell membranes and became encapsulated in cells. The cells contained clay crystals performing in a crude fashion the functions performed in a modem cell by nucleic acids. This primeval clay-based life may have existed and may have evolved for many millions of years. Then one day a cell made the discovery that RNA is a better genetic material than clay. As soon as RNA was invented, the cells using RNA had an enormous advantage in metabolic precision over the cells using clay. The clay-based life was eaten or squeezed out of existence and only the RNA-based life survived.

At the present time there is no compelling reason to accept or to reject any of the three theories. Any of them, or none of them, could mm out to be right. We do not yet know how to design experiments which might decide between them. I happen to prefer the Oparin theory, not because I think it is necessarily right but because it is unfashionable. In recent years the attention of the experts has been concentrated upon the Eigen theory, and the Oparin theory has been neglected. The Oparin theory deserves a more careful analysis in the light of modern knowledge. My own work on the origin of life grew out of an attempt to put the Oparin theory into a modem framework using the mathematical methods of Kimura.

I find it illuminating to look at these theories in the light of the question which I raised in Chapter 4, whether the origin of life was single or double, whether metabolism and replication originated together or separately. The Cairns-Smith theory is explicitly a double-origin theory. It has the first origin of life mainly concerned with the building of a protein metabolic apparatus, the clay particles adding to this apparatus a replicative element which may or may not be essential. The second origin of life, which Cairns-Smith calls "genetic takeover," is the replacement of the clay component by an efficient replicative apparatus made of nucleic acids. Cairns-Smith imagines the two origins of life to be separated by a long period of biochemical evolution, so that the nucleic acid invasion occurs in cells already highly organized with proteins and membranes. The Oparin theory and the Eigen theory were presented as single-origin theories. Each of them supposes the

origin of life to have been a single process. Oparin places primary emphasis on metabolism and barely discusses replication. Eigen places primary emphasis on replication and imagines metabolism falling into place rapidly as soon as replication is established. I am suggesting that the Oparin and Eigen theories make more sense if they are put together and interpreted as the two halves of a double-origin theory. In this case, Oparin and Eigen may both be right. Oparin is describing the first origin of life and Eigen the second. With this interpretation, we combine the advantages of the two theories and eliminate their most serious weaknesses. Moreover, the combination of Oparin and Eigen into a double-origin theory is not very different from the theory of Cairns-Smith. Roughly speaking, Cairns-Smith equals Oparin plus Eigen plus a little bit of clay. All three theories may turn out to contain essential elements of the truth.

There is a serious difficulty with the Eigen theory. The central problem for any theory of the origin of replication is the fact that a replicative apparatus has to function almost perfectly if it is to function at all. If it does not function perfectly, it will give rise to errors in replicating itself, and the errors will accumulate from generation to generation. The accumulation of errors will result in a progressive deterioration of the system until it is totally disorganized. This deterioration of the replicative apparatus is rolled the "error catastrophe." The same difficulty arises also in the Cairns-Smith theory. Since Cairns-Smith is relying on clay crystals to transmit genetic information from generation to generation, the copying of the crystals must be extraordinarily exact if the information is to be preserved.

Both in the Eigen theory and in the Cairns-Smith theory, the only way in which we can avoid the error catastrophe is to assume that there is a strong Darwinian selection process acting on the replicating molecules. We must assume that the errors in each generation are weeded out by selection. In other words, the correct molecules of RNA or clay most be rewarded and the incorrect molecules penalized by different rates of survival. Even when a strong Darwinian selection of this sort is operating, the error catastrophe will still occur unless the error rate is kept low. Eigen has worked out a mathematical theory of the error catastrophe. The conclusions of the theory are roughly as follows. Suppose that a self-replicating system is composed of N independent units. For example, in the Eigen theory the system is a molecule of RNA composed of N nucleotides, while in the Cairns-Smith theory the system is a clay crystal with N metal atoms on its surface. Then the error catastrophe will occur unless the error rate in the copying process is of the order of (1/N) or smaller.

This condition for avoiding the error catastrophe is very stringent. It is barely satisfied in modem higher organisms which have N of the order 0(108 and error rates of the order of 10—s. To achieve an error rate as low as 10—s, the modern organisms have evolved an extremely elaborate system of double-checking and error-correcting within the replication system. Before this delicate apparatus existed, the error rates must have been much higher. Eigen's criterion thus imposes severe requirements on any theory of the origin of life which makes replication a central element of life from the beginning.

All the experiments which have been done with RNA replication under abiotic conditions give error rates of the order of 10-2 at best. If we try to satisfy Eigen's criterion without the help of pre-existing organisms, we are limited to a replication system which can describe itself with less than one hundred bits of information. One hundred bits of information is far too few to describe any interesting protein chemistry. This does not mean that Eigen's theory is untenable. It means that Eigen's theory requires an information-processing system which is at the same time extraordinarily simple and extraordinarily free from error. We do not know how to achieve such low error rates in the initial phases of life's evolution.

I chose to study the Oparin theory because it offers a possible way of escape from the error catastrophe. In the Oparin theory, the origin of life is separated from the origin of replication. The first living cells had no system of precise replication and could therefore tolerate high error rates. The main advantage of the Oparin theory is that it allows early evolution to proceed in spire of high error rates. It has the first living creatures consisting of populations of molecules with a loose organization and no genetic fine-tuning. There is a high tolerance for errors because the metabolism of the population depends only on the catalytic activity of a majority of the molecules. The system can still function with a substantial minority of ineffective or uncooperative molecules. There is no requirement for unanimity. Since the statistical fluctuations in the molecular populations will be large, there is a maximum opportunity for genetic drift to act as driving force of evolution.

During the last few years I have been amusing myself with a simple theoretical model of the origin of life. I am trying to place the Oparin theory within a framework of strict mathematics so that its consequences can be calculated. I reduce the theory to a my model by assuming a simple and arbitrary rule for the probability of molecular interactions. The entire intricate web of biochemical processes is replaced in the model by a single formula. The habit of constructing toy models of this sort is one to which theoretical physicists easily become addicted. When the real world is recalcitrant, we build ourselves toy models in which the equations are simple enough for us to solve. Sometimes the behavior of the my model provides illuminating insight into the behavior of the real world. More often, the toy model remains what its name implies, a plaything for mathematically inclined physicists. In the present case, the toy model may have some connection with reality or it may not. Whether or not its premises are reasonable, at least its conclusions are definite. Given the premises from which it starts, it behaves as one would with a primeval molecular population to behave, jumping with calculable probability between two states which differ by the presence or absence of metabolic organization.

We have here a situation analogous to the distinction between life and death in biological systems. I call the ordered state of a population of molecules alive,' since it has most of the molecules working together in a collaborative fashion to maintain the catalytic cycles which keep them active. I call the disordered state "dead," since it has the molecules uncoordinated and mostly inactive. A population, either in the dead or in the alive state, will generally stay there for a long time, making only small random fluctuations around the stable equilibrium. However, the population of molecules in a cell is finite, and there is always the possibility of a large statistical fluctuation which takes the whole population together over the saddle-point from one stable equilibrium to the other. When a "live" cell makes the big statistical jump over the saddle-point to the lower state, we call the jump "death." When a "dead" cell makes the jump up over the saddle-point to the upper state, we call the jump "origin of life."

There are three main ingredients in the model. First, elementary equations of population biology applied to a population of molecules. Second, elementary chemical thermodynamics giving a formula for the rates of various chemical reactions. Third, a statistical treatment of the transition from chemical disorder to chemical order, similar to the treatment of order-disorder transitions in physics.

We have then a definite model to work with. It remains to calculate its consequences, and to examine whether it shows interesting behavior. "Interesting behavior" here means the occurrence with reasonable probability of a jump from the disordered to the ordered state. We find that interesting behavior occurs for populations of molecules containing a total of about 10,000 building blocks. A population of several thousand building blocks linked into a few hundred large molecules would give a sufficient variety of structures to allow interesting catalytic cycles to exist. A population of the order of 10,000 is large enough to display the chemical complexity characteristic

of life, and still small enough to allow the statistical jump from disorder to order to occur with probabilities which are not impossibly small.

The basic reason for the success of the model is its ability to tolerate high error rates. It overcomes the error catastrophe by abandoning exact replication. It neither needs nor achieves precise control of in molecular structures. It is this lack of precision which allows a population of 10,000 building blocks to jump into an ordered sure without invoking a miracle. In a model of the origin of life which assumes exact replication from the beginning, with a low tolerance of errors, a jump of a population of N building blocks from disorder to order will occur spontaneously only with N of the order of 100 or less. In contrast, a non-replicating model can make the transition to order with a population a hundred times larger. The error rate in the ordered state of our model is typically between 20 and 30 percent. An error rite of 25 percent means that three out of four of the building blocks in each molecule are correctly placed. A catalyst with five building blocks in its active site has one chance out of four of being completely functional. Such a level of performance is tolerable for a non-replicating system, but would be totally unacceptable in a replicating system. The ability to function with a 25 percent error rate is the decisive factor which makes the ordered sure in our model statistically accessible, with populations large enough to be biologically interesting.

One striking feature of our model which is absent in modem organisms is the symmetry between life and death. In the model, the ordered state and the disordered state are mirror images of each other. The probability of a transition from disorder to order is exactly equal to the probability of a transition from order to disorder. Death and resurrection occur with equal frequency. The origin of life is as commonplace an event as death.

How did it happen that, as life evolved, death continued to be commonplace while resurrection became rare? What happened was that the catalytic processes in the cell became increasingly fine-tuned and increasingly intolerant of error. The error rate in the metabolic apparatus of a modern cell is about 10-4. An environmental insult such as a time of X-rays which increases the error rare to 10-3 will disrupt the fine- tuned apparatus and cause the cell to die. Death is easy and resurrection is difficult, because the lethal error rate has moved so close to the ordered state and so far from the disordered state. For life to originate spontaneously it was essential to have an ordered state with a high error rate, but when life was once established the whole course of evolution was toward more specialized structures with lower tolerance of errors.

The model has many other unrealistic features. It includes none of the subtleties of structure and design that are present even in the simplest forms of life today. Nevertheless, it may throw some light on one of the central questions of biology, Why is life so complicated? The essential characteristic of living cells is homeostasis, the ability to maintain a steady and more or less constant chemical balance in a changing environment. Homeostasis is the machinery of chemical controls and feedback cycles which make sure that each molecular species in a cell is produced in the right proportion, not too much and not too little. Without homeostasis, there can be no ordered metabolism and no quasi-stationary equilibrium deserving the name of life. The question, Why is life so complicated? means in this context, Given that a population of molecules is able to maintain itself in homeostatic equilibrium at a steady level of metabolism, how many different molecular species must the population contain?

The biological evidence gives a rather definite answer to the question how many kinds of molecule are needed to make a homeostatic system, at least so long as we are talking about homeostatic systems of the modem type. There is a large number of different varieties of bacteria, and most of them contain a few thousand molecular species. If modern cells require a few thousand types of molecule for stable homeostasis, what does this tell us about primitive cells? Strictly speaking, it tells us nothing. Without the modem apparatus of genes, the ancient mechanisms of homeostasis

must have been very different. In my my model of the Oparin theory, the arithmetic of the model implies that the population of a cell at the origin of life should have been about 10,000 building blocks combined into a few hundred molecular species. The question remains, whether ancient cells in the real world could have achieved homeostasis with a few hundred molecules instead of the thousands required by modem cells. This question must be answered before we can build credible theories of the origin of life. It can be answered only by experiment. Forty years ago, Erwin Schrodinger suggested to biologists that they should investigate experimentally the molecular structure of the gene. That suggestion turned out to be timely. I am now suggesting that biologists investigate experimentally the population structure of homeostatic systems of molecules. If I am lucky, this suggestion may also turn out to be timely.

I now return to the toy model and examine some other questions which it raises. The questions are not specific to this particular model. They will arise for any model of the origin of life in which we have molecular populations achieving metabolism and homeostasis before they achieve replication. I comment briefly on each question in turn. After another twenty years of progress in biological research we may perhaps know whether my tentative answers are correct.

I. Was the Central Dogma of molecular biology true from the beginning?
The Central Dogma says that genetic information is carried only by nucleic acids and not by proteins. The dogma is true for all contemporary organisms, with one or two possible exceptions. The model implies that the dogma was untrue for the earliest forms of life. According to the model, the first cells passed genetic information to their offspring in the form of proteins. There is no logical reason why a population of proteins mutually catalyzing each other's synthesis should not serve as a carrier of genetic information.

The question, how much genetic information can be carried by a population of molecules without exact replication, is intimately bound up with the question of the nature of homeostasis. Homeostasis is the preservation of the chemical architecture of a population in spite of variations in local conditions and in the numbers of molecules of various kinds. Genetic information is carried in the architecture and not in the individual components. But we do not know how to define architecture or how to quantify homeostasis. Lacking a deep understanding of homeostasis, we have no way to calculate how many items of genetic information the homeostatic machinery of a cell may be able to preserve.

It seems to be true, both in the world of cellular chemistry and in the world of ecology, that homeostatic mechanisms have a general tendency to become complicated rather than simple. Homeostasis seems to work better with an elaborate web of interlocking cycles than with a small number of cycles working separately. Why this is so we do not know. We are back again with the question, Why is life so complicated? But the prevalence of highly complex homeostatic systems, whether we understand the reasons for it or not, is a fact. This fact is evidence that large amounts of genetic information can in principle be expressed in the architecture of molecular populations without nucleic acid software and without apparatus for exact replication.

2. How late was the latest common ancestor of all living species?
The evidence of similarity in the chemical architecture of modern species proves that all existing cells have a common ancestor but does not provide an absolute date for the epoch of the latest common ancestor. Genetic evidence gives us good relative dating of the different branches of the evolutionary tree, but no absolute dating. For absolute dates we must mm to the evidence of fossils. The pioneer in the discovery of fossil evidence for the absolute dating of early life was Elso Barghoorn. The rock in which microfossils are best preserved is chest, the geologists' name for the fine-grained silica rock which ordinary people call flint. Chest is formed by the slow precipitation of dissolved silica from water, a process which puts minimal stress on any small creatures that may

become embedded within it. The chert once formed is hard and chemically inert, so that fossils inside it are well protected. The microfossils which Barghoorn and others have collected are little black blobs in which internal structure is barely discernible. Not all of them are definitely known to be organic in origin. I myself cannot pretend to decide whether a microscopic blob is a fossil cell or an ordinary grain of dust. I accept the verdict of the experts who say that most of the blobs are in fact fossils.

The results of a great number of observations of microfossils can be briefly summarized as follows. I use the word "eon" to mean a billion years. In rocks which are reliably dated with an age of about three eons, mainly in South Africa, we find microfossils which resemble modern bacteria in shape and size. In rocks which are dated with an age of about two eons, mainly in Canada, we find fossils which resemble modern algae, including chains of cells and other multicellular structures. In rocks which are dated with an age of one eon, mainly in Australia, we find fossils which resemble modern cells with some traces of internal structure.

The geological dating of the various fossil groups is accurate and reliable. Unfortunately, we do not know with equal accuracy what it is that is being dated. We do not know how to identify the various fossils with particular branches of the evolutionary tree. Except for the general similarity of size and shape, there is no evidence that the cells of the three-eon age group were cousins of modem bacteria. There is no evidence that they possessed a modem genetic apparatus. There is no evidence of the presence of nucleic acids in any of the ancient microfossils. So far as the evidence goes, the cells of the three-eon age group may have been either cells of modem type with a complete genetic apparatus, or cells of a rudimentary kind lacking nucleic acids altogether, or anything in between. Only the cells of the one-eon group were definitely modern. So far as the evidence goes, the latest common ancestor of all living cells may have lived before the three-eon group of fossils, or between the three-eon group and the two-eon group, or even later than the two-eon group. The dating of the latest common ancestor requires a reliable linkage of the branch points of the evolutionary tree with the various groups of fossils. The most urgent problem for evolutionary geneticists is to establish the calibration of relative ages determined by genetic linkages in terms of absolute ages determined by geology. Until this problem is solved, neither the genetic evidence nor the fossil evidence will be sufficient to determine the date of out latest common ancestor.

It is possible that the evolution of the modern genetic apparatus took eons to complete. The ancient microfossils may date from a time before there were genes. The pace of evolution may have accelerated after the genetic code was established. It is possible that the latest common ancestor came late in the history of life, perhaps as late as halfway from the beginning.

3. Does there exist a chemical realization of my model, for example a population of a few thousand amino acids forming an association of proteins which can catalyze each other's synthesis with 80 percent accuracy? Can such an association of molecules be confined in a droplet and supplied with energy and raw materials in such a way as to maintain itself in a stable homeostatic equilibrium?

These are the crucial questions which only experiment can answer.

4. What will happen to my little toy model when the problem of the origin of life is finally solved?

This is the last question raised by the model and it is easily answered. The answer was given nearly two hundred years ago by my favorite poet, William Blake:

To be an Error and to be Cast out is a part of God's Design.

At the end of his book What Is Life?, Schrodinger put a four-page epilogue with the title On Determinism and Free Will." He there describes his personal philosophy, his way of reconciling his objective understanding of the physical machinery of life with his subjective experience of free will. Schrodinger writes with a clarity and economy of language which have rarely been equaled. I will not try to compete with.

I'm summing up in four pages the fruits of a lifetime of philosophical reflection. Instead, I will end my discussion of }he origin of life with some remarks about its wider implications, not for personal philosophy but for other areas of science. I use the word "science" here in a broad sense, including social as well as natural sciences. The sciences which I have particularly in mind are ecology, economics, and cultural history. In all these areas we are confronting the same question which is at the root of the problem of understanding the origin of life: Why is life so complicated? It may be that each of these areas has something to learn from the others.

The concept of homeostasis can be transferred without difficulty from molecular to ecological, economic and cultural contexts. In each area we have the unexplained fact that complicated homeostatic mechanisms are more prevalent, and seem to be more effective, than simple ones. This is most spectacularly true in the domain of ecology, where a typical stable community, for example, a few acres of woodland or a few square feet of grassland, comprises thousands of diverse species with highly specialized and interdependent functions. But a similar phenomenon is visible in economic life and in cultural evolution. The open-market economy and the culturally open society, notwithstanding all their failures and deficiencies, seem to possess a robustness which centrally planned economies and culturally closed societies lack. The homeostasis provided by unified five-year economic plans and by unified political control of culture does not lead to a greater stability of economies and cultures. On the contrary, the simple homeostatic mechanisms of central control have generally proved more brittle and less able to cope with historical shocks than the complex homeostatic mechanisms of the open market and the uncensored press.

But this chapter is not intended to be a political pep talk in defense of free enterprise. My purpose in mentioning the analogies between cellular and social homeostasis was not to draw a political moral from biology but rather to draw a biological moral from ecology and social history. Fortunately, I can claim the highest scientific authority for drawing the moral in this direction. It is well known to historians of science that Charles Darwin was strongly influenced in his working out of the theory of evolution by his readings of the political economists from Adam Smith to Malthus and McCullough. Darwin himself said of his theory: "This is the doctrine of Malthus applied to the whole animal and vegetable kingdom." What I am proposing is to apply in the same spirit the doctrines of modem ecology to the molecular processes within a primitive cell.

In our present state of ignorance, we have a choice between two contrasting images to represent our view of the possible structure of a creature newly emerged at the first threshold of life. One image is the replicator model of Eigen, a molecular structure tightly linked and centrally controlled, replicating itself with considerable precision, achieving homeostasis by strict adherence to a rigid pattern. The other image is the "tangled bank" of Darwin, an image which Darwin put at the end of his Origin of Species to make vivid his answer to the question, What is Life?, an image of grasses and flowers and bees and butterflies growing in tangled profusion without any discernible pattern, achieving homeostasis by means of a web of interdependences too complicated for us to unravel.

The tangled bank is the image which I have in mind when I try to imagine what a primeval cell would look like. I imagine a collection of molecular species, tangled and interlocking like the plants

and insects in Darwin's microcosm. This was the image which led me to think of error tolerance as the primary requirement for a model of a molecular population taking its first faltering steps toward life. Error tolerance is the hallmark of natural ecological communities, of free market economies and of open societies. I believe it must have been a primary quality of life from the very beginning. But replication and error tolerance are naturally antagonistic principles. That is why I like to exclude replication from the beginnings of life, to imagine the first cells as error-tolerant tangles of non- replicating molecules, and to introduce replication as an alien parasitic intrusion at a later stage. Only after the alien intruder has been tamed, the reconciliation between replication and error tolerance is achieved in a higher synthesis, through the evolution of the genetic code and the modem genetic apparatus.

The modern synthesis reconciles replication with error tolerance by establishing the division of labor between hardware and software, between the genetic apparatus and the gene. In the modern cell, the hardware of the genetic apparatus is rigidly controlled and error-intolerant. The hardware must be error-intolerant in order to maintain the accuracy of replication. But the error tolerance which I like to believe inherent in life from its earliest beginnings has not been lost. The burden of error tolerance has merely been transferred to the software. In the modem cell, with the infrastructure of hardware firmly in place and subject to a strict regime of quality control, the software is free to wander, to make mistakes and occasionally to be creative. The transfer of architectural design from hardware to software allowed the molecular architects to work with a freedom and creativity which their ancestors before the transfer could never have approached.

The analogies between the genetic evolution of biological species and the cultural evolution of human societies have been brilliantly explored by Richard Dawkins in his book The Selfish Gene. The book is mainly concerned with biological evolution; the cultural analogies are only pursued in the last chapter. Dawkins's main theme is the tyranny which the rigid demands of the replication apparatus have imposed upon all biological species throughout evolutionary history. Every species is the prisoner of its genes and is compelled to develop and to behave in such a way as to maximize their chances of survival. Only the genes are free to experiment with new patterns of behavior. Individual organisms must do what their genes dictate. This tyranny of the genes has lasted for 3 billion years and has only been precariously overthrown in the last hundred thousand years by a single species, Homo sapiens.

We have overthrown the tyranny by inventing symbolic language and culture. Our behavior patterns are now to a great extent culturally rather than genetically determined. We can choose to keep a defective gene in circulation because our culture tells us not to let hemophiliac children die. We have stolen back from our genes the freedom to make choices and to make mistakes.

In his last chapter Dawkins describes a new tyrant which has arisen within human culture to take the place of the old. The new tyrant is the "meme," the cultural analogue of the gene. A meme is a behavioral pattern which replicates itself by cultural transfer from individual to individual instead of by biological inheritance. Examples of memes are religious beliefs, linguistic idioms, fashions in art and science, in food and in clothes. Almost all the phenomena of evolutionary genetics and speciation have their analogues in cultural history, with the meme taking over the functions of the gene. The meme is a self-replicating unit of behavior, like the gene. The meme and the gene are equally selfish. The history of human culture shows us to be as subject to the tyranny of our memes as other species are to the tyranny of genes. But Dawkins ends his discussion with a call for liberation. Our capacity for foresight gives us the power to transcend our memes, just as our culture gave us the power to transcend our genes. We, he says, alone on Earth, can rebel against the tyranny of the selfish replication.

Dawkins's vision of the human situation as a Promethean struggle against the tyranny of the replicators contains important elements of truth. We are indeed rebels by nature, and his vision explains many aspects of our culture which would otherwise be mysterious. But his account leaves out half of the story. He describes the history of life as the history of replication. Like Eigen, he believes that the beginning of life was a self-replicating molecule. Throughout his history, the replicators are in control. In the beginning, he says, was simplicity. The point of view which I am expounding in this book is precisely opposite. In the beginning, I am saying, was complexity. The essence of life from the beginning was homeostasis based on a complicated web of molecular structures. Life by its very nature is resistant to simplification, whether on the level of single cells or ecological systems or human societies. life could tolerate a precisely replicating molecular apparatus only by incorporating it into a translation system which allowed the complexity of the molecular web to be expressed in the form of software. After the transfer of complication from hardware to software, life continued to be a complicated interlocking web in which the replicators were only one component.

The replicators were never as firmly in control as Dawkins imagined. In my version the history of life is counterpoint music, a two-part invention with two voices, the voice of the replicators attempting to impose their selfish purposes upon the whole network, and the voice of homeostasis tending to maximize diversity of structure and flexibility of function. The tyranny of the replicators was always mitigated by the more ancient cooperative structure of homeostasis inherent in every organism. The rule of the genes was like the government of the old Hapsburg Empire, "Despotismus gemildert durch Schlamperei" ("Despotism tempered by sloppiness").

One of the most interesting developments in modern genetics is the discovery of "Junk DNA,' a substantial component of our cellular inheritance which appears to have no biological function. Junk DNA is nucleic acid which does us no good and no harm, merely taking a free ride in our cells and taking advantage of our efficient replicative apparatus. It is difficult to measure the fraction of our DNA that is functional. Several lines of evidence indicate that as much as half of it may be junk. The prevalence of Junk DNA is a striking example of the sloppiness which life has always embodied in one form or another. It is easy to find in human culture the analogue of Junk DNA. Junk culture is replicated together with memes, just as Junk DNA is replicated together with genes. Junk culture is the rubbish of civilization, television commercials and astrology and jukeboxes and political propaganda. Tolerance of junk is one of life's most essential characteristics. In every sphere of life, whether cultural, economic, ecological or cellular, the systems which survive best are those which are not too fine-tuned to carry a large load of junk. And so, I believe, it must have been at the beginning. I would be surprised if the first living cell were not at least 25 percent junk.

I have been trying to imagine a framework for the origin of life, guided by a personal philosophy which considers the primal characteristics of life to be homeostasis rather than replication, diversity rather than uniformity, the flexibility of the cell rather than the tyranny of the gene, the error tolerance of the whole rather than the precision of the parts. The framework which I have found is an abstract mathematical model, far too simple to be true. But the model incorporates in a crude fashion the qualitative features of life which I consider essential: looseness of structure and tolerance of errors. The model fits into an overall view of life and evolution more relaxed than the traditional view.

The new and looser picture of evolution is strongly supported by recent experimental discoveries in molecular biology. Edward Wilson describes the new picture of the genes in a cell as "a rainforest with many niches occupied by a whole range of elements, all parts of which are in a dynamic state of change." The metaphor of the rain forest, which we applied earlier to the luxuriant growth of particle physics, now reappears in molecular biology. My philosophical bias leads me to believe that Wilson's metaphor describes not only the modem cell but the evolution of life all the way back to

the beginning. I hold the creativity of quasi-random complicated structures to be a more important driving force of evolution than the Darwinian competition of replicating monads. But philosophy is nothing but empty words if it is not capable of being tested by experiment. If my remarks have any value, it is only insofar as they suggest new experiments. I leave it now to the experimenters to see whether they can condense some solid facts out of this philosophical hot air.

Chapter 6 - How Will It All End?

In Chapter 3,1 said that I wanted to find connections between cosmology and biology, between the architecture of the universe and the existence of its living inhabitants. But then the next two chapters discussed the nature and origin of life without any further mention of cosmology. In separating the origin of life from the origin of the universe, I was following the rule which every student of modem science is taught to follow: local events are to be explained by local causes. The origin of life is assumed to have been a local event, occurring on a particular planet at a particular time. The age of the Earth is known to be less than half of the age of the universe. The origin of life was far removed in time and in physical conditions from the days when the universe was young. Therefore, following the role of local causation, we seek to explain the origin of life as a consequence of physical and chemical processes here on earth, unaffected by any teleological influences from the remote past or from the remote future.

If a theory of the origin of life is successful, it means that a particular chain of hypothetical local events is found to lead to the emergence of life with reasonable probability. Theories of the origin of the universe are the concern of a separate group of experts in a separate scientific discipline. The separation between the disciplines of biology and cosmology may be philosophically regrettable but it is built into the structure of modern science. All our cosmological theories assume that the early history of the universe was driven by purely physical processes in which fore-shadowings of life played no part.

I will not describe in detail what we know about the early universe. One reason I leave the early universe aside is that it seems to have been biologically barren and not directly relevant to my theme. The other reason is that there is an excellent book, The First Three Minutes, by Steven Weinberg, which gives an account of the state of our knowledge about the beginning of the universe, written in lucid nontechnical language. Although Weinberg's book was published in 1977, almost everything in it is still true. I have some disagreement with Weinberg's philosophy, but I have no disagreement with his facts.

One of the facts to which Weinberg calls attention is the timidity of theorists. Before 1965, when Arno Penzias and Robert Wilson discovered the microwave background radiation pervading the universe, nobody took theories of the early universe seriously. Even the people who invented theories did not take them seriously. George Gamow, who correctly predicted the existence of the background radiation in 1948, was generally considered to be a popularizer of science rather than a serious scientist. As Weinberg remarks, progress in understanding and observing the universe was delayed for a long time by the timidity of theorists:

This is often the way it is in physics. Our mistake is not that we take our theories too seriously, but that we do not take them seriously enough. It is always hard to realize that these numbers and equations we play with at our desks have something to do with the real world. Even worse, there often seems to be a general agreement that certain phenomena are just not fit subjects for respectable theoretical and experimental effort.... The most important thing accomplished by the discovery of the radiation background in 1965 was to force all of us to take seriously the idea that there was an early universe.

Thanks to Penzias and Wilson, Weinberg and others, the study of the beginning of the universe is now respectable. Professional physicists who investigate the first three minutes or the first microsecond no longer need to feel shy when they talk about their work. But the end of the universe is another matter. I have searched the literature for papers about the end of the universe and found very few. And the striking thing about these papers is that they are written in an apologetic or jocular style, as if the authors were begging us not to take them seriously. The study of the remote future still seems to be as disreputable today as the study of the remote past was thirty years ago. I am particularly indebted to Jamal Islam, a physicist colleague now living in Bangladesh, for an early draft of his 1977 paper which started me thinking about the remote future. Islam and I are hoping to hasten the arrival of the day when eschatology, the study of the end of the universe, will be a respectable scientific discipline and not merely a branch of theology.

Weinberg himself is not immune to the prejudices that I • am trying to dispel. At the end of his book about the past history of the universe, he adds a short chapter about the future. He takes 150 pages to describe the first three minutes, and then dismisses the whole of the future in five pages. Without any discussion of technical details, he sums up his view of the future in twelve memorable words:

> The more the universe seems comprehensible, the more it also seems pointless.

Weinberg has here, perhaps unintentionally, identified a real problem. It is impossible to calculate in detail the long-range future of the universe without including the effects of life and intelligence. It is impossible to calculate the capabilities of life and intelligence without touching, at least peripherally, philosophical questions. If we are to examine how intelligent life may be able to guide the physical development of the universe for its own purposes, we cannot altogether avoid considering what the values and purposes of intelligent life may be. But as soon as we mention the words "value" and "purpose,' we run into one of the most firmly entrenched taboos of twentieth-century science. Hear the voice of Jacques Monod, high priest of scientific rationality, in his book Chance and Necessity: "Any mingling of knowledge with values is unlawful, forbidden."

Monod was one of the seminal minds in the flowering of molecular biology in this century. It takes some courage to defy his anathema. But I will defy him and encourage others to do so. The taboo against mixing knowledge with values arose during the nineteenth century out of the great battle between the evolutionary biologists led by Thomas Huxley and the churchmen led by Bishop Wilberforce. Huxley won the battle, but a hundred years later Monod and Weinberg were still fighting Bishop Wilberforce's ghost. Physicists today have no reason to be afraid of Wilberforce's ghost. If our analysis of the long-range future leads us to raise questions related to the ultimate meaning and purpose of life, then let us examine these questions boldly and without embarrass-ment. If our answers to these questions are naive and preliminary, so much the better for the continued vitality of our science.

I described in Chapter 3 an older example of the timidity of theorists: Isaac Newton, the greatest theorist of his age, suppressed and concealed the writings in which he went outside the hounds of scientific orthodoxy. In spite of his immense achievements and worldly success, he remained at heart a timid soul. He was a secret Unitarian, afraid to risk his tenured position at Cambridge University by expressing in public the unorthodox theology which is to be found in his private papers. And he was a secret cosmologist, afraid to risk the disapproval of his scientific colleagues by expressing in public his private thoughts about the place of life in the universe.

It is fruitless to speculate upon the might-have-been’s of history. What might have been the effect on the cultural history of Europe in the eighteenth and nineteenth centuries, if Newton had had the courage to publish his speculative cosmology? Judging from the state of the manuscript, which is a

finished copy accompanied by several rough drafts, he had at one time intended to publish it. If he had done so, placing his unparalleled prestige as the supreme intellect of the Age of Enlightenment behind an unashamedly romantic and poetic view of the cosmos, would it have made any difference? Would European culture have avoided that whole disastrous split between the narrow rationalism of the Enlightenment, dominated by Newton's public image, on the one hand, and the excessive irrationalism of the romantic reaction on the other? Could we have avoided the political manifestations of this split in Napoleonic centralism on the one hand and nationalistic frenzy on the other? Could we have avoided the conflict between science and religion, the conflict which soured the intellectual life of the nineteenth century and continues to impoverish Western culture even today? It is unfair to hold Newton responsible for all these later misfortunes. It was not his fault that the universe beyond the Earth turned out to be dead and empty.

Perhaps it is inevitable that every great theorist, exhausted by the supreme effort of creating a new scientific vision, should be afraid of exploring still further into the surrounding darkness. The timidity of theorists is a natural human reaction. After a great discovery, the discoverer would like to settle down and consolidate the new territory. It is natural then to set limits, to draw lines beyond which further speculation should not go. Perhaps we should not be surprised that Darwin, the theorist who dominated the nineteenth century as Newton dominated the eighteenth, was also on many occasions as timid as Newton. Darwin was a less secretive character than Newton, but he was equally hesitant in publishing his ideas. There is a curious parallelism between Darwin's twenty-year delay in publishing his theory of evolution and Newton's twenty-year delay in publishing the Principia. And Newton's refusal to publish his cosmological speculations finds a parallel in Darwin's silence concerning the problem of the origin of life.

If we are to understand in general terms the place of life in the universe, we must also understand life's origin. Darwin explicitly excluded the origin of life from the scope of his theory of evolution. In his earliest outline of the theory, drawn up in 1839 or soon thereafter, he wrote, "Extent of my theory—having nothing to do with first origin of life, grow [sic], multiplication, mind (or with any attempt to find out whether descended from one form and what that form was)." He knew that only a massive and meticulous marshaling of evidence could make his theory convincing to his contemporaries; he had no hope of finding observational evidence relevant to the origin of life, and he therefore made no claim that the theory might throw light on the question of origins. Any such claim would expose a weak point in the structure of facts upon which his argument rested. He could, and did, discuss the origin of life privately among his friends. He could not discuss it publicly for fear of handing to his enemies the choice of a battleground which he could not defend with factual evidence. So, like Newton, Darwin kept his more radical thoughts private and presented to the world a scientific edifice of grand design but limited scope. "Hypotheses non fingo" became his motto, too. The effect of Darwin's caution was similar to the effect of Newton's. In both cases, a new science was created with clearly demarcated boundaries, and speculation transcending the boundaries was severely discouraged. The separation between biology and cosmology was reinforced by territorial boundaries on both sides. The question of the origin of life, which should have been a common meeting ground for the practitioners of both disciplines, became a no-man's-land accepted by neither.

We are fortunate to be living at a time when the barriers are breaking down. The collapse of the barriers was celebrated a few years ago at a meeting in Cambridge, where biologists as respectable as Sydney Brenner mingled with cosmologists as respectable as Stephen Hawking. The title of the meeting was "Matter into Life, and the discussions were memorable not for the number of problems solved but for the number of problems unsolved. A huge territory now lies open, ranging from the crystallography of clay at one end to neurophysiology at the other, and over this whole area there is a continuity of unsolved problems ready to sprout into new sciences. There is also a stream of pioneers infiltrating the territory from both ends.

At the Cambridge meeting, Eigen and Cairns-Smith talked about the competing theories of the origin of life which I described in Chapter 5. Chemists talked about experiments and mathematicians talked about computer simulations. The new science of the origin of life, having at last achieved respectability, was launched into a period of vigorous growth. Only the cosmologists at the meeting did not say much. The closer the problem of the origin of life comes to being accessible to experimental attack, the less it has to do with cosmology. In the end, the testing of the various theories will be a job for chemists, not for cosmologists.

I came home from the meeting with mixed feelings. On the one hand, the meeting was successful in bringing together the diverse points of view which can contribute to an understanding of life's origins. Biologists and chemists and physicists and mathematicians told us what they knew and learned to understand each other's ways of thinking. On the other hand, the meeting failed to bring together biology and cosmology. Biology and chemistry and physics and mathematics are coming to grips with the problem of the origin of life without any help from cosmology. The meeting confirmed my belief that, if we are interested in bringing biology and cosmology into a single picture of the universe, we must look to the future and not to the past.

Looking to the future, we give up immediately any pretence of being scientifically respectable. From this point on, I make no apology for mixing science with science fiction. Science fiction is, after all, nothing more than the exploration of the future using the tools of science. Unfortunately, science fiction acquired a bad reputation because much of it is poor fiction and even worse science. I will try to keep the fiction plausible and the science accurate.

Progress in understanding the origin of life goes hand in hand with progress in understanding the structure of existing creatures, and progress in biochemistry goes hand in hand with progress in genetic engineering. Newton discarded his youthful dream of a life-filled universe, but the time may soon come when we may be in a position to take matters into our own hands, to make Newton's dream come true by our own efforts. Suppose that we find no radio messages traveling through space, transmitted by extraterrestrial civilizations for our enlightenment. Suppose that we fail to find traces of life anywhere outside our own planet. What then would be the minimum modifications that would have to be imposed upon terrestrial life to enable us to make good nature's lack? Now that genetic engineering is rapidly becoming a practical proposition, it is not absurd to think of redesigning terrestrial creatures so as to make them viable in space or on other celestial bodies. Once we have successfully planted a variety of species in space and provided appropriate mechanisms of dispersal for their spores, we can safely rely on the ancient processes of mutation and natural selection to take care of their subsequent evolution. The mistakes which we shall inevitably make in our initial plantings will in time be rectified as their offspring diversify and spread through the cosmos.

There are three principal obstacles to be overcome in adapting a terrestrial species to life in space. It must learn to live and be happy in zero-g, zero-T, and zero-P, that is to say, zero-gravity, zero-temperature, and zero-pressure. Of these, zero-g is probably the easiest to cope with, although we are still ignorant of the nature of the physiological hazards which it imposes. To deal with zero-T is simple in principle although it may be complicated and awkward in practice. Fur and feathers provide even better insulation in a vacuum than they do in air or in water. Creatures adapted to space must learn to balance the energy generated by their metabolism and by • absorption of sunlight or starlight against the energy lost by • radiation from their surfaces. Some active control of the radiating surfaces will probably be required. But the low temperature of the environment makes the regulation of an organism's internal temperature easier rather than more difficult. It is easier to keep warm on Pluto than to keep cool on r Venus. Once a species has learned to keep warm on Pluto, it will soon be able to keep warm almost anywhere in the universe. The main

innovation which the adaptation of life to zero-T requires is that plants as well as animals must become warm-blooded. It seems to be only a curious historical accident that the natural evolution of life on earth produced warm-blooded animals before it produced warm-blooded plants. Only because of this poverty of invention in the plant kingdom do we find the coasts of our Arctic Ocean thinly populated with polar bears rather than thickly populated with living greenhouses. A warm-blooded plant, growing around itself a living greenhouse as effortlessly as a polar bear grows fur or a whale blubber, could spread quickly over the plains of Pluto.

But the most important and most difficult part of the adaptation of life to the cosmos is the adaptation to zero-P. It is only by adapting to zero-pressure, by learning to live in vacuum, that life can be liberated from narrow and malodorous confinement in space capsules and space suits. The move of life from air to vacuum is as fundamental and as liberating as the move which our ancestors made from water to air half a billion years ago. I cannot pretend to have understood the problems of adaptation in detail. I could not define the specifications of a zero-P potato precisely enough for a genetic engineer to sit down and begin working out the DNA sequences to put into its chromosomes. The best I can do is to quote from that old and frustrated engineer Konstantin Tsiolkovsky, who already understood the essentials of the problem of zero-P life when he published his book Dreams of Earth and Sky in the Russian provincial town of Kaluga in 1895. The passage which I quote is a dialogue between Tsiolkovsky and the guide who is escorting him around the solar system.

> These remarkable creatures combine the characteristics of animals and plants and so I call them animal-plants.... All right. Don't get angry. Just explain how your creatures avoid gating dried up like mummies.
>
> That is simple. Their skin is covered with a glassy layer, thin and flexible but absolutely impermeable to gases and liquids and all kinds of particles, so that the creatures are protected from any loss of material.... Their bodies have appendages which look like wings and are exposed to the sun, serving as chemical laboratories for the production of energy and food. Such appendages would be an encumbrance in earth's gravity-field, but in the zero-g environment of space they are hardly noticeable even with a surface area of several thousand square meters.
>
> Stop! How do your animal-plants talk to each other and exchange ideas without any air? ...
>
> They have a much more perfect and natural means of communication. One pan of their body carries under the transparent skin an area like a camera obscura, on which moving pictures are continually playing, following the flow of their thoughts and representing them precisely. The pictures are formed by fluids of various colors which flow through a web of fine channels under the skin.

I will leave Tsiolkovsky at this point, dreaming of celestial creatures who communicate with each other in glorious technicolor sign language. This dream is made especially poignant by the fact that Tsiolkovsky himself was cut off from easy communication with his terrestrial fellow creatures by his deafness. For a deaf man, sign language and television are natural channels of communication; radio is not.

Tsiolkovsky might have said of himself what the British Foreign Secretary George Canning said in 1826 when he had broken away from the alliance of reactionary monarchical governments in Europe and recognized the independence of the Latin American republics: "I look at the Indies and I call the new world to redress the balance of the old." Tsiolkovsky called into existence the new world of cosmic biology, toward which his invention of interplanetary rocketry was only a stepping stone, to

redress the balance between living ~psd non-living in the old world of natural cosmology, to redress the balance that was destroyed when Newton consigned ~tbis more speculative manuscripts to the attic. Newton banished life from the celestial spaces. Tsiolkovsky showed us the t way to bring it back. Newton was a unifier, Tsiolkovsky a diversifier. If we are striving to reach a balanced view of the universe, we need to listen to them both.

For the remainder of this chapter I shall assume that life is able to solve the technical problems of adapting itself to zero-g, zero-t, and zero-p. I assume that life is capable of making itself at home in every corner of the universe, just as it has made itself at home in every corner of this planet. I wish now to go beyond qualitative statements and begin a quantitative assessment of the potentialities of life in the universe. For a quantitative assessment, even at the rudimentary level which • is all I can hope to achieve, some degree of abstraction is required. In order to make quantitative statements which are independent of local accidents, we need to introduce an abstract description of living processes independent of mechanical and chemical details. My argument will be based on a fundamental assumption concerning the nature of life, that life resides in organization rather than in substance. I am assuming that my consciousness is inherent in the way the molecules in my head are organized, not in the substance of the molecules themselves. If this assumption is true, that life is organization rather than substance, then it makes sense to imagine life detached from flesh and blood and embodied in networks of superconducting circuitry or in interstellar dust clouds.

Let me now state my assumptions in a precise and quantitative fashion. I call the assumption that life can be described abstractly the hypothesis of abstraction. The hypothesis of abstraction says that every living creature is characterized by a number Q which is a measure of the complexity of the creature. To measure Q, we do not need to know anything about the internal structure of the creature. Q can he measured by observing from the outside the behavior of the creature and its interaction with its environment. Q is simply the quantity of entropy produced by the creature's metabolism during the time it takes to perform an elementary response to a stimulus. "Entropy" is a jargon word meaning waste heat divided by temperature. By an elementary response, I mean a simple action such as moving when poked or yelling when hurt. When the quantity of entropy is expressed in bits of information, the natural unit of entropy according to the law of equivalence of entropy and information, the quantity Q becomes a pure number.

For a human being, Q turns out to be about 1023, which is a rough measure of the amount of waste heat we have to generate in order to do anything at all. It measures the number of bits of information that must be processed to keep a person alive long enough to say, "Cogito, ergo sum." It is probably not an accident that Q happens also to be roughly equal to the number of large molecules in a human body. But the hypothesis of abstraction says that we can make general statements about life in the abstract, not knowing anything about its molecular structure, using the externally measured Q as a sufficient description of its hidden complexity. Complexity is an extensive quantity; that is to say, the complexity of a group of creatures is the sum of the complexities of the individuals in the group. The complexity that can be achieved by life in a given environment is ultimately proportional to the quantity of matter available for its use.

In addition to the hypothesis of abstraction, I make a much stronger assumption which I call the hypothesis of adaptability. The hypothesis of adaptability says that, given sufficient time, life can adapt itself to any environment whatever. This is certainly an exaggeration of the truth. But it is of interest to examine first the idealized case of perfect adaptability. Prac tical limitations and qualifications can always be added later. The formal statement of the hypothesis of adaptability is then as follows. Suppose that we have two environments A and B with a sufficient supply of matter and energy but with different environmental conditions of temperature, pressure, chemistry and so on. If a creature of complexity Q can exist in A, then an equivalent creature with the same

complexity Q can exist in B. The word "equivalent ' means that the creature in B has the same behavior patterns as the creature in A. If one is intelligent, the other is equally intelligent. If one is conscious, the other is also conscious. If one of them can talk to its friends about the content of its consciousness, the other will describe in an equivalent language a subjectively identical consciousness.

The hypotheses of abstraction and adaptability have some similarity to the first and second laws of thermodynamics. They are simple statements of a qualitative nature, and yet they provide a foundation for a quantitative theory of cosmic ecology. I will not burden you with the mathematical details of the theory.

The main theorem of cosmic ecology is that for a life form of fixed complexity adapting itself to a variety of environments, the rate of metabolism of energy varies with the square of the temperature. This fact, that energy consumption goes like temperature squared, has important consequences. It means that cold environments are fundamentally more hospitable to complex forms of life than hot environments. Life is, after all, an ordered form of matter, and low temperature favors order. In the long run, life depends lesson an abundant supply of energy than on a good signal-to-noise ratio. The colder the environment, the quieter the background, the more thrifty life can be in its use of energy.

How far life can go depends not only on biological adaptability but also on physical cosmology. If the physical universe is finite in space and time, the possible scope of life is also finite. In this case, as John Wheeler graphically describes it, the universe which begins its existence with a Big Bang ends its existence with a big crunch. The big crunch is a universal collapse into heat-death, with the sky growing hotter and hotter until it finally falls in on us and carries us into a space-time singularity at infinite temperature. Nothing living can survive the big crunch. If our universe is finite, then life will barely have time to spread itself once around the cosmos before the inexorable collapse begins. If that is to be our fate, then life is as the poet Housman described it:

> Here on the level sand
> Between the sea and land,
> What shall I build or write
> Against the fall of night?
> Tell me of runes to grave
> That hold the bunting wave,
> Or bastions to design
> For longer date than mine.

There is a great melancholy in the picture of a finite universe, its life force spent, its days of passion over, counting the hours remaining before it slides into oblivion. What will our last poets sing, whoever they may be, human or alien, as they watch the stars crowding together and streaming faster and faster across the imploding sky? Perhaps in their final moments they will remember the words of our contemporary, Ivor Gurney, echoing down the eons from the springtime of our species:

> The songs I had are withered
> Or vanished clean,
> Yet there are bright tracks
> Where I have been,
> And there grow flowers
> For others delight.
> Think well, 0 singer,

Soon comes night.

If, on the other hand, we live in an open universe, infinite in space and time and continuing to expand into a future without end, then life has to face a prospect of slow freezing rather than quick frying. The universe grows constantly colder as it expands, and the supply of free energy is constantly dwindling. To many people this future of endless ice has seemed even more dismal than the future of cataclysmic fire. But the laws of cosmic ecology put these futures into a very different perspective. If the hypothesis of adaptability is correct, life has a clear preference for ice over fire. In an expanding universe, life can adapt itself as the eons go by, constantly matching its metabolism of energy to the falling temperature of its surroundings. Since we are assuming perfect adaptability, the rate of energy metabolism falls with the square of the temperature. This has the consequence that, in an expanding universe, life of any fixed degree of complexity can survive forever upon a finite store of energy. The pulse of life will beat more slowly as the temperature falls but will never stop.

My theoretical physicist colleagues have recently found serious reasons to believe that all matter may be unstable. According to their latest theoretical models, the Grand Unified models of particle physics, the nuclei of all atoms will disappear into positrons and photons and neutrinos with a lifetime of the order of 10>3 years. The reality of this universal decay of matter into radiation is now to be put to experimental test. Within a few years we should know for sure whether matter is permanent or transient. If the experiment decides that matter is transient, then life will have to face some severe problems about 10" years from now. By human standards 10t3 years is a long time, but in the eye of eternity it is but an instant. If the universe is open, the history of life will be only just beginning when the disappearance of matter threatens its existence.

This will be the supreme test of life's adaptability. I do not know whether we can survive without protons. But I do not we any reason even then to declare the situation hopeless. If the assumptions of abstraction and adaptability are correct, the patterns of life and consciousness should be transferable without loss from one medium to another. After the protons are gone, we shall still have electrons and positrons and photons, and immaterial plasma may do as well as flesh and blood as a vehicle for the patterns of our thought. Perhaps the best possible universe is a universe of constant challenges, a universe in which survival is possible but not too easy. If optimism is the philosophy of people who welcome challenges, then we have plenty of reason to be optimists.

One of the great scientists of this century was the crystallographer Desmond Bernal, who began looking at the crystal structure of nucleic acids with X-rays long before DNA became fashionable. Bernal was also a gifted writer and philosopher. In the year 1929 he wrote a little book, The World, the Flesh and the Devil; an Inquiry into the Three Enemies of the Rational Soul. He explored with extraordinary vision and boldness the possible future of mankind, and the ways in which we may defeat the three traditional enemies of our progress: the World symbolizing material obstacles, famine and flood and poverty; the Flesh symbolizing our bodily infirmities, disease and senility and death; and the Devil symbolizing the dark irrational forces within our own minds, greed and fear and jealousy and madness. His vision went far into the future, and at the end he described what he saw as the ultimate transformation of life in the universe. Bernal anticipated some of the discoveries which biologists and physicists were to make fifty years later. In particular, he foresaw and welcomed the transition of life from material substance into etheriality which, if the Grand Unified models are right, the decay of protons will make inevitable:

> One may picture, then, these beings, nuclearly resident, so to speak, in a relatively small set of mental units, each utilizing the bare minimum of energy, connected together by acomplex of etherial intercommunication, and spreading themselves over immense areas and periods of time by means of inert sense organs which, like the field of their active

> operations, would be, in general, at a great distance from themselves. As the scene of life would be more the cold emptiness of space than the warm, dense atmosphere of the planets, the advantage of containing no organic material at all, so as to be independent of both of these conditions, would be increasingly felt. .. .
>
> Bit by bit the heritage in the direct line of mankind, the heritage of the original life emerging on the face of the world, would dwindle, and in the end disappear effectively, being preserved perhaps as some curious relic, while the new life which conserves none of the substance and all the spirit of the old would take its place and continue its development. Such a change would be as important as that in which life first appeared on the earth's surface and might be as gradual and imperceptible. Finally, consciousness itself may end or vanish in a humanity that has become completely etherialized, losing the close-knit organism, becoming masses of atoms in space communicating by radiation, and ultimately perhaps resolving itself entirely into light. That may be an end or a beginning, but from here it is out of sight.

That is Bernal writing in 1929. From here it is out of sight. Or, if you find Bernal's description too optimistic for our present mood of doom and gloom, there is the more sardonic but equally bold statement of the biologist J. B. S. Haldane. Haldane was one of the angry young men who fought in the trenches in World War I and came out of that inferno with a bitter laugh. Writing in 1923, six years before Bernal, he summarized his view of the human situation in a little book called Daedalus, or Science and the Future. Here is Haldane's verdict on the prospects of life in the universe:

> The human intellect is feeble, and there are times when it does not assert the infinity of its claims. But even then— Though in black jest it bows and nods, I know it is roaring at the Gods, Waiting the last Eclipse.

When I published my speculations about the furore of the universe in the Reviews of Modern Physics, the literary quotations were put in as occasional embellishments to break the monotony of the main argument. The main argument was a chain of mathematical calculations beginning with equation 1 and ending with equation 137. This chapter contains the embellishments without the equations. There is a danger that the argument presented here may seem to be nothing but literary frills without any scientific substance. The mathematical core of the argument was solid enough to be approved by the referees of a professional physics journal. The reader will have to take my word for it that the equations were right. I cannot explain here everything that went into the equations. Instead, I will summarize briefly the results that came out at the end.

I was attempting to find answers to three questions within the framework of an open and indefinitely expanding universe.

> (1) Does the universe freeze into a state of permanent physical quiescence as it expands and cools?
> (2) Is it possible for life and intelligence to survive forever?
> (3) Is it possible to maintain communication and transmit information across the constantly expanding distances between galaxies?

Tentatively, I answer these three questions with a no, a yes, and a maybe. No, the laws of physics do not predict any final quiescence but show us things continuing to happen, physical processes continuing to operate, as far into the future as we can imagine. Yes, life and intelligence are potentially immortal, with resources of knowledge and memory constantly growing as the temperature of the universe decreases and the reserves of free energy dwindle. And maybe, intelli-

gent beings in different parts of the universe can keep alive forever a network of communication, exchanging their ideas and constantly increasing their circle of acquaintances. The third answer is tentative because it assumes that transmitters and receivers of information can always be built with efficiency close to the theoretical ideal. The theoretical ideal of efficiency can be calculated from the laws of physics and information theory. To find out whether real transmitters and receivers could approach the ideal performance, one would need to be an electrical engineer rather than a physicist.

The numerical results of my calculations show that the quantities of energy required for permanent survival and communication are surprisingly modest. For a society with the same complexity as the present human society on Earth, starting from the present time and continuing forever, the total reserve of energy required is about equal to the energy now radiated by the Sun in eight hours. The total energy reserve contained in the Sun would be sufficient to support forever a society with a complexity 10 trillion times greater than our own. The energy required to keep open forever a high-speed intergalactic communication system is only about 1 gigawatt- year per channel, an extremely small quantity of energy by astronomical standards. The energy reserve contained in the Sun would be sufficient to keep open forever as many communication channels as would be needed to keep us talking with every star in the visible part of the universe. These statements are based on rough numerical estimates which may easily be wrong by a factor often or a hundred. Nevertheless, they give strong support to an optimistic view of the potentialities of life. They imply that the world of physics and astronomy is inexhaustible. No matter how far we go into the future, there will always be new things happening, new information coming in, new worlds to explore, a constantly expanding domain of life, consciousness and memory.

When I write in this style, I am mixing knowledge with values, disobeying Monod's prohibition. But I am in good company. Before the days of Darwin and Huxley and Bishop Wilberforce, in the eighteenth century, scientists were not subject to any taboo against mixing science and values. When Thomas Wright, the discoverer of galaxies, announced his discovery in 1750, he was not afraid to use a theological argument to support an astronomical theory.

Since as the Creation is, so is the Creator also magnified, we may conclude in consequence of an infinity, and an infinite all-active power, that as the visible creation is supposed to be full of siderial systems and planetary worlds, so on, in like similar manner, the endless immensity is an unlimited plenum of creations not unlike the known. That this in all probability may be the real case, is in some degree made evident by the many cloudy spots, just perceivable by us, as far without our starry Regions, in which tho' visibly luminous spaces, no one star or particular constituent body can possibly be distinguished; those in all likelihood may be external creation, bordering upon the known one, too re, mote for even our telescopes to reach.

Thirty-five years later, Wright's speculations were confirmed by William Herschel's precise observations. Wright also computed the number of habitable worlds in our galaxy: "In all together then we may safely reckon 170,000,000, and yet be much within compass, exclusive of the comets which I judge to be by far the most numerous part of the creation.°

Wright's statement about the comets may also be correct, although he does not tell us how he estimated their number. For him the existence of so many habitable worlds was not just a scientific hypothesis but a cause for moral reflection:

> In this great celestial creation, the catastrophy of a world, such as ours, or even the total dissolution of a system of worlds, may possibly be no more to the great Author of Nature, than the most common accident in life with us, and in all probability such final and general Doomsdays may be as frequent there, as even Birthdays or mortality with us upon the earth.

> This idea has something so cheerful in it, that I own I can never look upon the stairs without wondering why the whole world does not become astronomers; and that men endowed with sense and reason should neglect a science they are naturally so much interested in, and so capable of enlarging their understanding, as next to a demonstration must convince them of their immortality, and reconcile them to all those little difficulties incident to human nature, without the least anxiety.
>
> All this the vast apparent provision in the starry mansions seem to promise: What ought we then not to do, to preserve our natural birthright to it and to merit such inheritance, which alas we think created all to gratify alone a race of vain-glorious gigantic beings, while they are confined to this world, chained like so many atoms to a grain of sand.

There speaks the eighteenth century. But Steven Weinberg says, The more the universe seems comprehensible, the more it also seems pointless." If Weinberg is speaking for the twentieth century, then I prefer the eighteenth.

When Lord Gifford established these lectures, he directed that they be concerned with Natural Theology. The passages which I quoted from Thomas Wright fit splendidly into the framework of Lord Gifford's directive. I do not know precisely what Lord Gifford had in mind when he spoke of Natural Theology, but I imagine he meant to encourage that combination of scientific learning with moral eloquence which we find in Wright. Thomas Wright, if he were alive today, would have been the ideal Gifford Lecturer.

But I do not wish to leave you with the impression that Wright's theology is a quaint relic of the eighteenth century, irrelevant to our modern science, or that Weinberg's nihilistic voice speaks for all twentieth-century scientists. The universe that I have explored in a preliminary way in this book is very [different from the universe which Weinberg envisaged when he called it pointless. I have found a universe growing without limit in richness and complexity, a universe of life surviving,forever and making itself known to its neighbors across unimaginable gulfs of space and time. Whether the details of my calculations turn out to be correct or not, there are good scientific reasons for taking seriously the possibility that life and intelligence can succeed in molding this universe of ours to their own purposes. Twentieth-century science, when it looks to the future, provides a solid foundation for a philosophy of hope. A rational soul, knowing what we now know about the universe, has no reason to dismiss as fantasy the optimistic visions of Bernal and of Thomas Wright.

To conclude this chapter I venture a little further than Thomas Wright in the direction of theological speculation. To me the most astounding fact in the universe, even more astounding than the flight of the Monarch butterfly, is the power of mind which drives my fingers as I write these words. Somehow, by natural processes still totally mysterious, a million butterfly brains working together in a human skull have the power to dream, to calculate, to see and to hear, to speak and to listen, to translate thoughts and feelings into marks on paper which other brains can interpret. Mind, through the long course of biological evolution, has established itself as a moving force in our little corner of the universe. Here on this small planet, mind has infiltrated matter and has taken control.

It appears to me that the tendency of mind to infiltrate and control matter is a law of nature. Individual minds die and individual planers may be destroyed. But, as Thomas Wright said, The catastrophe of a world, such as ours, or even the total dissolution of a system of worlds, may possibly be no more to the great Author of Nature, than the most common accident of life with us." The infiltration of mind into the universe will not be permanently halted by any catastrophe or by any barrier that I can imagine. If our species does not choose to lead the way, others will do so, or

may have already done so. If our species is extinguished, others will be wiser or luckier. Mind is patient. Mind has waited for 3 billion years on this planet before composing its first string quartet. It may have to wait for another 3 billion years before it spreads all over the galaxy. I do not expect that it will have to wait so long. But if necessary, it will wait. The universe is like a fertile soil spread out all around us, ready for the seeds of mind to sprout and grow. Ultimately, late or soon, mind will come into its heritage.

What will mind choose to do when it informs and controls the universe? That is a question which we cannot hope to answer. When mind has expanded its physical reach and its biological organization by many powers of ten beyond the human scale, we can no more expect to understand its thoughts and dreams than a Monarch butterfly can understand ours. Mind can answer our question only as God answered Job out of the whirlwind: Who is this that darkeneth counsel by words without knowledge?' In contemplating the future of mind in the universe, we have exhausted the resources of our puny human science. This is the point at which science ends and theology begins.

Like the majority of scientists in this century, I have not concerned myself seriously with theology. Theology is a foreign language which we have not taken the trouble to learn. My personal theology is the theology of an amateur. But I did once have some help from a professional theologian in formulating my ideas in an intellectually coherent fashion. I happened to meet Charles Hartshorne at a meeting in Minnesota and we had a serious conversation. After we had talked for a while he informed me that my theological standpoint is Socinian. Socinus was an Italian heretic who lived in the sixteenth century. If I remember correctly what Hartshorne said, the main tenet of the Socinian heresy is that God is neither omniscient nor omnipotent. He learns and grows as the universe unfolds. I do not pretend to understand the theological subtleties to which this doctrine leads if one analyzes it in detail. I merely find it congenial, and consistent with scientific common sense. I do not make any clear distinction between mind and God. God is what mind becomes when it has passed beyond the scale of our comprehension. God may be considered to be either a world-soul or a collection of world-souls. We are the chief inlets of God on this planet at the present stage of his development. We may later grow with him as he grows, or we may be left behind. As Bernal said: That may be an end or a beginning, but from here it is out of sight." If we are left behind, it is an end. If we keep growing, it is a beginning.

The great virtue of my version of the Socinian theology is that it leaves room at the top for diversity. Just as the greatness of the creation lies in its diversity, so does also the greatness of the creator. Many world-souls are better than one. When mind grows to fill the universe, it comes as a diversifier as well as a unifier.

Another theologian, with whom I have a more distant acquaintance, is St. Paul. St. Paul had some good things to say about diversity. Now there are diversities of gifts, but the same spirit. And there are differences of administrations, but the same Lord. And there are diversities of operations, but it is the same God which worketh all in all." That passage from First Corinthians would make a good text for my sermon if I were preaching in church. But I am not preaching a Christian sermon. I am describing the universe as I encounter it in my life as a scientist and as a politically engaged citizen. I should not pretend to agree with St. Paul when in fact I find his point of view alien. For St. Paul, the diversity of the creation is less important than the unity of the creator. For me, it is the other way round. I do not know or particularly care whether the same God is working all in all. I care deeply for the diversity of his working.

Once upon a time, about thirty-five years ago, I went to see a play called Spring 1600 by Emlyn Williams. I have never seen it again and I do not know whether it is a good play, but it left a deep impression. The hero is the actor Richard Burbage, who is presented as he probably was in real life, a rough and impetuous fellow with a heart of gold. He has a wife who looks as if she may have given

Shakespeare the idea for the character of Mistress Quickly in Henry IV. There is a lot of noise offstage, thumping and hammering. Across the street from the Burbages' home in South London the Globe Theater is being built, the theater in which Richard is destined, during the next ten years, to be playing for the first time the roles of Hamlet, Othello, King Lear, Macbeth. But in Spring 1600 this is all far in the future. They have just had a great success with Henry V and are getting things ready for Twelfth Night. Will Shakespeare himself never appears on stage. He is busy taking care of the new theater and negotiating with the people at court for the Queen's patronage. Through the Burbages' home pours a constant stream of members of the company, a turbulent and undisciplined lot, held together only by a shared respect for Mistress Burbage's common sense and Will Shakespeare's genius.

The last act is the opening night of the new theater with the first performance of Twelfth Night. We do not we the performance. We see only the desperate last-minute improvisations which barely succeed in getting the show together in time for the opening. The show is, of course, a huge success. The Queen herself is there. In the final scene, after the play is finished and the Queen and the crowds have gone home, Richard goes alone to relax and meditate in the dark and silent theater. After a while he comes back onto our stage. "Did you hear anything? says his wife. "Yes," says Richard, ' 1 heard whispers of immortality."

That is perhaps too sentimental an ending for our modem taste. But I still like it. We know that when Will Shakespeare died in 1616 he left twenty-six shillings and eight-pence to Richard to buy a ring, as a token of his affection. It is not absurd to imagine Richard standing in that empty theater in Spring 1600 and hearing those whispers. So I will use the same ending for my cosmology. We know very little yet about the potentialities and the destiny of life in the universe. In speculating about these matters we follow a great tradition. We are in the same company with Bernal and Newton, Tsiolkovsky and Thomas Wright. Letting our imagination wander among the stars, we too may hear whispers of immortality.

May 1988
Elder M. Russell Ballard, Quorum of the Twelve
How Important It Is For Every Human Soul To See And Appreciate The Glory And Grandeur Of God In Everything About Us
Conference Address

Brothers and sisters, this is a beautiful time of year with spring beginning to burst forth in many parts of the world, bringing all of its colors, scents, and cheerful sounds. The miracle of the changing seasons, with the reawakening and rebirth in nature, inspires feelings of love and reverence within us for Gods marvelous, creative handiwork.

The Easter season is a good time for people everywhere to appreciate the wonders of nature and give thanks to the Creator of this beautiful world. Men and women in all parts of the world have a desperate need to take time from their demanding routines of everyday life and to quietly observe Gods miracles taking place all around them. Think of what would happen if all of us took time to look carefully at the wonders of nature that surround us and devoted ourselves to learning more about this world that God created for us!

My family and I recently had a simple but impressive experience with one of Gods creations. I gave my wife, Barbara, a dozen roses for a valentine. They were a delicate shade of peach in color and had a rich scent. Barbara put them in a vase and placed them on the table in our family room. As the days passed, the family watched the blossoms unfold from buds to full flower.

As I watched this miracle, I became curious about roses. I was amazed to learn from a botanist friend that there are thousands of different varieties of roses. Inside each rose is a giant storehouse of genetic coding that develops a seed or a slip into roots, stems, thorns, leaves, colors, and blooms.

Each rose is a compact chemical-processing factory. Using sunlight, the green leaves take carbon dioxide from the air and replace it with oxygen, which we breathe. When other chemicals within the plant react with sunlight, it produces starch that becomes food. As you know, this process is called photosynthesis, and without it the earths atmosphere would soon be devoid of oxygen, and most living things would disappear from the earth. My friend told me that the chemical energy and the electrical energy our brains were using at that very moment were once sunlight that was absorbed by the chlorophyll in green vegetation we previously had eaten.

This experience led me to consider the myriad forms of plant and animal life that thrive in astounding balance upon the earth. My esteem for our little roses took on an element of wonder and reverence. I pondered the power of the creative genius who lovingly provided such marvels for his children. I thought then how important it is for every human soul to see and appreciate the glory and grandeur of God in everything about us. Into my mind came the words and message of a beautiful hymn:

When thru the woods and forest glades I wander,
And hear the birds sing sweetly in the trees,
When I look down from lofty mountain grandeur
And hear the brook and feel the gentle breeze,
Then sings my soul, my Savior God, to thee,
How great thou art! How great thou art!
(Hymns, 1985, no. 86)

I felt a deep reverence for both the creation and the Creator. Reverence may be defined as a profound respect mingled with love and awe. Other words that add to our understanding of reverence include gratitude, honor, veneration, and admiration. The root word revere also implies an element of fear. Thus, reverence might be understood to mean an attitude of profound respect and love with a desire to honor and show gratitude, with a fear of breaking faith or offending.

In the book of Moses we read, And behold, all things have their likeness, and all things are created and made to bear record of me, both things which are temporal, and things which are spiritual; things which are in the heavens above, and things which are on the earth, and things which are in the earth, and things which are under the earth, both above and beneath: all things bear record of me (Moses 6:63).

Truly, the heavens and the earth and all things in them evidence the handiwork of God, their Creator. In the Book of Mormon we learn of Korihor, an anti-Christ who was brought to the Prophet Alma. He asked for a sign of Gods existence before he would believe. But Alma said unto him: Thou hast had signs enough; will ye tempt your God? Will ye say, Show unto me a sign, when ye have the testimony of all these thy brethren, and also all the holy prophets? The scriptures are laid before thee, yea, and all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator (Alma 30:44). These eternal evidences continue to testify to us today.

Astronauts viewing the earth from space have stated how incredibly beautiful it is and how alive it appears. United States Senator Jake Garn wrote of his experience in space: It is impossible for me

to describe the beauty of the earth. It is a breathtaking, awe-inspiring, spiritual experience to view the earth from space while traveling at twenty-five times the speed of sound. I could also look into the blackness of the vacuum of space and see billions of stars and galaxies millions of light-years away. The universe is so vast as to be impossible to comprehend. But I did comprehend the hand of God in all things. I felt his presence throughout my seven days in space. I know that God created this earth and the universe. I know that we are his children wherever we live on the earth, without regard to our nationality or the color of our skin. Most important, I know that God lives and is the Creator of us all (letter to M. Russell Ballard, 3 March 1988).

Again, the words of the hymn came to mind:

O Lord my God, when I in awesome wonder
Consider all the worlds thy hands have made,
I see the stars, I hear the rolling thunder,
Thy powr thruout the universe displayed;
Then sings my soul, my Savior God, to thee,
How great thou art! How great thou art!
(Hymns, 1985, no. 86)

The psalmist wrote, When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained;

What is man, that thou art mindful of him? and the son of man, that thou visitest him?
For thou hast made him a little lower than the angels, and hast crowned him with glory and honour (Ps. 8:3-5).

The Lord gave an answer to the psalmists question; it is recorded in the book of Moses: For mine own purpose have I made these things.

And by the word of my power, have I created them.
For behold, this is my work and my gloryto bring to pass the immortality and eternal life of man (Moses 1:31-32, 39).

When we look to see the evidence of creation all around us, from a grain of sand to the majestic planets, we begin to realize that we are the greatest of all Gods creations; we are created in his image. I was joyfully reminded of this fact three weeks ago when our twenty-fourth grandchild was born. I was again filled with wonder and love to hold this precious infant in my arms, to contemplate the miracle of birth, and to see a child born into mortality who had come so recently from the presence of our Father in Heaven.

The gift of new life brings a profound feeling of reverence. Parents and other family members are drawn closer together. Even little children sense a feeling of awe and wonder. They want to hold the baby, touch it, run their hands over its warm, soft head, or extend a finger for it to grasp and hold.

Welcoming this new little spirit into our family circle brought home once more to me an incredible truth. I realized again that God created the earth in all its magnificent glory, not as an end in itself, but for us, his children. Indeed, we are his children, his offspring, and he is the Father of our spirits.

We sometimes feel great respect and reverence for creative genius as expressed in great art or music. How much more should we revere the power and majesty of our Divine Creator? We may

stand in awe of mans creations of beautiful buildings or bridges. But remember the Apostle Pauls words to the Hebrews: He who hath builded the house hath more honour than the house.

For every house is builded by some man; but he that built all things is God (Heb. 3:3-4).

Those who feel no reverence for the creations and the divine attributes of God likely will have little appreciation for other sacred things. Such a lack of veneration for Gods creations may diminish until a person becomes totally insensitive to the feelings of others. This, I am afraid, is the condition in some parts of the world.

When we consider people who are irreverent, we may think of those who lack manners, sensitivity, and courtesy, and who show little or no respect for the finer things or for sacred things. Perhaps some lack reverence for life and for their fellowmen because they do not understand who they are and what they have the potential to become.

God expresses his love for us by providing the guidance we need to progress and reach our potential. Perhaps a simple story will illustrate this point. Recently, a young man purchased a used computer but could not get it to work properly. Soon he became discouraged. His temper grew short and he threatened the inanimate object with painful destruction unless its performance improved. A wise father intervened and took his son to a local vendor, where they obtained an instruction manual. After all, who would know more about a complex computer than the person or company that created it? Who would know most about its capacity and potential? Who would better know the safeguards required to avoid damaging or ruining this fine instrument? Soon the boy enjoyed the full potential of his computer by working within the guidelines given in the instruction book provided by its creator.

Likewise in our lives, he who knows most about us, our potential, and our eternal possibilities has given us divine counsel and commandments in his instruction manualsthe holy scriptures. When we understand and follow these instructions, our lives have purpose and meaning. We learn that our Maker loves us and desires our happiness. In an incomparable manifestation of this divine love for us, he sent his Only Begotten Son, Jesus Christ.

For God so loved the world, that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life.
For God sent not his Son into the world to condemn the world; but that the world through him might be saved (John 3:16-17).

Jesus was born into mortality. He led a perfect life and, in so doing, marked the path for us to follow. He taught his disciples: I am the light of the world: he that followeth me shall not walk in darkness, but shall have the light of life (John 8:12).

His gospel is a gospel of lovel: ove for God and love for one another. He directs us to follow his example. Our discipleship is measured by how well we comply.

A new commandment I give unto you, That ye love one another; as I have loved you, that ye also love one another.
By this shall all men know that ye are my disciples, if ye have love one to another (John 13:34-35).

Can you imagine what an impact following this instruction would have on society today?

Many people, I fear, never come to understand that the commandments of God are for our benefit and that as we sow, so shall we reap.

Our return to our Heavenly Father is through his Son, Jesus Christ. Jesus told his disciples, I am the way, the truth, and the life: no man cometh unto the Father, but by me (John 14:6). He instructed us to keep his commandments if we love him (John 14:15). He taught further that He that hath my commandments, and keepeth them, he it is that loveth me: and he that loveth me shall be loved of my Father, and I will love him, and will manifest myself to him (John 14:21).

In the atonement and the resurrection of Jesus Christ, we can glimpse the reality of his divine mission to redeem all who will come unto him and will honor and reverence God, our Eternal Father.

We may begin to understand the depths of Christs love for us when we consider that he was willing to atone and suffer the pain for our sins, which suffering caused [him], even God, the greatest of all, to tremble because of pain, and to bleed at every pore, and to suffer both body and spirit (D&C 19:18). Nevertheless, he gave glory to his Father and partook and finished his preparations unto the children of men (D&C 19:19).

The crowning words of the inspired hymn continue:

And when I think that God, his Son not sparing,
Sent him to die, I scarce can take it in,
That on the cross my burden gladly bearing
He bled and died to take away my sin,
Then sings my soul, my Savior God, to thee,
How great thou art! How great thou art!
(Hymns, 1985, no. 86)

Brothers and sisters, on this Easter Sunday, let us give special thanks to God for the atonement and resurrection of his beloved Son, Jesus Christ. For in him, by him, and through him, this temporary mortal condition can be made into a permanent, perfect existence, for which words cannot express our joy.

To truly reverence the Creator, we must appreciate his creations. We need to plan to take time to observe the marvels of nature. Today, we can easily become surrounded by brick buildings and asphalt surfaces that shelter us from real life around us. Plan to share with your family the miracle of buds changing to fragrant blossoms. Take time to sit on a hillside and feel the tranquillity of the evening when the sun casts its last golden glow over the horizon. Take time to smell the roses.

All the marvels of nature are glimpses of his divine power and expressions of his love. Yet the greatest of all miracles awaits us. It will occur when, by his power, we will come forth from death and the grave to a new world that will not pass away, where, if we are worthy, we will be with him and our Father in Heaven forever and ever.

With humility but with firm conviction, we declare to all the world that we know for a surety that God the Father and Jesus Christ, his Son, live. We know that they visited the Prophet Joseph Smith in the spring of 1820. They spoke to Joseph and, through him, they revealed wonderful, true doctrines and restored the fulness of the gospel of Jesus Christ that had been lost from the world.

We invite all men and women everywhere to know of the restoration of the gospel, for in so doing they will develop a deep reverence and love for God, his beloved Son, Jesus Christ, and their creations. I bear testimony that true reverence will bring peace, joy, and happiness to us all. In the sacred name of Jesus Christ, amen.

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Korihor the Anti-Christ
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After the people of Anti-Nephi-Lehi left their homeland among the Lamanites, they were allowed to live among the Nephites in the land of Jershon, where they were called the people of Ammon. Later came a great battle between the Lamanites and the Nephites in which the Lamanites were defeated. After this great battle was a period of peace throughout the land. Then appeared a man named Korihor, who came into the land of Zarahemla and preached against the prophecies of the coming of Christ. He also went to the land of Jershon and preached among the people of Ammon. However, these people took him before their high priest, who commanded him to be carried out of the land. Korihor then went to the land of Gideon to preach and was eventually brought before Giddonah, the high priest there. When Giddonah saw the hardness of Korihor's heart, he had him brought before Alma, the chief judge and governor over the land. Alma 30 discusses what Korihor taught in Zarahemla, Jershon, and Gideon; his trial before Alma; and his downfall.

The writer of this account is Mormon, who called Korihor an anti-Christ. Alma 30 is part of an abridgment made by Mormon-under the direction and inspiration of the Lord-from a larger, more detailed account by earlier prophets. In vision Nephi saw that this record would eventually come forth in the latter days for the benefit of our modern generation. (1 Ne. 13:32-36.) Keeping this in mind, why would the Lord direct Mormon to devote an entire chapter to the details of the teachings and final destiny of Korihor when so many other things were written on the original plates? As we compare the teachings of this man and the beliefs of those today who advocate the philosophy of naturalism, we see a striking similarity. I believe that the Lord foresaw the adverse effects of naturalism on our modern world and therefore purposely directed Mormon to include the teachings of Korihor in his record. Those who read and accept the Book of Mormon are thereby warned against accepting the philosophical assumptions of naturalism. What one believes about the universe is important because it affects one's behavior, for "as [a man] thinketh in his heart, so is he." (Prov. 23:7.)

The Rise of Naturalism
E. A. Burtt, in his book The Metaphysical Foundations of Modern Physical Science, traces cosmological thinking from medieval to modern times. He points out that the naturalistic viewpoint has made great inroads into the thinking of many of our modern generation. Even though we may not all be philosophers or scientists, still the philosophies of those around us affect our thinking even though we may not realize it. Burtt explains that sometimes we accept a philosophical position without being aware of its implications and hence it produces a subtle and pervasive control over our thinking.

How curious, after all, is the way in which we moderns think about our world! And it is so novel, too. The cosmology underlying our mental processes is but three centuries old-a mere infant in the history of thought-and yet we cling to it with the same embarrassed zeal with which a young father fondles his new-born baby. Like him, we are ignorant enough of its precise nature; like him, we nevertheless take it piously to be ours and allow it a subtly pervasive and unhindered control over our thinking.

Bertrand Russell was a renowned mathematician and philosopher who advocated the naturalistic viewpoint. He claimed that as science has arisen in the past 300 years and has become so

pragmatically successful in our lives, it has become a dominant factor in determining the beliefs of educated people: "As a result of the new control over the environment which scientific knowledge has conferred, a new philosophy is growing up, involving a changed conception of man's place in the universe." He went on to explain that it is our personal acceptance of the premises on which the scientific method was based that has changed our way of thinking about the world around us:

Out of the work of the great men of the seventeenth century a new outlook on the world was developed, and it was this outlook, not specific arguments, which brought about the decay of the belief in portents, witchcraft, demoniacal possession, and so forth. I think there were three ingredients in the scientific outlook of the eighteenth century that were specially important.

(1) Statements of fact should be based on observation, not on unsupported authority.

(2) The inanimate world is a self-acting, self-perpetuating system, in which all changes conform to natural laws.
(3) The earth is not the center of the universe, and probably Man is not its purpose (if any); moreover, "purpose" is a concept which is scientifically useless.

We advocate the philosophy of naturalism (whether we realize it or not) when we no longer regard these statements as restricted outlooks to be taken only in scientific endeavors but shift to the following positions: knowledge cannot be gained by any other means than by the use of the natural senses, the universe is really an inanimate self-acting and self-perpetuating system, and there is no real purpose in the existence of the universe. This chapter will compare these fundamental assumptions of naturalism with Korihor's teachings to show the similarity between the two. The implications of accepting these assumptions will then be examined.

Methods of Gaining Knowledge
Science has become successful in predicting, controlling, and explaining many natural events by making the restriction that in any scientific endeavor all conclusions must be based upon public, repeatable observations using the natural senses. This has proved advantageous for the progress of science, but if we allow this restriction to become part of our personal epistemology or method of gaining knowledge of the world around us, it automatically eliminates any knowledge coming to us from God through the living prophets, the scriptures, or personal revelation.

Korihor took the naturalistic viewpoint. He advocated that what the prophets say and have said (their recorded words, or scriptures) are foolish traditions (Russell's unsupported authority), since we cannot know of anything that does not come through the natural senses (things we cannot see): "O ye that are bound down under a foolish and a vain hope, why do ye yoke yourselves with such foolish things? Why do ye look for a Christ? For no man can know of anything which is to come. Behold, these things which ye call prophecies, which ye say are handed down by holy prophets, behold, they are foolish traditions of your fathers. How do ye know of their surety? Behold, ye cannot know of things which ye do not see." (Alma 30:13-15; emphasis added.)

Because of Korihor's position that we cannot know anything of the world around us except through empirical observation, he claimed we cannot know that there is a God, "a being who never has been seen or known, who never was nor ever will be." (Alma 30:28.) When Alma confronted him directly and asked him if he believed in a God, he answered no (Alma 30:38) and went on to explain that he would believe in God only if he were given a sign, some empirical evidence: "If thou wilt show me a sign, that I may be convinced that there is a God, yea, show unto me that he hath power, and then will I be convinced of the truth of thy words." (Alma 30:43.) Later he took more of an agnostic rather than an atheistic position, but he still maintained his position that knowledge of such things

comes only by empirical observation: "I do not deny the existence of a God, but I do not believe that there is a God . . . and except ye show me a sign, I will not believe." (Alma 30:48.)

Alma, on the other hand, held that we can obtain knowledge from God by revelation as well as through the natural senses. By not hardening our hearts, we can receive revelation to our spirits that confirms to us that the words of the prophets and the scriptures are true. Alma rebuked Korihor, saying that he was resisting the promptings of the Holy Spirit; otherwise he would accept the words of the prophets and the scriptures and believe in God:

And now what evidence have ye that there is no God, or that Christ cometh not? I say unto you that ye have none, save it be your word only. But, behold, I have all things as a testimony that these things are true; and ye also have all things as a testimony unto you that they are true; and will ye deny them? Believest thou that these things are true?

Behold, I know that thou believest, but thou art possessed with a lying spirit, and ye have put off the Spirit of God that it may have no place in you. . . .

Will ye say, Show unto me a sign, when ye have the testimony of all these thy brethren, and also all the holy prophets? The scriptures are laid before thee, yea, and all things denote there is a God. . . . And yet do ye go about, leading away the hearts of this people, testifying unto them there is no God? And yet will ye deny against all these witnesses? And he said: Yea, I will deny, except ye shall show me a sign.

And now it came to pass that Alma said unto him: Behold, I am grieved because of the hardness of your heart, yea, that ye will still resist the spirit of the truth, that thy soul may be destroyed. (Alma 30:40-42, 44-46; emphasis added.)

The Nature of the Universe

Russell's second point was that science has become pragmatically successful by assuming that the world around us is a self-acting, self-perpetuating system in which all changes conform to natural laws. Russell explains that before the rise of modern physics, it was thought that all motion resulted from the action of living beings with souls:

Before Galileo it had been thought that a lifeless body will not move of itself, and if it is in motion it will gradually come to rest. Only living beings, it was thought, could move without help of some external agency. Aristotle thought that the heavenly bodies were pushed by Gods. Here on earth, animals can set themselves in motion and can cause motion in dead matter. . . . Everything depends upon impulsion from the souls of living beings.

So long as this view prevailed, physics as an independent science was impossible, since the physical world was thought to be not causally self-contained. But Galileo and Newton between them proved that all the movements of the planets, and of dead matter on the earth, proceed according to the law of physics, and once started, will continue indefinitely. There is no need of mind in this process.

At a later date the philosopher and mathematician Descartes "held that not only dead matter, but the bodies of animals also, are wholly governed by the laws of physics." The French freethinkers and the eighteenth-century materialists took the next step by saying that all causes are material in nature, and that mental occurrences are inoperative by-products. We will see, however, that if we accept these views as part of our personal cosmology, certain implications result that are contrary to the words of the prophets and the scriptures.

Belief in a self-acting, self-perpetuating system in which all changes conform to natural law eliminates a belief that God has any power to direct or control matter. Such a position is that of naturalism. Instead of believing that God is the author of all natural law and therefore ultimately controls all phenomena in the physical universe (theism), the naturalist believes that self-existing "Law" is the sovereign power in the universe and ultimately controls all phenomena. According to this view, all causation is material (according to natural law) rather than mental (originating in the mind of God or some other living creature).

Burtt points out that the shift from theism (in medieval times) to naturalism (in modern times) was gradual. In the early history of science, many scientists held theistic views. Their religious beliefs led them to conclude that God controls all matter by his power and that he commands this matter to behave in certain ways. To them God was sovereign and therefore the author of all natural laws. As scientists, they attempted to discover these laws by gathering facts empirically in an attempt to induce from them certain regularities in nature. Once these regularities (natural laws) were found, the scientists could better predict, control, and explain the phenomena in the universe around them. However, to them God was not just a super scientist or super engineer who discovered and worked with self-existing natural laws; rather, he was the Great Creator, who authored the laws they were attempting to discover. Thus, a description of how matter behaves would also be a description of the handiwork of God. This was the position of Alma when rebutting the position of Korihor: "Will ye say, Show unto me a sign, when ye have the testimony of all these thy brethren, and also all the holy prophets? The scriptures are laid before thee, yea, and all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator." (Alma 30:44; emphasis added.)

If God had no power to command and direct matter, then Alma would not have given God credit for the orderly motion of the earth and other heavenly bodies. Alma's position is substantiated by the word of the Lord in modern revelation wherein the regular motion of the heavenly bodies is attributed to God's commands (law), which reach all matter through the Spirit of Christ:

Which truth shineth. This is the light of Christ. . . . Which light proceedeth forth from the presence of God to fill the immensity of space-the light which is in all things, which giveth life to all things, which is the law by which all things are governed, even the power of God who sitteth upon his throne. . . . And again, verily I say unto you, he hath given a law unto all things, by which they move in their times and their seasons; and their courses are fixed, even the courses of the heavens and the earth. . . . The earth rolls upon her wings, and the sun giveth his light by day, and the moon giveth her light by night, and the stars also give their light, as they roll upon their wings in their glory, in the midst of the power of God. . . . Behold, all these are kingdoms, and any man who hath seen any or the least of these hath seen God moving in his majesty and power. (D&C 88:7, 12-13, 42-43, 45, 47; emphasis added.)

The Nature of Humanity

In Russell's second statement, he not only advocated a self-acting and self-perpetuating universe, but also one that was inanimate. A universe that was self-acting and self-perpetuating, where all changes result from the operation of natural law, would of necessity be one where man was merely a physical machine. Such a machine would be controlled completely by natural law, leaving no room for a spirit within the physical body to interact with the body and influence its actions. Some early scientists such as Johannes Muller believed that humans were composed of more than a mere body that was a physical machine. However, some of Muller's own students made a pact among themselves to promote the idea that people's actions were the result of no forces other than the operation of natural law. They were eventually successful in promoting that view, which has now

become a traditional way of thinking for many of our modern scientists, especially in the field of behavioristic psychology.

Coming back to Korihor, we find that his views pertaining to humanity were consistent with these naturalistic views. Korihor implied that people had no spirits when he said that "when a man was dead, that was the end thereof." (Alma 30:18.) Furthermore, in such a mechanical universe as that advocated by Korihor, there could be no place for such things as God's law given by his prophets. Consequently, Korihor taught that the words of the prophets were not from God but were mere traditions of men. We also find Korihor teaching that even if people did not live according to the words of the prophets, they still would not "offend some unknown being, who they say is God." (Alma 30:28.)

The Effects of Korihor's Naturalistic Doctrine

In such a naturalistic universe as that advocated by Korihor, where there were no laws of God to break, there could be no sin nor spiritual death that results from sin. Instead of being motivated in their behavior by a fear or love of God, people's actions would be motivated by a survival of the fittest, both physically and mentally, which was no crime. Holding such naturalistic views would influence people to believe that they were not accountable to a higher power for their actions. As a result, they would be led away into sin. Mormon comments on Korihor's teachings and their effect on the people of his day as follows: "Many more such things did he say unto them, telling them that . . . every man fared in this life according to the management of the creature; therefore every man prospered according to his genius, and that every man conquered according to his strength; and whatsoever a man did was no crime. And thus he did preach unto them, leading away the hearts of many, causing them to lift up their heads in their wickedness, yea, leading away many women, and also men, to commit whoredoms." (Alma 30:17-18.)

Since Korihor's universe held no room for a God, God's laws, or certain effects resulting from the breaking of these laws, to be consistent he would have to deny the fall of man which came as the result of the transgression of Adam and Eve. The scriptures describe how the transgression of a commandment of God in the Garden of Eden by our first parents affected not only them but all their posterity by causing them to become mortals subject to spiritual and temporal death. (Alma 42:2-14.) It seems that Korihor was denying the fall when he said: "Ye say that this people is a guilty and a fallen people, because of the transgression of a parent. Behold, I say that a child is not guilty because of its parents." (Alma 30:25.)

Ancient as well as modern scriptures teach that an atonement was needed to provide a remission of personal sins (on conditions of repentance) as well as to overcome the effects of the fall of Adam and Eve. (2 Ne. 9:1-13; Alma 42:12-16.) Again to be consistent with his other naturalistic views, Korihor would have had to deny a need for an atonement and of course a need for Christ to perform the atonement. Concerning the atonement, he said "that there could be no atonement made for the sins of men." (Alma 30:17.) He also stated that to "look forward and say ye see a remission of your sins . . . is the effect of a frenzied mind; and this derangement of your minds comes because of the traditions of your fathers, which lead you away into a belief of things which are not so." (Alma 30:16.) Since Korihor did not believe in sin or a need for an atonement to overcome the effects of sin, he claimed that the idea of a Christ slain for the sins of the world was a foolish tradition of the Nephites used by their priests to keep them in bondage: "Ye . . . say that Christ shall come. But behold, I say that ye do not know that there shall be a Christ. And ye say also that he shall be slain for the sins of the world-and thus ye lead away this people after the foolish traditions of your fathers, and according to your own desires; and ye keep them down, even as it were in bondage, that ye may glut yourselves with the labors of their hands." (Alma 30:26-27; emphasis added.)

Consequently, he taught the people "that there should be no Christ" (Alma 30:12) and that to look forward to the coming of Christ was to yoke themselves "under a foolish and a vain hope" (Alma 30:13).

Why Korihor Was An Anti-Christ

It is now easy to see why Mormon labeled Korihor an Anti-Christ: Korihor was denying the truth of those doctrines that made it necessary that Jesus was (and is) the Christ. The role of Christ is two-fold. First, he is the Lord God of this world. He attained to this position in premortal life. (Abr. 3:19-21; D&C 38:1-3.) As the Lord God, his word is law to the physical elements, and by his word or power he created or organized this world and continues to sustain and uphold it. He also gives his word (or law) to people on earth, and they have a spirit within them with the capacity to receive and obey his word (or law) or to reject it. Even though each person has a physical body subject to natural law, the spirit within that body can control the body's outward behavior.

Christ's second role is that of Savior or Redeemer. Because Jesus was born the Son of God and performed the atonement during his mortal ministry, he gained power to overcome the effect of people's breaking the very laws he gave in his role as the Lord God. (2 Ne. 2:10.) Hence, he gained power to overcome the effects of the fall as well as to overcome the effects of individual sin, if the person sincerely repents and strives to live the gospel. The purpose of creation was to give people joy, which comes when they overcome spiritual and temporal death through the atonement of Christ. Korihor denied all this (Alma 30:22, 35), as do the "naturalists" of our day who hold similar viewpoints.

In his final confrontation with Alma, Korihor exclaimed he would never believe in God unless he received a physical sign as a manifestation of God's power. Finally, the Lord allowed Alma to give him a sign, but it was to his condemnation: Korihor was struck dumb by the power of God. Korihor then confessed that his doctrines were false and were authored by the devil:

Now when Alma had said these words, Korihor was struck dumb, that he could not have utterance, according to the words of Alma. . . . And Korihor put forth his hand and wrote, saying: I know that I am dumb, for I cannot speak; and I know that nothing save it were the power of God could bring this upon me; yea, and I also knew that there was a God. But behold, the devil hath deceived me; for he appeared unto me in the form of an angel, and said unto me: Go and reclaim this people, for they have all gone astray after an unknown God. And he said unto me: There is no God; yea, and he taught me that which I should say. And I have taught his words; and I taught them because they were pleasing unto the carnal mind; and I taught them, even until I had much success, insomuch that I verily believed that they were true; and for this cause I withstood the truth, even until I have brought this great curse upon me. (Alma 30:50, 52-53; emphasis added.)

Summary and Conclusions

If we accept the Book of Mormon as the word of God, the account of Korihor teaches us that the beliefs associated with the philosophy of naturalism are anti-Christ in nature. Science itself should not be anti-Christ, for its methodology should restrict scientists to making statements only about things that can be observed through the natural senses. Some scientists have taken theistic views while others have taken naturalistic views about the nature of the universe, but both groups have acted as philosophers, making statements that go beyond what can be confirmed publicly through the natural senses. According to C. S. Lewis, what is behind the things science observes cannot (and should not) be answered by the scientist if he or she is speaking as a scientist. Lewis comments on the role of science in solving the question of whether God created the universe and continues to uphold it, or whether it is merely an inanimate, self-perpetuating system with no God involved:

Wherever there have been thinking men both views turn up. And note this too. You cannot find out which view is the right one by science in the ordinary sense. Science works by experiments. It watches how things behave. Every scientific statement in the long run, however complicated it looks, really means something like, "I pointed the telescope to such and such a part of the sky at 2:20 on January 15th and saw so-and-so," or, "I put some of this stuff in a pot and heated it to such-and-such a temperature and it did so-and-so." Do not think I am saying anything against science: I am only saying what its job is. And the more scientific a man is, the more (I believe) he would agree with me that this is the job of science-and a very useful and necessary job it is too. But why anything comes to be there at all, and whether there is anything behind the things science observes-something of a different kind-this is not a scientific question. If there is "Something Behind," then either it will have to remain altogether unknown to men or else make itself known in some different way. The statement that there is any such thing, and the statement that there is no such thing, are neither of them statements that science can make. And real scientists do not usually make them.

C. S. Lewis makes a good point. As a result of scientists using the methodology of science in the last few centuries, an enormous amount of valuable knowledge has been gained about the world around us, knowledge that can be confirmed by empirical observation. However, God has given us revelation through his prophets and through scripture, which reveal to us many things about the universe that cannot be observed in a scientific way. Sometimes what the philosophers say about our universe disagrees with what God has revealed. However, God will confirm to us that the knowledge he has given to us by the prophets and the scriptures is true. That confirmation can come to our spirits through the Holy Ghost if we sincerely ask for it. God has said that part of our test here is to see if we will seek the truth through the power of the Holy Ghost: "Ye shall live by every word which proceedeth forth out of the mouth of God. For he will give unto the faithful line upon line, precept upon precept; and I will try you and prove you herewith." (D&C 98:11-12.)

Consequently, if we seek and gain a confirmation through the power of the Holy Ghost that the Book of Mormon is true, we can use the contents of that book as a guide in detecting the beliefs of our modern generation that are anti-Christ in nature. It is our responsibility to not "put off the Spirit of God" (Alma 30:42) as did Korihor so that we may not "be seduced by evil spirits, or doctrines of devils, or the commandments of men; for some are of men, and others of devils." (D&C 46:7.)

Footnotes

1. LaMar E. Garrard is professor of Church history and doctrine at Brigham Young University.
2. Edwin Arthur Burtt, The Metaphysical Foundations of Modern Physical Science (London: Routledge & Kegan Paul Ltd., 1950).
3. Bertrand Russell, The Impact of Science on Society (New York: Simon and Schuster, 1953), pp. 1-2.
4. The Impact of Science on Society, p. 6.
5. Russell held the extreme position of naturalism by advocating all three of these assumptions as being true. There are various other positions that are not quite so extreme. However, advocating any one of these assumptions as being true results in holding a position that is still not in accordance with the words of the scriptures and the prophets. For example, a "deist" believes that God created the universe to begin with but then withdrew, and that since then the universe has run by itself according to natural law. In such a universe there could be no miracles or revelations because there would be no divine intervention after the creation.
6. Alma 5:45-48. Joseph Smith stated that revelation comes "to our spirits precisely as though we had no bodies at all." (Joseph Smith, Teachings of the Prophet Joseph Smith, selected by Joseph Fielding Smith [Salt Lake City: Deseret Book Company, 1938], p. 355.) See also D&C 6:14-17, 22-24; 18:1-5; 29:7; Moroni 10:4-5.

7. The Impact of Science on Society, pp. 9-10.
8. The Impact of Science on Society, p. 10.
9. The Prophet Joseph Smith and the scriptures indicate that when God commands the elements, they obey his will. (Abr. 2:7; Moses 1:25; Hel. 12:7-17; D&C 133:23; Teachings of the Prophet Joseph Smith, pp. 197-98.) This earth had its origin first as a plan in the mind of God. (Abr. 3:24; 5:1-3.) He then spoke to or commanded the elements (D&C 38:3) by means of his spirit (D&C 29:30-32), and they obeyed him (Abr. 4:9-11, 18, 21, 25). They continue to obey him and are thus governed (D&C 88:7-13) or upheld by his power (Teachings of the Prophet Joseph Smith, pp. 55-56, 345). In other words, what we describe the elements as doing (natural law) is nothing more than what God has prescribed them to do. Furthermore, God tells us that it is offensive to him to not acknowledge his hand in all things. (D&C 59:21.) A more detailed discussion on this subject is given by the author in "Creation, Fall, and Atonement," Studies in Scripture, Vol. 7: 1 Nephi to Alma 29, ed. Kent P. Jackson (Salt Lake City: Deseret Book Company, 1987), pp. 87-90, 98-100.
10. A more detailed discussion on the shift from theism to naturalism is given by the author in "What Is Man?" Hearken O Ye People (Sandy, Utah: Randall Book Company, 1984), pp. 134-42.
11. As an example, Burtt points out that both Robert Boyle and Isaac Newton held theistic beliefs. See The Metaphysical Foundations of Modern Physical Science, pp. 289-90.
12. Joseph Smith also gave God credit for the movement of the heavenly bodies when he said that "God set the sun, the moon, and the stars in the heavens, and gave them their laws, conditions and bounds, which they cannot pass, except by His commandments; they all move in perfect harmony in their sphere and order." (Teachings of the Prophet Joseph Smith, pp. 197-98.)
13. Edwin G. Boring, A History of Experimental Psychology (New York City: Appleton-Century-Crofts, 1957), p. 708.
14. A more detailed discussion of the naturalistic views on humanity is given by the author in "What Is Man?" pp. 133-39.
15. A more detailed discussion of the two roles of Christ is given by the author in "Jesus Is the Christ," Studies in Scripture, Vol. 5: The Gospels, ed. Kent B. Jackson and Robert L. Millet (Salt Lake City: Deseret Book Company, 1986), pp. 323-40.
16. As an example, Christ's spirit ruled over his body at all times. (Mosiah 15:5-7.)
17. 2 Nephi 2:10-13, 25; Alma 42:16; D&C 101:35-38; Teachings of the Prophet Joseph Smith, p. 255. A more detailed discussion on the subject of the joy that comes from overcoming spiritual and temporal death is given by the author in "The Fall of Man," Principles of the Gospel in Practice (Salt Lake City: Randall Book Co., 1985), pp. 48-58.
18. It should be recalled that the naturalist denies that there is "purpose" in the universe. Burtt summarizes Russell's naturalistic beliefs on this subject as follows: "To Russell, man is but the chance and temporary product of a blind and purposeless nature, an irrelevant spectator of her doings, almost an alien intruder on her domain. No high place in a cosmic teleology is his; his ideals, his hopes, his mystic raptures, are but the creations of his own errant and enthusiastic imagination, without standing or application to a real world interpreted mechanically in terms of space, time, and unconscious, though eternal atoms. His mother earth is but a speck in the boundlessness of space, his place even on the earth but insignificant and precarious, in a word, he is at the mercy of brute forces that unknowingly happened to throw him into being, and promise ere long just as unknowingly to snuff out the candle of his little day. Himself and all that is dear to him will in course of time become 'buried in a universe of ruins.' " (The Metaphysical Foundations of Modern Physical Science, p. 10.)
19. C. S. Lewis, Mere Christianity (New York: Macmillan, 1960), p. 32, emphasis added.
20. Moroni 10:4-5; D&C 6:14-17, 22-24; 18:1-4; James 1:5-6; Matt. 7:7-11.

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How did the Prophet Joseph Smith respond to skepticism in his time? And what can we learn from him about how to respond to modern-day skeptics?
"I Have a Question," Ensign Article (Discusses Joseph and William Paley)

There have been unbelievers in all periods of history, of course. But skepticism in Joseph Smith's time had at its core a distinctive argument. Impressed by Sir Isaac Newton's method of scientific observation and reasoning (but ignoring his Christian orthodoxy), many people had adopted a philosophy that religious principles could be discovered by the same scientific method, without the exercise of faith. This philosophy was called deism.

Deists acknowledged the necessity of a Creator and the existence of moral principles. Some even believed in an afterlife. But they also felt that the miracles the scriptures record were an affront to the perfection of God's creations—that once the world was established, God should have no need to tinker with it. Deists considered the Resurrection, the Atonement, and the divine sonship of Christ contrary to the natural order, lacking in supporting evidence—and therefore unreasonable.

Because these skeptics borrowed from the most advanced scientific thinking of the time, many Christian intellectuals felt compelled to defend their faith in terms deists would accept—with fact and reason, grounded in objective observation.

For many of the Christian apologists, authentication of biblical miracles seemed to be the answer. Because a miraculous healing occurred outside the natural order of things, they felt it was "proof" of the supernatural. Thus, a miracle would be a "stamp" of divine authenticity on a miracle-worker's teachings. One Christian apologist, for example, claimed that if it could be proved that Moses did indeed part the Red Sea, "it must necessarily follow, that he was sent from God." 1 Similarly, Christians of the time felt that proof of the Resurrection would authenticate Christ's teachings.

But authentication of miracles was no simple matter. How could a neutral observer distinguish Moses' powers from those of the Egyptian wizards? And how could Christians "authenticate" biblical miracles?

By the end of the eighteenth century, William Paley, onetime lecturer at Cambridge and archdeacon of Carlisle, had examined "the direct historical evidences of Christianity." For him, the crux of the matter was the credibility of witnesses. Paley showed that "many professing to be original witnesses of the Christian miracles, passed their lives in labours, dangers, and sufferings, voluntarily undergone in attestation of the accounts which they delivered." 2 The point was that the witnesses were willing to suffer for their beliefs with no other motivation than their faith in the truthfulness of the miracle.

Paley claimed that those who had witnessed miracles firsthand and who had had an opportunity to detect fraud would not have suffered so much to spread Christ's teachings had Christ been a deceiver. Their lives, Paley claimed, were proof that they had seen miracles. No promise of wealth, power, or glory won Jesus' followers to his cause, Paley claimed; their only motive for believing in him was the evidence of their senses. Christianity, therefore, was grounded in reason. 3

Paley's arguments appeared in more than a score of books on Christian evidences printed in the United States and Britain in the first half of the nineteenth century. Consequently, Christians of Joseph Smith's time were highly sensitive about the subject of false prophets. False prophets and miracle-working shysters threatened the reasoning on which rational faith was founded; each one had to be proved counterfeit in order to protect the authentic prophets' integrity.

Thus, Christian apologists treated false prophets with contempt, and they were serious about invalidating their claims.

This is one reason why Joseph Smith was attacked so vigorously by some Christian apologists. He was automatically assumed to be a false prophet and hence needed to be exposed. Among these writers and thinkers was Alexander Campbell, who in February 1831 began writing about the Book of Mormon in his own newspaper, the Millennial Harbinger. Another was Obediah Dogberry, editor of the Palmyra Reflector, whose six-part series on Joseph Smith had begun a month earlier.

Efforts to Discredit Joseph

Campbell and Dogberry both began their "analyses" with accounts of religious imposters. The names differed, but both messages were the same: "Every age of the world has produced imposters and delusions." 4 Dogberry, for example, referred to Joanna Southcote, a false prophetess who had recently attracted a large following in London: "If an imposture, like the one we have so briefly noticed, could spring up in the great metropolis of England and spread over a considerable portion of that kingdom, it is not surprising that one equally absurd, should have its origin in this neighborhood." 5 The effect in both cases was the same: association in readers' minds with religious imposters discredited Joseph Smith before anything about him was known.

Having classified Joseph Smith among the imposters, Campbell and Dogberry then followed Paley's and other apologists' established patterns for distinguishing false prophets. Dogberry, for example, sought to "prove" that Joseph Smith had not begun his prophetic career with a miracle.

"It is well known that Joe Smith never pretended to have any communion with angels, until a long period after the pretended finding of his book," he wrote. 6 Dogberry argued that Joseph was merely a money-digger who propagated and believed superstitions associated with hidden treasures. To Dogberry, it appeared "quite certain that the prophet himself never made any serious pretentions to religion until his late pretended revelation." 7 By these arguments, Dogberry tried to undercut Joseph's accounts of heavenly visitations by saying that Joseph made the miracles up later to confirm his call as a prophet. According to Dogberry, since Joseph had something to gain from claiming miracles, his testimony was invalid.

Joseph Smith's Response to His Critics

In such a climate, Joseph Smith might have been expected to answer the skeptics' charges with miraculous "proof." After all, the scriptures promised signs to believers. But Joseph Smith didn't. Why?

The answer lies in the Lord's reply to those who sought signs and miracles as "proof." In July 1830 the Lord told Joseph Smith and Oliver Cowdery to "require not miracles." (D&C 24:13.) "He that seeketh signs shall see signs, but not unto salvation," the Lord said a year later. (D&C 63:7.) "Faith cometh not by signs," he continued, "but signs follow those that believe. … Wherefore, I, the Lord, am not pleased with those among you who have sought after signs and wonders for faith, and not for the good of men unto my glory." (D&C 63:9–12.) Miracles occur to bless the faithful, not to convert skeptics.

To Campbell, it seemed preposterous that he "must believe [the Book of Mormon] first, and then ask God if it be true!" 8 Christian rationalists expected miracles first, then faith. "Have they wrought any miracles?" Campbell asked. 9 Without evidence of a miracle, he readily dismissed even the Three Witnesses' testimony, implying that it was no more weighty than testimonials in patent medicine advertisements.

It is true that the witnesses made little of the supernatural aspect of the experience; they were more concerned about testifying of the Book of Mormon's truth. For them, the angel's appearance was not the heart of the matter.

Only once, to my knowledge, did Joseph Smith even partway meet the rationalists' demand for evidence. The 1838 account of the First Vision meets Paley's standards: Joseph was a neutral observer whose call began with a miracle, and he remained committed to his account of the story despite persecution and even death. When he later reported what he had seen, he was scorned. Yet he never denied it: "Though I was hated and persecuted for saying that I had seen a vision, yet it was true." (JS—H 1:25.) Joseph suffered for a miraculous story just as the early Christians did. Though he said little to counter skeptics' arguments, the "proof," by rationalist standards, is that he stuck with his story to the end.

Modern Answers to Skeptics

Since Joseph's time, a number of Latter-day Saints have dealt with skeptics using the arguments of Christian rationalists like Paley. B. H. Roberts's New Witness for God presents both internal and external evidences for the Book of Mormon, much like the rationalists' defense of the Bible. In fact, B. H. Roberts devotes a large part of his external evidences to miracles and prophecy.

The work of more recent Latter-day Saint apologists departs from the standard nineteenth-century patterns but still seeks rationalist answers to the skeptics' questions. Their work is interesting and helpful to people with a scholarly bent of mind. Hugh Nibley's Lehi in the Desert sustained my faith at a critical moment. Other Latter-day Saint scholars have subjected the Book of Mormon to rational tests and come up with illuminating analyses of the narrative's complexity, its unexpected consistencies, and its clear marks of antiquity.

Yet we do not depend on such "proofs" to persuade unbelievers. A testimony of the gospel comes through faith—not from proofs based on the parting of the Red Sea or the raising of the dead. The Prophet Joseph Smith and Sidney Rigdon simply declared, "He lives! For we saw him." (D&C 76:22–23.) Today, millions of Church members also testify that he lives because the Holy Ghost has impressed the reality of God's existence on their minds and hearts. This is our evidence.

Footnotes:

1. Charles Leslie, A Short and Easy Method with Deists, wherein the Certainty of the Christian Religion is Demonstrated by Infallible Proof from Four Rules, in a Letter to a Friend (Cambridge: New American Edition, 1805), p. 5.
2. J. Belcher, A View of the Evidences of Christianity, in The Works of William Paley, 5 vols. (Boston: 1810–12), 2:title page, v, 65, 66.
3. Ibid.
4. Alexander Campbell, Delusions: An Analysis of the Book of Mormon (Boston: Benjamin H. Greene, 1832), p. 5.
5. Palmyra Reflector, 28 Jan. 1831, quoted in Francis W. Kirkham, A New Witness for Christ in America: The Book of Mormon, 4th ed., 2 vols. (Salt Lake City: Utah Printing Co., 1967), 1:289.
6. Ibid., 4 Feb. 1831—see Kirkham, 1:291.
7. Ibid., 21 Jan. 1831—see Kirkham, 1:287–88.
8. Campbell, Delusions, p. 15.
9. Ibid.

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Jonathan Wells
Darwinism and the Argument to Design

The controversy between Christianity and Darwinism involves a number of complex issues. One of these is a conflict over design. According to the received view, the root of the conflict is that Darwinism undermines the argument that God's existence can be proved from design in living things.

It seems to me that there is a basic conflict between Christianity and Darwinism on the issue of design. In my view, however, the source of the conflict is not the argument that God's existence can be proved from design, but something far more serious. The purpose of this essay is to analyze the logical function of design in the controversy between Christianity and Darwinism.

Christianity
As used in the following discussion, "Christianity" refers to the mainstream theological traditions of the Eastern Orthodox, Roman Catholic, and Protestant branches of Christianity. To make the discussion manageable, I have chosen two representative theologians from each branch: Athanasius and Maximus from Orthodoxy; Augustine and Aquinas from Catholicism; and Luther and Calvin from Protestantism. The only issue of interest here is design: how does design function in the thought of these representative theologians?

The first noteworthy observation is that arguments for the existence of God from design in the creation are almost completely absent. Aquinas, to be sure, referred in his Summa Theologiae to the tendency of natural bodies to act for ends, as a way to prove the existence of God; and he referred in his Summa Contra Gentiles to the argument that God's existence can be proved from the general order of the world.(1) In the context of Aquinas' work as a whole, however, these references are isolated and almost insignificant. Indeed, it has been argued that Aquinas did not advocate a natural theology at all, but was merely cataloging arguments used by others.(2) Likewise, although Calvin wrote that God "daily discloses himself in the whole workmanship of creation," he considered the disclosure to be "in vain" (because of the fall) without the "spectacles" of scripture.(3)

In fact, the argument for God's existence from design in the creation was something of an aberration in the history of Christian theology, its prominence being limited to Anglo-American thought from the end of the seventeenth century to the middle of the nineteenth century. References to design are prominent in the history of Christian theology, but not as premises in proofs for the existence of God. Instead, design consistently functions as a conclusion which follows from the nature of God. God's existence thus implies design, rather then vice versa.

For example, Athanasius affirmed, in opposition to Arianism, that the full divinity of the Logos is the basic starting point for all Christian theology. This means that the generation of the Logos must not have been an act of God's will, as though God could have chosen to be without the Logos or as though there could have been a time when the Logos did not exist. To be fully divine, the Logos must have been generated not by will but by nature: "A man by counsel builds a house, but by nature he begets a son; and what is in building began to come into beginning at will, and is external to the maker; but the son is proper offspring of the father's essence, and is not external to him." Therefore, the fundamental difference between the Logos and the creation is that the former is eternally generated by nature, from God's own substance; while the latter is produced by an act of God's will, and has a beginning in time.(4)

The creation, then, unlike the Logos, is the result of divine counsel or deliberation. Athanasius emphatically rejected the notion that "things have come into being of themselves, and in chance fashion," or that things have originated independently of purpose. On the contrary, "counselling

goes before things which once were not, as in the case of all creatures," and the Son "is Himself the Living Counsel of the Father, by which all things have come to be." The Son, however, like the Father, is "unalterable and unchangeable"; so the divine counsel is eternal, and God's will and purpose were with God "before the world." Whatever exists is thus preceded by "its pattern in God."(5)

Athanasius maintained that God's creatorship, like God's providence, extended to small details: "If then it be not unworthy of God to exercise His Providence, even down to things so small, a hair of the head, and a sparrow, and the grass of the field, also it was not unworthy of Him to make them. For what things are the subjects of His Providence, of those He is Maker through his proper Word."(6) Since God's providence and creatorship extend " even down to things so small," they extend a fortiori to the human species. God not only "fashioned the race of men" in "His own image," but also foresaw the fall and provided for redemption: just as a wise architect would make provisions for repairing a house "should it any time become dilapidated," so "in the same way prior to us is the repair of our salvation founded in Christ."

In other words, the incarnation of the Logos in a human body was predestined from eternity. Christ's body, which "is of no different sort from ours,"was thus made, at the proper time, according to God's eternal plan.(7)

Maximus the Confessor, in opposition to Origen's implicit claim that God creates by necessity, relied on the Athanasian distinction between nature and will to reaffirm God's freedom. According to Maximus, the logoi, or patterns, of all creatures exist eternally in the mind of God, but they are the products of God's will rather than God's nature. At the appropriate time, God creates substantial realities according to their pre-existent logoi, which are thus the bases for diversity and movement in the corporeal universe. Therefore, all things are the intended products of God's creative act. This does not mean that every detail of every being conforms perfectly to its pe-existent logos. Maximus allowed for some variation due to the tropos, or mode of existence, which affects the extent to which a being actualizes its eternal and unchanging logos. Nevertheless, by affirming that God's will is the origin not only of all created beings, but also of their pre-existent patterns, Maximus safeguarded God's sovereignty and purposefulness.(8)

Human beings, in particular, are created according to the will of God. Whereas Origen had taught that human bodies were the result of the fall of pre-existent souls, Maximus held that God creates body and soul together. Though body and soul are distinguishable, they are inseparable, and only together do they form a complete species. The one constitutive factor for both is the will of God, whose divinity is reflected in the psycho-physical unity of the whole human being, and not just the soul.(9) According to Maximus, the human being is designed to be a microcosm in which the mental, spiritual, and physical aspects of creation are united. Furthermore, this microcosm is intended to unite with, and partake of, the divine nature, thereby uniting the world with its creator. This cosmic union, which is finally achieved in the incarnation of the Logos in Christ, is the fulfillment of God's original purpose for creating the universe. The incarnation was thus foreordained, independently of the fall, from eternity.(10)

Augustine, opposing the cosmogonic dualism of the Manicheans, affirmed that the creator of all that exists is God: "Whatever is, since it is, and in whatever degree it is, has its existence from the one God." In defense of God's sovereignty, Augustine insisted that all created beings have their forms or rationes aeternae in "the very mind of the Creator." All things are thus made according to God's eternal and unchanging plan: "Because therefore the Word of God is One, by which all things were made, which is the unchangeable truth, all things are simultaneously therein, potentially and unchangeably; not only those things which are now in this whole creation, but also those which

have been and those which shall be." In other words, "the Wisdom of God, by which all things have been made contains everything according to design before it is made."(11)

According to Augustine, God's creatorship extends to all forms of existence: "even the lowest form is of God. And the same may be said of species." The "lowliest and the smallest creatures are obviously fashioned by such a remarkable plan that a moment's serious attention to them fills the beholder with inexpressible awe and wonder"; and if they appear to us to be tiny and contemptible, it may only be that "on account of our pride, God appointed that tiny and contemptible creature to torment us." But if God's design extends even to the lowest forms of life, it extends a fortiori to human beings, who were "certainly" created in the form which God foreordained "before the ages."(12)

Although it is not completely clear whether Augustine believed that foreordination extends to the precise form of every individual, it is clear that Augustine considered human beings and every other kind of creature to be designed by God: "all things are created on a rational plan, and man not by the same rational plan as horses, for it is absurd to think this. Therefore individual things are created in accord with rationes unique to them."(13)

Aquinas endeavored to synthesize Christian theology with Aristotelian philosophy. Since Augustine's notion of the rationes aeternae was borrowed from the Neoplatonists (though unlike Plato or the Neoplatonists, Augustine placed the ideas in the mind of the supreme deity), and since Aristotle had rejected the Platonic doctrine of ideas, it might be expected that Aquinas would reject the Augustinian doctrine of ideas. Quite to the contrary, however, Aquinas considered it "necessary to suppose ideas in the divine mind," just as "the likeness of a house pre-exists in the mind of the builder." According to Aquinas, things receive their determinate forms because "in the divine wisdom are the types of all things, which types we have called ideas, i.e., exemplar forms existing in the divine mind."(14)

The fact that Aquinas' view of the divine ideas resembles Augustine's, however, does not mean that Aquinas merely incorporated the doctrine in his theology out of respect for authority. Although the language may be borrowed from Augustine, the concept follows directly from central aspects of Aquinas' doctrine of God. First, it follows from God's intelligent, purposeful, and free creatorship. Since "the world was not made by chance, but by God acting by His intellect," therefore "there must exist in the divine mind a form to the likeness of which the world was made. And in this the notion of idea consists." The doctrine safeguards God's intelligent purposefulness, since it necessarily implies previous planning in the production of creatures, and "those who say that all things happen by chance cannot admit the existence of ideas." It also safeguards God's freedom, in opposition to the notion that the world emanates by necessity from God's nature. Creatures pre-exist in God's nature only "after the mode of intellect," but they "proceed from Him after the mode of will." Since "a form considered by the intellect does not move or cause anything except through the will," it is God's free will and not God's nature which determines what is actually created.(15)

Second, the doctrine of ideas is implied in the doctrine of the trinity, since "in the Word is implied the operative idea of what God makes." Just as there "pre-exists in the mind of a craftsman a certain image of his external work," so also does there "pre-exist in the mind of one who pronounces an exterior word a certain archetype of it." This archetype, or "interior word," is the word of God; and the ideas of things to be made are thus metaphorically called the word of God. Aquinas interpreted the prologue to the Gospel of John accordingly: "In the beginning was the Word" means the things originate from God's intellect and purpose, "and not from chance."(16)

In particular, the human species was deliberately designed by God. Although it is possible that some species distinctions do not have their source in the divine ideas, Aquinas maintains that the

human soul is "made to the image of God," and that "God fashioned the human body" in order to "make it suitably proportioned to the soul."(17)

Luther considered the essential teaching of the Old and New Testaments to be our total dependence on God in Christ. Our total dependence on God, in turn, presupposes that we owe our very existence to God as our creator.(18) For God to be the creator means, for Luther, that "the creation is not fortuitous but the exclusive work of divine foresight." From all eternity, God "has a Word, a speech, a thought, or a conversation with Himself in His divine heart"; and from this conversation, "heaven and earth, all creatures, both the visible and the invisible, come into being." Therefore, "all His works are some words of God, created by the uncreated Word." Since God creates out of nothing, which means without the need for any instrumentality or pre-existing material, Luther considers creation to be "a kind of birth." This birth, however, takes place "at the command of God," as a product of God's will rather than as a pantheistic emanation from God's nature. But Luther is less concerned with issues such as this than he is with the immediate significance of the doctrine of creation for the faith of the believer: we should know, for example, that even " great sea animals" are created by God, "lest we be frightened;" then "we may more readily believe that God can preserve us too, even though we are far smaller beings." Similarly, according to Luther, God tells us in Isaiah 40:28, "I have made all these things, they are my creatures, they are under My control, they cannot touch the least hair of your head. Do not be afraid." God's creatorship, then, means that "we must take note of God's power that we may be completely without doubt about the things which God promises in His word."(19)

It is not merely the initial creation of the universe which demonstrates God's power. Luther explained that God is not like a carpenter who "turns over the house to its owner" when he finishes constructing it; instead, God "continues to preserve His creation through the Word." In fact, "if the Creator, who continues to work forever and ever, and His Co-worker were to interrupt Their work, all would go to wrack and ruin in a twinkling." Luther draws from this the lesson that "as we human beings did not create ourselves, so we can do nothing at all to keep ourselves alive for a single moment by our own power. The fact that I grow and develop is God's work alone," and Luther meant this in the strongest possible sense. He even interpreted Isaiah 44:24 as being equivalent to a statement by God that "whatever is done, I alone have done it."(20) Modern commentators point out that, for Luther, God is thus the only true agent. God does absolutely everything, and whatever happens is a direct result of God's activity. Therefore, created beings are what Luther calls larva dei, or visible masks of the invisible God, testifying to God's omnipresent power, and encouraging us to "fear and trust only in God."(21)

Given Luther's belief that God does all and creatures can do nothing, it is unlikely that he would attribute even the smallest detail of creation to anything other than God's purposeful activity. Among the forms of life that he specifically attributes to God's design are "herbs and trees," which were created "for our sustenance." He also considers the mouse to be "created by the Word of God with a definite plan in view," so that "here, too, we admire God's creation and workmanship." Furthermore, "the same thing can be said about flies." Above all, however, man and woman were "created by the special plan and providence of God," specifically "for the knowledge and worship of God."(22)

Calvin considered the creation a "theater of the divine glory," but because of the fall "we have not the eyes to see this unless they be illumined by the inner revelation of God through faith." Once we have been given the "spectacles" of scripture, however, "the most perfect way of seeking God" is "to contemplate him in his works." Through the eyes of faith the believer sees design in the creation, which then nourishes that faith in return. Thus "although it is not the chief evidence for faith, yet it is the first evidence in the order of nature, to be mindful that wherever we cast our eyes, all things

they meet are works of God, and at the same time to ponder with pious meditation to what end God created them."(23)

Of all God's works, the "most excellent example" is humankind. Calvin interprets the "let us make man" of Genesis 1:26 as God's way of "commending to our attention the dignity of our natures," since God made all other creatures by command, but "enters into consultation" before making us. Furthermore, human beings are created in the divine image, the "chief seat" of which is in the mind and heart, though some "scintillations" shine in every part, including the body. Human beings are especially created "to seek God" and "to behold the works of God," and they are endowed with reason and under-standing "that they might acknowledge their Creator." The rest of the universe, in turn, was "established especially for the sake of mankind." According to Calvin, "the world was originally created for this end, that every part of it should tend to the happiness of man." God "filled the earth, waters, and air with living things, and brought forth an abundance of fruits," and thereby "shows his wonderful goodness toward us."(24)

Calvin emphasized that God not only created but also preserves and governs the world. In fact, according to Calvin, God completely controls all events. Without denying the existence of secondary causes, Calvin nevertheless insisted that "nothing happens except what is knowingly and willingly decreed" by God. Calvin specifically objected not only to those who would "substitute nature for God" by making nature "the artificer of all things," but also to those who would attribute anything less than absolute control to God. Included in this latter category are people who "in place of God's providence substitute bare permission--as if God sat in a watchtower awaiting chance events," as well as people who attribute to God a providence which merely "by a general motion revolves and drives the system of the universe" but which "does not specifically direct the action of individual creatures." For Calvin, God "so regulates all things that nothing takes place without his deliberation," and "not one drop of rain falls without God's sure command." What may appear to be a chance occurrence is "only that of which the reason and cause are secret," and the secret cause is God's foreordination. Though "for us they are fortuitous," such events are "governed by God's incomprehensible plans."(25) Since there is no such thing as chance, according to Calvin, God must have designed every detail of every living thing.

This survey of representative theologians demonstrates that design was important to all of them. It was not important, however, as a reason for believing in God; instead, it followed as a logical consequence from their understanding of God's nature. In a sense, they used, not an argument from design, but an argument to design. Although they differed in their notions of what creatures, exactly, were designed by God, they all agreed that human beings were designed, and that this claim is central to Christian belief.

In Christian theology, then, two fundamentally different design arguments can be distinguished:

The Argument From Design

If human beings are designed, then God exists.

Human beings are designed.

Therefore, God exists.

The Argument To Design

If God exists, then human beings are designed.

God exists.

Therefore, human beings are designed.

In a discussion of Darwinism, it is important to note that the logical consequences of denying design differ radically in the case of these two arguments. It would be illogical, for example, to conclude from a denial of design, via the argument from design, that God does not exist: this would be the fallacy of denying the antecedent. On the other hand, it follows necessarily (by modus tollens) that a denial of design, in the argument to design, is tantamount to a denial of God's existence. Since the argument to design is prominent in the mainstream theological traditions of Christianity, any theory which denies that human beings are designed would amount, for those traditions, to an affirmation of atheism. (This was the reasoning used by Princeton theologian Charles Hodge in his 1874 book, What Is Darwinism?)(26)

The question, then, is: does Darwinism claim that human beings are not designed?

Darwinism

It is well known that Charles Darwin did not originate the notion of evolution. Etymologically, "evolution" means "unrolling," and it was first used in biology about two centuries ago to refer to the development of an embryo. As used in modern biology, however, evolution refers in its most general sense to the origin and diversification of living organisms, in which later stages are somehow descended or derived from earlier ones. Although Darwin contributed to the wide acceptance of biological evolution by adducing a large amount of evidence for it, his principal contribution was to propose a theory about its mechanism. Since the general phenomenon of evolution is distinct from any particular theory about its mechanism, one may be an evolutionist without being a Darwinist (as, for example, Lamarck was an evolutionist before Darwin.)

As used in the following discussion, Darwinism refers to the theory set forth by Charles Darwin himself in the various editions of The Origin of Species, The Descent of Man, The Variation of Plants and Animals Under Domestication, and in his correspondence. Darwin's theory ascribes evolution to the natural selection of small variations which occur among the individuals in any given species. According to the theory, those variations are random with respect to the fitness of the in-dividual or to the direction of evolution (i.e., they do not arise in response to the needs of an organism or in accordance with any plan), and any given environment "selects" (in a manner analogous to a breeder of plants or livestock) those individuals whose variations render them more likely to survive (i.e., natural selection is survival of the fittest).

Harvard botanist Asa Gray, Darwin's most influential ally in nineteenth-century America, defended every aspect of Darwin's Origin of Species except its apparent exclusion of design. Gray believed that naturalists are justified in seeing design in the variations which give rise to species, and he advised Darwin to assume "that variation has been led along certain beneficial lines. Streams flowing over a sloping plain by gravitation (here the counterpart of natural selection) may have worn their actual channels as they flowed; yet their particular courses may have been assigned." Gray also compared variations to raindrops: those which fall into the ocean "are as much without a final cause as the incipient varieties which come to nothing! Does it therefore follow that the rains which are bestowed upon the soil with such rule and average regularity were not designed to support vegetable and animal life?" Gray did not insist, however, that all variations must be designed: "the accidental element may play its part in Nature without negativing design in the theist's view." Indeed, the accidental element in Darwin's theory is the basis of its advantage in explaining useless or harmful adaptations. But Gray was convinced that useful adaptations testify to design: since natural selection merely picks out variations which are independently presented to it, the presence of design in the result indicates that at least some variations are designed.(27)

Darwin disagreed. He wrote to Gray that he was "charmed" with the stream metaphor, but he concluded his next book, The Variation of Plants and Animals Under Domestication, with a lengthy refutation of Gray's position.(28) Using the metaphor of a house built by an architect utilizing uncut fragments of stone, Darwin explained that "the fragments of stone, though indispensable to the architect, bear to the edifice built by him the same relation which the fluctuating variations of each organic being bear to the varied and admirable structures ultimately acquired by its modified descendants." The shape of each fragment "may be called accidental, but this is not strictly correct; for the shape of each depends on a long sequence of events, all obeying natural laws." Nevertheless, "in regard to the use to which the fragments may be put, their shape may be strictly said to be accidental." In Darwin's metaphor, of course, the architect is natural selection.(29) Darwin continued:

Can it be reasonably maintained that the Creator intentionally ordered, if we use the words in any ordinary sense, that certain fragments of rock should assume certain shapes so that the builder might erect his edifice? If the various laws which have determined the shape of each fragment were not predetermined for the builder's sake, can it with any greater probability be maintained that He specially ordained for the sake of the breeder each of the innumerable variations in our domestic animals and plants; - many of these variations being of no service to man, and not beneficial, far more often injurious, to the creatures themselves? Did He ordain that the crop and tail-feathers of the pigeon should vary in order that the fancier might make his grotesque pouter and fantail breeds? Did He cause the frame and mental qualities of the dog to vary in order that a breed might be formed of indomitable ferocity, with jaws fitted to pin down the bull for man's brutal sport? But if we give up the principle in one case - if we do not admit that the variations of the primeval dog were intentionally guided in order that the greyhound, for instance, that perfect image of symmetry and vigor, might be formed - no shadow of reason can be assigned for the belief that variations, alike in nature and the result of the same general laws, which have been the groundwork through natural selection of the formation of the most perfectly adapted animals in the world, man included, were intentionally and specially guided.(30)

In his correspondence, Darwin elaborated on his claim that variations could not be designed. His reasoning can be divided into three categories: scientific, philosophical, and theological. The first category includes the observation that the vast majority of variations are useless or harmful rather than beneficial. It thus makes no sense to Darwin to say that variations are designed: if someone says "God ordained that at some time and place a dozen slight variations should arise, and that one of them alone should be preserved in the struggle for life and the other eleven should perish in the first or first few generations, then the saying seems to me mere verbiage. It comes to merely saying that everything that is, is ordained." The second category of reasons includes the philosophical assumption that naturalistic science is competent to investigate and explain the origin of species. The idea that "each variation has been providentially arranged seems to me to make Natural Selection entirely superfluous, and indeed takes the whole case of the appearance of new species out of the range of science." The third category includes Darwin's conviction that designing each slight variation would be beneath God's dignity and contrary to God's benevolence. Referring once again to the breeding of domestic pigeons, Darwin notes that "it seems preposterous that a maker of the universe should care about the crop of a pigeon solely to please man's silly fancies." Furthermore, "I cannot persuade myself that a beneficent and omnipotent God would have designedly created the Ichneumonidae with the express intention of their feeding within the living bodies of Caterpillars, or that a cat should play with mice. Not believing this, I see no necessity in the belief that the eye was expressly designed."(31)

Darwin reasons that unless all variations are designed, none of them are. If the "interposition of the Deity" is uncalled for in the case of domestic variations, he could "see no reason whatever for

believing in such interpositions in the case of natural beings." Or "if anything is designed, certainly man must be," but Darwin "cannot admit that man's rudimentary mammae...were designed," therefore (by implication) man is not designed. Such all-or-nothing reasoning seems to be based primarily on Darwin's commitment to naturalistic explanation: either the origin of species can be explained in exclusively naturalistic terms, or it cannot really be explained at all. Darwin writes that he "would give absolutely nothing for the theory of Natural Selection, if it requires miraculous additions at any one stage of descent." To a lesser extent, his reasoning may have been based on his understanding of the idea of God: if the deity were going to pre-ordain any details, then an omnipotent and omniscient deity would presumably pre-ordain all; but a wise and benevolent deity would not ordain many of the details which are actually observed; therefore (by implication), no details are pre-ordained. Whatever the basis, Darwin's reasoning leads him to conclude that all variations are undesigned.(32)

Darwin also denies that natural selection, the second major element in his theory, could lead to designed results. Although he compares natural selection to an architect, he repeatedly denies that he intends to attribute conscious agency to it. He repudiates the anthropomorphic connotations which many of his contemporaries associate with the selection metaphor, insisting that he uses it only "as a geologist does the word denudation - for an agent, expressing the result of several combined actions." Since natural selection is power-less without variations, which arise independently of it, he sometimes wishes he had used the term "natural preservation"; but by the time the confusion became obvious, the former term was "so largely used abroad and at home that I doubt whether it could be given up." In addition to this negative reason for retaining the term, Darwin has positive reasons as well: natural selection is analogous to artificial selection not only in its dependence on variations, but also in the impressiveness of its results. Natural selection solves the problem of how organisms become adapted to the conditions of life, "as artificial selection solves the adaptation of domestic races for man's use." Furthermore, the former is more efficient than the latter: a domestic breeder "scarcely selects except external and visible characters, and secondly, he selects for his own good; whereas under nature, characters of all kinds are selected exclusively for each creature's own good." Darwin can thus see "no limit to the perfection of the coadaptations which could be effected by Natural Selection." It is still the case, however, that "natural selection means only the preservation of variations which independently arise."(33)

In what senses, then, could natural selection be said to produce designed results? One twentieth-century study of Darwin's own views on the subject concludes that there are at least three such senses: natural selection [1] will always produce adaptation of the organism to its environment, [2] will never produce in an organism structures that are harmful to it, and [3] will never produce structures in one organism solely for the benefit of another. Since these can legitimately be regarded as "purposes," it would be incorrect to say that Darwin considers natural selection totally purposeless. On the other hand, natural selection does seem to exclude the claim that specific organs or organic forms are designed. According to Darwin, not even organs of sight or the order of primates, much less the human eye or the human species, could be considered designed results of natural selection.(34)

Therefore, Darwin concluded that "there seems to be no more design in the variability of organic beings, and in the action of natural selection, than in the course which the winds blow."(35) This does not mean, however, that Darwin is willing to attribute every aspect of evolution to chance. He repeatedly affirmed his "inward conviction" that "the Universe is not the result of chance." Although he distrusted this conviction, since he believed that the human mind is descended from the minds of lower animals, he appeared to be genuinely persuaded of "the extreme difficulty or rather impossibility of conceiving this immense and wonderful universe" as "the result of blind chance or necessity." This put him in "a simple muddle; I cannot look at the universe as the result of blind chance, yet I can see no evidence of beneficent design, or indeed of design of any kind, in the

details." Although he feared that the issue may ultimately be incomprehensible, he is "inclined to look at everything as resulting from designed laws, with the details, whether good or bad, left to the working out of what we may call chance."(36)

This last statement is probably the best summary of Darwin's mature position on design. Although it is likely that he never resolved the question of ultimate purpose to his own satisfaction, he at least believed that his theory does not exclude all design: someone could embrace Darwinism and yet consistently maintain that natural laws, including the laws of variation and natural selection, are designed. According to Darwin's own understanding of the theory, however, specific details are due to chance, not merely in the sense that their causes are unknown but in the sense that they are really accidental. Neither of the two major elements in the theory can be plausibly interpreted as directed: not variation, because it is predominantly useless or harmful; and not natural selection, because its only function is to insure that the few survivors of the struggle for life will be better able to withstand the next round. If evolution is really due to these two factors, then the particular forms taken by organisms, species, genera, and orders are accidental. Therefore, Darwin's version of Darwinism excludes the possibility that any specific form of life is designed. In particular, it implies that human beings, as the latest products of an inherently directionless process, must be regarded as undesigned.

Note that this issue here is not methodological agnosticism with regard to design, but a complete exclusion of designed results. The former, it seems, is a necessary characteristic of all scientific theories, and in that sense such theories might be called "ateleological." Darwin's theory, however, (at least according to his interpretation of it) takes a further step and might properly be called "anti-teleological." To illustrate: Newton's laws of motion ignore the issue of design, but they may be used to produce designed results; given a complete knowledge of initial conditions, the result can be predicted. Darwin's theory, however, precludes any determinate outcome of evolution. In particular, Darwinism excludes design in human beings.

Thus there is a fundamental conflict between Darwin's theory and the Christian theological tradition. The conflict is not between Christianity and evolution, and has nothing to do with natural theology. For the Christian theologians surveyed here, a basic consequence of Christian belief in God is the belief that the human species was designed by God. Darwin denies the latter, and thus logically denies the former as well.

There are, of course, people who disagree, and who regard Christianity and Darwinism as perfectly compatible with each other. The two cannot be regarded as compatible, however, unless the former is taken to mean something other than what the mainstream theological tradition through the Protestant Reformation has meant by Christianity, or the latter is taken to mean something other than what Charles Darwin meant by Darwinism.

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Chapter 8 - Designer Universe

HUMAN BEINGS have always been awestruck by the subtlety, majesty, and intricate organization of the physical world. The march of the heavenly bodies across the sky, the rhythms of the seasons, the pattern of a snowflake, the myriads of living creatures so well adapted to their environment—all these things seem too well arranged to be a mindless accident. There is a natural tendency to attribute the elaborate order of the universe to the purposeful workings of a Deity.

The rise of science served to extend the range of nature's marvels, so that today we have discovered order from the deepest recesses of the atom to the most distant galaxies. But science has also provided its own reasons for this order. No longer do we need theological explanations for snowflakes, or even for living organisms. The laws of nature are such that matter and energy can organize themselves into the complex forms and systems which surround us. Though it would be rash to claim that scientists understand everything about this self-organization, there seems to be no fundamental reason why, given the laws of physics, all known physical systems cannot be satisfactorily explained as the product of ordinary physical processes.

Some people conclude from this that science has robbed the universe of all mystery and purpose, and that the elaborate arrangement of the physical world is either a mindless accident or an inevitable consequence of mechanistic laws. "The more the universe seems comprehensible, the more it also seems pointless," believes physicist Steven Weinberg: The biologist Jacques Monad echoes this dismal sentiment: "The ancient covenant is in pieces: man at last knows that he is alone in the unfeeling immensity of the universe, out of which he has emerged only by chance. Neither his destiny nor his duty have been written down.'"

Not all scientists, however, draw the same conclusions from the facts. Though accepting that the organization of nature can be explained by the laws of physics, together with suitable cosmic initial conditions, some scientists recognize that many of the complex structures and systems in the universe depend for their existence on the particular form of these laws and initial conditions. Furthermore, in some cases the existence of complexity in nature seems to be very finely balanced, so that even small changes in the form of the laws would apparently prevent this complexity from arising. A careful study suggests that the laws of the universe are remarkably felicitous for the emergence of richness and variety. In the case of living organisms, their existence seems to depend on a number of fortuitous coincidences that some scientists and philosophers have hailed as nothing short of astonishing.

The Unity of the Universe

There are several different aspects to this "too-good- to-be- true" claim. The first of these concerns the general orderliness of the universe. There are endless ways in which the universe might have been totally chaotic. It might have had no laws at all, or merely an incoherent jumble of laws that caused matter to behave in disorderly or unstable ways. Alternatively, the universe could have been extremely simple to the point of featurelessness—for example, devoid of matter, or of motion. One could also imagine a universe in which conditions changed from moment to moment in a complicated or random way, or even in which everything abruptly ceased to exist. There seems to be no logical obstacle to the idea of such unruly universes. But the real universe is not like this. It is highly ordered. There exist well-defined laws of physics and definite cause-effect relationships. There is a dependability in the operation of these laws. The course of nature continues always uniformly the same, to use David Hume's phrase. This causal order doesn't follow from logical necessity; it is a synthetic property of the world, and one for which we can rightly demand some sort of explanation.

The physical world does not merely display arbitrary regularities; it is ordered in a very special manner. As explained in chapter 5, the universe is poised interestingly between the twin extremes of simple regimented orderliness (like that of a crystal) and random complexity (as in a chaotic gas). The world is undeniably complex, but its complexity is of an organized variety. The states of the universe have "depth," to use the technical term introduced in chapter 5. This depth was not built into the universe at its origin. It has emerged from primeval chaos in a sequence of self-organizing processes that have progressively enriched and complexified the evolving universe. It is easy to imagine a world that, though ordered, nevertheless does not possess the right sort of forces or conditions for the emergence of significant depth.

There is another sense in which the order of the physical world is special. This concerns the general coherence and unity of nature, and the very fact that we can talk meaningfully about "the universe" at all as an all-embracing concept. The world contains individual objects and systems, but they are structured such that, taken together, they form a unified and consistent whole. For example, the various forces of nature are not just a haphazard conjunction of disparate influences. They dovetail together in a mutually supportive way which bestows upon nature a stability and harmony that are hard to capture mathematically but obvious to anyone who studies the world in depth. I have already tried to convey what I mean by this dovetailing consistency with the use of the crossword analogy.

It is particularly striking how processes that occur on a microscopic scale—say, in nuclear physics—seem to be fine-tuned to produce interesting and varied effects on a much larger scale—for example, in astrophysics. Thus we find that the force of gravity combined with the thermodynamical and mechanical properties of hydrogen gas are such as to create large numbers of balls of gas. These balls are large enough to trigger nuclear reactions, but not so large as to collapse rapidly into black holes. In this way, stable stars are born. Many large stars die in spectacular fashion by exploding as so-called supernovae. Part of the explosive force derives from the action of one of nature's most elusive subatomic particles—the neutrino. Neutrinos are almost entirely devoid of physical properties: the average cosmic neutrino could penetrate many light-years of solid lead. Yet these ghostly entities can still, under the extreme conditions near the center of a dying massive star, pack enough punch to blast much of the stellar material into space. This detritus is richly laced with heavy elements of the sort from which planet Earth is made. We can thus attribute the existence of terrestrial-like planets, with their huge variety of material forms and systems, to the qualities of a subatomic particle that might never have been discovered, so feeble is its action. The life cycles of stars provide just one example of the ingenious and seemingly contrived way in which the large-scale and small-scale aspects of physics are closely intertwined to produce complex variety in nature.

In addition to this coherent interweaving of the various aspects of nature, there is the curious uniformity of nature. Laws of physics discovered in the laboratory apply equally well to the atoms of a distant galaxy. The electrons that make the image on your television screen have exactly the same mass, charge, and magnetic moment as those on the moon, or at the edge of the observable universe. Furthermore, these qualities persist with no detectable change from one moment to the next. The magnetic moment of the electron, for instance, can be measured with ten-figure accuracy; even to such fantastic precision, no variation in this property has been found. There is also good evidence that the basic properties of matter cannot have varied much, even over the age of the universe.

As well as the uniformity of the laws of physics, there is also uniformity in the spatial organization of the universe. On a large scale, matter and energy are distributed extremely evenly, and the universe appears to be expanding at the same rate everywhere and in all directions. This means that an alien being in another galaxy would see very much the same sort of large-scale arrangement of things that we do. We share with other galaxies a common cosmography and a common cosmic history. As described in chapter 2, cosmologists have attempted to explain this uniformity using the so-called inflationary-universe scenario, which involves a sudden jump in the size of the universe shortly after its birth. This would have the effect of smoothing out any initial irregularities. It is important to realize, however, that explaining the uniformity in terms of a physical mechanism does nothing to lessen its specialness, for we can still ask why the laws of nature are such as to permit that mechanism to work. The point at issue is not the way in which the very special form came about, but that the world is so structured that it has come about.

Finally, there is the much-discussed simplicity of the laws. By this I mean that the Laws can be expressed in terms of simple mathematical functions (like the inverse-square law). Again, we can imagine worlds in which there are regularities but of a very complicated sort requiring a clumsy combination of different mathematical factors. The charge that we develop our mathematics precisely to make the world look simple I have dealt with in chapter 6. I believe that the "unreasonable effectiveness" of mathematics in describing the world is an indication that the regularities of nature are of a very special sort.

Life Is So Difficult

I have tried to make a case that the existence of an orderly, coherent universe containing stable, organized, complex structures requires laws and conditions of a very special kind. All the evidence suggests that this is not just any old universe, but one which is remarkably well adjusted to the existence of certain interesting and significant entities (e.g., stable stars). In chapter 7 I explained how this feeling had been formalized by Freeman Dyson and others into something like a principle of maximum diversity.

The situation becomes even more intriguing when we take into account the existence of living organisms. The fact that biological systems have very special requirements, and that these requirements are, happily, met by nature, has been commented upon at least since the seventeenth century. It is only in the twentieth century, however, with the development of biochemistry, genetics, and molecular biology, that the full picture has emerged. Already in 1913 the distinguished Harvard biochemist Lawrence Henderson wrote: "The properties of matter and the course of cosmic evolution are now seen to be intimately related to the structure of the living being and to its activities; . . . the biologist may now rightly regard the Universe in its very essence as biocentric." Henderson was led to this surprising view from his work on the regulation of acidity and alkalinity in living organisms, and the way that such regulation depends crucially upon the rather special properties of certain chemical substances. He was also greatly impressed at how water, which has a number of anomalous properties, is incorporated into life at a basic level. Had these various substances not existed, or had the laws of physics been somewhat different so that the substances did not enjoy these special properties, then life (at least as we know it) would be impossible. Henderson regarded the "fitness of the environment" for life as too great to be accidental, and asked what manner of law is capable of explaining such a match.

In the 1960s the astronomer Fred Hoyle noted that the element carbon, whose peculiar chemical properties make it crucial to terrestrial life, is manufactured from helium inside large stars. It is. released therefrom by supernovae explosions, as discussed in the previous section. While investigating the nuclear reactions that lead to the formation of carbon in the stellar cores, Hoyle was struck by the fact that the key reaction proceeds only because of a lucky fluke. Carbon nuclei are made by a rather tricky process involving the simultaneous encounter of three high-speed helium nuclei, which then stick together. Because of the rarity of triple-nucleus encounters, the reaction can proceed at a significant rate only at certain well-defined energies (termed "resonances"), where the reaction rate is substantially amplified by quantum effects. By good fortune, one of these resonances is positioned just about right to correspond to the sort of energies that helium nuclei have inside large stars. Curiously, Hoyle did not know this at the time, but he predicted that it must be so on the basis that carbon is an abundant element in nature. Experiment subsequently proved him right. A detailed study also revealed other "coincidences" without which carbon would not be both produced and preserved inside stars. Hoyle was so impressed by this "monstrous series of accidents," he was prompted to comment that it was as if "the laws of nuclear physics have been deliberately designed with regard to the consequences they produce inside the stars.'" Later he was to expound the view that the universe looks like a "put-up job," as though somebody had been "monkeying" with the laws of physics.'

These examples are intended merely as a sample. A long list of additional "lucky accidents" and "coincidences" has been compiled since, most notably by the astrophysicists Brandon Carter, Bernard Can, and Martin Rees. Taken together, they provide impressive evidence that life as we know it depends very sensitively on the form of the laws of physics, and on some seemingly fortuitous accidents in the actual values that nature has chosen for various particle masses, force strengths, and soon. As these examples have been thoroughly discussed elsewhere, I will not list them here. Suffice it to say that, if we could play God, and select values for these quantities at whim by twiddling a set of knobs, we would find that almost all knob settings would render the universe uninhabitable. In some cases it seems as if the different knobs have to be fine-tuned to enormous precision if the universe is to be such that life will flourish. In their book Cosmic Coincidences John Gribbin and Martin Rees conclude: “The conditions in our Universe really do seem to be uniquely suitable for life forms like ourselves.”

It is a truism that we can only observe a universe that is consistent with our own existence. As I have mentioned, this linkage between human observership and the laws and conditions of the universe has become known, somewhat unfortunately, as the Anthropic Principle. In the trivial form just stated, the Anthropic Principle does not assert that our existence somehow compels the laws of physics to have the form they do, nor need one conclude that the laws have been deliberately designed with people in mind. On the other hand, the fact that even slight changes to the way things are might render the universe unobservable is surely a fact of deep significance.

Has the Universe Been Designed by an Intelligent Creator?
The early Greek philosophers recognized that the order and harmony of the cosmos demanded explanation, but the idea that these qualities derive from a creator working to a preconceived plan was well formulated only in the Christian era. In the thirteenth century, Aquinas offered the view that natural bodies act as if guided toward a definite goal or end "so as to obtain the best result." This fitting of means to ends implies, argued Aquinas, an intention. But, seeing as natural bodies lack consciousness, they cannot supply that intention themselves.

> Therefore some intelligent being exists by whom all natural things are directed to their end; and this being we call God.

Aquinas' argument collapsed in the seventeenth century with the development of the science of mechanics. Newton's laws explain the motion of material bodies perfectly adequately in terms of inertia and forces without the need for divine supervision. Nor did this purely mechanistic account of the world have any place for teleology (final or goal-directed causes). The explanation for the behavior of objects is to be sought in proximate physical causes—i.e., forces impressed upon them locally by other bodies. Nevertheless, this shift of world view did not entirely put paid to the idea that the world must have been designed for a purpose. Newton himself, as we have seen, believed that the solar system appeared too contrived to have arisen solely from the action of blind forces: This most beautiful system of the sun, planets and comets, could only proceed from the counsel and dominion of an intelligent and powerful Being.'" Thus, even within a mechanistic world view, one could still puzzle over the way in which material bodies have been arranged in the universe. For many scientists it was too much to suppose that the subtle and harmonious organization of nature is the result of mere chance.

This point of view was articulated by Robert Boyle, of Boyle's-law fame:

> The excellent contrivance of that great system of the world, and especially the curious fabric of the bodies of the animals and the uses of their sensories and other parts, have been made the great motives that in all ages and nations induced philosophers to acknowledge a Deity as the author of these admirable structures.

Boyle introduced the famous comparison between the universe and a clockwork mechanism, which was most eloquently elaborated by the theologian William Paley in the eighteenth century. Suppose, argued Paley, that you were "crossing a heath" and came upon a watch lying on the ground. On inspecting the watch, you observed the intricate organization of its parts and how they were arranged together in a cooperative way to achieve a collective end. Even if you had never seen a watch and had no idea of its function, you would still be led to conclude from your inspection that this was a contrivance designed for a purpose. Paley then went on to argue that, when we consider the much more elaborate contrivances of nature, we should reach the same conclusion even more forcefully.

The weakness of this argument, exposed by Hume, is that it proceeds by analogy. The mechanistic universe is analogous to the watch; the watch had a designer, so therefore the universe must have had a designer. One might as well say that the universe is like an organism, so therefore it must have grown from a fetus in a cosmic womb! Clearly no analogical argument can amount to a proof. The best it can do is to offer support for a hypothesis. The degree of support will depend on how persuasive you find the analogy to be. As John Leslie points out, if the world were littered with pieces of granite stamped MADE BY God, after producing still more white bears. Before long, the white bears are predominating, taking all the food, and driving the brown bears to extinction.

It's hard to imagine that something like the foregoing story isn't close to the truth. But notice how crucial it is that there be many bears to start with. One member of the bear ensemble is accidentally born white, and a selective advantage is gained over the others. The whole argument depends on nature being able to select from a collection of similar, competing individuals. When it comes to the laws of physics and the initial cosmological conditions, however, there is no ensemble of competitors. The laws and initial conditions are unique to our universe. (I shall come to the question of whether there may exist an ensemble of universes with differing laws shortly.) If it is the case that the existence of life requires the laws of physics and the initial conditions of the universe to be fine-tuned to high precision, and that fine-tuning does in fact obtain, then the suggestion of design seems compelling.

But before we leap to that conclusion, it is as well to consider some objections. First, it is sometimes argued that, if nature did not oblige by producing the right conditions for life to form, we would not ourselves be here to argue about the matter. That is of course true, but it hardly amounts to a counterargument. The fact is, we are here, and here by grace of some pretty felicitous arrangements. Our existence cannot of itself explain these arrangements. One could shrug the matter aside with the comment that we are certainly very lucky that the universe just happened to possess the necessary conditions for life to flourish, but that this is a meaningless quirk of fate. Again, it is a question of personal judgment. Suppose it could be demonstrated that life would be impossible unless the ratio of the mass of the electron to that of the proton was within 0.00000000001 percent of some completely independent number—say, one hundred times the ratio of the densities of water and mercury at 18 degrees centigrade (64.4 degrees Fahrenheit). Even the most hard-nosed skeptic must surely be tempted to conclude that there was "something going on."

So how are we to judge just how "fishy" the setup is? The problem is that there is no natural way to quantify the intrinsic improbability of the known "coincidences." From what range might the value of, say, the strength of the nuclear force (which fixes the position of the Hoyle resonances, for example) be selected? If the range is infinite, then any finite range of values might be considered to have zero probability of being selected. But then we should be equally surprised however weakly the requirements for life constrain those values. This is surely a *reductio ad absurdum* of the whole argument. What is needed is a sort of meta-theory—a theory of theories—that supplies a well-

defined probability for any given range of parameter values. No such metatheory is available, or has to my knowledge even been proposed. Until it is, the degree of "fishiness" involved must remain entirely subjective. Nevertheless, fishy it is!

Another objection sometimes raised is that life evolves to suit the prevailing conditions, so that it is no surprise after all to find life so well adapted to its circumstances. This may be true as far as the general state of the environment is concerned. Moderate climatic changes, for example, are likely to be accommodated. It would certainly be a mistake to point to the Earth and say; "Look how favorable the conditions are for life! The climate is just right, there is a plentiful supply of oxygen and water, the strength of gravity is just right for the size of limbs, etc., etc. What an extraordinary series of coincidences!" The Earth is but one planet among a huge ensemble spread throughout our galaxy and beyond. Life can form only on those planets where the conditions are suitable. Had the Earth not been one of them, then this book might have been written in another galaxy instead. We are not concerned here with anything so parochial as life on Earth. The question is, under what conditions might life arise at least somewhere in the universe? If that life arises, it will inevitably find itself situated in a suitable location.

The specialness argument I have been discussing refers not to this or that niche, but to the underlying laws of physics themselves. Unless those laws meet certain requirements, life won't even get started. Obviously carbon-based life could not exist if there were no carbon. But what about alternative life forms, much beloved of science-fiction writers? Once more we cannot really know. If the laws of physics differed a bit from their actual form, new possibilities for life might arise to replace the lost possibility of life as we know it. Set against that is the general view that biological mechanisms are actually rather specific and difficult to operate, and would be unlikely to emerge from a haphazard arrangement of physics. But until we have a proper understanding of the origin of life, or knowledge about alternative life forms elsewhere in the universe, the question must remain open.

The Ingenuity of Nature

To return once more to Einstein's famous utterance that "God is subtle but not malicious," we gain a clue to another intriguing aspect of the natural order. Einstein meant that to achieve an understanding of nature one must exercise considerable mathematical skill, physical insight, and mental ingenuity, but that nevertheless the goal of understanding is attainable. This is a topic I discussed in somewhat different language in chapter 6, where .I pointed out that the world seems to be structured in such a way that its mathematical description is not at all trivial yet is still within the capabilities of human reasoning.

As I have remarked once or twice already, it is very difficult to communicate the concept of nature's mathematical subtlety to those unacquainted with mathematical physics, yet to the scientists involved what I am referring to is clear enough. It is, perhaps, at its most striking in the topics of particle physics and field theory, where several branches of advanced mathematics must be amalgamated. Put at its most crude: You find that a straightforward application of mathematics gets you so far, and then you get stuck. Some internal inconsistency appears, or else the theory yields results that are hopelessly at variance with the real world. Then some clever person comes along and discovers a mathematical trick—some obscure loophole in a theorem, perhaps, or an elegant reformulation of the original problem in entirely new mathematical language—and, hey presto, everything falls into place! It is impassible to resist the urge to proclaim nature at least as clever as the scientist for "spotting" the trick and exploiting it. One often hears theoretical physicists, speaking in the highly informal and colloquial way that they do, promoting their particular theory with the quip that it is so clever/subtle/elegant it is hard to imagine nature not taking advantage of it!

Let me give a thumbnail sketch of one example. In chapter 7 I discussed the recent attempts at the unification of the four fundamental forces of nature. Why should nature deploy four different forces? Wouldn't it be simpler, more efficient, and more elegant to have three, or maybe two or even one force, but with four distinct aspects? Or so it seemed to the physicists concerned, and so they looked for similarities between the forces to see if any mathematical amalgamation were possible. In the 1960s promising candidates were the electromagnetic force and the weak nuclear force. The electromagnetic force was known to operate through the exchange of particles called "photons." These photons flit back and forth between electrically charged particles such as electrons, and produce forces on them. When you rub a balloon and stick it to the ceiling, or feel the pull and push of magnets, you are witnessing this network of itinerant photons invisibly doing their work. You can think of these photons as rather like messengers, conveying the news about the force between particles of matter, which must then respond to it.

Now, theorists believed that something similar was going on inside nuclei when the weak nuclear force acts. A hypothetical particle, cryptically known as W, was invented to play a messenger role analogous to that of the photon. But whereas photons were familiar in the lab, nobody had ever seen a W, so the main guide in this theory was mathematics. The theory was recast in a way that brought out its essential similarity to electromagnetism most suggestively. The idea was that, if you have two mathematical schemes more or less the same, you can join them together and make do with a single, amalgamated scheme. Part of this rejigging meant introducing an additional messenger particle, known as Z, which resembles the photon even more closely than does W. The trouble was, even in this new improved mathematical framework the two schemes—electromagnetism and the weak-force theories—still differed in one rather basic way. Although Z and the photon share many properties, their masses have to be at opposite ends of the spectrum. This is because the mass of the messenger particle is related in a simple way to the range of the force: the more massive the messenger particle, the shorter the range of the corresponding force. Now, electromagnetism is a force of unlimited range, requiring a messenger particle of zero mass, whereas the weak force is confined to sub-nuclear distances and requires its messenger particles to be so massive they would outweigh most atoms.

Let me say a few words about the masslessness of the photon. The mass of a particle is related to its inertia. The smaller the mass, the smaller the inertia, so the faster it will accelerate when pushed. If a body has a very low mass, a given impulse will impart a very great speed. If you imagine particles with less and less mass, then their speeds will be greater and greater. You might think that a particle with zero mass would move at an infinite speed, but that is not so. The theory of relativity forbids travel faster than light, so zero-mass particles travel at the speed of light. Photons, being "particles of light," are the obvious

example. By contrast, W and Z particles were predicted to have masses of about eighty and ninety times the mass of the proton (the heaviest known stable particle), respectively.

The problem the theorists faced in the 1960s was how to combine two elegant mathematical schemes describing the electromagnetic and weak forces if they differ so markedly in one important detail. The breakthrough came in 1967. Building on the mathematical framework constructed some time earlier by Sheldon Glashow, two theoretical physicists, Abdus Salam and Steven Weinberg, independently spotted a way forward. The essential idea was this. Suppose the great mass of W and Z is not a primary quality, but something acquired as a result of interaction with something else; that is, suppose these particles are not, so to speak, born massive, they are just carrying someone else's load? The distinction is a subtle one, but crucial. It means that the mass is attributed not to the underlying laws of physics, but to the particular state that the W and Z are usually found in.

An analogy might make the point clearer. Stand a pencil on its tip and hold it vertical. Now let go. The pencil will topple over and line up, in some direction. Say it points northeast. The pencil reached that state as a result of the action of the Earth's gravity. But its "northeastliness" is not an intrinsic quality of gravity. The Earth's gravity certainly has an intrinsic "up-down-ness," but not a north-south-ness or an east-west-ness or anything in between. Gravity makes no distinction between different horizontal directions. So the northeastness of the pencil is merely an incidental property of the system pencil-plus-gravity that reflects the particular state that the pencil happens to be in.

In the case of W and Z, the role of gravity is played by a hypothetical new field, called a Higgs field after Peter Higgs of the University of Edinburgh. The Higgs field interacts with W and Z and causes them to "topple over" in a symbolic sense. Rather than picking up "northeastness," they pick up mass—and lots of it. The way is now open to unification with the electromagnetic force, because, underneath, W and Z are "really" massless, like the photon. The two mathematical schemes can then be amalgamated, yielding a unified description of a single "electroweak" force.

The rest, as they say, is history. In the early 1980s accelerators at the Centre for European Nuclear Research (CERN), near Geneva, finally produced W particles, and then Z. The theory was brilliantly confirmed. Two of nature's forces were seen to be in reality two facets of a single force. The point I want to make is that nature has evidently spotted the loophole in the argument that you can't join massless and massive particles together. You can if you use the Higgs mechanism.

There is a postscript to this story. The Higgs field, which does the all-important job, has its own associated particle, called the "Higgs boson." It is probably very massive indeed, which means you need a lot of energy to make it. Nobody has yet detected a Higgs boson, but it is number one on the list of discoveries waiting to happen. Its production will be one of the main goals for the giant new accelerator planned for the Texas scrubland in the late nineties. Known as the "superconducting supercollider" (SSC), this monstrous machine will be some fifty miles in circumference, and will accelerate protons and antiprotons to unprecedented energies. Counter-rotating beams will be allowed to collide, producing encounters of awesome ferocity. The hope is that the SSC will pack enough punch to make the Higgs boson. But the Americans will be racing the Europeans, who hope that a Higgs will show up in one of the machines at CERN. Of course, until one is found, we can't be sure that nature really is using the Higgs mechanism. Perhaps she has found an even cleverer way. Watch out for the final act in this drama!

A Place for Everything and Everything in Its Place

When scientists ask of their subject matter, "Why would nature bother with this?" or "What is the point of that?" they seem to be ascribing intelligent reasoning to nature. Though they usually intend such questions to be in a lighthearted spirit, there is a serious content too. Experience has shown that nature does share our sense of economy, efficiency, beauty, and mathematical subtlety, and this approach to research can often pay dividends (as with the unification of the weak and electromagnetic forces). Most physicists believe that beneath the complexities of their subject lies an elegant and powerful unity, and that progress can be made by spotting the mathematical "tricks" that nature has exploited to generate an interestingly diverse and complex universe from this underlying simplicity.

There is, for example, an unstated but more or less universal feeling among physicists that everything that exists in nature must have a "place" or a role as part of some wider scheme, that nature should not indulge in profligacy by manifesting gratuitous entities, that nature should not be arbitrary. Each facet of physical reality should link in with the others in a "natural" and logical way. Thus, when the particle known as the muon was discovered in 1937, the physicist Isidor Rabi was

astonished. "Who ordered that?" he exclaimed. The muon is a particle more or less identical to the electron in all respects except its mass, which is 206.8 times bigger. This big brother to the electron is unstable, and decays after a microsecond or two, so it is not a permanent feature of matter. Nevertheless, it seems to be an elementary particle in its own right and not a composite of other particles. Rabi's reaction is typical. What is the muon for? Why does nature need another sort of electron, especially one that disappears so promptly. How would the world be different if the muon simply did not exist?

The problem has since become even more marked. There are now known to be two bigger brothers. The second, discovered in 1974, is called the "tauon." Worse still, other particles also possess highly unstable big brothers. The so-called quarks—the building blocks of nuclear matter, like protons and neutrons—each have two heavier versions too. There are also three varieties of neutrino. The situation is set out schematically in table 1. It seems that all known particles of matter can be arranged into three "generations." In the first generation are the electron, the electron-neutrino, and the two quarks called "up" and "down," which together build protons and neutrons. The particles in this first generation are all essentially stable, and go to make up the ordinary matter of the universe that we see. The atoms of your body, and of the sun and stars, are composed of these first-generation particles.

The second generation seems to be little more than a duplicate of the first. Here one finds the muon, which so astonished Rabi. These particles (with the possible exception of the neutrino) are unstable, and soon decay into first-generation particles. Then, lo and behold, nature does it again, and gives us yet another replication of the pattern in generation three! Now, you may be wondering whether there is any end to this replication. Perhaps there is an infinity of generations, and what we are witnessing is really some simple repeating pattern. Most physicists disagree. In 1989 the new particle-accelerator at CERN, called Lep (for Large Electron-Position ring), was used to examine carefully the decay of the Z particle. Now, Z decays into neutrinos, and the decay rate depends on the number of distinct neutrino species available in nature, so a careful measurement of the rate can be used to deduce the number of neutrinos. The answer came out to be three, which suggests that there are just three generations.

So we have a puzzle: why three? One or infinity would be "natural," but three seems plain perverse. This "generation puzzle" has been the spur to some important theoretical work. The most satisfactory progress in particle physics has come from the use of a branch of mathematics known as "group theory." This is closely connected with the subject of symmetry, one of nature's "favorite" manifestations. Group theory can be used to connect apparently distinct particles into unified families. Now, there are definite mathematical rules about how these groups can be represented and combined, and how many of each type of particle they describe. The hope is that a group-theory description will emerge that commends itself on other grounds, but which will also demand three generations of particles. Nature's apparent profligacy will then be seen as a necessary consequence of some deeper unifying symmetry.

Of course, until that deeper unification is demonstrated, the generation problem seems to offer a counterexample to the argument that nature is subtly economical rather than maliciously arbitrary. But so confident am I that nature shares our sense of economy, I am happy to offer as a hostage to fortune that the generation problem will be solved within the next decade or so, and that its solution will provide further striking evidence that nature really does abide by the rule "A place for everything and everything in its place."

There is an interesting corollary to this generation game which reinforces my point. I have not been completely truthful in the entries to table 1. At the time of writing, the top quark has not yet been definitively identified. On several occasions it has been "discovered," only to be undiscovered

shortly afterward. Now, you might wonder why physicists are so confident that the top quark exists that they are prepared to expend a significant fraction of their scarce resources looking for it. Suppose it doesn't exist? Suppose there is actually a gap in the table (which is, after all, a human construction), so that there aren't three generations at all, but two and three-quarters? Well, you'd be hard-pressed to find a physicist who really believed that nature would be so perverse, and when the top quark is discovered (as I have no doubt it eventually will be), it will provide another example of nature doing things tidily.

The generation problem is actually part of the larger unification scheme to which I have alluded, and which is being tackled head-on by a small army of theorists. John Polkinghome, who used to be a particle physicist before he took up the priesthood, writes about the confidence that physicists have in this next step of the unification program:

> My erstwhile colleagues are labouring away in the endeavour to produce a theory yet more all-embracing. . . would say that at present their efforts have an air of contrivance, even desperation, about them. Some vital fact or idea seems still to be missing. However, I do not doubt that in due course some deeper understanding will be achieved and a more profound pattern discerned at the basis of physical reality.

As I have mentioned, the so-called superstring theory is the current fashion, but doubtless something else will come along soon. Although major difficulties lie ahead, I agree with Polkinghorne. I cannot believe that these problems are truly insoluble, and that particle physics cannot be unified. All the pointers compel one to suppose that there is unity rather than arbitrariness beneath it all, despite the head-scratching.

As a final remark on the question of the "need" for all these particles, it is a curious thought that muons, though absent from ordinary matter, do play a rather important role in nature after all. Most of the cosmic rays that reach the surface of the Earth are in fact muons. These rays form part of the natural background of radiation, and contribute to the genetic mutations that drive evolutionary change. Therefore, at least to a limited extent, one can find use for moons in biology. This provides another example of the felicitous dovetailing of the large and the small that I mentioned earlier in this chapter.

Is There Need for a Designer?

I hope the foregoing discussion will have convinced the reader that the natural world is not just any old concoction of entities and forces, but a marvelously ingenious and unified mathematical scheme. Now, words like "ingenious" and "clever" are undeniably human qualities, yet one cannot help attributing them to nature too. Is this just another example of our projecting onto nature our own categories of thought, or does it represent a genuinely intrinsic quality of the world?

We have come a long way from Paley's watch. To return to my favorite analogy once more, the world of particle physics is more like a crossword than a clockwork mechanism. Each new discovery is a clue, which finds its solution in some new mathematical linkage. As the discoveries mount up, so more and more cross-links are "filled in," and one begins to see a pattern emerge. At present there remain many blanks on the crossword, but something of its subtlety and consistency can be glimpsed. Unlike mechanisms, which can slowly evolve to more complex or organized forms over time, the "crossword" of particle physics comes ready-made. The links do not evolve, they are simply there, in the underlying laws. We must either accept them as truly amazing brute facts, or seek a deeper explanation.

According to Christian tradition, this deeper explanation is that God has designed nature with considerable ingenuity and skill, and that the enterprise of particle physics is uncovering part of

this design. If one were to accept that, the next question is: to what purpose has God produced this design? In seeking to answer the question, we need to take into account the many "coincidences" mentioned earlier in connection with the Anthropic Principle and the requirements of biological organisms. The apparent "fine-tuning" of the laws of nature necessary if conscious life is to evolve in the universe then carries the clear implication that God has designed the universe so as to permit such life and consciousness to emerge. It would mean that our own existence in the universe formed a central part of God's plan.

But does design necessarily imply a designer! John Leslie has argued that it doesn't. Recall that in his theory of creation the universe exists as a result of "ethical requirement." He writes: "A world existing as a result of an ethical need could be just the same, just as rich in seeming evidence of a designer's touch, whether or not the need depended for its influence on creative acts directed by a benevolent intelligence.' In short, a good universe would look designed to us, even if it had not been.

In The Cosmic Blueprint, I wrote that the universe looks as if it is unfolding according to some plan or blueprint. The idea is (partially) captured in a schematic way by figure 12, where the role of the blueprint (or cosmic computer program, if you prefer) is played by the laws of physics, and represented by the sausage machine. The input is the cosmic initial conditions, and the output is organized complexity, or depth. A variant on the image is shown in figure 13, where the input is matter and the output mind. The essential feature is that something of value emerges as the result of processing according to some ingenious pre-existing set of rules. These rules look as if they are the product of intelligent design. I do not see how that can be denied. Whether you wish to believe that they really have been so designed, and if so by what sort of being, must remain a matter of personal taste. My own inclination is to suppose that qualities such as ingenuity, economy, beauty, and so on have a genuine transcendent reality—they are not merely the product of human experience—and that these qualities are reflected in the structure of the natural world. Whether such qualities can themselves bring the universe into existence I don't know. If they could, one could conceive of God as merely a mythical personification of such creative qualities, rather than as an independent agent. This would, of course, be unlikely to satisfy anyone who feels he or she has a personal relationship with God.

Multiple Realities

Undoubtedly the most serious challenge to the design argument comes from the alternative hypothesis of many universes, or multiple realities. I introduced this theory in chapter 7 in connection with the cosmological argument for the existence of God. The basic idea is that the universe we see is but one among a vast ensemble. When deployed as an attack on the design argument, the theory proposes that all possible physical conditions are represented somewhere among the ensemble, and that the reason why our own particular universe looks designed is that only in those universes which have that seemingly contrived form will life (and hence consciousness) be able to arise. Hence it is no surprise that we find ourselves in a universe so propitiously suited to biological requirements. It has been "anthropically selected."

First we must ask what evidence there is for these other worlds. The philosopher George Gale has compiled a list of several physical theories that in one way or another imply an ensemble of universes. " The most Frequently discussed theory of multiple universes concerns an interpretation of quantum mechanics. To see how quantum uncertainty leads to the possibility of more than one world, consider a simple example. Imagine a single electron immersed in a magnetic field. The electron possesses an intrinsic spin which endows it with a "magnetic moment." There will be an energy of interaction of the electron's magnetism with the external magnetic field, and this energy will depend on the angle between the direction of the imposed field and the direction of the electron's own magnetic field. If the fields are aligned, the energy will be low; if they are opposed,

it will be high; and at intermediate angles it will vary between these values. We can effectively measure the orientation of the electron by making a measurement of this magnetic-interaction energy. What is found, and what is fundamental to the rules of quantum mechanics, is that only two values of the energy are ever observed, corresponding, roughly speaking, to the electron's magnetic moment pointing either along the magnetic field or opposed to it.

An interesting situation now arises if we set out deliberately to prepare the electron's magnetic field to be perpendicular to that of the imposed field. That is, we satisfy ourselves that the electron is pointing neither up nor down the external field, but across it. Mathematically, this arrangement is described by representing the electron by a state that is a "superposition" of the two possibilities. That is to say, the state is—again, roughly speaking—a hybrid of two overlapping realities: spin-up and spin-down. If, now, a measurement is made of the energy, the result will always be found as either up or down, and not some weird mixture of the two. But the inherent uncertainty of quantum mechanics forbids your knowing in advance which of these two possibilities will actually prevail. The rules of quantum mechanics will, however, allow you to assign relative probabilities to the alternatives. In the example considered there is equal probability for up or down. Then, according to a crude version of the many-universes theory, when a measurement is made, the universe splits into two copies, one in which the spin is up, the other in which it is down.

A more refined version envisages that there are always two universes involved, but that prior to the experiment they are identical in all respects. The effect of the experiment is to bring about their differentiation in respect of the electron's spin direction. In the case that the probabilities are unequal, one can imagine that there are many identical worlds in proportion to the relative probability. For example, if the probabilities were 1/2 up and Vs down, one could imagine three initially identical universes, two of which remain identical and have spin-up, the other differentiating itself by having spin-down. In general, one would need an infinite number of universes to cover all possibilities.

Now imagine extending this idea from a single electron to every quantum particle in the universe. Throughout the cosmos, the inherent uncertainties that confront each and every quantum particle are continually being resolved by differentiation of reality into ever more independently existing universes. This image implies that everything that can happen, will happen. That is, every set of circumstances that is physically possible (though not everything that is logically possible) will be manifested somewhere among this infinite set of universes.

The various universes must be considered to be in some sense "parallel" or coexisting realities. Any given observer will, of course, see only one of them, but we must suppose that the conscious states of the observer will be part of the differentiation process, so that each of the many alternative worlds will carry copies of the minds of the observers. It is part of the theory that you can't detect this mental "splitting"; each copy of us feels unique and integral. Nevertheless, there are stupendously many copies of ourselves in existence! Bizarre though the theory may seem, it is supported, in one version or another, by a large number of physicists as well as some philosophers. Its virtues are particularly compelling to those engaged in quantum cosmology, where alternative interpretations of quantum mechanics seem even less satisfactory. It must be said, however, that the theory is not without its critics, some of whom (e.g., Roger Penrose) challenge the claim that we would not notice the splitting.

This is by no means the only conjecture for an ensemble of worlds. Another, somewhat easier to visualize, is that what we have been calling "the universe" might just be a small patch of a much larger system extended in space. If we could look beyond the ten billion or so light-years accessible to our instruments, we would see (so the theory goes) other regions of the universe that are very different from ours. There is no limit to the number of different domains that could be included in

this way, as the universe might be infinitely large. Strictly speaking, if we define "universe" to be everything that there is, then this is a many-regions rather than a many-universes theory, but the distinction is irrelevant for our purposes.

The question we now have to address is whether the evidence for design can equally well be taken as evidence for many universes. In Some respects the answer is undoubtedly yes. For example, the spatial organization of the cosmos on a large scale is important for life. If the universe were highly irregular, it might produce black holes, or turbulent gas rather than well-ordered galaxies containing life-encouraging stable stars and planets. If you imagine a limitless variety of worlds in which matter was distributed at random, chaos would generally prevail. But here and there, purely. by chance, an oasis of order would arise, permitting life to form. An adaptation of the inflationary-universe scenario along these lines has been proposed and studied by the Soviet physicist Andrei Linde. Although the quiescent oases would be almost unthinkably rare, it is no surprise that we find ourselves inhabiting one, for we could not live elsewhere. We are, after all, not surprised that we find ourselves atypically located on the surface of a planet, when the overwhelming proportion of the universe consists of near-empty space. So the cosmic order need not be attributed to the providential arrangement of things; but, rather, to the inevitable selection effect connected with our own existence.

This type of explanation might even be extended to some of the "coincidences" of particle physics. I discussed how the Higgs mechanism is invoked to explain the way in which the W and Z particles acquire their masses. In more elaborate unification theories, other Higgs fields are introduced to generate masses for all particles, and also to fix some other parameters of the theory related to force strengths. Now, just as in the falling-pencil analogy that I used on page 208, the system could topple into one of a whole variety of states (northeast, southeast, south-southwest, etc.), so, in these more elaborate Higgs-type mechanisms, the particle system can "topple" into different states. Which states are adopted would depend, randomly, on quantum fluctuations—i.e., on the inherent uncertainty built into quantum mechanics. In the many-universes theory one must suppose that every possible choice is somewhere represented by a complete universe. Alternatively, different choices might occur in different regions of space. Either way one would be presented with an ensemble of cosmological systems in which masses and forces took on different values. It would then be possible to argue that only where those quantities assumed the "coincidental" values needed for life, would life form.

In spite of the power of the many-universes theory to account for what would otherwise be considered remarkably special facts about nature, the theory faces a number of serious objections. The first of these I have already discussed in chapter 7, which is that it flies in the face of Occam's razor, by introducing vast (indeed infinite) complexity to explain the regularities of just one universe. I find this "blunderbuss" approach to explaining the specialness of our universe scientifically questionable. There is also the obvious problem that the theory can explain only those aspects of nature that are relevant to the existence of conscious life; otherwise there is no selection mechanism. Many of the examples I have given for design, such as the ingenuity and unity of particle physics, have little obvious connection with biology. Remember that it is not sufficient for the feature concerned simply to be relevant to biology, it has to be crucial to its actual prevalence.

Another point which is often glossed over is that, in all of the many-universe theories that derive from real physics (as opposed to simply fantasizing about the existence of other worlds), the laws of physics are the same in all the worlds. The selection of universes on offer is restricted to those that are physically possible, as opposed to those that can be imagined. There will be many more universes that are logically possible but contradict the laws of physics. In the example of the electron which can have either spin-up or -down, both worlds contain an electron with the same

electric charge, obeying the same laws of electromagnetism, etc. So, although such many-universe theories might provide a selection of alternative states of the world, they cannot provide a selection of laws. It is true that the distinction between features of nature that owe their existence to a true underlying law, and those that can be attributed to the choice of state, is not always clear. As we have seen, certain parameters, like some particle masses, that previously were fixed into the theory as part of the assumed laws of physics, are now ascribed to states via the Higgs mechanism. But this mechanism can only work in a theory equipped with its own set of laws, and these will contain further features in need of explanation. Moreover, although quantum fluctuations might cause the Higgs mechanism to operate differently in different universes, it is far from clear in the theories being formulated at present that all possible values of particle masses, force strengths, etc., could be attained. Mostly the Higgs mechanism and similar so-called symmetry-breaking devices produce a discrete—indeed, finite—set of alternatives.

It is therefore not possible, as some physicists have suggested, to account for nature's lawfulness this way. Might it not be possible, however, to extend the many-universes idea to encompass different laws too? There is no logical objection to this, although there is no scientific justification for it either. But suppose one does entertain the existence of an even vaster stack of alternative realities for which any notion of law, order, or regularity is absent. Here chaos rules totally. The behavior of these worlds is entirely random. Well, just as a monkey tinkering with a typewriter will eventually type Shakespeare, so somewhere among that vast stack of realities will be worlds that are partially ordered, just by chance. Anthropic reasoning then leads us to conclude that any given observer will perceive an ordered world, mind-bogglingly rare though such a world may be relative to its chaotic competitors. Would this account for our world?

I think the answer is clearly no. Let me repeat that anthropic arguments work only for aspects of nature that are crucial to life. If there is utter lawlessness, then the overwhelming number of randomly selected inhabited worlds will be ordered only in ways that are essential to the preservation of life. There is no reason, for example, why the charge of the electron need remain absolutely fixed, or why different electrons should have exactly the same charge. Minor fluctuations in the value of the electric charge would not be life-threatening. But what else keeps the value fixed—and fixed to such astonishing precision—if it is not a law of physics? One could, perhaps, imagine an ensemble of universes with a selection of laws, so that each universe comes with a complete and fixed set of laws. We could then perhaps use anthropic reasoning to explain why at least some of the laws we observe are what they are. But this theory must still presuppose the concept of law, and one can still ask where those laws come from, and how they "attach" themselves to universes in an "eternal" way.

My conclusion is that the many-universes theory can at best explain only a limited range of features, and then only if one appends some metaphysical assumptions that seem no less extravagant than design. In the end, Occam's razor compels me to put my money on design, but, as always in matters of metaphysics, the decision is largely a matter of taste rather than scientific judgment. It is worth noting, however, that it is perfectly consistent to believe in both an ensemble of universes and a designer God. Indeed, as I have discussed, plausible world-ensemble theories still require a measure of explanation, such as the Jawlike character of the universes and why there exists a world-ensemble in the first place. I should also mention that discussions which start out with observations of only one universe and go on to make inferences about the improbability of this or that feature, raise some deep issues concerning the nature of probability theory. I believe that these have been satisfactorily attended to in John Leslie's treatment, but some commentators allege that attempts to argue backward "after the event"—the event in this case being our own existence—are fallacious.

Cosmological Darwinism

Recently an interesting adaptation of the many-universes theory has been proposed by Lee Smolin which avoids some of the objections to the other many-universes schemes by providing a curious linkage between the needs of living organisms and the multiplicity of the many universes. In chapter 2 I explained how the investigations of quantum cosmology suggest that "baby universes" can arise spontaneously as a result of quantum fluctuations, and that one may envisage a "mother universe" giving rise to progeny in this way. One circumstance under which new universes might be born is the formation of a black hole. According to classical (prequantum) gravitational theory, a black hole conceals a singularity, which can be regarded as a sort of edge of space-time. In the quantum version, the singularity is smeared out somehow. We don't know how, but it could be that the sharp boundary of space-time is replaced by a sort of tunnel or throat or umbilical cord connecting our universe to a new, baby universe. As explained in chapter 2, quantum effects would cause the black hole to evaporate eventually, severing the umbilical cord, and dispatching the baby universe to an independent career.

Smolin's refinement of this speculation is that the extreme conditions of near-singularity would have the effect of causing small random variations in the laws of physics. In particular, the values of some of the constants of nature, such as particle masses, charges, and so on, might be slightly different in the daughter universe from what they were in its mother. The daughter universe might then evolve slightly differently. Given enough generations, quite wide variations would occur among the many universes. It is likely, however, that those which differ substantially from our own would not evolve stars like ours (recall that the conditions for the formation of stars are rather special). Because black holes are most likely to form from dead stars, such universes would not produce many black holes, and hence would not give birth to many baby universes. By contrast, those universes with physical parameters well suited to form many stars would also form many black holes and thence many baby universes possessing similar values of these parameters. This difference in cosmic fecundity acts as a type of Darwinian selection effect. Although the universes don't actually compete, there are "successful" and "less successful" universes, so that the proportion of "successful" universes—in this case, efficient star-makers—in the total population will be rather large. Smolin then goes on to point out that the existence of stars is also an essential prerequisite for the formation- of life. So the same conditions that encourage life also encourage the birth of other life-giving universes. In the Smolin scheme, life is not an extreme rarity, as it is in other many-universe theories. Instead, the large majority of universes are habitable.

In spite of its appeal, it is not clear that Smolin's theory makes any progress in explaining the specialness of the universe. The linkage between biological and cosmological selection is an attractive feature, but we can still wonder why the laws of nature are such that this linkage occurs. How fortunate that the requirements of life match those of the baby universes so well. Moreover, we still require the same basic structure of the laws in all these universes in order to make sense of the theory. That this basic structure also permits the formation of life remains a remarkable fact.

1995
Paul Davies, Ph.D., Physicist, Arizona State University
+ Templeton Prize Address

It is both an honour and a pleasure for me to deliver my acceptance address for the 1995 Templeton Prize to such a distinguished audience in this world-famous Abbey, just a few metres from the remains of Isaac Newton. Along with Einstein and Darwin, Newton is one of the few scientists known to almost every member of the population. He is one of the great heroes of my own discipline, physics, even if his career as a civil servant left a lot to be desired.

It was Newton, Galileo and their contemporaries who created science as we know it, three centuries ago. Today we take the scientific method of enquiry so much for granted that few people stop to think how astonishing it is that science works.

I was fascinated to learn that one of the judges for the Prize was Baroness Thatcher. This is in fact the second time she has been involved in giving me a prize. The first occasion was in 1962, at the Speech Day of Woodhouse Grammar School in North Finchley, when she presented me with a copy of Norton's Star Atlas for doing well in my O level exams. I doubt if her Ladyship recalls the encounter, but I can trace my own decision to become a scientist to more or less that event.

Like all school pupils, I learned science as a set of procedures that would reveal how nature works, but I never questioned why we were able to do this thing called science so successfully. It was only after a long career of research and scholarship that I began to appreciate just how deep scientific knowledge is, and how incredibly privileged we human beings are to be able to unlock the secrets of nature in such a powerful way.

Of course, science didn't spring ready-made into the minds of Newton and his colleagues. They were strongly influenced by two longstanding traditions that pervaded European thought. The first was Greek philosophy. Most ancient cultures were aware that the universe is not completely chaotic and capricious: there is a definite order in nature. The Greeks believed that this order could be understood, at least in part, by the application of human reasoning. They maintained that physical existence was not absurd, but rational and logical, and therefore in principle intelligible to us. They discovered that some physical processes had a hidden mathematical basis, and they sought to build a model of reality based on arithmetical and geometrical principles.

The second great tradition was the Judaic world view, according to which the universe was created by God at some definite moment in the past and ordered according to a fixed set of laws. The Jews taught that the universe unfolds in a unidirectional sequence - what we now call linear time - according to a definite historical process: creation, evolution and dissolution. This notion of linear time - in which the story of the universe has a beginning, a middle and an end - stands in marked contrast to the concept of cosmic cyclicity, the pervading mythology of almost all ancient cultures. Cyclic time - the myth of the eternal return - springs from mankind's close association with the cycles and rhythms of nature, and remains a key component in the belief systems of many cultures today. It also lurks just beneath the surface of the Western mind, erupting occasionally to infuse our art, our folklore and our literature.

A world freely created by God, and ordered in a particular, felicitous way at the origin of a linear time, constitutes a powerful set of beliefs, and was taken up by both Christianity and Islam. An essential element of this belief system is that the universe does not have to be as it is: it could have been otherwise. Einstein once said that the thing which most interested him is whether God had any choice in his creation. According to the Judaeo-Islamic-Christian tradition, the answer is a resounding yes.

Although not conventionally religious, Einstein often spoke of God, and expressed a sentiment shared, I believe, by many scientists, including professed atheists. It is a sentiment best described as a reverence for nature and a deep fascination for the natural order of the cosmos. If the universe did not have to be as it is, of necessity - if, to paraphrase Einstein, God did have a choice - then the fact that nature is so fruitful, that the universe is so full of richness, diversity and novelty, is profoundly significant.

Some scientists have tried to argue that if only we knew enough about the laws of physics, if we were to discover a final theory that united all the fundamental forces and particles of nature into a

single mathematical scheme, then we would find that this superlaw, or theory of everything, would describe the only logically consistent world. In other words, the nature of the physical world would be entirely a consequence of logical and mathematical necessity. There would be no choice about it. I think this is demonstrably wrong. There is not a shred of evidence that the universe is logically necessary. Indeed, as a theoretical physicist I find it rather easy to imagine alternative universes that are logically consistent, and therefore equal contenders for reality.

It was from the intellectual ferment brought about by the merging of Greek philosophy and Judaeo-Islamic-Christian thought, that modern science emerged, with its unidirectional linear time, its insistence on nature's rationality, and its emphasis on mathematical principles. All the early scientists such as Newton were religious in one way or another. They saw their science as a means of uncovering traces of God's handiwork in the universe. What we now call the laws of physics they regarded as God's abstract creation: thoughts, so to speak, in the mind of God. So in doing science, they supposed, one might be able to glimpse the mind of God. What an exhilarating and audacious claim!

In the ensuing three hundred years, the theological dimension of science has faded. People take it for granted that the physical world is both ordered and intelligible. The underlying order in nature - the laws of physics - are simply accepted as given, as brute facts. Nobody asks where they come from; at least they don't in polite company. However, even the most atheistic scientist accepts as an act of faith the existence of a lawlike order in nature that is at least in part comprehensible to us. So science can proceed only if the scientist adopts an essentially theological world view.

It has become fashionable in some circles to argue that science is ultimately a sham, that we scientists read order into nature, not out of nature, and that the laws of physics are our laws, not nature's. I believe this is arrant nonsense. You'd be hard-pressed to convince a physicist that Newton 's inverse square law of gravitation is a purely cultural concoction. The laws of physics, I submit, really exist in the world out there, and the job of the scientist is to uncover them, not invent them. True, at any given time, the laws you find in the textbooks are tentative and approximate, but they mirror, albeit imperfectly, a really-existing order in the physical world. Of course, many scientists don't recognize that in accepting the reality of an order in nature - the existence of laws "out there" - they are adopting a theological world view. Ironically, one of the staunchest defenders of the reality of the laws of physics is the American physicist Steven Weinberg, a sort of apologetic atheist who, though able to wax lyrical about the mathematical elegance of nature, nevertheless felt compelled to pen the notorious words: "The more the universe seems comprehensible, the more it also seems pointless."

Let us accept, then, that nature really is ordered in a mathematical way - that "the book of nature", to quote Galileo, "is written in mathematical language". Even so, it is easy to imagine an ordered universe which nevertheless remains utterly beyond human comprehension, due to its complexity and subtlety. For me, the magic of science is that we can understand at least part of nature - perhaps in principle all of it - using the scientific method of enquiry. How utterly astonishing that we human beings can do this! Why should the rules on which the universe runs be accessible to humans?

The mystery is all the greater when one takes into account the cryptic character of the laws of nature. When Newton saw the apple fall, he saw a falling apple. He didn't see a set of differential equations that link the motion of the apple to the motion of the moon. The mathematical laws that underlie physical phenomena are not apparent to us through direct observation; they have to be painstakingly extracted from nature using arcane procedures of laboratory experiment and mathematical theory. The laws of nature are hidden from us, and are revealed only after much labour. The late Heinz Pagels - another atheistic physicist - described this by saying that the laws of

nature are written in a sort of cosmic code, and that the job of the scientist is to crack the code and reveal the message - nature's message, God's message, take your choice, but not our message. The extraordinary thing is that human beings have evolved such a fantastic code-breaking talent. This is the wonder and the magnificence of science; we can use it to decode nature and discover the secret laws that make the universe tick!

Many people want to find God in the creation of the universe, in the big bang that started it all off. They imagine a super-being who deliberates for all eternity, then presses a metaphysical button and produces a huge explosion. I believe this image is entirely misconceived. Einstein showed us that space and time are part of the physical universe, not a pre-existing arena in which the universe happens. Cosmologists are convinced that the big bang was the coming-into-being, not just of matter and energy, but of space and time as well. Time itself began with the big bang. If this sounds baffling, it is by no means new. Already in the fifth century St. Augustine proclaimed that "the world was made with time, not in time". According to James Hartle and Stephen Hawking, this coming-into-being of the universe need not be a supernatural process, but could occur entirely naturally, in accordance with the laws of quantum physics, which permit the occurrence of genuinely spontaneous events.

The origin of the universe, however, is hardly the end of the story. The evidence suggests that in its primordial phase the universe was in a highly simple, almost featureless state: perhaps a uniform soup of subatomic particles, or even just expanding empty space. All the richness and diversity of matter and energy we observe today has emerged since the beginning in a long and complicated sequence of self-organizing physical processes. What an incredible thing these laws of physics are! Not only do they permit a universe to originate spontaneously; they encourage it to self-organize and self-complexify to the point where conscious beings emerge, and can look back on the great cosmic drama and reflect on what it all means.

Now you may think I have written God entirely out of the picture. Who needs a God when the laws of physics can do such a splendid job? But we are bound to return to that burning question: Where do the laws of physics come from? And why those laws rather than some other set? Most especially: Why a set of laws that drives the searing, featureless gases coughed out of the big bang, towards life and consciousness and intelligence and cultural activities such as religion, art, mathematics and science?

If there is a meaning or purpose to existence, as I believe there is, we are wrong to dwell too much on the originating event. The big bang is sometimes referred to as "the creation", but in truth nature has never ceased to be creative. This ongoing creativity, which manifests itself in the spontaneous emergence of novelty and complexity, and organization of physical systems, is permitted through, or guided by, the underlying mathematical laws that scientists are so busy discovering.

Now the laws of which I speak have the status of timeless eternal truths, in contrast to the physical states of the universe which change with time, and bring forth the genuinely new. So we here confront in physics a re-emergence of the oldest of all philosophical and theological debates: the paradoxical conjunction of the eternal and the temporal. Early Christian thinkers wrestled with the problem of time: is God within the stream of time, or outside of it? How can a truly timeless God relate in any way to temporal beings such as ourselves? But how can a God who relates to a changing universe be considered eternal and unchangingly perfect?

Well, physics has its own variations on this theme. In our century, Einstein showed us that time is not simply "there" as a universal and absolute backdrop to existence, it is intimately interwoven with space and matter. As I have mentioned, time is revealed to be an integral part of the physical

universe; indeed, it can be warped by motion and gravitation. Clearly something that can be changed in this manner is not absolute, but a contingent part of the physical world.

In my own field of research - called quantum gravity - a lot of attention has been devoted to understanding how time itself could have come into existence in the big bang. We know that matter can be created by quantum processes. There is now a general acceptance among physicists and cosmologists that spacetime can also originate in a quantum process. According to the latest thinking, time might not be a primitive concept at all, but something that has "congealed" from the fuzzy quantum ferment of the big bang, a relic, so to speak, of a particular state that froze out of the fiery cosmic birth.

If it is the case that time is a contingent property of the physical world rather than a necessary consequence of existence, then any attempt to trace the ultimate purpose or design of nature to a temporal Being or Principle seems doomed to failure. While I do not wish to claim that physics has solved the riddle of time - far from it - I do believe that our advancing scientific understanding of time has illuminated the ancient theological debate in important ways. I cite this topic as just one example of the lively dialogue that is continuing between science and theology.

A lot of people are hostile to science because it demystifies nature. They prefer the mystery. They would rather live in ignorance of the way the world works and our place within it. For me, the beauty of science is precisely the demystification, because it reveals just how truly wonderful the physical universe really is. It is impossible to be a scientist working at the frontier without being awed by the elegance, ingenuity and harmony of the lawlike order in nature. In my attempts to popularize science, I'm driven by the desire to share my own sense of excitement and awe with the wider community; I want to tell people the good news. The fact that we are able to do science, that we can comprehend the hidden laws of nature, I regard as a gift of immense significance. Science, properly conducted, is a wonderfully enriching and humanizing enterprise. I cannot believe that using this gift called science - using it wisely, of course - is wrong. It is good that we should know.

So where is God in this story? Not especially in the big bang that starts the universe off, nor meddling fitfully in the physical processes that generate life and consciousness. I would rather that nature can take care of itself. The idea of a God who is just another force or agency at work in nature, moving atoms here and there in competition with physical forces, is profoundly uninspiring. To me, the true miracle of nature is to be found in the ingenious and unswerving lawfulness of the cosmos, a lawfulness that permits complex order to emerge from chaos, life to emerge from inanimate matter, and consciousness to emerge from life, without the need for the occasional supernatural prod; a lawfulness that produces beings who not only ask great questions of existence, but who, through science and other methods of enquiry, are even beginning to find answers.

You might be tempted to suppose that any old rag-bag of laws would produce a complex universe of some sort, with attendant inhabitants convinced of their own specialness. Not so. It turns out that randomly-selected laws lead almost inevitably either to unrelieved chaos or boring and uneventful simplicity. Our own universe is poised exquisitely between these unpalatable alternatives, offering a potent mix of freedom and discipline, a sort of restrained creativity. The laws do not tie down physical systems so rigidly that they can accomplish little, nor are they a recipe for cosmic anarchy. Instead, they encourage matter and energy to develop along pathways of evolution that lead to novel variety, what Freeman Dyson has called the principle of maximum diversity: that in some sense we live in the most interesting possible universe.

Scientists have recently identified a regime dubbed "the edge of chaos", a description that certainly characterises living organisms, where innovation and novelty combine with coherence and

cooperation. The edge of chaos seems to imply the sort of lawful freedom I have just described. Mathematical studies suggest that to engineer such a state of affairs requires laws of a very special form. If we could twiddle a knob and change the existing laws, even very slightly, the chances are that the universe as we know it would fall apart, descending into chaos. Certainly the existence of life as we know it, and even of less elaborate systems such as stable stars, would be threatened by just the tiniest change in the strengths of the fundamental forces, for example. The laws that characterize our actual universe, as opposed to an infinite number of alternative possible universes, seem almost contrived - fine-tuned some commentators have claimed - so that life and consciousness may emerge. To quote Dyson again: it is almost as if "the universe knew we were coming". I can't prove to you that that is design, but whatever it is it is certainly very clever!

Now some of my colleagues embrace the same scientific facts as I, but deny any deeper significance. They shrug aside the breathtaking ingenuity of the laws of physics, the extraordinary felicity of nature, and the surprising intelligibility of the physical world, accepting these things as a package of marvels that just happens to be. But I cannot do this. To me, the contrived nature of physical existence is just too fantastic for me to take on board as simply "given". It points forcefully to a deeper underlying meaning to existence. Some call it purpose, some design. These loaded words, which derive from human categories, capture only imperfectly what it is that the universe is about . But, that it is about something, I have absolutely no doubt.

Where do we human beings fit into this great cosmic scheme? Can we gaze out into the cosmos, as did our remote ancestors, and declare: "God made all this for us!" Well, I think not. Are we then but an accident of nature, the freakish outcome of blind and purposeless forces, an incidental by-product of a mindless, mechanistic universe? I reject that too. The emergence of life and consciousness, I maintain, are written into the laws of the universe in a very basic way. True, the actual physical form and general mental make-up of homo sapiens contains many accidental features of no particular significance. If the universe were re-run a second time, there would be no solar system, no Earth and no people. But the emergence of life and consciousness somewhere and somewhen in the cosmos is, I believe, assured by the underlying laws of nature. The origin of life and consciousness were not interventionist miracles, but nor were they stupendously improbable accidents. They were, I believe, part of the natural outworking of the laws of nature, and as such our existence as conscious enquiring beings springs ultimately from the bedrock of physical existence - those ingenious, felicitous laws. That is the sense in which I have written in my book The Mind of God: "We are truly meant to be here". I mean "we" in the sense of conscious beings, not homo sapiens specifically. Thus although we are not at the centre of the universe, human existence does have a powerful wider significance. Whatever the universe as a whole may be about, the scientific evidence suggests that we, in some limited yet ultimately still profound way, are an integral part of its purpose.

How can we test these ideas scientifically? One of the great challenges to science is to understand the nature of consciousness in general and human consciousness in particular. We still haven't a clue how mind and matter are related, nor what process led to the emergence of mind from matter in the first place. This is an area of research that is attracting considerable attention at present, and for my part I intend to pursue my own research in this field. I expect that when we do come to understand how consciousness fits into the physical universe, my contention that mind is an emergent and in principle predictable product of the laws of the universe will be borne out.

Secondly, if I am right that the universe is fundamentally creative in a pervasive and continuing manner, and that the laws of nature encourage matter and energy to self-organize and self-complexify to the point that life and consciousness emerge naturally, then there will be a universal trend or directionality towards the emergence of greater complexity and diversity. We might then expect life and consciousness to exist throughout the universe. That is why I attach such

importance to the search for extraterrestrial organisms, be they bacteria on Mars, or advanced technological communities on the other side of the galaxy. The search may prove hopeless - the distances and numbers are certainly daunting - but it is a glorious quest. If we are alone in the universe, if the Earth is the only life-bearing planet among countless trillions, then the choice is stark. Either we are the product of a unique supernatural event in a universe of profligate overprovision, or else an accident of mind-numbing improbability and irrelevance. On the other hand, if life and mind are universal phenomena, if they are written into nature at its deepest level, then the case for an ultimate purpose to existence would be compelling.

Finally, let me turn to the theme of the Templeton Prize itself: progress in religion. It is often pointed out that people are increasingly turning away from the established religions. However, it remains as true as ever that ordinary men and women yearn for some sort of deeper meaning to their lives. Our secular age has led many people to feel demoralised and disillusioned, alienated from nature, regarding their existence as a pointless charade in an indifferent, even hostile, universe, a meaningless three score years and ten on a remote planet wandering amid the vastness of an uncaring cosmos. Many of our social ills can be traced to the bleak world view that three hundred years of mechanistic thought have imposed on us, a world view in which human beings are presented as irrelevant observers of nature rather than an integral part of the natural order. Some may indeed recoil from this philosophy and find comfort in ancient wisdom and revered texts that place mankind at the pinnacle of creation and the centre of the universe. Others choose to put their faith in so-called New Age mysticism.

I would like to suggest an alternative. We have to find a framework of ideas that provides people with some broader context to their lives than just the daily round, a framework that links them to each other, to nature and to the wider universe in a meaningful way, that yields a common set of principles around which peoples of all cultures can make ethical decisions, yet remains honest in the face of scientific knowledge; indeed, that celebrates that knowledge alongside other human insights and inspirations. The scientific enterprise as I have presented it to you today may not return human beings to the centre of the universe, it may reject the notion of miracles other than the miracle of nature itself, but it doesn't make human beings irrelevant either. A universe in which the emergence of life and consciousness is seen, not as a freak set of events, but fundamental to its lawlike workings, is a universe that can truly be called our home.

I believe that mainstream science, if we are brave enough to embrace it, offers the most reliable path to knowledge about the physical world. I am certainly not saying that scientists are infallible, nor am I suggesting that science should be turned into a latter-day religion. But I do think that if religion is to make real progress, as Sir John Templeton so passionately advocates, it cannot ignore the scientific culture; nor should it be afraid to do so, for as I have argued, science reveals just what a marvel the universe is.

Sir John Templeton recognizes that if religion is to progress it must confront modern scientific thought. Many religious leaders also accept this, and over the years I have enjoyed fruitful discussions on science and religion with theologians of varying persuasions - behind closed doors. What has most impressed me about my encounters with these theologians has been their open-mindedness and willingness to accept the conclusions of modern science. While the interpretation of the scientific account of the world may be contentious, the scientific facts are rarely questioned. Basic notions like the big bang theory, the origin of life and consciousness by natural physical processes, and Darwinian evolution, seem to cause these theologians little difficulty.

Yet among the general population there is a widespread belief that science and theology are for ever at loggerheads, that every scientific discovery pushes God further and further out of the picture. It is clear that many religious people still cling to an image of a God-of-the-gaps, a cosmic

magician invoked to explain all those mysteries about nature that currently have the scientists stumped. It is a dangerous position, for as science advances, so the God-of-the-gaps retreats, perhaps to be pushed off the edge of space and time altogether, and into redundancy.

The position I have presented to you today is radically different. It is one that regards the universe, not as the plaything of a capricious Deity, but as a coherent, rational, elegant and harmonious expression of a deep and purposeful meaning. I believe the time has now come for those theologians who share this vision to join me and my scientific colleagues to take the message to the people!

1995
Henry B. Eyring, Jr., C.E.S.
Christ and the Creation
Henry B. Eyring, ed., On Becoming a Disciple Scholar (Book)

Restoration theology is expansive, not constraining. We do not face the problems Copernicus faced, when many mistakenly believed that the earth was the center of the universe.

For instance, through revelations we learn that Jesus played a remarkable role even premortally. Yet, given His stunning past, He was so meek! Under the direction of the Father, before His birth at Bethlehem, Jesus was actually the creating Lord of the universe. Clearly, God the Father is not the God of merely one planet!

Putting our planet in perspective Stephen W. Hawking wrote: "The earth is a medium-sized planet orbiting around an average star in the outer suburbs of an ordinary spiral galaxy, which is itself only one of about a million million galaxies in the observable universe" (A Brief History of Time, p. 126).

Figure 2 shows the placement of our comparatively tiny solar system in the suburbs of the Milky Way galaxy. The visuals will relate to the hymn we sang, "If You Could Hie to Kolob."

Figure 3 is the brightest portion of our "ordinary" Milky Way galaxy. This breathtaking view brings to mind the Lord's words about His having created "worlds without number" (Moses 1:33).

Figure 4 is a spiral galaxy-much like our galaxy, with millions of stars. This recalls the divine words that "there is no end to my works" (Moses 1:38).

Figure 5 is the Doradus Nebula. If it were as close to us as is very distant Orion, it would cover one-fourth of the night sky. Think of the words about how God's creations "cannot be numbered unto man, but they are numbered unto [Him]" (Moses 1:37).

Figure 6 is called Baade's Window. These myriad stars in just one region of the Milky Way galaxy recall the words "and the stars . . . give their light, as they roll upon their wings. . . . and any man who hath seen any or the least of these hath seen God moving in his majesty and power." (D&C 88:45, 47.)

When we contemplate the stunning vastness, it is wise to remember, "Behold . . . all things are created and made to bear record of me" (Moses 6:63). Alma similarly declared, "All things denote there is a God . . . all the planets which move in their regular form do witness that there is a Supreme Creator" (Alma 30:44). It is a witnessing and overwhelming universe!

At the other end of the spectrum of size we also see divine design in the tiny but significant DNA molecule. This molecule (figure 7), which performs so many large chores, is formed by a double, intertwined helix.

It is instructive that the Lord told Moses, "But only an account of this earth, and the inhabitants thereof, give I unto you" (Moses 1:35). Even so, the Lord has told us some soaring, salvational things: "That by [Christ], ... the worlds are and were created, and the inhabitants thereof are begotten sons and daughters unto God" (D&C 76:24).

Truly, "The heavens declare the glory of God; and the firmament sheweth his handywork" (Ps. 19:1), including the announcing star of Bethlehem.

Amid such cosmic vastness overseen by God and Jesus, however, we can also have faith in their loving personal-ness.

1996
The Explanatory Power of Design
DNA and the Origin of Information
Stephen C. Meyer, Historian And Philosopher Of Science
Article

SINCE THE LATE NINETEENTH CENTURY MOST BIOLOGISTS HAVE rejected the idea that biological organisms display evidence of intelligent design. While many acknowledge the appearance of design in biological systems, they insist that Darwinism, or neo-Darwin-ism, can give a full account for how this appearance arose naturalistically—i.e., without invoking a directing intelligence or agency. Following Darwin, modem neo-Darwinists generally accept that natural selection acting on random variation (or mutations) suffices to explain the appearance of design in living organisms. *As* evolutionary biologist Francisco Ayala has explained,

The functional design of organisms and their features would ... seem to argue for the existence of a designer. It was Darwin's greatest accomplishment [however] to show that the directive organization of living beings can be explained as the result of a natural process, natural selection, without any need to resort to a Creator or other external agent (Ayala 1994, 4-5)

Yet whatever the explanatory efficacy of the Darwinian program, the appearance of design in at least one important domain of biology cannot be so easily dismissed. Since the late 1950s advances in molecular biology and biochemistry have revolutionized our understanding of the miniature world within the cell. Modem molecular biology has revealed that living cells—the fundamental units of life—possess the ability to store, edit and transmit information and to use information to regulate their most fundamental metabolic processes. Far from characterizing cells as simple "homogeneous globules of plasm," as did Ernst Haeckel (Haeckel 1905, 111) and other nineteenth-century biologists, modern biologists now describe cells as, among other things, "distributive real-time computers" and complex information processing systems.

Darwin, of course, neither knew about these intricacies nor sought to explain their origin. Instead, his theory of biological evolution sought to explain how life could have grown gradually more complex *starting* from "one or a few simple forms." Strictly speaking, therefore, those who insist that the Darwinian mechanism can explain the appearance of design in biology naturalistically overstate their case. The complexities within the microcosm of the cell beg for some kind of explanation, yet they lie beyond the purview of strictly biological evolutionary theory which assumes, rather than explains, the existence of the first life and the information it would have required.

This essay will argue that the complexity and specifity of even the simplest living cells suggest

more than just apparent design. Indeed, it will argue that actual or "intelligent" design now constitutes the best explanation for the origin of the information required to make a living cell in the first place. In so doing, this essay will also critique naturalistic theories of chemical, rather than biological, evolution. Whereas biological evolutionary theories such as Darwinism or neo-Darwinism seek to explain the origin of new biological forms from preexisting forms, theories of chemical evolution seek to explain the ultimate origin of life starting from inanimate matter.

The discussion that follows will evaluate and compare the explanatory power of competing classes of explanation with respect to the origin of biological information. It will show the causal inadequacy of explanations based upon both chance and necessity (and the two working in combination). As it happens, the recent history of origin-of-life research can be understood nicely by reference to Jacques Monod's famous categories "chance" and "necessity," which were addressed by William Dembski in his discussion of the explanatory filter in the previous chapter. From the 1920s to the mid-1960s, chemical evolutionary theories emphasized the creative role of random variations (i.e., chance)—often working in tandem with so-called pre-biotic natural selection. Since the late 1960s, theorists have instead generally invoked deterministic "self-organizational properties," i.e., necessity or law, the other naturalistic node on Dembski's explanatory filter (see previous chapter). This essay will trace the recent history of origin-of-life research to show the inadequacy of scenarios invoking either chance or necessity (or the combination) as causal mechanisms for the origin of that third type of explanation—intelligent design—provides a better explanation for the origin of the information, including the information content present in large bio-macromolecules such as DNA, RNA and proteins.

The Problem of life's Origin

After Darwin published the O*rigin of Species* in 1859, many scientists began to think about a problem that Darwin had not addressed,' namely, how life had arisen in the first place. While Darwin's theory purported to explain how life could have grown gradually more complex starting from "one or a few simple forms," it did not explain nor did it attempt to explain where life had originated.

Yet scientists in the 1870s and 1880s assumed that devising an explanation for the origin of life would be fairly easy. For one thing, they assumed that life was essentially a rather simple substance called protoplasm that could be easily constructed by combining and recombining simple chemicals such as carbon dioxide, oxygen and nitrogen. Thus Haeckel and others would refer to the cell as a simple "homogeneous globule of plasm" (Haeckel1905, 111; Huxley 1869, 129-45). To Haeckel a living cell seemed no more complex than a blob of gelatin. His theory of how life first came into existence reflected this simplistic view. His method likened cell "autogony," as he called it, to the process of inorganic crystallization (Haeckel 1866, 179-80; 1892, 411-13; Kamminga 1980, 60, 61). Haeckel's English counterpart, T. H. Huxley, proposed a simple two-step method of chemical recombination to explain the origin of the first cell (Huxley 1869, 138-39). Just as salt could be produced spontaneously by adding sodium to chloride, so, thought Haeckel and Huxley, could a living cell be produced by adding several chemical constituents together and then allowing spontaneous chemical reactions to produce the simple protoplasmic substance that they assumed to be the essence of life.

Orthodox Chemical Evolutionary Theory: The Oparin Scenario

During the 1920s and 1930s a more sophisticated version of this so-called chemical evolutionary theory was proposed by a Russian biochemist named Alexander L Oparin. Oparin had a much more accurate understanding of the complexity of cellular metabolism, but neither he nor any one else in the 1930s fully appreciated the complexity of the molecules such as protein and DNA that make life possible. Oparin, like his nineteenth-century predecessors, suggested that life could have first evolved as the result of a series of chemical reactions. Unlike his predecessors, however, he envisioned that this process of chemical evolution would involve many more chemical transformations and reactions and many hundreds of millions or even billions of years.

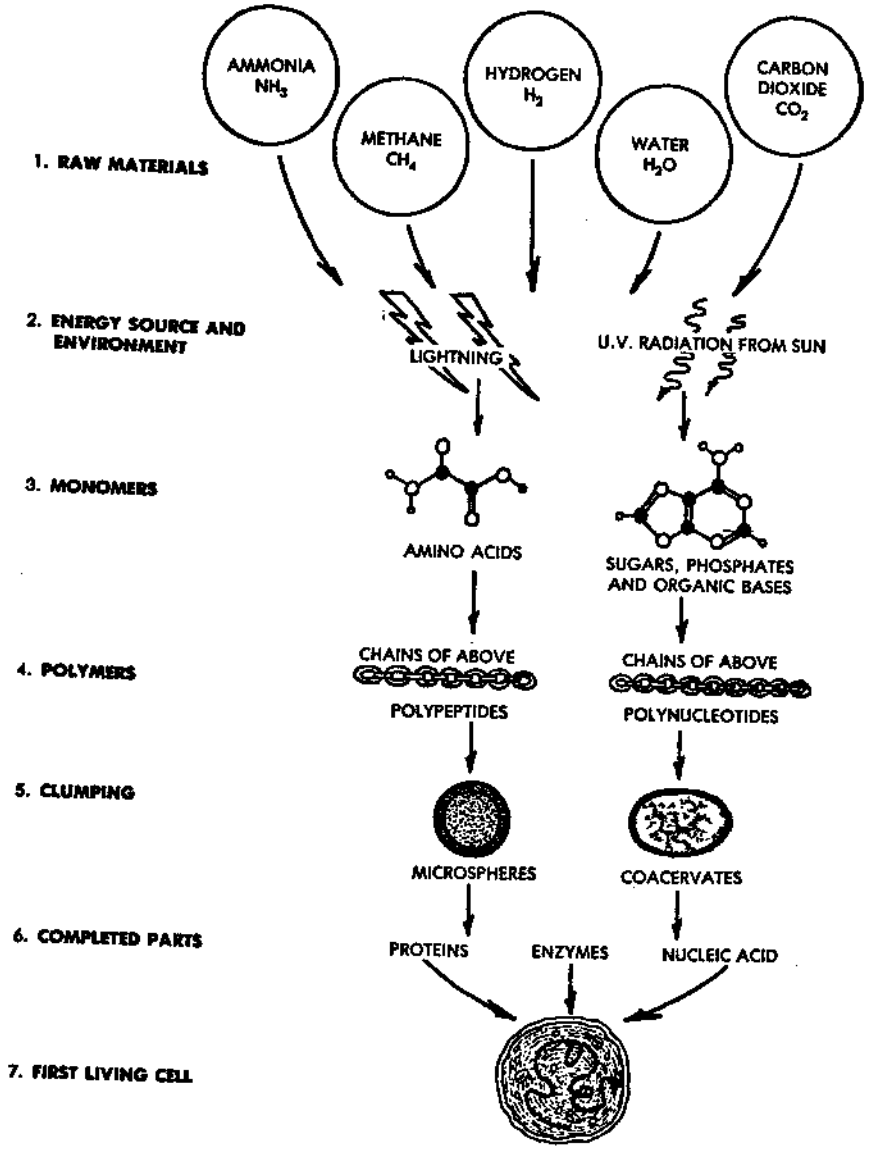
Oparin's theory envisioned a series of chemical reactions (see figure 5.1) that he thought would enable a complex cell to assemble itself gradually and naturalistically from simple chemical precursors. Oparin

believed that simple gases such as ammonia (NH3), methane (CH4), water (1120), carbon dioxide (CO2) and hydrogen (Hs) would have rained down to the early oceans and combined with metallic compounds extruded from the core of the earth (Oparin 1938, 64103). With the aid of ultraviolet radiation from the sun, the ensuing reactions would have produced energy-rich hydrocarbon compounds (Oparin 1938, 98, 107, 108). These in turn would have combined and recombined with various other compounds to make amino acids, sugars, phosphates and other building blocks of the complex molecules (such as proteins) necessary to living cells (Oparin 1938, 133-35). These constituents would eventually arrange themselves into simple cell-like enclosures that Oparin called coacervates (Oparin 1938, 148-59). Oparin then proposed a kind of Darwinian competition for survival among his coacervates. Those that developed increasingly complex molecules and metabolic processes would have survived and grown more complicated. Those that did not would have dissolved (Oparin 1938,195-96).

Thus cells would have become gradually more and more complex as they competed for survival over billions of years. Like Darwin, Oparin employed time, chance and natural selection to account for the origin of complexity from initial simplicity. Moreover, nowhere in his scenario did mind or intelligent design or a Creator play any explanatory role. For Oparin, a committed Marxist (Graham 1973, 262-63; Araujo 1981, 19), such notions were explicitly precluded from scientific consideration. Matter interacting chemically with other matter, if given enough time and the right conditions, could produce life. Complex cells could be built from simple chemical precursors without any guiding personal or intelligent agency.

The Miller-Urey Experiment

The first experimental support for Oparin's hypothesis came in December 1952. While doing graduate work under Harold Urey at the University of Chicago, Stanley Miller conducted the first experimental test of the Oparin chemical evolutionary model. Miller circulated a gaseous mixture of methane (C1^{-}14), ammonia (NH^3),water vapor (H20) and hydrogen (H2) through a glass vessel containing an electrical discharge chamber (Miller 1953, 528-29). Miller sent a high-voltage charge of electricity into the chamber via tungsten filaments in an attempt to simulate the effects of ultraviolet light on prebiotic atmospheric gases. After two days Miller found a small (2 percent) yield of amino acids in the U-shaped water trap he used to collect ducts at the bottom of the vessel. While Miller's initial experiment yielded only three of the twenty amino acids that occur naturally in proteins, subsequent experiments performed under similar conditions have produced all but one of the others. Other simulation experiments have produced fatty acids and the nucleotide bases found in DNA and RNA but not the sugar molecules deoxyribose and ribose necessary to build DNA and RNA molecules (Thaxton and Bradley 1994,182; Shapiro 1988, 71-95; Ferris 1987, 30; Thaxton, Bradley, and Olsen 1984, 24-38; Harada and Fox 1964, 335; Lemmon 1970, 95-96). Miller's success in producing biologically relevant building blocks under ostensibly prebiotic conditions was heralded as a great breakthrough. His experiment seemed to provide experimental support for Oparin's chemical evolutionary theory by showing that an important step in Oparin's scenario—the production of biological building blocks from simpler atmospheric gases—was possible on the early earth. Miller's work inspired many similar simulation experiments and an unprecedented optimism about the possibility of developing an adequate naturalistic explanation for the origin of life.



Thanks largely to Miller's experimental work, chemical evolution is now routinely presented in both high school and college biology textbooks (e.g., Alberts et al. 1983, 4; Lehninger 1975, 23) as the accepted scientific explanation for the origin of life. Yet chemical evolutionary theory is now known to be riddled with difficulties, and Miller's work is understood by the origin-of-life research community itself to have little if any relevance have to explaining how amino acids, let alone proteins or living cells, could arisen on the early earth.

Problems with the Oparin/Miller Hypothesis

Despite its status as textbook orthodoxy, the Oparin chemical evolutionary theory has in recent years encountered severe, even fatal, criticisms on many fronts. First, geochemists have failed to find evidence of the nitrogen-rich prebiotic soup required by Oparin's model. Second, the remains of single-celled organisms in the very oldest rocks testify that, however life emerged, it did so relatively quickly; that is, fossil evidence suggests that chemical evolution had little time to work before life emerged on the early earth.[3] Third, new geological and geochemical evidence suggests that prebiotic atmospheric conditions were hostile, not friendly, to the production of amino acids and other essential building blocks of life. Fourth, the revolution in the field of molecular biology has revealed so great a complexity and specificity of design in even the simplest cells and cellular components as to defy

materialistic explanation. Even scientists known for a staunch commitment to materialistic philosophy now concede that materialistic science in no way suffices to explain the origin of life (Dose 1988, 348-56; Shapiro 1986). *As* origin-of-life biochemist Klaus Dose has said, "More than 30 years of experimentation on the origin of life in the fields of chemical and molecular evolution have led to a better perception of the *-r* the problem of the origin of life on Earth rather than to its solution. At present all discussions on principle theories and experiments in the field either end in stalemate or in a confession of ignorance" (Dose 1988, 348-56; cf. Crick 1981, 88).

To understand the crisis in chemical evolutionary theory, it will be necessary to explain in more detail the latter two difficulties, namely, the problem of hostile prebiotic conditions and the problem posed by the complexity of the cell and its components.

When Miller conducted his experiment simulating the production of amino acids on the early earth, he presupposed that the earth's atmosphere was composed of a mixture of what chemists call reducing gases such as methane ($C14_4$), ammonia (NH3) and hydrogen (H_2). He also assumed that the earth's atmosphere contained virtually no free oxygen. Miller derived his assumptions about these conditions from Oparin's 1936 book (Miller 1953, 528-29). In the years following Miller's experiment, however, new geochemical evidence made it clear that the assumptions that Oparin and Miller had made about the early atmosphere could not be justified. Instead evidence strongly suggested that neutral gases such as carbon dioxide, nitrogen and water vapor (Walker 1977, 210, 246; 1978, 22; Kerr 1980, 4243; Thaxton, Bradley, annd Olsen 1984, 73-94)—not methane, ammonia and hydrogen—predominated in the early atmosphere.

Moreover, a number of geochemical studies showed that significant amounts of free oxygen were also present even before the advent of plant life, probably as the result of volcanic outgassing and the photo-dissociation of water vapor (Berliner and Marshall 1965, 225; Brinkman 1969, 5355; Dimroth and Kimberly 1976, 1161; Carver 1981, 136; Holland, Lazar; and McCaffrey 1986, 27-33;!Castings, Liu, and Donahue 1979, 3097-3102; Kerr 1980, 4243; Thaxton, Bradley, and Olsen 1984, 73-94).

This new information about the probable composition of the early atmosphere has forced a serious reevaluation of the significance and relevance of Miller-type simulation experiments. *As* had been well know *even* before Miller's experiment, amino acids will form readily in an appropriate mixture of reducing gases. In a chemically neutral atmosphere, however, reactions among atmospheric gases will not take place readily, and those reactions that do take place will produce extremely low yields of biological building blocks." Further, even a small amount of atmospheric oxygen will quench the production of biologically significant building blocks and cause any biomolecules otherwise present to degrade rapidly.

The Molecular Biological Revolution and the Origin of Information

Yet a more fundamental problem remains for all chemical evolutionary scenarios. Even if it could be demonstrated that the building blocks of essential molecules could arise *in* realistic prebiotic conditions. the problem of assembling those building blocks into functioning proteins or DNA chains would remain. This problem of explaining the specific sequencing and thus the information within biopolymers lies at the heart of the current crisis in materialistic evolutionary thinking.

In the early 1950s, the molecular biologist Fred Sanger determined the structure of the protein molecule insulin. Sanger's work made clear for the first time that each protein found in the cell comprises along and definitely arranged sequence of amino acids. The amino acids in protein molecules are linked together to form a chain, rather like individual railroad cars composing a long train. Moreover, the function of all such proteins, whether as enzymes, signal transducers or structural components in the cell, depends upon the specific sequencing of the individual amino acids (Alberts et at 1983, 91-141), just as the meaning of an English text depends upon the sequential arrangement of the letters. The various chemical interactions between amino acids in any given chain will determine the three-dimensional shape or topography that the amino acid chain adopts. This shape in turn determines what function, if any, the amino acid chain can perform within the cell.

For a functioning protein, its three-dimensional shape gives it a hand-in-glove fit with other molecules in the cell, enabling it to catalyze specific chemical reactions or to build specific structures within the cell. The proteins histone 3 and 4, for example, fold into very well-defined three-dimensional shapes with a precise distribution of positive charges around their exteriors. This shape and charge distribution enable them to form part of the spool-like nucleosomes that allow DNA to coil efficiently around itself and to store information (Lodish et at 1995, 347-48). The information storage density of DNA, thanks in part to nucleosome spooling, is several trillion times that of our most-advanced computer chips (Girt 1989, 4).

To get a feel for the specificity of the three-dimensional charge distribution on these histone proteins, imagine a large wooden spool with grooves on the surface. Next picture a helical cord made of two strands. Then visualize wrapping the cord around the spool so that it lies exactly into perfectly hollowed-out grooves. Finally, imagine the grooves to be hollowed so that they exactly fit the shape of the coiled cord, with thicker parts nestling into deeper grooves, thinner parts into more shallow ones. In other words, the irregularities in the shape of the cord exactly match irregularities in the hollow grooves. In the case of histone and DNA there are not actually grooves, but there is an uncanny distribution of positively charged regions on the surface of the histone proteins that exactly matches the negatively charged regions of the double-stranded DNA that coils around it (Lodish et al. 1995, 347-48). Proteins that function as enzymes or that assist in the processing of information stored on DNA strands often have an even greater specificity of fit with the molecules to which they must bind. Almost all proteins function as a result of an extreme hand-in-glove three-dimensional specificity that derives from the precise sequencing of the amino acid building blocks.

The discovery of the complexity and specificity of protein molecules has raised serious difficulties for chemical evolutionary theory, even Wan abundant supply of amino acids is granted for the sake of argument. Amino acids alone do not make proteins, any more than letters alone make words, sentences or poetry. In both cases the sequencing of the constituent parts determines the function or lack of function of the whole. In the case of human languages the sequencing of letters and words is obviously performed by intelligent human agents. In the cell the sequencing of amino acids is directed by the information—the set of biochemical instructions--encoded on the DNA molecule.

Information Transfer: From DNA to Protein

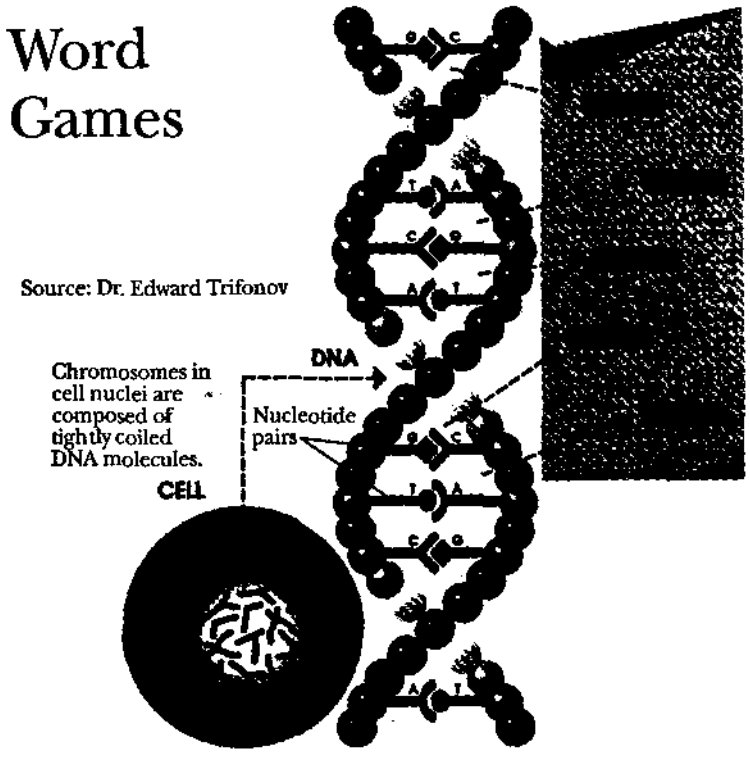
During the 1950s and 1960s, at roughly the same time molecular biologists began to determine the structure and function of many proteins, scientists were able to explicate the structure and function of DNA, the molecule of heredity. After James Watson and Francis Crick elucidated the structure of DNA (Watson and Crick 1953, 737), molecular biologists soon discovered how DNA directs the process of protein synthesis within the cell. They discovered that the specificity of amino acids in proteins derives from a prior specificity within the DNA molecule—from information on the DNA molecule stored as millions of specifically arranged chemicals called nucleotides or bases along the spine of DNA's helical strands *(see* figure 5.2). Chemists represent the four nucleotides with the letters A, T, G and C (for adenine, thymine, guanine and cytosine).

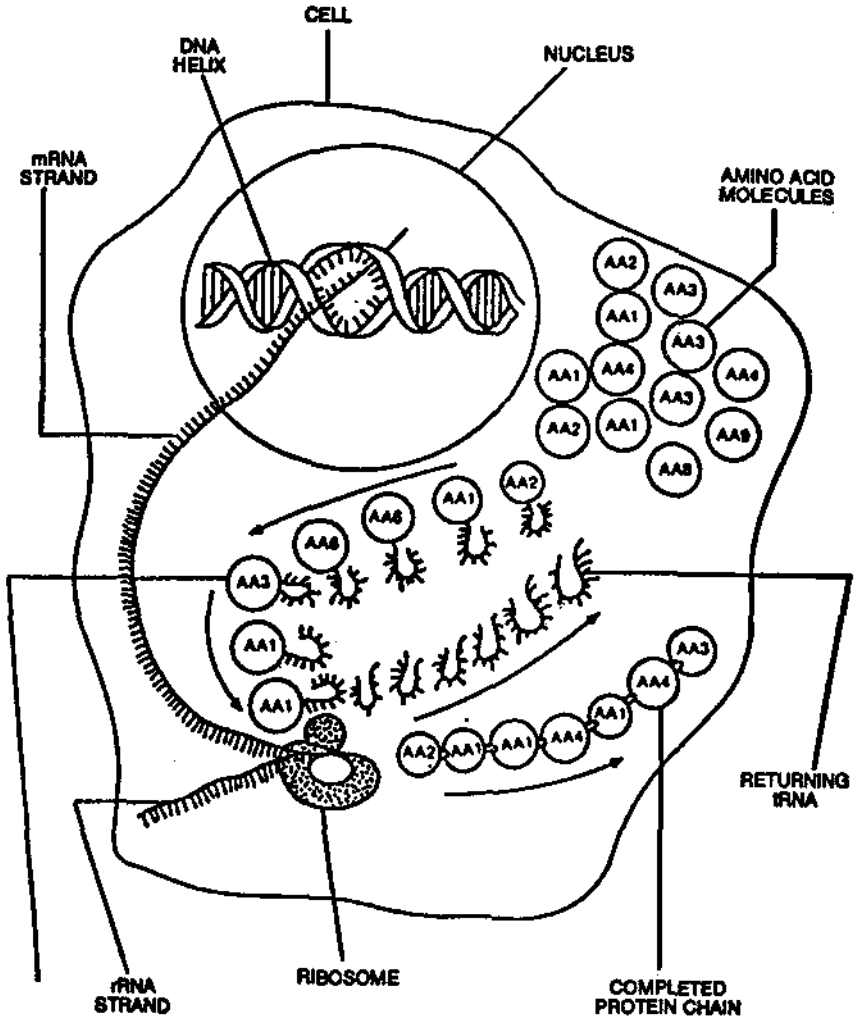
As in the case of protein, the sequence specificity of the DNA molecule strongly resembles the sequence specificity of human codes or languages. Just as the letters in the alphabet of a written language may convey a particular message depending on their sequence, so too do the sequences of nucleotides or bases in the DNA molecule convey precise biochemical messages that direct protein synthesis within the cell. Whereas the function of the protein molecule derives from the specific arrangement of twenty different amino acids (a twenty-letter alphabet), the function of DNA depends upon the arrangement ofjust four bases. Thus it takes a group of three nucleotides (or triplets, as they are called) on the DNA molecule to specify the construction of one amino acid. This process proceeds as long chains of nucleotide triplets (the genetic message) are first copied during a process

known as DNA transcription and then transported (by the molecular messenger m-RNA) to a complex organelle called a ribosome (Borek 1969, 184). At the ribosome site the genetic message is translated with the aid of an ingenious adaptor molecule called transfer-RNA to produce a growing amino acid chain (Alberts et al. 1983, 108-9; see figure 5.3). Thus the sequence specificity in DNA begets sequence specificity in proteins. Or put differently, the sequence specificity of proteins depends upon a prior specificity—upon information—encoded in DNA.

Naturalistic Approaches to the Problem of the Origin of Information

The explication of this system by molecular biologists in the 1950s and 1960s has raised the question of the ultimate origin of the specificity—the information—in both DNA and the proteins it generates. Many scientists now refer to the information problem as the Holy Grail of origin-of-life biology (Thaxton and Bradley 1994, 190). As Bernd-Olaf Kuppers recently stated, the problem of the origin of life is clearly basically equivalent to the problem of the origin of biological information" (Koppers 1990, 170-72). *As* mentioned previously, the information contained or expressed in natural languages and computer codes is the product of intelligent minds. Minds routinely create informative arrangements of matter. Yet since the mid-nineteenth century scientists have sought to explain all phenomena by reference to exclusively material causes (Gillespie 1979; Meyer 1994a, 29-40; Meyer 1993, Al4; Johnson 1991; Ruse 1982, 72-78). Since the 1950s three broad types of naturalistic explanation have been proposed by scientists to explain the origin of information.





Biological Information: Beyond the Reach of Chance

After the revolutionary developments within molecular biology in the 1950s and early 1960s made clear that Oparin had underestimated the complexity of life, he revised his initial theory. He sought to account for the sequence specificity of the large protein, DNA and RNA molecules (known collectively as biomacromolecules or biopolymers). In each case the broad outlines of his theory remained the same, but Oparin invoked the notion of natural selection acting on random variations within the sequences of the biopolymers to account for the emergence of the specificity within these molecules (Kamminga 1980, 326; Oparin 1968, 146-47). Others invoked the idea of a chance formation for these large information-bearing molecules by speaking of them as "frozen accidents" (Crick 1968, 367-79; Kamminga 1980, 303-4).

While many outside origin-of-life biology may still invoke chance as a causal explanation for the origin of biological information, few serious researchers still do (de Duve 1995, 112). Since molecular biologists began to appreciate the sequence specificity of proteins and nucleic acids in the 1950s and 1960s, many calculations have been made to determine the probability of formulating functional proteins and nucleic acids at random. Various methods of calculating

probabilities have been offered (Morowitz 1968, 5-12; Cairns-Smith 1971, 92-96; Hoyle and Wickramasinghe 1981, 2427; Shapiro 1986,117-31; Yockey 1981,13-31; Yockey 1992, 246-58; Bowie and Sauer 1989, 2152-56; Bowie et al. 1990, 1306-10; Reidhaar-Olson and Sauer 1990, 306-16). For the sake of argument these calculations have generally assumed extremely favorable prebiotic conditions (whether realistic or not) and theoretically maximal reaction rates among the constituent monomers (i.e., the constituent parts of the proteins, DNA and RNA). Such calculations have invariably shown that the probability of obtaining functionally sequenced biomacromolecules at random is, in Prigogine's words, 'Vanishingly small ... even on the scale of ... billions of years" (Prigogine, Nicolis, and Babloyantz 1972, 23).[5] As Cairns-Smith (1971, 95) wrote:

Blind chance ... is very limited. Low-levels of cooperation he [i.e., blind Chance] can produce exceedingly easily (the equivalent of letters and small words), but he becomes very quickly incompetent as the amount of organization increases. Very soon indeed long waiting periods and massive material resources become irrelevant.

Consider the probabilistic hurdles that must be overcome to construct even one short protein molecule of about 100 amino acids in length. (A typical protein consists of about 300 amino acids, and some are very much longer; Alberts et al. 1983, 118). First, all amino acids must form a chemical bond known as a peptide bond so as to join with other amino acids in the protein chain. Yet in nature many other types of chemical bonds are possible between amino acids; peptide and nonpeptide bonds occur with roughly equal probability. Thus at any given site along a growing amino acid chain the probability of having a peptide bond is roughly 1/2. The probability of attaining four peptide bonds is: (1/2 x 1/2 x 1/2 x 1/2) = 1/16 or $(l/2)^4$. The probability of building a chain of one hundred amino acids in which all linkages involve peptide linkages is $(l/2)^{1"}$ or roughly 1 chance in 10 to the 50th power.

Second, in nature every amino acid has a distinct mirror image of itself, one left-handed version or L-form, and one right-handed version, or D-form. These mirror-image forms are called optical isomers. Functioning proteins tolerate only left-handed amino acids, yet the right-handed and left-handed isomers occurs in nature with roughly equal frequency. Taking this into consideration compounds the improbability of attaining a biologically functioning protein. The probability of attaining at random only L-amino acids in a hypothetical peptide chain 100 amino acids long is again $(1/2)^{1"}$ or roughly 1 chance in 10^{90}. The probability of building a 100 amino acid length chain at random in which all bonds are peptide bonds and all amino acids are L-form would be $(1/4)^{100}$ or roughly 1 chance in $10^{6°}$ (zero for all practical purposes given the time available on the early earth).

Functioning proteins have a third independent requirement, the most important of all: their amino acids must link up in a specific sequential arrangement, just like the letters in a meaningful sentence. In some cases changing even one amino acid at a given site can result in a loss of protein function. Moreover, because there are 20 biologically occurring amino acids, the probability of getting a specific amino acid at a given site is small (i.e., l/20; the probability is even lower because there are many nonproteineous amino acids in nature). On the assumption that all sites in a protein chain require one particular amino acid, the probability of attaining a particular protein 100 amino acids long would be $(l/20)^{14°}$ or roughly 1 chance in le°.

We know now, however, that some sites along the chain do tolerate several of the twenty proteineous amino acids, while others do not. The biochemist Robert Sauer of MIT has *used* a technique known as "cassette mutagenesis" to determine just how much variance among amino acids can be tolerated at any given site in several proteins. His results have shown that, even taking the possibility of variance into account, the probability of achieving a functional sequence of amino acids[6] in several functioning proteins at random is still 'vanishingly small," roughly I chance in 10 to the 65 power le—an astronomically large number (there are 10^{65} atoms in our galaxy; Reidhaar-Olson and Sauer 1990, 306-16). In light of these results, biochemist

Michael Behe has compared the odds of attaining proper sequencing in a 100 amino acid length protein to the odds of a blindfolded man finding a single marked grain of sand hidden in the Sahara Desert not once but three times (Behe 1994, 68-69). Moreover, if one also factors in the probability of attaining proper bonding and optical isomers, the probability of constructing a rather short functional protein at random becomes so small as to be effectively zero (I chance in le^{ss}) even given our multibillion-year-old universe (Borel 1962, 28; Dembski 1998). All these calculations thus reinforce the opinion that has prevailed since the mid-1960s within origin-of-life biology: Chance is not an adequate explanation for the origin of biological specificity. What P. T. Mom said (1963, 215) still holds:

Statistical considerations, probability, complexity, etc., followed to their logical implications suggest that the origin and continuance of life is not controlled by such principles. An admission of this is the use of a period of practically infinite time to obtain the derived result. Using such logic, however, we can prove anything.

Prebiolic Natural Selection: A Contradiction in Terms

At nearly the same time that many researchers became disenchanted with chance explanations, theories of prebiotic natural selection also fell out of favor. Such theories allegedly overcome the difficulties attendant pure chance theories by providing a mechanism by which complexity-increasing events in the cell would be preserved and selected. Yet these theories share many of the difficulties that afflict purely chance-based theories.

Oparin's revised theory, for example, claimed that a kind of natural selection acted upon random polymers as they formed and changed within his coacervate protocells (Oparin 1968, 146-47). As more complex molecules accumulated, they presumably survived and reproduced more prolifically. Nevertheless Oparin's discussion of differential reproduction seemed to presuppose a preexisting mechanism of self-replication. Self-replication in all extant cells depends upon functional and therefore to a high degree sequence-specific proteins and nucleic acids. Yet the origin of these mole. arks is precisely what Oparin needed to explain. Thus many rejected the postulation of prebiotic natural selection as question begging (Mom 1965, 311-12; Bertalanffy 1967, 82). Functioning nucleic acids and proteins (or molecules approaching their complexity) are necessary to self-replication, which in turn is necessary to natural selection. Yet Oparin invoked natural selection to explain the origin of proteins and nucleic acids. As the evolutionary biologist Theodosius Dobzhansky would proclaim, "prebiological natural selection is a contradiction in terms" (Dobzhansky 1965, 310). Or as H. H. Pattee (1970, 123) put it:

There is no evidence that hereditary evolution occurs except in cells which already have the complete complement of hierarchical constraints, the DNA, the replicating and translating enzymes, and all the control systems and structures necessary to reproduce themselves.

In any case, functional sequences of amino acids (i.e., proteins) cannot be counted on to arise via random events, even if some means of selecting them exists after they have been produced. Natural selection can only select what chance has first produced, and chance, at least in a prebiotic setting, seems an implausible agent for producing the information present in even a single functioning protein or DNA molecule. Oparin attempted to circumvent this problem by claiming that the first polymers need not have been terribly specific. But lack of polymer specificity produces "error catastrophes" that efface the accuracy of self-replication and eventually render natural selection impossible. Further, the mathematician von Neumann (1966) showed that any system capable of self-replication would need to contain subsystems that were functionally equivalent to the information storage, replicating and processing systems found in extant cells. His calculations and similar ones by Wigner (1961, 231-35), Landsberg (1964, 928-30) and Morowitz (1966, 446-59; 1968, 10-11) showed that random fluctuations of molecules in all probability would not produce the minimal complexity needed for even a primitive replication system. The improbability of developing a replication system vastly exceeds the improbability of developing the protein or DNA components of such a system. Thus appeals to prebiotic natural selection increasingly appear indistinguishable from appeals to chance.

Nevertheless, Richard Dawkins (Dawkins 1986, 47-49) and Bernd-Olaf Koppers (Koppers 1987, 355-69) recently have attempted to resuscitate prebiotic natural selection as an explanation for the origin of biological information. Both accept the futility of naked appeals to chance and invoke what /Cuppers calls a "Darwinian optimization principle." Both use a computer to demonstrate the efficacy of prebiotic natural selection. Each selects a target sequence to represent a desired functional polymer. After creating a crop of randomly constructed sequences and generating variations among them at random, they then program the computer to select those sequences that match the target sequence most closely. The computer then amplifies the production of those sequences and eliminates the others (thus simulating differential reproduction) and repeats the process. As Wrappers puts it,

Every mutant sequence that agrees one bit better with the meaningful or reference sequence . . . will be allowed to reproduce more rapidly.(Rippers 1987, 366)

In Kuppers's case, after a mere thirty-five generations his computer succeeded in spelling his target sequence, "NATURAL SELECTION."

Despite superficially impressive results, these "simulations" conceal an obvious flaw: molecules *in situ* do not have a target sequence in mind, nor will they confer any selective advantage on a cell and thus differentially reproduce until they combine in a functionally advantageous arrangement Thus, nothing in nature corresponds to the role that the computer plays in selecting functionally non-advantageous sequences that happen to agree "one bit better" than others with a target sequence. The sequence "NORMAL ELECTION" may agree more with "NATURAL SELECTION" than does the sequence "MISTRESS DEFECTION," but neither of the two yields any advantage in communication over the other if, that is, we are trying to communicate something about natural selection. If so, both are equally ineffectual. Similarly, a nonfunctional polypeptide would confer no selective advantage on a hypothetical protocell, even if its sequence happens to "agree one bit better" with an unrealized target protein than some other nonfunctional polypeptide.

Indeed, both Kippers's and Dawkins's published results of their simulations show the early generations of variant phrases awash in nonfunctional gibberish. In Dawkins's simulation, not a single functional English word appears until after the tenth iteration (unlike the more generous example above, which starts with actual albeit incorrect words). Yet to make distinctions on the basis of function among sequences that have no function whatsoever would seem quite impossible. Such determinations can only be made if considerations of proximity to possible future function are allowed, but this requires foresight that molecules do not have. A computer, programmed by a human being, can perform these functions. To imply that molecules can *as* well only illicitly personifies nature. Thus, if these computer simulations demonstrate anything, they subtly demonstrate the need for intelligent agents to elect some options and exclude others—that is, to create information.

Self-Organizational Scenarios

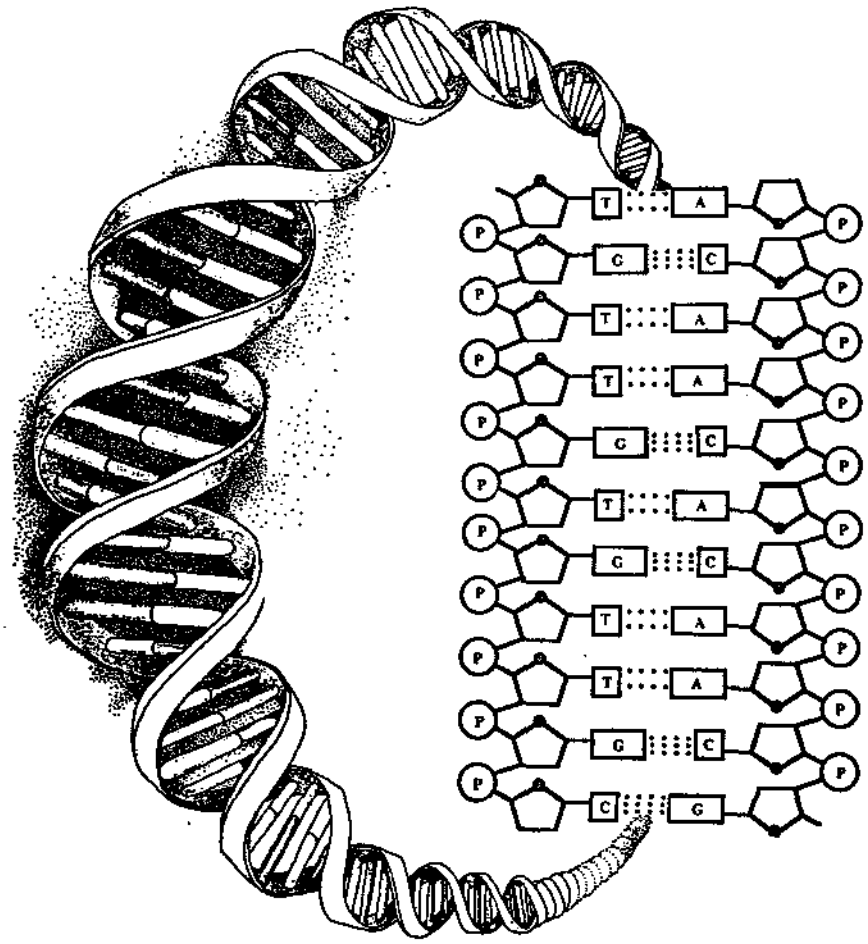
Because of the difficulties with appeals to prebiotic natural selection, many origin-of-life theorists after the mid-1960s attempted to address the problem of the origin of biological information in a new way. Rather than invoking prebiotic natural selection or "frozen accidents" (Crick 1968, 367-79; kamminga 1980, 303-4), many theorists suggested that the laws of nature and chemical attraction may themselves be responsible for the information in DNA and proteins. Some have suggested that simple chemicals might possess "self-ordering properties" capable of organizing the constituent parts of proteins, DNA and RNA into the specific arrangements they now possess (Morowitz 1968). Steinman and Cole, for example, suggested that differential bonding affinities or forces of chemical attraction between certain amino acids might account for the origin of the sequence specificity of proteins (Steinman and Cole 1967, 735-41; Steinman 1967, 533-39; for recent criticism see Kok, Taylor, and Bradley 1988, 135-42). Just as electrostatic forces draw sodium ion (Na+) and chloride ions (Cl-) together into highly ordered

patternswithin a crystal of salt (NaCI),so too might amino adds with special affinities for each other arrange themselves to form proteins. This idea was developed in *Biochemical Predestination* by Kenyon and Steinman (1969). They argued that the origin of life might have been "biochemically predestined" by the properties of attraction that exist between constituent chemical parts, particularly between amino acids in proteins (Kenyon and Steinman 1969, 199-211, 263-66).

In 1977 another self-organizational theory was proposed by Prigogine and Nicolis based on a thermodynamic characterization of living organisms. In *Self Organisation in Non-equilibrium Systems,* they classified living organisms as open, non-equilibrium systems capable of "dissipating" large quantities of energy and matter into the environment (Prigogine and Nicolis 1977, 339-53, 429-47). They observed that open systems driven far from equilibrium often display self-ordering tendencies. For example, gravitational energy will produce highly ordered vortices in a draining bathtub; thermal energy flowing through a heat sink will generate distinctive convection currents or "spiral wave activity" Prigogine and Nicolis then argued that the organized structures observed in living systems might have similarly self-originated with the aid of an energy source. In essence they conceded the improbability of simple building blocks arranging themselves into highly ordered structures under normal equilibrium conditions. But they suggested that under non-equilibrium conditions, where an external source of energy is supplied, biochemical building blocks might arrange themselves into highly ordered patterns.

Order Versus Information

For many current origin-of-life scientists, self-organizational models (see, e.g., Kauffman 1993; de Duve 1995) now seem to offer the most promising approach to explaining the origin of biological information. Nevertheless critics have called into question both the plausibility and the relevance of self-organizational models. Perhaps the most prominent early advocate of self-organization, Dean Kenyon, has now explicitly repudiated such theories also failed to solve the sequencing problem[7]—that is, the problem of explaining how information present in all functioning RNA molecules could have arisen in the first place.



as both incompatible with empirical findings and theoretically incoherent (Kok, Taylor, and Bradley 1988, 13542).

First, empirical studies have shown that some differential affinities do exist between various amino acids (i.e., particular amino acids do form linkages more readily with some amino acids than others; Steinman and Cole 1967, 735-41; Steinman 1967, 533-39). Nevertheless these differences do not correlate to actual sequencing in large classes of known proteins (Kok, Taylor, and Bradley 1988, 135-42). In short, differing chemical affinities do not explain the multiplicity of amino acid sequences that exist in naturally occurring proteins or the sequential ordering of any single protein.

In the case of DNA this point can be made more dramatically. Figure 5.4 shows the structure of DNA depends upon several chemical bonds. There are bonds, for example, between the sugar and the phosphate molecules that form the two twisting backbones of the DNA molecule. There are bonds fixing individual nucleotide bases to the sugar-phosphate backbones on each side of the molecule. There are also hydrogen bonds stretching horizontally across the molecule between nucleotide bases making so-called complementary pain. These bonds, which hold two complementary copies of the DNA message text together, make replication of the genetic instructions possible. Most importantly, however, notice that there are =chemical bonds between the nucleotide bases that run along the spine of the helix. Yet it is precisely along this axis of the molecule that the genetic instructions in DNA are encoded (Alberts et al. 1983, 105). In other words, the chemical constituents that are responsible for the message text in DNA do not interact chemically in any significant way.

Further, just as magnetic letters can be combined and recombined in any way to form various sequences on a

metal surface, so too can each of the four bases A, T, Gand C attach to any site on the DNA backbone with equal facility, making all sequences equally probable (or improbable). Indeed, there are no differential affinities between any of the four bases and the binding sites along the sugar-phosphate backbone. The same type of so-called "n-glycosidic" bond occurs between the base and the backbone regardless of which base attaches. All four bases are acceptable; none is preferred. As Koppers has noted,

the properties of nucleic acids indicates that all the combinatorially possible nucleotide patterns of a DNA are, from a chemical point of view, equivalent. (Koppers 1987, 364)

Thus, "self-organizing" bonding affinities cannot explain the sequential ordering of the nucleotide bases in DNA because (l) there are no bonds between bases along the message-bearing axis of the molecule, and (2) there are no *differential* affinities between the backbone and the various bases that could account for variations in sequencing. Because the same holds for RNA molecules, researchers who speculate that life began in an "RNA world" have ……..

For those who want to explain the origin of life as the result of self-organizing properties intrinsic to the material constituents of living systems, these rather elementary facts of molecular biology have devastating implications. The most logical place to look for self-organizing properties to explain the origin of genetic information is in the constituent parts of the molecules carrying that information. But biochemistry and molecular biology make clear that forces of attraction between the constituents in DNA, RNA and proteins do not explain the sequence specificity of these large information-bearing biomolecules.

Significantly, information theorists insist that there is a good reason for this. If chemical affinities between the constituents in the DNA message text determined the arrangement of the text, such affinities would dramatically diminish the capacity of DNA to carry information. To illustrate, imagine receiving the following incomplete message over the wire: the "q-ick brown fox jumped over the lazy dog." Obviously someone who knew the conventions of English could determine which letter had been rubbed out in the transmission. Because *q* and u always go together by grammatical necessity, the presence of one indicates the probable presence of the other in the initial transmission of the message. The u in all English communications is an example of what information theorists call "redundancy." Given the grammatical rule "it must always follow *q,"* the addition of the u adds no new information when *q* is already present. It is redundant or unnecessary to determining the sense of the message (though not to making it grammatically correct).

Now consider what would happen if the individual nucleotide letters (A, T, G, C) in a DNA molecule did interact by chemical necessity with each other. Every time adenine (A) occurred in a growing genetic sequence, it would attract thymine (T) to it. Every time cytosine (C) occurred, guanine (G) would follow[5] *As* a result the DNA message text would be peppered with repeating sequences of A's followed by T's and C's followed by G's. Rather than having a genetic molecule capable of unlimited novelty with all the unpredictable and aperiodic sequences that characterize informative texts, we would have a highly repetitive text awash in redundant sequences, much as happens in crystals. In a crystal the forces of mutual chemical attraction do completely explain the sequential ordering of the constituent parts and consequently crystals cannot convey novel information. Sequencing in crystals is highly ordered or repetitive but not informative. Once one has seen Na followed by CI in a crystal of salt, for example, one has seen the extent of the sequencing possible. In DNA, however, where any nucleotide can follow any other, innumerable novel sequences are possible, and a countless variety of amino acid sequences can be built.

The forces of chemical necessity, like grammatical necessity in the q-and-u example, produce

redundancy or monotonous order but reduce the capacity to convey information and create novelty. As Polanyi has said:

Suppose that the actual structure of a DNA molecule were due to the fact that the bindings of its bases were much stronger than the bindings would be for any other distribution of bases, then such a DNA molecule would have no information content Its code-like character would be effaced by an overwhelming redundancy . . . Whatever may be the origin of a DNA configuration, it can function as a code only if its order is not due to the forces of potential energy. It *must be* as physically indeterminate as the sequence of words is on a printed page. (Polanyi 1968, 1309, emphasis added)

So, if chemists had found that bonding affinities between the nucleotides in DNA produced nucleotide sequencing, they would have also found that they had been mistaken about DNA's information-bearing properties. To put the point quantitatively, to the extent that forces of attraction between constituents in a sequence determine the arrangement of the sequence, to that extent will the information-carrying capacity of the system be diminished.' As Dretske has explained:

As p (si) [the probability of a condition or state of affairs] approaches 1 the amount of information associated with the occurrence of si goes to O. In the limiting case when the probability of a condition or state of affairs is unity [p (si) = l], no information is associated with, or generated by, the occurrence of si. This is merely another way to say that no information is generated by the occurrence of events for which there are no possible alternatives. (Dretske 1981, 12) Bonding affinities, to the extent they exist, militate against the maximization of information (Yockey 1981, 18). They cannot therefore be used to explain the origin of information. Affinities create mantras, not messages.

The tendency to conflate the qualitative distinction between order and information has characterized self-organizational research efforts and calls into question the relevance of such work to the origin of life. *As* Yockey has argued, the accumulation of structural or chemical order does not explain the origin of biological complexity (i.e., genetic information).[10] He concedes that energy flowing through a system may produce highly ordered patterns. Strong winds form swirling tornadoes and the eyes of hurricanes; Prigogine's thermal baths do develop interesting "convection currents"; and chemical elements do coalesce to form crystals. Self-organizational theorists explain well what does not need explaining. What needs explaining is not the origin of order (in the sense of symmetry or repetition) but the origin of information—the highly improbable, aperiodic and yet specified sequences that make biological function possible.

To illustrate the distinction between order and information compare the sequence ABABABABABABAB to the sequence THE BIG RED HOUSE IS ON FIRE! The first sequence is repetitive and ordered but not complex or informative. The second sequence is not ordered in the sense of being repetitious, but it is complex and also informative. The second sequence is complex because its characters do not follow a rigidly repeating or predictable pattern; that is, it is aperiodic. It is also informative because, unlike a merely complex sequence such as RFSXDCNCTQJ, the particular arrangement of characters is highly exact or specified so as to perform a (communication) function. Systems that are characterized by both specificity and complexity (what information theorists call "specified complexity") have "information content"

Since systems have the qualitative feature of complexity (aperiodicity), they are qualitatively distinguishable from systems characterized by simple periodic order. Thus attempts to explain the origin of order have no relevance to discussions of the origin of specified complexity or information content Significantly, the nucleotide sequences in the coding regions of DNA have by all accounts a high information content—that is, they are both highly specified and complex, just like meaningful English sentences (Thaxton and Bradley 1994, 173-210; Thaxton, Bradley and Olsen 1984, 127-66; Yockey 1992, 242-93).

Conflating order and information (or specified complexity) has led many

to attribute properties to brute matter that it does not possess. While energy in a system can create patterns of symmetric order such as whirling vortices, there is no evidence that energy alone can encode functionally specified sequences, whether biochemical or otherwise. As Yockey (1977, 380) warns: Attempts to relate the idea of order ... with biological organization or specificity must be regarded as a play on words which cannot stand careful scrutiny. Informational macromolecules can code genetic messages and therefore can carry information because the sequence of bases or residues is affected very little, if at all, by [self-organizing] physicochemical factors.

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The preceding discussion suggests that the properties of the material constituents of DNA, like those of any information-bearing medium, are not responsible for the information conveyed by the molecule. In all informational systems, the information content or message is neither deducible from the properties of the material medium nor attributable to them. The properties of matter do not explain the origin of the information.

To amplify this point, consider first that many different materials can express the same message. The headline of this morning's *New York* limes was written with ink on paper. Nevertheless, many other materials could have been used to convey the same message. The information in the headline could have been written with chalk on a board, with neon-filled tubes in a series of signs, or by a skywriter over New York harbor. Clearly the peculiar chemical properties of ink are not necessary to convey the message. Neither are the physical properties (i.e., the geometric shapes) of the letters necessary to transmit the information. The same message could have been expressed in Hebrew or Greek using entirely different alphabetic characters.

Conversely the same material medium and alphabetic characters can express many different messages; that is the medium is not sufficient to determine the message. In November of an election year the *Times* will use ink and English characters to tell the reading public that either a Democrat, a Republican or a third-party candidate has won the presidential election. Yet the properties of the ink and the twenty-six letters available to the typesetter will not determine which headline will be published by the limes. Instead the ink and English characters will permit the transmission of whatever headline the election requires, as well as a vast ensemble of other possible arrangements of text, some meaningful and many more not Neither the chemistry of the ink nor the shapes of the letters determines the meaning of the text In short, the message transcends the properties of the medium.

The information in DNA also transcends the properties of its material medium. Because chemical bonds do not determine the arrangement of nucleotide bases, the nucleotides can assume a vast array of possible sequences and thereby express many different messages. (Conversely various materials can express the same messages, as happens in variant versions of the genetic code or when laboratory chemists use English instructions to direct the synthesis of naturally occurring proteins.) Thus, again, the properties of the constituents do not determine the function—the information transmitted—by the whole. As Polanyi (1968, 1309) has said, "As the arrangement of a printed page is extraneous to the chemistry of the printed page, so is the hate sequence in a DNA molecule extraneous to the chemical forces at work in the DNA molecule."

If the properties of matter (i.e., the medium) do not suffice to explain the origin of information, what does? Blind chance is a possibility but not, as we have seen in the case of DNA and proteins, where the amount of information or the improbability of arrangement gets too immense. The random selection and sequencing of Scrabble pieces out of a grab bag might occasionally produce a few meaningful words such as cat or ran. Nevertheless undirected selection will inevitably fail as the numbers of letters required to make a text increases. Fairly soon chance becomes clearly inadequate, as origin-of-life biologists have almost universally acknowledged.

Some have suggested that the discovery of new scientific laws might explain the origin of biological information. But this suggestion betrays confusion on two counts. First, scientific laws do not generally explain or

cause natural phenomena; they describe them. For example, Newton's law of gravitation described but did not explain the attraction between planetary bodies. Second, scientific laws describe (almost by definition) highly regular phenomena—that is, order. Thus to say that any scientific law can describe or generate an informational sequence is essentially a contradiction in terms. The patterns that laws describe are necessarily highly ordered, not complex. Thus, like crystals, all law-like patterns have an extremely limited capacity to convey information. One might perhaps find a complex set of material conditions capable of generating high information content on a regular basis, but everything we know suggests that the complexity and information content of such conditions would have to equal or exceed that of any system produced, thus again begging the question about the ultimate origin of information.

For example, the chemist J. C. Walton has argued (echoing earlier articles by Mom) that even the self-organization produced in Prigogine-style convection currents does not exceed the organization or information represented by the experimental apparatus used to create the currents (Walton 1977, 16-35; Mora 1965, 41). Similarly, Maynard-Smith (1979, 445-46) and Dyson (1985, 9-11, 35-39, 65-66, 78) have shown that Manfred Eigen's (Eigen and Schuster 1977, 541-65; 1978a, 7-41; 1978b, 341-69) so-called hypercycle model for generating information naturalistically is subject to the same law of information loss. They show, first, that Eigen's hypercycles presuppose a large initial contribution of information in the form of a long RNA molecule and some forty specific proteins. More significantly, they show that because hypercycles lack an error-free mechanism of self-replication, they become susceptible to various error-catastrophes that ultimately diminish, not increase, the information content of the system over time.

Instead our experience with information-intensive" systems, especially codes and languages, indicates that such systems always come from an intelligent source—that is, from mental or personal agents. This generalization holds not only for the information present in languages and codes but also for the non-grammatical information (also describable as specified complexity) inherent in machines or expressed in works of art. Like the text of a newspaper, the parts of a supercomputer and the faces on Mount Rushmore require many instructions to specify their shape or arrangement [12] and consequently have a high information content. Each of these systems is also, not coincidentally, the result of intelligent design, not chance or material forces.

Our generalization about the cause of information has ironically received confirmation from origin-of-life research itself. During the last forty years, *every* naturalistic model proposed has failed to explain the origin of information.13 Thus mind or intelligence or what philosophers call "agent causation" now stands as the only cause known to be capable of creating an information-rich system, including the coding regions of DNA, functional proteins and the cell as a whole.

Because mind or intelligent design is a necessary cause of an informative system, one can detect (or, logically, retrodict) the past action of an intelligent cause from the presence of an information-intensive effect, even if the cause itself cannot be directly observed (Meyer 1990, 79-99). Since information requires an intelligent source, the flowers spelling 'Welcome to Victoria" in the gardens of Victoria harbor lead visitors to infer the activity of intelligent agents even if they did not see the flowers planted and arranged. Similarly the specifically arranged nucleotide sequences—the encoded information—in DNA imply the past action of an intelligent mind, even if such mental agency cannot be directly observed.

Moreover, the logical calculus underlying such inferences follows a valid and well-established method used in all historical and forensic sciences. In historical sciences knowledge of the present causal powers of various entities and processes enables scientists to make inferences about possible causes in the past When a thorough study of various possible causes turns up just a single adequate cause for a given effect, historical or forensic scientists can make fairly definitive inferences about the past (Meyer

1990, 79-99; Sober 1988, 4-5; Scriven 1966, 249-50). Several years ago, for example, one of the forensic pathologists from the original Warren Commission that investigated the assassination of President John F. Kennedy spoke out to quash rumors about a second gunman firing from in front of the motorcade. Apparently the bullet hole in the back of President Kennedy's skull evidenced a distinctive beveling pattern that clearly indicated its direction of entry. In this case it revealed definitely that the bullet had entered from the rear. The pathologist called the beveling pattern a "distinctive diagnostic" to indicate a necessary causal relationship between the direction of entry and the presence of the beveling.

Inferences based on knowledge of necessary causes (distinctive diagnostics) are quite common in historical and forensic sciences and often lead to the detection of intelligent as well as natural causes. Since Criminal X's fingers are the only known cause of Criminal X's fingerprints, X's prints on the murder weapon incriminate him with a high degree of certainty. In the same way, since intelligent design is the only known cause of information-rich systems, the presence of information, including the information-rich nucleotide sequences in DNA, implies an intelligent source.

Scientists in many fields recognize the connection between intelligence and information and make inferences accordingly. Archaeologists assume a mind produced the inscriptions on the Rosetta stone. Evolutionary anthropologists try to demonstrate the intelligence of early hominids by arguing that certain chipped flints are too improbably specified to have been produced by natural causes. NASA's Search for Extraterrestrial Intelligence (SE 11)14 presupposed that information imbedded in electromagnetic signals from space would indicate an intelligent source (McDonough 1987). As yet, however, radio astronomers have not found information-bearing signals coming from space. But closer to home, molecular biologists have identified encoded information in the cell. Consequently the presence of information in DNA justifies making what probability theorist William A. Dembski (1998) calls *the design inference* (see also Behe 1996; Kenyon and Mills 1996, 9-16; Ayoub 1996,19-22; Moreland 1994; Bradley 1988, 72-83; Augros and Stanciu 1987; Denton 1986, 326-43; Thaxton, Bradley and Olsen 1984; Ambrose 1982; Walton 1977, 16-35).

An Argument from Ignorance?

Against all that has been said, many have maintained that this argument from information content to design constitutes nothing more than an argument from ignorance. Since we don't yet know how biological information could have arisen we invoke the mysterious notion of intelligent design. Thus, say objectors, intelligent design functions not as a legitimate inference or explanation but as a kind of place holder for ignorance.

And yet, as Dembski has demonstrated (Dembski 1998, 9-35, 62-66) we often infer the causal activity of intelligent agents as the best explanation for events and phenomena. Moreover, we do so rationally, according to objectifiable, if often tacit, information and complexity theoretic criteria. His examples of design inferences—from archeology and cryptography to fraud detection andaiminal forensics—show that we make design inferences all the time, often for a very good reason (Dembski 1998, 9-35). Intelligent agents have unique causal powers that nature does not When we observe effects thatwe know only agents can produce, we rightly infer the antecedent presence of a prior intelligence even if we did not observe the action of the particular agent responsible. In other words, Dembski has shown that designed events leave a complexity and information-theoretic signature that allows us to detect intelligent design reliably. Specifically, when systems or artifacts have a high information content or (in his terminology) are both highly improbable and specified, intelligent design necessarily played a causal role in the origin of the system in question.

While admittedly the design inference constitutes a provisional, empirically-based conclusion and not a proof (science can provide nothing more), it most emphatically does not constitute an argument from ignorance. Instead, the design inference from biological information constitutes an "inference to the best explanation." Recent work on the method of "inference to the best explanation" (Lipton 1991; Meyer 1994b, 88-94) suggests that determining which among a set of competing possible explanations constitutes the best depends upon assessments of the causal powers of competing explanatory entities. Causes that have the

capability to produce the evidence in question constitute better explanations of that evidence than those that do not This essay has evaluated and compared the causal efficacy of three broad categories of explanation—chance, necessity (and chance and necessity combined) and design—with respect to their ability to produce high information content. As we have seen, neither chance- nor necessity-based scenarios (nor those that combine the two) possess the ability to produce biological information in a prebiotic context This result comports with our ordinary, uniform human experience. Brute matter—whether acting randomly or by necessity—does not have the capability to produce information-intensive systems or sequencing.

Yet it is not correct to say that we do not know how information arises. We know from experience that intelligent agents create information all the time. Indeed, experience teaches that whenever high information content is present in an artifact or entity whose causal story is known, invariably creative intelligence—design—has played a causal role in the origin of that entity. Moreover, citing the activity of an intelligent agent really does explain the origin of certain features such as, for example, the faces on Mount Rushmore or the inscriptions on the Rosetta Stone. (Imagine the absurdity of an archeologist who refused to infer an intelligent cause for the incriptions on the Rosetta Stone because such an inference would constitute a scribe-of-the gaps fallacy.) Inferences to design need not depend upon our ignorance, but instead are often justified by our knowledge of the demonstrated causal powers of nature and agency, respectively. Recent developments in the information sciences formalize this knowledge, helping us to make inferences about the causal histories of various artifacts, entities or events based upon the information-theoretic signatures they exhibit (Dembski 1998, 62-66). Thus knowledge (albeit provisional) of established cause-effect relationships, not ignorance, justifies the design inference as the best explanation for the origin of biological information in a prebiotic context.

Conclusion

During the last forty years, molecular biology has revealed a complexity and intricacy of *design* that exceeds anything that was imaginable during the late nineteenth century. We now know that organisms display any number of distinctive features of intelligently engineered "high-tech" systems: information storage and transfer capability; functioning codes (Wolfe 1993, 671-79); sorting and delivery systems (Wolfe 1993, 835-44); regulatory and feedback loops; signal transduction circuitry (Wolfe 1993, 237-53); and everywhere complex, mutually interdependent networks of parts (Behe 1996). Indeed, the complexity of the biomacromolecules discussed in this essay does not begin to exhaust the full complexity of living systems.

Norbert Wiener once said, "Information is information, neither energy nor matter. No materialism that fails to take account of this can survive the present day" (quoted in Gitt 1989, 5). The informational properties of living systems suggest that "no materialism" can suffice to explain the origin of life. Indeed, as molecular biology and the information sciences have revolutionized our understanding of the complexity of life, they have also made it progressively more difficult to conceive how life might have arisen naturalistically. The complexity and specificity of DNA, RNA and proteins simply exceed the creative capacities of the explanatory entities that scientific materialists employ. The origin-of-life research community has generated a multiplicity of explanations involving either random and/or deterministic interactions of matter and energy. It has refused on principle to consider explanations that involve intelligent design.

Yet this methodological commitment to naturalistic explanation at all costs has created an unnecessary impasse. Experience teaches that information-rich systems (or to use Dembski's terminology, "small probability specifications") invariably result from intelligent causes, not naturalistic ones. Yet origin-of-life biology has artificially limited its explanatory search to the naturalistic nodes of causation on Dembski's explanatory filter: chance and necessity. Finding the *best* explanation, however, requires invoking causes that have the power to produce the effect in question. When it comes to information, we know of only one such cause. For this reason, the biology of the information age now requires a new science of design.

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Atheism and Theism
J.J. C. Smart (Atheist) and J.J. Haldane (Theist)
Book

J.J.C. Smart (Atheist)
5 - Fine Tuning and the Anthropic Cosmological Principle
The so-called anthropic cosmological principle entered into recent discussions among certain cosmologists and philosophers because of what seems to be a fortunate and a priori improbable 'fine tuning' of some of the fundamental constants of nature. I am of course using the words `fine tuning' metaphorically to point to the important and improbable relations between the constants of nature without which stars, planets and life would be impossible. I do not use the words so as to imply the existence of design and a `Fine Tuner'. This last theistic hypothesis would be a further inference, the merits of which will be considered below. In discussing the relations between fundamental constants of physics we have to be concerned with pure numbers. For example, if we say that the mass of an electron is of the order of 9 x 10-31 kilograms we are not talking about a pure number, because the number depends partly on the arbitrary convention of measuring mass in kilograms. However when we say that the ratio of the mass of the proton to that of the electron is 1836 we are referring to a pure number. Our statement is true whatever the units in which we measure mass. The number 1836 would be as familiar to a physicist in Alpha Centauri or wherever as it is to the terrestrial physicist. In fact, trying to get into communication with extraterrestrials would involve sending such numbers as 1836. This would of course depend on sending clues to an arithmetical notation. '.. + ... _ .....' and things like that would enable them to guess what `+' and `=' mean. We could also give them a clue to our decimal notation by sending such things as `7 + 5 = 12' (with, say, dot notations for 7, 5, 1 and 2). Now if the extraterrestrials received a piece of discourse containing `1836' they would guess that the discourse had something to do with protons and electrons. The pure numbers are of cosmic interest, unlike the impure numbers such as 12.5 kilograms, which are terrestrial and conventional. Sometimes the pure numbers are defined in more complicated ways, as with the fine structure constant, which determines the strength of electromagnetic interactions relative to those that explain the other fundamental forces of nature. The `fine tuning' consists in the relative values of the fundamental constants of physics (constants determined in the end by pure numbers) being in certain ratios to one another. Slight differences in any of these ratios would lead to a universe very different from that which actually exists. 25

In particular, life as we know it could not have emerged, and without life there could not have been observers. This has led to some curious reasoning in connection with the so-called `Anthropic Principle' in cosmology. For the moment I shall ignore the possibility of life as we don't know it, for example in an environment of ammonia instead of oxygen, or life that is silicon-based (instead of carbon-based), or life in a dust cloud, such as in Fred Hoyle's science fiction novel The Black Cloud.26 Now, the proposition that the universe we observe is such as to contain observers is as it stands tautologous and utterly uninformative. What is informative comes from propositions about the fine tuning which seems to be necessary for the universe to allow for the evolution of galaxies, stars, planets, life, and ultimately observers and theoreticians. The tautologous proposition obviously cannot explain anything but it can draw our attention to interesting facts. If we could show that galaxies, stars, planets, carbon-based life and observers could not exist unless certain relations held between the fundamental constants of physics, we could deduce that these relations do exist. Initially, however, the facts about the 'fine tuning' are known independently, and then we see how necessary they are for a universe like ours, and hence for us to be here to know it. Much of it is necessary for there to be, say, stars. So there could be a `stellar' principle no less than an `anthropic' one. Also there may possibly be intelligent beings very different from us humans all over

the universe, on planets of distant stars. Indeed Brandon Carter, who introduced the term `Anthropic Principle', has, I think, come to dislike the choice of terminology.

Does the fact that if it were not for the fine tuning we would not be here to know it explain the fine tuning, as some incautious purveyors of the anthropic principle have at least seemed to suggest? Surely not. It is the fine tuning that (partially) explains the existence of observers, not the existence of observers that explains the fine tuning.

Faulty Anthropic Arguments

The matter many be illustrated by a faulty argument of G.J. Whitrow in the appendix to the second edition of a book published in 1959 27 and earlier in a paper in The British Journal for the Philosophy of Science.28 This was some time before Brandon Carter formulated his `anthropic cosmological principle', and there is some similarity between Whitrow's reasoning and Carter's, and yet an important difference. Carter's reasoning was not faulty in the way (as I shall show) Whitrow's was. This is because Carter connected his anthropic principle with a 'many universe' hypothesis which I shall discuss shortly.

Whitrow begins by assuming plausibly enough that in a space of s + 1 dimensions there would be an inverse 5th power law of gravitational attraction. (This is the case in Newtonian dynamics and is approximately true in general relativity.) Whitrow also assumes, perhaps plausibly, that life, and hence observers, would not have arisen on a planet which had a very eccentric or unstable orbit. He then goes on to make use of a theorem in classical mechanics that a stable and near circular orbit can occur only in a space of either two or three dimensions. He makes use of an argument to the effect that a brain would not be possible in two-dimensional space: only in a space of three or more dimensions could many neurons be connected in very many ways so as to form a complicated network. (Whitrow acknowledges a suggestion by J.B.S. Haldane and a mathematical discussion with M.C. Austin.) Whitrow thus concludes that `the number of dimensions of space is necessarily three, no more and no less, because it is the unique natural concomitant of the higher forms of terrestrial life, in particular of Man, the formulator of the problem' (Whitrow's italics).

Modern cosmologists play around with theories that space has ten or more dimensions and a complicated topology, but they still hold that macroscopically it has three dimensions and a Euclidean type of topology. (Compare the way in which an oil pipe hundreds of miles long would look like a straight line from far enough away in space, whereas looked at closely its surface is seen to be two-dimensional, with the topology of the surface of a cylinder.) That space has three dimensions at least macroscopically is good enough for Whitrow's argument and we can agree that it does follow from Whitrow's premises, together with some uncontroversial mathematics, geometry, mechanics and natural history, that humans could not exist unless the number of dimensions of space was (macroscopically) three. Nevertheless, insofar as he put the argument as an explanatory one, it is quite preposterous. The supposed explanation is back to front.

Surely we should think that it is the three-dimensionality of space that explains the existence of habitable planets containing intelligent life. I do not think of `explanation' as a very clear notion, and its use depends a good deal on context. I mainly think of it in terms of coherence, of fitting the explanandum proposition into our web of belief,29 but in a scientific or cosmological context at least we should explain the more particular by the more general, the parochial by the cosmic. Whitrow's argument does indeed establish connections between the three dimensions of space and the existence of intelligent life on earth. That space has three dimensions is shown to be a necessary but not sufficient condition of the existence of inhabitable planets and intelligent life.

Is it that explanations come from the giving of necessary conditions, not of sufficient conditions? This will not do, because sometimes it is a sufficient condition that is explanatory. Decapitation is a

sufficient condition for the death of Charles I and is explanatory of it. It is not a necessary condition for his death, since he might have died in his bed or by shooting. A cause is sufficient for an effect (given constancy in our contextual assumptions about background states of affairs — e.g. putting a match to a fire causes it to flame, assuming the presence of oxygen, that the wood is not wet, etc.) but is not necessary (e.g. Charles I might have been simultaneously decapitated and shot through the heart.)

These complications make it difficult to say clearly and precisely just why Whitrow's putative explanation of the three-dimensionality of space is back to front. I suspect that it is just a matter of the particularity of the suggested explanans and of the cosmic nature of the supposed explanandum. Let us consider an even more preposterous argument, also due to Whitrow. This is that if space had only two dimensions we could not have any alimentary canal, since we would be divided into two disconnected parts. However, is it not mad to say that space has more than two dimensions because we can eat, instead of saying that the cosmic fact that space has three dimensions is (in part) the explanation of why we can eat?

Brandon Carter who first formulated the anthropic cosmological principle (in fact both a `weak and a `strong' version of it) did so in connection with the hypothesis that our universe is only one of a huge variety of universes, a 'world ensemble', in which the fundamental constants of nature, which seem so arbitrary to us, differ randomly from universe to universe.30 Strictly speaking, of course, `universe' should refer to everything that there is (perhaps excluding God if we talk of God creating the universe) and so could be taken to refer not to what we think of as our universe but to the ensemble of universes. However, I think that it will not be confusing if I use the word 'universe' ambiguously and rely on context to make it clear whether I am talking of one of the many members of the world ensemble or of the whole lot.

Carter's many universes hypothesis may be held to explain the fine tuning of our universe. If there is a sufficiently large number of universes with the values of the fundamental constants randomly distributed between them, then it could be virtually certain that some universes would be such that galaxies, stars, planets, life and intelligence evolved within them. The anthropic principle allays surprise that we are in such a universe. Obviously as intelligent beings we must be in a universe that allows intelligence to arise. This explanation, depending as it does on the many universes hypothesis, does not have the back to front character of the example that we have recently been discussing. But how good is the world ensemble explanation?

An unattractive feature of the explanation is its apparent prodigality. We may be reminded of Ockham's razor, the principle that entities should not be multiplied beyond necessity. `Necessity' is a bit strong: let us say, 'without more than compensating explanatory advantage'. Ontological parsimony must be balanced against explanatory power. If Carter's hypothesis really does explain the fine tuning of our universe, then perhaps it should be accepted. Simplicity and symmetry are features which make for a good explanatory theory or hypothesis. Now the random distribution of relations between the fundamental constants in the various universes which belong to the huge ensemble of universes restores a symmetry that is missing in our ordinary 'one universe' theory, with its antecedently improbable set of relations between the fundamental constants. A random distribution of the fundamental constants of nature presumably requires no explanation in the way that a particular and arbitrary looking set of such values would. There is a of symmetry in randomness.

John Leslie has told a `firing squad' story that illustrates Carl point.31 Suppose that you are put for execution before a firing sq and to your surprise all the members of the squad, good shots though they are, all miss. You would be extremely surprised to be still al Suppose, however, that you knew that there were a billion people you being executed by firing squad; you might calculate that it

quite probable that there would be a few lucky survivors, and so must be one of them. You should feel surprised and fortunate, (there would not be the sort of puzzlement that you might feel if had been the only candidate for execution. You would feel only sort of surprise that the winner of a lottery might feel. In a practice possible case, of course, there could not be a billion other sin,'firing squads and victims and you would guess that the firing sq tad some reason not to kill you, and this would be a sort of analysis of the design (theistic) explanation of the fine tuning. Leslie's considerations, however, do support the view that Carter's multiple 'universes hypothesis, or something very like it, could provide a non-the: 'explanation of the fine tuning of our universe, as a serious rival to theistic design explanation. If our universe were not one of the 1 "proportion of fine tuned ones we would not be here to tell the Similarly, if the man is missed by the firing squad he reflects Atheism, so of course he must be one of the few to survive.

Some readers will react adversely to the moral drawn from the first: =squad story and so also to the supposed explanatory value of Carl Many universes hypothesis. Why should your surprise at survival the firing squad be allayed by the story of a billion other firing squad "Certainly with the real world it would not be: we know that it could not be a billion other firing squads on this small planet.,answer is that if we rule out the hypothesis that the firing squad ~~,'Some reason for trying not to kill you, the question `Why me?' is 't1& proper metaphysical question. Indeed I hold that all inexplicable, `you', 'I' and also tenses of verbs, should be expunged from m ~,`A physical theory.32 Compare Quine's `canonical notation'.33 We she try to see the world as much as possible *sub specie aeternitatis,* to Spinoza's metaphor. Metaphysically 'Why me?' is not an appropriate question. It could in some cases be a sensible, but not metaphysical question. The story assumed that the firing squads were hard-head incorruptible. If the story is changed 'Why me?' might indeed an answer, such as `The captain of the firing squad is your wife's cousin'. Now the analogy with Carter's idea is quite lost. It is nearer to the design hypothesis: 'God arranged the fine tuning so that conscious life could evolve'.

Carter's many universes were supposed to be completely separate from one another. However Carter's type of argument would work equally well if all the `universes' were vast parts of one single space—time universe as in a theory proposed by Andrei Linde.34 Linde's cosmological theory is like a theory suggested by A.H. Guth in 1980 in proposing an inflationary scenario.35 Linde supposes that the universe expanded exponentially by a factor of something like 101,000,000 from an almost point-like beginning to a size comparable to that of a football. In Linde's version of the inflationary story the inflation occurs before the hot big bang in standard cosmology. His theory solves certain problems to do with the flatness and smoothness of space in the early universe. So the motivation was not that of Carter's multiple universes theory, and so there is some independent justification for believing in many universes or sub-universes with random variations in the constants that relate the fundamental forces, which arose from a single proto-force by symmetry breaking. (For symmetry breaking, consider the analogy of a needle in classical mechanics, balanced in a vertical position on its point. There is symmetry about its axis, but the symmetry will be broken by the smallest perturbation, whereby the needle will fall so as to lie in some particular horizontal direction.)

According to Linde's theory what we think of as the universe is only one sub-universe among a huge number of them, like a crystal in a randomly oriented array of such things (as, say, in a metal). Our particular `crystal', vast as it is, extending beyond the reach of the best telescopes, clearly has values of fundamental constants that are suitable for the evolution of galaxies, stars, planets, life and intelligence. We are obviously not in one of the vastly more common `crystals' or sub-universes that are not 'fine tuned' in this way.

I am of course not competent to assess or even properly understand Linde's theory. However I have mentioned it as a possible way in which something like a `many universes' theory could get some

independent justification. But Carter's and Linde's theories both have the additional advantage of restoring symmetry in the large, Carter's in the world ensemble and Linde's in his total super-universe. This symmetry comes from that of randomness. (But not complete randomness. There are the symmetrical proto-laws, the unified force and scalar field, which by symmetry breaking crystallizes out into the different relations between the four fundamental forces.) This leads me on to a purely metaphysical supposition, that of a completely random universe, without laws or even proto-laws.

Here is the idea. Suppose that the universe was infinite and completely random in the large. Then our huge, apparently ordered universe could be just one infinitesimal part of a disordered whole. We would be living in a Humean world: we would have no reason to suppose that in the next microsecond everything around us would not go into a total chaos rather like a puff of smoke. We of course would do well to suppose that the pseudo-laws, the temporary apparent regularities, would continue to operate. If they do not then no matter — nothing we do matters. But if they do continue to operate it is as well that we plan according to them.

Is not this a chilling thought, that our huge and beautiful universe (as it seems to us) might be a mere speck, a mere infinitesimal random fluctuation into apparent orderliness in what is really an infinite chaos? The image of a monkey typing randomly on a typewriter to produce Shakespeare's Hamlet would pale into insignificance beside the awful reality. Carter's and Linde's hypotheses do not quite have the chilling quality of this hypothesis but it is still true that they lack some of the motional appeal of the design hypothesis. Still, emotional appeal is .got proof or rational persuasiveness, and so it is time now to turn to "theistic explanations of the `fine tuning' and to examine their credentials as an argument for the existence of God.

6 The Argument from the Appearance of Design

Contemplating the beautiful laws of nature, many physicists have quite understandably taken them as evidence of design, and, as has been noted above, the apparent `fine tuning' of the fundamental constants of nature lent additional weight to this way of looking at things. It should clear of course that this talk of `fine tuning' is not to be taken as by If implying a fine tuner: if so the argument would become both quick and circular. This argument from ostensible fine tuning is the presently fashionable form of the traditional 'teleological argument' the existence of God. Sometimes this is called `the argument from design' but this, like a too literal construal of 'fine tuning', would be question begging. Years ago Norman Kemp Smith suggested that the argument should be called `the argument to design'.36 Equally we could call it 'the argument from apparent design', or for brevity 'the design argument'.

Unlike some other traditional arguments for the existence of God the design argument was never meant to be apodeictic. In contrast the ontological argument was meant to be quite a priori and the cosmological argument almost so, requiring only the assertion that something contingently exists. The design argument is best thought of as an argument to the best explanation, such as we use in science and everyday life. The best explanation for the appearance of design in the world is said to be a designer.

David Hume in his great posthumously published book, Dialogues Concerning Natural Religion,37 obviously thought that there were alternative explanations which are as plausible as that of design. However, he retained a sceptical position, rather than a dogmatically atheist one. Philo, who was probably Hume's representative mouthpiece in the Dialogues, said that the universe might as well be compared to an organism as to an artefact, and organisms, prima facie, are not designed. They `just grow'. (Antony Flew has commended the childlike acumen and common sense of Topsy in Harriet Beecher Stowe's Uncle Tom's Cabin.38) Of course we know from the modern synthesis of the theory of evolution by natural selection together with neo-Mendelian genetics that organisms do

not need to have been designed. If we appreciate the huge time-scale of evolutionary processes and the opportunistic way in which they work, our minds need not be intellectually overwhelmed, even though perhaps imaginatively at a loss. However, I am here considering the argument from design in a post-Darwinian context, the new teleology not the old, in relation to the great appearance of design in the laws of physics.

As was just remarked, Hume held that the analogy between the universe and an organism was as good as that between the universe and an artefact. There are possibly many other analogies, equally good or bad. Indeed Hume's Dialogues concludes with Philo's concession to his main interlocutor Cleanthes that there is some analogy between the cause of the universe and a human mind. This is perhaps in one way a very small concession since with enough ingenuity one can find some analogy between almost any two things. However, in another way it is a big concession, namely that the universe does have a cause external to itself.

One trouble with the design argument is that there would have to be a 'cosmic blueprint'39 in the mind of God. This conflicts with the supposition that God could be a perfectly simple being. At first sight, is Hume seems to have thought, the designer of a universe would need to be at least as complex as the universe itself. It is not clear that this need be so. Complex forms of life evolve as a result of physical law together with the randomness characteristic of mutation and natural selection. Even repeated application of a fairly simple set of rules will allow for very complex but in the large regular patterns, as with the Mandelbrot set which is discussed in chaos theory. Does this mean that the designer of the universe could be less complex than the universe that is designed? Such a designer need not be the infinite Creator God of the great theisms, at least. Nevertheless the designer's mind would have to have within it a structure at least as complex as he conjunction of fundamental laws and initial conditions. So the question surely arises: what designed the designer? The design hypothesis thus seems to raise more questions (and so is less explanatory) than Ike atheist one. (I shall reconsider this when I come to discuss John Leslie's conception of God as an ethical principle.40) Stephen Hawking as famously, or notoriously, looked forward to a simple `theory of everything', which would give us knowledge of 'the mind of God'." Of course if God's internal structure were that of the fundamental Laws and initial conditions this would make Hawking's metaphor of mind of God' appropriate. Nevertheless, the hypothesis of God, east as designer, would be redundant, and belief in this sort of God would collapse ontologically into atheism. if the universe needed a designer which was not identical with the structure of the universe (i.e. laws and initial conditions) we would get o a regress, the designer needing a designer, and so on ad infinitum. may be reminded of Fred Hoyle's fictional interstellar `Black Cloud'.42

Kyle believed in an infinite steady state universe. If one asked where (highly intelligent) black cloud came from the answer was supposed to be that it was designed by another black cloud, and this by another black cloud, and so on *ad infinitum*. Whether or not the urology was good (the steady state theory is in fact not generally accepted) the biology was unsatisfying. One expects a complex organism, even a `black cloud', to have evolved from simpler organisms ultimately from inorganic life.

Artefacts do not evolve in this way, though it is possible that one self-replicating robots with occasional random variations in their programming may mimic biological evolution. An engineer designing apparatus may produce a blueprint. Any complexity in the apparatus then appear in the blueprint. (If we neglect complexity antecedently rent in the components, such as transistors, which are the original materials for the engineer's design.) Here I am taking 'apparatus' in the sense of 'hardware'. One may be reminded of Descartes' rather obscure dictum that there must be as much reality in the cause as there is in the effect.43 (Descartes used the principle in an attempted proof of the existence of God, but my reference to it has a different motivation.) There can be a

simple recipe for creating complexity, so long as one does not want to predict the particular type of complexity. Illuminate a planet rather like the Earth which is about a hundred million miles from a star rather like the Sun for so many hundreds of millions of years and (with luck) complex organisms, perhaps like elephants or mermaids, will eventually evolve. Still, this is not like the case of designing the universe itself — designing the fundamental laws and boundary conditions. For this there would have to be something like a blueprint in the mind of the designer, and it would have to have a complexity equal to that of a complete specification of laws and boundary conditions. Or can a regional order arise spontaneously out of a universal chaos, the chilling thought of a few pages back? But if we accepted this last idea there would be no need to suppose a designer, or anything else for that matter.

Thus, even if it were supposed that the designer determines only the laws of nature (with non-arbitrary constants in them) and a suitable set of initial conditions, then considerations of simplicity and of Ockham's razor suggest that the supposition was an unnecessary one which should be rejected. Any complexity in the laws and initial conditions would be duplicated in the mind of the designer. (Otherwise I could get no purchase on the notion of design that is involved.)

The matter may take on a different complexion if we look at the apparent arbitrariness of the fundamental constants of nature, as we at present understand them, and the way in which the relations between them are peculiarly fitted for the evolution of a universe which contains life, consciousness and intelligence. There is an appearance of a cosmic purpose which may appeal to someone who concedes the points made in the previous paragraph. It is tempting to think that the arbitrary constants must have been chosen by some purposive agent so as to make the universe conducive to the evolution of galaxies, stars, planets and eventually conscious and intelligent life.

At any rate this purposive explanation of the happy values of the constants of nature and of the forms of the fundamental laws could strengthen belief in a deity whose existence was made probable by some other argument. Of course the view that God designed the universe because he wanted conscious beings in it who would be the objects of his love is a not unfamiliar theological one. I have wondered whether this view could have a touch in it of psychocentric hubris. (I .,.Say `psychocentric' not `anthropocentric' in view of the possibility ' that conscious and intelligent life is scattered throughout the universe.) Certainly the Judaeo-Christian tradition sets a high value on humans the scheme of things, and this value should also be ascribed to minds on other worlds, some of which may indeed be far superior our human ones. Perhaps there is a bit of human vanity involved the idea that the universe was created in order for there to be conciousness and intelligence. Bertrand Russell held that vanity is a prime motive for religious belief. Even the horrible view that there •j a hell to which the infinite God will consign us for our sins may give us an admittedly miserable sense of importance. Belief in highly superior beings on distant planets may be a blow to our hubris. Of course religious belief in the existence of angels may have had a similar effect,44 even though in the nineteenth century angels came to be thought of as rather pale creatures, whose main talent was playing the (There did not seem to be reports of super-Einsteins among them.)

Still we should not put too high a value on intelligence. Nor should forget the sufferings of the non-human animals on earth. As Jeremy Bentham said, `The question is not "Can they reason?" or "Can they?" but "Can they suffer?"'.45 To see suffering is a corrective to disparagement of a possible `psychocentrism'. It would be inconsistent of me to object to psychocentrism while at the same time taking seriously — as surely one must — the importance of human and animal Bring when I come to discuss the problem of evil.

Even so, the hypothesis that God designed this huge material universe so as to produce consciousness seems to be ad hoc. What a longwinded and chancy way of creating conscious beings.

Surely an potent being could have created happy spirits directly, rather a universe which might produce entities like us, or higher than as a result of long and chancy evolutionary processes (see p. 31). The possibility that the universe contains vast numbers of (and if universe is infinite, which is of course questionable, infinitely y) stars like our sun, with planets suitable for evolution of life and ultimately intelligent beings, raises interesting theological problems, which have, with some exceptions, been neglected by theologians. Christianity appears to be anthropocentric in its doctrine of the incarnation that God became man. To avoid this anthropocentrism we should sage the possibility of incarnations on other worlds throughout the universe, a question to which, with a few exceptions, theologians seem to me to have given insufficient attention.

The new teleology, as I have said, is quite different from that associated with such as Paley. It concentrates on the awe and wonder at the beauties of the laws of physics and the starry heavens above. In its most recent form it focuses on the apparent `fine tuning', the happy coincidences of the value of the fundamental constants. The ontological extravagance of postulating `a Designer' could be outweighed by its value in explaining these coincidences. However in assessing the plausibility of such a hypothesis we might also consider the possibility of there being an as yet unknown physical or cosmological hypothesis which might have as its consequence these arbitrary looking values. This would also provide an alternative to `the many universes' hypotheses.

As a possibly misleading analogy consider the way in which three at first sight unrelated numbers, i the square root of minus one, 7t the ratio of a Euclidean circle to its diameter and the Euler number e should be related by the simple formula e" = —1. Once one knows the proof it becomes almost obvious, though still beautiful. Could the fine tuning one day be deduced from some simple laws, the constants in which do not have an arbitrary appearance? The trouble is that the ratios of the fundamental constants do not look mathematically significant, as do i, e and it. This consideration of a possible theory to explain the fine tuning is more parsimonious than the design hypothesis and than the many universes hypotheses. It partakes, however, of an appearance of wishful thinking, `something may turn up', to which a theist could rightly object. Furthermore, since i, e and it are all mathematically significant (n can indeed be defined analytically, without geometry) they could be expected, antecedently of the proof, to be related somehow, even if not so beautifully. One trouble with the fine tuning is that the constants involved do not have importance in pure mathematics, and this does support the design hypothesis. There are pros and cons in this part of the debate.

J.J. Haldane (Theist)
4 `Old' Teleology
The case of biology is a significant test of attitudes, for, as Smart notes, living systems were long cited in design proofs and neo-Darwinian theory is supposed to have put an end to this. My earlier point about actual sciences being built around the recognition of distinctive forms of organization of matter tells against reductionism as a general policy and applies to the relation between chemistry and quantum mechanics as much as to that between zoology and general physics. But the traditional teleological argument is concerned with a special claim of irreducibility, viz, that of purpose to mechanism. Teleologists maintain that organisms exhibit beneficial order: that is to say both in their general organization and in the functioning of their parts they generally operate in ways that are, in one or another way, good for them. For example, the lungs absorb oxygen, the heart pumps blood, the kidneys remove waste products, the genitals enable procreation and so on. Naively, it seems natural to say that these parts and functions exist for the well-being of the animals, be they individuals or species, and, assuming that they are not intelligent entities prudently directing their own behaviour, that the existence of such well-organized structures points to a benign designer.

This, in essence, is the last of Aquinas's famous five ways (quinque vise) or proofs set out in response to the second question `whether there is a God' of the Summa Theologiae (Ia, q. 2, a. 3.). The text is brief and worth quoting in full to give a flavour of the directness of Aquinas's style:

> The fifth way is based on the guidedness of nature. Goal-directed behaviour is observed in all bodies in nature, even those lacking awareness; for we see their behaviour hardly ever varying and practically always turning out well, which shows they truly tend to goals and do not merely hit them by accident. But nothing lacking awareness can tend to a goal except it be directed by someone with awareness and understanding; arrows by archers, for example. So everything in nature is directed to its goal by someone with understanding and this we call God.'

St Thomas's formulation can be applied to the issue of fine tuning but at this stage I am concerned with apparent purpose in the organization and activity of living things. Belief in real teleology and in the need of a purposeful agent to create and sustain it has been held to be refuted on the basis of the theory of natural selection. Given replication, inheritance, variation, environment and time the range of animate species is, explicable in physico-mechanical terms. So it is said, but the issue is not quite so clear.

First, a concession to the anti-teleologist or mechanist. It is right for him or her to argue that the traditional design argument is challenged by the mere possibility of evolutionary explanations. If the existence of such complex animals could be the result of natural mechanicoevolutionary processes then any argument to the effect that they could only have come into existence through a special creation is thereby refuted. This is correct, but note where the concession leaves the debate. Unless the evolutionist has an argument to show that creation excluded we are faced with competing hypotheses. Indeed the dialectic is subtler still, since the theist may not want to exclude evolutionary theory as an account of the history of species development but my to reject it as a complete explanation. However, even this position requires that he or she produce reasons for thinking that natural selection cannot be the whole story. I think there are three places, or points of transition, at which such?????sons may be found. First, the step from non-living to living entities; second, the step from basic 'life forms' to reproductive species; and Mind, the transition from mindless to minded life. I shall deal with the effect of these later and at some length but take the first and second together now.

The Emergence of Life and the Origins of Reproduction

Old style vitalism, the dualistic idea that living things are composites of two substances, a quantity of inanimate matter and a motivating ion vital or life force, has little to be said for it. Indeed, from the point of view of the Aristotelian picture I favour it is quite the wrong ay to think of the nature of living things. On this preferred account e difference between an inanimate object and a living thing is not at the latter is a lump of matter plus an immaterial agent resident •thin it; rather it is that the latter has an intrinsic functional organization in virtue of which its movements are explicable in terms of that towards which they are directed. Notice that this is an avowedly non-reductive and teleological characterization. That is not a problem or me; rather it presents a challenge to the anti-teleologist to provide a non-teleological account of the difference between living and nonliving things.

Appeal to their matter alone will hardly do. First, the pure reductionist will not want to rest his account at any level that is not further reducible to physics, so an ineliminable chemical theory will be problematic. Second, bracketing this point, no merely compositional account seems adequate since it need not be an issue of contention what non-living and living things are made of. The question is what makes one and not another alive. To deploy the Aristotelian terminology it may be agreed that inanimate A and animate B have the same kind of material cause (physical substratum),

the issue is whether this is sufficient to explain their natures as kinds of things, living and nonliving respectively. According to the neo-vitalist account each has a formal cause, that which makes it be the sort of thing it is, and the latter has a final cause — its organic well-being or efficient functioning — towards which it is moving.

I began this contrast in terms that suggest comparing two objects sitting side by side on a table — or more realistically two specimens beneath a microscope or in some other apparatus. But any purported naturalistic account of the nature of vitality will want to serve in a historical account of the origins of life. That is because the naturalism in question is materialist and involves the familiar idea that life itself has evolved from non-living matter. Thus the difference between the living and the inanimate has first to be specified, and then it has to be shown how there could be a natural transition from one kind of state to another. There will be no principled obstacle to success in the latter task if the former leaves no vitalist or teleological residue. For then one will only have to show how one spatio-temporal arrangement of microphysical particles led to another. But notice that this course involves the denial that there are any such entities as living things and that there was ever any such process as the emergence of life. In reality, the situation is no different from that obtaining before the earth and the sun were formed.

This 'eliminativist' conclusion is at odds with what is generally supposed to be the case, including the presuppositions of most working scientists. We do believe there are living things and that they exhibit features additional to those of matter as that is characterized by physics. The nature of such features is precisely what the life sciences are concerned to describe and understand. Moreover, nothing in elementary physics forces us to say that this is an illusion; there is nothing in physics that is incompatible with biology, even teleology. It is only the philosophical imperative of reductionist materialism that requires the denial of ontological and explanatory irreducibility.

Suppose then that this point is conceded, but it is maintained that the existence and emergence of life do not call for any explanation beyond that available to naturalism. My objection is now this: if these accounts eschew eliminativism and allow the veridicality of biological characterizations, then they have to show why descriptions of beneficial teleology are not also warranted, and how the laws of nature operating on inanimate matter could generate life. The former is so to • speak a `stopping' problem, the latter a `starting' one. If the existence of complex living forms is allowed why not grant what appearances also suggest, namely that these forms exhibit beneficial order? Why stop with mere life? And if even mere life is granted how did it start? The latter question is intended as a philosophical one. I am not asking what the natural mechanism is but how it is even conceivable that there could be one. Since no conjunction of descriptions of purely physical states together with non-biological laws entails a description of biological states any account of these issues is going to be open to;.a vitalist interpretation. The advocate of neo-vitalism, in the Aristotelian sense explained above, can claim that what has been described as the material-causal substratum of life not something that is of itself Sufficient for it. It may be countered that this is ontologically extravagant, to which I would respond that it is not superfluous if a materialistic explanation seems incomplete, and that only a non-scientific insistence on reductionism motivates the thesis that it must be no more than mechanism even where there could be no deductive explanation of how it is so.

The next stage in the defence of teleology concerns not the origins Of life but its evolutionary history. First, however, let me observe that contrary to some popular expositions evolutionary biologists do not try to show that every advantageous characteristic is the direct product of natural selection. Genetic mutations rarely have single effects;and if some of these improve the reproductivity of breeding populations *hen while they will tend to be selected for, other collateral effects;nay be preserved so long as they are not seriously disadvantageous. Thus features may emerge that were not themselves selected, and some of these may be good, some indifferent, and

some bad — though not so bad as to be fatal. In other words, even within the sphere of Contemporary evolutionary theory it is conceded that not every significant characteristic, organ or power is an evolutionary adaptation.

That selection is not a necessary condition of species development may not be so troubling given the general presumption of evolution. More problematic is the suggestion that it might not be sufficient: that a further cause may need to be operative. The standard evolutionary account of speciation is in terms of cumulative selection. That is to say, very roughly, it is supposed that the origination of one species from another is not by a single step (that would defy belief) but by progressive sifting and sorting as the product of one selection is then subjected to further selection, and so on. Think, for example, of a gardener who wants to grow large, strong vegetables but currently has only small, frail flowers. He could try planting the seeds from the latter and waiting until spring but it would be a miracle if these seeds developed into what he wanted. However, if he were patient and lived long enough, then he might proceed by gathering seeds from the largest and strongest of the flowers, planting these, training and nurturing the seedlings eliminating the weaker ones; then gathering the seeds from the largest and strongest plants, and so on. It would be less surprising if eventually cumulative selection proved effective in leading to the development of a species of the desired sort.

Purged of intention and agency this is how evolutionary theory explains development. Notice, however, that cumulative selection presupposes some form of replication possessed by the original and intervening living entities. They need to have some mechanism of reproduction. This is a feature to be explained by selection no less than others, but it is hard to see how it can be. Selection purports to explain adaptive features of which replication is prime; but it operates over generations, and successive generations only come into existence because of the replicative powers of their ancestors. These powers cannot themselves be the product of cumulative selection. So, contrary to its implausibility, the claim has to be that their emergence occurred in a single step; somehow non-replicating entities just turned into reproducing species.

A likely rejoinder to this observation will be the claim that the initial step was not to full-scale reproduction but to proto-replication. Organic reproduction proceeds asexually or sexually. In the first case parts of the organism become detached and form new individuals; and in the second, special cells (gametes) are formed within individuals, and the joining of these in fertilization yields a cell that develops into an individual of the same type as its parents. The selection of advantageous parts and powers is made possible because of the inheritance by one generation of features possessed by the previous one, and the transmission of the same or relatively similar characteristics to its offspring. One way of regarding this process is in terms of the transmission of organizational information through enduring and reliable channels to which the various parties have access. The present worry is that any theory claiming that communication produces the channels — along with everything else — faces the objection that without the channels there could be no communication. They are part of what the organizational information creates. The envisaged reply is that initially something arises which is less than a power of transmission but enough to get the process of communication started.

One way of framing the worry I have about this is that it seems to be trying to account for a significant qualitative difference in terms of a merely quantitative one. Let me illustrate what I mean, and indicate why I think there is a problem, by switching to a parallel case concerning the nature of mental phenomena. I shall be saying more about the philosophy of mind and theism shortly; at this point the feature to focus on is simply the structural analogy between the case I am about to discuss and that of reproduction.

A few years ago I wrote an essay in the course of which I criticized the efforts of Daniel Dennett to give an adequate reductionist account of mental representation.' The problem is this. Thoughts are intentional in the technical sense that they are directed towards, or are •about, something or other (from the Latin *'intendere':* to aim or direct). How is this possible? One much discussed suggestion is that to think `There is a tree in the garden' is for one's mental system to be in a computational state involving a representation — a sentence in the mind and/or in the head — the content of which is that there is a tree in the garden. Very crudely indeed, one might thus suppose that someone thinks that p when his or her information processing system entertains a mental sentence `S' the meaning of which is that p. Much could be said about this, but here simply note that it involves a homuncular regress ('homo' (man), '-culvs' (little)). The problem of mental representation has not gone away. It has just been moved from the personal to the subpersonal level: I think that p because (in some sense or other) there is something — a `processing module' — in me that can interpret a symbol `S' that means that p. To his credit, Dennett sees that this proposal is hopelessly regressive if treated in realist terms, i.e. as maintaining that representational power is derived from a representational subsystem, and so he offers an alternative reductionist-Cum-eliminativist version of it. He writes:

> [You] replace the little man in the brain with a committee [whose members] are stupider than the whole; they are less intelligent and `know' less. The subsystems don't individually reproduce all of the talents of the whole. That would lead you to an infinite regress. Instead you have each subsystem doing a part, so that each homuncular subsystem is less intelligent, knows less, believes less. The representations are themselves, as it were, less representational ... a whole system of these stupid elements can get to exhibit behaviour which looks distinctly intelligent, distinctly human.'

Engaging as it is, I suggest that this proposal fails because of a fallacy of equivocation committed in the sentence: 'The representations are themselves, as it were, less representational.' To say that something is `less representational' is ambiguous between claiming that it represents less and maintaining that it is less a representation. Dennett hopes to 'discharge the homunculi' by progressive reduction of representational content; but the fact that some representations contain less information does not on that account make them any less representations. The non-representation - representation distinction is not the same as the much representation - less representation distinction; and one cannot explain the former in terms of the latter, since however little intentional content a representation carries it is still on that very account a representation.

Commenting on this objection Kathy Wilkes proposes that it can easily be set aside:

> For Haldane, intentionality, or the existence of representations, is all or nothing ... I find this impossible to believe ... We need only look to neuroscience; where time and again the `homuncular strategy' is bearing fruit. Low-level function can be called 'expecting/comparing', 'detecting', 'synthesizing'; as we go down the hierarchy the degree of intentionality fades, the representations do indeed (pace Haldane) become more limited (cf. the primary visual cortex, where cell-columns 'detect horizontals', or `detect colour contrasts').

However, if one compares this passage with that from Dennett it should be clear that it invites exactly the same response. The intentionalizing of low-level functions may be methodologically convenient, but if a regressive homuncularism is to avoided it has to be discharged. Mention of `fading' intentionality does not begin to achieve this when, as here, it is explained in terms of the representations becoming more limited. If one process detects both horizontals and verticals, and another detects only horizontals, then the second is to that extent more limited, but it is not thereby any less a process of detection.

Recall now the response that although the evolution of species proceeds by cumulative selection which presupposes reproduction, which itself could only plausibly be the product of cumulative selection, nonetheless the process could begin with proto-replication. What is envisaged is quantities of primitive organic matter 'giving rise' in one way or another to further quantities that resemble the originals, and so on. The inescapable question, however, is whether this initial process involves the exercise of powers of reproduction, be they ever so limited. To say that it does, intending by this a realist non-reductionist interpretation, is to ascribe teleology to the process and to admit the failure of mechanistic evolutionary theory. However, to say that it does not leaves it unexplained how reproduction could emerge out of successive non-reproductive events.

Admittedly, there are many conceivable circumstances in which chance forces act upon something in such a way that the effect is the production of things like the first. Imagine, for example, the improbable but not impossible situation in which three pieces of slate fall in succession and at different angles on to a cube of clay cutting it into eight smaller cubes. Interesting as this might be, it is not the exercise by the cube of a power of reproduction. Similarly, the mere sundering of organic matter into several pieces is not a form of asexual reproduction, and nor is it made such by repetition. Certainly if a number of distinct individuals of relevantly similar sorts participate in processes

systematically give rise to the existence of further individuals of the same sorts, which in turn lead to more of the same or similar and,so on, then it becomes reasonable to attribute powers of replication. But this is not an explanation of reproduction; it is a description of it. And if to avoid this conclusion one says that each successive stage is really like the first, not reproductive but 'reproductive' or `protoreplicative', i.e. the product of chance, then not only does evolutionary biology have no account of systematic reproduction, which is the basis of its theory of speciation, but what was an initial improbability is now multiplied unimaginably many millions of times over.

On this account anything could result from anything at any time. It is not even that one would be saying that the reproductive process can sometimes go wildly wrong. The idea of going wrong presupposes a background of operational normality, and the idea of a reproductive process is that of something different in kind from a mere statistical pattern. Certainly it is not logically impossible that every single step of evolutionary history should have been a biological accident in the radical sense now envisaged, as if falling slates kept quartering cubes here, there and everywhere, many millions of times. No contradiction is involved in this supposition. Nonetheless it is incompatible with a realist interpretation of general biology, let alone special evolutionary theory; and to borrow a delightfully low-key phrase from Richard Swinburne it is `not much to be expected'; or as a Scot might say (with greater effect, if perhaps less accuracy) 'nae chance'.

I am not arguing the case for creationist science, the not logically impossible but foolish view that there is nothing to evolution; that God made the world as we find it today, a few thousand or a few hundred thousand years ago, complete with the fossil record. Early in chapter 1 Jack Smart writes of how his beliefs about reality are formed in the light of total science. As would be expected I cannot agree that this is a wholly adequate methodological principle (at least as he interprets it). Yet I certainly think that reason supports the claim of the empirical sciences to be a major source of our knowledge about reality, and no one who takes scientific canons of enquiry seriously should be willing to suppose that the world came into being in the period suggested by literal biblical creationists. Further, I acknowledge that there is a history of evolutionary processes and that our evidence and inferential grounds for thinking this also provide reason for linking humankind with pre-human species. What I have been arguing, however, is that biology, including its evolutionary dimension, cannot be understood or adequately accounted for in purely mechanical non-teleological terms. The emergence of life and the start of speciation call for explanations and what

reductionism has to offer fails to provide these, giving at best a blank cheque to chance, which is to say offering no intelligible explanation at all. to think that this action type could be correlated with any specifiable type of bodily movement, or even with a disjunction of these, preparatory to identifying the former with the latter (and eliminating the one in favour of the other). That is to say, any suggestion of the form `action type `I' is identical with physical type D, or with one or other of the physical types (1, V, c1)3, (1, .' is refuted by actual or easily imagined cases of the former that are not cases of the latter.

What I now want to add to this is the suggestion that it is equally impossible to sustain a `token—token' identity theory. Such a theory would insist that while action types cannot be identified with physical event types, nevertheless individual instances (or tokens) of the former can be identified with instances of the latter. In other words I am claiming that actions cannot be identified with, reduced to, or eliminated in favour of movements of quantities of matter. Imagining an appropriate scene, ask yourself the question what is the physical event that is the reality otherwise described as `Kirsty's writing a sentence'? No doubt some bodily movement, but which? As one begins to think about individuating a series of events within a region of space—time the nature of the problem starts to become clear. Consider all the movements involving Kirsty's body that might have occurred in the specified region: heartbeats, hair quiverings, eye blinkings, nerve impulses, muscle contractions, desk impactings and so on. There is no prospect, not even 'in principle', of identifying relevant movements save by non-dispensable use of action concepts involving reference to Kirsty's intentional behaviour. The relation between the movements thereby identified and the action itself is not one of identity but composition. Actions are more than movements; persons are more than bodies. Eliminativists and other reductive materialists are led to suppose otherwise because they bring to the issue a prior presumption that all there is, and so all that can be involved, is matter in the physicalist sense.

Let me note here that while Smart is certainly a materialist he does not, I believe, go along with those who claim that it is possible, in principle, to give definitional or deductive equivalents of psychological terms, and nor does he agree with Churchland that psychological descriptions can be eliminated. His view is that notwithstanding the impossibility of reductions or eliminations it is plausible to hold that there are no genuine mental properties, no features over and above those acknowledged by physics. How can someone defend such a view? After all if it is allowed that talk of beliefs, desires, intentions and so on is appropriate, and that it is not equivalent to talk about physical states, is this not reason to acknowledge that there are irreducible psychological attributes? Indeed does it not involve an implicit commitment to the reality of the mental as a distinct category?

If I have him aright, Smart's view is that some kind of property dualism or mental emergentism would be the appropriate conclusion were it not for other considerations. More precisely, he believes, first, that the circumstances in which we find ourselves attributing psychological states to one another, and the styles of those attributions, encourage an identification of the former with states of the brain; and second, that we have reasons not to posit non-physical properties, these being the sufficiency of physics and the difficulty of reconciling other sorts of facts and explanations with it.

In discussing the problem of evil towards the end of chapter 1 Smart describes and defends determinism. I shall have reason to come back to both issues later; for now, however, I want to pick up what he has to say about the explanation of actions. In keeping with a widely shared;'view he holds that in citing an agent's reasons we are giving causes of his actions. This will seem to support the identification of psychological with physical states if we also assume that the brain fits into the explanation of behaviour in a similar way. Let us suppose Kirsty wrote her sentence because she wanted to communicate her ideas. In writing It her body moved in various ways

because of events in her brain and nervous system. Putting these two together we might conclude that here was one sequence of behaviour describable psychologically and physiologically, and one cause (or subset of causes) specified in the 'first case by talk of reasons and in the second by talk of events in the central nervous system. This inference constitutes the first of the considerations against property dualism. The second is less an argument is an extended assumption. It is that physics is all we need and that advance the recognition of any other kind of reality would ex hypothesis inexplicable physicalistically, it would be at odds with physics. x ' Taking these in reverse order, the issue of whether the physicalist world-view is adequate is precisely what is in question and so it cannot be assumed as part of a case against any alternative. Equally the idea that acknowledgement of mental attributes is incompatible with physics is only true if by `physics' one means not physical science but •'Physicalism, the doctrine that there is nothing other than what physics deals with. Certainly the latter is incompatible with acceptance of aui generis psychological states and features, let alone the existence of • an immaterial deity, but again the truth of physicalism is what is at 'issue. It cannot be part of an argument in favour of itself.

As regards what one might term `the argument from causation' recall my earlier comments about the variability of causal ('because') explanations. When we say 'Kirsty wrote because she wanted to communicate' and 'her body moved because of events in her brain' it is by no means obvious that the two 'becauses' signify the same kind of relation. In the second case we are dealing with efficient causation; very crudely, a case of an energy transfer communicated from one place to another through the intervening physical medium, sections of the body. But in the first case what 'because' introduces seems to be an item from the rational and not the physical order; in Aristotelian-Thomistic terms it is a formal-cum-final cause. Compare this with the difference between saying `the circular stain on the table is there because of a coffee mug', and saying 'the area of the stain is not equal to that of a square of the same breadth because it has a circular boundary'. In the first case the base of the mug left an impression on a surface, but in the second circularity is not doing any impacting or pushing, the relation in question is an abstract geometrical one. So from the fact that `because' features in explanations of writing and of bodily movements we cannot immediately proceed to the conclusion that both are statements of efficient causation, and then look for this single inner causal factor.

Moreover the causal argument I sketched helped itself to an ambiguity in the term `behaviour'. We can say the writing was a piece of behaviour on Kirsty's part and that during the relevant period her body was behaving in various ways. But it would be another hasty inference to suppose that what is referred to is the same in both cases, and thus that if the cause of the latter was a set of brain events then ex hypothesi this was the cause of the former. Writing is intentional behaviour, i.e. action; bodily movements may or may not be intentional. So although there is an appropriate use of the term by which we may speak of the behaviour of muscles and bones it would be a fallacy of equivocation to infer that movements and actions are the same. Of course, this fails to show that they are not the same; for all I have just said they could be. The point was rather to defuse an argument that assumed they were and on that basis inferred that actions are nothing other than bodily movements effected by brain events.

Now, however, I want to go further and argue that there are grounds for not regarding action and psychological explanation more generally as a species of causal explanation in the sense required by the physicalist argument. Assuming the law-like nature of efficient causation, and the claim that giving reasons is giving efficient causes, it ought to be the case that there are psychological laws connecting psychological states to one another and (as reasons) to actions. As Paul Churchland has been concerned to emphasize there are indeed well- established psychological generalizations of an apparently law-like form — what he calls the 'explanatory laws of folk psychology'. Consider the following examples:

For any subject x and any propositional content p: if x fears that p then x desires that it not be the case that p,

For any subject x and any propositional contents p and q: if x believes that p, and believes that if p then q, then barring confusion, distraction, etc., x believes that q.

Lice first that while (1) is an unrestricted generalization it is mostly false, and when one tries to accommodate counter-examples, where someone fears that p but does not desire that not p, by lacing a ceteris paribus clause, or, as in (2) by various excluit quickly becomes apparent that the character of other things equal and that of relevant exclusion conditions cannot be fully fled. No genuine, universal psychological generalizations — that say `laws' — can be specified. Furthermore, such reason/action generalizations as seem to approximate to law-like status are, if true, a priori. Consider

For any subject x and any action type A: if x believes that A is logically impossible then x cannot sincerely try to A.

:alike an empirical causal law, hypothesized on the basis of observed sequences, this principle identifies a relation between elements in a rational order — `the sphere of reasons'. This comes out in the fact that the principles constrain the application of psychological concepts. If had good reason to maintain that someone believed that a course of tion was logically impossible then we rationally could not describe m or her as sincerely trying to effect it. Anything that supported attributing the belief would ipso facto be reason for not attributing e attempt, and vice versa.

How then do action explanations work, if not by citing antecedent (efficient) causal factors? Part of my general approach has been to resist reductions, allowing that reality can be, as it seems to be, composed of various distinct sorts of things constituted at different levels. Unsurprisingly, therefore, I see no reason to suppose that the explanation of the intentional behaviour of rational animals conforms to a single pattern. In particular I see no need to subsume every factor that might be adverted to in psychological explanation under a heading termed `rational causation'. Consider again the scene in which Kirsty is writing a sentence and we ask ourselves why she is doing this. The answer I proposed was that she wants to communicate her ideas, but many other explanations might be offered: she is in a creative mood; she has promised to produce a story; she has abandoned pencil and paper and is experimenting with a word processor; she doesn't have the time to write a whole page, and so on. Notice that these need not compete with one another; they could all be true. Notice also that in many cases the explanation takes the form of a redescription of the actual behaviour, not a move away from it to describe something else to which it is only contingently related — an ontologically independent antecedent cause. To say 'she is writing because she wants to communicate' need not be held to identify some event of wanting to communicate which led to this behaviour; rather it can be viewed as interpreting the behaviour as communicative. Here the wish to understand what is going on is satisfied by being told what the agent is doing. No mention of antecedent events is necessary. While one may say `she is writing because.. .' I have argued that it is a mistake to regard this as necessarily introducing an efficient cause.

In order to act an agent must be able to deliberate, considering the pros and cons of alternative courses. In doing so he or she is not reflecting upon actual events but possible ones. Possible events are always types; the only token events there are actual ones. So in thinking about what to do one is entertaining general descriptions: 'writing an essay', `cutting the grass', 'polishing the silver', `changing the baby', `phoning a friend', and so on. Unless we could think in terms of types we could not deliberate and without being able to deliberate we could not act. It is also true that when we think about the present and the past we consider events through the mediation of general

categories. Even where the object of thought is a particular, the content of the thought will be constructed out of general concepts (whether thoughts are wholly general in content is a matter of dispute). If I think of my wife Hilda I think of someone who is a woman, a mother, a Scot, and so on; and while she is a unique individual these are general and can be multiply instantiated — many indi -Scottish women, wives and mothers.

about the future is only ever thinking in general terms and)out the present involves bringing individuals under gen[n short, thinking involves universal concepts. This fact remains for materialism and for the effort to show that human,d have developed by physical processes from non-thinking were do concepts come from? Traditionally there have been answers to this question: innatism and abstractionism. to the first the ability to classify things under general cattgory something one is born with. According to the second the derives concepts from experience by selectively attending to features and ignoring other aspects of the things in question. 1950s Peter Geach produced a powerful argument against thesis.13 The suggestion that the concept square, say, is y experiencing a variety of square objects and attending to their squareness, while bracketing their other aspects, is absurd because attend selectively to the squareness of square objects you may have the concept square: attending to an instance of ass an exercise of the concept f. is well placed in this regard since it claims that all normalness do have the concept square and many more concepts it this quickly gives rise to problems of its own. How many o we have — 1, 10, 100, 1,000, 10,000? how are they related? a with the concept square and the concept rectangle or just id, if so, which one? are our innate geometrical concepts or non-Euclidean? how could we be born with concepts of didn't exist at the time? did cavemen have the concept but just never have occasion to use it? how did innate ideas As Jack Smart observes at the outset of his essay there are ever knock-down arguments in philosophy and an innatist find something to say; but I am pretty sure that Smart and would defend this view you have to be willing to make large such as that our ideas were given us by God who implanted umber, of the right sort, at the right time. In the past this my famous innatists maintained. More recently, the fashion o rely on evolution, but even those who take a naturalistic point of view and are willing to invoke evolution to existence are generally doubtful that it can offer an explanatate ideas.14

Does this leave the issue? We certainly have general concepts but if we were not born with them and we did not acquire them by abstraction how did we come by them? One answer is suggested by the later writings of Wittgenstein when he emphasizes again and again the fact that we are language users whose understanding is shaped by our participation in forms of life that are not of our own making. Wittgenstein never explicitly presents a theory of anything (depending upon one's attitude therein lies his wisdom or his pretension); and in order to develop the possibility that may lie in what he has to say it will be useful to refer back to Aquinas who also has interesting suggestions about the origin of concepts." For Wittgenstein we learn to think as we learn to speak. The ability to structure experience is acquired through the learning of general terms. Alice is enabled to think cat by being taught the word 'cat' (or an equivalent). On this account, therefore, the concept is not innate, the child had to be taught it; and nor is it abstracted, she was not able to attend to cats as cats prior to being instructed in the use of the concept.

Bringing Aquinas into the picture enables one to see how something of this sort may not just be an alternative to innateness and abstractionism but a via media. In order for something like the Wittgensteinian explanation to work it has to be the case that the child has a prior predisposition or potentiality to form concepts under appropriate influences; and it also has to be the case that the influence in question is itself already possessed of the concept. Alice will not pick up the meaning of the term `cat' unless she has a relevant potentiality, unless the structure of her receptivity is of the right sort. By the same token that potentiality will not be actualized except by an intellect that is already active in using the concept, her older brother James, for example. This vocabulary of `actuality' and `potentiality' is drawn from the Aristotelian—Thomistic tradition, as is the less

familiar terminology of the mind's `receptivity' and 'activity'. Aquinas himself speaks of the active and passive intellects as powers of one and the same thinker, which raises a question as to whether he is over-individualistic in his conception of the mind. In any event, here I am forging a link with Wittgenstein's linguistic-communitarian account of the origins of thinking in the individual and that suggests dividing these aspects of the intellect, at least in the first instance, between the teacher and the taught. In these terms one may say that Alice's intellect is receptive to, or potentially informed by, the concept cat, while the mind or intellect of James who has already mastered the use of the term is active with or actually informed by this concept. In teaching Alice the word, James imparts the concept and thereby actualizes her potentiality. This picture grants something both to innatism and to abstractionism. On the one hand, in order to explain possession of concepts a native power has to be postulated; but on the other it is allowed that, in a sense, concepts are acquired through experience.

Notice two features of this explanation. First it seems to give rise to a regress, and second and relatedly it instantiates the structure of Aquinas's primary proof of the existence of God. He writes:

The first and most obvious way is based on change. For certainly some things are changing: this we plainly see. Now anything changing is being changed by something else. This is so because what makes things changeable is unrealized potentiality, but what makes them cause change is their already realized state: causing change brings into being what was previously only able to be, and can only be done by something which already is. For example, the actual heat of fire causes wood, able to be hot, to become actually hot, and so causes change in the wood. . . what is changing can't be the very same thing that is causing the same change, can't be changing itself, but must be being changed by something else. . . But this can't go on for ever, since then there would be no first cause of the change, and as a result no subsequent causes ... So we are forced eventually to come to a first cause of change not itself being changed by anything, and this is what everyone understands by God (et hoc omnes intelligunt Deum).'s

This is a cosmological proof, that is to say it argues to God-as-Cause)m the mere fact of existence — here the existence of change or motion. I shall be returning to this general style of argument in section For the present, though, note that while the coming-to-be of a conceptual power in the mind of a child is certainly a change, and hence qualifies as a starting point for the first way, the particular change in question suggests a more specific proof. To bring this out consider the progress arising within the 'Wittgensteinian—Thomistic' account of con- pt formation.

Alice possesses a power that parrots lack, for while a bird may pick a sound and repeat it — quicker and more accurately than the child no amount of `instruction' will teach the parrot the meaning of a rm. Alice's innate power is in fact a second-order one; it is a power acquire a (conceptual) power. Another human being — James — ready has the first-order power; he uses the term meaningfully and inks thoughts with the same conceptual content. Through instruction Alice's hitherto unrealized potentiality is made actual through the activity of James. But as Aquinas says, this cannot go on for ever. James's conceptual ability calls for explanation and the same considerations as before lead to the idea of his instruction by an already active thinker/language user, Kirsty, say, whose ability is itself the product of an innate potentiality and an external actualizing cause. The Wittgensteinian proposal that concepts are inculcated through membership of a linguistic community suggests an interesting escape from the dilemma posed by the innatist/abstractionist dispute, but it is not itself ultimately explanatory because for any natural language user it requires us to postulate a prior one. This regress will be halted if there is an actualizing source whose own conceptual power is intrinsic; and that, of course, is precisely what God is traditionally taken to be.

The cosmological argument itself is often described as the argument to a `Prime Mover'; but the particular adaptation I have been concerned with might better be termed the argument to a `Prime

Thinker' or even, though metaphorically, to a 'Prime Sayer'. Here, one may be reminded of two well-known Hebrew and Christian reflections on `beginnings' — those of the first chapters of Genesis and of the Gospel of John:

> Then God said, 'Let us make man in our image, after our likeness...' [then] out of the ground the Lord God formed every beast of the field and every bird of the air, and brought them to the man to see what he would call them; and whatever the man called every living creature that was its name. (Genesis 1: 26; 2: 19)
>
> In the beginning was the Word, and the Word was with God, and the Word was God. He was in the beginning with God; all things were made through him, and without him was not anything made that was made. In him was life, and the life was the light of men. (John 1: 1-4)

This line of argument will provoke various objections. Some of these are general complaints about philosophical theology (e.g. whether invoking God as a self-explanatory cause is consistent, and whether philosophy and scripture belong together) and are best dealt with at a later stage. At this point, however, I want to make explicit the connection between the reflections on conceptual thought and the issues of evolution and emergence.

Wittgenstein was a cautious thinker and held back where his reasoning neared the limits of experience. Consequently I am not sure to what extent he can be said to be a philosophical naturalist. He is reported to have said of himself `I am not a religious man but I cannot help seeing every problem from a religious point of view'17 and it is clear that he had respect for religious sensibilities. At the same time, these attitudes can be interpreted in ways compatible with atheism. It is difficult to say, therefore, what his attitude to the problem I have posed might have been. Whatever Wittgenstein's own view about it, however, the language-learning account of concept-formation might seem to escape the regress if it can show how at some earlier point the sequence of concept-conferring exchanges could have arisen. Any such account faces two difficulties: first that arising from the dialectic between innatism and abstractionism, and second a version of that resented earlier in connection with Dennett's homunculi-discharging
A strategy. If the linguistic view is to be a genuine alternative to the other theories it cannot revert to them in explaining earlier stages in our conceptual history. It cannot say, for example, that Adam's (and Eve's?) concepts were innate though Alice's were acquired. If innatism and abstractionism are incoherent they are not made any more intelligible 1. being introduced to halt a regress.

This sort of difficulty will be generally acknowledged; what is less likely to be conceded is the second objection, namely that no history of ought or language can be philosophically adequate if it tries to meet e genesis problem by postulating 'fading conceptuality'. Though it is t put in these terms, or indeed very often discussed at all, something this sort is presumably part of a naturalistic version of Wittgenstein's theistic theory. On this account the history of concept-formation and is the history of language; a history that leads back to pre-linguistic activities, back further to pre-mental life, to pre-replicating life and ultimately to pre-animate matter. It is unnecessary for me to elaborate An objection. What needs to be accounted for is a natural transition m the non-conceptual to the conceptual and that is not the same distinction as one between degrees of conceptual complexity. Doubts Stone Age cave dwellers made fewer and less abstract discriminations than a contemporary physicist, but that is irrelevant; the point that the ability to make any general classifications is a conceptual

Let me add a further consideration in this cumulative case against inaturalism. Thus far I have cast my objections concerning the nature thought in terms of the genesis of concepts. However there is

an additional difficulty for the materialist or physicalist so far as concerns the relation between concepts and the objects and features that 11 under them. Consider again the concept cat. Setting aside issues wing to do with its non-specificity and possible indeterminacy (e.g. there are significant differences between species of cats and there may be animals concerning which it is an issue whether they are cats) let us say that the extension of this concept (the things of which it is true), or of the corresponding term 'cat' and its equivalents in other languages, is the set of cats.

Smart discusses the need to allow sets into his otherwise materialist ontology but I am concerned to argue that in the present case this admission is an insufficient concession to non-materialism. It is natural to think that the concept cat designates not only actual cats but future and `counterfactual' cats. That is to say, one might contemplate and discuss with others the prospects for cats in the environment of Chernobyl 30 years hence, or consider what would have been done with the kittens that Mother Cat might have had had she not been neutered. Thus there is a problem with the attempt to give the 'semantic value' of this term, or concept, by reference to actual material objects. Additionally, it is easily imaginable that the members of the set of actual cats fall under another concept, let us say that of being the most-common-four-legged-animals-whose-average-weight-is-W, call this the concept `maxifourn'. In this situation the extensions of the concepts cat and maxifourn are identical: they have all and only the same members. Nonetheless, it is natural to say that the property of being a cat is not the same as that of being a maxifourn. Little Felix would still be a cat even if, because of population changes, he were no longer a maxifourn; meanwhile in the same situation though Derek the dachshund might then be a maxifourn he would thereby not have become a cat.

The point is clear: concepts distinguish objects in virtue of their properties and even where two concepts are co-extensive — have all and only the same instances — the properties they designate may differ. This is so even where the properties in question are not merely co-extensive but necessarily so, i.e. where, unlike the cat/maxifourn example, there is no possibility of their extensions diverging. Every triangle is a trilateral and vice versa, and in some sense possession of the one property necessitates possession of the other. Yet triangularity and trilaterality are not the same attribute and it takes geometrical reasoning to show that these properties are necessarily co-instantiated. This latter possibility raises what for the empiricist is the spectre of a priori knowledge, i.e., true, appropriately warranted belief that does not require to be verified in experience — because it could not fail to be.

These are various aspects of a general problem for the naturalist. Our concepts transcend material configurations in space—time. As was observed earlier, to think of an item is always to think of it via some conception. A naturalistic account of experience and thought will need to relate such ways of thinking to the nature of the objects in question and very likely add that the genesis of our concepts derives (in whole or in part) from the causal influence on us or on earlier generations of particular material objects. The trouble with this is brought about by the trilateral/triangular example. To the extent that he can even concede that there are distinct properties the naturalist will want to insist that the causal powers — as he conceives them — of trilaterals and triangulars are identical. Thus he cannot explain the difference between the concepts by invoking causal differences between the members of their extensions (as one might seem to be able to account for the difference between the concepts square and 'circle). For any naturally individuated object or property there are definitely many non-equivalent ways of thinking about it. That is to say, the structure of the conceptual order, which is expressed in judgements and actions, is richer and more abstract than that of the natural order, and the character of this difference makes it difficult To see how the materialist could explain the former as arising out of the latter.

In summary, I have been arguing that there is a good deal of life remaining in `old style' design arguments. Evolutionary theory, and naturalism more generally, are not equipped to explain three

important differences which common sense and philosophically unprejudiced science both recognize: those between the inanimate and the animte; the non-reproductive and the reproductive; and the non-mental end the mental. Assuming a history of development, these differences involve a series of ascents giving rise to explanatory gaps in evolutionary Naturalism in its modern materialist versions has negative and positive aspects. It precludes certain sorts of explanations on the grounds that they are incompatible with physicalism, and it presumes the availability, in principle, of wholly adequate naturalistic accounts of reality. I have been arguing that in its negative aspect it begs the question in its own favour, and that its positive claim is demonstrably 'false in respect of one or more features of the world.

One reaction to this might be to concede both aspects of the case 'against naturalism, yet to query whether it advances the cause of theism. Philosophers and others have written disparagingly of 'God of the gaps' apologetics, meaning by this the effort to save religion from the onward march of scientific naturalism by finding phenomena for which science has not provided an explanation. These critics have not

5 `New' Teleology

The comparative brevity of this section is made possible by the fact at Smart gives a clear and detailed discussion of the `fine tuning' argument. He is right to point out the absurdities of some treatments of the anthropic cosmological principle and I aim to steer a course through these that is parallel to his own. Some discussions reduce it To a trivial tautology that cannot introduce anything worth thinking bout; others elevate it to a metaphysical mystery so great that it defies comprehension. Both are mistaken.

If the necessary conditions of our existence did not obtain we would not be; and if the necessary conditions of the necessary conditions of Our existence had not obtained then neither we nor many other aspects, And elements of the present universe would have been. Any scientific theory that is incompatible with things having been as they had to have been, in order for the universe to be as it is, is thereby refuted. `Tone of this may be very profound and it did not take science to establish it; but it does raise a question: is the obtaining of the necessary conditions in question explicable, and if so how? At this point some writers career to another lane on the far side of the via media and argue that our existence necessitates the laws of the universe — we made it be the case that the cosmos is congenial to our existence. This is not only fallacious reasoning; it betrays a lack of intuitive judgement that is unsettling when exhibited by intelligent people. If you think you have an argument to show that the fact of your existence determined the initial conditions of the universe, think again, and again, and again.

The real interest of the issues introduced by the question of the conditions necessary for the world to be as it is, complete with beings able to investigate its structure and to ask this very question, lies in the fact that those conditions seem to call for some explanation. What we know about the observable universe and that which we can infer about what lies over the `visible' horizon indicates that it is composed out of a number of types of microphysical entities whose members exhibit common properties and are subject to a small number of simple laws. There is nothing obviously inevitable about this fact. It seems perfectly intelligible to suppose that the universe could have been spatially and temporally chaotic. There might have been little or no regularity in the nature of its parts and the flow of events might have been entirely haphazard. Yet it is not so. Chemistry tells us that there are elements whose instances share well-defined structural properties in virtue of which they can and do enter into systematic combinations; and physics tells us that these elements are themselves constructed out of more basic items whose properties are if anything purer and simpler. A stock of components with regular modes of combination subject to perfectly general laws is not the only possibility, and it invites speculation as to why there is order rather than chaos.

One might say that if there had been chaos then we would not exist and the question would not have arisen. In a sense that is true — no actual inquirers, no actual inquiry; but it leaves untouched the central theme which is that of the preconditions of the possibility of order. Cosmic regularity makes our existence possible, the underlying issue concerns the enabling conditions of this order itself, and that issue 'arises' even if no one exists to raise it.

Some teleological proofs argue from spatio-temporal regularity alone. They reason that while events in nature can be explained by reference to the fundamental particles and the laws under which they operate, these explanatory factors cannot themselves be accounted for by natural science. Since scientific explanations presuppose them as first principles, they cannot derive them as conclusions from more general facts about the universe. Natural explanations having reached their logical limits we are then forced to say that either the orderliness of the universe has no explanation or that it has an 'extra-natural' one.

The latter course cannot plausibly take the form of embedding the facts of nature within the laws and initial conditions of a SuperNature. That would amount to retracting the previous claim that one had specified the ultimate facts of the material universe; and `nature' would then be regarded as a spatial and/or temporal part of SuperNature. The search for the source of order must reach a dead end if scientific explanation is the only sort there is. However, as I have emphasized in earlier sections, there is more than one kind of 'because'. In particular, explanations sometimes proceed by tracing events to rational agency. These words are on the page before you because I chose them to express my thoughts; I found myself thinking about the issues because I accepted an invitation to exchange views with Jack Smart on atheism and theism; and I did this because it seemed fitting. Such facts explain by citing reasons why something was brought into being and made to be as it is. Similarly, the otherwise inexplicable regularity that surrounds and inhabits us will have an adequate explanation if it derives from the purposes of an agent. Ex hypothesi, no natural agent could have made the universe; so if the question which its `regularity gave rise to has an answer it can only be one that connects natural order to a supernatural order — et hoc dicimus Deum.

This traditional argument pre-dates the physical and cosmological investigations that have produced the evidence of `fine tuning'. What;that evidence involves is well described by Smart, and I take it he:agrees that it adds to the strength of the argument to the extent that it makes the existence of an orderly universe even less likely than might have been supposed. The basic laws of nature feature contingent ratios that the laws do not themselves explain, and the fundamental particles whose behaviour they regulate also exhibit apparently contingent numerical properties. If any of these ratios and quantities had been different in the slightest degree then not only we, and our predecessors in the history of life, but orderly matter itself would not hae existed. Crudely, the conditions necessary for the development and continued existence of anything like the universe lie within a narrow range bounded on one side by the possibility of `implosion' and on the other by that of `explosion'. As before, any explanation of this fact has to look beyond the framework of natural causation and that leads to a conclusion of purposeful agency.

Assuming our common commitment to realism Smart and I would oppose neo-Kantian relocations of the source of order in the minds of observers. Whether the facts are as fundamental science now depicts them we are not of the view that order is always a projection and never a detection of something that is there independently of our conception of it. So the debate concerns the possibility of explaining finely-tuned order in non-theistic terms. As in the discussion of organic teleology one is faced with an initial branching, down one limb of which lies another fork. First, then, there is the issue of whether cosmological order can be a basic unaccountable fact. To say that it can is to maintain that functional regularity is independent of any other kind of explanation. If one thinks that this is not a satisfactory conclusion, and it is after all no more than a restatement

of that for which an explanation was being sought, then two courses present themselves: explanation by reference to purposeful agency; and explanation by reference to chance.

Smart follows the latter course adopting a version of it that postulates many universes. If there is a vast multiplicity of these differing from one another in respect of their components and modes of interaction, some being highly regular, some less so, some fairly chaotic, some utterly so, then it will be sufficient explanation of the general regularity and particular fine tuning of our universe that is it but one of indefinitely many. Chance alone will explain its existence. Given enough opportunities the realization of order becomes unpuzzling.

Note that the question of whether to conclude to design or chance is not one that scientific observation can decide. We need to reason our way ahead. How reasonable, therefore, is the reduction of order to chance? It is not true to say that because any other outcome might have occurred a particular one requires no explanation. One way of bringing this out is in terms of significant orderings. Suppose someone tears out the pages of this book numbered 1 to 100, thoroughly shuffles them and stacks them in a pile. Assuming relevantly similar causal antecedents any stacking has the same prior probability as any other — 1 in 3,628,800, and under the description `papers in a pile' no particular arrangement is significant. Suppose, however, that one of these piles has the pages lying in numerical order from page 1 to page 100. As a distribution of paper, and assuming similar operative factors, this stack is no more or less likely than any other; but considered as a significant (numerical) ordering — which it certainly is — it invites an explanation which the others do not. For while the probability of its occurring is as before, the probability of some or other non-significant ordering (i.e. any other than it) is 3,628,799. That is to say, while your chance of stacking them in sequence is 0.00002756 per cent, the chances of doing otherwise are 99.99997244 per cent.

Admittedly it remains possible that the significantly ordered stacking is the result of chance, but that hypothesis is much more implausible than one which invokes a different causal ancestry, hypothesizing that the seemingly random shuffling was in fact a well-controlled manipulation designed to order the pages sequentially. Where an explanation is available that renders an improbable outcome more likely one should prefer it to an explanation that preserves the improbability, and the greater the differential the more one should favour the probabilizing hypothesis. I do not know what the probabilities in question are, but on the assumption that the range of possible universes is very large, if not infinite, the chances of any particular outcome are small and diminish as that outcome moves up the scale of significant ordering. Equivalently, the occurrence of 'harmonious' arrangements is less likely than that of `discordant' ones. The evidence of fine tuning is precisely of this sort. For example, if it is accurate, it tells us that a tiny percentage of possible universes having structurally equivalent laws to our own, but varying in respect of fundamental ratios and quantities, are life permitting. The fact that one such exists (that it is ours is only relevant to the extent that it allows us to contemplate the issue) calls for explanation. The hypothesis that this fact is not the outcome of chance renders it far less unlikely than does the hypothesis that it is. Accordingly, unless other factors exclude the hypothesis of design it is to be preferred over that of chance.

Suppose, however, someone argues that there are infinitely many other universes, ordered either in parallel or in temporal sequence, and hence that it is inevitable that one with the fundamental configuration of ours should exist. To begin with this needs correction. Even if there were an infinity of universes it would not be inevitable that this or any other one should be among them. All one can say is that as the number of universes proceeds towards infinity the probability of a difference between the actual distribution and the probable one diminishes to zero. Taking the earlier example of the pages, if one shuffles and piles them over and over again infinitely many times then the chances of not getting 1 to 100 diminish. However it is not guaranteed that 1 to 100

will eventually result. Infinitely many operations may never yield the significant ordering. Nonetheless they will make its occurrence very much less unlikely than if there were only one operation.

The logic of the many worlds response involves postulating an infinity of actual universes because while this does not determine that the significant one will occur it diminishes its improbability. There is another reason for postulating an infinity rather than just finitely many universes and this is connected with the next argument I shall be considering, viz, the cosmological one. For if one envisages an infinity of possibilities, but stipulates that only some (however many) shall be realized, this invites the question of what debars the others, or equivalently of what occasions the occurrence of those that are realized. This then introduces the idea of contingency and of the need of a source of selection from among possibilities. In order to avoid this issue, and to eliminate any element of improbability in the occurrence of this universe, one might suggest that the set of worlds (this included), is the totality of all possible universes; or one might claim that there is and could only be one world — the actual one. In either event since it could not fail to exist no question arises as to the fact of its existence.

Deferring consideration of the cosmological argument, how effective is the many universes response? Unless it claims that all possibilities are or must be actualized it concedes that a finely tuned universe might not have existed and thereby allows scope for a probability argument for design. Rather than try to build on that reduced base, however, the theist may query the coherence of the many universes hypothesis itself. Can it be excluded? The question is ambiguous. If it asks whether there is any argument to show that it is contradictory or otherwise impossible then I suspect that there is not; at any rate I do not have one. However, one might mean less than that, for we often exclude suggestions on the grounds that they are obscure or inadequately supported, and here I think there is a significant weakness in the hypothesis.

To bring this out consider a further ambiguity. What is meant by talking about 'many universes'? In futuristic fantasies, space travellers often journey to other worlds. This way of speaking of far away and hitherto unknown places pre-dates science fiction. The European explorers of the fifteenth and sixteenth centuries sailed from the `old' world and discovered the `new', but in saying so no one intends that they left the planet. Similarly one might speak of 'other universes' meaning far distant and currently unobservable regions of the Universe — the one spatio-temporal-causal continuum. Alternatively one might mean, though this is much harder to make sense of, entirely distinct cosmic set-ups, wholly discontinuous with the Universe we inhabit.

If the hypothesis of plural universes invokes the former idea then it is clear enough what is being said, but it should also be evident that it fails to serve the purpose intended. Any evidence we could have for the existence of spatially or temporally distant regions and systems would necessarily be evidence for situations generally like those obtaining in our sector — that is to say situations exhibiting the same finely tuned features whose existence seemed to call for explanation. This is so because all that could lead us to postulate and predict the character of distant universes would be the application of observational-cuminferential methods to empirical-cum-theoretical data available to us here. So if `many universes' means `many local set-ups' within the Universe the hypothesis fails to defuse the power of the new design argument. If on the other hand it is being claimed that there could be many Universes — entirely distinct realities, wholly discontinuous and sharing no common elements — then, while it is uncertain how to interpret this, it is clear that there could be no empirical evidence in support of the hypothesis, and nor could it be derived as a necessary condition of the possible existence and character of the only universe of which we have or could have scientific knowledge. In short the hypothesis appears as entirely ad hoc, introduced only to avoid what for the naturalist is an unpalatable conclusion, viz., that the

general regularities and particular fine tuning are due to the agency of a designer — et hoc dicimus Deum.

Some readers will be struck by the parallels between the many universes hypothesis and another theoretical construction, namely the so-called 'Many-Worlds Interpretation' of quantum mechanics. This is a response to a deeply puzzling feature of a major part of fundamental physics. In a quantum-mechanical situation it seems that there are indeterministic transitions between states. The theory tells us that a system will go from A to either B or C but in principle it cannot tell us which one it will go to — the outcome is indeterminate. Among those who find this situation unacceptable some maintain that the uncertainty is only epistemological. There is a fact of the matter involving `hidden variables' but for one reason or another we do not, or cannot, know what it is. A more radical determinacy-preserving proposal is that the transition is to both states: at this point the universe divides into two worlds and so does the observer. In world', A goes to B and is observed to do so by John'; in World' A goes to C and this event is recorded by John'. Two points need to be added: first, this is supposed to be happening all the time, there is endless branching; second, it is in principle impossible to have trans-world access. So while the particular motivation and details of the proposal differ from those of the many universes theory the philosophical position is the same: an unverifiable hypothesis of finitely or infinitely many wholly distinct actual universes is introduced in order to save having to yield up doctrines of modern science: the sufficiency of natural explanation and the determinacy of nature, respectively. Both moves look decidedly ad hoc.

The basic components of the material universe and the forces operating upon them exhibit properties of stability and regularity that invite explanation — the more so given the narrow band within which they have to lie in order for there to be embodied cognitive agents able to investigate and reflect upon the conditions of their own existence. Even given these improbable cosmic circumstances the emergence of life, the development of species and the emergence of rational animals all call for explanations that it does not seem to be within the power of natural science to provide. The limitations of science in these respects concern its very nature and the nature of the phenomena in question. Obviously I have been arguing philosophically and if these arguments are correct then their conclusions are immune to empirical refutation. Unsurprisingly, I feel more confident about some phases of my reasoning than about others. For example, notwithstanding what has been argued, I think the obstacles to mechanistic reduction of life to chemistry and physics are fewer than those standing in the way of a naturalistic explanation of mind and all that it implies.

In connection with the last point let me add a further argument, picking up some of what I said in sections 1 and 2 about general metaphysical perspectives. The presuppositions of scientific realism are that there are things the existence and nature of which are independent of our investigations, and that we possess intellectual powers adequate to their identification and description. (This claim allows that not all that exists may be mind-independent and not all that is may be knowable by us). There is nothing inevitable about this; the world might not have been intelligible and we might not have had the kind of intelligence that is shaped to understanding it. The fact that there is a harmony makes it possible for us to have knowledge of some of the most profound features of the empirical order. From astronomy to zoology via chemistry, physics and the rest of the natural sciences, we have discovered an enormous amount about reality (not to mention non-empirical orders of logic, geometry, mathematics, and so on).

This is improbable even granting naturalism, and if my earlier arguments against materialism are right it is entirely inexplicable on that basis. I reasoned that there cannot be an evolutionary account of conceptual powers; but even if there could be, that would not account for our having the kinds of concepts we do, ones that go beyond practical utility and so cannot be explained in

terms of adaptive value. One might here appeal to the fact I mentioned earlier, namely that present day biologists do not claim that every significant characteristic is an evolutionary adaptation. That, however, is a move away from the possibility of giving a natural explanation of the harmony of thought and world. It would be within the power of an intelligent creator to effect such a harmony, and indeed there would be something fitting in creating a universe that had within it the power of its own understanding which is what in one sense empirical knowledge involves. I offer this as one interpretation of the Judaeo-Christian-Islamic idea that a human being is made in the image, indeed is an image, of God (imago Dei). The hypothesis of theism explains the existence of an orderly universe, of rational animals and of the harmony of thought and world. Scientific materialism explains none of these things.

J.J. Haldane - Reply to Smart

2 The Existence of God

How does theism fare given this principle? In my essay (chapter 2) I offered arguments to the existence of God that fall under two broad patterns: teleological (sections 4 and 5) and cosmological (section 6). Contemporary philosophical theists who find merit in reasoning of the first sort generally favour arguments from regularity. While presenting a version of these I have also claimed, in contrast with most philosophers,5 that the possibility of an old style design argument from the `directedness' of things is not excluded by the development of evolutionary theory. Here it may be useful to have a 'map' (Figure 4.1) summarizing the various lines of reasoning presented in chapter 2.

These diagrams are intended only as reminders and I shall not attempt to repeat the details of the arguments they abbreviate. However, a short resume of part of the argumentation mapped in Figure 4.1A is appropriate. First, I began with the assumption — which Smart and I share — that science is the systematic study of a largely mind-independent world. That world contains a plurality of kinds of things animate and inanimate. The members of these various kinds are united by sharing qualitatively similar natures. In the case of living things these natures include principles of organic development and activity.

With regard to the apparent functional or vital attributes, powers and activities of organisms one must either be a realist or an eliminativist. Realism is the claim that such features are genuinely as they seem and are possessed by their subjects independently of our conceptions of them. For one reason or another eliminativism rejects this, holding instead that what appear to be real biological and teleological attributes of such and such a sort are either reducible to more basic properties which are real, or else are simply shadows cast by the light of human interest. My first argument was to the effect that the natural sciences are realist in their assumptions and that Smart faces a dilemma: either to endorse this view, thereby giving scope for an old style 'directedness' design argument, or else to reject it without scientific warrant in favour of an ideologically driven, mechanistic reductionism. The point of the latter disjunct is that nothing in the study of nature requires that we only allow as real what physics deals with; to suppose otherwise is a prejudice of philosophy not a discovery of science.

In his reply Smart reaffirms his physicalism but denies that it forces him to be a conceptual reductionist; as he writes `My physicalism is an ontological one, not a translational one' (chapter 3, p. 170). The possibility of such a position is not in dispute; indeed I allowed for it and described an example when discussing the difference between ontological and conceptual or explanatory behaviourism (chapter 2, p. 93). My point was rather that while Smart may allow the non-translatability of teleological descriptions he denies that there is — in reality (ontologically) — any teleological behaviour. What he has to say later about levels of organization understood 'in a weak sense' does not alter this fact. On his account a tree is still `nothing over and above a physical

mechanism.. . even though talk of a tree is not translatable into talk of electrons and protons' (chapter 3, p. 172). The reductionism remains, as does my objection that it is unwarranted by empirical observation and theory. On the contrary we should suppose that the irreducibility of explanatorily rich and powerful biological theory is evidence for the reality of biological entities and powers — including teleological ones. This is in no way incompatible with the claim that such entities are composed of electrons and protons; but composition is not identity. We need to distinguish in living things, as in artworks, between the medium of realization and that which is realized in it, and to acknowledge that both are real.

My next step was to argue that natural 'mechanico-evolutionary processes' are not sufficient to explain the emergence of living things, reproductive species and thinking animals. Smart addresses the transition from the non-reproductive to the reproductive by suggesting that there is no problem for naturalism and that a hypothesis of this sort is to be preferred. Why is naturalism unembarrassed? Because, Smart supposes, there is no difficulty in principle to the natural emergence of replication: `Why could not a self-replicating molecule come about through the coming together of a number of non-replicating molecules?' (chapter 3, p. 169). Well, first of all self-replication is not sufficient for evolution. The latter requires reproduction involving the coming to be of entities sufficiently like their predecessors to be continuants of their basic nature but sufficiently different to allow for selection, in point of varying degrees of adaptation, to take place. And what reproduction requires is a highly adaptive mechanism of the sort which it has been the goal of evolutionary theory to explain. Given teleology, evolutionary theory has a role; the question is whether it is intelligible to suppose that it could be the whole story.

Second, however, is the fact that there is no satisfactory naturalistic account even of primitive replication. There is nothing unintelligible about the idea which Smart mentions, that life on earth may have begun in consequence of organic molecules having arrived here from interstellar space. The problem with this suggestion, which Smart does not himself endorse, is that it is regressive. In answer to the question of ultimate origin Smart offers what is in effect a 'why not?' reply. Why could replicating molecules not just arise from non-replicating ones — be it that this occurrence may have a very low probability? My objection, however, was not to this being more or less likely, but to the very idea that there could be a natural explanation of the emergence of replicators from non-replicators. Indeed, this is just the sort of case that illustrates the notion of radical emergence. Some feature F is radically emergent if it is novel in a subject S (i.e. if it is not just a linear combination of instances of the same property type, as the size of a quilt is a linear function of the sizes of its constituent squares), and no naturalistic theory of the components of S can predict or explain F.6 Thus my claim is that the power of self-replication is novel and not explicable by reference to lower-level entities and properties.

Standard evolutionary explanations posit replication as spontaneously arising some three or four billion years ago in a form more primitive than DNA. Needless to say there is no direct evidence of this, rather it is an assumption of naturalistic theory. The behaviour of DNA itself is acknowledged to be so qualitatively advanced that it is unimaginable that it could just have sprung into being uncreated. So the task is to show how DNA could have arisen from more primitive replication, say RNA, and how that could have resulted from non-replicating systems. Although molecules exhibit dynamic properties they are not normally self-duplicating, so the question remains: how could replication and hereditary variation arise?

Talk of 'proto-replicators' is vulnerable to a version of the dilemma with which I challenged the claim that intentionality arose from protorepresentation. Representing or replicating very many features is certainly different from representing or replicating very few, but (pace Smart's remarks in his reply, chapter 3, p. 169) it is a difference of the wrong kind so far as the needed explanation is concerned. Low level is not no level, and it is the jump from none to some that needs to be

effected. I conclude, a priori, that this gap is one of kind not quantity. The emergence of reproductive beings is radical and thus by definition not naturalistically explicable. If natural explanations were the only sort available we might despair of understanding. But there is another way of accounting for the emergence of novel entities as when a painter brings together quantities of powder suspended in oil and fashions a likeness of a sitter. Such is the style of explanation I offer of the emergence of life. Like the portrait it is the work of creative intelligence.

I have already touched upon the question of how mindedness introduces a domain distinct from that of physical properties and relations. The character of this difference has an important part to play in the extended argument (schematized in Figure 4.1B) from thought and language to the existence of God as source of conceptual activity. Smart's rejoinder is principally addressed to the premis concerning intentionality. Since I remain attached to what I argued earlier I suggest that readers compare what each of us has had to say on the matter and draw their own conclusions. I would only add by way of encouragement that the issue of intentionality is of immense interest and importance in its own right.

3 Metaphysical Matters

Thus far, the left-hand side of Figure 4.1A has not been mentioned. The cosmological reasoning set out in section 6 of chapter 2 is really a presentation and defence of Aquinas's first three ways, and primarily of the first and second of them. In passing, let me strongly urge those who have not already done so to read the relevant article of the Summa (S. T., Ia, q. 2, a. 3). The whole thing only runs to three pages! There cannot be many such short sections of text that have deserved or received so much study.

In his reply, Smart observes that it is not necessary in arguing for a first cause to assume that it is temporally prior. I agree and said as much, noting that Aquinas's proofs are intended 'to establish the ontological not the temporal priority of the first cause' (chapter 2, p. 136). What then followed, in order to show that there could not be an infinite series of causes, is not essentially tied to temporality. Smart introduces a reason to suggest that it had better not be, namely that the theistic conception of God should not locate him in time. As I suggested, however, the question of God's relation to time, especially as that bears upon the issue of divine agency, is complicated by the fact that there is a sense in which an 'activity' may be dated and timed though its source cannot be. If x caused y at t, we can say that x's agency was effective at t without being committed to the claim that at t, x began to do something. Thus one might wish to argue that a series of causes and effects could not regress infinitely in time, while yet denying that its originating source — effective in a temporally first event — was itself temporally located.

Smart remains worried about other metaphysical and theological ideas deployed in my presentation. There is not the space to elaborate on these matters here, but again I would ask readers to go back and try to judge the adequacy of what I wrote in the light of Smart's criticisms. For the most part he is generous in allowing that what I claim is defensible, and only contends that better — non-theistic — options are available. But on one topic he is clearly quite unsympathetic, or at any rate bemused. This is the issue of free action.

It is a common experience that there are certain philosophical issues where differences of view are accompanied by perplexity as to how one's opponents imagine that what they maintain is or even could be satisfactory. One such issue is weakness of will; another is consequentialism in ethics; a third is free will and determinism. Smart recognizes that part of my defence against the argument to atheism from evil rests on the claim that were God to act continuously so as to prohibit or limit the evil caused by human choices he would remove our freedom and thereby inhibit the realization of our natures as rational agents. Setting aside the question of the value of rational self-realization, Smart has a more immediate objection to my defence, namely that it presupposes an incoherent

notion of free action as action that is uncaused. Once again readers will have to make a judgement from preceding pages but it may be helpful if I address Smart's puzzlement about the idea that human action issues from a source `within' the agent.

Recall that I rejected the view favoured by Smart, and championed by Davidson,' that action is behaviour caused by antecedent mental states — `reasons'. There are two broad categories of considerations against the identification of reasons with causes: the first is that nothing about the rational explanation of action requires this identification; the second is that the nature of action explanation prohibits it. Smart has the latter concern in mind when he writes that we must distinguish `reason' as cause and `reason' as justification. He thinks it would be a mistake to pass from the fact that justifying reasons are normative propositions (e.g. the truth of `it is wrong to lie' is a `reason' not to lie) to the conclusion that they cannot be causes, for what is cited in explanation of behaviour is not the truth of the proposition but the agent's belief in or endorsement of it. I agree this would be a faulty inference but it does not feature in my anti-causalist view of reasons. My argument as presented above (chapter 2, pp. 109ff) has to do with the difficulty of conceiving of the relation between beliefs, desires and other mental attitudes and actions as being a causal one.

It was in response to the question of how the connection between them should be understood, if not causally, that I introduced the scholastic phrase `moved from within'.' This troubles Smart because the only relevant 'inside' from his point of view is that defined in relation to the skull. It may help if I explain that the origin of this phrase lies in a contrast marked in Aristotelian thinking about the movements of objects, between those whose behaviour is to be explained in terms of forces acting upon them, and those which are originating sources of movement in their own right. This is not the distinction between mere behaviour and rational action since there may be internal principles of non-rational agency. Rather it relates to the issue of whether some behaviour is expressive of the nature of the thing in question or is an effect imposed upon it.

Among the things there are, are natural substances, that is, unified subjects of predication. Such substances have characteristic powers of action and reaction; and sometimes their names and descriptions indicate these powers. Thus if we hear that something is an 'acid' we know that in certain sorts of circumstances (which we may not be able to specify) it will exert a corrosive effect. Similarly if we know that something is an `animal' then we know that it has organic powers, typically ones of metabolism, growth and reproduction. In explaining an occurrence by mentioning its agent we are adverting to the operation of such powers as providing a full and adequate account. It is a mistake, I believe, to assume that if a substance is cited as the cause of an event the latter must, as a matter of logic or metaphysics, be due to some other event or events having taken place literally inside the agent. What it is to be an agent is to be possessed of certain powers with natural tendencies to exercise them in appropriate circumstances. Certainly, if such power is actualized one may well look for a prior event that was the occasion for this, but in doing so it will generally be more appropriate to look to the surrounding environment than to the substance itself, for the operation of the power will usually be in response to an external event.

In the case of intelligent agents the relevant power may be termed `rational willing'; though in describing it as such it is important not to think in terms of a mechanism the parts of which are brought into operation as one element exerts an influence on the next. Instead one should think of a structural description that relates aspects of agency (reason and action) to one another without assuming that these are distinct items. To emphasize what was said earlier, voluntary action expresses the nature of a being qua rational animal. It is in that person-related sense that action proceeds `from within'; though, of course, there are also physically necessary conditions of human activity including internal physiological ones. The distinction to keep in view, however, is that

between agency and its causal preconditions. To revert to an earlier example, the latter stand to the former somewhat as canvas and paint stand to a portrait; and just as an interest in character looks to the depicted face of the sitter and not to the chemical bonding of the pigment, so an interest in action looks to the agent and not to his or her neurophysiology.

1996
Daniel Peterson, Ph.D.
Intelligent Design and Evolution
FARMS Review of Books

Evolving Developments
I want to draw attention to several other books, as well. They have not received reviews here, and very probably will not, but they have provided me some high-grade intellectual entertainment in recent months and I think others beside myself may well find them interesting.

The Foundation for Ancient Research and Mormon Studies does not have an official position on the question of organic evolution. We certainly do not have an officially negative position. Indeed, I fully know the opinion on the matter of only one member of the FARMS Board of Trustees, and he is a convinced evolutionist. This Review, moreover, has published only one article dealing with evolution, and that article proceeded from an avowedly pro-evolutionary stance.2

Evolution is not a question over which I myself have lost much sleep. I have, for years, been pretty much an agnostic on the subject. Nevertheless, since a more or less Darwinian evolutionary theory is important to virtually every form of modern naturalism or anti-supernaturalism, I have occasionally given a glance in its direction. "The entire scientific ethos and philosophy of modern western man," notes Michael Denton, is based to a large extent upon the central claim of Darwinian theory that humanity was not born by the creative intentions of a deity but by a completely mindless trial and error selection of random molecular patterns. The cultural importance of evolution theory is therefore immeasurable, forming as it does the centrepiece, the crowning achievement, of the naturalistic view of the world, the final triumph of the secular thesis which since the end of the middle ages has displaced the old naive cosmology of Genesis from the western mind. . . .[T]oday it is perhaps the Darwinian view of nature more than any other that is responsible for the agnostic and sceptical outlook of the twentieth century.3

There is a great deal, an inexpressibly great deal, resting on the question of whether this universe is a closed system of atoms and the void--a system in which all can be explained without residue as merely matter in ultimately pointless motion. Shakespeare's Macbeth, burdened with bloody sin and looking unrepentantly into the face of death, summed that view up eloquently:

Life's but a walking shadow, a poor player
That struts and frets his hour upon the stage
And then is heard no more: it is a tale
Told by an idiot, full of sound and fury,
Signifying nothing.4

I have been surprised, in recent years, to notice what I now suspect is a growing tendency among very good and reputable thinkers to question evolutionary dogma. I had naively assumed that, conservative Latter-day Saints and fundamentalist Protestants aside, all educated people--certainly all intellectuals--accepted evolution. I was immensely surprised, therefore, when, in talking with him repeatedly over the summer of 1990, I began to realize that Huston Smith, the eminent authority on world religions, is an outspoken critic of the theory of evolution. He is far from being a

Christian fundamentalist and, with his impeccable academic credentials (including years of teaching at the Massachusetts Institute of Technology), he is nothing at all like the backwoods bumpkin creationists that I had been led to imagine were the only folks who rejected Darwinism. Yet there he is.

Since that time, I have watched with mounting interest what I see as the emergence of an intellectual critique of evolution that has little if any link to Protestant fundamentalism or, indeed, directly to religion of any kind. It cannot be dismissed as a reprise of the infamous Scopes Monkey Trial. It features neither simplistic appeals to the authority of scripture nor sermonizing on the fact that my grandpappy wasn't a monkey. So far as I can see, it offers up no conveniently ignorant William Jennings Bryan to be fatally humiliated by a new Clarence Darrow.

Norman Macbeth's Darwin Retried was the first book I read on the subject, and I was intrigued by the logical case he constructed against Darwinian evolution.5 Michael Denton's Evolution: A Theory in Crisis argued, on the basis of a lengthy analysis ranging from molecular biology to paleontology, that "the problems [with evolutionary theory] are too severe and too intractable to offer any hope of resolution in terms of the orthodox Darwinian framework."6 Phillip Johnson, a prominent law professor at the University of California at Berkeley, subjected the theory of evolution to calm but withering criticism in his Darwin on Trial and followed it up with his important book Reason in the Balance.7 Within just the past few months, David Berlinski, a mathematician and philosopher who has taught in both the United States and France, has written a fascinating piece on "The Deniable Darwin" for Commentary.8 Finally, Michael Behe, who teaches biochemistry at Lehigh University in Pennsylvania, has just published a new book entitled Darwin's Black Box.9 In it, he contends that the astonishing complexity of the cell, which we have only begun to appreciate in recent decades, is impossible to explain on the basis of the gradualistic changes assumed by evolutionary theory. Rather, he says, the structure of the cell must have been purposefully devised by an intelligent designer--whether that designer be God or some other vastly intelligent and powerful being or beings.

What is the relevance of this? I am, as I have said, largely unconcerned with the truth or falsity of the theory of evolution. I think it possible, though not at all certain, that the central principles of the restored gospel can ultimately be reconciled with some modified form of evolution. But since faith in a blind evolutionary process is essential to the most common forms of naturalism, which are in turn among the chief enemies of belief in the gospel, I must admit that these recent writings have put me in exceptionally good spirits. I am pleased that some are beginning to recognize that evolution can itself be just as much a faith commitment and a world view as any religion, and can be just as dogmatically held, for reasons that are just as susceptible to psychological reduction, as a religion can be.10 "One might have expected," observes Michael Denton,

that a theory of such cardinal importance, a theory that literally changed the world, would have been something more than metaphysics, something more than a myth. Ultimately the Darwinian theory of evolution is no more nor less than the great cosmogenic myth of the twentieth century. Like the Genesis based cosmology which it replaced, and like the creation myths of ancient man, it satisfies the same deep psychological need for an all embracing explanation for the origin of the world which has motivated all the cosmogenic myth makers of the past, from the shamans of primitive peoples to the ideologues of the medieval church.11

I commend the books by Macbeth, Denton, Johnson, and Behe, and the article by Berlinski, to anybody interested in evolution, or in the broader question of whether good science commits us to a world view that excludes God. They make a powerful case for the proposition that rational people can be theists, believers in an intelligent and purposeful creator. This is a valuable contribution. After all, if one is convinced that a purposeful cosmos is an impossibility, there is little reason to

look at the particular claims of any specific religion. Such claims will have already been destroyed by the one universal solvent, blind evolution. For those who are inclined to think along such lines, perhaps overawed by the sheer weight of the scientific authority that seems to be arrayed against theistic belief, it is pleasant to know that the foundation of evolutionary theory, which itself lies at the foundation of modern naturalism, may not be wholly secure. Not a few serious and reasonable observers have concluded, with Michael Denton, that "after a century of intensive effort biologists have failed to validate it in any significant sense."12

While I am on the issue, permit me also to commend a book by Hugh Ross, an astrophysicist/cosmologist and former postdoctoral fellow at the California Institute of Technology, entitled The Creator and the Cosmos.13 Dr. Ross has established an organization in southern California called "Reasons to Believe," which specializes in often quite intriguing scientific apologetics for a conservative form of Christianity. Like Professor Behe, he argues for the presence of intelligent design in the universe.

Finally, I shall recommend with considerable enthusiasm a pair of books about the greatest miracle of them all, the resurrection of the Lord Jesus Christ: The volume Did Jesus Really Rise from the Dead? supplies the text of a debate between Antony Flew and Gary Habermas about the historicity of Christ's resurrection, accompanied by the postdebate comments of several prominent thinkers of various persuasions.14 Reading it, I was genuinely surprised to realize how strong the historical case for the resurrection is. (And, I must say, I was delighted to see a well-known and widely respected atheist philosopher get thoroughly thumped on this issue by a little-known professor of philosophy at a small Christian college.) Last, but certainly not least, I heartily endorse Stephen Davis's wonderful recent book, Risen Indeed.15 A philosophy professor in Claremont, California, Davis argues forcefully and rigorously for the plausibility of Christ's resurrection as a genuine event in nonmetaphorical history.

It need scarcely be said that, if Jesus is alive, naturalism is dead.

Notes

3 Michael Denton, Evolution: A Theory in Crisis (Bethesda, Md: Adler and Adler, 1985), 358-59.
4 Macbeth 5.5.24-28 (Rowse).
5 Norman Macbeth, Darwin Retired: An Appeal to Reason (Boston: Gambit, 1971).
6 Denton, Evolution, 16.
7 Phillip E. Johnson, Darwin on Trial (Washington, D.C.: Regnery Gateway, 1991); Phillip E. Johnson, Reason in the Balance: The Case against Naturalism in Science, Law, and Education (Downers Grove: InterVarsity Press, 1995).
8 David Berlinski, "The Deniable Darwin," Commentary 101/6 (June 1996): 19-29.
9 Michael J. Behe, Darwin's Black Box: The Biochemical Challenge to Evolution (New York: Free Press, 1996).
10 Many years ago, I read a little book by Robert T. Clark and James D. Bales, entitled Why Scientists Accept Evolution (Grand Rapids: Baker Book House, 1966). It is a very partisan polemic, but it does present some interesting evidence on a number of prominent early evolutionists, suggesting that their rejection of religion prepared the way for their acceptance of evolution, rather than the other way around.
11 Denton, Evolution, 358.
12 Ibid., 357.
13 Hugh Ross, The Creator and the Cosmos: How the Greatest Scientific Discoveries of the Century Reveal God, 2nd ed., expanded (Colorado Springs: NavPress, 1993).
14 Gary R. Habermas, Did Jesus Really Rise from the Dead? The Resurrection Debate (San Francisco: Harper and Row, 1987).

15 Stephen T. Davis, Risen Indeed: Making Sense of the Resurrection (Grand Rapids: Eerdmans, 1993). I might add here that I consider at least some of the vast literature on so-called "Near Death Experience" a significant and, thus far, unanswered challenge to the naturalistic world.

1998
Nature's Destiny - How the Laws of Biology Reveal Purpose in the Universe
Michael J. Denton
Book, The Free Press

Note to the Reader

> *Time out of mind it has been by the way of the "final cause," by the teleological concept of end, of purpose or of "design," in one of its many forms... that men have been chiefly wont to explain the phenomena of the living world: and it will be so while men have eyes to see and ears to hear withal. With Galen as with Aristotle, it was the physician's way; with John Ray as with Aristotle it was the naturalist's way, with Kant as with Aristotle it was the philosopher wry.... It is a common way, and a great way, for it brings with it a glimpse of a great vision, and it lira deep as the love of nature in the hearts of men.*
>
> *—D'! Arcy Wentworth Thompson, On Growth and Form, 1942*

The aim of this book is, first, to present the scientific evidence for believing that the cosmos is uniquely fit for life as it exists on earth and for organisms of design and biology very similar to our own species, Homo sapiens, and second, to argue that this "unique fitness" of the laws of nature for life is entirely consistent with the older teleological religious concept of the cosmos as a specially designed whole, with life and mankind as its primary goal and purpose.

Although this is obviously a book with many theological implications, my initial intention was not specifically to develop an argument for design; however, as I researched more deeply into the topic and as the manuscript went through successive drafts, it became increasingly dear that the laws of nature were fine-tuned for life on earth to a remarkable degree and that the emerging picture provided powerful and self-evident support for the traditional anthropocentric teleological view of the cosmos. Thus, by the time the final draft was finished, the book had become in effect an essay in natural theology in the spirit and tradition of William Paley's Natural Theology or the Bridgewater Treatises.

The basic thesis of the book, that the cosmos is uniquely fit for human existence, is of course not novel. For centuries before the birth of modern science, this thesis was one of the foundational axioms of medieval Christianity. More recently, it has begun to reemerge in various fields of science, most notably in physics and cosmology. Readers familiar with the views of physicists such as Freeman Dyson, Fred Hoyle, and Paul Davies will be aware that over the past few decades many physicists have pointed out that the existence of life in the cosmos is critically dependent on the laws and constants of physics having the precise values they do. The values are so critical that several well-known authors have argued that the cosmos gives every appearance of having been very finely adjusted or "prefabricated" for our existence.' As Paul Davies points out in his Accidental Universe: "If nature had opted for a slightly different set of numbers, the world would be a very different place. Probably we would not be here to see it." In his words: "The impression of design is overwhelming."2 Because of the perceived support for the traditional teleological worldview of the major religious traditions, the views of Davies and others have received wide publicity.

There is, however, a fundamental problem with any attempt to argue for the biocentricity or anthropocentricity of nature based on evidence drawn only from physics. While such evidence may be sufficient to argue that the cosmos is arranged for "complex chemistry" solar systems, or even intelligence, it is necessarily insufficient to argue that the cosmos is in some sense uniquely fit for the specific type of biological life as it exists on earth, that is, for organisms constructed out of carbon compounds based in water and utilizing DNA and proteins for self-replication. And it is completely incapable of providing any support for the notion that our own species, Homo sapiens, has any special place in the cosmos.

Davies is careful to distance himself from any claim that humanity is central in the cosmic scheme: "Where do human beings fit into this great cosmic scheme? Can we gaze out into the cosmos, as did our remote ancestors, and declare God made it all for us? I think not "3 And in his latest book he states explicitly that "I am not saying that we Homo sapiens are written into the laws of physics in a basic way."4 And continues: "We should not expect extraterrestrial life to resemble our own in its basic chemistry.... There is no need, for example, to demand liquid water or even carbon. We could anticipate exotic life forms, such as creatures that float in the dense atmosphere of Jupiter or swim in the liquid nitrogen seas of Titan."5

Contrary to Davies and others, I believe the evidence strongly suggests that the cosmos is uniquely fit for only one type of biology—that which exists on earth—and that the phenomenon of life cannot be instantiated in any other exotic chemistry or lass of material forms. Even more radically, I believe that there is a considerable amount of evidence for believing that the cosmos is uniquely fit for only one type of advanced intelligent life—beings of design and biology very similar to our own species, Homo sapiens. I do not agree with Davies when he claims, "The physical species Homo sapiens may count for nothing."6

To defend the postulate that the cosmos is specifically fit for biological life as it exists on earth necessarily involves consideration of a vast number of natural laws, phenomena, and processes which are quite outside of the areas of physics and cosmology and pertain uniquely to the biological realm, phenomena such as the thermal properties of water, the characteristics of the carbon atom, the solubility of carbon dioxide, the self-assembling properties of proteins, the nature of the cell, and so forth. Although from the evidence of physics we may be able to infer that the cosmos is uniquely fit for chemistry, stars and planets, or even intelligent beings, we cannot infer that it is specifically fit for large, air-breathing terrestrial mammals. Only through biology can our unique type of carbon-based life and especially advanced forms Eke ourselves lay claim to a central place in the cosmic scheme.

This book is divided into two major parts. In Part 1, evidence is presented that the laws of nature are uniquely fit for the being or existence of the type of carbon-based life that exists on earth. The chapters in this section deal with evidence drawn from many areas of the biological sciences, from molecular biology to mammalian physiology. The physical and chemical properties of the fundamental constituents of the cell, such as water, carbon dioxide, the bicarbonate buffer, oxygen, DNA, proteins, the transitional metals, the cell membrane, etc., are systematically reviewed to show that the existence of carbon- and water-based cellular life depends critically on a number of remarkable adaptations in the properties of many of life's basic constituents. What is particularly striking is that in almost every case, each constituent appears to be the only available or unique candidate for its particular biological role and, further, gives every appearance of being ideally fit not in one or two but in all its physical and chemical characteristics. Also reviewed is evidence drawn from other areas of science that attests to the fitness of the earth's hydrosphere, the fitness of the electromagnetic radiation of the sun, and the fitness of the periodic table for the carbon-based type of life as it exists on earth. As the book also shows, the existence of some higher forms of life, such as large warm-blooded, air-breathing terrestrial vertebrates, are critically

dependent on the properties of some of the basic constituents of life, such as water, carbon dioxide, and oxygen; in other words, not only are the laws of nature fit for the cell and for simple microbial fife, but also for advanced complex organisms very like ourselves.

The argument developed in Part 1, that the cosmos is uniquely fit for life's being, leads naturally to the second argument, developed in Pan 2, that the cosmos is fit also for the origin and evolutionary development of life—life's becoming. It is hard to escape the logic of this connection, for if the first argument is accepted, that the existence of the life forms on earth, both microscopic and macroscopic, depends on a remarkable set of mutual chemical and physical adaptations in the nature of things, the second argument, that the evolutionary development of this same set of life forms was also written into the cosmic script and directed from the beginning, is hard to refuse. Or, put another way: if the laws of nature are so finely tuned to facilitate life's being in the form of a unique set of carbon-based organisms, both simple and complex, on the surface of a terraqueous planet like the earth, then it seems conceivable that their becoming through the process of evolution might have been determined also by natural law.

At present, the evidence that the cosmos is uniquely fit for life's being is certainly far more convincing than the evidence that it is also fit for lifts becoming. Nonetheless, even though direct evidence for believing that life's becoming is "built in" is lacking, there are many features of the cosmos that make sense if the becoming of life is in some way programmed into the laws of nature. Facts such as the synthesis in stars throughout the cosmos, of carbon and the more complex atoms essential for life, by intricate processes; that interstellar space contains vast quantities of organic carbon compounds7 and some meteors such as the Murchison meteor contain considerable quantities of amino acids,' the building blocks of life; that planets like the earth which are probably capable of sustaining carbon-based life would appear to be very common if not almost ubiquitous throughout the cosmos 9—all these make eminent sense if life is a natural phenomenon programmed into nature from the beginning, and fated inevitably to arise and evolve on any suitable planetary environment.

The claim that the constituents of life are uniquely designed for the roles they serve cannot be defended convincingly without detailed discussion of the relevant scientific facts. This is true of any similar type of teleological argument. If we are to argue, for example, that the components of a watch are all specially designed to function together to tell the time, the argument can only be convincing if we have some understanding of the structure and workings of the watch. We have to open up the watch, to observe the mechanisms within, particularly the reciprocal fit of the various cogs to one another and have some comprehension of the way the mechanism works overall. And we need to understand clearly, as William Paley emphasized in his famous discourse on the watch, "that if the parts had been differently shaped from what they are," the watch could never function.10 The same is true in arguing that the constituents of the cosmos are uniquely fit for life. The argument only works if we have some knowledge of "the machinery of the cell" and some understanding of the many reciprocal adaptations in the nature of its constituents that make life possible. Consequently, the presentation of the argument in a book of this sort is quite challenging, because the nature of these mutual adaptations can only be fully appreciated by a relatively in-depth and detailed presentation of the relevant scientific facts.

However, despite the technical nature of many sections of the book, I believe that most areas covered can be easily grasped by anyone with a high-school knowledge of biology and chemistry. And even a committed reader with no scientific training should be able to grasp the essence of the argument in most of the chapters, even if this necessitates skipping some of the more highly technical sections. There are several chapters which require very little scientific background. And most chapters include at the beginning an introductory section requiring very little specialized knowledge, in which I have attempted to explain the main theme of the chapter.

I have also tried to organize the presentation of the evidence so that many of the chapters represent a fairly independent module which can be read and understood without reference to other chapters or arguments in other sections of the book. I hope this makes the book easier for a non-specialist to handle. Finally, as mentioned above, each chapter begins with an italicized precis that may allow nontechnical readers to skip ahead.

Further, as with any such argument because the argument is essentially accumulative, deriving its power from the sheer number of the adaptations observed, it is essential that as many as possible of these are presented and discussed. The conclusion is convincing primarily because so many independent arguments, each drawn from a great number of different areas of science, all appear to point in the same direction. This inevitably involves a degree of repetition that will be a problem for some readers. However, a degree of repetition is the very essence of the whole line of attack.

Because the validity of the argument depends on so many independent lines of evidence, the conclusion is not materially threatened because the whole picture is not yet complete or because this or that phenomenon such as the origin of life or the mechanism of evolution is not understood. Just as the meaning of a jigsaw puzzle may be obvious long before all the pieces are perfectly placed, so too my argument does not necessitate that everything be explained. Nevertheless, critics of the argument will have certain dear avenues of attack. They can argue (correctly) that I have been selective in my topics. The burden of disproof will, however, rest on them to show that an area I ignored somehow opens up the possibility of either non-earthlike life in the cosmos or a superior alternative to one of the constituents of life—for example, water, carbon dioxide, etc. Or they may argue that my position merely reflects a lack of imagination and that I have not discussed possible alternatives in depth. But again, the burden of proof will be on them to offer specific alternatives. I do not see how I can be accused of omitting discussion of alternative forms of life, based in silicon or liquid ammonia or within the field of nanotechnology, when no detailed blueprints for such hypothetical life forms have ever been developed.

Although there has been little debate or interest in the question of the fitness of the cosmos for life in mainstream biology since the Darwinian revolution, and indeed the idea has been very unfashionable in many circles in the English-speaking world, interest in the question has never been completely extinguished. Throughout the twentieth century, a number of first-rate biologists have kept the tradition alive. These have included Lawrence Henderson, professor of biological chemistry at Harvard University during the first quarter of the century and author of the great classic The Fitness of the Environment (1913);" D'Arcy Wentworth Thompson, author of an other great classic, On Growth and Form (1942);2 George Wald, professor of biology at Harvard in the fifties and sixties, discoverer of the role of vitamin A in vision, who was one of the leading authorities on the chemistry of photorecaption;13 A. E. Needham, Oxford zoologist and author of an excellent and comprehensive review, The Uniqueness of biological Materials (1965);1`' and Carl Pantin, professor of zoology at Cambridge during the sixties and author of the widely acclaimed The Relations Between the Sciences, published in 1968.15

My chapters on the properties of water, carbon, oxygen, and carbon dioxide borrow heavily from Henderson's Fitness and can be considered to a large degree an update of that great classic in the light of modern knowledge. Another major source cited in several chapters is Needham's The Uniqueness of Biological Materials.

One recent book that invites some comparison is Stuart Kauffman’s At Home in the Universe, in which he argues that much of the course of evolution has been determined and driven by self-organizing and emergent properties of complex systems.16 There is certainly more than a whiff of teleology about Kauffman's arguments, and his overall conclusion is consistent with my own when

he claims, for example: "We will have to see that we are all natural expressions of a deeper order. Ultimately, we will discover in our creation myth that we are expected after all."° And further: "We may be at home in the universe in ways we have hardly begun to comprehend."18

Another book that also invites comparison is Vital Dust by the biologist and Nobel laureate Christian de Duve. Dc Duve has also "opted in favour of a meaningful universe"19 and argues that the cosmos is fit for the origin and evolution of life and that the progress of evolution from simple to complex life forms was largely inevitable. However, de Duve's position falls a long way short of defending the traditional anthropocentric view of the cosmos. The unique fitness of the laws of nature for the biology of higher, air-breathing life forms such as ourselves is not discussed in any depth and nowhere does de Duve argue that the pattern of evolution was directed specifically toward the human race. Regarding mans place in the cosmos, de Duve concludes in his final chapter, "The human mind may be only a side link in an evolutionary saga far from completed."20 (My emphasis.)

Because this book presents a teleological interpretation of the cosmos which has obvious theological implications, it is important to emphasize at the outset that the argument presented here is entirely consistent with the basic naturalistic assumption of modern science—that the cosmos is a seamless unity which can be comprehended ultimately in its entirety by human reason and in which all phenomena, including life and evolution and the origin of man, are ultimately explicable in terms of natural processes. This is an assumption which is entirely opposed to that of the so-called "special creationist school." According to special creationism, living organisms are not natural forms, whose origin and design were built into the laws of nature from the beginning, but rather contingent forms analogous in essence to human artifacts, the result of a series of supernatural acts, involving God's direct intervention in the course of nature, each of which involved the suspension of natural law. Contrary to the creationist position, the whole argument presented here is critically dependent on the presumption of the unbroken continuity of the organic world—that is, on the reality of organic evolution and on the presumption that all living organisms on earth are natural forms in the profoundest sense of the word, no less natural than salt crystals, atoms, waterfalls, or galaxies.

In large measure, therefore, the teleological argument presented here and the special creationist worldview are mutually exclusive accounts of the world. In the last analysis, evidence for one is evidence against the other. Put simply, the more convincing is the evidence for believing that the world is prefabricated to the end of life, that the design is built into the laws of nature, the less credible becomes the special creationist worldview.

Ironically, both the Darwinian and the creationist worldviews are based on the same fundamental axiom—that life is an unnecessary and fundamentally contingent phenomenon. Where the creationist sees organisms as the artifacts of God the supreme engineer, the Divine watchmaker, Darwinists see them as the artifactual products of chance and selection. That both should view life as contingent is not so surprising considering that both doctrines developed in the early nineteenth century, the heyday of the machine age, when organisms were widely seen to be analogous in some way to machines. Clearly, if life's design is indeed embedded in the laws of nature and the major paths of evolution are largely determined from the beginning, then neither creationism nor Darwinism can possibly be valid models of nature.

My argument may be unpalatable for completely different reasons to certain liberal theologians. Academic theology in the twentieth century has largely abandoned traditional natural theology. Many have held the view "that theological propositions and scientific propositions somehow occupy different epistemological realms. Hence the neo-orthodox wall between religion and science."21 Some liberal theologians have recently explored the relationship between science and theology,22 showing how, in Arthur Peacock's words, "God creates in the world through what we call chance'

operating within the created order."23 Yet nowhere do they attempt to present a natural theology (they may even object to the term) along traditional lines. The aim of their work is to show how it is possible to believe in God while at the same time accepting the findings of science. It is not to argue that the fatty of science provide evidence that the laws of nature are uniquely prefabricated for life as it exists on earth, including complex forms such as our own species.

Another final point that perhaps should be clarified here at the outset is that I am using the term "anthropocentric" throughout the text in the generic sense. The cosmic "telos" I have in mind is advanced carbon-based humanlike or humanoid life. It is not specifically our own unique species Homo sapiens. At present, there is insufficient evidence to argue that the laws of nature are uniquely fit for every detail of human biology exactly as found in our own species today. However, I believe that the current evidence points strongly in this direction and that future scientific advances will confirm the absolute centrality of mankind in the cosmic scheme.

In the last analysis, the teleological perspective presented and defended here is good for science, because it renders scientific knowledge relevant to human existence. In the doctrine of final causation, science unites man and cosmos. The pursuit of scientific knowledge becomes no longer of merely practical value but also vital and central to the spiritual and intellectual life of man.

—Michael j Denton Dunedin, November 1996

Prologue
The ancient opinion that man was microcosmos, an abstract or model of the world, hath been fantastically strained by the alchemists, as if there were to be found in man's body remain correspondences and parallels which should have respect to all variety of things, as stars, planets, minerals, which are extant in the great world.
—Francis Bacon, The Advancement of Learning 1605

Living as we do in the late twentieth century, in a culture that has rejected the traditional teleological view of man as the center and purpose of the cosmos, which views our human existence as in essence a matter of profound contingency, it is fascinating to recall just how different was the medieval worldview in the late fifteenth century, shortly before the birth of modern science.

For both Christian and Islamic philosophers and theologians of the Middle Ages, the cosmos was a unique whole specially designed by God with man as its central focus and purpose. All facets of reality found their explanation in this central fact. Man was the inner microcosm. Every aspect of his being reflected the outer macrocosm, the universe in its entirety and all it contained.

For Christian scholars, the biblical revelation, and particularly the Incarnation, sanctioned the profoundly anthropocentric character of their medieval worldview. The extraordinary anthropocentricity of the culture of the Christian Middle Ages was wonderfully conveyed by Aaron Gurevich in his classic work Categories of Medieval Culture,

The effort to grasp the world as a single unified whole rum through all the medieval summae, the encyclopaedias and the etymologies.... The philosophers of the twelfth century speak of the necessity of studying nature; for in the cognition of nature in all her depths, man finds himself... underlying these arguments and images is a confident belief in the unity and beauty of the world, and also the conviction that the central place in the world which God has created belongs to man.

The unity of man with the universe is revealed in the harmony interpenetrating them. Both man and the world are governed by the cosmic music which expresses the harmony of the whole with its

parts and which permeates all from the heavenly spheres to man. Musica humana is in perfect concord with musica mundana. Everything that is measured by time is bound up with music. Music is subordinate to number. Therefore both macrocosm and manmade microcosm are ruled by numbers which define their structure and determine their motion.... It is in numbers that the secret of the beauty of the world lies; for the medieval mind the concepts "beauty," "orderliness," "harmony," "proportion," "comeliness," and "propriety" were very dose to each other if not identical.1

So intensely anthropocentric was their conception of nature that, as Gurevich points out:

> Each part of the human body corresponded to a part of the universe: the head to the skies, the breath to the air, the stomach to the sea, the feet to the earth; the bones corresponded to the rocks, the veins to the branches of the trees?
>
> The presumption that the entire cosmos was man-centered, that every facet of reality and all the laws of nature reflected this central reality, was the overriding axiom upon which the whole civilization of medieval Europe was built. Not even the slightest deviation from such an all-embracing man-centered teleology was compatible with the Christian revelation. For the Bible implied that the great drama of human history was central to the purpose of God in creation. The earth was the unique and divinely chosen stage for the drama, and God himself had taken on the form of a man to bear the sins of creation.
>
> Even after the medieval period, for many early modern thinkers such as Francis Bacon, whose scientific philosophy, with its emphasis on experiment, had an empirical tendency that was quite similar to that of modern science, mankind's teleological centrality in the natural order was presumed without question. The following section from Bacons De sapientia veterum illustrates Bacon's commitment to an intensely anthropocentric framework:
>
> Man ... may be regarded as the centre of the world ... if man were taken away from the world, the rest would seem to be all astray, without aim or purpose ... leading to nothing.... the whole world works together in the services of man.. . in so much that all things seem to be going about man's business and not their own?

The anthropocentric perspective was not, of course, restricted to the West. It was highly developed in the Islamic world in the ninth and tenth centuries. And Judaism, Hinduism, and Buddhism also view mankind as significant in the cosmic scheme. In ancient Indian thought, for example, the general ethos was "one of an integrated man-spirit-cosmos view, a wide and comprehensive view of nature in which the Homo sapiens, or man, the thinker, occupied a distinct place."4 According to the eleventh-century neoConfucianist philosopher Shao Yung, "Man is central in the universe, and the mind is central in man.... Man occupies the most honoured position in the scheme of things because he combines in him the principles of all species.... The nature of all things is complete in the human species."5

The idea is practically universal, being expressed in all human cultures, as John Barrow and Frank Tipler summarize:

> the idea that humanity is important to the cosmos and indeed the idea that the material world was created for man both seem to be present in many cultural traditions; they may even be universal ... a cursory search of the anthropologic literature shows teleological notions defended in Mayan, Zufii (New Mexican Indian) ... Sumerian, Bantu, ancient Egyptian, Islamic-Persian, and Chinese.'

It is remarkable to think that only five centuries separates the current skeptical ethos in the West from this profoundly teleological view of reality.

The anthropocentric vision of medieval Christianity is one of the most extraordinary—perhaps the most extraordinary—of all the presumptions of humankind. It is the ultimate theory and in a very real sense, the ultimate conceit No other theory or concept ever imagined by man can equal in boldness and audacity this great claim-that everything revolves around human existence—that all the starry heavens, that every species of fife, that every characteristic of reality exists for mankind and for mankind alone. It is simply the most daring idea ever proposed. But most remarkably, given its audacity, it is a claim which is very far from a discredited prescientific myth. In fact, no observation has ever laid the presumption to rest. And today, four centuries after the scientific revolution, the doctrine is again reemerging. In these last decades of the twentieth century, its credibility is being enhanced by discoveries in several branches of fundamental science.

Part I - LIFE

Chapter 1 - The Harmony of the Spheres

In which evidence from physics and cosmology suggesting that the laws of physics are fine-tuned for carbon-based life, is briefly summarized The fitness of the universe fir fife depends on a number of factors, including: the relative strength of the four fundamental forces (gravity, electromagnetism, and the strong and weak nuclear forces), the speed of expansion of the universe, the spacing and frequency of supernovae, the nuclear energy levels of certain atom, etc. If these were not precisely what they are, then carbon-based lift would certainly not exist. Many previous authors have covered this ground, but it bean repeating and is introductory to the theme of the book.

> It has been shown in the preceding chapters that a great number of qualities and laws appear to have been selected in the construction of the universe; and that by the adjustment to each other of the magnitudes and laws thus selected, the constitution of the world is what we find it, and is fitted for the support of vegetables and animals in a manner in which it could not have been, if the properties of the elements had been different from what they are.
>
> —William Whewell, Bridgewater Treatises, l833
>
> This now tells us how precise the Creator's aim most have been, namely to an accuracy of one part in IV'". Thus is an extraordinary figure. One could not possibly even write the number down in f41 in the ordinary denary notation: it would be I followed by 1O 0's. Even if we were to write a 0 on each separate proton and on each separate neutron in the entire universe—and we could throw in all the other particles for good measure—we should fall far short of writing down the figure needed.
> —Gager Penrose, The Emperors New Mind, 1989

On July 4 in the year 1054 A.D., Chinese astronomers observed a spectacular event in the sky. In the constellation of Taurus, the Bull, a brilliant new star suddenly appeared. So brilliant was this new star that it was easily visible in daylight and its light at night like that of the fill moon. Carl Sagan relates how on the other side of the world the ancestors of the Hopi Indians also recorded this remarkable event:

> Halfway around the world in the American Southwest, there was then a high culture, rich in astronomical tradition, that also witnessed this brilliant new star. From carbon 14 dating of the remains of a charcoal fire, we know that in the middle eleventh century ... the antecedents of the Hopi were living under an overhanging ledge in what is today New Mexico. One of them seems to have drawn on the cliff overhang, protected from the weather, a picture of a new star. Its position relative to the crescent moon would have been just as was depicted.1

What the Hopi Indians and the Chinese astronomers had observed was a supernova. Supernovae are among the most dramatic of all astronomical phenomena. An entire star self-destructs in a colossal explosion, scattering all its constituent matter and energy in a gigantic wave through adjacent regions of space.

As a result of advances in astronomy and physics over the past half century, we now know that the dying of stars in these immense self-destructive explosions is intimately related to our own existence as living organisms on earth. All the elements necessary for life—carbon (C), nitrogen (N), oxygen (0) and iron (Fe), etc.—are manufactured in the nuclear furnaces in the interiors of the stars. If these elements are to accumulate in rocky planets such as earth, they must be released from the stellar interiors and dispersed widely throughout the cosmos. The crucial release and dispersal of these key building blocks of life is one of the results of a supernova explosion. It is in the dying of scars that life has its birth.

Biocentric Fine-Tuning

Over the past three decades, facts such as these drawn from astrophysics and cosmology have led many physicists to argue that the cosmos appears to be finely tuned for life. The evidence and argument has been presented many times;2 consequently, I will not discuss it in great detail here. Nonetheless, it is the foundation upon which the argument from biology rests, so a brief review is in order.

Supernovae play another role which is critical to the existence of life. The shock waves they generate are probably important in initiating the condensation of interstellar gas and dust into planetary systems such as our own solar system. Those ancient stargazers in China and America would surely have been amazed to know that without such strange new stars, like that which so dramatically lit up the sky on that far-off July night, there would be no astronomers, no stargazers, no earth, perhaps no life of any sort.

The fateful connection between those ancient astronomers and the new star they had witnessed involves more than the mere fact that such explosions spill the atoms of life into the cosmos and set in motion the turbulence that causes the birth of planets. If that supernova had been closer to the earth, then it might have bathed the earth in a lethal radiation, obliterating life. If it had been very close, the earth might have been engulfed in a fireball and vaporized. The frequency and distribution of exploding stars are therefore also critical parameters. Supernovae are essential for life—without them none of the chemical building blocks of life will ever accumulate on the surface of a planet like earth—but they are also immensely destructive phenomena, eliminating all life on any nearby solar systems.

The distances between supernovae and indeed between all stars is critical for other reasons. The distance between stars in our galaxy is about 30 million miles. If this distance was much less, planetary orbits would be destabilized. If it was much more, then the debris thrown out by a supernova would be so diffusely distributed that planetary systems like our own would in all probability never form? If the cosmos is to be a home for life, then the flickering of the supernovae

most occur at a very precise rate and the average distance between them, and indeed between all stars, must be very close to the actual observed figure.

In addition, it turns out that the production of the key elements for carbon-based life not only requires the enormous energy levels within the interiors of stars but is also critically dependent on what appears to be another set of very precise conditions in the nuclear structure of certain atoms, more specifically, the nuclear energy levels of the atoms 8beryllium, 'carbon, and 16 oxygen. These energy levels affect the manufacture and abundance of carbon, oxygen, and other heavier elements essential for life. If they had been slightly different, no life-giving carbon or oxygen would have been manufactured.

That the manufacture of the key elements of life should depend on a set of such highly specific conditions is commented on by Paul Davies in his book The Accidental Universe.4 Fred Hoyle considers the carbon-oxygen synthesis coincidence so remarkable that it seems like a "put-up job." Regarding the delicate positioning of the nuclear resonances, he comments:

If you wanted to produce carbon and oxygen in roughly equal quantities by stellar nucleosynthesis, these are the two levels you would have to fix, and your fixing would have to be just about where these levels are actually found to be.... A commonsense interpretation of the facts suggests that a super intellect has monkeyed with physics, as well as chemistry and biology, and that there are no blind forces worth speaking about in nature .5

The picture that has emerged from modern physics and astronomy suggests that the formation of the chemical elements for life, and planetary systems capable of sustaining life and evolution over millions of years, are only possible if the overall structure of the universe and all the laws of nature are almost precisely as they are.

Physicists recognize four fundamental forces. These largely determine the way in which one bit of matter or radiation can interact with another. In effect, these four forces determine the main characteristics of the universe.6 They are the gravitational force, the electromagnetic force, the strong or nuclear force, and the weak force.

An extraordinary feature of these four fundamental forces is that their strength varies enormously over many orders of magnitude. In the table below they are given in international standard units:

The fact that the gravitational force is fantastically weaker than the strong nuclear force by an unimaginable thirty-eight orders of magnitude is critical to the whole cosmic scheme and particularly to the existence of stable stars and planetary systems.' If, for example, the gravitational force was a trillion times stronger, then the universe would be far smaller and its life history far shorter. An average star would have a mass a trillion times less than the sun and a life span of about one year—far too short a time for complex life to develop and flourish. On the other hand, if gravity had been less powerful, no stars or galaxies would ever have formed. As Hawking points out, the growth of the universe—so dose to the border of collapse and external expansion that man has not been able to measure it—has been at just the proper rate to allow galaxies and stars to form?

The other relationships and values are no less critical. If the strong force had been just slightly weaker, the only element that would be stable would be hydrogen. No other atoms could exist. If it had been slightly stronger in relation to electromagnetism, then an atomic nucleus consisting of only two protons would be a stable feature of the universe—which would mean there would be no hydrogen, and if any stars or galaxies evolved, they would be very different from the way they are.10

Clearly, if these various forces and constants did not have precisely the values they do, there would be no stars, no supernovae, no planets, no atoms, no life. As Paul Davies summarizes:

> The numerical values that nature has assigned to the fundamental constants, such as the charge on the electron, the mass of the proton, and the Newtonian gravitational constant, may be mysterious, but they are crucially relevant to the structure of the universe that we perceive. As more and more physical systems, from nuclei to galaxies, have become better understood, scientists have begun to realise that many characteristics of these systems are remarkably sensitive to the precise values of the fundamental constants. Had nature opted for a slightly different set of numbers, the world would be a very different place. Probably we would not be here to we it.
>
> More intriguing still, certain crucial structures, such as solar-type stars, depend for their characteristic features on wildly improbable numerical accidents that combine together fundamental constants from distinct branches of physics. And when one goes on to study cosmology—the overall structure and evolution of the universe—incredulity mounts. Recent discoveries about the primeval cosmos oblige us to accept that the expanding universe has been set up in its motion with a cooperation of astonishing precision."

In short, the laws of physics are supremely fit for life and the cosmos gives every appearance of having been specifically and optimally tailored to that end: to ensure the generation of stable stars and planetary systems, to ensure that these will be far enough apart to avoid gravitational interactions which would destabilize planetary orbits; to ensure that a nuclear furnace is generated in the interior of stars in which hydrogen will be converted into the heavier elements essential for life; to ensure that a proportion of stars will undergo supernovae explosions to release the key elements into interstellar space; to ensure that galaxies last several times longer than the lifetime of an average star, for only then will there be time for the atoms scattered by an earlier generation of supernovae within any one galaxy to be gathered into second-generation solar systems; to ensure that the distribution and frequency of supernovae will not be so frequent that planetary surfaces would be repeatedly bathed in lethal radiation but not so infrequent that there would be no heavier atoms manufactured and gathered onto the surface of newly formed planets; to ensure in the cosmos's vastness and in the trillions of its suns and their accompanying planetary systems a stage immense enough and a time long enough to make certain that the great evolutionary drama of life's becoming will inevitably be manifest sometime, somewhere on an earthlike planet.

And so we are led toward life and our own existence via a vast and ever-lengthening chain of apparently biocentric adaptations in the design of the cosmos in which each adaptation seems adjusted with almost infinite precision toward the goal of life.

That there is indeed a deep teleological connection between the Chinese stargazers and the new star which exploded into that July night in 1054 A.D. has now been established beyond any reasonable doubt. There is simply no tolerance possible in the design of the celestial machine. For us to be here, it must be precisely as it is.

The new picture that has emerged in twentieth-century astronomy presents a dramatic challenge to the presumption which has been prevalent within scientific circles during most of the past four centuries: that life is a peripheral and purely contingent phenomenon in the cosmic scheme. These advances in astronomy and physics have established what for Newton and generations of natural theologians was only an affirmation of belief: that there is indeed a deep and necessary connection between virtually every characteristic of the cosmic stage and the drama of life. It is ironic that those very features of the cosmos that were so troubling to the astronomers of the early

seventeenth century—its vast site and the apparently infinite number of stars stretched out across its immensity—which inclined Kepler to wonder, "How can all things be for man's sake?"12 and which seemed to render the earth an irrelevant mote of dust in the cosmic scheme, have turned out to be absolutely critical and essential for our existence.

The evidence provided by modern cosmology and physics is exactly the kind of evidence that the natural theologians were looking for in the seventeenth century but failed to find in the science of their day. This can be seen in this short passage from Richard Bentley's famous "A Confutation of Atheism from the Origin and Frame of the World," published in 1692. It was prepared under the guidance of Newton and may well represent a position dose to Newton's own.

Let us now turn our thoughts and imagination to the frame of our system, if there we may trace any visible foot steps of the Divine Wisdom and Beneficence.... What we have always seen to be done in one constant and uniform manner; we are apt to imagine there was but that one way of doing it, and that it could not be otherwise. This is a great error and impediment in a disquisition of this nature: to remedy which, we ought to consider every thing as not yet in Being; and then diligently examine if it must needs have been at all or what other ways it might have been as possibly as the present; and if we find a greater Good and Utility in the present constitution, than would have accrued either from the total Privation of It, or from other frames and structures that as possibly have been as It: we may then reasonably conclude, that the present constitution proceeded neither from the necessity of material Causer nor the blind shuffles of an imaginary Chance, but from an Intelligent and Good Being, that formed it that particular way out of choice and design. And especially if this Usefulness be conspicuous not in one of a few only; but in a long train and series of things, this will give us a firm and infallible assurance, that we have not passed a wrong judgement.13 [My emphasis.]

If the existence of life had been compatible with a greater range of values for the fundamental constants, or, in other words, if the design of the celestial machine could have been different at least to some degree and yet still have sustained life, then the teleological conclusion would be far weaker. It is the necessity that it be exactly as it is—adjusted to what is in effect near infinite precision in a long train and series of things that makes the teleological conclusion so compelling.

As Davies comments in the last paragraph of The Court< Blueprint, "The impression of Design is overwhelming."14 And Paul Davies is not alone.

Chapter 2 - The Vital Fluid

In which it is argued that water gives every appearance of being uniquely fit for the type of carbon-based lift that exists on earth. Every one of its chemical and physical properties seems maximally fit not only for microscopic life but afro for large warm-blooded organisms such as mammals, as well as for the generation and maintenance of a stable chemical and physical environment on the surface of the earth. Some of the properties of water reviewed include its thermal properties. its surface tension, its capacity to dissolve a vast number of different substances, and its low viscosity which allows small molecules to enter and leave cells by diffusion and which also makes possible a circulatory system. If the properties water were not almost precisely what they are carbon-based lift would in all probability be impossible. Even the viscosity of ice a fit. If it were any greater, then all the water on earth might be trapped in vast immobile ice sheets at the poles. If the thermal properties of water were even slightly different, the maintenance of stable body temperatures in warm-blooded organisms would be problematical No other fluid comes close to water as the ideal medium for carbon- based life. Indeed, the properties water in themselves provide perhaps as much

evidence as physics and cosmology in support of the proposition that the laws of nature are specifically arranged for carbon-based fife.

For is not the whole substance of all vegetables mere modified water? and consequently of all animals too; all of which either feed upon Vegetables or prey upon one another? is not an immense quantity of it continually exhaled by the Sun, to fill the atmosphere with Vapours and Clouds, and feed the Plants of the Earth with the balm of Dews .... It seems incredible at first hearing, that all the Blood in our Bodies should circulate in a trice, in a very few minutes: but I believe it would be more surprising, if we knew the short and swift periods of the great Circulation of Water, that vital Blood of the Barth which composeth and nourisheth all things.
—Richard Bentley, A Confutation of Atheism from the Origin and Frame of the World," 1692

Although water is one of the most familiar of all substances, its remarkable nature never fails to impress. As a liquid, it accumulates on the earth's stir-face in bodies varying in size from the great oceans to small lakes to tiny puddles. In motion it may swirl violently down a great cataract, or flow serenely as a mature river meandering across a plain. On the surface of large bodies of water, the wind pushes up waves both great and small. Tiny droplets of the substance form the matrix of the clouds. Slightly larger drops fall through the atmosphere from the clouds to the ground as rain. As a solid, it falls as snow blanketing the earth in white, it forms the great ice sheets of the polar regions and the valley glaciers in the mountains, and it forms the frosted pattern on a windowpane in winter. In the higher latitudes water forms the entire scenery of the earth, the ice caps at the fringes of the polar continents, the icebergs floating in the restless gray and ice-cold sea, the spray carried from wave tops by the wind and frozen instantly into tiny pellets of ice in the subzero temperature and splattered like shrapnel onto the nearby ice shelves. Even the sounds associated with water are no less diverse: there is the rhythmic pounding of the surf, the deafening roar of a great waterfall, the babbling of a mountain brook, the gentle patter of summer rain, the latter of hail against an iron roof, the grinding booms and sharp reports of an advancing glacier, and the thunder of an avalanche.

These diverse manifestations of water are remarkable indeed. But as we shall see, they are not nearly as extraordinary or amazing as the various ways in which water is so ideally and uniquely adapted to serve its biological role as the medium or matrix for life on earth.

Water has long been seen to have some special significance. That it is essential to life has been evident since the earliest of times, and many cultures have invested it with magical life-giving qualities. It is fitting that Thales, the first of the Greek philosophers, should have based his science on the assertion that water is the origin of all things, and that Bentley should describe it as "the vital blood of the Earth."'

Water forms the fluid matrix in which occur all the vital chemical and physical activities upon which life on earth depends. Without water, life that exists on earth would be impossible. If the vital activities of the cell are the movements of pieces on a chess board, then water would be the board. Chess is impossible without the board; life is impossible without water. Water also forms most of the bulk of most living things. Most organisms are made up of more than 50 percent water; in the case of man, water makes up more than 70 percent of the weight of the body.

The Necessity of Liquid
That life is based in a liquid medium is certainly no accident. For it is difficult to imagine how any sort of complex chemical system capable of assembling and replicating itself, of manipulating its atomic and molecular components and drawing its vital nutrients and constituents from its envi-

ronment—that is, anything that displays the characteristics we attribute to life--could exist except in a liquid medium.

As A. E. Needham points out in The Uniqueness of Biological Materials, the other two states of matter, the solid and the gaseous, would seem to be excluded on fundamental grounds. In the case of both a crystalline solid, where the atoms are held in regular crystalline arrays and a glassy solid, where the atoms are irregularly packed, the atoms are in rigid contact with one another and there is very little scope for the occurrence of the dynamic molecular processes associated with life to occur. In gases, on the other hand, the constituent atoms are freely mobile, and consequently gases are far too volatile and labile to be considered seriously as candidates for the chemical matrix of life.' We are all familiar with clouds which are nebulous masses of tiny liquid droplets—or in more scientific terms, "segregations of liquid-in-gas colloids." Clouds are a rare exception to the rule that segregating subsystems are unusual in a gas. However, the very transience of cloud patterns graphically illustrates the unsuitability of gas as a medium for the support of stable, segregating subsystems.

If the laws of physics sanctioned matter to exist in our universe only in the solid or gaseous state and outlawed liquids, then life, defined above as a complex chemical system capable of assembling and replicating itself, of manipulating its components and drawing its vital nutrients and constituents from its environment, would almost certainly not exist. Interestingly, John von Neumann, one of the fathers of the computer, in his Theory of Self-Reproducing Automata, envisaged his mechanical replicators floating on an infinite lake, the surface of which was covered with all the basic constituents they required to construct themselves. In other words, the medium in which the replicators "lived" was a fluid.3

Because the full impact of the argument for the fitness of water is accumulative and depends on a relatively exhaustive consideration of all the individual adaptations which seem to fit water so ideally for its biological role, it is important that no adaptation is omitted, even if it is very well known, so that all the evidence is laid out as comprehensively as possible and in some detail.

Water's Unique Thermal Properties

Curiously, even as recently as the late eighteenth century, shortly after Antoine Lavoisier had first determined the chemical structure of water and shown that it was made up of two hydrogen atoms combined with one oxygen atom, its chemical and physical properties were insufficiently understood to argue that it was specially adapted for life. Just how little was known of the properties of water around 1800 is obvious from this section in Paley's Evidences, where he concedes that "when we come to the elements. we come to those things of the organisation of which, if they be organised, we are confessedly ignorant," and continues by quoting an earlier writer as observing "that we know water sufficiently to boil, ... to freeze, ... to evaporate... without knowing what water is." And as Paley notes, even after Lavoisier's discovery, "The constituent parts of water appear in some measure to have been lately discovered, yet it does not, L think, appear, that we can make any better use of water since the discovery than we did before it."4

The first significant consideration of water's fitness came only thirty years after the publication of Paley's Evidences when William Whewell, master of Trinity College, Cambridge, examined the topic in his Bridgewater Treatise entitled Astronomy and General Physics Considered with Reference to Natural Theology published in 1832.5 During those thirty years scientific knowledge had rapidly increased and Whewell was able to present the first systematic argument for the fitness of water.

Although Whewell's discussion of the properties of water is somewhat vague and nonquantitative from a modern perspective, and although he restricts his discussion to the thermal properties of

water and their apparent adaptation to climatic amelioration, it nevertheless represents the first significant systematic consideration of the unique fitness of water and represents an enormous advance on Paley's Evidences. Beginning with its thermal properties, he points out:

> Water expands by heat and contracts by cold [but if this contraction were continued all the way to the freezing point] ... the lower parts of water would have been first frozen and being once frozen hardly any heat applied at the surface could have melted them.... This is so far the case that in a vessel containing ice at the bottom and water at the top, Rumford made the upper fluid bog without thawing the congealed cake below.
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> Now a law of water with respect to heat operating in this manner would have been very inconvenient if it had prevailed in our lakes and seas.... They would all have had a bed of ice, increasing with every occasion, till the whole was frozen. We would have no bodies of water, except such pools on the surfaces of these icy reservoirs as the summer sun could thaw to be again frozen to the bottom with the first frosty night. How is this inconvenience obviated?
>
> [This situation] is obviated by a modification of the law which takes place when the temperature approaches this limit. Water contracts by the increase of cold till we come near the freezing temperature; but then ... expands till the point at which it becomes ice. Hence the water [at 4°C] will lie at the bottom with cooler water ... above it.... In approaching the freezing point the coldest water will rise to the surface where congealment will rake place. [But this is only part of the story] ... Another peculiarity in the laws which regulate the action of cold on water is, that in the very act of freezing sudden and considerable expansion takes place.... [Consequently, ice flows.]6

Thus, because of these two anomalous properties, water is not bound up in vast beds of submarine ice. We now know that these two properties of water are practically unique, a fact not known in 1832, as Whewell admits: "We do not know how far these laws of expansion are connected with or depend on, more remote and general properties of this fluid or of all fluids." Note that what we have here are two different characteristics of water, both of which are mutually adapted toward the end of preserving bodies of liquid water on a planetary surface.

One of Whewell's most interesting insights comes in a passage in which he points out that some of the thermal properties which endow water with its peculiar fitness, such as the decrease in the density of water below 4'C, and the fact that the density of ice is less than that of water, seem to be due to an apparently contrived violation of what would appear to be a natural law:

This gradual progress of freezing and thawing, of evaporation and condensing is produced, so far as we can discover, by a particular contrivance. Like the freezing of water from the top, or the floating of ice, the moderation of the rare of these changes seems to be the result of a violation of a law: that is, the simple rule regarding the effects of change of temperature which at first sight appears to be the law and which from its simplicity would seem to us the most obvious law for these as well as for other cases is modified at certain critical points so as to produce these advantageous effects .8

In recapitulating his argument, Whewell concludes that the various thermal properties of water, including the anomalous expansion below 4°C and its expansion on freezing, which together contribute to its remarkable fitness for the preservation of water in the liquid state, appear to be mutually independent properties. Moreover, he continues, as far as we can tell, these properties could have been different. And in a key section of his treatise, he concludes that where we see a number of natural phenomena, all of which might have been different and which also seem to be

providentially arranged for the `welfare of things," this is very suggestive of design. In his own words from this classic of natural theology, he lays down the basic logic of his argument:

> All natural philosophers will, probably, agree, that there most be.. . a great number of things entirely without any mutual dependence.... laws are unlike one another.. . steam.. . expands at a different rate to air.. water expands in freezing, but mercury contracts.. heat travels in a manner quite different through solids and fluids. We have ... fifty substances in the world; each of which is invested with properties ... altogether different from those of any other substance.
>
> There are, therefore, it appears, a number of things which might have been otherwise ... substances, which might have existed any how exist exactly in such a manner ... as they should to secure the welfare of other things ... that the laws are tempered and fitted together in the only way in which the world could have gone on.9

Following Whewell, by far the most important discussion of the unique fitness of water and still the most significant to date was that of Lawrence Henderson, then professor of biological chemistry at Harvard University, in his great classic The Fitness of the Environment published in 1913.10 Henderson is remembered by every student of biochemistry and medicine as the Henderson of the Henderson-Hasselbach equation. The Fitness of the Environment most rate as one of the most important and influential books in the biological sciences in the first decades of the century. This is acknowledged by Joseph Needham in his Sceptical Biologist, published in 1929. It made, according to Needham, `unquestionably, the most important contribution to the philosophy of biology"" in the first quarter of the century, and this view was recently seconded by Harold Morowitz, professor of biophysics at Yale, in his Cosmic joy and Local Pain of 1987.12

The Fitness of the Environment differs from Whewell's Astronomy and General Physics in two important respects. It is quantitative and comparative. Moreover, the chain of adaptations enumerated by Henderson is greater, and because something of the chemical nature of life was understood by 1900, Henderson is able to show water to be ideally fit, not only for the maintenance of global climatic stability but also to function as the matrix of living matter.

The Fitness of the Environment deals with the peculiar fitness not only of water but with other important chemical components of living things, including carbon dioxide, carbonic acid, and carbon compounds in general. The book was published in 1913. Since then and particularly over the past forty years, a vast amount of new knowledge of chemistry and molecular biology has accumulated, but this has not only entirely confirmed Henderson's position but extended it to a degree that would have seemed unimaginable in 1913.

Henderson's aim was not to present an argument for design (although his arguments could be used for that purpose) but merely to argue for an undeniable yet mysterious biocentricity in the order of things and to establish that the key components of life, including water, carbon dioxide, and bicarbonate, exhibit together a unique mutual fitness which could hardly exist in any other equivalent set of chemicals. To show, in other words, that in fundamental characteristics the environment [that is, the various chemicals and physicochemical processes which constitute living things and the chemical and physical character of the hydrosphere] is the fittest possible abode for life.

He continues by admitting that

> This is not a novel hypothesis. In rudimentary form it has already a long history behind it, and it was a familiar doctrine in the early nineteenth century. It presents itself anew as a result of the science of physical chemistry.13

In presenting his argument for the unique fitness of water, Henderson alludes to the following thermal properties:

1. The anomalous facts (already referred to above) that water contracts as it cools until just before freezing, after which it expands until it becomes ice, and that it expands on freezing. These properties are practically unique.

2. When ice melts or water evaporates, heat is absorbed from the environment. Heat is released when the reverse happens. This is the phenomenon known as latent heat. The latent heat of freezing of water is again one of the highest of all known fluids. In the ambient temperature range only ammonia has a higher latent heat of freezing. Waters latent heat of evaporation is the highest of any known fluid in the ambient temperature range.14

3. That the thermal capacity or specific heat of water, which is the amount of heat required to raise the temperature of water one degree centigrade, is higher than most other liquids.

4. That the thermal conductivity of water, which is its capacity to conduct heat, is four times greater than any other common liquid.15 That the thermal conductivities of ice and snow are low.

If it were not for the properties given in point 1, most of the water on earth would be permanently frozen into vast beds of ice at the bottom of the oceans. Lakes would freeze completely from the bottom up each winter in the higher latitudes. Without those properties in point 2, the climate would be subject to far more rapid temperature changes. Small lakes and rivers would vanish and reappear constantly. Without 3, the difference between winter and summer would be more extreme and weather patterns would be less stable,16 and the great ocean currents such as the Gulf Stream, which currently transfer vast quantities of heat from the tropics to the poles, would be far less capable of moderating the temperature differences between high and low latitudes. Without 2, again, warm-blooded animals would have a far harder time ridding their bodies of heat. Henderson was particularly struck by the adaptive significance of the cooling effect of the latent heat of evaporation in the case of warm-blooded animals. Because, as Henderson points out, `in an animal like man ... heat is a most prominent excretory product, which has to be constantly eliminated in great amounts, and to this end only three important means are available—conduction, radiation, and evaporation."° But at body temperature, as Henderson continues, `very little heat can be lost by conduction or radiation and evaporative cooling is therefore the only significant means of temperature reduction." And he concludes: "To sum up, this property appears to possess a threefold importance. First, it operates powerfully to equalise and to moderate the temperature of the earth; secondly, it makes possible very effective regulation of the temperature of the living organism; and thirdly it favours the meteorological cycle. All of these effects are true maxima, for no other substance can in this respect compare with water. Conversely, as the temperature falls, condensation occurs and this releases heat which tends to counteract the rate of temperature fall. Moreover, as Henderson points out, there is another aspect of the fitness of the latent heat of evaporation—the fact that as the temperature rises so does the rate of evaporation and so consequently does the cooling effect of evaporation. So the cooling effect of evaporation increases when the usefulness of the property is most needed Without 4, it would be harder for cells which cannot use convection currents to distribute heat evenly throughout the cell.19 Without 5, the protective insulation of snow and ice, essential to the survival of many forms of fife in the higher latitudes, would be lost. Also, water would cool more rapidly and small lakes would be more likely to freeze completely.

And so, as Henderson argues, it turns out that not one or two, not most, but all the thermal properties of water are mutually adaptive not only for the maintenance of thermal stability on a planetary scale but also for the buffering of individual macroscopic life forms against sudden temperature changes. Even the low conductivity of ice is adaptive, protecting life from frost and the water below the ice from excessive cooling. Amazement mounts at the wonderful elegance and parsimony in the way the various thermal adaptations of water conspire together to achieve so many different life-sustaining ends. For example, the preservation of large bodies of liquid water on the earth's surface is ensured almost entirely by the thermal properties of water itself and of its solid form, ice. This is a particularly critical suit of adaptations because liquid water is essential to all life on earth, not only because water is the matrix in which life's chemistry occurs, but also because without bodies of liquid water no aquatic life would be possible and the evolution of complex life forms would almost certainly have been impossible. Further, the preservation of large bodies of liquid water in the oceans ensures temperature stability worldwide, which in itself ensures climatic stability on which the existence of large complex life forms depend. Moreover, complex macroscopic life forms astonishingly utilize these same thermal properties to buffer themselves against thermal change, which is the inevitable outcome of their metabolic processes. And so via a series of deeply interconnected and wondrously teleological thermal adaptive properties, water bestows its vital magic on earth and its living inhabitants.

The parsimony and elegance in this design is self-evident. As far as its thermal properties are concerned, water would appear to be uniquely, and in many different ways ideally, adapted for life on earth. In thermal terms, water is the unique and ideal candidate for its biological role.

Surface Tension

Of course, the thermal properties of water are by no means the only physical characteristics which make this remarkable fluid so supremely fit for its biological role. Yet another is its very high surface tension. This has many biological implications 30 It is the high surface tension of water which draws water up through the soil within reach of the roots of plants and assists its rise from the roots to branches in tall trees. Large terrestrial plants would probably be a physiological impossibility if the surface tension of water was similar to that of most liquids. Recently, A. E. Needham commented on the utility of the high surface tension of water:

Water has a uniquely high surface tension exceeded by few substances other than liquid selenium and this at a very much higher temperature. Water, therefore, is ideal for the formation of discrete living bodies, with stable limiting membranes. Air-water interfaces are less important, perhaps, than those between water and lipids, which likewise have high values. Other biologically useful consequences of the high tension are that materials which can lower the tension, surface active materials, tend to accumulate at the surface, and also to orientate there. Most of the biologically important carbon compounds have this property, which promotes their aggregation and concentration, as well as the formation of organised membranes.21

Remarkably, the very high surface tension, because it tends to draw water into the narrow cracks and fissures in the rocks, assists in the process of weathering and washing chemicals from the rocks. Also, when it freezes, the rocks are fragmented, which in turn also assists the weathering process and the formation of soils. 22 Here is another instance where a physical property of water is adapted for a role in fashioning the planetary environment for life while at the same time being adapted for a number of specific biological functions.

The Alcahest

All the various physical properties of water which endow it with such a remarkable biological fitness would of course be of no utility if its chemical properties were not similarly fit. Water could

have no biological role if it was not a good solvent. The capacity to dissolve a great number of different chemical substances is presumably a criterion that must be satisfied by any Fluid if it is to function as a matrix for any kind of chemical "life" remotely similar to our own.

Lt turns out that, as a solvent, water is indeed ideally fit, so much so that water approaches far nearer than any other liquid to the alcahest, the universal mythical solvent of the alchemists.23 This is a property of critical importance to water's biological role. Felix Franks recently commented on the solvent action of water:

> Other remarkable properties include the almost universal solvent action of liquid water, making its rigorous purification extremely difficult. Nearly all known chemicals dissolve in water to a slight, but detectable extent 24

Water's power as a universal solvent is also geologically significant, as the distribution of vital minerals through the hydrosphere would be far less equitable if its solvation powers were less marked.25

The solvation power of water and the distribution of diverse chemical species in large amounts throughout the hydrosphere is illustrated by the vast amount of dissolved materials carried to the sea by all the rivers of the earth in one year. This quantity has been estimated to be some 5 billion tons. Henderson lists thirty-three different elements which can be found in the sea, and probably many more are present in trace amounts. To illustrate the utility of its solvation power in biological systems, he cites over fifty different compounds which are found dissolved in human urine. m Today one could cite many hundreds.

As one might expect from such a universal solvent, water is also a surprisingly reactive chemical. It catalyzes almost all known reactions." But although quite reactive, water is far less reactive than many other liquids. Many well-known acids and alkalines are far more chemically reactive, and will dissolve substances almost insoluble in water in a matter of seconds. Yet these liquids react with the chemicals dissolved in them, exhausting themselves and consuming the solutes.28

Water could not fulfill its biological role if it was a highly reactive fluid, like sulfuric acid, or if it was an entirely unreactive fluid like liquid argon. Lt seems that, like its other properties, the reactivity of water is ideally fit for both its biological and its geological role.

We should note in passing that in his discussion of water Henderson omits two characteristics of water which might have been construed at the time as "defects" in its fitness for life. First, many compounds containing long hydrocarbon chains such as the lipids are virtually insoluble in it. Second, many synthetic reactions in organic chemistry can only be carried out in the absence of water. We now know, as we shall see in the following chapters, that the first of these two apparent defects, the insolubility of hydrocarbons, plays a vital role in the design of the cell system, while the other defect is circumvented by carrying out many of these synthetic reactions in special water-excluding reaction chambers in the center of proteins.

Viscosity and Diffusion

One physical property of water that was not discussed in Henderson's Fitness is its viscosity. The viscosity of liquids varies considerably. The viscosity of tar, glycerol, olive oil, and sulfuric acid are respectively, 10 billion times, one thousand times, about one hundred times, and twenty-five times that of water. Compared with many liquids, water has a low viscosity. Although the viscosity of water is dose to the minimum known for any fluid, a few other liquids have viscosities less than water. The viscosity of ether is four times less, liquid hydrogen a hundred times less. However, as a rule, only gases have viscosities markedly less than water.29

The fitness of water would in all probability be less if its viscosity were much lower. The structures of living systems would be subject to Far more violent movements under shearing forces if the viscosity were as low as liquid hydrogen. Shearing forces are set up in a structure when a force applied to it tends to distort its shape. A structure composed of pitch, which has a high viscosity, will tend to resist such shearing forces far more effectively than a structure composed of treacle.

If the viscosity of water was much lower, delicate structures would be easily disrupted by shearing forces and water would be incapable of supporting any permanent intricate microscopic structures. The delicate molecular architecture of the cell would probably not survive.

On the other hand, if the viscosity was much higher than it is, no fish or anything we would call a fish would be possible. One can well imagine the difficulty of attempting to sail or swim through treacle! Nor would any microorganism or cell be able to move. Lf the viscosity of water was higher, the controlled movement of large macromolecules and particularly structures such as mitochondria and small organelles would be impossible, as would processes like cell division. All the vital activities of the cell would be effectively frozen, and cellular life of any sort remotely resembling that with which we are familiar would be impossible. The development of higher organisms, which is critically dependent on the ability of cells to move and crawl around during embryogenesis, would certainly be impossible if the viscosity of water was even slightly greater than it is.

Viscosity also has a very important influence on the vital process of diffusion, and this has enormous bearing on the existence of our type of cellular life. Lt is difficult to see how else but by diffusion the necessary flow of matter into and out of any conceivable chemical self-replicating system based in a fluid medium could be maintained.

Diffusion rates in water are very rapid over short distances. Oxygen, for example, will diffuse across the average body cell in approximately one-hundredth of a second.30 The very great rapidity of diffusion of small molecules in water over short distances explains why small microorganisms, bacteria and protozoa, and even very small multicellular organisms are able to obtain their nutrients and get rid of their waste products simply by diffusion, without the need for a circulatory system.

The rate of diffusion of a molecule in a fluid varies inversely with its viscosity; Lf the viscosity goes up, the rate of diffusion goes down. If the viscosity of water had been, say, ten times greater and diffusion rates ten times less, it would be far more difficult for organisms to derive their vital nutrients by diffusion to sustain their metabolic activities. This is because the volume of a sphere is the cube of its diameter; consequently, to maintain the same level of metabolic activity, cells would have to be a thousand times smaller. In which case only the very simplest of microbial cells would be possible. If diffusion rates were a hundred times less, cells would have to be a million times smaller to maintain their metabolic activities—a volume equivalent to a sphere containing a few protein molecules.

The low viscosity of water is fit in another way because in a liquid of low viscosity the rate of diffusion of different molecules does not vary greatly from molecule to molecules1 Measurement of the actual diffusion rates of a variety of compounds in water shows that the diffusion rate varies inversely as the cube root of the molecular weight. This is a fascinating and important law, which is probably of critical significance. As Herbert Stern and D. L. Nanny explain in their Biology of Cells, "it means that the rate of diffusion is much the same for most molecules."32 Even in the case of a molecule like a protein, of molecular weight a thousand times that of glucose, its rate of diffusion is only ten times slower. As the range of molecular weights of the great majority of key metabolites

used by the cell, such as the sugars and amino acids, is no more than tenfold, the resultant variation in diffusion rates is very small.

To serve its biological role, diffusion most not be only very rapid over short distances, but its rate must be approximately the same for most of the key metabolites used by the cell. Both these criteria are satisfied by the diffusion of small metabolites in water.

The diffusion of molecules in any fluid, whatever its viscosity, including water, has an important characteristic in that it is very rapid over short distances but very slow if there is far to go. In fact, the diffusion time increases with the square of the diffusion distance. Thus, if the diffusion distance is increased ten times, the time taken will be increased a hundred times. The physiologist Knut Schmidt-Nielsen calculated that in the case of oxygen diffusing into the tissues, it will attain an average diffusion distance of 1 micron (one-thousandth of a millimeter) in one ten-thousandth of a second, 10 microns in one-hundredth of a second, 100 microns in one second, 1 millimeter in one hundred seconds, 10 millimeters in three hours, and I meter in three years.33

Viscosity and the Circulatory System

Because of the increasing inefficiency of diffusion as a transport mechanism over distances greater than a fraction of a millimeter, no highly active organism more than a few millimeters thick can acquire and dispose of its metabolites by diffusion. Hence, to be viable all large organisms most have some additional means of acquiring and disposing of metabolites. In practice, this means some sort of circulatory or perfusion system.34 In mammals billions of tiny capillaries permeate all the tissues of the body, transporting the necessary nutrients, including oxygen and glucose, to within diffusional reach of all cells where metabolic activities are occurring. Because diffusion is so ineffective over large distances, no active cell can survive in a mammal on-less it is within about 50 microns from a capillary. In the active muscles of a guinea pig, there may be 3,000 open capillaries per square millimeter of muscle. This is a great number, occupying approximately 15 percent of the volume of the muscle, equivalent to 10,000 tiny parallel tubes running down a pencil lead.

However, a capillary system will work only if the fluid being pumped through its constituent tubes has a very low viscosity. A low viscosity is essential because flow is inversely proportional to the viscosity. A twofold increase in viscosity causes the flow to halve. From this it is easy to see that if the viscosity of water had a value only a few times greater than it is, pumping blood through a capillary bed would require enormous pressure and almost any sort of circulatory system would be unworkable. One can readily appreciate the problem by trying to envisage pumping treacle through a narrow glass tube.

But there is a further, very striking relationship between the diameter of the rubes and the resistance to flow, one which imposes enormous design constraints on any son of circulatory system. The resistance to flow is inversely proportional to the fourth power of the diameter of the tube. Which means that halving the diameter of a tube causes a sixteenfold increase in resistance to the flow of fluid through the tube.

Very little decrease in the size of capillaries could be achieved even if the viscosity of water was an order of magnitude lower. To achieve the same rate of blood flow through a capillary half the size of those which exist in the mammalian body with the same blood pressure would require either a lowering of viscosity of sixteen times, or a sixteenfold increase in pressure. In fact, no liquid at body temperature is known which has a viscosity this low. The bioengineering problems associated with redesigning a muscular pumping system like the heart to generate a perfusion pressure sixteen times as great would appear insurmountable. The smallest capillaries are about 3 to 5 microns in diameter. Given the viscosity of water, the laws which govern the flow of fluids through small

tubes, and the design constraints on muscular pumping systems, the figure of 3 to 5 microns is equivalent to a physical constant—there is no way in which it could be decreased!

It is fortunate that capillaries can function down to such a small size. Because diffusion in a liquid is only effective over very small distances, the existence of higher organisms is only possible because of the existence of a myriad of tiny capillaries permeating their tissues. Lf the viscosity of water had been slightly greater and the smallest functional capillaries had been 10 microns in diameter instead of 3, then the capillaries would have had to occupy virtually all of the muscle tissue to provide an effective supply of oxygen and glucose. Obviously, the design of macroscopic life forms would be impossible, or enormously constrained.

The tiny diameter of the capillary also has another essential bearing on its primary function as a carrier of nutrients to the tissues. This is because the tension in the wall of a tube equals the product of the pressure within the tube and the diameter of the tube. s' This implies that for a given pressure the tension in the wall increases in direct proportion to the radius of the tube. For this reason, as Schmidt-Nielsen points out, a large artery most have a thicker wall than a small artery. However, in the case of capillaries, "because of their very small radius a wall consisting of a single layer of cells has sufficient strength. Thus the smallness of the capillary has the important consequence that its walls can be thin enough to permit rapid diffusional exchange of material between the blood and the tissues."37

It seems, then, the viscosity of water most be very close to what it is if water is to be a fit medium for life. Lt is sufficiently high to provide some protective buffering against shearing forces for the delicate structures of the cell and sufficiently low to ensure diffusion rates fast enough to allow for material exchange between the cell and its environment. In the case of higher organisms it must be low enough to permit perfusion of the tissues via a system of capillaries down to 3 to 5 microns in diameter, which are sufficiently small to bring within diffusional distance all the tissue cells of the body without their occupying a large proportion of the volume of the tissues. If it was much higher, diffusion would be prohibitively slow, and while very simple cell systems might be possible, large, complex, metabolically active organisms would not. No conceivable set of compensatory changes—increasing the number or diameter of the capillaries, increasing the flow rate or decreasing average cell size, etc.—could be engineered to make mammalian life possible.

Non-Newtonian Fluids

There is a final and fascinating aspect of the phenomenon of viscosity related to the viscous properties of nonhomogeneous fluids which has an important bearing on the function and design of the circulatory system. Ordinary homogeneous fluids have a constant viscosity. Their flow is directly related to the pressure applied. However, as Marcus Reiner points out in his Scientific American article "The Flow of Matter," when a nonhomogeneous fluid, containing a suspension of particles like blood, is forced to flow through a tube, it exhibits a curious behavior: when the pressure is doubled, the we of flow may triple. Remarkably, its viscosity becomes less as the pressure is increased. Liquids that behave in this way are called non-Newtonian 38

Now this apparently esoteric aspect of the phenomenon of viscosity is no triviality but rather a crucial adaptive property of blood. It means that when the blood supply to a tissue most be increased severalfold, because blood behaves as a nonhomogeneous fluid consisting of red cells suspended in a Watery fluid, then as the perfusion pressure increases, the viscosity conveniently reclines. This effect greatly facilitates the increased delivery of blood to an organ when its metabolic activity is increased. The twenty-fold increase in the perfusion of mammalian muscles as strenuous activity commences is only possible because of this characteristic of a non-Newtonian fluid.

What is particularly remarkable about this adaptive property is that the packaging of the hemoglobin (the oxygen carrying molecules in the red blood cell) in small particles, i.e., the red cells, rather than having them free in solution in the plasma, is itself adaptive, but for reasons completely unrelated to fluid flow or viscosity. These include the linking of the association and dissociation of oxygen and hemoglobin to a variety of sophisticated metabolic controls, which among other things assist in the buffering of the body against changes in its acidity and assist in the transport of carbon dioxide to the lungs. If the oxygen carrying molecules were free in solution, many of these adaptations associated with the reversible oxygenation of hemoglobin would have been in all likelihood impossible, and at the same time the advantage of the anomalous drop in viscosity when a suspension of particles is subjected to increased perfusion pressure would not accrue.

The Viscosity of Ice

Remarkably, the viscosity of ice, the solid form of water, is also adaptive for life on earth. Just as the viscosity of liquids varies greatly, the viscosity of solids also varies over many orders of magnitude. Pitch, one of the least viscous of solids, has a viscosity about 101 (1 trillion) times greater than that of water, while ice, which is a crystalline solid, has a viscosity 1016 times that of water. The rocks which make up the crust of the earth have viscosities ranging between 1025 and 1028 times that of water. So the range of viscosities of solids is 10th 39 Lf the viscosity of ice had been several times lower than it is, then glacial activity would have been much less effective in grinding down the mountains and releasing vital minerals into the hydrosphere. Lf ice had the viscosity of pitch, then glaciers would only have been a few feet thick and would have run gently down mountainsides, making little impression on the much harder rocks that make up the earth's crust.

On the other hand, it is fortunate that the viscosity of ice is not much higher than it is. If it were anything approaching that of granite, then all the water on earth would be immobilized at the poles and on the high mountain ranges. The earth's higher latitudes would have been covered in vast sheets of granite-solid ice caps and the earth would have been sterile. There would be no liquid water on earth and no life. Today about 10 percent of the earth's water is locked up as ice in the Antarctic and Greenland ice caps. It is possible that even if the viscosity of ice had been only 100 times greater, there would have been far less liquid water on earth and the climate would have been subject to rapid fluctuations from extreme heat to extreme cold, and it is very doubtful whether life as rich as it now exists on earth would have evolved. The actual value of the viscosity of ice would appear to be yet another adaptation of "water" that ensures that large bodies of liquid water can exist on a planetary surface such as the earth's.

The Density of Water

Unlike viscosity, which varies over many orders of magnitude, the density of substances on earth varies much less. Tar, which has the same density as water, is billions of times more viscous. The density of water is 1 gram per cubic centimeter. The density of air at atmospheric pressure is about one-thousandth that of water; the density of tar and glycerol is about the same as water. The density of petrol is about 0.65 and that of many hydrocarbons ranges from between about 0.7 and 0.9 gram per cubic centimeter. Apart from the lipids and fats, many organic compounds which form the basic fabric of the cell have densities very close to that of water. Other well-known substances are more dense than water. Many common minerals have densities between three and seven times that of water. The density of two of the heaviest substances, mercury and gold, are 13.6 and 19 respectively.40

It is clear that as living organisms are made up largely of water, then the density of water largely determines their weight. In the case of large terrestrial organisms on a planet the size of the earth, if water were several times as dense, then the maximum site that could be attained would be only

a fraction of that actually attained by existing organisms. An upright bipedal humanoid species of design similar to Homo sapient would not be feasible, for the weight of the body might well prevent its being lifted off the ground and maintained in an upright position. Nor could the limbs be moved unless the proportion of muscle was greatly increased. This is because—for reasons that will be discussed in chapter 11—the power exerted by muscles per unit volume of muscle tissue cannot be much increased. If our limbs were four times their current weight, the muscles would have to be four times the volume to achieve the same level of mobility.

One set of adaptations that would theoretically be facilitated if water were less dense and organisms consequently less heavy per unit volume are those associated with flight. However, as far as aquatic life is concerned, the consequences of water having a density much less than I gram per cubic centimeter would be severe. In such a hypothetical world, all other things being equal, carbon-based life forms (composed of 30 percent non-aqueous materials, mainly organic carbon compounds) would tend to sink like lead balloons to the ocean floor. On the other hand, if water was just a fraction heavier than it is, all carbon-based aquatic life would be restricted to floating on the surface. It is doubtful that many life forms, particularly microorganisms on the surface which prevents further heat loss. Eventually, the surface layer freezes—a process which because of the high latent heat of fusion gives out a considerable amount of heat, thus retarding further the temperature fall. After ice has formed, because it is lighter than water, it remains on the surface, preventing, because of its poor conductivity, further cooling of the water below. Further freezing now occurs at the interface between the ice and the water so that the latent heat given out will be trapped, because of the poor conductivity of ice, below the surface of the ice, thereby warming the water below and thus retarding further cooling. Eventually, no matter how cold the air above the sea, the layer of ice will not increase beyond a few meters thick. Moreover, if large quantities of ice are formed in some situations because of the relatively low viscosity of ice, eventually it flows downhill or outward toward warmer temperatures or toward the sea, where it inevitably melts, generating liquid water again.

Keeping Cool

As a final example, consider the way that the large heat capacity, high latent heat of evaporation, heat conductivity, and low viscosity conspire together to serve the end of temperature regulation in a large organism like a man.

All activity, including the work of machines, requires the expenditure of energy, and this necessarily involves the generation of heat. During a one-hour run over a distance of ten miles, an average man will generate a considerable amount of heat. Yet at the end of the run his body temperature will • only be raised a few degrees. We are so familiar with this fact that it never occurs to us that there might be something unusual about it. But in fact it is a remarkable phenomenon.

Altogether, the work expended when a 100-kilogram man runs 10 miles in one hour will generate approximately 1,000 kilocalories of heat. Lf none of this heat were lost from the body during the run, it would raise the temperature of the body by 10°C. Such a temperature rise would almost certainly be fatal. If the body was constructed mainly out of, say, iron, salt, lead, or alcohol, rather than water, the temperature would be raised by J00°C, 50°C, 300°C, and 20°C respectively. The reason for the relatively modest rise in body temperature of only 10°C is that the heat capacity of water is greater than most other substances and greater than all known liquids except ammonia within the temperature range commonly encountered on the earth's surface.

But water has another unique advantage for temperature regulation. As we saw above, the latent heat of vaporization of water is the highest of any liquid in the ambient temperature range. Thus,

in addition to buffering the rise in temperature, because of its very great heat capacity, the very great tooling effect when it evaporates from the skin further attenuates the rise in temperature. The evaporation of one liter of sweat from a 100-kilogram man removes about 600 kilocalories of heat from the body, lowering the body temperature by 6°C. Lf water was substituted for, say, alcohol or ammonia, then the cooling on evaporation would only be 2.2'C and 3.6°C respectively. Moreover, at body temperature, radiation and conduction are insufficient to rid the body of heat, so the whole burden is thrown on evaporation.

But there is much more to the story than this. Even these two nearly • unique thermal properties of water would not in themselves be sufficient to maintain temperature stability unless the heat generated in the core of the body could be transported to the surface of the body. There are only two ways by which this could be done: conduction or convection.

The range of thermal conductivities among common substances is considerable. Silver and copper, for example, two of the most efficient heat conductors, have thermal conductivities more than ten thousand times greater than some of the poorest conductors, like silica gel and wood, and some thousand times greater than that of water. Liquids are poor conductors compared with metals, but of all liquids, again water is at a unique maximum, having a thermal conductivity several times as great as the vast majority of liquids at ambient temperatures.43

Although the thermal conductivity of water is high compared with most other liquids, it is still too low to transport heat from the center of the body to the periphery at the rate required to rid animals of the heat generated by metabolism. Only if conduction is assisted by some sort of convection mechanism is it possible to transfer heat from the core of the body to the skin. There is indeed such a convection mechanism: the circulatory system, which conveys in the average adult man nearly 6 liters of blood throughout the body, through every organ, via the capillaries, every minute carrying with it any heat generated in the body's core to the periphery. But the circulatory system, as we have seen, in turn depends on another important physical property of water, its viscosity, having almost precisely the very low value it does.

If the conductivity of water had been several times less, like that of absorbent cotton or wood, then even with the circulatory system conductivity would almost certainly have been too low to transfer heat to the surface of the body, and its elimination from the body, especially in situations of strenuous exercise, would pose insurmountable problems. The body would seize up like an overheated car engine. On the other hand, if the thermal conductivity of water was many times more, like that of copper, then the temperature of living things would equilibrate very rapidly with their environment, so that temperature regulation would be far more difficult to achieve. Changes in the environmental temperature would be rapidly conducted (as is the case with a piece of metal) throughout the body of the organism, which consequently would suffer continual swings of temperature. Small warm-blooded animals would probably be impossible, and even a large organism would experience difficulties in drinking a large quantity of cold water. To be fit for macroscopic life the thermal conductivity of water most be dose to what it is.

We see, then, that the very modest rise in body temperature after strenuous exercise is no ordinary phenomenon. Lt turns out to be dependent on the unique fitness of water as a buffer against changes in temperature. This fitness is dependent on four quite different physical properties of water that all exhibit a coincidental mutual fitness and which together perfectly fit water for this biological role.

No other liquid is known which can even remotely approach the fitness of water for temperature regulation of a large terrestrial carbon-based form of life at the ambient temperature range of 0°C to 50°C. And, moreover, although some liquids such as ammonia and liquid sodium exhibit some of

the thermal properties of water, none possess quite the same set of mutually adaptive properties. At certain temperatures liquid sodium, for example, exhibits a higher latent heat of evaporation than water but its thermal conductivity is very many times more than water, too high to permit any theoretical organism based in that medium to maintain a steady temperature in the face of environmental challenges.

Conclusion
The evidence reviewed in this chapter indicates that water is uniquely and ideally adapted to serve as the fluid medium for life on earth in not just one, or many, but in every single one of its known physical and chemical characteristics.

The unique and ideal fitness of water can be illustrated in graphic form by plotting all known fluids against their utility for carbon-based life as shown on page 46.

As Henderson concluded,

> If doubts remain, let a search be made for any other substance which, however slightly, can claim to rival water as the milieu of simple organisms, as the milieu interwar of all living things or in any of the countless physiological functions which it performs."

There is indeed no other candidate fluid which is remotely competitive with water as the medium for carbon-based life. Lf water did not exist, it would have to be invented. Without the long chain of vital coincidences in the physical and chemical properties of water, carbon-based life could not exist in any form remotely comparable with that which exists on earth. And we, as intelligent carbon-based life forms, would almost certainly not be here to wonder at the life-giving properties of this vital fluid. And if there is life like our own anywhere in the cosmos on some other earth, there will also be water and in all probability there will be seas and rivers and clouds and rain. There will be storms and waterfalls and icebergs, and surf will break on the beaches of that distant world.

In the many mutually adaptive properties of this most remarkable of all fluids, we are brought dramatically face-to-face with an extraordinary body of evidence of precisely the sort we would expect on the hypothesis that the laws of nature are uniquely fit for our own type of carbon-based life as it exists on earth.

Chapter 3 - The Fitness of the Light

In which it is shown that the electromagnetic radiation reaching the surface of the earth is uniquely fit for carbon-based lift. The sun's radiation is mainly in the visual range—from the near ultraviolet to the far infrared. Not only it most of the electromagnetic radiation outside this tiny range harmful to life, but the energy levels within the visual spectrum are precisely fit for photochemistry y. Remarkably; the atmospheric gases, including water vapor and liquid water, absorb virtually all the harmful radiation outride the visual range and transmit only this tiny band of biologically useful radiation. These coincidences provide convincing evidence of nature's fitness for carbon-based lift. On tap of its utility for photochemistry the wavelength and energy levels of visual light are fit for biological vision with a camera-type eye of the son utilized in higher vertebrates, including man. Like water, the light of the sun appears to be of optimal biological utility.

Think of the Sun's heat on your upturned fare on a cloudless summer's day, think how dangerous it is to gaze at the Sun directly. From 150 million kilometers away, we recognize its power. What would we feel on its seething self-luminous surface, or immersed in its heart of nuclear fire? The Sun warms us and feeds as and permits us to see. It fecundated the Earth. It is powerful beyond human experience. Birds greet the sunrise with an audible ecstasy. Even some one-celled organisms know to swim to the light. Our ancestors worshipped the Sun and they were far from foolish.
—Carl Sagan. Cosmos, 1980

It may form an interesting intellectual exercise to imagine ways in which life might arise and having arisen might maintain itself, on a dark planes; but I doubt very much that this has ever happened, or that it can happen.
—Cease Wald, Scientific American magazine, 1959

As Sagan so rightly comments, ancient man was right to worship the sun as the giver and sustainer of life. The sun provides heat and light, both of which are essential to life.

It is the heat provided by solar radiation in the infrared region of the spectrum which warms the earth, keeping the mean temperature of the earth above the freezing point of water and within the temperature range where the chemical reactions upon which life depends can occur. It is the sun's heat which energizes the great water cycle, drawing water by evaporation from the oceans into the atmosphere which then, via the precipitation of rain and snow, forms rivers and glaciers which carry the evaporated water back again to the ocean. And it is the energy provided by solar radiation within the visual region of the spectrum which drives the process of photosynthesis through which light energy is utilized to synthesize the fuels of life, the sugars and fats, which power the activities of virtually all complex forms of life on earth.

The sun's radiation is essential in two ways: it provides the heat energy which keeps the earth's temperature within the appropriate range for life and it provides the light energy necessary for photosynthesis.

The Electromagnetic Spectrum
Both heat and light are forms of radiant energy known as electromagnetic radiation. All the various different types of electromagnetic radiation, including heat and light, flow through space in the form of energy waves analogous to ripples on the surface of a pond. And just as the waves on the surface of a pond may have different wavelengths—small ripples may be only a few centimeters from crest to crest, while large waves might be more than a meter—so similarly the wavelength of the various types of electromagnetic radiation also varies, but over a vastly greater range.

The longest electromagnetic waves are radio waves, which measure several kilometers across (10s microns), while the smallest are the gamma rays, which measure less than a trillionth of a centimeter (10-16 microns) across. The wavelength of microwaves is around 1 centimeter (104 microns). The wavelength of visible fight ranges from about one ten-thousandth of a centimeter (0.70 microns) at the long, or red, end of the spectrum to about one twenty-five-thousandth of a centimeter (0.40 microns) at the short, or blue, end of the spectrum. The wavelength of infrared, or heat, radiation ranges from one ten-thousandth of a centimeter (1 micron) to one-tenth of a centimeter (103 microns).

Note that the wavelength of the longest type of electromagnetic radiation it unimaginably longer than the shortest by a factor of 1025, or 10,000,000,000,000,000,000,000,000. Some idea of the immensity this figure represents can be grasped by the fact that the number of seconds since the formation of the earth 4 billion years ago, is only about 10°. To count 1025

seconds we would have to keep counting every day and night through a period of time equal to 100 million times the age of the earth we were to build

agile of 10~5 playing cards, we would end up with a stack stretching halfway across the observable universe.

Remarkably, although the wavelength of electromagnetic radiation in the atmosphere varies over such a colossal range, 70 percent of the electromagnetic radiation emitted from the surface of the sun is concentrated in an exceedingly narrow radiation band extending from the near ultraviolet (0.3 millions) through the visible light range into the near infrared (1.50 microns).

This minute band represents the unimaginably small fraction of approximately one part in 1025 of the entire electromagnetic spectrum—equivalent Neon playing card in a stack of cards stretching halfway across the cosmos, at one second in 100 quadrillion (100,000,000,000,000,000) years.

There is nothing exceptional about this amazing compaction of the sun's radiant energy into such a small radiation band. The spectrum of radiation emitted by a star is determined by its surface temperature. The temperature of the sun's surface is dose to 6,000°C. Because the sun is an "ordinary, even mediocre, star,"2 being about in the middle of the range of stellar temperatures and sizes, many stars have surface temperatures close to this value and emit nearly all their radiation in this same very small band.

Solar Radiation
When electromagnetic radiation interacts with matter, energy is imparted. If the radiation is highly energetic in the X-ray or gamma-ray regions, this can tear atoms and molecules apart. On the other hand, radiation in the radio region imparts so little energy that it passes through matter with hardly thy detectable effect. Only radiation in this tiny band in the visual and inhaled region—interacts gently enough with matter to be of utility to life. Consequently, the fact that the suns radiation (and that of many main sequence stars) is compressed into this tiny region of the spectrum is of enormous biological significance.

Atoms and molecules only react together when they possess energies equal to or greater than a particular threshold value, which is known as their energy of activation. For the great majority of chemical reactions which occur in living things, the activation energy of the reactions (the amount of energy needed to cause a chemical reaction between two molecules) generally lies between 15 and 65 kilocalories per mole. The common way of expressing these energy levels is in terms of quantity of heat—i.e., calories—per quantity of matter (moles). These energy levels are provided by electromagnetic radiation between 0.80 microns and 0.32 microns, more or less exactly that provided by visible light.3 Radiation at wavelengths slightly longer than 0.70 microns is too weak to raise molecules into energy states which can activate chemical reactions. But on the other hand, radiation in the ultraviolet (shorter than 0.30 microns) is too energetic and causes disruption of life's delicate molecular structures.

The correspondence between the "energy needs" of biological chemistry and the "energy levels" of solar radiation was discussed by George Wald in a well-known Scientific American article entitled "Life and Light." As Wald comments, the radiation that is useful in promoting orderly chemical reactions comprises the great bulk of that of our sun. The commonly stated limit of human vision-400-700 millimicrons—already includes 41% of the sun's radiant energy."4 The diagram below illustrates the intensity of solar radiation between 0.20 microns and 1.50 microns.5

Infrared radiation is also essential to life but for a different reason. When radiation in the infrared region of the spectrum interacts with matter, energy is imparted, which causes the random

movement and vibration of atoms and molecules to increase. This we register as heat. As already mentioned, it is the heat imparted to the earth by radiation in the infrared region of the spectrum that keeps the earth's hydrosphere warm, keeps water a liquid, and drives the climatic systems and the water cycle.

Moreover, heat energy is important in another way. At least some heat is necessary for chemical reactions, because to interact chemically with one another, atoms and molecules most come into contact and this can only occur if they are in motion and may collide. Note, however, that heat energy is only of utility to the orderly chemical processes of life in a narrow temperature range—approximately that in which water is a liquid, a point discussed again in chapter 5. The heat imparted to the earth's hydrosphere by infrared radiation from the sun would, if unchecked, eventually raise the temperature of the earth by many hundreds of degrees. At such temperatures the velocity of atomic and molecular collisions becomes such that the orderly chemistry of life is impossible. The earth escapes this fate because—via a variety of feedback systems (see next chapter) and other not fully understood controls—over time heat loss exactly balances heat gain.

That the radiation from the sun (and from many main sequence stars) should be concentrated into a minuscule band of the electromagnetic spectrum which provides precisely the radiation required to maintain life on earth is a very remarkable coincidence described as "staggering" by Ian Campbell in Energy and the Atmosphere. Now that the compaction of solar radiation into the visible and near infrared is determined by a completely different set of physical laws to those that dictate which wavelengths are suitable for photobiology.

Our amazement grows further when we note that not only is the radiant energy in this tiny region the only radiation of utility to life but that radiant energy in most other regions of the spectrum is either lethal or profoundly damaging. Electromagnetic radiation from gamma rays through X rays to ultraviolet rays is all harmful to life. Similarly, radiation in the far infrared and microwave regions is also damaging to life. Just about the only region of the electromagnetic spectrum which is harmless to life apart from the visible and the near infrared is the region of very long wavelength radiation—the radio waves. So the sun not only puts out all its radiant energy in the tiny band of utility to life but virtually none, in those regions of the spectrum which air harmful to lift. This coincidence is expressed in graphic form in the two diagrams below.

The Absorption of the Atmosphere

Now this is a remarkable enough coincidence in itself. But there are further coincidences to consider. To be of any utility to life, the radiation of the sun has to reach the surface of the earth. To do so it most pass through the atmosphere. Necessarily, any atmosphere surrounding a terraqueous planet containing carbon-based life is bound to contain some carbon dioxide gas, water vapor, at least some nitrogen, and for advanced highly active life forms considerable concentrations of oxygen. It is difficult to see how the actual concentrations of these gases could be very different from what they are in any atmosphere supporting a carbon-based biosphere (see discussion in chapter 6). At the temperature range that exists at the earth's surface, there is bound to be water vapor in considerable amounts in the atmosphere.

The fact that the atmospheric gases oxygen, nitrogen, carbon dioxide, and water vapor transmit 80 percent of the sun's radiation in the visible and near infrared and allow it to reach the earth's surface is another coincidence of enormous significance. The great majority of all atoms and molecular substances are completely opaque to visible light and radiation in the near-infrared region of the spectrum. Window glass, an example of a transparent solid which transmits light in the visible region, is exceptional. Lf the atmosphere had contained gases or other substances which absorbed strongly visible light, then no life-giving light would have reached the surface of the earth. In the case of nearly all solid substances, layers only a fraction of a millimeter thick are

sufficient to prevent the penetration of light. Even the atmospheric gases themselves absorb electromagnetic radiation very strongly in those regions of the spectrum immediately on either side of the visible and near infrared. The diagram below indicates the spectral regions absorbed by the atmosphere.? Note that the only region of the spectrum allowed to pass through the atmosphere over the entire range of electromagnetic radiation from radio to gamma rays is the exceedingly narrow band including the visible and near infrared. Virtually no gamma, X, ultraviolet, far-infrared, and microwave radiation reaches the surface of the earth.

Despite these three remarkable coincidences, life would still not be possible without a fourth coincidence—the fact that liquid water is highly transparent to visible light.

The Absorption of Water

The significance of the transparency of water to light cannot be exaggerated. All biological chemistry occurs in liquid water. lithe energy of sunlight is to sustain life in the ocean then it must be capable of penetrating some distance below the surface of the sea. Even on land if light energy is to reach the chemical machinery of the cell it must invariably penetrate a thin layer of water.

Nearly all electromagnetic wavelengths are strongly absorbed by water, except radio waves and light within the visible spectrum.' Even far ultraviolet and infrared radiation, the two bands immediately adjacent to the visible band, are absorbed readily by water and only penetrate a fraction of a millimeter below the surface. The absorption of visible light by water varies markedly across the visible spectrum. No red light can be observed below 18 meters. Yellow light only penetrates to 100 meters. By 240 meters most of the green and blue light has been absorbed. The absorbency spectrum of liquid water is shown in the diagram below.9

The very remarkable fact that the only region of the spectrum allowed through water is the tiny (15th) of the Encyclopaedia Britannica "Considering the importance of visible sunlight for all aspects of terrestrial life, one cannot help being awed by the dramatically narrow window in the atmospheric absorption ... and in the absorption spectrum of water."° (My emphasis.)

The fact that light at the blue end of the spectrum penetrates further into water than light at the red end may explain why chlorophyll so strongly absorbs light in the blue region. The question as to why in a biocentric world chlorophyll should absorb light in a region of the solar spectrum where the incident radiation is not maximum is raised in chapter 9. We have here in

the differential penetration of light a possible answer to the conundrum. Photosynthesis in water, especially several meters below the surface, is only Possible if chlorophyll absorbs light in the blue end of the spectrum.

The fact that water absorbs light in the far ultraviolet is of obvious biological significance, as it acts as another device to shield life from the damaging influence of ultraviolet radiation. Note that there are three independent mechanisms attenuating the W flux reaching biological systems:

1. The radiant output of the sun falls dramatically from 0.40 microns to 0.30 microns so that vay4{ale ultraviolet radiation leaves the sun in

2. Ozone in the upper atmosphere absorbs W light strongly below 0.30 microns.

3. Water (liquid and vapor) absorbs strongly below 0.20 microns.

These factors together create a discontinuity at about 0.30 microns (see diagram below).

The fact that water absorbs damaging IN radiation while allowing visual light to penetrate to considerable depths has a very important consequence; it means that photosynthesis can occur in water even in the absence of the protective ozone layer. This apparently esoteric fact was of crucial significance to the evolution of life on earth because it allowed primitive microscopic plant life to thrive in the primeval oceans before the advent of oxygen and the protection of ozone. It was through their activities that the original anoxic atmosphere was eventually converted to the oxygen-containing atmosphere of today. If damaging IN radiation had penetrated as deeply as visual light, then photosynthesis could never have been exploited to generate the current oxygen-containing atmosphere. And as we shall see in chapter 6, without oxygen in the atmosphere, actively metabolizing complex multi-cellular life forms would not have been possible, and lacking the protection of ozone, terrestrial plant and animal life would have been enormously constrained if not impossible. In a very real sense, the existence of all complex life on earth is dependent on the relative absorbance of W and visual light in water being very dose to what it is.

The very small amount of ultraviolet radiation that does reach the earth's surface has clearly not hindered the evolution and development of life on earth. The spectacular success and persistence of life over the past 4 billion years indicates that life can thrive when subjected to at least some ultraviolet radiation and that the ultraviolet reaching the earth's surface most have had • little, if any, deleterious effect on life in general. In fact, very small amounts of ultraviolet may have played a significant role in evolution by raising slightly the average mutation rate. Without munitions, there can be no evolutionary change, and it is possible that the raised levels of mutation caused by the ultraviolet flux could have played a critical role in the evolutionary history of life.

In man and other vertebrates ultraviolet radiation (between 0.29 and 0.32 microns) is essential for the synthesis of vitamin D. This occurs in the skin when it is irradiated by ultraviolet light. As vitamin D is vital for the maintenance and control of calcium levels in the body and for the forma-don of bone in all vertebrates, and as the only means of its synthesis is via ultraviolet light in the skin, then as far as humans are concerned, ultraviolet light is essential to life. The fact that a vital vitamin is produced in this way raises the question as to whether low levels of ultraviolet radiation may have other important biological influences.° Another important role of near UV light may be the photochemical release of nitrogen from aquatic dissolved organic matter. This plays an important role in the recycling of nitrogen in marine and freshwater ecosystems.12

As well as strongly absorbing ultraviolet light, liquid water also strongly absorbs radiant energy in the infrared region. Very little radiation in the infrared region penetrates more than a few millimeters into water, which means that all the heat reaching the surface of the sea is absorbed and retained in the surface layers.13 As was mentioned in chapter 2, water, like all other fluids, is a poor conductor of heat. This helps retain the heat in the surface layers of the ocean. Consequently, in most parts of the sea there is a relatively thin surface layer about 20 meters thick of warm, less dense water. Below 100 meters the temperature of the sea in all parts of the globe falls rapidly till it reaches about 4°C at 1,000 meters below the surface. The re-tuition of heat in the thin surface layer facilitates the transference of heat to the air and winds and by surface currents to colder regions of the ocean, thereby assisting in the maintenance of global temperature equilibration. In the higher latitudes this retention of the heat at the surface of the ocean tends to slow down the rate of freezing.

So both the transparency of water to visible light and its opacity to infrared radiation contribute to the fitness of the earth's hydrosphere for life. The radiation needed for photobiology, radiation in the visible region of the spectrum, penetrates to depths of 100 meters, while the infrared needed to warm the hydrosphere and drive the climate and the water cycle is retained in the surface layers where its utility is greatest. And in addition, all highly destructive ultraviolet radiation below 0.20 microns is almost entirely absorbed in the first few millimeters.

Another fascinating aspect of the fitness of the electromagnetic spectrum for life is the fact that both types of useful radiation, the visible and the infrared, are adjacent in the spectrum. What we have in effect are two adjacent playing cards back-to-back in a deck which extends across the cosmos. Just as the transparency of water to visible light and the fitness of the solar radiation for photochemistry are of necessity, so the close proximity of these two vital types of radiant energy gives every appearance of also being of necessity. Lf these two vital types of radiation were far apart in the spectrum, the possibility of prearranging nature so that they could both reach the surface of a watery planet in appropriate quantities from one unique source, such as the sun, would in all probability have been impossible.

We should indeed be awed and staggered by this series of coincidences: that the electromagnetic radiation of the sun should be restricted to a tiny region of the total electromagnetic spectrum, equivalent to one specific playing card in a deck of 1025 cards stretching across the universe; that the very same infinitely minute region should be precisely that required for life; that the atmospheric gases should be opaque to all regions of the spectrum except this same tiny region; that water should likewise be opaque to all regions of the spectrum save this same infinitesimally tiny region, etc. Lt is as if a card player had drawn precisely the same card on four occasions from a deck of 1025.

Even with all these coincidences, unless the sun's radiation reaching the earth's surface had remained virtually constant throughout the past 4 billion years, life could never have survived and evolved as it has. The sun is fit as an energy source for carbon-based life forms not only in providing radiant energy with precisely the levels necessary for life, but also because it has provided that vital and necessary energy at an almost perfectly constant intensity for unimaginable eons of time. Even the slightest change in the output of radiant energy from the sun at any stage during the history of life would have had disastrous consequences.

Alternatives to Light

Life does not depend on light. There is a vast diversity of microbial species which can survive in total darkness and which derive energy from the oxidation of substances such as hydrogen, hydrogen sulfide, and ferrous iron that are generated by geochemical processes in the earth's crust. Lt is even possible chat a considerable proportion of the earth's biomass may consist of bacteria in the crustal rocks. Near the deep-sea hydrothermal vents a quite complex community of multicellular species is sustained by nutrients synthesized by bacteria which derive their energy from the oxidation of sulfides released from the vents. Geothermal springs are another site where a complex biota of microorganisms derive energy from the oxidation of hydrogen sulfide.14 However, it is difficult to imagine how these other potential sources of en-erg' could sustain complex aquatic or terrestrial ecosystems on the surface of a planet like the earth. And it is difficult to envisage the evolution of advanced and complex life forms in such restricted environments as microscopic fissures in the crustal rocks, thermal springs, or deep-sea hydrothermal vents.

In the last analysis, there is no alternative to stellar radiation to sustain a rich and diverse biosphere over billions of years on a planetary surface like the earths. Lf the radiant energy of stars was not fit for photochemistry and to provide the heat to energize a hydrosphere like that which exists on earth, then the cosmos would in all probability be only capable of sustaining carbon-based biospheres far less complex than our own.

Fitness for Vision

The light of the sun is uniquely fit in yet another way for life on earth—the energy levels and wavelength of electromagnetic radiation in the visual spectrum are both uniquely fit for high-resolution vision. One reason that visual light is fit for biological vision is that if an eye is to "see" it

must be able to detect the type of radiation forming the image. Light radiation is the only type of electromagnetic radiation that has the appropriate energy level for detection by biological systems. UU, X my, and gamma rays are too energetic and are highly destructive, while infrared and radio waves are too weak to be detected because they impart so little in energy interacting with matter. Moreover, most electromagnetic radiation outside the visual region is strongly absorbed by water and other biological materials, so it is difficult to imagine what biological substances could be utilized for the construction of a lens sufficiently transparent to transmit and focus the radiation. Our ability to discriminate between different wavelengths in the visual spectrum—i.e., to see colors—is also dependent on the perfect correspondence between the energy levels of electromagnetic radiation in the visual region and those required for photochemical detection by biological systems.

Not only are the energy levels and absorbance characteristics of light waves fit for detection by biological systems, but the actual length of the waves in the visual region of the spectrum is perfectly fit for the high-resolution camera-type eye of the precise design and dimension as that found in all higher vertebrate species, including man.

Instrumental Constraints

The wavelength of light imposes constraints on the design and dimension of the eye mainly because of the phenomenon of diffraction, which is an inevitable consequence of the wave nature of light itself. Like the ocean swell entering a small harbor, when light waves pass through a small aperture, they suffer dispersion or diffraction. As a consequence, when light from a point source in the visual field (A or B, in the diagram below) passes through the pupil and is focused on the retina, instead of being focused to a point, it spreads out into a tiny disc surrounded by concentric rings (a, b). The disc is known as the Airy disc. (Sec opposite.)

And again just like an ocean swell entering a harbor, where the degree of diffraction is determined by the size of the swell, in the case of light, the larger the wavelength, the larger the diffractional effect, the larger the Airy disc, and the poorer the resolution. At any wavelength the phenomenon of diffraction and its consequence, the Airy disc, imposes a limit on the resolving power of any sort of optical instrument, camera, or eye.

In addition to wavelength, the other factor which influences diffraction is aperture. And again in terms of the ocean swell–harbor analogy, just as the greater the opening of the harbor the less the swell is diffracted, so the greater the aperture the less the diffraction in the case of an optical instrument.

In short, the size of the Airy disc is determined by two primary factors—the wavelength of the radiation itself and the size of the aperture of the instrument.

To achieve optimal resolving power the effect of diffraction most be minimized. One way this may be achieved is by increasing the size of the aperture. The resolving power of the Mount Palomar telescope is a thousand times greater than that of the human eye, mainly because its aperture (the mirror) is approximately a thousand times wider than the pupil of the human eye.

Unfortunately, in the case of the eye, which focuses an image by refraction through a lens, because chromatic and spherical aberration also increase as the aperture is increased, increasing the site of the aperture can only bring limited improvement in resolution. Therefore, minimizing the effect of diffraction involves the satisfaction of several conflicting criteria; if the aperture of an eye or a camera is increased, then the diffraction may be decreased and resolution improved but spherical aberration is also increased, thereby minimizing any improvement that might have been gained; if the pupil or aperture is decreased, then although spherical and chromatic aberration is decreased,

diffraction effects increase and the resolution is decreased while at the same time the illumination of the retina (or photographic plate in the case of a camera) is decreased, and so on.15

Although large telescopes have very much greater resolving power (aperture) than the vertebrate eye, their field of view is far smaller and only distant objects can be brought into focus. In the case of an eye, any advantage that might be gained in resolution would be more than offset in the case of an organism by the decrease in the field of view and the inability to bring objects close at hand into focus.

Consideration of the many conflicting criteria which most be satisfied in attempting to optimize the resolution of a camera-type eye utilizing light of a wavelength of about 0.5 microns, including minimizing diffraction, maximizing illumination, maximizing field of view, minimizing spherical and chromatic aberration, etc., suggests that all high-resolution optical devices will necessarily be of the same design and dimensions. Each will consist of a small lightproof hollow rounded structure between 1 and 6 centimeters in diameter, containing at the front an aperture or "pupil" through which the light can enter, capable of varying from about 1 to 8 millimeters in diameter, and a lens through which the light can be focused onto a light-sensitive plate. In fact, all high-resolution vertebrate eyes and high-quality modern cameras approximate to this design.

In such an eye, the minimum-sized Airy disc formed on the retina from a point source of light will be about 2 microns in diameter, which is the size of the Airy disc in many vertebrates, including man. This cannot be reduced and represents the optimum resolving power of the vertebrate eye. As one of the foremost authorities in this area, Horace Barlow comments:t6 "Lt is easy to verify that the highest resolving power achieved by man is quite close to the limiting resolution set by the diameter of the pupil and the wavelength of light."

Note that although many factors influence the resolving power of the vertebrate eye, it is the actual wavelength of light itself, or more specifically the degree of diffraction that inevitably occurs when radiation of that specific wavelength passes through an aperture, which more than any other factor determines the actual dimensions of the high-resolution vertebrate camera eye. For example, if the wavelength of light had been ten times less (0.05 microns), then an eye with the resolving power of the human eye would need to be only a few millimeters in diameter. Conversely, if the wavelength of light had been ten times greater (5 microns), then an eye with the same resolving power would need to be 25 centimeters in diameter—larger than the human head.

Note that the optimized vertebrate camera eye is quite a large object on the scale of all biological structures on earth, which range from about ten thousandths of a micron, the size of small subcellular structures, to 100 mc- (I billion microns) in the case of a California redwood. Clearly, if the optimum possible site of the camera-type eye constructed out of biological materials had been only ten or twenty times more, then no large organism would have possessed high-acuity vision. To begin with, its shape must be held in an approximately globular conformation. This is partly achieved in The case of many vertebrates by placing the eye in a round bony socket (which also preserves the eye's delicate structure from damage). Another adaptation which helps maintain the spherical shape of the eye is the main- Mace of a relatively high hydrostatic pressure in the interior of the eye.° But even with these adaptations, the globe of the human eye still suffers some degree of distortion. " In the case of some whales, which have the largest eyes of any mammal, more than half the mass within the globe is made up of an immensely thickened tough fibrous coat. So thick is this coating that it may make up three-quarters of the length of the anteroposterior axis of the eyeball. This is considered by some to be an adaptation to maintain the approximately spherical shape of the eye against distortion when the whale dives to great depths.19 The size of the lens, which is made up of living tissue and which most obtain its nutrients by diffusion, must also place an upper limit on the size of the vertebrate camera-type eye. From these and many other

considerations it seems likely that the size of the vertebrate camera eye approximates closely to the maximum possible size of a camera-type eye constructed out of biological materials.

But although the high-resolution camera eye is quite a large structure, it is still small enough for function and anatomical placement in a very wide variety of large terrestrial organisms, including the human species.

Thus, various factors, including the wavelength of light, diffraction, the size of aperture, and chromatic and spherical aberration, together impose what we might term, after Horace Barlow, an instrumental limit on the resolution of the camera-type eye. However, this instrumental limit is not the only limit to the resolving power of the eye.

Micro-optical Constraints

Clearly, no eye can resolve images smaller than the diameter of its individual photoreceptor units, and because of the inevitable constraints on cell design it is difficult to envisage photoreceptors much smaller than a few microns in diameter. (Most cells in higher organisms are between 10 and 50 microns in diameter.) This suggests that the cellular limit cannot be far removed from the incremental limit of 2 microns imposed by the various factors alluded to above. Interestingly, the smallest photoreceptors in the vertebrate retina are in fact about 2 microns across.20

Moreover, recent work in the field of fiber optics suggests that even if photoreceptors could be theoretically reduced in size below 2 microns in diameter, no improvement in resolving power would be gained because there are other constraints arising from the wavelength of light which impose a minimum size on photoreceptor cells.21 As one authority comments: "Optical cross talk between receptors would occur if they were smaller and packed more closely together than about 2 microns.... On this view, limiting retinal resolution, expressed in linear units, is the same in all eyes and results from the properties of light passing through a set of waveguides. As expected on this view, cones smaller than 2 microns across have never been found."22

This is mother remarkable coincidence. The two optical limits to the resolving power of the eye—the one set by the waveguide optics of the photoreceptor, which we might refer to as the micro-optical limit; the other set by the laws of classical optics relating to the resolving power of a camera-type eye, the instrumental limit—have the same value: 2 microns. Moreover, both these limits imposed on the resolving power of the eye, the micro-optical and the instrumental limit, one imposed by the laws of fiber optics, and the other by the laws of classical optics, correspond very closely with a third—the cellular limit—imposed by purely biological constraints which limit the minimum size of any soft of feasible cellular receptor system. Our high-resolution vision is only possible because these three limits precisely coincide.

There is almost certainly yet another factor which imposes a limit on the minimum possible size of the photoreceptor cell—the need of the cell to respond to exceedingly small quantities of light energy. The amount of light falling on the retina from a distant star is I trillion times (1012) less than that from a brightly lit snowfield.33 The extreme sensitivity of the eye to very small quantities of light makes vision possible at night and in other situations of low light intensity.

The eye is able to detect extremely small quantities of light because each photoreceptor is able to respond to a single photon of light—the smallest possible quantity of light energy.24 A photon of light is detected in the photoreceptor cell when it interact, with a single light-sensitive molecule, called rhodopsin. The photoreceptor cell is able to interact with a single photon only because it is packed with many millions of rhodopsin molecules, which maximizes the probability that an individual photon will be absorbed.2s The need for many millions of rhodopsin molecules in an

individual photoreceptor cell, if the cell is to detect a single photon, is another factor imposing a lower limit on the size of the photo-detector A. Only relatively large photoreceptor cells could detect individual photons and make night vision possible. The energy change resulting from the interaction of a single rhodopsin molecule with a single photon of light is extremely tiny, and the cell is only able to depict it after it has been massively amplified via a complex chain of enzymic reactions, which ultimately change the electrochemical state of the cell.26 Because of the complexity of the molecular system needed to amplify the tiny initial signal, it is hard to believe that any photoreceptor cell capable of responding to a single photon of light, and of therefore "seeing" in the dark, could be much smaller than the photoreceptor cells in the vertebrate retina.

The energy levels and the wavelength of light are of course only two aspects of the natural order that must possess precisely the properties and values they do for high-resolution vision to be possible. There are other features as well: there is the transparency of water to light; there is the low refractive index of water; there is the diffusion rates of small organic compounds in water to nourish the lens, which is a living tissue; there is the necessity for a large nervous system to analyze the visual data; and so on.

Seeing Outside the Visual Spectrum

Finally, let us consider some of the hypothetical problems that would be met in attempting to construct a biological high-resolution camera-type eye to 'see" in wavelengths outside the visual region of the spectrum.

For example, to obtain, with infrared or radio waves, the same degree of resolution as that which can be achieved with the human eye and many other optimized vertebrate camera eyes would require eyes of vastly increased size, even if a biological detector device could be constructed. To obtain the same resolving power as that of the human eye with, say, radio waves with a wavelength of 100 centimeters would require a reflector disc 10 kilometers in diameter. Even far-shorter-frequency radio waves, or microwaves of! millimeter wavelength, would require a lens or disc with a diameter of 10 meters to equal the resolving power of the human eye. So in addition to the profound difficulty that would be encountered in designing biological detector devices capable of measuring the low energy levels of infrared and radio waves, there would also be the tremendous engineering challenge of having to construct immense telescopes of planetary dimensions. Evidently, the infrared and radio regions of the spectrum are totally unfit for biological vision.

Curiously, not only is light far fitter for biological seeing and particularly for high-resolution vision than infrared or radio waves, it would also seem to be fitter for nonbiological eyes such as the radio and infrared telescopes used by astronomers. Even though a vast diversity of materials can be recruited for constructional purposes, no telescope has been built with a resolving power remotely equal to the human eye using wavelengths longer than those in the visual spectrum. A cursory comparison of the many photographs taken of galaxies and other astronomical objects through light, infrared, and radio telescopes shows clearly the far greater resolving power of optical devices in the visual region of the spectrum??

Like the X ray, and gamma rays are also unfit for biological vision. One reason already alluded to is that the energy of the radiation at these shorter wavelengths is so high that it would be bound to destroy any biological materials used in the construction of a hypothetical eye designed specifically to see in these regions of the spectrum. And again (as in the infrared and radio regions of the spectrum), the design of imaging devices to function in the UV, X-ray, and gamma-ray regions poses severe engineering problems even outside of biology! In the UV region, for example, a lens most be made of special materials that are transparent to UV light. Substances such as quartz and metal fluorides are commonly used. Unfortunately, because nearly all substances absorb in the far UV, focusing an image requires reflection optics in a vacuum chamber.'° The use of X rays is also

problematical. Because X rays are only reflected if they hit a metal surface at a very shallow angle, the design of X-ray telescopes is necessarily complex, involving a series of highly polished nickel-coated surfaces of first a paraboloid and then a hyperboloid surface.29 Similarly, gamma rays cannot be focused through a lens because all substances absorb them. Even reflection cannot be used because gamma rays are far smaller than the atoms making up any mirror. To detect the radiation in this region of the spectrum, a variety of electronic systems are used, including scintillation counters, proportional counters, and microchannel plates.3° Despite the progress made by astronomers over the past thirty years to construct telescopes which utilize the various short-wavelength regions of the spectrum, to date their resolving power is still far less than conventional light telescopes.

Assuming, for the sake of argument, that we could get around the detection problem and find some biological material capable of focusing W and X rays, the theoretical resolving power in the far UV, where wavelengths are a hundred times less than in the visible band, would be a hundred times better. For X rays ten thousand times less, the resolving power would be theoretically ten thousand times better. However, no improvement in visual acuity could be gained by having such eyes, because the smallest possible biological photodetector cell would be many orders of magnitude larger than the tiny UV or X-ray images that could theoretically be focused on such a hypothetical "retina."

Compared with the visual spectrum, the other regions of the electromagnetic spectrum are not only totally unfit for biological vision, they would also appear to be far less fit for nonbiological vision. Even today, despite the development of radio and X-ray telescopes, much of our knowledge of astronomy has come from observations made through light telescopes. The following diagram summarizes some of the conclusions discussed above.

And so it would appear that for several different reasons the visual region of the electromagnetic spectrum is the one region supremely fit for biological vision and particularly for the high-resolution vertebrate camera eye of a design and dimension very close to that of the human eye.

Conclusion

While high-quality vision may not be essential to all life on earth, human existence would be inconceivable without it. While other species may be as reliant on seeing as humans are for survival, our uniquely human desire for knowledge could only have been satisfied, as Aristotle rightly points out in the opening paragraph of his Metaphysics, by the gift of sight. Virtually all our knowledge of the world, and particularly scientific knowledge, acquired over the past four centuries has been largely dependent on our possession of eyes of very high resolving power, or visual acuity, and capable therefore of bringing us a very detailed and information-rich image of our surroundings.

We saw in the previous chapter that water, in many fascinating and highly intriguing ways, is uniquely and ideally fit for the type of carbon-based life that exists on earth, not just for simple unicellular microbial life but also for large terrestrial organisms. The evidence presented in this chapter shows that the light of the stars is also, no less than water, supremely fit for life, again in a multitude of different ways. Moreover, again, as in the case of water, this fitness is not merely for simple microbial life, but for large complex organisms such as ourselves. It is fit to provide the warmth upon which all life on the earth's surface depends. Lt is fit for photosynthesis, which generates the reduced carbon fuels, whose oxidation provides energy for all complex life on earth, and it is fit for vision, the key adaptation through which our own species gained knowledge of the world.

1998
David Clark, Editor and Contributor
Of Heaven and Earth: Reconciling Scientific Thought with LDS Theology
Book

Philip F.Low

For the forty-five years I was on the faculty at Purdue University, I taught classes on the physical chemistry of soils and conducted research on that subject. Throughout my life I have been an active member of The Church of Jesus Christ of Latter-day Saints and have served in several of its administrative offices, including district president, stake president, and regional representative. Being deeply involved in both science and religion for so long, I have often observed how they seem to reinforce and contradict each other. For peace of mind, I have been obliged to develop a philosophy in which science and religion can be integrated in a rational way. My purpose in writing the present article is to share this philosophy in the hope that it might be helpful to someone else. Naturally, the religious aspects of the philosophy are based on the tenets of The Church of Jesus Christ of Latter-day Saints.

The Age of Earth and the Creation of Man
Conflicts between science and religion seem to arise mostly in regard to the age of Earth6 and biological evolution. I cannot speak authoritatively on how these conflicts can be resolved because I am not a geologist, nor a biologist, nor an official apologist for the LDS Church. Further, it is unlikely that sufficient information currently exists to allow any permanent resolution to be reached. If the scriptures could be entirely reconciled with the scientific theories of today, they could not be entirely reconciled with the scientific theories of tomorrow, because these theories are constantly changing. Nevertheless, I will offer a few tentative ideas about the creation of Earth and the creation of man.

Although the scriptures tell us that Earth was created (organized) as a habitat for God's children, they were not intended to be textbooks of geology, and so they do not tell us how our planet was created. The details of creation were left for us to seek as we search for truth. As some of these details have come into focus, they sometimes appear to contradict the scriptures. In particular, the scriptures seem to support the concept that Earth was created in a period of six days, but scientific findings support the concept that it took millions of years for Earth to reach its present state. The evidence for the latter concept is overwhelming, and I subscribe to it. Therefore, I am of the opinion that the scriptures in question have suffered from errors in writing, translation, or interpretation.

Regarding the scriptural account of Earth's creation, I would like to make two observations. Both are based mostly on the Pearl of Great Price because its account of the creation is more informative and likely more accurate than that given in the Bible. An excerpt from the creation account in Abr. 4:1-8 follows:

> And then the Lord said: Let us go down. And they went down at the beginning, and they, that is the Gods, organized and formed the heavens and the earth.
>
> And the earth, after it was formed, was empty and desolate, because they had not formed anything but the earth; and darkness reigned upon the face of the deep, and the Spirit of the Gods was brooding upon the face of the waters.
>
> And they (the Gods) said: Let there be light; and there was light.

> And they (the Gods) comprehended the light, for it was bright; and they divided the light, or caused it to be divided, from the darkness.
>
> And the Gods called the light Day, and the darkness they called Night. And it came to pass that from the evening until morning they called night; and from the morning until the evening they called day; and this was the first, or the beginning, of that which they called day and night.
>
> And the Gods also said: Let there be an expanse in the midst of the waters, and it shall divide the waters from the waters.
>
> And the Gods ordered the expanse, so that it divided the waters which were under the expanse from the waters which were above the expanse; and it was so, even as they ordered.
>
> And the Gods called the expanse, Heaven. And it came to pass that it was from evening until morning that they called night; and it came to pass that it was from morning until evening that they called day; and this was the second time that they called night and day.

One possibility is that after Earth was organized and formed, it may have remained in an empty and desolate condition before the accounting of time began. Hence, it could have aged in this condition for unmeasured eons. Now consider the creative periods that followed. In verses subsequent to those cited, the Gods continued to redefine night and day after each creative period, and they continued to equate the number of creative periods with the number of times they had defined night and day. What significance can be attached to this unusual procedure? Did the definition prescribe the units of time that should be used in measuring the duration of the creative period? Also, how long was the duration of each creative period in conventional units? The answers to these questions would certainly be helpful in resolving arguments about the age of Earth.

Now let's consider the creation of man in light of the following scriptures:

> So God created man in his own image, in the image of God created he him; male and female created he them. (Gen. 1:27)
>
> And the Lord God formed man of the dust of the ground, and breathed into his nostrils the breath of life; and man became a living soul. (Gen. 2:7)
>
> And God saw these souls that they were good, and he stood in the midst of them, and he said: These I will make my rulers; for he stood among those that were spirits, and he saw that they were good; and he said unto me: Abraham, thou art one of them; thou wast chosen before thou wast born.
>
> And there stood one among them that was like unto God, and he said unto those who were with him: We will go down, for there is space there, and we will take of these materials, and we will make an earth whereon these may dwell;
>
> And we will prove them herewith, to see if they will do all things whatsoever the Lord their God shall command them. (Abr. 3:23-25)
>
> So the Gods went down to organize man in their own image, in the image of the Gods to form they him, male and female to form they them. (Abr. 4:27)

> And the Gods formed man from the dust of the ground, and took his spirit (that is, the man's spirit), and put it into him; and breathed into his nostrils the breath of life, and man became a living soul. (Abr. 5:7)

From these quotations we learn that spirits existed in the presence of God before Earth was organized, that man (and woman also) was formed in the image of God, that he was formed from the dust of the earth, that his spirit was put into his body, and that he became a living soul when the breath of life was breathed into his nostrils. But we do not learn the process by which the body of man was formed. I suggest that this process could have involved some aspects of evolution as described by modern science and that it could have continued until the body was "in the image of God," at which point it was a fit abode for a divine, preexistent spirit. Then the spirit of Adam, our common progenitor, was put into his body, and he became a living soul. By reason of his divine spirit, Adam was distinguished from all forms of life that preceded him. This spirit endowed him (and his progeny) with special attributes, particularly the ability to reason. As a result, he could "subdue" the earth and "have dominion . . . over every living thing that moveth upon the earth" (Gen. 1:28).

Regardless of the means by which Earth and man came into being, I believe that God was in charge. This belief stems from my religious philosophy, but there also is scientific support for it. In science there is a quantity called the entropy. This quantity is a measure of the degree of disorder, randomness, or disorganization of the matter in any system (region in space). The higher the entropy, the greater the degree of disorder. Thermodynamic theory dictates that the entropy of a closed system (a system with boundaries that are impermeable to matter) increases as the system proceeds spontaneously toward equilibrium and that the entropy is at maximum at equilibrium. If Earth was a closed system, the original Earth should have become progressively more disordered with the passage of time. But the opposite is true. Earth now exhibits order and beauty, whereas it was once chaotic according to science and "without form, and void" and "empty and desolate" according to religion (Gen. 1:2; Abr. 4:2). It is reasonable to conclude, then, that Earth's development from a chaotic condition to an orderly condition did not proceed spontaneously. Because of energy from the Sun, Earth is not a closed system. In my opinion that additional force or influence emanated from God.

Biochemistry Affirms God's Creative Role

My son Philip S. Low holds the rank of Distinguished Professor of Chemistry at Purdue University, where he teaches and conducts research in biochemistry. He is an active, orthodox member of the LDS Church, and we often discuss the issues of science and religion. I would like to present a few of the ideas that he has shared with me.

The concept that life evolved from a single living cell may seem to simplify the theory of evolution, but it does not answer the fundamental question of how the living cell originated. The probability is infinitesimally small that (1) elements like carbon, hydrogen, oxygen, and nitrogen came together accidentally in the right proportions, arrangements, and energies to form simple molecules like amino acids; (2) that such simple molecules came together accidentally in the right proportions, arrangements, and energies to form complex molecules like proteins; (3) or that such complex molecules came together accidentally in the right proportions, arrangements, and energies to form extended, organized structures like the nucleus or mitochondrion.

And since the probability of a succession of events is the product of the probabilities of the separate events, the probability that the components of the living cell were formed accidentally is virtually zero. But even if this probability had a finite value, an intriguing question would still remain: what causes these components to perform the vital functions of the cell in a cooperative

and harmonious way? In other words, what endows the cell with life? The above questions are more easily understood if we recognize the influence of an omnipotent, omniscient creator.

The concept that the spirit of man gives life to what would otherwise be an inanimate body is consistent with what is known about the chemistry of life's processes. Biochemists endeavor to understand and describe the molecular processes that collectively constitute a living organism. They have found that, with proper precautions, the organelles, cells, enzymes, and substrates within a tissue can be maintained in good functioning condition for hours, if not days, after their isolation from the tissue. This finding demonstrates the durability of the chemical structures and reactions that contribute physically to life. Virtually all biochemists will agree that the biochemical systems in the body lose their functionality slowly and that the biochemistry of the body remains unchanged from one second before death to one second after death. However, death is always an event that occurs in a moment, regardless of whether it is caused by heart failure or a severe blow to the head. Consequently, the most plausible explanation for the suddenness of death is the separation of the body from the spirit that gives it life.

Another religious concept that seems to defy scientific logic but that is actually consistent with scientific observations is the concept that our bodies will be immortalized following this earthly existence. Biological immortality has been a well-established fact for a long time. For example, many years ago a woman named Henrietta Lacks died of cervical cancer. So that the cause of her cancer could be studied, the malignant tissue was removed and cells derived therefrom were proliferated in a nutrient-rich growth medium. Since the cells multiplied rapidly, they were frequently separated into batches, transferred to fresh media, and shared with other interested scientists.

Now, decades later, these so-called HeLa cells are maintained in culture in numerous research laboratories around the world for use in the study of cancer. Simply stated, HeLa cells from the cancer of Henrietta Lacks are immortal and will live and grow for as long as they are nourished. Further, there are many other cell lines that have arisen from other patients' cancers that are equally immortal. It is important to note that this kind of immortality is not characteristic of normal, nonmalignant cells. Normal, nonmalignant cells express genes that ensure cell death at the end of a definite life span. To be specific, genes encoded in the DNA of normal cells ensure that the cells can divide fewer than one hundred times before they must die. In other words, they confer mortality on the cells. Cellular immortality arises when one or more of these genes mutates to a dysfunctional state, thereby allowing the cell to live indefinitely. Thus death is clearly a predetermined process prescribed by specific genes in all living organisms, and it is destined to occur unless these genes are changed or removed. Consequently, it is tempting to speculate that immortality can be imparted to man by the simple deletion of a select few mortality genes. It is also interesting to consider that the gradual shortening of the life span of man documented in the Old Testament could have arisen as mortality genes were gradually induced and expressed themselves.

The Soil Affirms God's Creative Role

Most living things depend directly or indirectly on the soil for their sustenance. This makes soil a very important part of nature, one that should manifest the handiwork of God if, indeed, he was the Creator. Let's consider how the soil lends support to the concept of a divine creation.

Clay particles in the soil are so small that the combined area of their surfaces can reach eight hundred square meters per gram. Many of these particles are composed of very thin crystalline layers that are stacked one above the other like the leaves in a book. When such particles are placed in contact with water, the water penetrates between their superimposed layers and forces them apart. As a result the clay swells. In a fully swollen clay, the interlayer of water can be forty

times thicker than the layers themselves, and the weight of the water can be more than fifteen times that of the clay. Thus clay is able to hold enormous amounts of water. Moreover, the process of soil formation tends to concentrate the clay in a region just below the soil surface. The overall result is that rainwater is retained in the root zone of plants and thus is more available to them.

Clay particles carry a net negative charge of high density due to ionic substitutions within their crystalline layers. Consequently, cations (positively charged atoms) are strongly attracted to them. This attraction keeps the cations from moving away from the layers. Since many of the major and minor plant nutrients are cations, they tend to remain where the clay is concentrated, in the root zone of plants. In this manner plant nutrition is facilitated.

The source of many plant nutrients is the rocks from which the soil is formed. For these nutrients to become available to plants, the mineral constituents of the rocks have to dissolve in the soil solution. Water is the ideal solvent for this purpose. No other solvent known to man would be as effective. Furthermore, water is ubiquitous. Without its solvent action in the soils of Earth, the processes that sustain life would stop.

The amount of heat required to raise the temperature of a substance by one degree is called the specific heat capacity. Water has a high specific heat capacity, and this characteristic allows it to serve a useful purpose. The presence of water in the soil prevents sudden or extreme changes in soil temperature because more heat has to be absorbed or released to effect a given change in temperature. Therefore, water helps to ameliorate the climate of the soil.

The strong interaction between clay surfaces and the adjacent water depresses the freezing point of the water. As a result, water next to the clay surfaces remains unfrozen at sub-zero temperatures even though the water farther removed from these surfaces freezes. Thus, a film of unfrozen or liquid water is interposed between clay surfaces and ice in a frozen soil. The thickness of this film depends on the temperature. It becomes thicker as the temperature rises. Minerals can still dissolve in this water, ions can still diffuse through it, and it can still flow along a pressure gradient. This means that during the winter, plant nutrients can be replenished and active plant roots can be supplied with nutrients and water, albeit at a slow rate.

Microorganisms in the soil decompose organic matter incorporated therein. In the process of decomposition, plant nutrients are released from the organic matter. Also, organic acids are produced, and they promote the release of plant nutrients from soil minerals. But the decomposition does not go to completion. A residue of partially decomposed organic matter, called humus, resists further decomposition. Humus gives the soil its black color, which is conducive to the absorption of radiant energy. It also stabilizes soil aggregates and thereby improves the tilth and permeability of the soil.

Another important function of soil microorganisms is to decompose the vegetative litter that would otherwise accumulate and eventually kill the plants that produce it. Accumulated vegetative litter would prevent sunlight from reaching the plants and reduce their supply of oxygen.

From what has been said, soil is obviously much more than what appears to the naked eye. Its properties, and the reactions and processes that occur within it, make it an ideal medium for plant growth. Without it, life as we know it could not exist. In this regard it is important to note that although plants and animals may have adapted to the soil, the soil did not adapt to plants and animals. Consequently, the soil could not have evolved like life is supposed to have evolved, for example, by natural selection. Under any given conditions, the characteristics of soil millennia ago must have been the same as they are today. When Earth was formed, these characteristics came

into being either by design or accident. In view of this, I believe they came into being by the grand design of God.

Chapter 3 - Henry Eyring
World of Evidence World of Faith

Essay 1: the Physical and Spiritual Worlds
My wife and I have a lot that is sixty feet across the front, one hundred feet deep, and extends straight up to the limits of space, so far as I know. Clearly, this qualifies me to speak on the broader aspects of the universe.

We live in a series of six worlds, from the infinitesimally small to the infinitely big. They can be represented by a point surrounded by five circles. This essay deals with the five physical worlds of the nucleus, the atom, the living cell, everyday experience, and the stars, as well as the sixth, or spiritual, world.

The Nucleus
The first, or central, world is the world of the atomic nucleus. The nucleus is where most of the weight of the atom is situated. One hundred thousand atomic nuclei touching each other in a line extend only across one atom, and it takes one hundred million atoms to make one inch! Vibrations inside the nuclei of atoms are about a million times more frequent than the vibrations between atoms.

It is natural to wonder how anything as small as the nucleus can have structure, and even if it does, how we can find out about it. The procedure for finding out is to shoot electrically charged atoms or electrons at nuclei and see how they bounce. This tells us a great deal about the kinds of forces that are acting between the colliding particles.

When a particularly violent collision results in penetration into the nucleus and causes it to fragment, we can watch the tracks left by the fragments in a cloud chamber. In this way we find out that the nucleus is made up of positively charged protons and uncharged neutrons of virtually the same weight.

For twenty-five years, scientists accepted parity, the principle that an atom does not know which end is up and has the same properties in all directions. However, an experiment suggested by Yang and Lee, for which they were given the Nobel Prize, showed otherwise. If we put radioactive cobalt sixty in a magnetic field, its nuclei line up with their south poles pointing toward the north pole of the earth. Every once in a while, one of the cobalt nuclei shoots out an electron. If the nuclei were indeed symmetrical, they would be equally likely to eject the electron through the north pole as through the south pole. However, a Geiger counter similar to the kindused to prospect for uranium reveals that the electrons are shot out preferentially through the nuclear south pole. Thus, the principle of parity must be given up.

Now the scientists have introduced quarks, fractional particles having a charge of one-third. When quarks were proposed in the early 1970s, they were conceived of as being undivided particles, although their charge was fractional. More recent observations have indicated the existence of one-dimensional conductors called solitons, which have fractional charge and a fractional electron number.

By such experiments we come to understand something of the complexity and intricacy of this almost unimaginably tiny world of the nucleus. One hesitates to speculate whether we have even yet found the indivisible building blocks of the physical world.

The Atom

The second world is the world of chemistry, made up of atoms and molecules. This, too, is a tiny world. I noted earlier that it would take one hundred million atoms placed side by side to make an inch. A molecule finishes one of its vibrations in about a ten million millionth of a second. We call this length of time a jiffy for lack of a better name. The quartz-crystal watch you wear on your wrist derives its great accuracy from such rapid vibrations.

An example of the exactness with which the universe works is found in the ammonia molecule. Ammonia consists of a nitrogen atom sitting on three hydrogen atoms. The startling fact is that this umbrella-like molecule turns wrong side out almost twenty-four thousand million times a second. If you beam radar through a tube containing ammonia, the signal fades just when the radar frequency equals the inversion frequency of the molecules. In this way the ammonia molecules can be used as a clock to break time up into twenty-four thousand millionths of a second with unprecedented accuracy. It is interesting that this ammonia molecule turns wrong side out just as often whether it is at room temperature or at the lowest temperature obtainable in the laboratory, whether in Soviet Russia or the United States, and whether this country is Democratic or Republican. Many things we think are important don't seem to affect the ammonia molecule much. The accuracy and order of the universe continue without regard to fashions in hairstyles, clothes, politics, science, or religion. What's true is true. What works, works.

When I went to Berkeley in 1925 to pursue my Ph.D., no one could explain more than a tenth of the attraction of two hydrogen atoms for each other. We knew that each hydrogen atom was uncharged, being made up of a positive nucleus whose charge was just neutralized by the charge on a negative electron. True, the atoms could distort each other and give about one-tenth of the observed binding energy, but the remaining part of the bond was a mystery.

The complete answer supplied by quantum mechanics was that the electron pair, by keeping out of the way of each other as they circulated around the two nuclei, could spend enough time between the two positive nuclei to glue them together to just the observed amount.

In order for the pair of bonded atoms to exchange partners with a similar pair, thus making a new compound, the pairs must approach each other closely. Accordingly, as two pairs of bonded atoms bump into each other, they can only approach and change partners if one or the other pair of electrons is pushed out of the way into an upper state. This collisional work that has to be done so a chemical reaction can take place is called the energy of activation.

Using this picture of the energy of activation accompanying a chemical reaction and building on the labors of my many able predecessors, it was possible for me, in 1935, to write down the general equation for the rate of all chemical reactions. This equation has become an integral part of chemistry, used universally.

The excitement of standing, in imagination, at a pass between two energy valleys representing the initial and final states in a chemical reaction and counting the activated complexes as they make their way over the pass in shattering collisions in which atoms are exchanged between the two colliding molecules is the thrill of a lifetime.

Further, to find that wave mechanics and thermodynamics, which have had so many other triumphs, are the same tools that enable us to quantitatively explain this all-pervading aspect of the material world in which we live brings a feeling of awe at the order and exactness of the universe that is never forgotten.

The Living Cell

The third world in which we live is the world of the living cell, the world of biology. Cells vary in size, but typically they are about a micron across, that is, about one ten-thousandth of a centimeter. An active cell divides into two cells about every twenty minutes.

The word life itself conjures up animation, movement, excitement, and perhaps a little mystery. Discussions of the origin of life disturb some people. Some are particularly disturbed by scientists who "tamper with creation" and actually try to start life in a laboratory. It would disturb me more to find that life couldn't be started in a laboratory. If life can't be started somehow in this physical world, then how did I get here? You see, I think I'm alive, although some of you might observe me dozing at my desk and wonder.

The human cell has near its center a nucleus containing forty-six chromosomes. Twenty-three of these come from the father and twenty-three from the mother. The chromosomes are made up of about a million genes that constitute our inheritance. A gene controls the synthesis of essential molecules, such as enzymes, that build and regulate our unbelievably complicated bodies.

A colleague, Frank Johnson, and I once wrote a paper of evolution and rate theory, "The Critical Complex Theory of Biogenesis." This paper outlines a theory of prebiological evolution. One of the principal questions addressed is why living things are optically active.

The body is made up of many types of molecules, just as a large building may be made up of many types of brick. Many of these molecules are asymmetrical, and frequently one optical isomer is found to occur in living things to the virtual exclusion to its mirror image. We can understand this selective choice of building blocks if we recognize that the body is built up by molecules that are incorporated into the body from the food we eat. This section is made by a process of fitting the molecules to the enzyme much as a left hand selects a left-hand glove and rejects a right-hand glove.

Muscles and enzymes are made by joining amino acids together into long chains called proteins. There are twenty different amino acids that are joined together in different proportions to form the links in the various types of protein chains. Of these twenty amino acids used by the body, all but one are asymmetric. Further, all the nineteen asymmetric amino acids used are like the left-hand glove and are called l-amino acids. In every living thing, the opposite optical isomers, which are called the d-amino acids, if present in the food, are rejected by the enzymes that build proteins, and are eliminated from the body. We therefore call this world we live in an l-amino acid world. The l comes from laevo, the Latin word for left; and d stands for dextro, or right.

Using absolute rate theory, Johnson and I arrived at a reasonable rate of appearance of these optically active templates, given assumed concentrations of certain chemicals in the primordial "soup."

The interesting thing is that from any given pot of "soup" it is as likely that a d- as an l-type world will start up. We can readily imagine a d-amino acid world. In fact, if we look into a large mirror, the world we see is a d-amino acid world, since every object, including the molecules, is the mirror image of those in the real world. Obviously, everything in the d-amino acid world would work exactly as well as everything in our real world, and it is a matter of no obvious consequence which world we happen to have. If there are other worlds that support life, there is no reason for supposing that they may not be d-amino acid worlds. If so, such worlds would be completely inhospitable to us, since we could not digest their foods, and marriages between people coming from d and l worlds would necessarily be sterile. On the other hand, there is, of course, no reason

why people from two such worlds might not converse with each other with complete understanding, and one could not tell the two types of people apart by their appearance.

The fact that in our world every living thing, from the tiniest living cell to man, uses only the l-amino acids along with the d-sugars highlights the unity running through the living world. Everything that grows collects those particular optical isomers needed for food and rejects the opposite isomers. Here again, we catch a glimpse of the unity that everywhere characterizes the cosmic design.

Everyday Experience

The fourth world is the world of everyday experience. Here, we measure time in seconds or minutes, and distances in feet or miles. This is the world we know most about.

Since Sir Isaac Newton discovered the universal law of gravitation and developed the laws of mechanics, his successors have been able to calculate the motion of the planets in their orbits to any desired degree of accuracy. Astronomers predict exactly when an eclipse will occur. Using this knowledge, men make great preparations, assemble expensive scientific equipment, and move to the ends of the earth when told that an eclipse is imminent. They get their cameras ready to take pictures and open the shutters at the right moment, and the eclipse begins at the predicted instant. If the eclipse were ever so little off schedule, it would make headline news around the world.

These same laws that enable astronomers to compute eclipses tell precisely, of course, how a satellite goes around in its orbit. A man who makes a good running broad jump only misses becoming an earth satellite by not running fast enough. Thus, if instead of running twenty miles and hour he ran twenty thousand miles an hour, he would find that as he jumped, the earth would curve away beneath him faster than he could fall toward it. Our jumper would settle into an elliptical orbit extending around the earth, except for one thing-the air resistance would slow his speed and set him on fire. To avoid air resistance, the satellite is shot above the atmosphere. This is the only reason for sending it up six hundred miles.

Satellites like Sputnik and the moon have a terrifically frustrating job. The moon has been falling toward the earth and overshooting the mark for billions of years and still has no prospect for a successful hit. Man has not succeeded in sending satellites up to such complete frustration yet. The reason is simple. Even at altitudes of six hundred or a thousand miles there is still a trace of hydrogen left. As the satellite circles the earth, it bumps into gas. When it has bumped into a weight of gas equal to its mass, its momentum is cut in half, except that by falling closer to the earth it picks up additional speed. Still, it is a remarkable human achievement to launch a satellite and in a small degree become a partner in creation.

All such achievements rely on the fundamental belief that the everyday world is exactly predictable. We may not yet know or completely understand the rules of when earthquakes occur, or what causes surprises for the weatherman, but we are sure that such events are not really capricious. The more we learn, the better we understand and the closer are our predictions.

The Stars

If we look at the stars, we see the fifth world. Men have probably always looked up and wondered: How far away are the stars? What makes them shine? How long have they been there? Will they exist forever? Some have believed that the stars were gods who controlled their destiny. Others noticed the regularity in the grouping of stars and used their knowledge of stellar movement to help mark the passage of the seasons and fix the times of planting and harvesting. The early Greeks believed the stars were fixed like nails to the vault of the heavens. Aristotle maintained

that celestial objects were permanent, immutable, and perfect. He so convinced the Greeks of this that when a new star appeared in 134 b.c., it was attributed by its discoverer to an omission by his predecessors.

In the Middle Ages, Copernicus showed that the earth was not the center of the solar system. But Aristotle's thinking continued to dominate astronomy until the 1500s when new stars were discovered, and then in the seventeenth century when Galileo used his telescope to discover spots on the sun-demonstrating that the solar complexion was somewhat less than perfect-and to prove that the sky was filled with stars that could not be seen with the naked eye.

Just so you know how old I am, I can remember when astronomers, using ever-larger telescopes, discovered that some of the "stars" thought to be part of the Milky Way were actually other galaxies-each containing billions of stars and lying far beyond the Milky Way's outermost limits.

Even so today, as we look out at the universe, the first impression is one of stupendous size. By using such instruments as the huge two-hundred-inch optical telescope on Mount Palomar and new radio, X-ray, and gamma-ray telescopes, modern-day stargazers have pushed the frontiers of understanding ever closer to the edges of the universe and into the very cores of stars. We can see out so far that the light reaching our eyes started on its journey toward us almost twelve billion years ago. You remember how fast light travels: 186,000 miles a second; it goes around the earth, a distance of twenty-four thousand miles, seven and one-half times in a second. A light-year is the distance that light travels in a year-about six trillion miles. If you multiply twelve billion years by six trillion miles, you get a seven followed by twenty-two zeros for the number of miles you can see in any direction you care to look. The known radius of the universe in miles is even bigger than the national debt. It is a very long distance indeed.

When you walk outside on a clear moonless night, all the celestial objects you can see with the naked eye are either planets or stars, or, if you have superman vision, you might be able to see the Andromeda galaxy that looks like a fuzzy star. All the stars you see are part of our own Milky Way galaxy. The closest star, other than our own sun, is Proxima Centauri, four light-years away. At our present rates of space travel, this journey would require one hundred twenty thousand years. Consequently, we seem to be marooned in our solar system, at least for the time being. Present missile travel, which proceeds at a speed about a thousand times as fast as man can run, will need to be speeded up by another factor of a thousand before we can undertake trips beyond our solar system.

Some scientists believe that the universe is the expanding remnant of a huge fireball created 20 billion years ago by a giant explosion. The stars and planets are the products of that cataclysmic blast and its aftereffects. In 1929 astronomer Edwin Hubble used shifts in the spectral lines of light coming from distant galaxies to calculate that these islands of stars are moving at tremendous speeds away from the earth-and from each other-like dots painted on the surface of an expanding balloon. Scientists at Bell Laboratories have even listened with their sensitive radio antenna to radiation interference, which amounts to the hissing echoes of creation: "In the beginning God created the heaven and the earth. And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters. And God said, Let there be light: and there was light" (Gen. 1:1-3).

Most cosmologists-scientists who study the structure and evolution of the universe-agree that the biblical account of creation, in imagining an initial void, is uncannily close to the truth. I might add, it is as if the one who wrote those words was there, or at least had talked to Someone who was.

Are we the only worshippers in this great cathedral called the universe? Professor Harlow Shapley, emeritus professor of astronomy at Harvard University, has written an interesting book, Of Stars and Men (New York: Washington Square Press, 1960), in which he estimates that there are one hundred million, million, million, million suns in space. Shapely has very conservatively estimated that at least one sun in a thousand should have acquired planets. Most of these satellites are at such distances from their suns that they are either too hot or too cold to support life as we know it. Still others lack life-giving water, while others lack the necessary oxygen. However, Shapley has estimated that of those suns with planets at least one in a thousand has a planet at the right distance for life.

Of those having a planet at the right distance, at least one in a thousand should have a planet large enough to hold an atmosphere; and, finally, one in a thousand of those having a large enough planet at the right distance should have an atmosphere of the right composition to support life. Thus, he concludes that there should be at the very minimum one hundred million planets that could support life, and the number is probably many times more. From the scientific point of view, it is hard to doubt that myriads of worlds are suitable for human habitation.

It is accordingly natural to conclude that the universe is filled with intelligent beings and, presumably, always has been. Any unfolding of intelligences on this earth only repeats what has happened previously elsewhere. Even if we believe beings on distant planets have progressed far beyond us, still the barrier to travel posed by interstellar distances seems quite sufficient to explain why mortal space travelers have not visited us.

So we envision a still-expanding universe that began almost twenty billion years ago, extends for twelve billion light-years, and contains ten billion galaxies-each one an island of hundreds of billions of stars. Actually, we also need to add the dimension of time. We see our nearby sun as it looked a little more than eight minutes ago. We see Proxima Centauri as it was about four years ago, and some of the farther galaxies as they looked billions of years ago. The farther out we look, the further we are looking back in time. Some objects we see may no longer exist.

With all that we do know, it is obvious to the serious student that there is a great deal more that we don't know. To the ultimate question-what existed before the big bang-most of modern science is mute. It's as if it were against the rules to ask questions when there isn't any scientific way to approach the answers. It's still a nice question though, isn't it?

From nucleus to galaxies, the universe is complex, orderly, consistent, and very, very interesting. It is also full of energy and motion. There is something peculiar about that.

If you picked up a watch far from human habitation and found it running, you would ask not only "Who made this watch?" but "Who wound it up?" So it is with the universe. The universe is running down. It is a universe of change. People are born and pass from the earth, and stars, too, come into existence and pass away.

The sun is about half hydrogen; the rest of it is composed of other materials. The hydrogen bomb shows us what happens to hydrogen down in the center of the sun where the pressures and temperatures are enormous. Four hydrogen atoms come together to make helium, andin the process a little of their weight is changed into energy. This energy falls on the earth as sunlight and makes the plants grow.

Thus, the sun is a giant furnace with a supply of hydrogen for fuel-quite a good supply. But if the sun ever burns out, it is going to be very cold in Salt Lake City. You might like an estimate of the

fuel supply on hand. I would say the supply should last at least five billion years, so we don't need to worry about it right away.

This picture of the sun as a furnace with a limited amount of fuel poses interesting problems. The second law of thermodynamics is a formal statement of the familiar fact that if energy is being obtained continuously from some source, then the supply of energy must run out sometime unless it is replenished from an outside source. As with any woodpile, if you keep burning up the hydrogen on the sun, it must ultimately be used up unless it is replenished. There is evidence that in the last billion years the sun's temperature has never varied by the small amount that would make the earth unfit for habitation.

It is a well-known fact of experience that if we set a pot of boiling water on a table in a cool room, the pot cools, and when once cooled it never returns to the boiling point without being reheated. In just the same way, the sun is giving off its heat and very gradually growing colder. When the sun ceases to shine, all living things will die; all changes will cease, and the world will reach a deadly, monotonous uniformity. This state is called the heat death and is a consequence of nature always moving toward more probable states and never in the reverse direction toward less probable states.

An interesting calculation illustrates the complete improbability of a hot sun arising by change. We suppose that in order to become hot again, the sun must accumulate an amount of heat equal to that which it gives off during its lifetime. This must be accumulated from its surroundings, which we shall assume in the heat death drops to a temperature of seven hundred degrees centigrade. Then, using the straightforward theory of chemical reactions, we find that a length of time in years equal to at least one with a hundred thousand billion, billion, billion, billion, billion zeros must elapse before a hot sun has a 50 percent probability of occurring again by chance. This is almost no chance at all! A universe filled with hot suns is no more likely. It is evident that our hot sun, or this universe, did not arise by such a chance fluctuation.

In a very real sense, then, the universe is like a clock that has been wound up. If it is self-winding, it is unique in scientific experience. In a talk before the National Academy of Sciences, I raised the obvious question, "How did the universe get wound up?" No one chose to answer. After the talk, I repeated my question privately to three scientists. President Millikan of the California Institute of Technology said, "I, like you, am a religious man." Professor Van Vleck of the Harvard physics department said, "Of course, one doesn't know." The third man said, "Don't you believe in your religion?" I answered, "Yes, but I wondered about yours."

The Sixth or Spiritual World

The five physical worlds display order and complexity. The second law of thermodynamics tells us that, even if we can explain this complexity, we have a problem of how it all got started within the working of the natural laws as we understand them. This leaves scientists no better off than anyone else. We all have to rely on a very small measure of information and a very large measure of faith.

This brings us, then, to the sixth world, which includes and surrounds all the others. This is the world that existed before the "big bang." It is the world of the Creator, who provided the energy to wind up the watch and the knowledge and power to establish the complex order we have come to understand in the five physical worlds. As far as we know, this sixth world is without beginning and end of space and of time. Presiding over all is the Creator, whom we worship. Holding everything together are the eternal laws, which will require an eternity for us to master.

One of the first Soviet cosmonauts who circled the earth in space boasted on his return that he hadn't seen anything of God on his journey. This raises the interesting question of where the sixth

world and its inhabitants are. Is heaven part of the physical universe as we know it, or is it in some other time and space-in another dimension?

Let's consider the notion of postulates. Postulates are those fundamental propositions that are assumed without proof, generally because there is no way to prove them other than to see if the theories built on them predict events that are then verified by experiments. For example, we all learned as part of our high school geometry class the postulate that parallel lines never meet. This is a postulate of euclidean geometry. However, if you're willing to walk far enough, I can show you a problem. If you and a friend both start out at the equator and walk due north, you are walking parallel paths. You both start out a right angles to the equator. But, you will meet at the North Pole! (You can check this out by looking at two different degrees of longitude on a globe. Each intersects the equator at a 90-degree angle, but they meet at the poles.) The problem is that plane geometry works only on a plane-a flat, two-dimensional world. It doesn't work when the plane curves into a third dimension.

This points up the importance of examining our postulate, our assumptions. Whether or not a particular theory actually predicts reality is more a function of the underlying assumptions than of the elegance of the proof itself. Thus, euclidean geometry is perfect for the flat world for which it was designed, but it results in poor predictions in a three-dimensional world.

The avenue to religious faith lies in the examination of evidence. The Lord himself outlined the procedure when He said, "If any man will do his will, he shall know of the doctrine, whether it be of God, or whether I speak of myself" (John 7:17).

The existence of the sixth world is necessary to an understanding of the other five. Put another way, the existence of the five worlds can be adequately explained only if we assume the existence of the sixth world. Of course, we can also look for evidence of the sixth world in history, and we can look for the evidence directly, by exercising that part of us that shares that other, spiritual dimension.

I worship the wisest being in the universe. I know there is a wisest being in the universe because you can take the wisest person in a room and say, "This is the smartest man in the room-and his wife is smarter." And then you can find the smartest person in the city, then state, then country, then world, then universe. I worship the wisest being in the universe. I know there is such a being. How could there not be? People are different in understanding, and there are lots of them. There must be one who is the smartest.

So I know there is a God. You say, "That still isn't religion." I say, "It is to me, because I can't believe that this wisest being in the universe wants anything except justice." You see, I know some things about Him. If you went out in your car tonight and were hit by a drunk driver and killed, there are others who would say, "Isn't it a tragedy that he couldn't live out his life, that he was cut off?" And do you know what they would do if they could? They'd give you another chance.

The wisest being in the universe is surely as compassionate as these good neighbors that we have. He must like justice and not injustice. So I know there is a God. Because otherwise the world would be unjust. This idea takes us a long way toward understanding God. He exists. He is compassionate. He loves justice and relates to us. We are His children. Isn't that a comforting thought? I'm sure of it, but you don't want to believe anything I say unless it's true.

I can say that I am certain that God is just as real as anybody I know, and that He likes me. And that He likes you too. Those are my postulates for the sixth, spiritual world. They perform exactly

the same function in helping me understand the sixth world as the postulates of science do in helping me understand the other five.

Henry Eyring Sr.
Essay 2: Faith and God

The more I try to unravel the mysteries of the world in which we live, the more I come to the conception of a single overruling power-God. One can come to this point of view by prayer and the testimony of the Holy Ghost, or because there seems to be no other explanation of the unity and wonder of the universe, or by the pragmatic method of science that the Savior suggested long ago-try it and you will know.

I have often met this question: "Dr. Eyring, as a scientist, how can you accept revealed religion?" The answer is simple. The gospel commits us only to the truth. The same pragmatic tests that apply in science apply to religion. Try it. Does it work? The conception of a God ruling the universe and concerned with how it works is impossible for me without the corollary that He should be interested in man, the most remarkable phenomenon in the world. Being interested in man, God naturally provided a plan for man's development and welfare. This plan is the gospel of Jesus Christ.

This immediately raises many questions. At best, men are faltering and imperfect. The Savior stands alone as the perfect example. The gospel is indeed the plan which the Creator of the universe has devised to guide His children and bring them back to Him. Through the ages, He has chosen from among His worthy sons prophets to act as guides to his children. Today, The Church of Jesus Christ of Latter-day Saints is presided over by good and wise men who instruct and counsel those who have the wisdom to listen.

In the great council of the premortal life, a tremendous decision was made that man was to have his free agency. This brings with it many interesting problems with tragic results. War and catastrophe are taken by some people to be evidence against the existence of God, or at least His unconcern for the evils that overtake man. I think this should be thought of in a completely different light.

Lucifer promised to bring salvation to every soul, whether the person to be saved desired it or not. Dictators have been operating in the same way from time immemorial. Never has there been a more concerted effort to take away free agency than in the modern communistic world where about 1 percent of the population rules through force and terror. God's non-intervention in human affairs is not a sign of His absence or His disinterest. Rather, it exemplifies one of His greatest gifts-free agency, which enables us to work out our individual salvation. If Lucifer were ruling the world, no one could doubt his presence.

There is a related argument that interests me. One sees good people cut off by death in their prime. This seems to me to be evidence for a life after death. It is impossible to reconcile such incompleteness with any other idea than that we will live again and that what we have lost through no fault of our own will be made up to us in full by a just God.

The wonderful gospel plan as advocated by the Savior in the premortal life, known by His prophets down through the ages and announced by him personally during his earthly ministry, has again been restored by the Prophet Joseph Smith, working as an instrument of the Father. With it we have a rational understanding of life. Eternal progression as a result of wise choices through the use of free agency gives the complete and satisfying explanation of the world in which we live and the struggles we are called upon to make. The success of man in sending satellites into space is arresting evidence of the great capabilities of and the destiny of man, the spirit child of God.

I, as mere man, instruct others. I am dedicated as a scientist, and the significant thing about a scientist is this: he simply expects the truth to prevail because it is the truth. He doesn't work very much on the reactions of the heart. In science, the thing is, and its being so is something one cannot resent. If a thing is wrong, nothing can save it, and if it is right, it cannot help succeeding.

So it is with the gospel. I had the privilege of serving with four other Church members in a conference in which, as a group, we undertook to answer the questions the assembled young folk might ask us.

One of the questions was addressed directly to me. A young man said: "In high school we are taught such things as pre-Adamic men, that kind of thing, but we hear another thing in church. What should I do about it?"
I think I gave the right answer. I said, "In this church, you only have to believe the truth. Find out what the truth is!"

If there is anyone else who is trying to teach anything else with authority, this church is not the least worried about that question or any other kind of question, because the Church is committed only to the truth. I do not mean to say that as individuals in the Church each one always knows the actual truth, but we have the humility sometimes to say we do not know the answers to these things. No Latter-day Saint needs to worry about any question of that kind, because the Church is committed to the truth.

Some have asked me: "Is there any conflict between science and religion?" There is not conflict in the mind of God, but often there is conflict in the minds of men. Through the eternities, we are going to get closer and closer to understanding the mind of God; then the conflicts will disappear.

In the great council in heaven, already referred to, two plans were offered-one whereby the minds of men would be compelled to accept the truth. There would be no choice. Man would make no error. The other plan was set forth by God. In His plan, man would have his free agency. He could decide between the Church of God and all other ways of operating in the world.

God rules from heaven. He does it with such silken threads that some think He has lost the reins. Some people do not even know that He exists. Others wonder whether He exists. I have often thought that a condition like this could never have come about if a dictator such as Hitler or Stalin were ruling.

God is so gentle, so dedicated to the principle that men should be taught correct principles and then govern themselves and take responsibility for their own mistakes, that His children can actually question whether He exists. I cannot think of anything that more wonderfully typifies His mercy, His kindness, His consideration for us, His concern for us, than that He does it all with bonds that are like the strongest steel but are so gentle that you cannot see them.

I do know that He exists. It is true, as great mean have known throughout the ages, that this great world we live in is governed by powers more powerful than those of the world. I ask you to look at the wisest man you know and ask yourself whether you believe he is the greatest intellect in the universe. Do you think the tremendous order and wonderful things that have come into the world were created by something with no more understanding than this wise man you know? Of course you do not. It is unthinkable.

I worship the Supreme Intelligence of the universe, and I am convinced that, wise as men are and in spite of the wonderful things they have done, the Creator of this universe goes so far beyond

anything that men understand that it is ridiculous to talk of the two in the same terms. So far as I have been able to observe, those who study deeply into scientific matters are often of that persuasion.

The Prophet Joseph Smith was indeed the inspired instrument in restoring the gospel of the Savior, as is shown by the way it works in the lives of men. Since all truth has a single source, the apparent conflicts that often trouble us reflect only our incomplete understanding and must eventually be happily resolved. Eternal progress is man's destiny.

Note
1. Reflections of a Scientist (Salt Lake City: Deseret Book Co., 1969), pp. 63-80; The Faith of a Scientist (Salt Lake City: Bookcraft, 1969), pp. 41-45.

Henry Eyring received degrees from the University of Arizona and the University of California at Berkeley. Following a brief period at the University of Wisconsin, he taught at Princeton until 1946, when he became dean of the graduate school and professor of chemistry at the University of Utah. His publications number more than six hundred. He was awarded fifteen U.S. and international honorary degrees, and he received eighteen prizes that include the National Medal of Science, the Priestly Medal, the Berzelium Medal of the Swedish Academy, and the Israel Wolf Prize. He was a member of the National Academy of Sciences and served as president of the American Chemical Society and the American Association for the Advancement of Science.

Dr. Eyring, who passed away in 1981, wrote two books that record his views concerning the integration of twentieth-century science with LDS theology. The following two essays, "The Physical and Spiritual Worlds" and "Faith and God," are adapted from those books, Reflections of a Scientist and The Faith of a Scientist, respectively.1

Chapter 4 - B. Kent Harrison
Truth the Sum of Existence

Creation of the Universe
Jesus Christ is a Creator; so there must have been a creation. What form did it take, and when did it happen? Gen. 1:1 suggests a moment of creation-but this presumably refers only to Earth. To find religious texts referring to larger assemblies than that, such as the entire universe, we must refer to other scriptures.24 D&C 76:24 speaks of creation, by the Only Begotten, of "the worlds" and their inhabitants. Is this the entire universe as we know it from astronomy and theory? No time scale is given in that scripture.

Moses 1:33 speaks of the creation of "worlds without number," and verse 35 says that many worlds have already passed away and that innumerable worlds yet remain. Joseph Smith's King Follett sermon and his sermon of 16 June 1844, both suggest an infinite extension of gods, although there is no agreement on exactly what his statements mean.25

Incidentally, when Joseph suggests in the King Follett sermon that matter can neither be created nor destroyed,26 he is essentially stating the law of conservation of mass-energy, a law currently and universally accepted in science but not known in his time. The Creation was an organization of preexisting matter. That this is our LDS belief-contrary to the theory of ex nihilo creation (out of nothing) of traditional Christianity and of creationism-has been clearly pointed out by numerous authors.27

The currently accepted scientific view of the origin of the universe is the "Big Bang" theory. According to this view, the universe-including the space and time in it-is presumed to have begun

at some definite moment in the past, expanding from an initially extremely small and extremely dense clump of matter to its present size. How long ago this took place is still very uncertain but is commonly estimated at 12-15 billion years. If there is enough gravitating matter in the universe, then it will eventually recollapse-fall back on itself. Then it may reexpand, perhaps many times (in which case it is said to "oscillate"). If there is not enough matter to make it fall back, the universe will expand forever. Within this theory, which of the two scenarios will take place is not known.

A number of persons, scientists as well as nonscientists, who are uncomfortable with the Big Bang's postulate of sudden initial expansion of matter and other features have sought alternative explanations of the universe's existence. For example, a rival theory called the "Steady State" universe competed for acceptance for a quarter of a century. It was abandoned because it could not explain the observed "microwave background radiation"-a constant radiation coming from all parts of the sky and apparently a result of the Big Bang.

Such observational evidence for the Big Bang indicates that that theory is in fairly good shape. However, many cosmologists currently believe-in order to explain some awkward features of the Big Bang-that after the initial event there was a tiny period of tremendous expansion called "inflation." There is also a new alternative explanation, one based on the idea of a recollapsing universe.28 For the interested reader, there are several good popular accounts of the current status of our scientific understanding of the creation of the universe.29

It is clear from the above comments that religion and science have little information in common regarding the Creation, except for the fact that (and this is in itself highly significant) there does seem to have been a specific creation. Whether our religious understanding of the creation of the universe is consistent with the scientific belief in the Big Bang is unclear. Ernan McMullin, speaking from the Roman Catholic point of view, observed, "What one cannot say is, first, that the Christian doctrine of creation 'supports' the Big Bang model, or second, that the Big Bang model 'supports' the doctrine of creation."30

In some versions of the "inflation" model, it is suggested that many additional universes could have come into being during inflation.31 Might these be new universes, awaiting the advent of those faithful individuals who inherit exaltation in the celestial kingdom?

The Big Bang's postulation that the universe suddenly comes into being sounds suspiciously like creation ex nihilo. Keith E. Norman raises the question whether modern cosmology in this sense might contradict LDS doctrine on the Creation as stated by Joseph Smith in the King Follett sermon and as noted earlier.32 My point of view is simply that, in the absence of information about a prior state, we cannot really say that the universe was indeed created out of nothing. (Incidentally, this "nothing," the vacuum, seems to be remarkably active in modern physics, because particles, maybe even universes, can come into or out of existence from the vacuum.) Our future prospects for gathering further scientific information on the Big Bang-despite the Hubble telescope-are quite limited, and so the problem seems to be unanswerable for the foreseeable future.

A useful idea discussed recently among cosmologists is the "weak anthropic principle" (WAP), which states that only those creations consistent with the existence of human life (ours in particular) can have taken place.33 In other words, we exist and so the universe must be consistent with that fact (obviously). However, a number of other possible "principles" have been suggested that are not so obvious; for example, the "strong anthropic principle" (SAP), which states that the universe must have those properties that allow life to develop within it at some stage in its history. This principle is somewhat similar to the older "argument from design," which argues that the design apparent in the universe is evidence for the existence of a designer (just as the existence of a watch argues for the existence of a watchmaker, to use an old metaphor). John Barrow and Frank Tipler state the

argument from design as follows: "There exists one possible Universe 'designed' with the goal of generating and sustaining 'observers.'"34

It has been noted that only certain conditions could have existed in order to make life possible (which can be taken as support for either the argument from design or the anthropic principle). For example, the noted British astronomer Fred Hoyle pointed out that a particular nuclear energy level occurs in carbon 12 at a position where a "resonance" (along with other features) makes the production of carbon in stellar interiors possible; a slight change in its placement would make carbon formation impossible, which in turn would mean that carbon-based life would be impossible.35 (The source of terrestrial carbon, and indeed of all elements beyond helium, is understood to be the interior of stars, generations earlier than our sun.)

The anthropic principle and the argument from design suggest to the mind a teleology-a purpose in creation-which in turn suggests the existence of God. Thus the existence of the favorable carbon energy level can be seen as an evidence for the existence of God, in particular a God who was interested in forming human life. Hoyle does not say this, but instead attributes the situation to more or less random accidents. True enough, it is not necessary to assume that this energy level was created by a supreme being, because if any of the processes favorable to our existence had failed, we would not be here anyway. Our existence demonstrates only that conditions were right for life formation in our own universe; there could have been billions of other universes that formed, existed, and passed away in which there was no life developed at all.

An interesting form of the anthropic principle is the "participatory universe" suggested by Princeton physicist John Archibald Wheeler, in which, perhaps in a quantum mechanics context of an observer-dependent reality, the creation of the universe is bound up with our ability to observe it. As Barrow and Tipler state this idea, "Observers are necessary to bring the Universe into being."36 They note that this idea is closely related to another possibility: "An ensemble of other different universes is necessary for the existence of our Universe."37 This is intriguing, although it is not clear how observers formed after the creation of the universe could have affected its initial creation.38 Barrow and Tipler suggest that this might be related to Hugh Everett's "many-worlds" interpretation of quantum mechanics, in which an infinitely branching set of possible worlds really exists.39 (A short story suggestive of the many-worlds approach was published in 1941-before Everett's work-by the Argentine author Jorge Luis Borges.)40

While the argument from design is not a proof of the existence of God, it suggests to us that God exists. Scriptures support this view: "The heavens declare the glory of God; and the firmament sheweth his handywork" (Ps. 19:1) "The earth rolls upon her wings. . . . Behold, all these are kingdoms, and any man who hath seen any or the least of these hath seen God moving in his majesty and power" (D&C 88:45, 47) "All things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator" (Alma 30:44). Such scriptures may be read not as an attempt by the writer to prove the existence of God (although the latter passage was such an attempt), but simply as an expression of worship and awe in the presence of a God already presumed to exist.

It should be noted that the SAP, as currently understood, indicates that the universe was created only to give rise to our own existence. Thus it implies that there are no other human civilizations in the universe, a view certainly contrary to LDS scriptures and thought (see D&C 76:24). 41

Hollis R. Johnson
Atoms Stars and Us

Stars and Atoms
Who would believe that Earth and the pile of atoms that constitutes our body are made of stardust? As we explore the magnificent universe about us-especially stars, stardust, and atoms-we will surely find some surprises! This short summary will at best whet the appetite.5

Why are there such things as stars? Some people might say stars exist because they are so beautiful. Some might say stars exist because God created them. Some might say a star exists because it has the right mass for a gas so that its internal temperatures and pressures are high enough that the outward force of hot gas and radiation perfectly balances the enormous inward force of gravitation throughout the star. Otherwise, stars simply could not exist. Our sun lies somewhere in the middle of that mass range. It so happens that the high central temperatures of most stars lie in a favorable range for many nuclear reactions, especially among the lighter elements, including the fusion of hydrogen to helium. This fusion and the resultant conversion of mass to energy provide the energy that allows stars to shine so brightly for so long. In that sense a star is similar to a giant hydrogen bomb, except that its powerful gravity holds it together against even this fierce outward push.

Stars change slowly over enormous periods of time. In a sense the life story of a star is the tale of its losing battle against gravity. Gravity never relaxes its grip, but the pressure of gas and radiation depends on temperature, and a high temperature depends on the presence of an energy source. However great the energy store of a star is, it is finite and will eventually be used up. Gravity then gains its final victory. But what a story is that battle!

In trying to deduce the life story of a star, scientists must be detectives. They first find the facts, as far as possible, and then try to construct a plausible scenario (a theory or several theories) to account for these facts. They try to answer this question: What happened to cause the things (facts) we observe? The more facts scientists can discover, the more tightly constrained is the scenario they can construct. Put another way, scientists proceed by constructing theories or making hypotheses (ideas of all kinds) and then trying to test these theories against observations or experiments (facts). A good theory is one that makes testable predictions and stimulates thought and research even if in the end it is disproved. Moreover, theories may be changed several times along the way, or new scenarios may be constructed in light of new facts. Often scientists have grand discussions and arguments over such matters. Laymen sometimes misinterpret what is happening and form the idea the scientists often change their minds. (Actually, it is often very difficult to get scientists to change their minds!) If scientists as a group change their minds, it is likely in response to new facts that cast doubt on their initial theories or hypotheses.

Eventually, if enough facts can be discovered, the main points of some theory may become sufficiently well attested (meaning that enough of its predictions are verified and it is not contradicted by any empirical fact) that scientists will regard it as more or less certain. But one should always be wary of saying science has proven something. Scientists search for facts. In this search they may disprove a theory, but it is extremely difficult to prove a theory. Thus science does not so much prove statements or theories or scenarios as it disproves them. Theories that stand the test of repeated experiments come to be regarded as more or less correct. Scientists are trained to keep facts separate from theories, and others should do so as well. Evidence for and against every theory or point of view should be cited so that each person can make his or her own decision regarding the likelihood that a statement is true or false.

Galaxies and Stars
Like all galaxies, our Milky Way galaxy consists of gas, dust, and stars along with a massive outer halo of more or less unknown stuff. The gas and dust are not spread evenly throughout the galaxy but are often clumped into clouds. Recall that our rotating Milky Way galaxy is about one hundred thousand light-years across and contains about 150 billion stars. Our sun, some twenty-five

thousand light-years from the galactic center, drags its planets along with it at a speed of 250 kilometers per second in an orbit so huge that it takes us 200 million years to go around!6

Far out in galactic space, these gigantic clouds are extremely cold, and their atoms are often associated as molecules, sometimes complex ones.7 Like clouds in Earth's atmosphere, these interstellar clouds form and dissipate over and over again. Once in a while, however, part or all of a cloud may be compressed so that it begins to contract gravitationally because every particle attracts every other particle. This contraction speeds up as the cloud collapses, and it also fragments into a spray of cloudlets. Cloudlets of the right size will become stars. Do astronomers actually see "starbirth"? In a way. They see young stars in regions of dense gas clouds. These are stars that are just beginning to burn (fuse) hydrogen and have not had time to dissipate the placental gas and dust from which they were formed.8

Because spectra of the oldest stars show extremely small amounts of any elements besides hydrogen and helium but stars formed later show increasing amounts of these elements, we must accept that atoms of heavier elements were not present in the early stages of our galaxy; rather, they gradually appeared during the lifetime of the galaxy and universe.9 Where were these atoms formed? Other sites with sufficient energy are excluded for one reason or another, leaving the interior of stars as the likely site. This idea is supported by the fact that scientists have also shown over the years how heavier atoms could in fact be manufactured from hydrogen and helium in stellar interiors. The whole argument has been nicely set forth quantitatively.10

Stars and Atoms (2)

As a cloudlet contracts and its volume decreases, its density, temperature, and energy density increase rapidly. At first this increasing energy is radiated away, but as the density increases so does the opacity, and the radiation becomes trapped in the gas, further heating it. Eventually, the outward force of gas and radiation balances the inward force of gravity, and the cloudlet becomes stable.11 However, if this were the entire story, a gas cloud with the mass of the sun would have enough gravitational energy to shine at its present energy output for about 100 million years. Unfortunately, this is far less than the length of time life has existed on Earth,12 and we must look for other, larger sources of energy. Fortunately, our sun has enough nuclear energy stores to keep shining for at least 10 billion years!

Our sun is a good, average star. Some stars have less mass (but a star must have about 0.06-0.08 solar masses in order to burn hydrogen and be a real star), some have more mass (up to about 60 solar masses, but these huge stars are very short-lived), and some are older and younger, brighter and dimmer. But the sun, with its long lifetime, is an ideal furnace to warm and light a planetary system. The more massive a star is the shorter is its lifetime. It is also true that high-mass stars are relatively rare, while tiny (low-mass) stars are much more abundant.

What will happen when hydrogen in the core has been burned (fused to helium)? Hydrogen continues to burn in a narrow shell around the now almost inert helium core, but gravity compresses the inert core, and the enormous energy released by this compression increases the luminosity and puffs out the star. As the star becomes larger, its temperature falls and it becomes a cool (red) giant star. Although the star has grown to more than fifty times its original diameter, its mass has not changed and its outer density must be as low as a good vacuum on Earth. As the core contracts, its central temperature increases until it is high enough (about 100 million degrees for the sun) for a new reaction: helium burns (fuses) to carbon with the emission of a great deal of energy.

Our story now gets more complicated, and the outcome depends more and more on the mass of the star. As the concentration of carbon in the core rises, helium can burn only in a shell around the

carbon core. In this double-shell phase of a red giant's life, hydrogen burns (to helium) in an outer shell, and helium burns (to carbon) in a slightly smaller shell. The carbon or carbon-oxygen core (some carbon captures helium and becomes oxygen) is now extremely compact. As time passes, the thin helium-burning shell begins to flicker, and some of the burned material is churned into the envelope (the deep gaseous layer overlying the core) and eventually to the surface of the red giant. This burned (nuclearly processed) material, enriched in carbon and often in heavier elements (by neutron-capture), changes the chemical composition of the surface.13 Fascinating as it is, the red-giant phase is relatively short, partly because these giants are blowing themselves apart. As a red-giant star grows in size and its temperature falls, gas starts flowing away from the surface with speeds of about ten kilometers per second. The rate of mass loss can be very large, rising to values of 10-6 or even 10-4 solar masses per year. At this high rate, a star would lose lots of its mass in one hundred thousand years.

"Stardeath"-to use a sensational term for the natural end of a star-occurs in one of three ways, depending sensitively on the star's mass. Ordinary stars like the sun, and all stars with masses up to about eight solar masses, blow away their outer envelope so that only the compact core remains. For a few thousand years, this expelled shell glows in exotic forms and colors before it finally fades away. The hot core cools rapidly at first and then more slowly. Amazingly, this core (a white dwarf star) is only slightly larger than Earth, but it must be about a million times as dense as water. White dwarfs are supported against gravity by the resistive pressure of their electrons, which are so squashed together that their motions are severely restricted. Although there is a maximum limit of 1.4 solar masses in order for a white dwarf to support itself against gravitation, stars up to about eight solar masses may shed enough mass (this is serious weight reduction!) during the red-giant stage to end as white dwarfs. There is no known way by which a white dwarf star can be revitalized.

If a star's mass exceeds about eight solar masses on the main sequence, its evolution is faster and different. It blazes forth as a super-giant star and burns (fuses) elements, one after the other, in sort of an onionlike chemical structure, up to iron. In addition, such a huge star, in its final collapse, forms the heaviest of the elements by neutron capture.14 For reasons explained below, its energy supply suddenly ends there, and the outward force of gas and radiation abruptly decreases, initiating a catastrophic collapse of the star. In the stellar core the enormous gravitational force crushes free electrons and protons into neutrons and pushes these neutrons tightly together until they form a hard core and abruptly halt the collapse. The in-falling material then rebounds, and a strong shock blasts most of the envelope into space in a supernova explosion. Only a neutron star remains, a star composed of hard-packed neutrons. Its mass may be as large as that of the sun, but it will be only ten or twenty kilometers across. Its density is stupendous. Neutron stars are actually seen as rapidly rotating objects whose radiation is channeled by extremely strong magnetic fields along the magnetic poles. As the object spins (on an axis different from the magnetic axis), whenever its magnetic pole happens to point in our direction we receive a pulse of radiation, and the objects are called pulsars. Often these remarkable stars pulse hundreds or thousands of times each second.

Perhaps the most incredible part of our story is still ahead. As with white dwarfs, there is also an upper limit of a few solar masses for neutron stars. Imagine now a star with, say, fifty solar masses. Although the star may lose much of its mass along the way, when it finally collapses and rebounds as a supernova, gravity may compress the core beyond the resistive capacity even of hard-packed neutrons. When this occurs, the star becomes a black hole-an object so compressed that the escape velocity at the surface exceeds the velocity of light.15

Why do atoms or ions of some elements combine (burn or fuse) to produce atoms of other elements? Natural processes "run downhill"; that is, they take the easiest path to the easiest

destination. As free particles are bound in an atomic nucleus, some energy is given up. For example, a helium nucleus (two protons and two neutrons to give a mass of four) is more tightly bound than two free protons and two neutrons, and a nucleus of carbon is more tightly bound than are three helium nuclei. In fact, atomic nuclei are more tightly bound (and therefore yield energy by fusion) along the periodic chart of the elements up to iron. Iron is the most tightly bound of all elements, and no energy can be extracted from it. In a sense, then, iron is the ultimate ash of the universe.

Stellar evolution, the life story of stars, presents us with an interesting opportunity to combine theory and observation. Of necessity, the calculations are theoretical. How much confidence can we have in the results? Whenever possible, comparison is made with observations. For example, theoretical models have been constructed for the sun, for which the chemical composition is well known. To be acceptable, such a model must predict the correct radius, temperature, and luminosity for the sun at its current age.16 The age for the sun is estimated to be 4.6 billion years-a value measured from radioactive dating of Earth17 and meteorites.18

Different requirements can be set for models of stars in star clusters, where all stars have the same age and are formed of the same materials but differ in mass. Repeated, exhaustive comparisons of brightness (luminosity) and color (temperature) of the predictions of model calculations to real star clusters assure us that the basic results of stellar evolutionary theory are correct.19 However, there is still much to be learned about binary stars, novae, supernovae, variable stars, convection, stellar seismology, solar and stellar activity, stellar dynamos, stellar winds, molecules, grain formation, mass loss, and evolution of the biggest and tiniest stars-just about everything! Although for simplicity we describe the evolution of single stars only, most stars are in binary systems, and these systems, especially interacting binary systems, are important to galactic evolution and the formation of the elements. Describing these systems would fill a whole book.

This is the time to note that fuel reactions often involve nuclei of 4 He. That is, the addition of 4 He to 12 C produces 16 O, and further addition of 4 He nuclei produces in order 20 Ne, 24 Mg, 28 Si, and so on up to iron. As the astute reader may have noticed, this series of elements with even atomic numbers are exactly those elements whose abundance in the universe is greatest. Clearly, the stellar atom factories have left their fingerprints in the abundance of the elements (and isotopes), and this fact neatly explains the odd-even effect noted earlier (and much more). Such heavier elements as mercury, gold, and uranium can also be manufactured in stellar cores when iron or other elements capture neutrons, but their production consumes energy rather than yields it. There are two processes: one process operates in red-giant stars (remember, these are the very abundant, low-mass stars like the sun) to fabricate the medium-heavy elements such as carbon, nitrogen, and oxygen; and the other process operates in supernovae (the rare, high-mass stars) to fabricate a different set of heavy elements. Detailed comparisons between the predictions of stellar evolutionary theory and spectra of real stars is a fascinating story that continues today.

Exotic as are stellar lives and evolution, the important point for our purpose here is that most of the material of the star, be it a red giant or a supernova, is blown outward into the galaxy. This material is rich in nuclearly processed material-heavier atoms created from hydrogen and helium deep within the star. As the ejected matter mixes with the gas of the galaxy, it enriches the material from which the next generation of stars and planets will be formed.20

There is, of course, a limit to starbirth. When all the raw material in a galaxy has been used up in stars, no new stars can be produced. Indeed, there are such galaxies. Most of the material in the Milky Way has already been used in stars. Gradually, in the distant future, no new stars will be formed, and the existing stars will gradually age and die.

Reflective Summary
Let's now step back and view the entire sweep of the history of a galaxy of stars. Several lines of evidence point to the origin of most galaxies, including the Milky Way, as a huge cloud of hydrogen and helium some 15 billion years ago.21 Spectra of the oldest stars, some of which appear to have been shining for 12 to15 billion years, show only extremely weak traces of any elements except hydrogen and helium. Apparently, when these old stars were formed, the galaxy consisted essentially of these two elements. They are notably the lightest and most abundant elements and the two that are believed to have been formed early in the expansion phase of the universe,22 lightheartedly called the "Big Bang."

Soon after the galaxies formed, the first stars formed. Any planets that might have circled these early stars were also composed mainly of hydrogen and helium, and these planets would have been sterile. Life as we know it is based on the chemistry of carbon, and its appearance had to await the formation of heavier elements.

As these early stars, composed of hydrogen and helium, went through the evolutionary stages described above, they formed heavier elements in their interiors, which are literally atom factories. The most massive stars formed quickly, raced through their lives, and exploded as supernovae. In doing so they blew out into space newly created heavy elements-those ranging from carbon through iron and used as fuel, and those heavier elements formed by neutron capture.23 Now imagine countless generations of massive stars forming and quickly dying, each contributing a load of heavier elements to the galactic gas. The far more numerous stars of solar mass evolved more slowly, but eventually these became red giants and blew away their newly formed heavier elements into space as well.

As time passed and generation after generation of stars formed and died (see Moses 1:35, 38), the Milky Way and all galaxies gradually became rich in heavier elements. After an enormous amount of time had passed, perhaps as long as 10 billion years after the Big Bang, our solar system formed. By that time-some 4.6 billion years ago-atoms of carbon, nitrogen, and oxygen and other heavier elements were available as described above. The stage was finally set for the appearance of planets like Earth, with the chemical elements necessary for life.

Are there other planets with life? That is an exciting question. On the one hand, it seems that if our solar system, with its life-bearing planet, is an ordinary natural product, there ought to be many other life-bearing planets (and this agrees with Moses 1:33). On the other hand, in spite of thorough searches, astronomers have found no evidence whatever of any other life-bearing planet. It is a puzzle, but even an elementary discussion would require at least another book. However, recent reports of possible fossils in a meteorite from Mars might be evidence for at least fossil life on other planets.24 In addition, astronomers have recently discovered a few planets in orbit around other stars, but these are huge planets, bigger than Jupiter. Finding an Earth-sized planet is a daunting challenge, but it is perhaps imaginable in our lifetime. We must wait for more answers from this exciting search.

A voyage over the entire universe, even if limited essentially to facts, would fill many books, and the universe is so remarkable as to be almost beyond our capacity to imagine. The descriptions we humans give, marvelously ingenious and complex as they are, may be poor representations of reality. Were any of us to write a science fiction story about a universe of our own imagining, it is highly doubtful that our imagined universe would be as remarkable as the real one!

One of the greatest accomplishments of mankind has been the discovery of the universe, and that voyage of discovery constitutes a grand adventure of the human mind and spirit. To be even a small part of that adventure is exciting for me. Those magnificent, sparkling stars are the atom factories,

where heavier elements are created out of hydrogen and helium. Our bodies are made of these elements. We are literally made of stardust!

And what is the place of mankind-our spirits and bodies-in this vast, cold, dark universe? What are we humans doing here? Are we a chance product of remarkable biochemistry, or are we the result of careful design?

Consider the incredible panorama of our universe, one that is billions of light years in extent and has been billions of years in the making! Giant clouds of hydrogen and helium (proto-galaxies) formed within a billion years after the Big Bang. Stars then formed in these clouds, and as they lit up the heavens, the stars also fabricated heavier atoms from the original hydrogen and helium. When the stars died in mild or titanic explosions, they dispersed these atoms into galactic space. Thus, the Milky Way Galaxy and all galaxies became slowly enriched in heavier elements with time, and this has been our focus in this brief article. Atoms of these heavier elements became associated into molecules, as are seen in abundance in interstellar space. When newer stellar systems, such as the Solar System, were later formed (about 4.6 billion years ago), they contained a load of these heavier elements, which formed complex molecules. From these complex molecules, living cells and then larger plants and animals, including man, could be created.

Where does God fit into this remarkable picture? The nonbeliever might say this spectacular caravan of events happened by chance or by the action of natural processes and laws. Every step is describable by mathematical equations. Some might even say the equations themselves are the Final Answer. The believer might maintain that when one views the whole picture, a pattern clearly emerges. There is a direction and a goal indicative of design and intelligence. The discussion will likely go on for a long time!

We humans are conscious of our own existence. We appreciate beauty and logic. We remember and decide and think. We worship. We know the difference between right and wrong. We could ask many questions here that would be wonderfully difficult to answer completely. It is clear, however, that humans are distinct from other animals intellectually and spiritually. From that point of view, one might say we are most human, in the best sense, when we develop and use to the fullest our great intellectual and spiritual powers.

According to the gospel, we human beings are much more than a pile of atoms, however wonderfully arranged. We are composite beings. We are composed of body and spirit. Our spirits existed before our bodies were created and will exist beyond the grave and beyond the resurrection.

Remarkable as our marvelous world and solar system and galaxy and universe are, and exciting as our search for further knowledge about them is, this kind of knowledge is not of paramount importance. Some knowledge has greater significance than other knowledge. What is of greatest importance to us? Both in our daily lives and in the long term, we are most concerned with our relationship with our Heavenly Father, with one another, and with our environment, and we must be if we and civilization are to survive. Spiritual truths and values take precedence over all else.

How do we learn the ethical and moral values that govern our lives? How do we know what is right or best? How do we know we should serve others? In particular, how do we learn the will of God? From science? Hardly. Powerful as it is in the discovery of facts about the universe and in attempting to put these facts into an understandable picture, science can tell us little about how we ought to live. Science can say little about ethics, morals, ideals, and values, and it can say next to nothing about God. For this knowledge we must look to experience, both of our own and others, and directly to the revelations of God.

Although to the prophet Alma, Earth and all the planets witness of a "Supreme Creator" (Alma 30:44), others may or may not accept the wonders of nature as proving the existence of God, and they will likely continue to argue about it for a long time. Only God, not nature, can tell us of himself and his plans. We Mormons believe God has revealed himself and his plans anew in our day, and we benefit from that knowledge. To me it is of the greatest importance to know and follow that plan. It is the plan of exaltation and happiness.

Truly the universe is remarkable and the gospel is wonderful. Each human being is precious to our Heavenly Father, and we should be to each other. Life is great. Our task is to learn to live a Christlike life, to build a righteous society, to serve one another, and to enjoy the work!

Notes

1. Hydrogen and helium are not the most abundant elements on the earth, however, where atoms of oxygen, silicon, iron, and magnesium are more numerous. How the composition of the earth came to be so different from that of the universe at large is another interesting story, but far outside the scope of this essay. For information on this topic, see C. J. Allegre and S. H. Schneider, "The Evolution of the Earth," Scientific American 271, no. 4 (October 1994): 44-51; R. P. Kirschner, 1994, "The Earth's Elements," Scientific American 271, no. 4 (October 1994): 58-65.
2. See E. Anders and N. Grevesse, in Geochim. et Cosmochim. Acta 53 (1994): 191-214; N. Grevesse, A. Noels, and A. J. Sauval, "Standard Abundances," in Stephen S. Holt and George Sonneborn, eds., Cosmic Abundances, Astronomical Society of the Pacific Conference Series, vol. 99 (San Francisco: n.p., 1996), pp. 117-26; N. Prantzos, E. Vangioni-Flam, and M. Casse, Origin and Evolution of the Elements (Cambridge, England: Cambridge University Press, 1993).
3. See D. N. Schramm, "Primordial Nucleosynthesis," in Holt and Sonneborn, eds., Cosmic Abundances, pp. 36-47; and R. P. Kirschner, "The Earth's Elements," Scientific American 271, no. 4 (October 1994): 58-65.
4. See E. R. Paul, Science, Religion, and Mormon Cosmology (Urbana: University of Illinois Press, 1992), which may well be the best current book on science and Mormonism.
5. See W. Kaufman, Discovery of the Universe (San Francisco: Freeman, 1996); J. Kaler, Astronomy! (New York: HarperCollins, 1994); J. Kaler, Stars (New York: Scientific American Library, 1991); R. Kippenhahn, 100 Billion Suns (New York: Basic Books, Inc., 1983); M. Zeilik, Astronomy: The Evolving Universe (New York: Wiley, 1996).
6. See S. van den Bergh and J. E. Hesser, "How the Milky Way Formed," Scientific American 268, no. 1 (January 1993): 72-78. See also sources listed in n. 5.
7. See G. L. Verschuur, "Interstellar Molecules," Sky and Telescope 83, no. 4 (April 1992): 269-384.
8. See S. Parker, "The Eagle's Nest," Sky and Telescope 91, no. 2 (February 1992): 32-34; R. Naeye, "The Story of Starbirth," Astronomy 26, no. 2 (February 1998): 50-55; F. H. Shu, F. C. Adams, and S. Lizano, "Star Formation in Molecular Clouds: Observation and Theory," Annual Reviews of Astronomy and Astrophysics 25 (1987): 23-81.
9. See F. X. Timmes, "Chemical Evolution of Galaxies," in Holt and Sonneborn, eds., Cosmic Abundances, pp. 298-306; and N. C. Rana, "Chemical Evolution of the Galaxy," Annual Reviews of Astronomy and Astrophysics 29 (1991): 129-62.
10. D. N. Schramm, "Primordial Nucleosynthesis," in Holt and Sonneborn, eds., Cosmic Abundances, pp. 36-47; I. Iben, Jr., "Asymptotic Giant Branch Stars: Thermal Pulses, Carbon Production, and Dredge Up; Neutron Sources and s-process Nucleosynthesis," Stellar Evolution: The Photospheric Abundance Connection, ed. G. Michaud and A. Tutukov (Dordrecht, Netherlands: Kluwer Academic Publications, 1991), pp. 257-74; R. Kippenhahn and A. Weigert, Stellar Structure and Evolution (New York: Springer-Verlag, 1990), pp. 308-62.
11. See S. W. Stahler, "The Early Life of Stars," Scientific American 264, no. 1 (July 1991): 48-55; 28-35.

12. See D. York, "The Earliest History of the Earth," Scientific American 269, no. 1 (January 1993): 72-81.
13. I. Iben, Jr., and A. V. Tutakov, "The Lives of Stars: From Birth to Death and Beyond," Sky and Telescope 74, no. 2 (December 1997): 36-43.
14. J. C. Hayes and A. Burrows, "A New Dimension to Supernovae," Sky and Telescope 90, no. 2 (August 1995):30-34.
15. Everyone seems to be fascinated by black holes, and there are several accounts of these remarkable objects. See, for example, S. W. Hawking, A Brief History of Time (Toronto: Bantam Books, 1988); K. S. Thorne, Black Holes and Time Warps (New York: Norton, 1994).
16. D. A. Vandenberg, "The Status of Stellar Evolutionary Models," in K. Janes, ed., The Formation and Evolution of Star Clusters, Astronomical Society of the Pacific Conference Series, vol. 13 (San Francisco: n.p., 1991), pp. 183-99.
17. See D. York, "The Earliest History of the Earth," Scientific American 269, no. 1 (January 1993): 72-81.
18. See C. J. Allegre, and S. H. Schneider, "The Evolution of the Earth," Scientific American 271, no. 4 (October 1994): 44-51; J. J. Cowan, F.-K. Thielemann, and J. W. Truran, "Radioactive Dating of the Elements," Annual Reviews of Astronomy and Astrophysics 29 (1991): 447-97.
19. See, for example, R. Kippenhahn and A. Weigert, Stellar Structure and Evolution (New York: Springer-Verlag, 1990), pp. 308-62; A. Renzini and F. Fusi Pecci, "Tests of Evolutionary Sequences Using Color-Magnitude Diagrams of Globular Clusters," Annual Reviews of Astronomy and Astrophysics 26 (1991): 199-244.
20. See N. C. Rana, "Chemical Evolution of the Galaxy," Annual Reviews of Astronomy and Astrophysics 29 (1991): 129-62; G. L. Verschuur, "Interstellar Molecules," Sky and Telescope 83, no. 4 (April 1992): 269-384.
21. See A. Dressler, "Observing Galaxies Through Time," Sky and Telescope 82, no. 2 (August 1991): 126-32; M. S. Longair, "Outside the Stars," in W. W. Weiss and A. Baglin, eds., Inside the Stars, Astronomical Society of the Pacific Conference Series, vol. 40 (San Francisco: n.p., 1993), pp. 1-24.
22. See P. J. E. Peebles et al., "The Evolution of the Universe," Scientific American 271, no. 4 (October 1994): 28-35; N. Prantzos, E. Vangioni-Flam, and M. Casse, Origin and Evolution of the Elements (Cambridge, England: Cambridge University Press, 1993).
23. See I. Iben, Jr., and A. V. Tutakov, "The Lives of Stars . . .," pp. 36-43; J. C. Hayes and A. Burrows, "A New Dimension to Supernovae," pp. 30-34.
24. See D. S. McKay et al., "Search for Past Life on Mars: Possible Relic Biogenic Activity in Martian Meteorite ALH84001," Science 273 (16 August 1996): 924-30.

Chapter X - David L. Clark

Earth History and Human History: Random Events or Ordered Sequences?

Science has successfully interpreted the major factors involved in the history of Earth as well as the history of its inhabitants. Putting together the sequence of events for the past four to five billion years has not been an easy task, but in spite of the idiosyncrasies of the fossil record, what has been interpreted as the "big picture" is remarkably complete. While these facts do not imply that everything is known concerning either Earth or its inhabitants, or even that all of the scientific interpretations are correct, some future historian will record these scientific accomplishments as among the greatest achievements of the nineteenth and twentieth centuries. Similarly, a future historian will conclude that during this same time interval the restoration of the gospel and the growth of the restored church of Christ were the most important religious accomplishments. In spite of these separate accomplishments in what are generally considered to be quite diverse areas of life's activities, the fact remains that science progresses without much regard for any religious principles, and most religions move on with only minor regard for scientific progress. There are

areas of harmony and areas of discord, but as the essays in this volume testify, the truth of both must converge at some level.

My personal life experiences, professional and religious, have focused on the harmony that should exist between religion and science because the gospel is true and, similarly, many scientific endeavors have eternal value. However, this fact raises a host of questions related to which part of science correlates with which part of theology, and which part of theology is in conflict with some area of science. Most important is the question concerning which scientific interpretation is in the most apparent conflict with theological understanding. While most of the possibilities identified for this last question center on organic evolution and the age of Earth, its solar system, and the universe, I am convinced that reduced to its most fundamental level, the question, as the title of this essay suggests, may really be thus: Are events of Earth history random, ordered, or some combination of the two? Randomness in both earthly and biological events is accepted as fact and can be taken as evidence against any grand design, while indications of an ordering of events can be used to support purpose and direction. So, are events of Earth history and organic evolution ordered or random? In order to examine this idea, I turn first to my own professional specialty, the Arctic Ocean.

Evolution of An Ocean

The modern Arctic Ocean is the least studied of Earth's oceans because of its north polar location and the logistical problems of working in an ocean with a permanent ice cover. Probably less is known concerning the Arctic Ocean than is known concerning any other of Earth's major features. For example, the largest unknown geologic feature on Earth, the Alpha Ridge (larger in areal extent than the Alps), is a prominent structure of the Arctic Ocean. In addition, only a few of the events associated with either the major crustal movements that were responsible for the ocean's origin or the climatic changes that have produced its inhospitable environment are understood. Because one of the objectives of geology, a historical science, is to reconstruct the sequence of events that produced Earth's present structure, for more than thirty years, I, along with a number of students from many countries, have tried to figure out the sequence of events that has resulted in the modern ice-covered Arctic Ocean and its organisms.

It is believed that most of the western half of the Arctic Ocean basin formed when a fracture in one of Earth's major crustal plates rotated a large part of present Alaska from its preexisting location against the present region of the Canadian Arctic Islands counterclockwise to its present position. And there is fairly good evidence from paleomagnetic and geochemical dating of rocks that were involved in this movement that this event occurred at rates of a few centimeters a year beginning more than 100 million years ago.1 As the rotation progressed, the gap that was created by separating the original Alaskan-Arctic Island complex was filled with magma that moved up from the lower part of Earth's crust along a rifting axis, and this became the floor of the modern deep Arctic Ocean basin.2

The eastern part of the Arctic Ocean formed in a similar manner but not until approximately fifty million years ago when the Nansen Ridge, an extension of the Mid-Atlantic Ridge, which includes Iceland, began the sea-floor spreading that enlarged the Arctic basin to its present size.3 We know a few more details of this "big picture" of the ocean's formation, but not much.

Perhaps the most distinctive feature of the modern Arctic Ocean is its ice cover. This layer of frozen seawater is a product of Earth's changing climate, probably initiated at least forty-five million years ago and attributable to both the tectonic forces that partially isolated the ocean as well as to profound changes in Earth's atmosphere.4 There were changes in Earth's ocean-current heat-transporting systems from low to high latitudes as well. The exact timing of the formation of the Arctic Ocean's permanent ice cover is unknown, but the consequences of a large, frozen

seawater ice cap around the North Pole have been profound for Earth's climate. Of course, also important for Earth's climate has been the formation of ice around the south rotational pole in the Antarctic continent, and this may have occurred at about the same time the north polar ice cap developed. All of these activities enhanced the general cooling of Earth from warmer conditions about forty-five million years ago to the present climate.

In addition to its effect on Earth's climate, the Arctic's ice cover has played a role in biologic changes in the polar areas. In the Arctic the polar bear, among a number of other mammals, is a product of the climatic change that produced the ice cover; similarly, in the Antarctic the evolution of the penguins has been directly linked to the development of the south polar ice mass.5

Thus, the modern Arctic ecosystem owes its origin to the energy of Earth's interior as well as to solar energy that drives the atmosphere. Earth's residual energy produced the rifting of its crust, and some variation in the amount of the sun's energy available for the Arctic produced the ice cover. And as is true for the Arctic Ocean, the geographic modification of all of Earth's surface began with crustal plate movement originating with forces deep beneath the surface of Earth. These forces ultimately are linked to heat generated deep in Earth, and this is related to the chemical structure of Earth at the time of its origin. This, in turn, was a result of sequences of events that began with the origin of our solar system and our galaxy.

There is little argument concerning cause and effect in what actually happened to produce Earth's modern configuration. There has been a sequence of events, each step of which has been a prerequisite for the succeeding step. This series of interdependent steps produced the modern Arctic Ocean just as different sequences of events produced others of Earth's structures. If any of the steps had involved different processes than those that actually occurred, we would be living on a different kind of Earth surface. While it is fun to think about alternative events, my professional objective has been to understand what actually happened, not what might have been. And this brings us to one of the fundamental questions in science, one already answered by most religions: Was the sequence of events that has resulted in Earth and its inhabitants a series of random events, a series of ordered events, or some combination of the two?

Earth's Other Structures

Before addressing that question, we need a few definitions. The Arctic Ocean is designated as one of Earth's "minor" ocean basins. The Pacific, Atlantic, Indian, and Antarctic Oceans are all larger in water volume and area than the Arctic, and each has an origin distinctive from the others yet involving the same kind of sequences of events that account for the Arctic Ocean. In contrast, Earth's continental areas have histories that include different kinds of events than those of the major modern ocean basins, and together the story of the origin of each of Earth's oceanic and continental features comprise the history of Earth. Some parts of this history are better understood than are other parts, and Earth scientists are constantly reminded of the place of humility in their studies because they realize that today's dogma may become tomorrow's discarded theory. During the past thirty years, fuzzy ideas concerning the long-term stability of Earth's major features, oceans, and continents have been replaced with the testable theory that Earth has a mobile crust. The concept of a mobile crust has forced scientists to think differently about Earth and its inhabitants. Yet humility does not necessary indicate ambiguity, and many of the basic theories of Earth science developed in the last few years are as sound as are some of the basic laws of physics. The important point is that Earth's structure, climate, and inhabitants are understood as the result of sequences of events that extend uninterrupted back 4.5 billion years or more.

Sequences of Events and Modern Earth

For the faithful who pay any attention to science, sequences of naturally occurring events represent God's method of creation, and the end product of scientific endeavors simply is an

understanding of this creation process. While the implications of God's hand in a perfectly ordered and predictable sequence of events is obvious, science insists that we cannot preclude the existence of randomness in Earth's systems. Indeed, random events are well documented and apparently are an important part of many physical and biological processes.

All of this introduces the major unresolved problem for religion and science: Are God's fingerprints apparent in Earth and human history? Is there evidence of ordering or progress in the sequence of events that resulted in the inhabitable Earth with human beings?

According to a prevalent scientific idea, if one could rewind (as if with a tape recorder) the history of the solar system and Earth and then push the "record" button and record what would happen the second time around, the randomness of the entire process would be evident and the next playing of the tape would show a different Earth perhaps with different dominant kinds of inhabitants than was recorded the first time. According to this idea, the random events that are involved in crustal processes in the Arctic 100 million years ago could have produced a different kind of ocean basin if a second "recording" were possible, a basin whose waters may not be so isolated from the warmer lower latitudes. If this happened, a different sequence of events would have been initiated, an ice cover may not have formed, and the evolutionary processes would not have produced a polar bear but possibly some other kind of organism. Because there are good reasons for considering that this could be true, we must consider the role of random processes in Earth history and how this could affect the idea of ordered sequences or direction.

Scientific Theory and Reality: 4.5 Billion Years of History

There is compelling evidence of randomness in many of Earth's natural processes. The argument is made that just because certain events happened as they did does not alter the fact that they might have occurred differently. While it is important to acknowledge this possibility of randomness in a number of systems, progress, the opposite of randomness, has been argued for several generations and must also be acknowledged as a scientific possibility. Moreover, there is the disturbing thought that at least some of those who argue against progress in evolution, for example, are more interested in eliminating the touch of a Creator from everything than in acknowledging the truth.

For the believer, good arguments can be made that what has actually happened in Earth and human history is the inevitable result of celestial mechanics under the direction of a higher power and that the apparent progress is not random. Is this argument as scientifically tenable as the argument that everything that has happened during the past 4.5 or 10 billion years is the result of random, non-repeatable processes with no hint of direction or progress?

The history of Earth, as suggested by the Arctic Ocean analogy, indicates that its surface features were produced by a combination of internal and external forces whose interactions might have resulted in different kinds of things if certain conditions that were involved during Earth's evolution were different. There is no real argument against this idea. However, magma is not released from deep crustal areas of Earth randomly, but only following the buildup of sufficient heat and pressure that occurs only in specific geographic areas. These internal factors are themselves the product of a different sequence of events that are, in turn, dependent on yet another series of events. Similarly, earthquakes are not random but have specific causes only partly understood yet certainly representative of crustal activity that is the result of a sequence of events that also is dependent on other sequences ultimately reflecting differential energy derived from Earth's interior. The sculpturing of Earth's external structures by atmospheric activity represents predictable results based on climate and rock chemistry.

So altering any of the factors involved in the events would certainly change the final structure that is produced. But it is reasonable to assume that this kind of randomness in Earth systems occurs

only within certain limits imposed by sets of chemical, physical, and biologic variables, and there could be progress or direction in this.

It seems that many features of modern Earth are the result of sequences of events that could have happened in different ways if conditions and timing events were different. Yet what has happened during the past 4.5 billion years only happened in the way it happened! The external and internal forces of Earth produced what has been produced, not something else, and the result is an Earth suitable for an enormous cargo of humans, and the human condition is accepted by a number of scientists (but certainly not by all) as good evidence for progress in evolution.

Organic Evolution: Progress or Random?

Perhaps most important for the whole argument for the Creator is the idea of progress in human evolution. If humans represent the end product of creation, it is logical to suppose there must have been direction along the way. Yet this basic concept is not widely accepted among biological scientists. Let's consider the kind of questions they ask: Is progress in evolution identifiable? Where is the evidence?

Of course, this kind of question is not new. Scholars still argue about the significance of Charles Darwin's concept of progress as part of his revolutionary nineteenth-century theory. Herbert Spencer's later ideas of social evolution, because they definitely included the idea of progress, receive little respect among some modern philosophers. For them the problem is this: If progress is acknowledged for human evolution, then this points toward a Creator. On the other hand, if all events that produced the human body are random and no progress or direction is obvious, then philosophers and scientists who reject God's role in creation have scored in a big way. Addressing the history of thought on the question of progress is important for resolution of the dilemma.

A recent review of thought on directionality or progress in evolution traces the idea of progress and direction in human evolution from the Greeks and the Romans through the early Christian era.6 Evidently, the idea of humans representing progress first became suspect only during the Renaissance.7 The fact that Darwin and other advocates of evolution, such as Spencer and Huxley, argued for progress is dismissed by some modern students. To them Huxley's idea that "humans are the pinnacle of evolutionary progress" is evidence only that nineteenth-century cultural values were superimposed on the facts of evolution.8

The ideas of recent students of evolution who see the hand of God in creation, such as Teilhard de Chardin and geneticist Theo Dobzhansky, are similarly dismissed.9 The strong antitheistic bias of William B. Provine leads him to the conclusion that even the National Academy of Sciences is intellectually dishonest because its actions can be interpreted as being in defense of progress in evolution. According to Provine, the idea of progress is perpetuated by the academy in order to secure support from the U.S. Congress, most members of which have similar "cultural bias" as did Huxley and de Chardin.10 While the implications of this charge are silly at best and insidious at worst, they are interesting to consider.

According to Robert J. Richards, both Darwin and Spencer had visions of moral and intellectual progress that were "sharpened by the Christianity of their youth; and when the vision dimmed, so that the Creator seemed to recede into the vague interstices of nature, the moral aspects of the vision were retained."11 Evidently, an important threshold was crossed in progressive evolutionary thought in 1966 when George Williams pointed out features of the evolutionary process that were in conflict with the possibility of long-term progress in evolution, something that is necessary if God was involved.12 We cannot ignore the fact that there are arguments against evolutionary progress.

In spite of these proclamations, the idea of progress in evolution is not dismissed by all in spite of (or because of) cultural basis. For example, there is widespread agreement that evolutionary progress is difficult to define because the "criteria for its recognition are subject to an extreme diversity of opinions."13 Thus Michael Ruse arguesthat in spite of the difficulty of agreeing on the concept of progress, "if one equates progress with cellular DNA content, then it is indeed true-that humans come out well ahead of bacteria."14 Maynard Smith adds that if complexity is the measure of progress, then it is obvious that both oak trees and elephants show progress over anything that existed a billion years ago.15 However, Smith concludes his essay with doubts concerning the inevitable consequences of evolution by natural selection.16

Much of the discussion on progress in evolution is, of course, related to the acceptance of the "nondirectional" nature of the source of evolutionary change-mutation. How could characteristics that are produced randomly and then are "selected" by whatever proper environmental processes exist at that time show real progress when the starting point is a random event? If we rewind the tape recorder, the next time it will probably record the production of a different character potential, and a different organism eventually will emerge. As far as Huxley's idea of humans being at the "pinnacle of the evolutionary process" is concerned, the fact is that Huxley recognized that it did happen in a particular way, and humans with the potential to be morally and intellectually superior to all other products of evolution did indeed appear. The apparent randomness of some things does not mean that all things are random. Still the argument continues:

The direction of evolution is the direction of increasing entropy and increasing organization. The thermodynamic arrow of time and the biological arrow of time point in the same direction and suggest a common law of entropy increase that is shared between thermodynamic systems and physical information systems. However, the increase in organization that is observed in evolutionary systems is not due to increasing tendency to perfection, nor does it signal progress. It is a byproduct of the historical constraints placed on species by past history.17

Others who have entered the debate do not proclaim victory as emphatically. According to David M. Raup, "It is unclear whether the presence or absence of evolutionary progress can be demonstrated rigorously."18 Raup uses his statistical background to demonstrate that at least some parts of the fossil record that seem to indicate progress are really the result of Markovian processes that really are random, without any driving forces.19 Raup does not deny the existence of progress in evolution (in fact, he concludes that the history of life on Earth observed from a great distance and only at a few points in the continuum shows directionality), but he is ever alert to the problem of firmly separating apparent evolutionary trends from those that may appear to be directional but actually may have resulted from random processes.20

Probably the most conspicuous and eloquent modern critic of the concept of progress in evolution is Stephen J. Gould. While his attempt at neutrality in the believer-versus-nonbeliever arguments is obscured behind the smoke screen of "culturally conditioned responses," it is very difficult for Gould to be neutral on any subject: "Progress is a noxious, culturally embedded, untestable, nonoperational, intractable idea that must be replaced."21 Even as he expounds on the untestable component of the idea, he simultaneously dismisses any notion of its validity with the dogmatic conclusion that humans are the afterthought rather than the goal of all creation.22 While there are not many who have the privilege to be so positive in testing an untestable theory, Gould also confesses that the fossil record does contain legitimate cases of progress.23 However, to superimpose any theistic interpretation on such cases would be contrary to Gould's thesis that progress is the human response and defense to real scientific discoveries.

Science has little patience with untestable hypotheses, yet the argument against progress in evolution may be a splendid example of just such a thing. Earth evolved and humans appeared, and

few disagree with this. To argue that it could have happened in a different way than it actually happened is an argument that is difficult to win, because it did not happen in a different way. It is an untestable hypothesis, a thing shunned by most scientists. The fact that a different sequence of events could have happened is factual, but it is stretching the point to use this as evidence against progress in evolution. It might be just as reasonable to argue that the polar bear would have appeared if no Arctic Ocean ice cover appeared. But either argument is untestable and is not good science.

Summary

Henry Eyring was fond of reminding people that they only need to believe the truth. The truth is that Earth structures could have had a different history, but they did not. Also, given the idiosyncrasies of genetics and the environment, humans, without direction, might not have appeared. But humans are around, and they have distinct biologic features that suggest considerable progress. Certainly, compared to the animals that surround us, we have a better brain, the most distinctive biological organ we possess. While the accomplishments of civilizations have been erratic and slow, the accomplishments also include the ability to define the fact that if the tape recorder analogy is valid, another Earth could have evolved with different organisms. This we should acknowledge. But we should also acknowledge that there has been progress in evolution and humans are at the top of the heap.

As far as I am concerned, this interpretation is viable, and it has sustained me through a variety of Church callings that have involved dialogue with equally serious students of religion who would ignore science and take the easier road of "true believers." It has not been easy to deal with such people, in spite of their sincerity. However, attempting to deal with them has taught me the important Christian principle of tolerance. Except for a few years of teaching at BYU, I have tried to keep my religious convictions personal, out of the secular classroom, especially not wanting to exercise unrighteous dominion over those dependent on me for a grade. From time to time, students have approached me after class to ask how the subject matter of the course might be reconciled with their own religious beliefs. I have interpreted that as the necessary invitation to explain my own reconciliation of science and religion and the proper time to suggest how they might reach a similar, comfortable philosophy of life. While I have no quantitative measurement of the success of this approach, it has kept me free from any charge of teaching theology instead of geology in a secular university and has provided a comfortable lifestyle. I know of at least one student who was impressed enough with my own reconciliation that he later joined the Church. Many others, I think, are less critical of Christianity in general and LDS theology in particular than they otherwise might have been. More important, it should be apparent that regardless of which approach to a reconciliation is taken, reconciliation is possible. In my own case it has been a necessary ingredient for intellectual honesty, professional responsibility, and serious religious conviction in my life.

Notes

David L. Clark studied at Brigham Young University and Columbia University and received his Ph.D. from the University of Iowa. He taught at Southern Methodist University in Dallas and at Brigham Young University before joining the Department of Geology and Geophysics at the University of Wisconsin in 1963. He was chairman of that department from 1971 to 1974 and associate dean for natural science in the university's College of Letters and Science from 1986 to 1991. Dr. Clark was a Senior Fulbright Fellow and visiting professor at the Institute for Paleontology at the University of Bonn and has conducted paleontologic research in Europe and western North America. During the past twenty-five years, his principal research has been focused on marine geology and paleoclimatology of the Arctic Ocean. In addition, he teaches paleontology and oceanography and has published more than 150 articles concerned with these specialties. Currently the W. H. Twenhofel Professor of Geology and Geophysics at the University of Wisconsin, he serves as the

chairman of the U.S. national committees for both the Antarctic and the Arctic in his position as chairman of the Polar Research Board of the National Academy of Sciences.

1. See David L. Clark, "Early History of the Arctic Ocean," Paleoceanography 3 (1988): 539-50.
2. See J. (Hans) R. Weber and Jack F. Sweeney, "Ridges and Basins in the Central Arctic Ocean," in A. Grant, L. Johnson, and J. F. Sweeney, eds., The Arctic Ocean Region, vol. L of The Geology of North America (Boulder, Colo.: Geological Society of America, 1990), pp. 305-36.
3. See David L. Clark et al., "Late Neogene Climate Evolution of the Central Arctic Ocean," Marine Geology 93 (1990): 69-94; D. L. Clark, "The Pliocene Record in the Central Arctic Ocean," Marine Micropaleontology 27 (1996): 157-64.
4. See David L. Clark, "Arctic Ocean Ice-Cover: Geologic History and Climatic Significance," in Grant, Johnson, and Sweeney, eds., Arctic Ocean Region, pp. 53-62.
5. See George G. Simpson, "Fossil Penguins," Bulletin of the American Museum of Natural History, no. 87 (1946): 99.
6. See Matthew H. Nitecki, ed., Evolutionary Progress (Chicago: University of Chicago Press, 1988), p. 354.
7. See David L. Hull, "Progress in Ideas of Progress," in ibid., pp. 27-48.
8. See William B. Provine, "Progress in Evolution and Meaning in Life," in Nitecki, ed., Evolutionary Progress, p. 49.
9. See ibid., pp. 51, 62.
10. See ibid., p. 69.
11. Robert J. Richards, "The Moral Foundations of the Idea of Evolutionary Progress," in Nitecki, ed., Evolutionary Progress, p. 147.
12. See ibid., p. 129.
13. See Adam Urbanek, "Morpho-Physiological Progress," in Nitecki, ed., Evolutionary Progress, pp. 195-96.
14. Michael Ruse, "Molecules to Men: Evolutionary Biology and Thoughts of Progress," in Nitecki, ed., Evolutionary Progress, p. 98.
15. See J. Maynard Smith, "Evolutionary Progress and Levels of Selection," in Nitecki, ed., Evolutionary Progress, p. 219.
16. See ibid., p. 229.
17. Edward O. Wiley, "Evolution, Progress and Entropy," in Nitecki, ed., Evolutionary Progress, p. 290.
18. David M. Raup, "Testing the Fossil Record for Evolutionary Progress," in Nitecki, ed., Evolutionary Progress, p. 293.
19. See ibid., p. 297.
20. See ibid., pp. 298-301.
21. Stephen J. Gould, "On Replacing the Idea of Progress with an Operational Notion of Directionality," in Nitecki, ed., Evolutionary Progress, p. 319.
22. See ibid.
23. See ibid., p. 234.

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Chapter 3 – The Decline and Fall of the Classical Conception

3.2 The Copernican Revolution

So far as philosophy is concerned, the great watershed separating pre-modernity from modernity is not the Renaissance. It is, rather, a later episode in the history of European thought which could not have occurred without the recovery of the many ancient Greek texts which occurred during the Renaissance. The great watershed separating pre-modernity from modernity is the seventeenth-century intellectual revolution known as the Copernican Revolution. In this intellectual upheaval, the geocentric cosmology which had held sway since the time of Plato and Aristotle was replaced, initially, by a simple form of heliocentrism, and, subsequently, by a still more radically different conception of the universe as unbounded and without any centre and governed by entirely different laws from those by which the universe had formerly been supposed bound. The earth became regarded as a satellite of the sun rather than, as it had formerly been, the unmoving centre of the universe.

Such a change of world-view could not fail but to have profound philosophical implications. Not the least of these was the wholesale repudiation of the previously almost sacrosanct distinction between the sub-lunary and the celestial realms. This distinction had been incorporated by Aristotle in his Metaphysics, as well as in geocentric physics and cosmology more generally. With the removal of the basis for supposing events in the terrestrial realm subject to different laws from those governing the celestial realm, the way became open for a revival of ancient Greek atomism. This occurred in the form of the corpuscularianism championed by Robert Boyle and John Locke. This physical theory supplied the grounds for the distinction between the ontologically objective primary qualities of shape, size, number and motion, and the mind-dependent subjective secondary qualities, such as colour, smell and taste. Such a distinction greatly aided the development of a mathematical approach towards the understanding of natural phenomena which has been the hallmark of natural science ever since. More than anything else, it has been the adoption of a quantitative approach towards the investigation of nature inaugurated by the Copernican Revolution that serves to mark off modernity from the pre-modern period.

Although originally developed and articulated within the framework of a geocentric cosmology, the classical conception of philosophy is not inherently incompatible with either heliocentrism or a mathematical approach to the understanding of nature. Almost without exception, all the major philosophers most closely associated with the Copernican Revolution explicitly subscribed to the classical conception of philosophy. Nothing could be further from the truth than to suppose that, because the classical conception of philosophy was first expounded within the terms of a geocentric cosmology, the case for theism on which this conception rests is somehow dependent upon the supposed truth of geocentrism and has no validity outside such a cosmological framework. That the classical conception of philosophy is independent of geocentrism is borne out by the fact that it was espoused by practically all the major seventeenth- and early eighteenth-century philosophers who pioneered and championed this revolution in thought. As I shall now show, this includes not just Descartes, Spinoza and Leibniz, but also several later thinkers.

Descartes is usually considered the father of modern philosophy and rightly so. For he was the first self-consciously to seek and effect a decisive break with the past, especially Aristotelian physics. Over the question of the purpose and value of philosophy, however, Descartes remains every bit as wedded to the classical conception as the majority of his classical and medieval predecessors had been. This is made plain by a letter of Descartes to the translator of the French edition of his Principles of Philosophy which subsequently became, as he had intended, the preface to that work. In this letter, Descartes sets out his conception of philosophy. He writes,

> Philosophy signifies the study of wisdom, ... and by wisdom we not only understand prudence in affairs, but also a perfect knowledge of all things that man can know.... We can have no greater good than the possession of true philosophy.... Speaking accurately, living without philosophy is just having the eyes closed without trying to open them; and the

> pleasure of seeing everything that is revealed to our sight, is not comparable to the satisfaction which is given by the knowledge of those things which are opened up to us by philosophy.... Men, in whom the principal part is the mind, ought to make their principal care the search after wisdom, which is its true source of nutriment.... There does not exist the soul so ignoble, so firmly attached to objects of sense, that it does not sometimes turn away from these to aspire after some other greater good, even though it is frequently ignorant as to wherein that good consists.... [T]his sovereign good ... is none other than the knowledge of the truth through its first causes, i.e. the wisdom whose study is philosophy.30

Descartes goes on to describe as the highest point in human wisdom, as well as the means for attaining the sovereign good of man, the adoption of two methodological principles propounded in the book of which this letter was to become the preface. The first of these principles is that, in the first instance, we should give our assent only to those propositions whose truth we have clearly and distinctly perceived. The second principle is that we should also give our assent to whatever other propositions we can deduce from those which have been clearly and distinctly perceived to be true.

Descartes claims that the highest possible good for man results from the adoption of these principles because their adoption leads to an intuitive knowledge of the existence of the self as a thinking thing, and, subsequently, on the basis of this first certainty, to a demonstrative knowledge of the existence of God. It was, for Descartes, no less than it was for Aristotle, the knowledge of God's existence to which philosophy leads that enables the philosopher to gain the highest possible good for man. It is well known that Descartes claimed God's existence to be capable of being demonstrated. It is not nearly so widely known, although it is hardly of less importance, that Descartes also supposed, as did other exponents of the classical conception, that the highest possible form of human happiness consists in the intellectual love, or contemplation, of God, an activity which is made possible by the knowledge of God which philosophy brings.

Descartes' best-known work is his Meditations, a work in which he seeks to determine in general terms those matters about which human beings can gain certain knowledge. The Third Meditation purports to contain a demonstrative proof of God's existence. Here, having set out the proof, Descartes is about to consider what other certainties it is possible for him to arrive at on the strength of this one, when he breaks off from his main task to enter the following highly significant aside. He writes,

> But before I ... pass on to the consideration of other truths which may be derived from it [viz. God's existence], it seems to me right to pause for a while in order to contemplate God Himself, to ponder at leisure His marvellous attributes, to consider, and admire, and adore, the beauty of this light so resplendent, at least as far as the strength of my mind, which is in some measure dazzled by the sight, will allow me to do so. For just as faith teaches us that the supreme felicity of the other life consists only in this contemplation of the Divine Majesty, so we continue to learn by experience that a similar meditation, though incomparably less perfect, causes us to enjoy the greatest satisfaction of which we are capable in this life.31

Descartes returned to this theme in a letter to his close friend, Pierre Chanut. He was the French ambassador to Sweden who was responsible for securing for Descartes an invitation from Queen Christina to visit her there to instruct her in philosophy. In this letter, Descartes responds to several queries which Chanut had previously raised. Among these is the question whether 'the natural light [of reason] alone teaches us to love God'. Descartes answers this question as follows. 'I do not doubt that we can truly love God by the sole force of our nature.... I venture to say that in regard to this life, it is the most ravishing and most useful passion we can have — and even that it can be the strongest, although that requires a very attentive meditation because we are continually diverted

by the presence of other objects.'32 Descartes goes on to explain how the sentiment of love towards God can best be cultivated. In so doing, he offers a highly instructive description of what he takes the activity of contemplating God to involve. He writes,

> [O]ne must consider God a mind, or a thing that thinks; so that the nature of our mind, having some resemblance to his, we come to persuade ourselves it is an emanation of the sovereign intelligence 'and, as it were, a particle of the divine gold' [Horace].... [I]f, in addition we heed the infinity of his power, through which he has created so many things, of which we are the least part; the extension of his providence, that makes him see in one thought alone everything that has been, is, shall be, and could be; the infallibility of his decrees, which, although they do not disturb our free will, nevertheless cannot in any fashion be changed; and finally, if, on the one hand, we heed our insignificance, and if, on the other hand, we heed the grandeur of all created things, by noting the manner in which they depend on God and by considering them in a fashion that has a relationship to his omnipotence, without confining them in a globe, as do they who think the world finite: meditation upon all this so abundantly fills the man who hears it with such extreme joy that, ... willingly and entirely joining himself to God, he loves God so perfectly that he desires nothing more in the world than that God's will be done. That is the reason he no longer fears either death, or pains, or disgraces, because he knows that nothing can happen to him save what God shall have decreed; and he so loves this divine decree, esteems it so just and so necessary, knows he ought so entirely to depend upon it, that even when he awaits death or some other evil, if per impossible he could change that decree, he would not wish to do so. But if he does not refuse evils or afflictions, because they come to him from divine providence, he refuses still less all the goods or licit pleasures one can enjoy in this life, because they too issue from that providence, and accepting them with joy, without having any fear of evils, his love renders him perfectly happy.33

Spinoza and Leibniz were to espouse similar views to those of Descartes on this subject. Spinoza is often claimed to have been an atheist. Despite Spinoza's conception of God being highly heterodox, having equated God with nature, it makes a mockery of this thought to regard him as an atheist. As he remarked in protest at this estimate of him, 'I would ask whether a man throws off all religion who maintains that God must be acknowledged as the highest good, and must, as such, be loved with a free mind?'34 The work in which Spinoza expresses these theistic doctrines is the Theologico-Political Treatise. This work also contains a clear statement of Spinoza's allegiance to the classical conception. There he writes,

> The highest good [is] the true knowledge and love of God.... [For] in as much as the intellect is the best part of our being, it is evident that we should make every effort to perfect it as far as possible if we desire ... what is really profitable to us.... [S]ince all our knowledge, and the certainty which removes every doubt, depend solely on the knowledge of God ... it follows that our highest good and perfection also depend solely on the knowledge of God.... Further, since without God nothing can exist or be conceived, it is evident that all natural phenomena involve and express the conception of God in proportion as far as their essence and perfection extend, so that we have greater and more perfect knowledge of God in proportion to our knowledge of natural phenomena.... So, then, our highest good not only depends on the knowledge of God, but wholly consists therein..., and hence the most perfect and the chief sharer in the highest blessedness is he who prizes above all else, and takes especial delight in, the intellectual knowledge of God, the most perfect being.35

Leibniz, too, equates man's highest good with the contemplation of God, a form of activity that philosophy makes possible. He wrote,

> Since God is the most perfect and the most happy and consequently the most lovable of substances, and since our true love consists in the state which causes pleasure to be felt in the perfections and happiness of the beloved, this love ought to give us the greatest pleasure of which a man is capable when God is the object of it.... It is easy to love him as we ought ... if we know him.... [L]ove of God gives us here and now a foretaste of future felicity.
>
> And ... it constitutes our greatest good.... It is true that supreme happiness (with whatever beatific vision, or knowledge of God, it may be accompanied) can never be complete because God, being infinite, cannot be entirely known. Thus our happiness will never consist, and ought not to consist, in a complete enjoyment, in which there would be nothing left to desire, ... but in a perpetual progress to new pleasures and new perfections.36

Similar views to those espoused by the so-called rationalists were also expressed by English philosophers and divines of the same period. For example, Benjamin Whichcote, the Wider of Cambridge Platonism, equates the highest human happiness with the contemplation of God, claiming such a form of activity to be made possible by the knowledge of God at which man is capable of arriving through philosophical reflection. Whichcote states these views in his sermon, 'The Use of Reason in Matters of Religion'. Here, Whichcote remarks that

> [i]t is the natural and proper employment of the mind and understanding to make search and enquiry after God.... Mind and understanding is given on purpose that man should search after God and acknowledge him.'37 In another of his sermons, 'The Manifestation of Christ and the Deification of Man', Whichcote claims 'there is more pleasure and satisfaction in contemplation, than in any of the pleasures of sense; and ... those men that live apart from the world, and are taken up in meditation, and contemplation, their pleasures are more intense and solid, than those of the licentious, and of such as please themselves in the gratification of sense'.38 He adds that 'man being made to know God, ... he is made happy in the enjoyment of Him'.39 Accordingly, he goes on to observe, 'if a man be separated from God, his mind and understanding are without their proper object ... if we give ourselves up to meditation upon God, ... we do thereby ennoble and enlarge our faculties.40

The view espoused by Whichcote in these quoted passages was by no means confined to divines in England during this period. It was shared, arguably, by no less a scientific authority than Isaac Newton. The General Scholium with which Newton concludes his Principia reveals the strength of his attachment to theism. It also suggests that, as well as believing theism to be fully compatible with the new cosmology, Newton was not without sympathy for the classical conception of philosophy. He writes,

> This most beautiful system of the sun, planets, and comets, could only proceed from the counsel and dominion of an intelligent and powerful Being.... This Being governs all things ... as the Lord over all; and on account of his dominion he is wont to be called Lord God.... The Supreme God is a Being eternal, infinite, absolutely perfect ... a living, intelligent, and powerful Being; ... supreme, or most perfect. He is eternal and infinite, omnipotent and omniscient; ... he governs all things, and knows all things that are or can be done.... He endures for ever.... [T]he supreme God exists necessarily.... He is utterly void of all body and bodily figure.... We know him only by his most wise and excellent contrivances of things and final causes; we admire him for his perfections; but we reverence and adore him on account of his dominion.41

The classical conception of philosophy continued to be explicitly espoused in Britain well into the eighteenth century. For instance, in his dialogue, 'The Moralist', Shaftesbury has one of its principal interlocutors go off into the countryside early one morning in order to be able to commune with nature which he addresses in the following terms:

> Ye fields and woods, my refuge from the toilsome world of business, receive me in your quiet sanctuaries, and favour my retreat and thoughtful solitude ... with its beloved tranquillity it affords a happy leisure and retreat for man, who, made for contemplation, and to search his own and other natures, may here best meditate the causes of things, and, placed amidst the various scenes of Nature, may ... nearer view her works.... 0 glorious nature ... whose study brings such wisdom, and whose contemplation such delight.... 0 mighty Nature! Wise substitute of providence! Impowered Creatress! Or thou Impowering Deity, supreme creator...! Since by thee, o sovereign mind, I have been formed such as I am, intelligent and rational, the peculiar dignity of my nature is to know and contemplate thee, ... since ... nor love of aught save thee alone inspires me with such thoughts as thee, be then my assistant and guide in this pursuit, whilst I venture to tread the labyrinth of wide Nature and endeavour to trace thee in thy works.42

Again, in his Illustrations on the Moral Sense, Francis Hutcheson, for example, claims that 'the knowledge and love of the Deity ... is as natural a perfection to such a being as man, as any accomplishment to which we arrive by cultivating our natural dispositions; nor is that mind come to the proper state and vigour of its kind where religion is not the main exercise and delight'.43 Adam Smith echoes the same sentiment, albeit more softly, when he claims that the idea of God is `of all the objects of human contemplation by far the most sublime'.44 He goes on to remark that '[t]he man whom we believe to be principally occupied in this sublime contemplation, seldom fails to be the object of our highest veneration; and though his life should be altogether contemplative, we often regard him with a sort of religious respect, much superior to that with which we look upon the most active and useful servant of the commonwealth'.45

In sum, that set of doctrines which I am calling the classical conception of philosophy was neither unknown to, nor had it been repudiated by, those philosophers who were most instrumental in or immediately influenced by the Copernican Revolution. Nonetheless, during the course of the eighteenth century, this conception of philosophy was increasingly to come under fire. So much was this so that, by the end of the century, it had become mortally wounded, and, before the end of the following century, had all but expired. Our task now is to consider what led to its downfall.

3.3 God's unwilling executioners

If it was not the emergence of modern science per se that was responsible for the demise of the classical conception of philosophy, who or what was? How did God come to be evicted from His traditional abode at the heart of the philosophical enterprise? For having effected this monumental transformation in human thought, credit or blame must largely go to a trio of philosophers. Two come from the eighteenth century, the third from the nineteenth. More than anyone else, it has been the combined influence of their thought that has been responsible for the steadily increasing secularisation of philosophy that has occurred since the end of the eighteenth century. The three philosophers are David Hume, Immanuel Kant and Friedrich Nietzsche: Hume is father of modern naturalism; Kant of modern anti-realism; and Nietzsche of currently fashionable post-modernism.

As we have seen, the cosmological change effected during the Copernican Revolution neither posed, nor, at the time, was thought to have posed, any immediate challenge or threat to God's existence. It did, however, indirectly call into question all those religious doctrines which had purportedly been disclosed by means of revelation. This is because the accounts given of their revelation in the Bible were couched in terms of a geocentric cosmology which had been decisively

discredited by the Copernican Revolution. The new cosmology, therefore, could not fail to call into question the status and authority of the text in which the account of the revelation of these doctrines was given. Hence, by implication, it could not fail to call into question the doctrines supposedly revealed. To all who bothered to think about it, therefore, there was a glaringly obvious prima facie incompatibility between the geocentric cosmology unselfconsciously assumed in the Bible and the heliocentrism which had gained ascendancy in the seventeenth century. This seeming incompatibility between the Bible and the new science issued in the eighteenth century in a great efflorescence of natural and revealed theology which was designed to reconcile the two. It was essentially this body of theology against which Hume and Kant were to react with such historic effect.

Natural theology blossomed as apologists for Christianity sought to provide for their most cherished religious convictions a new rational basis that would insulate them from the challenge which the new sciences had not spared those religious doctrines based purely on the authority of the Bible. The provision of a new rational basis for religious belief was accomplished in one or other of two ways. First, as had been done in the past when the Bible appeared at variance with empirical fact, biblical narratives became subject to non-literal interpretation so as to be squared with the new science. Second, as was to become increasingly common, attempts were made to provide religious convictions with a rationally unimpeachable warrant through representing them as the deliverance of reason alone, unaided by any putative divine acts of revelation.

To assert that the eighteenth century witnessed a huge increase of interest in and preoccupation with the subject of natural theology is not to suggest that until then no significant developments had taken place in this subject since its inception in classical antiquity. Ever since its original formulation by the ancient Greeks, natural theology had been the constant focus of attention of theologians and philosophers who had endlessly elaborated and refined it. Arguably, however, during the two millennia that separate Plato and Aristotle from Hume and Kant, only one major new argument had been propounded for the existence of God. This was the so-called Ontological Argument, first formulated by St Anselm in the twelfth century. This argument purports to establish the existence of God solely through unpacking what is involved in the idea of a most perfect Being. In what follows, this argument will not be considered, nor will the criticisms levelled against it by Hume and Kant. This is so for two reasons. First, since our chief concern is with the classical conception of philosophy, our prime interest is only with such arguments for God as posit God as the only or best explanation of the world and the order it manifests. Second, like many classical and contemporary authorities, I do not regard the Ontological Argument as being anywhere near as formidable an argument for God as, so I shall argue, are each of two other arguments for God on which proponents of the classical conception of philosophy have always been principally reliant. These are the so-called Cosmological Argument and the Argument from Design. In what follows, therefore, only these two arguments and the objections against them levelled by Hume and Kant will be considered.

Of the three philosophers who I have claimed were chiefly responsible for God's removal from philosophy, only Hume appears to have had any genuine sympathy for, or much understanding of, the classical conception of philosophy. He hints at his predilection for it in a letter of his written to a friend when Hume was only 16 years old. Hume wrote,

> The perfectly wise man ... outbraves fortune.... [T]his pastoral and Saturnian happiness, I have, in a great measure come at just now.... This greatness and elevation of soul is to be found only in study and contemplation. This alone can teach us to look down on human accidents.... [A]llow [me] to talk thus like a philosopher: `tis a subject I think much on, and could talk all day of.46

Hume further reveals his depth of understanding of and sympathy for the classical conception in a brief essay of his in which he offers a statement of the credo of an imaginary figure whom Hume calls the 'Platonist'. He is intended to represent one of four perennial types of philosopher who, according to Hume, 'naturally form themselves in the world and entertain different ideas of human life and happiness ...'.47 The three other perennial types to which Hume devotes seperate essays are the 'Epicurean', the 'Stoic' and the 'Sceptic', the last espousing the viewpoint which corresponds most closely with Hume's own. The account which Hume gives of the credo of the Platonist indicates how thoroughly conversant with the classical conception of philosophy Hume was and suggests that its attractions could not have been wholly lost upon him. Hume has his Platonist declaim that

> A rational soul made for the contemplation of the Supreme Being, and of his works, ... [can] [n]ever enjoy tranquillity or satisfaction, while detained in the ignoble pursuits of sensual pleasure or popular applause. The Divinity is a boundless ocean of bliss and glory: human minds are smaller streams, which arising at first from the ocean, seek still, amid all their wanderings, to return to it, and to lose themselves in that immensity of perfection.... Can we ... be so blind as not to discover an intelligence and a design in the exquisite and most stupendous contrivance of the universe? Can we be so stupid as not to feel the warmest raptures of worship and adoration upon the contemplation of that intelligent being, so infinitely good and wise?... The most perfect happiness surely must arise from the contemplation of the most perfect object. But what more perfect than beauty and virtue? And where is beauty to be found equal to that of the universe, or virtue which can be compared to the benevolence and justice of the Deity? ... It is our comfort, that if we employ worthily the faculties here assigned us, they will ... render us ... suitable worshippers of our Maker; and that ... task, which can never be finished in time, will be the business of an eternity.48

It is not surprising that Hume should have been so conversant with the classical conception and its attractions. For, by disposition, he seems not to have been at all atheistic, or even agnostic. The most authoritative biographer of Hume informs us that he 'gave up [religion] slowly and reluctantly, even against his will, as it were, in the face of what he regarded as ineluctable logic'.49 To an assembled gathering of French philosopher which included the notorious atheist, Baron D' Holbach, Hume reputedly remarked that he had never met an atheist in his life and did not believe in their existence. This quip supposedly drew from D' Holbach the riposte that sympathy was due Hume for having the misfortune of finding himself in the company of no less than 17 of them!50

If taken at his word, Hume would apparently have liked nothing better than to have been able to provide a secure basis for religious belief. To a friend who had urged him to assist him in finding philosophical arguments to support theism, Hume replied,

> Whatever you can think of to strengthen that side of the argument will be most acceptable to me. Any propensity you imagine I have to the other side crept in upon me against my will.... [B]efore I was twenty, ... the gradual progress of my thoughts on this head ... began with an anxious scent after arguments to confirm the common opinion; doubts stole in, dissipated, returned; were again dissipated, returned again; and it was a perpetual struggle of a restless imagination against inclination — perhaps against reason.... I wish ... [the theistic] argument could be so analysed as to be rendered quite formal and regular.... We must endeavour to prove that th[e] propensity [towards accepting it] is somewhat different from our inclination to find our own figures in the clouds, our faces in the moon, our passions and sentiments even in inanimate matter. Such an inclination may and ought to be controlled, and can never be a legitimate ground of assent. [My emphasis]51

Despite apparently having considerable sympathy with, if not a native propensity for, religious belief, Hume has not come to be remembered as an apologist for religion, and not without good reason. However genuinely reluctant he may have been to discredit the basis for religious belief, Hume, together with Kant, is one of the chief and most influential assailants of theism. Hume has been justly described as 'the real father of positivist philosophy — chronologically the first thinker we may call positivist without making any of the reservations we have to make with earlier thinkers'.52

Kant appears to have had far less sympathy for, or even comprehension of, the classical conception of philosophy than Hume did. Kant reveals this in what he wrote on the one occasion on which he discussed the several ideals of the different schools of ancient Greek philosophy. Like Hume, Kant identifies one that he calls 'the Platonic ideal'.53 He equates this ideal with 'man see[ing] himself in communion with the highest being'.54 As a characterisation of the Platonic ideal, Kant's description seems wide of the mark. As Kant uses the term 'communion', it suggests he had in mind a far more interactive relation between man and God than obtains between them when the former contemplates the latter in the activity of theoria. Kant dismisses the ideal on grounds of its unattainability. He writes, "An immediacy of union with the Supreme Being", were it possible, would be the highest moral perfection to which we could attain. This, however, is an ideal which is beyond our reach.... Such ethics is fanciful and visionary.'55 Kant provides no reason why it should be thought beyond human reach to engage in the contemplation of God. Nor does Kant give any indication that he was aware that nothing more than the contemplation of God was involved in the Platonic conception of the supreme human good.

Despite his lack of sympathy with, even apparent comprehension of, the classical conception of philosophy, Kant, in many respects, was far more religiously inclined than Hume. Kant's religious susceptibilities are revealed by the account which he reputedly gave of his reaction to an incident he witnessed late in his life. The incident in question was that of a swallow expelling some of her brood from her nest, which Kant interpreted had been prompted to ensure the survival of at least some of the brood, given the depleted food supplies available after an inclement summer. On recounting his reaction to this incident, Kant is reputed to have said, 'My intelligence stood still. There was nothing to do but to fall on one's knees and worship.' The friend to whom Kant supposedly related the incident remarked of Kant's demeanour at the time, '[t]he devout awe which glowed in his venerable face, the tone of his voice, the way he clasped his hands, his enthusiasm — it was all unique'.56

Despite strenuously opposing speculative theology, Kant made it clear that he had no intention to discredit belief in God. Indeed, he claimed the chief merit of his own system of critical philosophy to be that it had secured religious faith from otherwise unassailable rational doubt. In the Preface to the second edition of his Critique of Pure Reason, Kant explains how his philosophy will 'benefit the public without their knowing it'.57 He writes,

> [B]y means of a thorough investigation of the rights of speculative reason, [it is possible] once and for all, to prevent the scandal which, sooner or later, is sure to break out among the masses, as the result of the disputes in which metaphysicians (and, as such, finally also the clergy) inevitably become involved to the consequent perversion of their teaching. Criticism alone can sever the root of ... atheism.58

In developing his critical philosophy, it was, no doubt, part of his objective to demonstrate the indemonstrability of the truth of theism. However, he considered himself to have made an invaluable contribution to securing the reasonableness of religious faith by also having demonstrated the indemonstrability of God's non-existence. As he put it, he had 'found it necessary to deny knowledge [of God], in order to make room for faith'.59

The editor of an anthology of Kant's writings is, thus, correct to describe Kant as 'a profoundly religious man'. This same editor seems mistaken, however, when he goes on to state that 'Kant would have dearly loved to give a theoretical proof [of God's existence] himself'.60 On the contrary, Kant positively welcomed the indemonstrability of God's existence. He argued, not altogether convincingly,61 that possession of such a proof would foreclose to us the possibility of moral goodness. In order to be morally good, on his view, our actions must be motivated from a pure sense of duty alone, unmixed by any other motive. A demonstrative knowledge of God's existence, he claimed, would prevent us from being able to obey the moral law except from a self-interested concern to avoid divine punishment for disobedience. Conformity with the moral law would no longer stem from a regard to duty alone, but from self-interest. Kant puts this point as follows in his Lectures on Philosophical Theology:

> Our faith is not scientific knowledge, and thank heaven it is not! For God's wisdom is apparent in the very fact that we do not know that God exists, but should believe that God exists. For suppose that we could attain to scientific knowledge of God's existence.... Then, in this case, all our morality would break down. In his every action, man would represent God to himself as a rewarder or avenger. This image would force itself involuntarily on his soul, and his hope for reward and fear of punishment would take the place of moral motives. Man would be virtuous out of sensuous impulses.62

Towards the question of God's existence, therefore, Kant's attitude was complex. He considered it necessary to demonstrate the indemonstrability of God's existence so as to safeguard the possibility of moral goodness. At the same time, he felt compelled to establish the indemonstrability of God's non-existence so as to preserve the possibility of faith in God. He considered such faith equally necessary in order for moral goodness to be possible. His reasoning was that, in order for people to be able to act from respect for the moral law, it is necessary that they believe in a summum bonum or highest good in which perfect moral goodness is rewarded with the happiness it deserves. The attainment of perfect moral goodness requires immortality, for no one can become perfectly good during their lifetime. Perfect happiness as a reward for such goodness requires God to apportion it in accordance with desert. So, despite supposing God's existence to be incapable of being proved, Kant also supposed it was necessary for us to postulate God's existence, along with immortality and free will, so as to entertain the idea of the possibility of a summurn bonum in which happiness is combined with moral perfection.

Notwithstanding how sincere Kant might have been in wanting to make way for faith, his critique of speculative theology has been generally thought to have had a profoundly destructive effect upon religious belief. His contemporary, Moses Mendelssohn, called Kant the Alleszermalmer, 'the one who smashes everything'. And, in terms of the destructive impact which his thought had upon religion, Heinrich Heine likened Kant to Robespierre. Heine wrote,

We find in both the same talent of mistrust, only ... the one exercises it against thoughts, and calls it criticism, while the other applies it against men, and entitles it republican virtue.... One ... placed a king ... the other a God on the scale.... Had the citizens of Konigsberg divined the full meaning of this subversive, world-bruising thought they would have felt before that man a far more gruesome awe than before an executioner — an executioner who puts only men to death.63

Again, Arthur Schopenhauer remarks of Kant's Critique of Pure Reason that '[t]he detailed refutation of speculative theology ... is to a certain extent the aim and object of the whole work.... [T]he complete overthrow of that philosophy through this polemic stands to Kant's immortal credit. He has eliminated theism from philosophy....'64 Elsewhere, Schopenhauer describes Kant as having 'given the deathblow to speculative theology by criticism thereof'.65

Notwithstanding how religiously inclined Hume and Kant might personally have been, their respective critiques of natural theology have served to undermine the credibility of theism in the eyes of later generations of philosophers. Either by first-hand acquaintance with the relevant texts themselves, or else, and more often, by hearsay, most philosophers today are convinced that, between them, Hume and Kant have decisively refuted all the traditional philosophical arguments for the existence of God. Against the background of such a presumption, small wonder is it that few present-day philosophers subscribe to the classical conception of philosophy. In the following two sections, I propose to examine the various objections which Hume and Kant levelled against the two arguments for the existence of God upon which the classical conception of philosophy has always been traditionally reliant. Following that, in the following and concluding section of the chapter, I shall subject to similar scrutiny such arguments as Nietzsche may be thought to have advanced against theism. In the case of all three thinkers, my aim is to show that none of their arguments provides good reason for rejecting these two arguments for the existence of God.

3.4 The assault on the Cosmological Argument

To what considerations did Hume and Kant each appeal in their repudiation of natural theology? In what follows, for reasons given above, I confine discussion to a consideration of their objections to the

Cosmological Argument and the Argument from Design. I shall consider each in turn. I shall rehearse each argument in the form in which Hume criticised it before presenting and considering the various objections raised against these arguments by Hume and Kant. In the case of each argument, my aim will be to show that none of their objections succeeds in establishing either argument to be unsound. This holds true for the Argument from Design even in the face of Darwin's theory of evolution.

The objections which Hume levels against the two arguments are chiefly contained in his Dialogues Concerning Natural Religion. In this work, Hume places the following succinct and lucid formulation of the Cosmological Argument into the mouth of Demea, one of the principal interlocutors in the dialogues:

Whatever exists must have a cause or reason of its existence; it being absolutely impossible for any thing to produce itself, or be the cause of its own existence. In mounting up, therefore, from effects to causes, we must either go on in tracing an infinite succession, without any ultimate cause at all; or must at last have recourse to some ultimate cause, that is necessarily existent: Now that the first supposition is absurd may be thus proved. In the infinite chain or succession of causes and effects, each single effect is determined to exist by the power and efficacy of that cause, which immediately preceded; but the whole eternal chain or succession, taken together, is not determined or caused by any thing: and yet it is evident that it requires a cause or reason, as much as any particular object, which begins to exist in time. The question is still reasonable, why this particular succession of causes existed from eternity, and not any other succession, or no succession at all. If there be no necessarily-existent being, any supposition, which can be formed, is equally possible; nor is there any more absurdity in Nothing's having existed from eternity, than there is in that succession of causes, which constitutes the universe. What was it then, which determined something to exist rather than nothing, and bestowed being on a particular possibility, exclusive of the rest? External causes, there are supposed to be none. Was it Nothing? But that can never produce any thing. We must, therefore, have recourse to a necessarily- existent Being, who carries the REASON of his existence in himself; and who cannot be supposed not to exist without an express contradiction. There is consequently such a Being, that is, there is a Deity.66

For purposes of discussion, it will be convenient to represent the Cosmological Argument schematically as follows:

(1) Everything that exists must have a cause or reason for existing.

(2) Everything that exists must either exist necessarily in and of itself or not so exist.

Ergo, (

3) Everything that exists must either exist necessarily in and of itself or else must have been caused to exist by something else, which either exists necessarily in and of itself or else was caused to exist by something else that either exists necessarily in and of itself or was caused to exist by something else that either exists necessarily in and of itself or ... etc. ad infinitum.

Ergo, (4) Unless the physical universe exists necessarily in and of itself, then it was either caused to exist by something which exists necessarily in and of itself, or else it is nothing but a beginningless series of physical continuants none of which exists necessarily in and of itself, each having been brought into being by some earlier member(s) in the series.

(5) If the physical universe is nothing but a beginningless series of physical continuants none of which exists necessarily in and of itself, each having been brought into being by some earlier member(s), then, the series of such continuants as a whole, and hence the physical universe, would lack a cause.

(1) and (5) together entail:

(6) The physical universe is not just a beginningless series of physical continuants none of which exists necessarily, each having been caused to exist by some earlier member(s) of that series.

(4) and (6) together entail:

(7) Unless the physical universe is something the existence of which is necessary in and of itself, then its existence has been caused by something which exists necessarily in and of itself.

(8) The physical universe is not something the existence of which is necessary in and of itself.

(7) and (8) together entail:

(9) The physical universe has been caused to exist by something which exists necessarily in and of itself.

Not a single independent premise of this argument escapes criticism from Hume. Against premise (1), Hume advances two objections. The first objection occurs in his Treatise of Human Nature, the second in his Dialogues. The objection Hume offers in the Treatise is that, even though, as a matter of fact, it might be true that everything that begins to exist has a cause, it is not necessary that this should be so. It is perfectly possible, because, according to Hume, it is perfectly conceivable, that a thing might start to exist quite spontaneously without anything having caused it to do so. For Hume, there is no inherent internal incoherence in the notion of something's starting to exist at some moment in time quite spontaneously, without anything having caused it to do so. Hume advances the objection in the following words:

As all distinct ideas are separable from each other, and as the ideas of cause and effect are evidently distinct, 'twill be easy for us to conceive any object to be non-existent this moment, and existent the next, without conjoining to it the distinct idea of a cause or productive principle. The separation, therefore, of the idea of a cause from that of a beginning of existence is plainly possible for the imagination, and consequently the actual separation of these objects is so far possible that it implies no contradiction or absurdity.67

Against what Hume argues here, it may be questioned whether Hume is correct to claim us able to conceive of something's starting to exist without being caused to do so by anything, without some internal incoherence being involved in what we conceive. The difficulty with Hume's claim has been well put by John Haldane:

> Try ... imagining for your self something popping into existence .. . uncaused. You are sitting at an empty desk looking at its surface and all of a sudden a book, or an apple, or a lump of unidentifiable matter appears before you.... That is imaginable, but what is neither given nor required by the scenario is that the objects have come to be without a cause and that is not at all something one would suppose. Rather one would ask 'Where have they come from?' 'How did they get there?..., and so on.... [O]nce one moves from Hume's abstractions to an actual example it becomes clear that this invites questions in search of explanations by reference to antecedent causes. In short, to the extent that Hume's remarks lead in any direction it is towards and not away from the principle of sufficient reason.68

In his Dialogues, Hume offers somewhat different reasons for rejecting premise (1). Here, Hume suggests that it is possible that the universe is eternal, and hence that there was never a time at which it did not exist. Should the universe be eternal, argues Hume, its existence would not stand in need of a cause. Hence, for a somewhat different reason from that offered in the Treatise, not everything that exists would stand in need of a cause in order to exist. In the Dialogues, Philo is made to state this objection by asking rhetorically, 'How can any thing, that exists from eternity, have a cause, since that relation implies a priority in time and a beginning of existence?'69

The force of this objection of Hume's to premise (1) depends on whether he is correct to suppose that causes must always have prior temporal existence to their effects. It may be doubted whether this must always be so. For example, each physical thing in the universe supposedly exerts upon every other physical thing some degree of gravitational attraction. In so doing, each thing supposedly exerts upon every other thing some form of causal influence, at least so far as concerns their relative locations. This form of mutual causal influence is something which things exert upon one another without their having, or indeed being able to have, any temporal priority vis-a-vis each other in any way.

Even were the physical universe eternal, and so, in consequence, there was never a time at which it did not exist, its being eternal would not necessarily obviate its need for a cause at every moment of existence. This is so, if, as seems to be the case, its existence is contingent. No matter how long the world might have existed, even if from eternity, if its existence is only contingent, it seems legitimate to wonder, with respect to the universe at each moment of its existence, what sustains it in existence at that moment, granted that its existence at that moment is not necessary. By way of response, it might be said that, granted that the universe exists from eternity, no explanation is needed to account for its existence at each and every moment. To such a response, it can be replied that, provided that the existence of the universe is contingent, there is as much need of an explanation of its existence at each and every moment of its existence, as there is to account for its coming into existence at some moment. Therefore, even if the universe has always existed, its existence at each moment of it still stands in need of causal explanation, provided its existence is contingent and not necessary.

Hume rejects premise (2) by taking issue with the concept of something's existing necessarily in and of itself. Hume objects to this notion on the grounds that there is nothing of whose non-existence we are not able to form a notion without any internal inconsistency being contained in the notion of that thing's non-existence. Since, so he argues, the existence of a thing would only be necessary in and of itself, if the notion of its non-existence were to contain some inherent contradiction, it follows there is and could be nothing whose existence is necessary in and of itself. Hume states this objection so:

> Nothing is demonstrable, unless the contrary implies a contradiction. Nothing, that is distinctly conceivable, implies a contradiction. Whatever we conceive as existent, we can also conceive as non-existent. There is no being, therefore, whose nonexistence implies a contradiction.... [T]he mind [can] [n]ever lie under a necessity of supposing any object to remain always in being; in the same manner as we lie under a necessity of always conceiving twice two to be four. The words, therefore, necessary existence, have no meaning; or, which is the same thing, none that is consistent.70

This objection of Hume's has force only if he is correct that the existence of something could be necessary in and of itself, only if the thought of that thing's non-existence were to involve some internal contradiction. This, however, is open to doubt. To suppose that, unlike the physical universe, God exists necessarily in and of Himself is not to suppose that the notion of God's non-existence contains, or, by itself, entails, a formal contradiction. Rather, it is only to suppose that, in the words of John Haldane whose view we follow here, God `exists eternally, ... does not owe [His] being to anything else and ... cannot not exist'.71 Clearly, it is possible for us to conceive that no such Being exists, without any contradiction being involved in our conception. Our being able to do this does not show that it is not possible that there could be a Being who satisfies this description. It is only a Being who answers this latter description that the Cosmological Argument is designed to establish the existence of. It is not intended to establish it to be intrinsically necessary that such a Being exists.

Hume questions the legitimacy of the inference of premise (4) from premise (3) on the basis of two other claims he makes. First, he denies the physical universe as a whole to be an instance of any kind of which there can be more than one instance. Second, he asserts that only non-unique particulars admit of standing as the terms of causal relations, either as causes or effects. Hume takes the first of these two claims to be self-evident. He derives the second from his account of what is involved in one thing's being the cause or effect of some other thing(s). All that is involved, he argues, is for the first thing to be an instance of a kind each of whose instances is spatially or temporally adjacent to some instance of another kind. Given this, argues Hume, because the physical universe is singular and unique, it is not something whose existence admits of being conceived as an effect, and hence as standing in need of a causal explanation.

Hume can correctly deny the validity of the inference of premise (4) from premise (3), only if he is correct in both his claims. Their conjunction seems singularly implausible.72 By tracing the origin of the physical universe to a supposed `Big Bang', modern cosmology places Hume in the following dilemma. Either, he must deny that the physical universe as a whole is singular and unique, on the grounds that it resembles other things besides it that explode, such as grenades. Or, alternatively, should he insist on the uniqueness of the physical universe, he must concede that there are some unique things which are capable of standing as terms of causal relations.

Hume's denies premise (5) on the grounds that the cause of the existence of any series of physical continuants is nothing beyond the sum of the causes of each member of the series. Accordingly, so he argues, should each individual non-necessary physical entity have been caused to exist by some

previously existing but non-necessary member(s) of a beginningless series of such non-necessary existents, then the physical universe as a whole will not be without a cause. Hume writes, 'Did I show you the particular causes of each individual in a collection of twenty particles of matter, I should think it very unreasonable, should you afterwards ask me, what was the cause of the whole twenty. This is sufficiently explained in explaining the cause of the parts.'73

Hume's objection has force only if he is correct to suppose that the parts of any whole none of which exist necessarily in and of themselves can each and all be fully explained in terms of other members of that same whole. This supposition may be doubted. The causal explanations of the parts of any such whole in terms of other parts cannot add up to a causal explanation of the whole, if the items mentioned as causes are items whose own existence stands in need of a causal explanation. The fatal flaw in Hume's supposition has been well put by James Sadowsky. He asks,

> how any member [of any such causal series] can do any causing unless it first exists. B cannot cause A until D brings it into existence. What is true of D is equally true of F. and F without end. Since each condition for the existence of A requires the fulfilment of a prior condition, it follows that none of them can ever be fulfilled. In each case what is offered as part of the solution turns out instead to be part of the problem.74

We are left with Hume's objection to premise (8). Hume rejected this premise on the somewhat incongruous grounds, given his reasons for denying premise (2), that the physical universe might possibly be necessary in and of itself, despite human beings not being able to perceive the necessity of its existence. In support of such a possibility, Hume appeals to the fact that, in arithmetic, there are certain propositions which we can know are possibly true without our being able to perceive their necessity and despite them being necessary, if true. As an example of such an arithmetic proposition, Hume cites that which asserts the sum of the constituent integers of each product of the number 9 always to add up to 9 or else to some other number whose constituent integers add up to 9. (Thus, 2 x 9=18 [=1+8=9]; 3 x 9= 27 [=2+7=9]; 4 x 9=36 [=3+6=9]; and so on.) Hume observes that those proficient in mathematics might be able to demonstrate the truth of this proposition, and hence become able to apprehend its necessity. Others might simply be aware that it is possibly, or even probably true, without appreciating or being able to appreciate that, or why, it could not be otherwise and despite it not being able to be otherwise. Likewise, so Hume argues, the universe could appear to human beings to be something whose existence is merely contingent, despite its existence being necessary. Hume asks,

> Is it not probable ... that the whole economy of the universe is conducted by a ... necessity, though no human algebra can furnish a key ...? [M]ay it not happen, that, could we penetrate into the intimate nature of bodies, we should clearly see why it was absolutely impossible, they could ever admit of any other disposition.75

Hume's objection to premise (8) suffers from the following fatal weakness. It is possible, given the natures of physical things, that they could not but exist and possess the various properties they do. Despite this, their existence and their properties could not be supposed necessary unless it was necessary that they existed with the natures that they had. The natures of physical things can only render their existence necessary after they existed with those natures. Hence, the natures of physical things cannot, as Hume suggests here, be supposed capable of rendering the existence of the things that have these natures necessary.

We turn now to Kant's objections to the Cosmological Argument. These are contained in a section of his Critique of Pure Reason entitled, 'The Dialectical Inferences of Pure Reason'. Here, Kant takes issue with the argument on no less than three separate counts. Utilising that schematised form of the argument we set out earlier, we may say that Kant rejects premises (1), (2) and (8).

Premise (1), it will be recalled, asserts that everything that exists at any time must have a cause or reason for existing. Kant rejects this premise on the seemingly dubious grounds that all that we can think of as having causes are the various changes of state which are undergone by any physical substances at various moments of time, not their coming into existence at specific moments of time. 'Knowledge of nature ... refers to a cause, not the things themselves (substances), but only that which happens, that is, their states.'76

Kant's grounds for rejecting premise (1) seem weak. Pace Kant, innumerable physical substances seem to begin to exist at specific times. Moreover, for each such substance, it seems we can enquire after, and often succeed in identifying, the causes of its beginning to exist when it does. Kant's grounds for rejecting premise (1) seem less weak when it is appreciated that the physical substances of whose existence Kant denies we can and do seek or find the causes are not everyday physical objects, like chairs, mountains or planets. They are, rather, the ultimate particles, whatever they be, out of which everyday physical objects are composed and which are conserved throughout all substantival change. Kant argued that it is necessary for us to posit the permanency of such physical substances in order for us to be able to construe our sensory experience as the appearances of a single common spatio-temporal universe. Kant calls this type of argument for a category or principle, a 'transcendental deduction' of it. By this, he means a demonstration of our need to adopt this category or principle in all our thinking about the world. In the case at hand, the principle to which he claims we are obliged to subscribe is that which

he calls the principle of permanence of substance. This states that'[i]n all changes of appearances substance is permanent; its quantum in nature is neither increased nor decreased'.77 Kant argues that, were any such substance to be supposed capable of coming into existence or going out of existence, then our experience could not have the unity it does as the experience of a single common world.78 Furthermore, argues Kant, there could never have been a time when such a substance began to exist. This is because, for there to have been such a time, it would have been necessary that there be a time before any such substance existed. However, so argues Kant, it is impossible for there to have been any such time, since we can only conceive of the lapse of time in terms of changes which physical things have undergone, all of which changes presuppose the existence of physical substance. 79

Defenders of the Cosmological Argument are not without ways of replying to Kant. They can respond that, even if physical substance has always existed and would always continue to do so, its existence would still only be contingent and not necessary in itself. Therefore, it would remain legitimate to seek for a cause of its existence. Should this be so, Kant would not have provided any reason to reject premise (1), even should he be correct in what he asserts about the conservation of matter.

The second premise of the Cosmological Argument, to recall, was that everything that exists must either do so necessarily in and of itself or not so exist. Kant rejects this premise on much the same grounds as did Hume. He denies, that is, that it makes sense to suppose anything capable of existing necessarily in and of itself. 'There is nothing which absolutely binds Reason to accept such an existence; on the contrary it can always annihilate it in thought, without contradiction; absolute necessity is a necessity that is to be found in thought alone.'80 Kant may well be correct to assert, as he does here, that there is nothing of whose existence we may form an idea of whose non-existence we can equally form the idea without any internal incoherence being involved in our notion of that thing's non-existence. This applies even to something conceived of as incapable of not having existed. That is, we can without internal contradiction being involved conceive of there being no such thing. However, it does not follow from this that there is no internal incoherence in our notion of the nonexistence of a thing with such a status when such a notion is combined with

the notion of the contingency of the physical universe and the necessity for there to be something capable of accounting for the existence of the physical world. If all contingent existence requires a cause, then, ultimately, only the existence of something that is not itself contingent is able to serve as such a cause. Hence, the notion of the non-existence of a necessary being will involve an internal incoherence when it is combined with the notion of the existence of a contingently existing physical existence which stands in need of an explanation in terms of something that is not itself contingent. Consequently, Kant may be thought not to have supplied any valid reason for denying premise (2), in the sense in which it is needed for the remainder of the argument to go through.

Even were he to have accepted premises (1) and (2) of the Cosmological Argument, Kant would still resist the conclusion of the argument because he takes issue with premise (8). This premise, to recall, denies the physical universe to be something whose existence is necessary in and of itself. Kant rejects this premise on the grounds that we cannot know that the existence of physical substance is not necessary in and of itself. He writes, 'That substance (matter) is itself contingent in its existence would have to be known in a purely speculative [or a priori] manner.... Now I maintain that all attempts to employ Reason in theology in any merely speculative manner are altogether fruitless and by their very nature null and void.'$' It is curious that Kant makes this claim, given that, as we have just seen, he challenges the notion of necessary existence on the grounds of there being nothing the non-existence of which we are not capable of conceiving without contradiction. However, Kant's assertion that, for all we can know, the existence of physical substance might be necessary is no stray or idle one. Kant advances a considered argument for the assertion when commenting upon and criticising the Cosmological Argument. The relevant passage runs:

> In the strict meaning of the category, the contingent is so named because its contradictory opposite is possible. Now we cannot argue from empirical contingency to intelligible contingency. When anything is altered, the opposite of its state is actual at another time, and is therefore possible. This present state is not, however, the contradictory opposite of the preceding state. To obtain such a contradictory opposite we require to conceive, that in the same time in which the preceding state was, its opposite could have existed in its place, and this can never be inferred from [the fact of] the alteration.... Accordingly the succession of opposite determinations, that is, the alteration, in no way establishes contingency of the type represented in the concepts of pure understanding; and cannot therefore carry us to the existence of a necessary being. Alteration proves only empirical contingency; that is, that the new state, in the absence of a cause which belongs to the preceding time, could never of itself have taken place. This cause, even if it be viewed as absolutely necessary, must be such as can be thus met with in time, and must belong to the series of appearances.82

The sense of this passage is not exactly transparent. However, what Kant here seems to be arguing is that, just because each state of each physical substance is contingent, we must not suppose the existence of physical substance itself to be contingent. For physical substance persists through all changes of physical state. Therefore, the contingency of the various states of physical substance does not establish its existence to be contingent.

Ingenious though Kant's argument is, it gives us little reason to suppose that the existence of physical substance might itself be necessary in and of itself. Granted we are able to form a clear and distinct notion of the non-existence of the physical universe, it seems Kant has provided us with no good reason for supposing the existence of the physical universe to be anything other than contingent. Accordingly, Kant's objections to the Cosmological Argument may be judged to offer no more reason for supposing it unsound than do Hume's. We proceed next to a consideration of their objections to the Argument from Design.

3.5 The assault on the Argument from Design

Hume places the following eloquent formulation of this argument in his Dialogues in the mouth of Cleanthes. He invites his sceptical interlocutor, Philo, to

Look round the world: contemplate the whole and every part of it: You will find it to be nothing but one great machine, subdivided into an infinite number of lesser machines, which again admit of subdivisions, to a degree beyond what human senses and faculties can trace and explain. All these various machines, and even their most minute parts, are adjusted to each other with an accuracy, which ravishes into admiration all men, who have ever contemplated them. The curious adapting of means to end, throughout all nature, resembles exactly, though it much exceeds, the productions of human contrivance; of human designs, thought, wisdom, and intelligence. Since therefore the effects resemble each other, we are led to infer, by all the rules of analogy, that the causes also resemble; and that the Author of Nature is somewhat similar to the mind of man; though possessed of much larger faculties, proportioned to the grandeur of the work, which he has executed.... By this argument ..., do we prove at once the existence of a Deity, and his similarity to human mind and intelligence.83

We may schematically represent the Argument from Design as follows:

(1) Each living organism, together with the universe which they all inhabit, resembles some machine or other human artefact more closely than it resembles anything not deliberately designed through displaying some degree of adaptation to the well-being of some creature(s): their own well-being in the case of each organism; that of humans, in the case of machines and other artefacts, and that of all living organisms, in the case of the universe.

(2) In proportion as different things resemble each other, so is it likely that their causes will also resemble each other.

Ergo,

(3) Whatever is the cause of living organisms and the physical universe that they all inhabit is likely to resemble whatever is the cause of machines and artefacts.

(4) The cause of machines and artefacts is human intelligence.

Ergo,

(5) It is likely that the cause of living organisms and the physical universe that they all inhabit is some form of non-human intelligence.

Ergo,

(6) It is likely that some non-human intelligence exists which created the physical universe and the living organisms that inhabit it.

As the Argument from Design has been here set out, Hume takes issue with both its first and second premises. Against the first premise, Hume advances two separate objections. Hume's first objection is this. With our own solar system firmly in mind, Hume argues that, however conducive it might be to the well-being of the life-forms that it sustains, it bears less of a resemblance to some machine or other artefact than it does to some animal or, still more so, to some vegetable. Since no animal or vegetable has come into existence through intelligent design and deliberate creation, there is no

reason to suppose the universe has. This is notwithstanding its degree of adaptation to the well-being of organisms which inhabit it. Hume states the objection when he has Philo reply to Cleanthes as follows:

> [I]f we survey the universe ..., it bears a great resemblance to an animal or organized body, and seems actuated with a like principle of life and motion. A continual circulation of matter in it ...: a continual waste in every part is incessantly repaired: the closest sympathy is perceived throughout the entire system: and each part or member ... operates both to its own preservation and to that of the whole.... [I]t must be confessed, that ... the universe resembles more a human body than it does the works of human art and contrivance.... [Y]et is the analogy also defective in many circumstances ...: no organs of sense; no seat of thought or reason; no one precise origin of motion and action. In short, it seems to bear a stronger resemblance to a vegetable than to an animal.84

Hume proceeds to argue that, because the physical universe resembles an animal or vegetable more than it does a machine or other artefact, it is more likely that its cause will resemble the causes of animals and plants in not being intelligent than it is that it will resemble the causes of machines and artefacts in being such. Hume writes, 'If the universe bears a greater likeness to animal bodies and to vegetables, than to the works of human art, it is more probable, that its cause resembles the cause of the former than that of the latter, and its origin ought rather to be ascribed to generation or vegetation than to reason or design.'85

Hume's argument seems weak. Hume's claim is that the physical universe — more specifically, our solar system — bears a closer resemblance to some animal or a vegetable than it does some machine or other artefact. The claim is unconvincing.86 In its manifest workings, the physical universe in general, and our own solar system in particular, exhibits a degree of regularity and predictability that far exceeds that which is exhibited by any animal or vegetable. After all, it is by the sun that we set our clocks and not by the comings and goings of sun-flowers or salamanders! That this is so suggests that the physical universe more closely resembles some regular and predictable machine or artefact, for example a clock, than it does any far less regular and predictable animal or vegetable.

Hume's second objection to premise (1) is a variant of the time-honoured prima facie obstacle to the reasonableness of theistic belief posed by the existence of natural evil. Hume claims that our world generates and contains far more in the way of gratuitous natural evil than can be supposed consistent with its being the creation of some benevolent, omnipotent and omniscient intelligence. The physical universe and the living creatures in it are far less well adapted to the well-being of these creatures, even just the human ones, than machines are for achieving the ends for which they have been built.

> Look round this universe. What an immense profusion of beings, animated and organized, sensible and active! ... But inspect a little more narrowly these living existences.... How hostile and destructive to each other! How insufficient all of them for their own happiness!... The whole presents nothing but the idea of a blind Nature, impregnated by a great vivifying principle, and pouring forth from her lap, without discernment or parental care, her maimed and abortive children!87

Hume concludes, 'The course of nature tends not to human or animal felicity: therefore it is not established for that purpose.'88

Hume identifies four different ways in which the quantity of suffering which living creatures endure exceeds that which, he claims, might have been expected were they and the physical universe to

have been created for the purpose of their enjoying well-being. Of these four ways, Hume observes, '[n]one of them appear to human reason, in the least degree, necessary or unavoidable; nor can we suppose them such, without the utmost license of imagination'.89 First, animals and humans are susceptible to pain, not just to pleasure. Their susceptibility to pain is said to be unnecessary and gratuitous. To all appearances, a susceptibility to pleasure might seemingly have sufficed to equip living beings with all the psychological inducements they needed to ensure that they performed all the actions necessary for their self-preservation and reproduction. Second, the pain that animals and humans suffer results from the course of nature proceeding in a uniform and regular way. Should nature be the creation of a benevolent and omnipotent designer, we might have expected its course to display far less regularity than it does, as its creator intervened with its workings so to 'exterminate all ill, where-ever it were to be found; and produce all good, without any preparation or long progress of causes and effects'.90 Third, were animals and humans to have been created by some benevolent intelligence, their native powers and faculties might have been expected to be far more conducive to their felicity than in fact they are.

Nature seems to have formed an exact calculation of the necessities of her creatures; and like a rigid master, has afforded them little more powers or endowments, than what are strictly sufficient to supply those necessities. An indulgent parent would have bestowed a large stock, in order to guard against accidents, and secure the happiness and welfare of the creature, in the most unfortunate concurrence of circumstances. Every course of life would not have been so surrounded with precipices, that the least departure from the true path, by mistake or necessity, must involve us in misery and ruin.91

Finally, the course of nature contains far more by way of natural disasters and biological monstrosities than we should have expected were the world the result of intelligent and benevolent design.

> Rains are necessary to nourish all the plants and animals of the earth but how often are they defective? how often excessive? ... There is nothing so advantageous in the universe, but what frequently becomes pernicious, by its excess or defect; nor has Nature guarded, with the requisite accuracy, against all disorder or confusion. The irregularity is never, perhaps, so great as to destroy any species; but is often sufficient to involve the individuals in ruin and misery.92

In maintaining all or any part of the natural evil that our world contains to be gratuitous, Hume may be accused of having begged the question. An instance of natural evil may be supposed to be gratuitous, only if it might not have occurred without some greater evil having had to occur in its place, and without the loss of any good, of which that evil is the necessary condition, the occurrence of which is preferable, despite the evil which is its necessary condition, to the non-occurrence of that good and of all the evils which are necessary for it. Judged by reference to this criterion, none of the considerations which Hume cites establishes any or all of the natural evil which occurs in the world to be gratuitous.

The first such consideration, it will be recalled, is that living creatures might have been so created as to have only been susceptible to pleasure, not to pain as well. One might well wonder how, in such circumstances, creatures might have been induced to avoid performing injurious acts, such as putting their paws or hands into fires or ingesting injurious and poisonous substances.

In reply, it might be suggested, and this is Hume's second consideration, that a benevolent, omnipotent and omniscient creator might have been expected to intervene directly with the course of nature so as to prevent all harm befalling his creatures, as well as directly to supply them with all the goods they needed or might desire. Hume invites us to suppose that a benevolent creator

might have been expected to shepherd his creatures away from all contact with any dangerous objects or else to remove these objects from their paths in time to spare them injury, as well as to supply them directly with what they needed, instead of only supplying a lawful system of nature through which they must learn to navigate to satisfy their needs. Such a high degree of divine intervention as Hume is here inviting us to envisage, however, could not take place without many goods having to be forfeited whose forfeiture, arguably, would be worse than the natural evils that are their necessary conditions. Not least of these goods is the orderliness and regularity of nature. Without it, human beings might not have been as easily led to acquire such knowledge of God's existence and nature as facilitates their being able to engage in the loving contemplation of God. To such a claim, it might be replied that humans might have been created with an innate knowledge of God's existence and nature sufficient to enable them to experience the joys of theoria without first having to acquire sophia through engaging in philosophy. However, for human beings to have been created so would have deprived them of the undoubted joy that accompanies their discovery of the truth through their own reflection. Arguably, such a joy more than compensates for the natural evil that is a necessary condition of their being able to enjoy such a good.

The third consideration which Hume proffers in support of his claim that (at least some of) the natural evil in the world is gratuitous is that, were the universe the handiwork of some benevolent intelligence, its inhabitants might have been expected to be better provisioned than they are with the wherewithal for their enjoying felicity. Again, Hume fails to supply adequate reason for supposing this to be so. For example, were sheep better able to evade the fox, then foxes would have been less well able to survive and flourish. Should it be suggested that the world would have been a better place had sheep been allowed to graze without any predators, we might wonder whether they might not then have reproduced beyond the point at which pastures might have been able to sustain them, ... and so on.

The fourth consideration which Hume adduces in support of the gratuitousness of at least some of the natural evil in the world is that more natural disasters and individual misfortune and tragedy occur than we should expect were the world the product of benevolent design. Against Hume's claim, it can only be reiterated that, assuming it be desirable for the world to possess such order as sustains the variety of life-forms it does, there is no reason to suppose the world might have been differently ordered so as to provide any greater scope for felicity than it does. As John Haldane has argued,

> In general there cannot be a world of living things developing in accord with their inbuilt teleologies — growing, moving, sensing, reproducing and so on — without interactions that are to the detriment of some individuals and species.... Beings possessed of more and greater powers have open to them higher forms of self-realisation. By this very fact, however, they are vulnerable to more and greater losses.... Those who have more, have more to lose. The death of a human being thus constitutes a greater loss than does the death of a rabbit or tree.... To have created [such] a world ... is to have made something good, notwithstanding that it is a place of loss.93

We turn next to Hume's objections to premise (2) of the Argument from Design. To recall, this premise asserts that, in proportion as things resemble each other, so it is likely that their causes will resemble one another. Hume rejects this premise on the grounds that, even if living creatures and the physical universe bear to machines and other artefacts some degree of resemblance in being conducive to the well-being of organisms, there is no reason to suppose that the former have been created by a single omnipotent, omniscient, immaterial intelligence, such as God is taken to be. Hume claims that there are several alternative possible explanations for their possessing a degree of conduciveness to well-being each of which is as likely as their having been designed by

God. First, the life-sustaining order of the physical universe and of the living creatures which inhabit it might have been created by more than one intelligence acting in consort.94 Second, the intelligence or intelligences responsible for the life-sustaining order of the universe and its creatures might have been embodied, rather than immaterial.95 Finally, the life-sustaining order of the universe and the living creatures this order sustains might have been brought into existence without having been designed by any form or forms of intelligence whatsoever. Philo puts the last point so:

> A tree bestows order and organization on that tree, which springs from it, without knowing the order: an animal, in the same manner, on its offspring: a bird, on its nest.... To say, that all this order in animals and vegetables proceeds ultimately from design, is begging the question; nor can that great point be ascertained otherwise than by proving a priori, ... that order ..., from its nature, ... can never, of itself, or from original unknown principles, belong to matter.96

Philo goes on:

> [f]or ought we can know a priori, matter may contain the source or spring of order originally, within itself ...; and there is no more difficulty in conceiving, that the several elements, from an internal unknown cause, may fall into the most exquisite arrangement, than to conceive that their ideas, in the great, universal mind, from a like internal, unknown cause, fall into that arrangement.97

We can afford to be brief in considering the first two of the three possible explanations of the world which Hume offers as alternatives to its creation by a single intelligent and benevolent designer. If the physical universe is the product of intelligent design, rather than being a pure accident, it is more likely to be the handiwork of only one rather than more than one intelligence. This is so for two broad reasons. The first reason is the need for theoretical parsimony. In the absence of any evidence for supposing the universe to be the handiwork of more than one intelligence rather than only one, then, faced with a choice between supposing it the handiwork of one or of more than one intelligent designer, we should choose to suppose it to be the creation of only one. For it is not necessary to postulate more than one to account for the phenomena in question. The second reason for preferring the hypothesis of there being only one designer of the universe to supposing more than one is that the general harmony and uniformity of everything in the universe suggest that, should it be the product of design, it is more likely to be the handiwork of a single designer, rather than a plurality of designers who might have been expected to have left in their joint product some trace of their plural individualities.

Hume's strongest challenge to premise (2) derives from his suggestion that it is as likely that the degree of adaptation displayed by living creatures and the physical universe results from blind natural necessity as from intelligent design. Today, Charles Darwin is widely supposed to have supplied the wherewithal for an explanation of the vastly diverse range of living species which dispenses with the need to suppose that either they or the physical universe they inhabit have been designed. Very crudely, the so-called, but misleadingly named, process known as 'random variation' is supposed to be capable of explaining how biologically diverse organisms could have emerged from a common stock. Likewise, natural selection is supposed to be able to explain how only such variants from this common stock as are able to find for themselves a suitable ecological niche can survive and reproduce their kind successfully. To confirm Hume's conjecture that it is possible for life to have grown up in all its present diversity without need of design, all that this story need be supplemented by is the further conjecture, which many life-scientists are more than happy to make,98 that, in the course of the earth's cooling at some point early in its history, the earliest living matter 'emerged' quite fortuitously, without benefit of any design. In the face of the

apparent plausibility of such a narrative, small wonder is it that so many today are prepared to agree with Richard Dawkins that Darwin's theory has effectively destroyed the plausibility of theism. Dawkins speaks for many when he writes, 'although atheism might have been logically tenable before Darwin, Darwin made it possible to be an intellectually fulfilled atheist.... Natural selection, the blind, unconscious, automatic process which Darwin discovered ... we now know is the explanation for the existence and apparently purposeful form of all life.'99

How compelling is the preceding narrative as a materialist explanation of the variety of life-forms that exists today in which the need is entirely dispensed with for having to appeal to design at any part of the story? Is it equally as likely as, more likely, or less likely than an explanation of their existence in terms of design? Many today regard the above explanation as a much more likely explanation than design. They believe we have reason to prefer it over the hypothesis of design for much the same reason as, should we be obliged to explain the world in terms of intelligent design, we would have reason to prefer to postulate only one rather more than one designer. That reason is theoretical economy. We know the physical universe exists and that its constituents possess such basic properties as we know them to. If the basic properties of physical things are sufficient to account for the existence of living beings in all their manifold variety, then it would be otiose to invoke intelligent design to account for their existence — or so it has seemed to many.

The materialistic explanation of life, however, may be challenged on twd counts. First, the narrative may be deemed to contain certain crucial 'gaps' which do not seem, even in principle, capable of being filled within a purely materialistic framework. There are three varieties of biological phenomena for which, arguably, no materialistic narrative of the sort given above can account.100 The first is the very first emergence of living matter from non-living matter. In being alive, living matter possesses a teleological organisation that is wholly absent from everything that preceded it. Second, there is the emergence, from the very earliest life-forms which were incapable of reproducing themselves, of those life-forms with the capacity of reproducing themselves. Without the existence of such a capacity, it would not have been possible for different species to emerge through random mutation and natural selection. Accordingly, such mechanisms cannot be invoked in any explanation of how life-forms with this capacity first 'evolved' from those that lacked it. Third, there can be no materialistic explanation for the emergence of that species whose members engage in symbolic or conceptual thought — that is, Homo sapiens. If, as seems the case, human beings can only form concepts through acquiring some initial stock from beings who are previously in possession of them, it follows that the emergence of the very first concept-using members of the human species cannot be accounted for in terms of their evolution from any other natural species which may have preceded them. All three sets of biological phenomena, therefore, provide us with reason for doubting that it is possible to account for existent life-forms in purely materialistic terms and without recourse to design.

Even in the absence of any gaps in the narrative, the question still arises why a life-generating and life-sustaining universe should have existed in the first place rather than any one of the innumerably other seemingly no less logically possible physical universes which, had they existed, would not have been able to generate and sustain life as ours has. In the face of the apparent multiplicity of such other equally logically possible universes, we must say one or other of two things. Either we must assert with the materialists that the existence of the physical universe with its life-sustaining form is a matter of pure chance. Or else we must say with the theist that the existence of our universe is not accidental but was deliberately brought into being with the life-generating potential it had by an intelligence for the sake of the life-forms which would come into being as a result of its having this initial form. It seems far less likely that, were the universe not the result of design, a universe such as ours with its life-generating and sustaining capacities should have come about than any one of the innumerable other possible universes which are not capable of sustaining life. Conversely, were God to exist, it seems more likely that a universe capable of

generating life would have been brought into existence than any universe that was not capable of sustaining life. Therefore, given the existence of our universe, with its myriad life-forms, it seems more reasonable to suppose it the creation of some benevolent intelligence than to suppose it is purely accidental.101

None of Hume's various objections to the Argument from Design appears to succeed in casting any doubt on its validity, even when supplemented by considerations drawn from Darwin's theory of evolution. We must now consider whether Kant succeeds any better than Hume in refuting the argument. We can afford to deal briefly with Kant's objections to the Argument from Design. This is because Kant is prepared to concede that the argument can be thought to establish the existence of an intelligent designer or architect of the universe. All that Kant wished to deny of the argument is that, without its being supplemented by the Cosmological Argument, it can establish the existence of a divine creator of the universe. 'The utmost ... that the argument can prove is an architect of the world ..., not a creator of the world.... This, however, is altogether inadequate to the lofty purpose which we have before our eyes, namely, the proof of an all-sufficient primordial being.'102

In response to Kant's comment, we may remark that no one ever intended the Argument from Design to establish the existence of anything beyond some intelligent designer of the physical universe and the living beings who inhabit it. Therefore, if, as we have argued, the Cosmological Argument is sound, there is no reason for supposing that the designer of the world whose existence is established by the Argument from Design is not the necessary Being whose existence is established by the Cosmological Argument. Consequently, Kant's objections no more than Hume's give us reason to doubt the soundness of the argument.

3.6 God's jubilant obituarist

Nietzsche was far less sympathetic to the classical conception of philosophy than Hume and Kant were. Nietzsche discussed the conception in at least very general terms on several occasions. Each time, he is at pains to maintain that behind it lie various forms of moral pathology. He portrays the conception as symptomatic of a defective or descending vitality and a refuge for those with insufficient vitality and spirit to be able to enjoy life on its own terms. For example, in the Gay Science, Nietzsche asks rhetorically,

> [H]as not ... the claim that they possessed wisdom ... which has been made here and there ... by philosophers, the maddest and most immodest of all claims — has it not always been ... a screen above all ... behind which the philosopher saves himself because he has become weary, old, cold, hard ..., a screen behind which the philosopher hides from ... spirit?103

For Nietzsche, to conceive of philosophy as a quest for a form of wisdom exercised in the activity of theoria is the coping response of previously powerful individuals who are faced with the decline of their own powers. Of someone in such a condition, Nietzsche remarks:

> If he feels weary or ill or melancholy or satiated and as a consequence for the time being devoid of desires and wishes, ... he becomes thinker and prophet.... [B]ut ... all the products of his thinking are bound to reflect the condition he is in, which is one in which fear and weariness are on the increase and his valuation of action and active enjoyment on the decrease.... Later on, all those ... in this condition, ... and whose lives were melancholy .. . came to be called ... thinkers or priests or medicine-men.... In this muffled shape, in this ambiguous guise, with an evil heart and often an anguished head, did contemplation first appear on earth.104

Nietzsche claims that the only reason that contemplation came to be held in such high regard by proponents of the classical conception was because their own declining vitality had deprived them of all other more worldly sources of satisfaction. He writes,

> To revel in pallid images of words and things, to sport with such invisible, inaudible, impalpable beings was, out of contempt for the sensorily tangible.... world, felt as a life in another higher world... It is not the content of these sportings of spirituality, it is they themselves which constituted 'the higher life' in the prehistoric ages of science.... The thinker needs ... self-uplifting, ... desensualization, ... the impersonal mode of thinking, contemplativeness.... [A]ll these means to knowledge ... bestowed on their inventors that feeling of happiness which appears in the human soul when it catches sight of a final goal.105

In later works, Nietzsche is more explicit in his assessment of Plato and other proponents of the classical conception of philosophy. In Twilight of the Idols, he writes, 'The irreverent notion that the great sages are declining types first dawned on me in regard to just the case in which learned and unlearned prejudice is most strongly opposed to it: I recognised Socrates and Plato as symptoms of decay, as agents of the dissolution of Greece.'106 Of Plato, he later writes, 'Ultimately my mistrust of Plato extends to the very bottom of him: I find him deviated ... from all the fundamental instincts of the Hellenes.... Greek philosophy [i]s the decadence of the Greek instinct.'107 Passages such as these reveal just how much less sympathetic Nietzsche was to the classical conception of philosophy than even such ultimate critics of it as Hume.

Nietzsche's attitude here was clearly coloured by the militancy of his atheism. It would not be much of an exaggeration to say that Nietzsche considered it his life's mission to wage war against belief in God, especially in its Christian form. This war was conducted by Nietzsche in the name of an elect higher form of humanity of which Nietzsche considered himself the harbinger. In the opening aphorism of Book Five of his Gay Science, Nietzsche explains why the idea of God's non-existence induces such euphoria in him:

> The greatest recent event — that 'God is dead', that the belief in the Christian god has become unbelievable — is already beginning to cast its first shadows over Europe.... [Al long plenitude and sequence of breakdown, destruction, ruin, and cataclysm ... is now impending.... [W]e look forward to the approaching gloom ... without any worry and fear for ourselves... [because] ..., the consequences for ourselves, are quite the opposite of what we might perhaps expect: they are ... not at all sad and gloomy but rather like a new and scarcely describable kind of light, happiness, exhilaration, encouragement, dawn. Indeed, we philosophers and 'free spirits' feel, when we hear the news that 'the old god is dead', as if a new dawn shone on us; our heart overflows with gratitude, amazement, premonitions, expectation. At long last the horizon appears free to us again, even if it should not be bright; at long last our ships may venture out again, venture to face any danger; all the daring of the lover of knowledge is permitted again; the sea, our sea, lies open again; perhaps there has never yet been such an 'open sea'.108

Notwithstanding the uncanny prescience with which Nietzsche here predicted that a general conflagration would engulf Europe once the death of God became generally known, Nietzsche portrays the demise of God as an occasion for joy among the cadre of like-minded intellectuals and artists such as himself. This is because the death of God will give them free scope for thought and artistic endeavour unencumbered by the theologically riven moral constraints under which they have laboured for so long.

Nietzsche found cause to celebrate the death of God, not just, or even primarily, because he thought man would thereby become free from an intellectual error. For Nietzsche, the very notion that there is a knowable objective truth was, as much as the belief in God's existence, among the errors from which he hoped to liberate the elite audience of kindred spirits to whom his writings are always exclusively addressed. Nietzsche celebrated the death of God because he considered belief in such a Being, together with the morality or systems of morality invariably associated with such belief, to be profoundly enervating. This was especially so in the case of Christianity.

Nietzsche called his book, Twilight of the Idols, a 'grand declaration of war' against all those 'eternal idols' in which people continue to believe and which 'are not, in the most eminent case, called idols'.109 Among such idols, Nietzsche gives pride of place to God. The opening set of aphorisms includes the clearly rhetorical question, 'Which is it? Is man only God's mistake or God only man's mistake?"10 Later on, lest the reader be left in any doubt where Nietzsche stands on these questions, he makes his own answer pellucidly clear.

> What alone can our teaching be? — That no one gives a human being his qualities.... He is not the result of a special design, a will, a purpose; he is not the subject of an attempt to attain to an 'ideal of man' or an 'ideal of happiness'.... [T]his alone is the great liberation — thus alone is the innocence of becoming restored.... The concept 'God' has hitherto been the greatest objection to existence.... We deny God, we deny accountability: only by doing that do we redeem the world.111

Nietzsche elaborates on this theme in Ecce Homo, the final work before his untimely descent into madness. There, he writes:

> My task [has been] to prepare a moment of supreme coming-to-oneself on the part of mankind, ... when it steps out from the dominion of chance and the priesthood and poses the question why? To what end? for the first time.... This task follows of necessity from the insight that mankind is not of itself on the right path, that it is absolutely not divinely directed, that under precisely its holiest value-concepts rather the instinct of denial, of decay, the decadence instinct has seductively ruled.... The physiologist demands excision of the degenerate part.... What is the purpose of those lying concepts ... of morality 'soul', 'spirit', 'free will', 'God', if it is not the physiological ruin of mankind?... When one directs seriousness away from self-preservation, enhancement of bodily strength, when one makes of greensickness an ideal, of contempt for the body 'salvation of soul' what else is it but a recipe for decadence?112

Nietzsche concludes this work by reiterating his hostility towards belief in God and towards the morality associated with such belief. 'Have I been understood?', he asks. '... The concept 'God' [has been] invented as the antithetical concept of life — everything harmful, noxious, slanderous, the whole mortal enmity against life brought into one terrible unity!'l13

Although arrived at by entirely different routes from that taken by Nietzsche, and although motivated by decidedly different ethical aspirations from him as well as from each other, Marx and Freud both display towards belief in God an antipathy no less marked than Nietzsche's. All three thinkers portray such belief as pathological in some way, tracing its origin and tenacity to disreputable passions of one sort or another. All three thinkers take it for granted that all the arguments for God's existence had been previously so conclusively refuted as no longer to be worthy of serious consideration. So far as each was concerned, all that remains of interest in connection with religious belief is to explain how it could survive the demonstration of its groundlessness. The joint but independent verdict delivered by Marx, Nietzsche and Freud on religious belief has today almost become an orthodoxy among philosophers and other intellectuals.

In the previous two sections, it was argued that the objections levelled by Hume and Kant against the Cosmological Argument and the Argument from Design are not nearly as cogent as they have been widely taken to be from Schopenhauer onwards. If my defence of these arguments has been sound, it becomes apparent just how wide of the mark are those who adopt an atheistic standpoint so prevalent among philosophers and other intellectuals today. Those who adopt this standpoint, however, go well beyond anything which Hume or Kant can be claimed to have sought to establish. So far as these two eighteenth-century philosophers were concerned that God's existence might not be capable of being established did not mean that God's non-existence could be. Nor, did Kant, if not Hume, take the indemonstrability of God to establish the unreasonableness of faith in God. Most philosophers today go well beyond the agnosticism of Hume and the fideism of Kant by treating belief in the existence of God as somehow philosophically unconscionable. In the case of those who think this way, the philosopher who is likely more than any other to have persuaded them of this opinion is Nietzsche. I conclude this chapter by briefly examining such considerations as Nietzsche adduces on behalf of this view.

By far the best and most sympathetic account of Nietzsche's case against the reasonableness of belief in God is that which Richard Schacht gives in his book on Nietzsche.114 Schacht surely speaks for many more contemporary philosophers than just himself in claiming to find Nietzsche's emphatic repudiation of any suggestion that a transcendent deity does or might exist, and his often belittling and sometimes harsh treatment of those who fail to do likewise,.., are neither unconsidered nor unreasoned. His ... argument ... is compelling enough ... to render reasonable his contention that it is 'decisive'; and ... come[s] closer to ruling out the God-hypothesis than could be done in any other way.l15

Schacht terms Nietzsche's argument a 'historical refutation' or 'genealogical subversion'116 of the God-hypothesis. He bestows the first name upon the argument after an aphorism of Nietzsche's in which the argument is set out in condensed form. The aphorism in question runs:

> Historical refutation as the definitive refutation - In former times, one sought to prove that there is no God - today one indicates how the belief that there is a God could arise and how this belief acquired its weight and importance: a counter-proof that there is no God becomes superfluous. - When in former times one had refuted the 'proofs of the existence of God' put forward, there always remained the doubt whether better proofs might not be adduced than those just refuted: in those days atheists did not know how to make a clean sweep.117

Schacht summarises this argument of Nietzsche's as follows. In the absence of any valid proofs of God's existence, all warrant for belief in God will have been removed were it possible to explain the origin and tenacity of such belief in purely naturalistic terms, without need of positing God. Now, it is possible to explain the origin and tenacity of belief in God's existence in purely naturalistic terms without any need to posit God. Therefore, all warrant for believing in God's existence has been removed.

This argument seems perfectly sound when the terms 'ghost' or `monster' are substituted for 'God'. Whether the same holds true when God is the subject of the argument depends upon whether Nietzsche and Schacht are correct on two matters. First, they have to be correct that there are no more sound arguments for God's existence than there are for the existence of ghosts. Second, they have to be correct that it is possible to provide naturalistic explanations of both the origin and persistence of belief in God that do not require having to postulate the existence of God.

Neither issue, however, seems anything like as straightforward as Schacht and Nietzsche suppose it to be. So far as the first issue is concerned, it is possible - and, by now, I hope, we are in a position — simply to reject their claim that there are no sound arguments for God's existence. Once the possibility of a sound proof of God's existence is countenanced, it becomes possible to reject the adequacy of Nietzsche's naturalistic explanations of the origin and persistence of all beliefs in God's existence. In cases where people have been led to acquire such a belief as a result of having followed the steps of a sound proof of God's existence, neither the origination nor persistence of their belief in God's existence is wholly explicable in purely naturalistic terms without need of postulating God. This is so because, in order to understand their having been led to that belief, it is necessary to understand how they have been led to it. To understand this requires grasping the argument and hence requires coming to apprehend the existence of God. Thus, where people have been led to acquire a belief in God by means of following a sound argument for God's existence, it is impossible to explain their belief without also coming to posit God's existence. Those who espoused the classical conception of philosophy were arguably led to a belief in God's existence through having followed the steps of one or more sound arguments for God's existence. Consequently, no naturalistic explanations of belief in God's existence of the sort proffered by Nietzsche, Marx or Freud are singly or jointly able to account for all instances of theistic belief. In sum, the classical conception of philosophy is no more vulnerable to Nietzsche's genealogical subversion of religious belief than it is to Hume's or Kant's strictures against the speculative theology on which it is ultimately grounded.

The conclusion of this discussion of Hume, Kant and Nietzsche must be that the present-day repudiation of theism in philosophy is ill-founded. There is no reason for rejecting the classical conception.

Notes

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55. Ibid., p. 78.
56. Quoted ibid., p. vi.
57. I. Kant, Critique of Pure Reason, trans. N. Kemp Smith (London: Macmillan, 1929), Bxxxiv.
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69. Hume, Dialogues, p. 164.
70. Ibid., pp. 162-3.
71. Haldane, 'Atheism and Theism', p. 50.
72. I owe the following objection to Bryan Davies, An Introduction to the Philosophy of Religion (Oxford and New York: Oxford University Press, 1993).
73. Hume, Dialogues, p. 164.
74. J. Sadowsky, 'The Cosmological Argument and the Endless Regress', International Philosophical Quarterly, 20 (1980), 465. Quoted in Davies, An Introduction to the Philosophy of Religion, p. 90.
75. Hume, Dialogues, p. 165.
76. Kant, Critique of Pure Reason, A635/B663-A636/B664.
77. Ibid., A182.
78. 'The unity of experience would never be possible if we were willing to allow that new things, that is, new substances, could come into existence', ibid., A186/B229.

79. 'If we assume that something absolutely begins to be, we must have a point of time in which it was not. But to what are we to attach this point, if not to that which already exists? For a preceding empty time is not an object of perception', ibid., A188/B231.
80. Ibid., A617/B645.
81. Ibid., A635/B663-A636/B664.
82. Ibid., A461/B489-A460/B488.
83. Hume, Dialogues, pp. 115-16.
84. Ibid., pp. 143-5.
85. Ibid., p. 149.
86. 1 owe this argument to Davies, An Introduction to the Philosophy of Religion, p. 107.
87. Hume, Dialogues, p. 186.
88. Ibid., p. 172.
89. Ibid., p. 179.
90. Ibid., p. 180.
91. Ibid., p. 182.
92. Ibid., pp. 184-5.
93. J. Haldane, 'Atheism and Theism' in J. J. C. Smart and J. J. Haldane, Atheism and Theism (Oxford and New York: Oxford University Press, 1996), pp. 155-6.
94. Hume, Dialogues, pp. 140-1.
95. Ibid., p. 142.
96. Ibid., p. 152.
97. Ibid., p. 119.
98. See, for example, W. W. Fletcher, Modern Man Looks at Evolution (Redhill: Fontana, 1974), esp. pp. 77-8.
99. R. Dawkins, The Blind Watchmaker (Harlow: Longman Scientific and Technical, 1986), pp. 5-6 passim. These passages by Dawkins are quoted in J. A. Sadowsky, 'Did Darwin Destroy the Design Argument?', International Philosophical Quarterly, XXVIII (1988), 95-104, p. 95. The present author is deeply indebted to this article.
100. I am deeply indebted to John Haldane's treatment of this problem.
101. For this argument, I am deeply indebted to the work of Richard Swinburne. See, especially, R. Swinburne, Is There a God? (Oxford and New York: Oxford University Press, 1996), ch. 4.
102. Kant, Critique of Pure Reason, A627/B655.
103. F. Nietzsche, Gay Science, trans. W. Kauffmann (New York: Vintage Books, 1974), aph. 359, p. 315.
104. F. Nietzsche, Daybreak: Thoughts on the Prejudices of Morality, trans. R. J. Hollingdale (Cambridge, New York and Melbourne, Sydney: Cambridge University Press, 1982), aph. 42, pp. 42-3.
105. Ibid., aph. 43, p. 43.
106. F. Nietzsche, Twilight of the Idols in F. Nietzsche, Twilight of the Idols and The Anti-Christ, trans. R. J. Hollingdale (Harmondsworth: Penguin, 1968), p. 29.
107. Ibid., pp. 106-7.
108. Nietzsche, Gay Science, aph. 343.
109. Nietzsche, Twilight of the Idols, p. 22.
110. Ibid., p. 23.
111. Ibid., aph. 8.
112. F. Nietzsche, Ecce Homo, trans. R. J. Hollingdale (Harmondsworth: Penguin Books, 1979), pp. 96-7.
113. Ibid., pp. 133-4.
114. R. Schacht, Nietzsche (London, Boston, Melbourne and Henley: Routledge and Kegan Paul, 1983).
115. Ibid., p. 130.
116. Ibid., p. 126.

117. Nietzsche, Daybreak, p. 93.

April 2000
Elder Russell M. Nelson Of the Quorum of the Twelve Apostles
The Creation
Conference Address

We will long remember this inspiring conference in the new Conference Center.

Not long ago, there was only a deep hole in the ground where this building now stands. We have watched its construction with interest and awe.

The process of construction is truly inspiring to me. From conception to completion, any major building project reflects upon the work of the Master Creator. In fact, the Creationof planet Earth and of life upon it undergirds all other creative capability. Any manmade creation is possible only because of our divine Creator. The people who design and build are given life and capacity by that Creator. And all materials used in the construction of an edifice are ultimately derived from the rich resources of the earth. The Lord declared, The earth is full, and there is enough and to spare; yea, I prepared all things.1

It is difficult for mortal minds to comprehend the majesty of the Creation. It is much easier for us to think about good things to eat or fun things to do. But I would like to stretch our minds to think of things beyond our easy grasp. The creation of man and woman was wondrous and great.2 So was the creation of the earth as their mortal dwelling place.

The entire Creation was planned by God. A council in heaven was once convened in which we participated.3 There our Heavenly Father announced His divine plan.4 It is also called the plan of happiness,5 the plan of salvation,6 the plan of redemption,7 the plan of restoration,8 the plan of mercy,9 the plan of deliverance,10 and the everlasting gospel.11 The purpose of the plan is to provide opportunity for the spirit children of God to progress toward an eternal exaltation.

Components of the Plan
The plan required the Creation, and that in turn required both the Fall and the Atonement. These are the three fundamental components of the plan. The creation of a paradisiacal planet came from God.12 Mortality and death came into the world through the Fall of Adam.13 Immortality and the possibility of eternal life were provided by the Atonement of Jesus Christ.14 The Creation, the Fall, and the Atonement were planned long before the actual work of the Creation began.

While visiting the British Museum in London one day, I read a most unusual book. It is not scripture. It is an English translation of an ancient Egyptian manuscript. From it, I quote a dialogue between the Father and the Son. Referring to His Father, Jehovah the premortal Lord says:

> He took the clay from the hand of the angel, and made Adam according to Our image and likeness, and He left him lying for forty days and forty nights without putting breath into him. And He heaved sighs over him daily, saying, If I put breath into this [man], he must suffer many pains. And I said unto My Father, Put breath into him; I will be an advocate for him. And My Father said unto Me, If I put breath into him, My beloved Son, Thou wilt be obliged to go down into the world, and to suffer many pains for him before Thou shalt have redeemed him, and made him to come back to his primal state. And I said unto My Father, Put breath into him; I will be his advocate, and I will go down into the world, and will fulfil Thy command. 15

Although this text is not scripture, it reaffirms scriptures that teach of the deep and compassionate love of the Father for the Son, and of the Son for usattesting that Jesus volunteered willingly to be our Savior and Redeemer.16

The Lord God declared, This is my work and my glory - to bring to pass the immortality and eternal life of man.17 He who, under direction of the Father, had created the earth, subsequently came into mortality to do the will of His Father18 and to fulfill all prophecies of the Atonement.19 His Atonement would redeem every soul from the penalties of personal transgression, on conditions that He set.20

Phases of the Creation
Each phase of the Creation was well planned before it was accomplished. Scripture tells us that the Lord God, created all things spiritually, before they were naturally upon the face of the earth.21

The physical Creation itself was staged through ordered periods of time. In Genesis22 and Moses,23 those periods are called days. But in the book of Abraham, each period is referred to as a time.24 Whether termed a day, a time, or an age, each phase was a period between two identifiable events - a division of eternity.25

Period one included the creation of atmospheric heavens and physical earth, culminating in the emergence of light from darkness.26

In period two, the waters were divided between the surface of the earth and its atmospheric heavens. Provision was made for clouds and rain to give life to all that would later dwell upon the earth.27

In period three, plant life began. The earth was organized to bring forth grass, herbs, trees, and vegetationeach growing from its own seed.28

Period four was a time of further development. Lights in the expanse of the heaven were organized so there could be seasons and other means of measuring time. During this period, the sun, the moon, the stars, and the earth were placed in proper relationship to one another.29 The sun, with its vast stores of hydrogen, was to serve as a giant furnace to provide light and heat for the earth and life upon it.30

In period five, fish, fowl, and every living creature were added.31 They were made fruitful and able to multiplyin the sea and on the eartheach after its own kind.32

In the sixth period, creation of life continued. The beasts of the earth were made after their kind, cattle after their kind, and everything which creepeth upon the earthagain, after its own kind.33 Then the Gods counseled together and said: Let us go down and form man in our image, after our likeness.

So the Gods went down to organize man in their own image, in the image of the Gods to form they him, male and female to form they them.34 Thus, Adam and Eve were formed.35 And they were blessed to be fruitful, and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth.36

The seventh period was designated as a time of rest.37

The Creation Testifies of a Creator
I testify that the earth and all life upon it are of divine origin. The Creation did not happen by chance. It did not come ex nihilo (out of nothing). And human minds and hands able to build buildings or create computers are not accidental. It is God who made us and not we ourselves. We are His people!38 The Creation itself testifies of a Creator. We cannot disregard the divine in the Creation. Without our grateful awareness of Gods hand in the Creation, we would be just as oblivious to our provider as are goldfish swimming in a bowl. With deep gratitude, we echo the words of the Psalmist, who said, O Lord, how manifold are thy works! in wisdom hast thou made them all: the earth is full of thy riches.39

Purpose and Destiny of the Earth
This earth is but one of many creations over which God presides. Worlds without number have I created, He said. And I also created them for mine own purpose; and by the Son I created them, which is mine Only Begotten.40 Grand as it is, planet Earth is part of something even grander - that great plan of God. Simply summarized, the earth was created that families might be. Scripture explains that a husband and wife shall be one flesh, and all this that the earth might answer the end of its creation.41

And as part of the planned destiny of the earth and its inhabitants, here our kindred dead are also to be redeemed.42 Families are to be sealed together for all eternity.43 A welding link is to be forged between the fathers and the children. In our time, a whole, complete, and perfect union of all dispensations, keys, and powers is to be welded together.44 For these sacred purposes, holy temples now dot the earth.

Though our understanding of the Creation is limited, we know enough to appreciate its supernal significance. And that store of knowledge will be augmented in the future. Scripture declares: In that day when the Lord shall come [again], he shall reveal all things

> Things which have passed, and hidden things which no man knew, things of the earth, by which it was made, and the purpose and the end thereof
>
> Things most precious, things that are above, and things that are beneath, things that are in the earth, and upon the earth, and in heaven.45

Yes, further light and knowledge will come. The Lord said, If there be bounds set to the heavens or to the seas, or to the dry land, or to the sun, moon, or stars

All the times of their revolutions, all the appointed days, months, and years, and all their glories, laws, and set times, shall be revealed in the days of the dispensation of the fulness of times.46

Eventually, the earth will be renewed and receive its paradisiacal glory.47 At the Second Coming of the Lord, the earth will be changed once again. It will be returned to its paradisiacal state and be made new. There will be a new heaven and a new earth.48

Our Responsibilities
Meanwhile, brothers and sisters, we should understand our significant responsibilities. Both the creations of God and the creations of man teach us the importance of each component. Do you think that the absence of one piece of granite from the face of this building would be noticed? Of course it would!

So it is with each son or daughter of God. We cannot let the head say unto the feet it [has] no need of the feet; for without the feet how shall the body be able to stand?49 Just as the body [has] need

of every member,50 so the family has need of every member. All members of a family are to be linked, sealed, and edified together, that the system may be kept perfect.51

The Creation, great as it is, is not an end in itself but a means to an end. We come to the earth for a brief period of time, endure our tests and trials, and prepare to move onward and upward to a glorious homecoming.52 Our thoughts and deeds while here will surely be more purposeful if we understand Gods plan and are thankful for and obedient to His commandments.53

As beneficiaries of the divine Creation, what shall we do? We should care for the earth, be wise stewards over it, and preserve it for future generations.54 And we are to love and care for one another.55

We are to be creators in our own right - builders of an individual faith in God, faith in the Lord Jesus Christ, and faith in His Church. We are to build families and be sealed in holy temples. We are to build the Church and kingdom of God upon the earth.56 We are to prepare for our own divine destiny - glory, immortality, and eternal lives.57 These supernal blessings can all be ours, through our faithfulness.

Notes

1. D&C 104:17.
2. See Russell M. Nelson, The Magnificence of Man, Ensign, Jan. 1988, 64-69; We Are Children of God, Ensign, Nov. 1998, 85-87.
3. See Teachings of the Prophet Joseph Smith, sel. Joseph Fielding Smith (1976), 349-50, 365.
4. See 2 Ne. 9:13; Alma 34:9; Abr. 3:22-27.
5. See Alma 42:8, 16.
6. See Jarom 1:2; Alma 24:14; Alma 42:5; Moses 6:62.
7. See Jacob 6:8; Alma 12:25-34; Alma 17:16; Alma 18:39; Alma 22:13; Alma 29:2; Alma 34:16, 31; Alma 39:18; Alma 42:11-13.
8. See Alma 41:2.
9. See Alma 42:15, 31; 2 Ne. 9:6.
10. See 2 Ne. 11:5.
11. See Rev. 14:6; D&C 27:5; D&C 36:5; D&C 68:1; D&C 77:8-9, 11; D&C 79:1; D&C 84:103; D&C 99:1; D&C 101:22, 39; D&C 106:2; D&C 109:29, 65; D&C 124:88; D&C 128:17; D&C 133:36; D&C 135:3, 7; D&C 138:19, 25; JSH 1:34.
12. Latter-day revelation affirms that Michael (known also as Adam; see D&C 27:11; D&C 107:54; D&C 128:21) participated in the process of creation as well.
13. See 2 Ne. 2:25; Moses 6:48; JST, Gen. 6:49, The Holy Scriptures: Inspired Version.
14. See 2 Ne. 2:21-28.
15. Discourse on Abbatn by Timothy, Archbishop of Alexandria, in Coptic Martyrdoms etc. in the Dialect of Upper Egypt, ed. and trans. E. A. Wallis Budge (1914), 482. Timothy, archbishop of Alexandria, died in A.D. 385. Brackets are included in Budges English translation.
16. See John 3:16; John 10:14-15, 17-18.
17. Moses 1:39.
18. See 3 Ne. 27:13.
19. For a comprehensive study of the prophecies of prophets pertaining to Christ, see D. Kelly Ogden and R. Val Johnson, All the Prophets Prophesied of Christ, Ensign, Jan. 1994, 31-37; Liahona, Apr. 1994, 10-18.
20. See 2 Ne. 9:20-27; Mosiah 26:21-23; D&C 138:19.
21. Moses 3:5; see Moses 6:51.
22. See Gen. 1:5-2:3.
23. See Moses 2:5-3:3.
24. See Abr. 4:8-5:3.

25. Abraham likened one day in the Lords time to 1,000 years (see Abr. 3:4).
26. See Gen. 1:1-5; Moses 2:1-5; Abr. 4:1-5.
27. See Gen. 1:6-8; Moses 2:6-8; Abr. 4:6-8.
28. See Gen. 1:9-13; Moses 2:9-13; Abr. 4:9-13.
29. See Gen. 1:14-19; Moses 2:14-19; Abr. 4:14-19.
30. See Henry Eyring, World of Evidence, World of Faith, in Of Heaven and Earth: Reconciling Scientific Thought with LDS Theology, ed. and comp. David L. Clark (1998), 59.
31. Abr. 4:20-21.
32. See Gen. 1:20-23; Moses 2:20-23; Abr. 4:22-23.
33. See Gen. 1:24-31; Moses 2:24-31; Abr. 4:24-31.
34. Abr. 4:26-27.
35. Note that the Lord called the first man and woman Adam (see Gen. 5:2; Moses 6:9).
36. Gen. 1:28; Moses 2:28; see also Abr. 4:28; JST, Gen. 1:30.
37. See Gen. 2:1-3; Moses 3:1-3; Abr. 5:1-3.
38. See Ps. 100:3.
39. Ps. 104:24.
40. Moses 1:33; see also D&C 76:23-24.
41. D&C 49:16.
42. See D&C 128:15.
43. See D&C 2:2-3; D&C 49:17; D&C 138:48; JSH 1:39.
44. See D&C 128:18.
45. D&C 101:32-34.
46. D&C 121:30-31.
47. A of F 1:10.
48. See Rev. 21:1; Ether 13:9; D&C 29:23-24.
49. D&C 84:109.
50. D&C 84:110.
51. D&C 84:110; see also 1 Cor. 12:14-26.
52. See Ps. 116:15; Alma 42:8.
53. See D&C 59:20-21.
54. The Lord has entrusted us to care for the earth. He said: It is expedient that I, the Lord, should make every man accountable, as a steward over earthly blessings, which I have made and prepared for my creatures. I, the Lord, stretched out the heavens, and built the earth, my very handiwork; and all things therein are mine. And it is my purpose to provide for my saints, for all things are mine (D&C 104:13-15; see also Rev. 7:3).
55. See John 13:34-35; John 15:12; Rom. 12:10-13:8; Gal. 5:13; 1 Thes. 4:9; 1 Jn. 3:11-4:12; Mosiah 4:15; D&C 88:123.
56. See JST, Matt. 6:38 (KJV, Matt. 6:33, footnote a).
57. See Rom. 2:7; D&C 75:5; D&C 128:12; D&C 132:19-24.

January 2001
Edward L. Hart
A Conversation about Poetry (Beauties of Nature)
Casualene Meyer
BYU Studies v40, Number 1--2001

Dr. Edward L. Hart, a Mormon poet whose style is both classic and contemporary, lives in Utah. During the following interview, Dr. Hart, now in his 80 s, apologized for not speaking as fast as he used to; but had he spoken any faster, I would have missed even more of the rich fluency of his thought. As I spoke with him, I wished I could just listen and not write down what he said, but I

realized that would be selfish. I hope you will enjoy this interview and reprints of his poems in this and future issues.

CM: You write poems which are explicitly religious, one of which is sung all over the Church: "Our Savior's Love." Talk to me about the relationship between poetry and praise, poetry and witness, and about yourself as a "Mormon poet."

EH: Well . . . that's the most difficult question of all questions-I think the things one feels most deeply about become the things one writes about. So I suppose it's inevitable that since I do feel deeply about my religion that I should write about it.

My view of religion and Mormonism is that it embraces all truth so that even if its subject isn't explicitly religious, any great poem-in that broad sense-is a religious poem. And that's my justification for writing what some people might call secular poems-like about nature. The religion embraces nature, embraces everything. The heavens do declare the glory of God so that if you write about the beauties and glories of nature in a sense you are praising God, who is the author of the beauty and the grandeur.

CM: Tell me more about the composition of "Our Savior's Love."

EH: The form represents the three members of the Godhead: the first stanza is to the Savior, the second stanza deals with the Holy Ghost, and the third stanza praises God the Father.

In writing the lines "Our Father, God / Of all creation, hear us pray / In rev'rence, awed / By thy Son's sacrifice," I wanted to create a rhyme worthy of the Father. I can't have just any word rhyme with "God." I suppose it was inspiration that the word "awed"finally occurred to me; it maintains the dignity of the audacity of rhyming anything with "God." I don't think there's any other word in the language that would have sufficient power to be in that place. Rhymes call attention to themselves just by being rhymes, so it's important that the rhyming words mean something.

I wanted to make the poem upbeat-not in any way depressing. It's not a coincidence that the final word of the poem is "rejoice."

CM: It shows there's so much more to a poem than what people automatically see.

EH: I am in deep humility every time I hear "Our Savior's Love" because I feel it is something beyond me.

CM: Here's another question. You lived in Pakistan in 1973 and 1974. Like Utah, that country has awesome mountain landscapes. How would you compare the feeling of the Pakistani terrain to Utah's?

EH: In Utah, I plowed land that had never been plowed before-truly virgin soil. But in Pakistan, you can't go anywhere but you feel the presence of the past-hundreds of generations back to the beginning of history. The Indus Valley, for instance, was one of the places where civilization began. So it's very old. I've collected artifacts that go back hundreds-if not thousands-of years.

You can go to high places in Utah and get the feeling they're fresh from the hand of the Creator. I remember one time I've never forgotten from early days in Idaho: seeing a cirque with a lake at the bottom of it and mists blowing across-it looked like it had just been created.

The landscape has been very important to me, both as a person and as a poet. I have lived other places from time to time-and always when I've lived there, I've missed the mountains and have had a pull to come back.

CM: Your poems "Holiday," "The Coward," and "Processional" deal with men and arms-guns and hunts, guns and war. You are someone who lived through World War II and subsequent conflicts. You also live where the deer hunt is an annual event. Tell me more about your feelings about men and arms.

EH: To tell the truth, I've never been on a hunt for deer or anything else. I have always admired the grace and the beauty of wild animals like deer, and it's never entered my mind to kill them. I did see them fairly frequently when my brother and I spent a summer camping and plowing on a dry farm; it was a nightly occurrence to see wildlife like deer or coyotes silhouetted on the skyline. We felt like we were just part of the whole natural habitat. We had guns with us that we could use for protection if necessary, but we never tried to shoot a deer or coyote. I recognize that my view of hunters in "Processional" might not be fair. I know so many hunters that I admire, but still their way is not my way, and I can't help feeling the way I do.

CM: What about war?

EH: Of course, the war affected me very closely. I was all set to go to Oxford in the fall of 1939, and then on september first, Hitler invaded Poland, and the war in Europe began. The Rhodes Scholarships were suspended, and it was seven years before I was able to go. So I hold a personal grudge against Hitler.

As far as the war poems are concerned, I'll have to confess I wasn't close to any actual fighting . So poems like "The Coward" are pure imagination because of the impact the war was having on me and on my imagination.

CM: Were you drafted? Or did you enlist?

EH: I didn't get drafted; I enlisted in the navy. I did Japanese language training. My main job throughout the war was working with Japanese naval codes. After they had been broken out by the cryptographers, the job I shared with other translators was that of translating the messages into English.

CM: Talk to me about your influences. You are obviously influenced by Wordsworth, say in your poem "Insulations (against Intimations of Mortality)." Additionally, we see another Romantic, Blake, in "A Lesson in History," where you turn his phrase "Heaven in a Wild Flower" to "heaven in a potato."

EH: I had read Wordsworth of course and thought more highly of him in my youth than later. I became an eighteenth-century scholar-and I believed that education should increase the area of one's appreciation and not decrease it-but as my appreciation for the English Classical period increased, I started to look more askance at the Romantics. . . .

I was a classmate of Clinton Larson at the University of Utah. The two of us were in many creative writing classes taught by Brewster Ghiselin. He is, in my opinion, a great poet. Later, I took an M.A. in creative writing at the University of Michigan.

I read some of Ghiselin's poetry that had just been published. The language, the diction, the rhythms opened a whole new world for me. Everything I'd written before then seemed childish,

puerile. I went home and wrote what I thought was my first mature poem: "Morning." Without knowing it, I sort of invented a new stanzaic form. Ghiselin discovered that I repeated it exactly in the second stanza, but the third stanza was a little different. After my teacher pointed out the form to me, I rewrote that stanza to conform to the other two. I hadn't been aware consciously that there was any stanza form at all.

CM: Let's look at a specific poem: "On Listening to Jorge Luis Borges." " Tell me the history of that poem. Did you meet Borges? Wherein does Borges's power lie for you?

EH: Borges was at BYU, and he had an interpreter with him, but he really didn't need it. It amazed me that a person of foreign background could see so clearly into the heart of English poetry, of literature. What it revealed to me was that there's a truth about being human and that he had reached that and made it manifest to us. It didn't matter that he was from Argentina-he could have been from Timbuktu or anywhere else. The truths he revealed were the depths of the human heart. That's what impressed me about him.

He had sensitivity for language as well as for people-he made such an impression. It was forceful and magnetic.
CM: Language and form-the intrinsic power of the word and the delight in craft-are essential to creating good poetry. What does language mean to you? What are the tricks and limitations of language? Of form?

EH: The word trick is too mechanical; it goes deeper than that. You roll words around on your tongue and taste them and feel them-each one has a special life of its own. In great poetry, not a word can be changed, because each is exactly right. Science's truths have always been revised, from Newton to Einstein. But nobody finds a better way to say things than the way Shakespeare says them.

The feel for human truths goes hand in hand with the language and all that the words suggest, their history. The whole working together conveys a truth that was always known but comes with a shock of recognition, because we hadn't been aware that we knew it.

I can't imagine a poem existing without form-to me it isn't a poem unless it has form. I think form becomes part of the meaning. Form and content are inextricably connected.

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Edward L. Hart received a B.S. in economics from the University of Utah in 1939 and an M.A. in English at the University of Michigan in 1941 . He went on to receive a D.Phil. from Oxford in 1951 . A well-known Mormon poet, Dr. Hart wrote the text for the popular hymn "Our Savior's Love." He received a Presidential Citation from Brigham Young University in 1998 . He can be reached by email through BYU Studies at byu_studies@byu.edu.

Notes
1 . Edward L. Hart, "Processional," BYU Studies 34, no. 1 (1994): 30 - 31 .
2 . Edward L. Hart, "On Listening to Jorge Luis Borges," BYU Studies 13, no. 2 (1973): 135 .

Our Savior's Love

Our Savior's Love

Shines like the sun with perfect light,
As from above
It breaks through clouds of strife.
Lighting our way,
It leads us back into his sight,
Where we may stay
To share eternal life.
The Spirit, voice
Of goodness, whispers to our hearts
A better choice
Than evil's anguished cries.
Loud may the sound
Of hope ring till all doubt departs,
And we are bound
To him by loving ties.
Our Father, God
Of all creation, hear us pray
In reverence, awed
By thy Son's sacrifice.
Praises we sing.
We love thy law; we will obey.
O heavenly king,
In thee our hearts rejoice.
-Edward L. Hart

Editor's note: In the 1985 hymnbook, "through" was changed to "thru," "reverence" to "rev'rence," and "O" to "Our."

The Uintahs

The Uintah Mountains master the man, pinching
His inch-high image to a freckle on the rock he climbs.
Sometimes pride leads him to believe he conquers them
When he reaches peaks and leaves his name in bottles on the tops.
He descends and sees through the teasing haze of his distance-
Blearing vision, how oblivious above him the mountain Hayden
Stays.
These people think they know. Some hurried
Tourists who have seen Boulder Dam and the Grand
Canyon talk in the lodge of scenery.
The oppression
Of the pressing weight: upheaded Hayden's crowding
Of the ground downward, the lower ridges' deceiving,
Lead young couples to achieve the steepness and surmount
The mountains' mass and match the fixedness with feet.
Eager to be mystic as the summit mists and lifted,
Optimistically lightened by youth's delusion, they let height
And time die and climb far farther than they need,
To see what is not to be taken. Hard
Hills hide their precious spots so only the knowing
Find them. Columbine and wild fern-
Dove-flower and unwinding frond-sprout and seed

In a spot, guarded in the rock like a spark spared.
Lower the climbers come, closer to the ground,
Their sounded blood pumped passionless. They are pale, and pain
Means nothing. The mountain height has taught by taking all.
-Edward L. Hart

Bear Lake

A fog follows the levee
Along the drain canal.
The lake is drawn from the valley
Leaving sand and shell.
Ice is hiding the river,
Snow covers the sand,
Thick-lipped winter bends
The willow wands till they totter.
Winter weakens to spring,
The fog scatters out to the benches,
Unbending willow prongs
Lean up from the snow by the fences.
The wind blows away the sound
Of straining pumps at Lifton,
Within me I hear them in vision
Turning the lake into sand.
Mountains rise out of the water
The bottomlands sag into swales,
Sloughs are festered with frogweed,
In the mud lie leeches and shells.
Bear Lake lies in the sand
From the pumps to the Wasatch wall.
In its evening levels swell
Black shadows of the land.
Planting the upland fields,
I heard a far sound of flails,
And the wind washed by in a wave
Like the sway of swinging wheat.
Now the thin fringe of leaves
Has darkened and heavied to brooding.
Wind from the mountains crowding
Scatters the petals and seeds.
Water is gone from the marshes,
Pumps in silence are lying,
Grain in the valley flourishes:
All but the land will be dying.

-Edward L. Hart

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The Two Books Prior To The Scientific Revolution*

Abstract

The relationship between the revelation of God through nature and through Scripture is here studied, by focusing on the metaphor of "the Two Books", as it was used from the Fathers of the Church up to the XVII century. According to the majority of the Fathers, the book of Nature is as universal as the book of Scripture, and the content of each is to some extent equivalent. The authors of the Middle Ages emphasize that the capability of human reason to recognize God through the Book of Nature has been weakened by sin. Thus, it becomes necessary the reading of a "third" book, the Book of the Cross. The work of Raymond Sebond plays an important role to understand the historical evolution the metaphor underwent during the Renaissance and the Modern Age. The autonomy of the Book of Nature with respect to the Book of Scripture will increase accordingly, including the possibility to have access to an image of God different from that conveyed by Sacred Scripture. The way in which the metaphor is used during the Renaissance will pave the way to deism, in the XVIII century, and to naturalism, in XIX century.

Omnis mundi creatura quasi librum et pictura nobis est et speculum

Alan of Lille (XII century)
Hymn
(PL 210, 579)

The contemporary debate between science and theology often speaks of a comparison between the "Book of Nature" and the "Book of Scripture". There are basically two ways in which this metaphor can be used. In the more general way, it refers to the comparison between the knowledge of nature achieved by science and the one we achieve reading the Judaeo-Christian Revelation, and thus understanding nature as creation. In this case it is nothing but a different way of looking at the broad topic that is known as "Religion and Science". However, there is a second, and more intriguing way, to use it. Actually, we can refer to the term "book" in a specific and definite manner; that is, as a document written by someone and addressed to someone else; a document that is intended to convey an intelligible content; a text that might require a certain effort to be properly interpreted and explained according to its author's original and genuine meaning. But, we ask, how could this second way of understanding the metaphor be truly meaningful? In fact, if it is clear to everyone what we mean when we speak of the Book of Scripture, it might be less clear what we mean when we speak of the universe "as a book". It is obviously a metaphor, but its usage admits various degrees and nuances: up to what point are we allowed to consider nature as a "book"? How was such a metaphor, that originated in a religious context, employed throughout the history?

When speaking of the relationship between the Two Books, one first thinks to what happened from the XVII century onward, that is, from the epoch in which the so-called "scientific revolution" began to put in question some relevant belief owned by the theological establishment. It was in that context when we began to speak of a "conflict" between the Two Books. Prior to that epoch the use of the metaphor might seem less significant, and the whole subject lacking in interest. In

reality, the image of the Book had a wide literary usage well before the century of Galileo and Kepler. In this article I will focus precisely on what happened before the scientific revolution and try to shed light on three major questions: a) How were the "Two Books" mutually related and how was their content considered of some relevance to a better understanding of each other? b) How did the leading philosophical ideas concerning the Two Books evolve through history? c) What epistemological consequences are entailed when we accept that nature is a real and true book? While the first two questions include a historical perspective, the third one appeals to contemporary philosophy of science1. However, a complete answer to this last question is beyond the aims of this paper. For this reason, I will confine myself to offer only a few hints about it, asking the reader to refer to the abundant literature existing on the topic.

1. Is Nature seen as a "book" through the pages of the Holy Scripture?

It is well known by everyone that the Holy Scripture introduces the created world as an effect of the Word of God: «Then God said, "Let there be light", and there was light...» (Gen 1,3). This relationship between the world and the Word is strengthened in the New Testament, which affirms the dependence of the entire universe on the Word made flesh: «in these last days, he spoke to us through a son, whom he made heir of all things and through whom he created the universe [...] and who sustains all things by his mighty word» (Heb 1,2-3). With this biblical basis, theological and philosophical literature apply to the created universe metaphors which deal with the word as such. By words we narrate a text, we pray hymns or sing a song. Comparing the creatures to the letters of a book, or to the voices of a choir, is thus in accordance with a theology of creation centered on the Word-Logos. It is worth noting that when using other images, for instance stating that natural things are like the footprint, the traces or the mirror of God Creator, such a link with the word is less clear, or even absent. The metaphor of nature as a Book, therefore, seems particularly consistent with a Christian theology of creation.

Turning our attention now to the way in which Sacred Scriptures imagine or describe the aspect of the cosmos, especially the appearance of the sky, we first of all find the metaphor of a tent or a curtain. The heavens are spread out, or even stretched out, like a tent over the Earth, as we read in many passages from the Psalms, the books of Job or Isaiah2. The verbs here used correspond (Heb. natâ) to the action of pitching and fixing a tent, or rarely, to the action of extending a cloth3.

In a limited number of cases, and in the apocalyptic context of God's final judgement, we find an interesting expression. We read in the Book of Isaiah: «The heavens shall be rolled up like a scroll, and all their host shall wither away. As the leaf wilts on the vine, or as the fig withers on the tree» (Is 34,4). An almost parallel page is presented by the Book of Revelation: «Then the sky was divided like a torn scroll curling up, and every mountain and island was moved from its place» (Rv 6,14). These passages seem to indicate that, within the metaphor of the stretched curtain, the curtain is like a scroll; so the action opposite to that of laying out (or also of creating) the heavens is that of curling or rolling them back, similar to a scroll. Since "scroll" is nothing but the name used by the Bible to indicate a book, we have perhaps some indication that the heavens may be seen as both a curtain and a scroll. These are stretched out when God lays out the heavens, and will be rolled up in future times, in a new creation. From a merely philological point of view, we do not have enough

data to conclude that the Holy Scripture sees Nature as a book, but the reading of some of these passages are at least inspiring in this respect.

It is also worth mentioning that in the Holy Scripture, particularly the Book of Revelation (cf. Rv 20,12), we find two more metaphors: the Book of Life and the Book of History. In chapter 5, we find the solemn vision of a mysterious scroll which had writing on both sides, that is outside and inside (cf. Rv 5,1; cf also Ez 2,9). An angel then proclaims in a loud voice: «Who is worthy to open the scroll and break its seals?» (Rv 5,2). After the Lamb of God appears and receives this mysterious scroll from the hand of the Most High who sits on the throne, the angels and the elders finally cry out in a loud voice: «Worthy is the Lamb that was slain to receive power and riches, wisdom and strength, honor and glory and blessing» (Rv 5,12). We will come back to the meaning of this scene at the end of this paper. For the moment, it is sufficient to emphasize that the literary association between "nature as creation", and as a "book", relies upon the clear association existing between the world and the Word, a relationship that is remarkably theological in character. God creates by his Increated Word and the world conveys a divine logos, i.e. contains and expresses the words of God.

2. The Fathers of the Church and the early Christian writers until Scotus Eriugena

The number of authors who have spoken of the book of Nature is very high. The proposal of a philosophical path to recognize a provident Creator starting from the observation of His works, and the view that through these works He speaks to us, are ideas which belong to the entire history of human culture, from the very beginning up until today. In any case, it seems that the attitude of looking at Nature as if it were a book first began to be clearly recorded in the early Christian literature. Although we cannot exclude that it was present in previous cultures, for writing techniques were spread throughout the Mediterranean area from 3500 B.C., it certainly arises within a religious context. The Fathers of the Church employ it in two main ambits, namely the so-called cosmological argument, by which they invited others to acknowledge a provident God-Creator starting from the observation of the order and beauty of the creatures, and the cosmic dimension of liturgy, for God had to be celebrated and praised in His glory also in the context of Nature. By the same words of Anthony the Abbot (3rd Century), probably the first example of hermitage, «my book is the created nature, a one always at my disposal whenever I want to read God's words»4. As pointed out a bit later by Isaac of Nineveh, Nature was given to human beings prior to them receiving the sacred Scriptures5. Among the Fathers of the Church, explicit references to the Book of Nature can be found, in St. Basil, St. Gregory of Nyssa, St. Augustine, John Cassian, St. John Chrysostom, St. Ephrem the Syrian, St. Maximus the Confessor. If we also include those authors who implicitly refer to the Book of Nature, for example those that said that God "speaks to us through creation", the list would become much larger and quite uncontrollable6. It is enough, for our purposes, to offer here some quotes and afterwards to try to summarize some leading ideas.

According to the Greek father St. Basil of Cesarea (329-379) «We were made in the image and likeness of our Creator, endowed with intellect and reason, so that our nature was complete and we could know God. In this way, continuously contemplating the beauty of creatures, through them as if they were letters and words, we could read God's wisdom and providence over all things»7.

Despite his preference for apologetic arguments based on an anthropological, rather than on a cosmological path, among the Latin Fathers it is St. Augustine (354430) who dedicates various passages to the book of Nature, and interesting comparisons with the book of Scriptures are often involved. The following quote is, to this respect, very explicit: «It is the divine page that you must listen to; it is the book of the universe that you must observe. The pages of Scripture can only be read by those who know how to read and write, while everyone, even the illiterate, can read the book of the universe»8. «Some people — we read in one of his Sermons — in order to discover God, read a book. But there is a great book: the very appearance of created things. Look above and below, note, read. God whom you want to discover, did not make the letters with ink; he put in front of your eyes the very things that he made. Can you ask for a louder voice than that?»9. In a page of his Confessions, Ch. XIII, the metaphor of heaven as a book is combined with the biblical image of the starry sky stretched over us like a skin. God clothed our naked first parents with a skin just after they sinned, thus showing His mercy for us; likewise the heavens are a skin which also shows God's mercy, because, reading them as in a book, human beings can know the will of God and behave in a virtuous and honest way10. Referring to creation, Augustine says: «For we know no other books which so destroy pride, which so destroy the enemy, who resists your reconciliation by defending his own sins»11. In contrast to human beings, the angels do not need to read the heavens, for they always behold God's face and perfectly know God's will: indeed, God himself is their book 12.

With reference to our topic, a remarkable influence over the centuries that followed, especially during the Middle Ages, was exerted by Maximus the Confessor (580-662). In one of his works called Ambigua, commenting on the event of Christ's Transfiguration, he compares Nature and Scripture to two clothes with which the Incarnated Logos was endowed; the natural law being his humanity, and the divine law, revealed by Scripture, his divinity. These two laws were presented to us by means of two different books, Nature and Scripture. They veil and reveal the same Logos, they have the same dignity and teach the same things. Maximus is even more explicit: the two books have more or less the same content and he who want to know and carry out God's will, needs them both13. In reading the book of Nature, the deep mystery of the Logos does not vanish, nor is it destroyed. «The natural law, as if it were a book, holds and sustain the harmony of the whole of the universe. Material bodies are like the book's characters and syllables; they are like the first basic elements nearer to us, but allow only a partial knowledge. Yet such a book has also more general and universal words, more distant from us, whose knowledge is more subtle and difficult to reach. The same divine Logos who wrote these words with wisdom, is like embodied in them in an ineffable and inexpressible way. He reveals himself completely through these words; but after their careful reading, we can only reach the knowledge that he is, because he is none of those particular things. It is gathering with reverence all these different manifestations of his, that we are led toward a unique and coherent representation of the truth, and he makes himself known to us as Creator, by analogy from the visible, created world»14. It is worthwhile to mention here the great — and I would add the critical — equilibrium of Maximus Confessor. On one hand he affirms the need to know the natural law, and maintains that all that is contained in the Holy Scriptures is also contained in Nature (a statement which some centuries later would have brought about some problems, as we will see later). On the other hand, faithful to the Greek tradition, he is aware that

the knowledge of God through the book of Nature remains veiled, deficient, and certainly inferior to that provided by the Bible.

In the 9th Century John Scotus Eriugena (about 810-877) recalled Maximus' image of the Transfigured Christ-Logos, recommending to comprehend the human clothes of Jesus, which indicate the material creatures15. At the very beginning of the history of salvation, he says, Abraham was invited to recognize God not looking at the Scriptures, that did not exist yet, but by looking up at the starry sky16. In the works of the Celtic theologian, the idea that God reveals himself through the two Books is also present. Nature and Scripture can be both considered as God's theophanies. «The eternal light manifests it to the world in two ways, through Scripture and through creatures. In no other way the knowledge of God is renewed in us but in the characters (Lat. apices) of Scripture and in the forms (Lat. species) of creatures»17.

In addition to the quotations collected here, if we also take into account how the relationship between faith and reason was formulated by the majority of the authors of this same period, the following general conclusions can be drawn:

a) The Fathers of the Church employ the cosmological argument (to infer the Logos-God or the divine from nature), one already known to the Platonic, Aristotelian and Stoic philosophical traditions, and use it to ascend from created beings to the Creator. The metaphor of nature as one of God's books is clearly present. When creatures are not compared to letters or words which make up a book written by God, it is nevertheless certain that God speaks to us through nature. The cue is often taken from passages of the Holy Scripture which offered a sound basis to endorse the practicability of such a path18.

b) The book of Nature is as universal as the book of Scripture, and the content of each is to some extent equivalent. At times it transpires that the book of Nature is even more universal and more comprehensible than the book of Scripture. Creation is before everyone's eyes, as a source for a moral and spiritual appeal.

c) The knowledge of the book of Nature seems to be relevant, and for some authors even necessary, to understanding correctly the book of Scripture, for the knowledge acquired by observing and studying natural things precedes the knowledge of God's revealed words19.
d) With regard to moral and ethical dimensions, there is a strong analogy between natural law (i.e. those moral commandments that are particular to human nature as such) and the revealed divine law. The first is written by God in the world of created beings and in human conscience, the second is written by the same God in the Scriptures.

3. Authors of the Middle Ages: the case of Hugh of St. Victor and St. Bonaventure

The metaphor of the Two Books also survives during the Middle Ages; with theology continuing to inquire about the relationship existing between them20. References to the book of Nature can be found, with different nuances and to different degrees, among others, in St. Bernard of Clairvaux (1090-1153), Hugh of St. Victor (1096-1141), St. Bonaventure (1217-1274), St. Thomas Aquinas

(1224-1274), Thomas of Chobham (about 1255-1327), Dante Alighieri (1265-1321), Thomas of Kempis (1380-1471) and Raymond of Sebond (about 1385-1436), the subject of the next section.

In the Middle Ages, two authors deserve more room for discussion: Hugh of St. Victor and St. Bonaventure21. Both emphasize that the universal comprehension of the book of Nature is weakened by the reality of human sin. The book of Scripture exerts a kind of “healing action” over the book of Nature: after the original fall, and because of our sins, to recognize God in the spectacle of nature is not an easy task to accomplish. Thus a “third” book comes forth, the book of the Cross. Christ himself, his Incarnation and his redemption, is compared with a great book, whose reading is necessary to the proper understanding of the other two books. To this respect, Jesus Christ seems to play quite an interesting, twofold role. He acts indeed like a hinge between the Two Books. When considered as increated Wisdom, he shows a special relationship with the book of Scripture; when considered as the Incarnated Word, he is mainly associated to creation.

Hugh of St. Victor points out that to read the book of Nature properly, one needs to have a spiritual, not merely a natural (that is material) attitude: «For this whole visible world is a book written by the finger of God, that is, created by divine power; and the individual creatures are as figures in it, not derived by human will but instituted by divine authority to show forth the wisdom of the invisible things of God. But just as some illiterate man who sees an open book looks at the figures but does not recognize the letters: just so the foolish natural man who does not perceive what pertains to the Spirit of God [cf. 1Cor 2,14]. He sees the form and the beauty outside creatures without understanding their inner meaning. On the contrary, the spiritual person can judge everything, and when looking at the beauty of the works, he soon realizes how the Creator’s wisdom has to be much more admired»22. According to this mediaeval Master, God’s Wisdom is also a unique book, written inside (Holy Scripture) and outside (the works of creation). Nature is compared to a first scripture, the Bible to a second scripture. The Incarnation of the Word is a third scripture, which is seen as a book that also has an inner and an outer side, the first because of his invisible divinity, the second because of his visible humanity23. All these images recall that book written on both sides which both the prophet Ezekiel and St. John’s Book of Revelation speak of24. In a work titled De Arca Noe Morali, Hugh of St. Victor speaks of three books and of three words, but with a different meaning. The first book or word is all what is made by human activity; the second book/word is creation made by God; and the third book/word is Wisdom himself, that is the Increated Word. In this case, Jesus Christ, as Incarnated Wisdom, plays the role of Sacred Scripture, of which he is the fulfilment25.

In the works of St. Bonaventure, the metaphor of the Book is widely used, so that expressions such as liber naturae, liber mundi, or liber creaturae, are synonyms for nature, world, creation26. At the same time, the necessity to know God through Sacred Scripture and not only through nature, and the demand for a third book, that of Christ Redeemer, is nevertheless explicit. Here are two outstanding texts: «Before sin, man had the knowledge of created things and through their images he was led to know God, to praise, to worship and to love him. The purpose for which living beings exist, is to lead us to God. When human beings fell because of sin, they lost such knowledge and so there was no one who could bring all things back to God. Thus this book, that is the world, seemed dead and destroyed. Therefore, there was a need for another book through which the previous book had to be enlightened, in order to acknowledge the true meaning of things. This book is nothing but

Sacred Scripture, which contains metaphors, images and teachings about the book of the world. In this way, the book of Scripture restores the whole world, and allows the latter again to lead us to know, to praise and to love God»27. «If we want to contemplate spiritual things, we need to take up the cross as if it were a book. [...] Christ himself is this book of wisdom, who is written inside by the Father, as he comes from the power of God, and outside, when he took on a bodily form. However, this book was open on the cross, and it is this book that we have to read in order to understand the depths of God's wisdom»28.

Although these texts allow different interpretations, for instance whether it was our intellect to be mainly wounded by original sin, or our knowledge of God also weakened by our personal sins, the doctrine here underlying is clear enough. The book of Scripture and the book of the Cross have a kind of priority with respect to the book of Nature, at least regard to our ability to clearly recognize God. At the same time, St. Bonaventure cannot deny a chronological priority of the book of Nature over that of Scripture, as shown by this quote from the Breviloquium: «The first Principle is made known to us through Scriptures and creatures. By the book of Nature shows itself as the principle of power; by the book of Scripture as the principle of restoring. And since the restoring principle cannot be known without first knowing the principle of power, though the Bible tell us mainly about the work of redemption, it must also tell us about the work of creation». Despite the fact we are dealing here with a knowledge of nature through the pages of Scriptures, it is clear that such a knowledge calls for a comparison with the natural knowledge acquired by reason29.

Other passages of the Franciscan Master recall the image of the book written both inside and outside, an image that works at different levels. All things are like a book written outside, insofar as we confine ourselves to read them as merely effects of God's power. Here is the step where natural philosophers seem to stop. Yet creatures are written inside, when we recognize them as traces or images (Lat. vestigia) of God. On a second level, material and irrational things are a book written outside, while rational and spiritual creatures, like humans and angels, are a book written inside, in the depth of their conscience. Finally, Scripture too turns out to be a twofold written book. The outer writings refer to those meanings of Scriptures which are explicit and clear, while inner writings represent those implicit senses and more obscure understandings30.

The metaphor of the book is used by other mediaeval Masters, among them Thomas Aquinas. He seems to use it explicitly quite a few times, although it is difficult to pick out a complete set of quotes if our research is confined to expressions such as liber naturae or liber creaturarum, since the full context is always needed31. Nevertheless, it is worthwhile recalling that Aquinas provided a synthetic formulation of the relationship between the knowledge of God we acquire looking at nature, and the one we are taught by reading the Scriptures. With a sentence that will be quoted down through the centuries by many documents of the Church, he affirmed that human natural reason is able to reach a certain knowledge about spiritual realities, such as the existence of God, the immortality of the human soul, the existence of a moral responsibility before a provident Creator, etc.; however, God himself also wanted to reveal these same truths by the pages of the Holy Scripture, so that in this present condition of the human race, they can be readily known by all, with firm certitude and with no admixture of error32.

To summarize, we can say that the Middle Ages introduce a certain theological realism in the question of the Two Books. Human reason is able to read the book of Nature to ascend to God, but we have to take into account the wounds suffered by our intellect because of sin. This great Book continues to bind us to our Creator33, but a spiritual and clear sight is required to recognize such a link34. Authors of the Middle Ages do not lose optimism, but seem to gain realism. Actually we could say, by using the words of John Abbot of Ford (d. 1220), «Est enim liber creaturae et est liber scripturae et est liber gratiae — there is the book of creatures, the book of Scripture and the book of Grace»35. The book of Nature does not lose its universality, but is framed within a strong christological perspective, and so demands other theological categories, such as Incarnation and redemption, fall and grace. Mediaeval Masters thus extend the metaphor of the book to Christ and to God. God himself, according to the beautiful verses of Dante's Comedia, is the book, the volume, whose pages are scattered through the world, and which also allows Creation to be a book in itself: «In its depth I saw ingathered, bound by love in one single volume, that which is dispersed in leaves throughout the universe: substances and accidents and their relations, as though fused together in such a way that what I tell is but a simple light»36

4. The first Renaissance: the case of Raymond of Sebond

A work deserving a specific attention is the Theologia Naturalis seu Liber Creaturarum (1436), written by Raimundo de Sebunde (Raymond of Sebond, about 1385 - 1436), a Catalan born scholar, Doctor in Medicine and Theology, who was professor at Toulouse and president of that same University (1428-1435). The title of Sebond's treatise changes a bit depending on the manuscripts existing in different European Libraries: Liber Naturae sive Creaturarum (Paris), Scientia Libri creaturarum seu Naturae et de Homine (Toulouse), Liber Creaturarum sive de Homine (Clermond-Ferrand), etc. The subtitle Theologia naturalis was added by the publishers, starting from its second printing in 1485. This book was remarkably successful: it had sixteen editions and many translations, including a French one made by Michel de Montaigne in 1569. Until the beginning of the 18th century, various editors also re-arranged and re-organized the content of the book for different 37 purposes.

The aim of the work is clear and explicit in the author's Prologue: the knowledge of the book of Nature allows us to understand, in a true and infallible way, and without much effort, all truths about created things, man and God. The book of Nature tells us all that is necessary for our perfection and moral fulfilment, so that, by reading this Book, we can achieve our eternal salvation. Moreover – Sebond adds – it is thanks to the knowledge of the book of Nature that we can understand without error what is contained in the book of Scripture38. In the book of Nature each creature is nothing but a byte and a letter, written by the finger of God, such that all these letters and words together form a kind of manuscript, in which the human creature constitutes the most important word39.

The relationship between the two Books is explained in detail but in a way that deviates, at least on some matters, from the teachings of the mediaeval Masters. Both books were given to us by the same and unique God; we received the first one from the creation of the world, while the second one was written thereafter. The book of Nature seems to have a certain priority, for it is said that our knowledge of it precedes and confirms the book of Scripture; it is like a door to enter the Bible

and a light to illuminate its words40. The knowledge of the book of Nature is available to everyone, while the book of Scripture can be read only by the clerics. Nevertheless, the book of Scripture was inspired and written to help us read the book of creatures properly, since we were like the blind41 — a consideration that certainly refers to human sins and brings Sebond closer to the theologians of the Middle Ages. With an epistemological optimism that would have certainly amazed many contemporary philosophers of science, Sebond says that we cannot falsify or misinterpret the book of Nature, adding that, when studying it, there is no room for heretics or heresies. Contrary to Scripture, Nature cannot be deleted nor lost42. We need both books and they do not contradict each other. They do not differ in their content: all that is present in the first, we also find in the second. They differ with regard to the way in which such content is taught and proved: the book of Creatures teaches by means of a rational demonstration (per modum probationis), while the Holy Scriptures are based on God's authority and they teach us by means of prescriptions, commands and exhortations (per modum praecepti, mandati, monitionis et exhortationis)43.

Raymond Sebond strives to keep his balance, but the matter is delicate and somewhat critical. The risk of over-evaluating the book of Nature at the expense of the sacred Scripture is real; one could think, for example, that all of what is contained in the Bible can be known simply looking at the creatures. It is true that he emphasizes in many places that the book of Scripture is "greater and higher" than that of Nature, because to speak with the authority of God is superior than demonstrating something by human reason: However, some of the arguments brought about by Sebond are precarious, and at times ambiguous. Trying to summarize his thought, we could say that from a cognitive point of view, the book of Nature is primary and more fundamental: its knowledge is more universal and con-natural to us, that is tailor-made for the human mind44; from the point of view of dignity, the book of Scripture has a higher value, because of the authority on which words contained therein are based45. Yet, the priority of Nature serves the Scriptures, because it is directed to the knowledge of the latter: thus all matter is counterbalanced once again, and Sebond finds his way once more46.

It is no surprise that the doctrine of the Liber Creaturarum was interpreted and judged in different and sometimes contrasting ways. Some scholars saw in it the danger of reducing the significance of Scripture and weakening the authority of the Church to interpret it. Others saw in the work of Raymond Sebond a nice example of natural theology, in tune with the Christian philosophy of the Early Centuries and the Middle Ages47. It was because of the implicit problems it contained that in 1559 the book was included by Pope Paul IV into the Index of the forbidden books. But a few years later, in 1564, Pope Pius IV limited the prohibition to the Prologue only, asking that a note of theological clarification be inserted in all the later publications of the book.

Beyond the course of events and opinions related to the work of Sebond, there is no doubt that the content of the Liber Creaturarum differs somewhat from the theological perspective hold during the Middle Ages. For the first time — and probably beyond the intentions of its author — we find an attempt to read a moral doctrine in Nature in such a way that, in principle, the consideration of the sacred Scriptures could be left out. Now the book of Nature can be seen as a book autonomous in itself. It is probably from this point, I guess, that the road is open for a "modern religion of nature" capable of conveying moral and spiritual values without a necessary reference to the

revealed religion based on the Bible. This will give rise at least to a couple of philosophical lines of thought.

The first is a kind of "lay sacralization" of Nature (we mean here something very different from those other sacred views of Nature, utterly Christian in character, highlighted by Scotus Eriugena, the Celtic Christianity, Hildegard of Bingen or Franciscus of Assisi). A new natural lay religion emerges, having its own rites, prayers and moral prescriptions, which can easily and dangerously meet the practice of magic and esoteric customs. It will coalesce in the Renaissance, giving rise to a pseudo-philosophy which lasts until our days through some of the manifold expressions of the New Age. The second line of thought is that related to the Deism of the Enlightenment, a religion of reason and nature which leaves aside, and often criticizes, all the revealed religions. The latter were considered as controversial, that is sources of intolerance and division, while a natural religion based on reason was, in the program of the Enlightenment, the only one capable of re-uniting in a peaceful way all humankind.

Notwithstanding the fact that the work of Raymond of Sebond could have nourished these philosophical roots, the ideas there contained deserve to be studied in more depth. His proposal possesses interesting suggestions that might help the development of the contemporary dialogue between Religion and Science, provided that the relationship between the two Books is explained in a slightly more convincing way than that of Sebond.

5. At the dawn of Science of the Modern Age: who can read the book of Nature?

The transition to the Renaissance is, for our topic, particularly critical48. The Patristic Age and the Middle Ages do not know the idea of a dialectic opposition between the Two Books, as if their mutual comparison were a question to be solved. Authors are not concerned about showing or demonstrating their "harmony", in the contemporary meaning of the word. Rather, they want to show their common dignity as divine revelation and their role to provide mankind with a true knowledge of the unique God. In light of a human history characterized by fall and redemption, their mutual gnoseological relationship (or subordination) is also determined and explained with different emphases, especially within a christological perspective. The two Books are discussed and compared without any need for healing or rectifying any conflict. A number of authors in the 15th and 16th centuries will continue to maintain that creatures are the words or the book of God, using this metaphor for rhetoric or spiritual purposes, as Nicholas of Cusa (1401-1464), Martin Luther (1483-1546) or Fray Luis of Granada (1504-1588), but far from any problem of clashing interests49.

In contrast it is the line of thought emphasized by Philippus Paracelsus (14931541) which gives rise to a different state of affairs. Following a peculiar interpretation of the work of Raymond of Sebond, the book of Nature now begins to permit a reading which seems to enter into conflict with the Holy Scripture. More than a conflict of contents, it seems to be a conflict of readers and languages. Against theologians and those scholars who based their studies on the Bible, Paracelsus affirms: «From the light of Nature must enlightenment come, that the text liber naturae be understood, without which enlightenment no philosopher nor natural scientist may be». And one of his students will add: «Let the others read their compendiums, while we study in the great picture book which God has opened for us outdoors»50. The development of natural studies and

experimental observations carried out in the late Renaissance introduced the idea that we can approach the world of the divine without the mediation of sacred Scripture, of theology or scholastic philosophy, and of course without the mediation of any Church. What is at stake is not the existence of God nor the choice of what is the best source (Nature or Scripture) to understand who we are and where are we going. In fact, for the Renaissance scientists it remains clear that God himself wrote the book of Nature. The point is that now they can read it directly, praising and worshipping the Architect and the Maker of the world. The accordance between natural philosophy and theology, between Nature and Scripture, between natural and revealed moral laws, an accord that was centered for a long time around the mystery of the two, human and divine, natures of the Incarnated Logos, is bound to be broken. A "spiritual" reading of the book of Nature is still possible, but it is no longer Christian, as will be shown later on by the philosophy of Deism and the spirit of Romanticism. Born in a Christian context, the concept of the world as a book now becomes secularized and alienated from its theological origin.

The discussion of the position held by Galileo Galilei (1564-1642) in such historical process is beyond the aims of present paper51. However, I want to make a couple of comments, because he uses the metaphor in a way that contributes to reducing the number of those who are allowed to read the book of the universe. It is true that, in contrast to Paracelsus and to what the deists will later maintain, for Galileo the Author of the Two Books is undoubtedly the unique God of the Judaeo-Christian Revelation, for «the Holy Scripture and Nature equally proceed from the divine Word, the former as the dictation of the Holy Ghost and the latter as most observant executrix of God's command»52, according to the well known Letter to Castelli (1613). Nevertheless it is clear that «the great book of Nature — as he wrote in the foreword of the Dialogue on the two Chief World Systems (1632) — is the proper object of natural philosophy»53, and that the reading of the book of Nature is matter for scientists, not for theologians.

The famous page of the Assayer (1923) should be read, in my opinion, precisely in that light: «Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the letters in which it is composed. It is written in the language of mathematics, and its characters are triangles, circles and others geometric figures without which it is humanly impossible to understand a single word of it; without these, one wanders about in a dark labyrinth»54. In 1641, in a letter addressed to Fortunio Liceti, the metaphor is clearly used against the cultural establishment of his time, whose books have now been surpassed, because «the book of philosophy is now that which stands perpetually open before our eyes; but because it is written in characters different from those of our alphabet, it cannot be read by everybody; and the characters of this book are triangles, squares, circles, spheres, cones, pyramids and other mathematical figures fittest for this sort of reading»55. It is worthwhile pointing out that since the epoch of the early Fathers of the Church, the meaning of the metaphor is now surprisingly overturned. If St. Augustine could state that «everyone, even the illiterate, can read the book of the universe», in Galileo's view people who are qualified to read it belong to a much narrower circle. Raymond of Sebond's proposition that the knowledge of the book of Nature is common to everyone, while the book of Scripture can be read only by the clerics, finds its mirror image here, but at the expense of the universality of the book of the world.

The position maintained by Johannes Kepler (1571-1630) seems, in this respect, a bit different. For the German astronomer too the book of Nature required a rational interpretation, but he was able to clothe his rationality with a mantle of mysticism and spirituality. Astronomers are the high priests of the Most High God and the universe is precisely their book. But its content is more than mere geometry or mathematics, since it can be used like a Missal to celebrate, pray and worship God Creator. Like Galileo, also Kepler holds that Nature is a book for scientists, not for theologians, but without giving it a solely "rationalistic" reading, according to the contemporary meaning we now give to this term56. The book of the universe is also suitable for praying and worshipping, and so it recovers part of its universality57. The astronomer is not forbidden from becoming a theologian.

Thus, having these different and somewhat contradictory nuances, the metaphor of the Two Books will enter into the Modern Age. With regard to the book of Nature, the "rationalistic" and the "spiritual" ways of reading it will survive until today, but in a new religious context, one that will also oblige scholars to distinguish carefully between the different ways in which the Bible must be read.

6. Reading Nature as a Book. Consequences for the study of theologians and the research of scientists: some philosophical perspectives

Returning to the philosophical core of the image of the Two Books, and particularly to that of Nature as a book, does the meaning of such image entail any consequences for the work of theologians and scientists? The issue is broad, but it is worthy to be explored, at least in a schematic way.

On the side of theology, I begin by mentioning that in line with the Fathers of the Church and the other authors I reported above, in our time also the teachings of John Paul II employ the metaphor of Nature as a book58. In the Encyclical Fides et ratio (1998), commenting on a passage of the Book of Wisdom that speaks of the knowledge of God, by analogy, from his works59, John Paul II states: «This is to recognize as a first stage of divine Revelation the marvellous "book of nature", which, when read, with the proper tools of human reason, can lead to knowledge of the Creator» (n. 19). Some years later, taking the cue from the commentary to Psalm 18, he will say: «For those who have attentive ears and open eyes, creation is like a first revelation that has its own eloquent language: it is almost another sacred book whose letters are represented by the multitude of created things present in the universe»60.

Thus, it is permissable, from a theological point of view, to present the material universe as part of God's revelation. Until now, the magisterium of the Catholic Church preferred to reserve the term "Revelation" only to refer to historical-supernatural word of God. For instance, in the documents of the First (1870) and Second (1965) Vatican Councils, when speaking of "creation" or "nature" other attributes were used, such as "testimony", "witnessing" or "manifestation" of God61. Conversely, the concept of revelation will be used in the context of creation by the Catechism of the Catholic Church (1992, 19972) and in other speeches by John Paul II62

If creation can be said to be a Book which reveals something of God, then it must have the capacity to appeal, to bear meaning, to incarnate an end. Human beings must not limit the experience they have of creation to the aesthetic level, but must ask themselves about the Author of beauty63. A book, as a written text, contains a message and is addressed to someone; and it does it more explicitly than the simple view of a landscape. The theological basis to consider creation as the initial stage of divine Revelation depends on its direct relationship with the Word-Logos, through Whom all things were made, and on that Christological dimension which permeates the created world as a whole, a world made through Him and for Him64.

Remarkable consequences can also be seen in the important field of the interreligious dialogue. If the book of Nature is in front of everyone and it manifests the revelation of the true God, then on the basis of this common acknowledgement a meaningful dialogue can start, provided that the simply aesthetic dimension is complemented with a reliable philosophical framework which is respectful of all the requirements of human rationality. With regard to those who have not received any historical revelation of God, the "word of creation" can play the role of a truly salvific revelation, in the place of Scriptures or other kinds of spiritual mediation. It must be pointed out, however, that Nature alone does not save anyone. The capability of creation to awaken and convert human hearts to the love of the Creator, closely depends on the link existing between the natural world and the salvific humanity of Christ, the center and the scope of all of creation65.

Finally, if theology is invited to open again the "Book of Nature" — a book that some suggested closing because it was too difficult to read, or because after Galileo and Darwin it became a source of trouble — it means that the result of natural sciences can be considered a source of positive speculation, so that they can truly help theology to better understand the word of God66.

When seen from the point of view of the activity of scientists, the metaphor of the "book" can be easily connected with the idea of an intelligible and rational universe, fit to be "read" by experiments as well as by theories. The question of the ultimate reason for the intelligibility of the world is indeed present in the contemporary interdisciplinary debate, and many authors have pointed out that such interrogation remains meaningful67. To believe that the natural world has the logic of a book, ordered and non-chaotic, written by God and containing a rational message, could influence the "spirit" with which a scientist carries out his or her activity. The following quote by Georges Lemaître seems, in this respect, quite impressive: «Both of them, (the believing scientist and the non-believing scientist) endeavour to decipher the palimpsest of nature, in which the traces of the various stages of the long evolution of the world are overlaid on one another and confused. The believer has perhaps the advantage of knowing that the enigma has a solution, that the underlying writing is, when all is said and done, the work of an intelligent being, therefore that the problem raised by nature has been raised in order to be solved, and that its difficulty is doubtless proportionate to the present or future capacity of mankind. That will not give him, perhaps, new resources in his investigation, but it will contribute to maintaining in him a healthy optimism without which a sustained effort cannot be kept up for long»68.

There are scientists who speak of their research activity as a sort of "dialogue" between themselves and nature, and of their discoveries as an experience of "revelation". According to John Polkinghorne, «Physicists laboriously master mathematical techniques because experience has

shown that they provide the best, indeed the only, way to understand the physical world. We choose that language because it is the one that is being "spoken" to us by the cosmos»69. Nature is understood as a mystic, appealing partner that appears before the scientist: «Sometimes, through a strong, compelling experience of mystical insight, a man knows beyond the shadow of doubt that he has been in touch with a reality that lies behind mere phenomena. He himself is completely convinced, but he cannot communicate the certainty. It is a private revelation»70. Beyond the words employed to describe such feelings, these experiences are consistent, once again, with the idea that the world can be read, that it conveys a message, that the universe reveals a sort of "cosmic code" — an expression that has become common in popular science. In conclusion, Nature seems to continue to be seen as a Book, despite the passing of the centuries and the change of philosophical paradigms.

At the beginning of this paper we mentioned that one of the most solemn visions described in St. John's Book of Revelation shows the Lamb who receives from the throne of the Most High a book, the seals of which only he is worthy to open. In this vision, the opening of the scroll is praised not only by peoples of every tongue and nations, but also by all living beings: «Then I heard every creature in heaven and on earth and under the earth and in the sea, everything in the universe, cry out: "To the one who sits on the throne and to the Lamb be blessing and honor, glory and might, forever and ever"»71. In other words, the book of all history, of which the Lamb is judge and redeemer, and the book of all natural creation, seem to be summarized and contained in that unique Book, the seals of which only the Incarnate Word is worthy of breaking. The Book of History and the Book of Nature belong to the same Book, of which the Incarnated Logos is the first and last word, the beginning and end, the alpha and the omega72.

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1 For the historical perspective, see: D.C. LINDBERG, R.L. NUMBERS (eds.), God and nature. Historical essays on the encounter between Christianity and science (Berkeley - London: Univ. of California Press, 1986); J. BROOKE, Science and Religion: Some Historical Perspectives (Cambridge: Cambridge University Press, 1991); J.J. CLARKE (ed.), Nature in Question. An Anthology of Ideas and Arguments (London: Earthscan, 1993); A.C. CROMBIE, Styles of Scientific Thinking in the European Tradition, 3 vols. (London: Duckworth, 1994).
2 «He commands the sun, and it rises not; he seals up the stars. He alone stretches out the heavens and treads upon the crests of the sea. He made the Bear and Orion, the Pleiades and the constellations of the south» (Jb 9,7-9). «I Bless the Lord, my soul! Lord, my God, you are great indeed! You are clothed with majesty and glory, obed in light as with a cloak. You spread out the heavens like a tent; you raised your palace upon the waters. You make the clouds your chariot; you travel on the wings of the wind. You make the winds your messengers; flaming fire, your ministers» (Ps 104,1-4). «It was I who made the earth and created mankind upon it; It was my hands that stretched out the heavens; I gave the order to all their host» (Is 45,12). «He who made the earth by his power, established the world by his wisdom, and stretched out the heavens by his skill» (Jer 10,12=51,15). Cf. also Is 44,24; Is 51,13; Zec 12,1. A different verb, but having an analogous meaning, is that offered by Is 48,13: «Yes, my hand laid the foundations of the earth; my right hand spread out (Heb. piel) the heavens. When I call them, they stand forth at once».

3 Cf. G.J. BOTTERWECK, H. RINGGREN, H.J. FABRY, Theological Dictionary of the Old Testament (Grand Rapids (MI) - Cambridge (UK): Eerdmans, 1998), vol. IX, pp. 381-387.
4 Reported by Socrates Scholasticus, Historia Ecclesiastica, IV, 23 (PG 67, 518).
5 «Nature was the first book God gave to us, rational beings; ink-written teachings were given after human transgression» (ISAAC OF NINEVEH, Sermones ascetici, V).
6 See, for example, ST. ATHANASIUS, Expositio in Psalmum XVII, n. 4 (PG 27, 124C); ST. JOHN CHRYSOSTOMUS, Homilia ad populum antiochenum, IX, 2 (PG 49, 105).
7 Homilia de gratiarum actione, 2 (PG 31, 221C - 224A)
8 «Liber tibi sit pagina divina, ut haec audias; liber tibi sit orbis terrarum, ut haec videas. In istis codicibus non ea legunt, nisi qui litteras noverunt; in toto mundo legat et idiota» (Enarrationes in Psalmos 45, 7 (PL 36, 518)).
9 «Alius, ut inveniat deum, librum legit. Est quidam magnus liber ipsa species creaturae: superiorem et inferiorem contuere, attende, lege. Non deus, unde eum cognosceres, de atramento litteras fecit: ante oculos tuos posuit haec ipsa quae fecit. Quid quaeris maiorem vocem?» (Sermones, 68, 6 (PLS 2, 505)).
10 «For heaven shall be folded up like a scroll; and now is it stretched over us like a skin. For your Divine Scripture is of more eminent authority, since those mortals by whom Thou dispenses it unto us, underwent mortality. And you know, Lord, you know, how you with skins did clothe men, when they by sin became mortal. Whence you have like a skin stretched out the firmament of your book, that is, your harmonizing words, by the ministry of mortal men — Caelum enim plicabitur ut liber et nunc sicut pellis extenditur super nos. Sublimioris enim auctoritatis est tua divina Scriptura, cum iam obierunt istam mortem illi mortales, per quos eam dispensasti nobis. Et tu scis, Domine, tu scis quemadmodum pellibus indueris homines, cum peccato mortalis fierent. Unde sicut pellem extendisti firmamentum libri tui, concordes utique sermones tuos, quos per mortalium ministerium superposuisti nobis» (Confessiones, XIII, 15, 16).
On the moral value of the book of Nature see also Reply to Faustus the Manichaean: «But had you begun with looking at the book of nature as the production of the Creator of all, and had you believed that your own finite understanding might be at fault wherever anything seemed to be amiss, instead of venturing to find fault with the works of God, you would not have been led into these impious follies and blasphemous fancies with which, in your ignorance of what evil really is, you heap all evils upon God — At si universam creaturam ita prius aspiceres, ut auctori Deo tribueres, quasi legens magnum quendam librum naturae rerum atque ita si quid tibi te offenderet, causam te tamquam hominem latere posse tutius credere quam in operibus Dei quicquam reprehendere auderes, numquam incidisses in sacrilegas nugas et blasphema figmenta, quibus non intellegens, unde sit malum, Deum implere conaris omnibus malis» (Contra Faustum, XXXII, 20).
11 «Neque enim novimus alios libros ita destruentes superbiam, ita destruentes inimicum et defensorem resistentem reconciliationi tuae defendendo peccata sua» (Confessiones, XIII, 15, 17)
12 «Let them praise your name, let them praise you, the supercelestial people, your angels, who have no need to gaze up at this firmament, nor to read it to know your Word. For they always behold your face, and there read without any syllables in time, what will your eternal will [...]. Their book is never closed, nor their scroll folded up; you are indeed their book, and you are this to them eternally — Laudent nomen tuum, laudent te supercaelestes populi angelorum tuorum, qui non opus habent suspicere firmamentum hoc et legendo cognoscere verbum tuum. Vident enim faciem tuam semper et ibi legunt sine syllabis temporum, quid velit aeterna voluntas tua [...]. Non

clauditur codex eorum nec plicatur liber eorum, quia tu ipse illis hoc es et es in aeternum» (ibidem, XIII, 15, 18)

13 «In the sacred Scriptures the Word is veiled as Logos; in the created world, He is veiled as Maker and Creator. Thus I state that both are needed by he who wants to turn to God judiciously. He needs the spiritual reading of Scripture and the spiritual contemplation of natural creatures. And so the natural law and the written law have the same dignity and teach the same things, in a way that one of them has nothing more, nothing less than the other» (Ambigua, 10 (PG 91, 1128 C)).

14 Ambigua, 10 (PG 91, 1129 A).

15 See on this author J. SCOTUS ERIUGENA, The voice of the Eagle. The Heart of Celtic Christianity (Great Barrington (MA): Lindisfarne Books, 2000)

16 «Nam et Abraham non per literas scripturae, quae nondum confecta fuerat, verum conversione siderum Deum cognovit». (cfr. De divisione naturae, PL 122, 723-724)

17 «Dupliciter ergo lux aeterna seipsam mundo declarat, pre Scripturam videlicet et creaturam. Non enim aliter in nobis divina cognitio renovatur, nisi per divinae scripturae apices et creaturae species. Eloquia disce divina, et in animo tuo eorum concipe intellectum, in quo cognosces Verbum. Sensus corporeo formas ac pulchritudines rerum perspice sensibilium, et in eis intelligens Dei Verbum. Et in his omnibus nichil aliud tibi veritas declarabit praeter ipsum qui fecit omnia, extra quem nichil contemplaturus es, quia ipse est omnia» (Homilia in prologum S. Evangelii secundum Johannem, ch. XI (SC 151, 254)).

18 Cf. Book of Wisdom, 13,1-9; Epistle to Romans, 1,18-20; Acts of the Apostoles, 14,13-18 and 17,22-27. It must be emphasized that such a philosophical path does not necessarily rely on a strong metaphysical apparatus, as it will do, for instance, in mediaeval theology. The Fathers of the Church appeal to common sense, to the notion of Providence, to aesthetical and moral arguments. In addition, the cosmological path is often associated with the anthropological path, that is, they appeal to the capability the pagans had to recognize God in moral imperatives of conscience and in the human search for happiness and love.

19 This doctrine is openly affirmed by, among others, St. Basil: «Which is first: knowledge or faith? We say that, on the whole, in the case of sciences, faith precedes knowledge, but in our teaching, even if anyone says that knowledge begins before faith, we do not disagree — but, a knowledge commensurate with human comprehension. In the case of sciences, we must believe first that alpha is so called, and afterwards, having learned the letters and their pronunciation, gain also an accurate notion of the force of the letter. But in our faith concerning God the thought that God exists goes before, and this we gather from His works. We recognize by observation His wisdom and power and goodness and all His invisible attributes from the creation of the world» (Epistula, 235, 1 (PG 32, 872B)). On the same subject, Tertullian: «We state that first we know God through nature and after we recognize Him in the doctrines. Knowledge through nature comes from His works; knowledge through doctrines, from preaching. — Nos definimus, Deus primo natura cognoscendum, deinde doctrina recognoscendum: natura ex operibus; doctrina ex praedicationibus» (Adversus Marcionem, I, 18 (PL 2, 266)).

It is worthwhile noting that the same teaching is recalled, using similar words, by John Paul II's Encyclical Fides et ratio: «The Acts of the Apostles provides evidence that Christian proclamation was engaged from the very first with the philosophical currents of the time. In Athens, we read, Saint Paul entered into discussion with "certain Epicurean and Stoic philosophers" (17,18); and exegetical analysis of his speech at the Areopagus has revealed frequent allusions to popular beliefs deriving for the most part from Stoicism. This is by no means accidental. If pagans were to

understand them, the first Christians could not refer only to “Moses and the prophets” when they spoke. They also had to point to the natural knowledge of God and to the voice of conscience in every human being (cf. Rom 1,19-21; 2,14-15; Acts 14,6-17)» (n. 36).

20 The consideration of the Islamic tradition is beyond my analysis. However, an overall look at the content of the Koran shows that the term “book” never refers explicitly to nature, but is always used to indicate the same Koran and its laws, that are seen as the book par excellence. Some Islamic authors have noted that the Koranic verses are called ayat (“signs”), as are the phenomena of nature, indicating that the Koran could be seen as the counterpart of a natural text translated into human words. Cf. S.H. NASR, Religion and the Order of Nature (New York: Oxford Univ. Press, 1996). An indirect reference to the difference between Christian and Islamic traditions is made by the Catechism of the Catholic Church, n. 108.

21 For the Middle Ages, see J.M. GELLRICH, The Idea of the Book in the Middle Age (Ithaca - London: Cornell University Press, 1985).

22 «Universis enim mundus iste sensibilis quasi quidam liber est scriptus digito Dei, hoc est virtute divina creatus, et singulae creaturae quasi figurae quaedam sunt non humano placito inventae sed divino arbitrio institutae ad manifestandum invisibilium Dei sapientiam. Quemadmodum autem si illiteratus quis apertum librum videat, figuras aspicit, litteras non cognoscit: ita stultus et animalis homo qui non percipit ea quae Dei sunt [cf. 1Cor 2,14] in visibilibus istis creaturis foris videt speciem sed intus non intelligit rationem. Qui autem spiritualis est et omnia dijudicare postest, in eo quidem quod foris considerat pulchritudinem operis, intus concipit quam miranda sit sapientia Creatoris» (Eruditiones Didascalicae, Book VII, ch. 4 (PL 176, 814B)).

23 «Sapientia liber erat scriptus intus, opus sapientiae liber erat scriptus foris. Voluit autem postea adhuc, aliter scribi foris sapientiam ut manifestius videretur et perfectius cognosceretur, ut oculus hominis illuminaretur ad scripturam secundam, quoniam caligaverat ad primam. Fecit ergo secundum opus post primum et illud evidentius erat, quoniam non solum demonstravit sed illuminavit. Assumpsit carnem non amittens divinitatem, et positus est liber scriptus intus et foris; in humanitate foris, intus in divinitate, ut foris legeretur per imitationem, intus per contemplationem; foris ad sanitatem, intus ad felicitatem; foris ad meritu, intus ad gaudium. [...] Liber ergo unus erat semel intus scriptus, et bis foris. Foris primo per visibilium conditionem, secundo foris per carnis assumptionem. Primo ad jucunditatem, secundo ad sanitatem; primo ad naturam, secundo contra culpam; primo ut natura foveretur, secundo ut vitium sanaretur, et natura beatificaretur» (De sacramentis, Book I, Pars VI, ch. 5 (PL 176, 266-267)).

24 Cf. Book of Ezekiel, 2,9-10; Book of Revelation, 5,1.

25 «Tres sunt libri. Primus est quem facit homo de aliquo; secundus, quem creavit Deus de nihilo; tertius quem Deus genuit Deum de se Deo. Primus est opus hominis corruptibile; secundus est opus Dei, quod nunquam desinit esse, in quo opere visibili invisibilis sapientia Creatoris visibiliter scripta est; tertius est non opus Dei, sed sapientia, per quam fecit omnia opera sua Deus, quam genuit non fecit, in qua ab aeterno cuncta, quae facturus erat, secundum sententiam providentiae et praedestinationis praescripta habuit. Et hic est liber vitae, in quo quidquid semel scriptum fuerit, numquam abolebitur, et omnes, qui meruerint pervenire usque ad ejus inspectionem, vivent in aeternum» (De Arca Noe Morali, Book III, ch. XII: De tribus libris (PL 176, 643
644)). «Item tria sunt verba. Primum est verbum hominis, quod prolatum desinit; secundum est verbum Dei, id est opus Dei, quod creatum non invariabiliter subsistit, nec tamen aliquando desinit; tertum est verbum Dei, quod genitum, non creatum, finem et principium nescit, neque

ullam mutabilitatem recipit, et hoc est, verbum vitae» (ibidem, Book III, ch. XIII: De tribus verbis (PL 176, 643-644)).

26 See, for instance, Itinerarium mentis in Deum, I, 14.

27 «Certum est quod homo stans habebat cognitionem rerum creturarum et per illarum repraesentationem ferebatur in Deum ad ipsum laudandum, venerandum, amandum; et ad hoc sunt creaturae et sic reducuntur in Deum. Cadente autem lumine, cum amississet cognitionem, non erat qui reduceret eas in Deum. Unde iste liber, scilicet mundus, quasi emortuus et deletus erat; necessarius autem fuit alius liber, per quem iste illuminaretur, ut acciperet metaphoras rerum. Hic autem liber est Scripturae, qui ponit similitudines, proprietates et metaphoras rerum in libro mundi scriptarum. Liber ergo Scripturae reparativus est totius mundi ad Deum cognoscendum, laudandum, amandum» (Collationes in Hexäemeron, XIII, 12).

28 «Si volumus spiritualia contemplari, oportet tollere crucem ut librum; quo erudiamur; de quo libro in Deuteronomio: Tollite librum istum et ponite eum in laterae arcae foederis Domini [cf. Dt 31,26]. Arca foederis Domini est beata Virgo, in qua omnia arcana sunt recondita. Liber sapientiae est Christus, qui scriptus est intus apud Patrem, cum sit ars onnipotentis Dei; et foris, quando carnem assumpsit. Iste liber non est apertus nisi in cruce; istum librum debemus tollere, ut intellegamus arcana sapientiae Dei» (Sermones de Tempore, Feria VI in Parasceve, sermo II, n. II).

29 «Cum primum principium reddat se nobis cognoscibile et per Scripturam et per creaturam, per librum creaturae se manifestat ut principium effectivum, per librum Scripturae ut principium reparativum; et quia principium reparativum non potest cognosci, nisi cognoscatur et effectivum: ideo sacra Scriptura, licet principaliter agat de operibus reparationis, agere nihilominus debet de opere conditionis, in quantum tamen ducit in cognitionem primi principii efficientis et reficientis» Breviloquium, Pars II, ch. 5).

30 Cf. Collationes in Hexämeron, XII; cf. also Breviloquium, ch. XII.

31 Explicit references can be found in Super Epistolam ad Romanos, ch. I, lect. 6 and in two other works, whose authenticity remain dubious: Expositio in Apocalypsim, ch. 3 and Sermo V de Dominica secunda de Adventu.

32 «It was necessary for the salvation of man that certain truths which exceed human reason should be made known to him by divine revelation. Even as regards those truths about God which human reason could have discovered, it was necessary that man should be taught by a divine revelation; because the truth about God such as reason could discover, would only be known by a few, and that after a long time, and with the admixture of many errors. Whereas man's whole salvation, which is in God, depends upon the knowledge of this truth. Therefore, in order that the salvation of men might be brought about more fitly and more surely, it was necessary that they should be taught divine truths by divine revelation. It was therefore necessary that besides philosophical science built up by reason, there should be a sacred science learned through revelation» (Thomas Aquinas, Summa Theologiae, I, q. 1, a. 1). This doctrine is recalled by the First and by the Second Vatican Council (cf. Dei Filius, DH 3005 and Dei Verbum, 6).

33 «Invisibilia Dei, apostolo teste, a creatura mundi per ea quae facta sunt intellecta conspiciuntur, et est velut communis quidam liber et catena ligatus sensibilis mundus iste, ut in eo sapientiam Dei legat quicumque voluerit» (St. Bernard of Clairvaux, Sermones, De Diversis, IX, 1). «Totus enim mundus diversis creaturis plenus est; quasi liber scriptus variis litteris et sententiis plenus in quo legere possumus quicquid imitari vel fugere debeamus» (Thomas of Chobham, Summa de arte praedicandi, ch. 7).

34 «Si rectum cor tuum esset, tunc ommis creatura speculum vitae et liber sacrae doctrinae esset — If thine heart were right, then every creature should be to thee a mirror of life and a book of holy doctrine» (Imitatio Christi, II, 4).
35 John Abbot of Ford, Super extremam partem Cantici canticorum sermones, Sermo 104, 1.
36 «Nel suo profondo vidi che s'interna / legato con amore in un volume / ciò che per l'universo si squaderna: / sustanze e accidenti e lor costume / quasi conflati insieme, per tal modo / che ciò ch'io dico è un semplice lume» (Commedia, Paradise, XXXIII, 85-90).
«At the end of the poem, the pilgrim's vision of the whole cosmos as a volume whose leaves are scattered through the layers of the material world merely confirms both Dante's notion that creation is a book and his imaginative impulse of conflating and reconstructing into a unity the rich, unfolding variety of creation» (G. Mazzotta, Dante's Vision and the Circle of Knowledge (Princeton (NJ): Princeton University Press, 1993), p. 18). We have enough reasons to infer that the word "volume" here means "book", and not merely "space". Other parallel pages of the Comedia present a volume as what is composed of various "quires" or "sheets" (cf. Paradise, II, 76 and XII, 121). For a philological introduction to Dante's Comedia, see C. SINGLETON, Commedia. Elements of Structure (Cambridge (MA): Harvard University Press, 1957).
37 Cf. M. DE MONTAIGNE, An Apology for Raymond Sebond, edited by M.A. Screech, Penguin Books, London 1987. On this Author see also J. DE PUIG, Les sources de la pensée philosophique de Raimond Sebond (Ramon Sibiuda), H. Champion, Paris 1994.
38 «Ista scientia docet omnem hominem cognoscere realiter, infallibiliter, sine difficultate et labore omnem veritatem necessariam, homini cognoscere, tam de homine, quam de Deo, et omnia, quae sunt necessaria homini ad salutem et ad suam perfectionem, et ut perveniat ad vitam aeternam.
Et per istam scientiam homo cognoscet sine difficultate infallibiliter, quidquid continetur in sacra Scriptura. Et quidquid in sacra Scriptura dicitur et praecipitur, per hanc scientiam cognoscitur infallibiliter cum magna certitudine [...]» (Theologia naturalis seu Liber creaturarum, fac-simile of 1852 publication at Sulzbach (Stuttgart-Bad Cannstatt: F. Frommann Verlag, 1966), Prologus, pp. 27*-28*).
39 «[...] quaelibet creatura non est nisi quaedam littera, digito Dei scripta; et ex pluribus creaturis, sicut ex pluribus litteris, est compositus liber unus, qui vocatur liber creaturarum. In quo libro etiam continetur ipse homo, et est principaliter littera ipsius libri» (ibidem, pp. 35*-36*).
40 «Et ideo liber creaturarum est porta, janua, introductorium and lumen quoddam ad librum sacrae Scripturae, in quo sunt verba Dei; et ideo ille praesupponit iste» (Titulus CCXI, p. 311).
41 «[Liber] Scripturae datus est homini secundo; et hoc in defectu primi libri, eo quia homo nesciebat legere in primo, eo quia erat caecus. Sed tamen primus liber, creaturarum, est omnibus communis; sed liber Scripturae non est omnibus communis, quia solum clerici sciunt legere in eo» (Prologus, p. 36*). The reference to the original sin becomes more explicit by the end of the Prologue: «Quam quidem sapientiam nullus potest videre nec legere per se in dicto libro semper aperto nisi sit a Deo illuminatus et a peccato originali mundatus» (Prologus, p. 38*)
42 «Primus liber, naturae, non potest falsificari, nec deleri, nec false interpretari. Ideo, haeretici non possunt eum false intelligere; neque aliquis potest fieri in eo haereticus. Sed secundus potest falsificari et false interpretari et male intelligi» (ibidem, pp. 36*-37*).
43 Cf. Titulus CCXII, pp. 314-315.
44 «Et ideo conveniunt ad invicem, et unus non contradicit alteri. Sed tamen primus est nobis connaturalis, secundus supernaturalis» (Prologus, p. 37*).

45 Cf. Titulus CCXV, pp. 322-324.
46 «Et sic apparet summa concordia, summa consonantia, et summa convenientia inter librum Sacrae Scripturae et librum creaturarum; et quod liber creaturarum servit et famulatur libro Sacrae Scripturae quasi imperanti, mandanti et praecipienti, et apparet, quod non differunt nisi in modo dicendi et loquendi; quia unus loquitur per modum probationis, et alter per modum praecepti et auctoritatis» (Titulus CCXII, p. 315).
47 The Liber Creaturarum was known and appreciated, among the others, by Nicholas of Cusa, Hugo Grotius, Blaise Pascal, Peter Canisio, Franciscus of Sales, Georg Wilhelm Hegel, Giovanni Regoli.
48 Cf. A.G. DEBUS, Man and Nature in the Renaissance (Cambridge: Cambridge University Press, 1978);
E. GARIN, Rinascite e rivoluzioni. Movimenti culturali dal XIV al XVII secolo (Bari: Laterza, 1975); E. GARIN, La cultura filosofica del Rinascimento italiano (Milano: Bompiani, 1994).
49 Concerning Nicholas of Cusa, see for instance Idiota - De sapientia, I, 5; De Beryllo, 36.
50 Cf. E.R. CURTIUS, European literature and the Latin Middle Ages (Princeton (NJ): Princeton University Press, 1990), p. 322. Cf. also W.E. PEUCKERT, Paracelsus, Die Geheimnisse. Ein Lesenbuch aus seinen Schriften (Leipzig: Dieterich, 1941), pp. 172-178.
51 For the philosophical and historical contexts, see: W.R. SHEA, Galileo's Intellectual Revolution (London: Macmillan, 1972); K.J. HOWELL, God's Two Books: Copernican Cosmology and Biblical Interpretation in Early Modern Science (Notre Dame (IN): University of Notre Dame Press, 2002); T.H. LEVERE, W.R. SHEA (eds.), Nature, Experiment, and the Sciences. Essays on Galileo and the History of Science in Honour of Stillman Drake (Dordrecht - London: Kluwer Academic, 1990). Cf. also L. DUPRE', Passage to Modernity. An Essay in the Hermeneutics of Nature and Culture (New Haven: Yale University Press, 1993).
52 «[...] Procedendo di pari dal Verbo divino la Scrittura sacra e la natura, quella come dettatura dello Spirito Santo, e questa come osservantissima esecutrice de gli ordini di Dio [...]» (G. GALILEI, Letter to P. Benedetto Castelli, 21.12.1613, "Opere", edited by A. Favaro (Firenze: Giunti-Barbera, 1968), vol. V, p. 282).
53 Dialogo sopra i due massimi sistemi del mondo, Dedica al Gran Duca, in ibidem, vol. VII, p. 27.
54 «La filosofia è scritta in questo grandissimo libro che continuamente ci sta aperto dinanzi a gli occhi (io dico l'universo), ma non si può intendere se prima non s'impara a intender la lingua, e conoscere i caratteri ne' quali è scritto. Egli è scritto in lingua matematica, e i caratteri son triangoli, cerchi, ed altre figure geometriche, senza i quali mezi [sic] è impossibile a intenderne umanamente parola; senza questi è un aggirarsi vanamente per un oscuro laberinto» (The Assayer, in ibidem, vol. VI, p. 232).
55 «Ma io veramente stimo il libro della filosofia, esser quello che perpetuamente ci sta aperto dinanzi agli occhi; ma perché è scritto in caratteri diversi da quelli del nostro alfabeto, non può esser da tutti letto: e sono i caratteri di tal libro triangoli, quadrati, cerchi, sfere, coni, piramidi et altre figure matematiche, attissime per tal lettura» (Letter to Fortunio Liceti, January 1641, in ibidem, vol. XVIII, p. 295).
56 «Since we astronomers are Priests of the Most High God with respect to the Book of Nature, it behooves us that we do not aim at the glory of our own spirit, but above everything else at the glory of God» (J. KEPLER, Letter to Herwath von Hohenburg, 26.3.1598, n. 91, in Gesammelte Werke, edited by the Kepler-Kommission, Bayerische Akademie der Wissenschaften (München: Beck, 1937ff), vol. XIII, p. 193). «For it is precisely the universe which is that Book of Nature in which God the Creator has revealed and depicted His essence and what He wills with man, in a

wordless script» (Epitome Astronomiae Copernicanae, in ibidem, vol. VII, p. 25). «I make an effort to divulge promptly all these things, for the glory of God, who wants to be known through the Book of Nature. The more they will be raised, the more I will rejoice, with no envy at all. This is what I want, for I consecrated myself to God. I wished to be a theologian. For a long time I was troubled. But look and see now how God shall be praised through my work» (Letter to M. Maestlin, 3.10.1595, n. 23, in ibidem, vol. XIII, p. 40). Cf. also Mysterium Cosmographicum. Praefatio, in ibidem, vol. I, p. 5. See O. PEDERSEN, The Book of Nature (Notre Dame - Città del Vaticano: University of Notre Dame Press - LEV, 1992), pp. 44-45.

57 Another example of a more "universal" way to read the book of Nature, within a scientific context, is that of Sir Thomas Browne, a physician who was contemporary of Galileo and Kepler. In his work Religio Medici (1643), he held that the book of Nature is easily understandable by everyone: «Thus there are two Books

from whence I collect my Divinity; besides that written one of God, another of His servant Nature, that universal and publick Manuscript, that lies expans'd unto the Eyes of all: those that never saw Him in the one, have discover'd Him in the other» (part I, ch. 15). Here "Divinity" means "theology" or "theological studies". Cf.

E.R. CURTIUS, European literature and the Latin Middle Ages, op. cit., p. 323. An attempt to read Thomas Browne's doctrine in a contemporary, personal context, is that provided by A. Peacocke, "The Religion of a Scientist: Explorations into reality ("Religio Philosophi Naturalis")", Zygon, 1994, 29: 639-659.

58 On the content of this section, cf. G. TANZELLA-NITTI, "The Book of Nature and the God of Scientists according to the Encyclical Fides et ratio", The Human Search for Truth: Philosophy, Science, Faith. The Outlook for the Third Millennium (Philadelphia: St. Joseph's University Press, 2001), pp. 82-90.

59 Cf. Book of Wisdom, 13,1-9.

60 JOHN PAUL II, General Audience, Rome, January, 30, 2002, n. 6.

61 Cf. First Vatican Council, Dei Filius, n. 2; Second Vatican Council, Dei Verbum, nn. 3 and 6.

62 Cf. Catechism of the Catholic Church: «Thus the revelation of creation is inseparable from the revelation and forging of the covenant of the one God with his People. Creation is revealed as the first step toward this covenant, the first and universal witness to God's all- powerful love» (n. 288). «Even before revealing himself to man in words of truth, God reveals himself to him through the universal language of creation, the work of his Word, of his wisdom: the order and harmony of the cosmos - which both the child and the scientist discover [...]» (n. 2500). Cf. also John Paul II, Address to the World Youth Day, August, 15, 2000.

63 Cf. Book of Wisdom, 13,5.

64 Cf. Epistle to Colossians, 1,16.

65 Cf. Epistle to Colossians, 2,9; Epistle to Ephesians, 1,10.

66 Cf. G. TANZELLA-NITTI, "Le rôle des sciences naturelles dans le travail du théologien", Revue des Questions Scientifiques, 1999, 170: 25-39. On the same topic, more extensively, Scienze naturali, utilizzo in teologia, in "Dizionario Interdisciplinare di Scienza e Fede. Cultura scientifica, filosofia e teologia", edited by

G. Tanzella-Nitti and A. Strumia, 2 vols. (Roma: Urbaniana University Press - Città Nuova Editrice, 2002), vol II, pp. 1273-1289 (English translation forthcoming in the web page "Interdisciplinary Encyclopedia of Religion and Science", http://www.disf.org/en).

67 It is common to quote Einstein's question on this subject: «It could be said that the eternal mystery of the world is its comprehensibility […] the fact that it is comprehensible is truly a miracle» ("Physik und Realität", Journal of Franklin Institute, 1936, 221: n. 3). On the question of the intelligibility of nature, see for instance: E. WIGNER, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences", Communications in Pure and Applied Mathematics, 1960, 13: 1-14; M. HELLER, "Scientific Rationality and Christian Logos", Physics, Philosophy and Theology. A Common Quest for Understanding, edited by R. Russell, W.R. Stoeger, G.V. Coyne (Città del Vaticano: LEV and University of Notre Dame Press, 1988), pp.
141-149; J.D. BARROW, Pi in the Sky. Counting, Thinking, and Being (Oxford: Clarendon Press, 1992); P. DAVIES, The Mind of God. Science and the Search for Ultimate Meaning (London: Simon & Schuster, 1992);
P. DAVIES, "The Intelligibility of Nature", Quantum Cosmology and the Laws of Nature, edited by R. Russell,
N. Murphy, C. Isham (Città del Vaticano: Vatican Observatory Publications and The Center for Theology and Natural Sciences, 1993), pp. 145-161. For a theological perspective, G. TANZELLA-NITTI, Gesù-Cristo, Rivelazione e Incarnazione del Logos, in "Dizionario Interdisciplinare di Scienza e Fede", op. cit, vol. I, pp. 693-710 (English translation Jesus Christ, Incarnation and Doctrine of Logos, web page "Interdisciplinary Encyclopedia of Religion and Science", http://www.disf.org/en).
68 O. GODART, M. HELLER, "Les relations entre la science et la foi chez Georges Lemaître", Pontificia Academia Scientiarum, Commentarii, vol. III, n. 21, p. 11, quoted in John Paul II, Discourse to the Pontifical
Academy of Sciences, November, 10, 1979, in "Osservatore Romano, English week edition", November, 26, 1979, p. 10.
69 J. POLKINGHORNE, One World. The Interaction of Science and Theology (Princeton (NJ): Princeton University Press, 1987), p. 46
70 E. HUBBLE, The Nature of Science and Other Lectures, San Marino (CA) 1954, quoted in O. Pedersen, "Christian belief and the Fascination of Science", Physics, Philosophy and Theology. A Common Quest for Understanding, edited by R. Russell, W.R. Stoeger, G.V. Coyne (Città del Vaticano: LEV and University of Notre Dame Press, 1988), p. 133. On the humanistic and religious experiences associated to scientist's activity, see. E. CANTORE, Scientific Man. The Humanistic Significance of Science (New York: ISH Publications, 1977).
71 Book of Revelation, 5,13, cf. 5,7-13.
72 Cf. Book of Revelation, 1,8; 21,6; 22,13.

January 2004
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Intelligent Design: Yesterday's Orthodoxy, Today's Heresy

Edited transcript from a lecture given Saturday, January 17, 2004, 10:00 a.m. at Grace Valley Christian Center, Davis, California

How Faith Is Lost

I want to begin with a story about an experience I had over twenty years ago, in 1980, which gives motivation for why I am doing this. I had just become a Christian about a year earlier. While walking on the streets of Chicago one day, I met two young men. I was only nineteen at the time, and they were in their early twenties. I started engaging them with the claims of Christ, talking to them about what Jesus meant to me and what he should mean to them. They had had a bit too much to drink and as I talked, they started mocking me. But after a while they broke down in tears.

It turns out these men were graduates of Wheaton College and were now students at one of the seminaries in Hyde Park. Hyde Park is where the University of Chicago is, and there are about seven theological schools there. I think they were in their first year. But they had lost their faith, and now they were literally crying. They told me, "We wish we could believe the way you do, but we can't anymore."

What happened to their faith? After all, they had gone to Wheaton College, one of the premiere evangelical Christian colleges in the country, and now they were in seminary. Yet in a very short time their faith seems to have disintegrated. Since I have been through the educational curriculum at a mainline seminary (Princeton), I would propose that there are two things one gets at a seminary like theirs that will undermine one's faith.

First, you get biblical criticism. You are taught that the Scriptures are a hodge-podge of various historical source documents put together by a religious community for various theological purposes. The idea that there is a God sovereignly directing these texts and putting them together, and that these texts are true, speaking legitimately about a God who has intervened in history, is totally lost. So if you take an Old Testament course on Isaiah, for instance, you will be taught that there were various Isaiahs, not just one, because from Isaiah 40 and following there is a predictive prophecy of a king named Cyrus. Because Isaiah is placed about 750 B.C., but Cyrus does not come on the scene until the sixth century B.C., Isaiah 40 and following had to have been written subsequent to Cyrus because no one can predict the future. This is the mindset of biblical criticism.

But, second, in addition to biblical criticism, you get a materialistic or naturalistic worldview. In fact, it is this materialistic or naturalistic worldview that accounts for biblical criticism. Biblical criticism is a corollary of this materialist worldview, which leads to a whole creation story and evolutionary picture of how we got here.

The Repercussion of Misconceptions

I would like to distinguish between orthodox Christianity and the materialist worldview. To frame the discussion, I want to read a single verse, John 3:12. The context is that Nicodemus has approached Jesus, and is asking, "We know you are a teacher sent from God. How do you do these things? What is going on here?" Jesus tells him, "You must be born again." Nicodemus says next, "How can this be?" Then comes the verse I want to get to: Jesus responds, "I have spoken to you of earthly things and you do not believe; how then will you believe if I speak of heavenly things?"

I think there is a deep principle to be found there. Our salvation history given in the Bible comes through this physical world—through experiences, through history. So if we do not understand what is going on here and now in the physical world, then our knowledge of spiritual things is going to be undercut. So this ends up being very significant. If we get things wrong about natural history, thinking that a naturalistic or materialistic evolutionary story is the way things are, then we will have been wrong about earthly things. Such thinking has vast repercussions on our understanding of spiritual things.

Worldviews:
Let us try to think of this in light of the story about those Wheaton College students. I mentioned that they got a materialistic worldview at seminary. This is very common, not just at the seminaries but across the academic world.

What is involved in worldviews generally, and what is the right worldview? There is a useful book that I would recommend to you by Charles Colson and Nancy Pearcey, How Now Shall We Live?, in which Colson makes the point that worldviews have four components.

First, worldviews involve a creation story that explains our origins: How did we get here? Second, they include some account of what the problem is: Why are we in the mess we are in? If everything was perfect, there would be no need even to think about worldviews. But there are problems; how did they come about? Third, worldviews ask: What is the solution? Finally, they ask: Where is this all going? So there are four questions, four components to a worldview. From a Christian perspective you could label them as creation, the fall, redemption, and eschatology, or where this is all going.

Christian Worldview
Within the traditional Christian worldview, God by his wisdom created the world. There is a purpose for us being here. The Fall is not just inherent limitations on the creation—that somehow the creation, in struggling to evolve, had to go through all these hard times. It is that humanity, by rebellion against God, has brought evil into the world, and this evil is not just personal evil, but it has translated into natural evil as well. So evil and suffering ultimately are not the result of some sort of natural forces or growing pains, but the result of conscious rebellion against God. That is traditional Christian orthodoxy.

The solution is the redemption in Jesus Christ. God becomes incarnate, takes the sin of the world upon himself on the cross, and dies for the life of the world. That is the means of our redemption. It is not a "fix" in the sense of psychotherapy or taking chemicals to help our brain processes go the right way. That is not the ultimate solution from the Christian vantage. The purpose of it all is union with God. The Westminster Catechism talks about enjoying and worshiping God forever. So the vision is that we will be united with God and will see him as he is, face to face. This is a glorious vision of the Christian.

Materialist Worldview
The materialist vision is not quite that good. It entails a world of mindless material entities that have always been here in some sense, and which, by a process of blind evolution, lead to us. What is our problem? What is the fall? What is our predicament? It is just that this evolutionary process is inherently clumsy. As we evolve, mistakes get thrown into our genetic mechanisms so that, for example, diseases occur. These are the growing pains of evolution.

Thus, now we even hear talk of transcending our bodies. Ray Kurzweil argues that in twenty years computers will exceed the power of the human brain for computation, at which point they will excel us and attain consciousness, so much so that we will be lucky if they keep us as pets. So, according to Kurzweil, the best solution is to upload ourselves onto computers and dispense with our present physical "wetware" entirely.

I kid you not—this vision is out there, and people buy it. But I think it is utterly misguided. I think our intelligence, our humanity, our consciousness, is not captured in our physicality. I am much more in agreement with the apostle Paul, that our bodies are a garment and that our fundamental reality is spiritual; it cannot be reduced to complexity and computation. In fact, I do not think

there is any good evidence that complexity and computation captures consciousness. There is certainly correlation—we need our brains to think and do things. If a safe falls on our head, we will not be able to express our intelligence as well. But that is a separate issue. It is a whole correlation/causation question, which I think gets lost in much of the cognitive neuroscience community.

The materialistic solution to the mess that evolution has made of us is that we just have to get our physical beings into shape. We try to do so by therapy and chemicals. And what is the glorious future of all this? You may have guessed it—there is none! The future of the materialistic worldview is the dissolution of all things. Bertrand Russell talked about the heat death of the universe, where everything goes to some sort of entropic equilibrium, and all our aspirations and hopes dwindle away. Actually, we do not have to wait until the heat death of the universe. In our solar system, our sun is going to turn into a red giant within about five billion years and burn up the earth, so it is actually quicker than that unless we can move to other star system, which I do not think looks all that likely. This is what the materialistic worldview offers us.

Historical Context

Thus, the materialistic worldview found in mainstream seminaries clashes with that of orthodox Christianity. But now I want to put these worldviews into more of a historical context. I often think we get the sense that the materialistic worldview is a recent development, stemming from the influence of modern science, as if science has given us positive proof that this is the only right way to look at the world. But, in fact, science has done no such thing. Each worldview is a set of fundamental presuppositions, philosophical and metaphysical assumptions about the world, which go all the way back to the origins of philosophy. They also go back into various religious traditions.

Religious Traditions

Let me start with the religious traditions. If you go to a mainline seminary and study Genesis, you will be told that Genesis is really a hodge-podge of various Middle Eastern sources, with parallels in Babylonian and other Near Eastern mythologies. One myth commonly used is called the Enuma Elish, the story of how Marduk, the chief of the Babylonian gods, came to be the head god. And, certainly, there will be some parallels in these accounts, because the Bible as well as these myths occurred in the matrix of the Near East. But despite the common elements, there are some fundamental differences, which is what I want to focus on now.

"Enuma elish" are the first words of the poem. They mean "when on high." The poem is talking about the origin of the world, and it ultimately tries to vindicate Marduk as the head god of the Babylonians. The poem starts out with Tiamat and Apsu, who are the salt and fresh waters. Notice that this starts with natural, material forces. As the salt and fresh waters mingle, there is a sort of cohabitation, and out of this comes a first generation of gods. As the gods go on, they kill each other and do various things. For generation upon generation you get new gods, and as you read along, you find that these gods are becoming more and more conscious and intelligent, until you finally get to the head god, Marduk.

Notice what is happening. It is not that you are starting out, as in Genesis, with "In the beginning God created the heavens and the earth;" that God speaks the world into existence; that God, a conscious, intelligent, personal agent, is the source of all being, and then everything is created as a result of this intelligence. Rather, intelligence is emerging as a byproduct of natural forces working themselves out. So we see an evolutionary story in the Enuma Elish. I am not just imposing it; it is there.

We also find this in other myths and religious traditions of the ancient world. Hesiod, who came just after Homer, wrote his Theogony to explain how the gods came about. It starts with an abyss,

or chaos, and then earth and heaven, Gaia and Uranus, who become husband and wife. This leads to one generation of gods, and which comes to more gods who end up being the gods of Mount Olympus. So here again we see a progression from natural forces and primeval simplicity to intelligent agents. This is always the trajectory of materialism. You have to explain the complex—the things meaningful and purposeful—as a result of primeval simplicity.

Christian worldviews and other theistic worldviews generally turn that around, saying it is not primeval simplicity, but a process guided by a conscious personal God. If there is an evolutionary process, God guides it also. You do not get something from nothing. That is what the materialists are looking for. They are looking for the ultimate free lunch.

Philosophical Traditions

What about philosophy? If you go back to its beginning, which is usually placed with the pre-Socratics, you find the same sort of polarity there, although it is expressed differently. There are some atomistic, materialistic philosophers, such as Democritus and Leucippus, who say that the world is fundamentally matter in motion, and that as these indivisible particles—atoms—bounce around, they organize themselves, giving rise to objects like us, among other things. Then there are philosophers such as Anaxagoras, who thought that the mind was the fundamental entity from which everything came.

Probably the most prominent representative of this materialist tradition is Epicurus, who lived at about 350 B.C. When most people think of Epicurus and Epicureans, they think of hedonism, the unbridled search for pleasure, and if they had to choose a contemporary representative of Epicurus, they might think of Hugh Hefner or someone like that. But that is really not the case at all.

What motivated Epicurus was peace and tranquility, which for him could only be purchased if two things were lacking: First, there could not be a god or gods who intervened in the material world, because there can be no tranquility in a world where a capricious god can interfere. Epicurus wanted a world operated by laws he could count on, so that his peace and tranquility would not be upset. The other thing was an afterlife with a God to whom one is accountable for how one lived. Epicurus did not want to spend eternity under some sort of judgment.

It is very interesting to read Epicurus, because he formulated a materialistic physics and metaphysics to prop up these two desiderata. He set up what by modern standards looks like a precursor to the sort of materialistic science that has emerged in this day. It was a world that operated on physical laws you could count on, with no interventions by God. By the way, he did not deny that the gods existed. He just believed they were far off somewhere and too high and ethereal to have any interest in what goes on on earth. That is why they did not get involved in our affairs. We see this tendency in modern theology as well, where there is no real power of God engaging the world. Deity is something "out there," something that has really no rubber-meets-the-road impact on our lives.

Let me give one more historical note. Karl Marx, the materialistic philosopher and dialectical materialist whose ideas held sway for years over about maybe 1.5-2 billion people, wrote his doctoral dissertation on Democritus and Epicurus. I mention this just so you know that these ideas go way back. Marx also wanted to dedicate the English edition of Das Kapital to Charles Darwin. So there are some interesting connections there.

The materialistic philosophy of Epicurus was well represented in the ancient world. The people I have mentioned thus far are Greeks, but it also existed among the Romans. Lucretius is probably the best known representative to this day because of a poem that he wrote extolling materialism. But I would say that it was never really that popular of a philosophy of old. We have traditions

from Plato, Aristotle, and the Stoics, which reject the materialistic worldview and assert that indeed there is fundamental purposefulness in the world; that there is teleology; that there are ends built into nature.

So Epicurus and his followers were actually reviled throughout much of the ancient world. By the time we get to the Church Fathers, maybe 300-400 years after Christ, Epicurus was in eclipse. By the time of Augustine and the Cappadocian Fathers, the intellectual elite of the Mediterranean world were Christians who had no time for this worldview. But the ideas still stuck around. I would say it was really with the Renaissance and then the rise of modern science that Epicurus and his legacy of materialism came back.

Why this sweeping historical overview? Because it is important to get a sense of history. The issues we are dealing with in confronting materialism and naturalism are not just the latest flash in the pan; they are longstanding issues that cut right across religion, philosophy and now even science.

The Rise of Mechanical Philosophy

How was Epicurus "resurrected" with the rise of modern science? I think it worked this way. With the rise of modern science there was a move to understand the physical world—the constitution and dynamics of matter. As science advanced, it became easy to model mathematically the idea of particles in motion, which was the atomistic, materialistic picture of Democritus, Leucippus, Epicurus, and Lucretius. For example, when Isaac Newton was trying to account for the orbits of planets around the sun, he thought of these as point masses and then did some mathematics to account for how one thing goes around the other so that he could come up with his theory of universal gravitation and his mechanics.

So when it became convenient for science to think in terms of particles in motion, a "mechanical philosophy" emerged. When I say "philosophy," I am referring to what we call science. Our use of the word science as an inquiry into the natural world is only about 150 to 170 years old. It used to be called "natural philosophy," to contrast it with moral philosophy or logic. It is natural philosophy, or the philosophy of the natural world. That is why, to this day, most of the advanced degrees that are given are Ph.D.s, whether they be in mathematics, chemistry or biology. It is a "doctor of philosophy" degree.

So originally science would have been called natural philosophy. But then a mechanical philosophy began to emerge, the science of mechanics, which asked how things interacted and worked together and moved about, and theories were proposed which agreed with the materialistic worldview.

Interestingly, many who were the main proponents of mechanical philosophy were Christians, or at least theists. There was Isaac Newton, who was an Arian who rejected the Trinity, but he certainly believed that the miracles of the Bible were true and was not trying to dismiss God. Then there was Robert Boyle, the notable chemist and devout Christian, who thought that this mechanical conception, at least for the purposes of doing science, was a good thing. He did so because he was concerned that if there were not a world of inert particles moving around and if there were no purposes or creative elements in nature, we would be tempted to embrace idolatry, because then we would want to worship these creative forces in nature rather than the God who is responsible for nature. So Boyle thought that this mechanical approach was actually a valuable way of preserving the faith.

I just want you to realize that this mechanical philosophy was being proposed by Christians, yet it had seeds of opposition which eventually ended up biting the Christians in the neck. Let me indicate to you how that happens, because I think it is an interesting historical study.

Natural Theology

Robert Boyle, one of the main proponents of this mechanical philosophy, was a contemporary of Isaac Newton in the late 1600s. He was also a big advocate of what is called "natural theology," although the best-known proponent of natural theology to this day is a fellow named William Paley, who actually wrote about 120 years after Robert Boyle. Paley's famous book, Natural Theology, was published in 1802. The subtitle of that book, in which the project of natural theology is perfectly captured, is: On the Existence and Attributes of the Deity Collected from the Appearances of Nature. In essence, Paley was asking the questions: Does God exist, and what can we know about the nature of this God?

How did Paley go about answering that question? By looking to the appearances of nature. That is the project of natural theology. You look at the natural world and ask, "Are there features of the natural world which would point us to God, demonstrate the existence of God, or demonstrate the attributes of God, such as his omnipotence and benevolence?"

Can we do that from nature? For the British natural theologians from Boyle through Paley, that was a legitimate project. But it ended up backfiring, and I would say it did so in light of this mechanical philosophy.

As far as people like Boyle or Newton were concerned, matter in motion was not enough to explain the world. That matter also had to be initially organized by God. Deity had to make things. So if you look at a biological system, it is not enough just to explain it in terms of matter in motion, but God actually had to form it, had to provide the initial and boundary conditions. God had to do something.

The problem is, this view ended up being a kludge of a divine interventionism and material philosophy, and the marriage did not last. You can see why by looking at Paley's best-known example of how the design argument works in natural theology. You have probably heard of the famous "watchmaker argument." It serves as the opening of Paley's Natural Theology.

The Watchmaker Metaphor

The watchmaker argument is this: Imagine somebody walking through a field and coming across a rock. For all he knows, that rock could have been there forever. But now imagine that person walking through that same field and coming across a watch. He would not draw the same conclusion. Instead, he would think that this watch had been designed for a purpose—in this case, for the purpose of telling time. And so the rock and the watch have features which distinguish them. The watch you are going to attribute to an intelligent agent, but you will have no reason or warrant to attribute the rock to an intelligent agent.

That is the distinction. On its face it seems perfectly valid. In fact, we do this as part of basic human rationality—we try to distinguish between the product of intelligent forces and the product of purely natural forces. We may ask, is this an arrowhead or just a random chunk of rock? Is that mound a burial mound or is it just randomly formed? We draw these distinctions all the time.

But now start probing things a little bit. If God is a perfect, benevolent creator God, what sort of watch is he going to create? It will be a perfect watch, one that never needs winding and keeps

perfect time. When we pose it that way, we realize there is no need for God to intervene once the watch is in place.

This watch metaphor was also used to represent the universe. In this Newtonian or mechanistic model, the universe itself is like a giant watch. But if the world or the universe is like a watch, and God is the watchmaker, then we expect a perfect watch which never needs winding.

We have suddenly moved from theism to deism. Deism pictures God as the absentee landlord who does not need to do anything with the creation once he sets it up, because it runs so perfectly.

A Better Metaphor

I am a much bigger fan of the Church Fathers than I am of William Paley. I like Paley and think he has a lot of good insights. But I think the watch metaphor was in many ways unfortunate. It is faulty, because the world is not like a watch.

The Church Fathers did not use the watch. Instead, they spoke about a musical instrument. Gregory of Nazianzus, I think in his second theological oration, makes a design argument which is virtually parallel to William Paley's, except in place of a watch he has a lute. The lute maker makes the lute, but that is not all. The lute maker is then also interested in playing the lute.

This has huge implications, because it is entirely appropriate to play, or interact with, a lute after it has been created. That is why I think this is a much better metaphor than that of the watch. As Christians, we believe that God is not an absentee landlord. God creates the world but then he also interacts with it.

The watch metaphor is the type of metaphor that we get from a mechanical philosophy, where things work automatically, one thing bumping into another as chain reactions, with things working themselves out. If you have a perfect watch that keeps perfect time and never needs winding, it will go on for ever. But with a lute, or with any musical instrument, you need a lute player; otherwise it is just sitting there. In fact, it is incomplete without the lute player.

A Watch That Makes Itself

Paley was a theist, but it is easy to see why with Paley's natural theology it was a very short step from theism to deism. But now push it a little further: If a perfect watch is one that never needs winding, would an even more perfect watch be one that constructs itself? A watch is just an object in motion. Material objects move. So why not just set it up so that material objects build the watch and then allow the watch to continue indefinitely? There was a fellow named Kingsley who described evolution as the result of God, but he said, "God makes a world which makes itself."

I think you see where this is going. You go from theism to deism, but once you have a perfect watch that does not need God except at the beginning stages, why not just take it further and just have a watch that constructs itself? I think that is where the logic of science went. By the time you get to Darwin you have a world in which everything makes itself. And what Darwin brings to the party, as it were, is an account of how you get biological organization and complexity.

There are really two things that Darwin gives us. First, he gives a theory of what natural history is like. He says that all organisms are related by universal common descent. This is his "great tree of life." So any two organisms, if you trace back their ancestry, will converge on a common ancestor. But then there is the question of how this tree grew, so he offers his theory of natural selection and

variation. I would say Darwin's theory is a logical result of what happens when one takes natural theology and uses the wrong metaphor, such as the watch metaphor. It takes us away from even deism, and so with Darwin we end up with agnosticism, a not-knowing. If there is a God, you do not know what this God did. In fact, you cannot know anything about this God, because any God that is involved with the world is just too distant. The world is a place that essentially just created itself. I think that is where we have finally gotten to. The modern scientific world is very much in love with this conception of a world that creates itself rather than a world in need of a Creator.

The Insufficiency of Materialism

Let me just say where I believe we are now. I think we are finding that this concept of a world that creates itself is no longer adequate. For the idea that the world created itself to be convincing, you are going to have to argue that material processes are adequate to explain everything in the world. To do that, there has to be a reduction to natural law. Basically, what you have to say is that for anything that happens, there is an antecedent circumstance and some law-like relationship that takes you from one thing to the other. You have this in Newtonian mechanics. For example, if you have a certain orbit, then there were some initial conditions, some properties of the matter which led to that. Or if you are trying to explain some instance of biological complexity, then there must be some background conditions, some natural selection pressures, or certain properties of variation that could account for that.

The way scientific explanation works within this materialistic framework is that there is always some sort of material mechanism, some law-like connection that explains how you got where you are. If you are trying to explain point B, there is a preceding point A which explains it.

But intelligence does not work that way. Why did Shakespeare write King Lear? Why did Michelangelo create his statue of David? What were the precise causal antecedents that led to that? What were the law-like relations? What were the antecedents for God creating the world? Whereas the world is an open book within materialism—everything has a proper explanation which can be entirely reduced to antecedent circumstances and law-like relations—intelligence does not operate that way. Intelligence is free.

It is not that the principle of sufficient reason breaks down. It is just that when intelligence is a sufficient reason, there is no reduction possible. If God in his wisdom creates the world, it makes no sense to ask: What is behind that wisdom? Who designed that wisdom? There is nothing behind it. That is how intelligence works. Intelligence is creative. Intelligence is not an open book; intelligences write books. They create novel information. You cannot reduce them to these material mechanisms.

If I had to characterize in a nutshell what is happening within the Intelligent Design (ID) movement, I would say this: We in ID are saying that this picture of a materialistic world, entirely controlled and capable of being explained by mechanisms is no longer adequate, and we have good solid reasons for showing the insufficiency of that worldview on scientific grounds.

A similar thing happened in the 1930s in mathematics, when a mathematician named Kurt Gödel showed that there were true mathematical statements that could not be proven. The things that are proven in science are those things that you can explain in terms of material mechanisms. Gödel's result is called "the incompleteness theorem" because it is saying that there are truths that are not susceptible to this sort of mechanization of mathematics. Likewise, the mechanization of science is incomplete—it does not account for everything.

Detecting Intelligence through Design

What we are finding now, through some of my own research and that of others, is that there are reliable ways in which we can detect intelligence. We do this in a lot of different contexts. I already gave some homespun examples from archaeology: Is it an arrowhead? Is it a chunk of rock? Why is Mt. Rushmore not the result of wind and erosion? What are the sorts of reasons we give for saying that one thing is the result of design and something else is not?

What I do in my work is offer precise mathematical criteria for how we can draw that distinction. Once we are able to identify these signs of intelligence, what happens when we start looking for them in biological systems? It appears we are now finding convincing signs of intelligence in biology, and if that is the case, these signs of intelligence are not going to be amenable to these sorts of material mechanisms. In fact, the very tools we use to show that these signs of intelligence exist in biology are precisely the sorts of analyses that also show the inadequacy of Darwinian and material mechanisms.

Let me give you one example. There are machines of extreme functional complexity in all cells. One which is very popularly pointed to in the Intelligent Design movement is known as a bacterial flagellum. It is a little outboard rotary motor with, basically, a propeller that spins very fast, around 20,000 rpm, and can change direction in a quarter turn. It sits on the back of a certain bacteria. When you look at it, it is clearly a molecular machine. It has a propeller joint, a drive shaft, various discs that mount onto the cell membrane, and an acid powered drive. All these pieces have to be in place. They are functionally integrated, so you cannot remove anything and have it be functional. But without all the pieces being in place there is nothing for natural selection to select. So how did this thing emerge?

Natural selection is the only designer substitute that the materialist biologists have. But when you start analyzing systems like this, you find that they are beyond the reach of these material mechanisms, and in fact they have these key indicia or markers of intelligence. It is these sorts of systems and analyses that are showing that the material mechanisms to which this mechanical philosophy and the materialists have looked are, in the end, inadequate.

Why Do People Believe?

Where is all this going, and what is riding on this? What we find is that there is a big disconnect between mass culture and elite culture. When I say "elite culture" I am thinking of the National Academy of Sciences, the media, etc. By "mass culture" I mean people out there, most of whom are believers in God, who are trying to make a living and not trying to subvert traditional Christian values and beliefs. Let me put it in those terms. Gallup polls have been taken, and the results have been consistent now for about twenty years, and what you find is that only about 10% of the population buys this materialistic Darwinian perspective. About 90% of the rest believe that God either directly, through some special act of creation, or by guiding an evolutionary process, brought about humanity and the complexity that we see in the world.

I have a colleague on the other side named Michael Shermer, a professional skeptic, who wrote a book a few years back called How We Believe. Before writing it, he commissioned a poll of ten thousand people. He asked various questions, but the two questions that stuck out at me were: "Why do you think other people believe in God?" and, "Why do you personally believe in God?"

When the question was posed: "Why do you think other people believe in God?" the following reasons were right at the top: "God is a crutch," "God is a support," "He helps them through the day," "To provide a moral structure of the universe," "To make sense out of life." Those were not the top reasons, though, when people were asked: "Why do you personally believe in God?" Those

reasons were further down. What was at the top of the list was "The design, order and complexity of the world." So I think that is where we start out. That is where our intuitions are.

Richard Dawkins wrote a book titled The Blind Watchmaker, subtitled Why the Evidence of Evolution Reveals a World without Design. On page one he writes, "Biology is the study of complicated things that give the appearance of having been designed for a purpose." That is page one. Then he needs three hundred pages to explain why it is only an appearance of design, why, when you know what really happened, it in fact is a materialistic evolutionary story that accounts for why we are here. This sentiment is widely held throughout the biological world. Francis Crick, Nobel laureate, co-discoverer of the structure of DNA, wrote, "Biologists must constantly keep in mind that what they see was not designed, but rather, evolved."

So what is going on there? Why are people saying that? Our natural intuition tells us that these systems are designed. But as you go through the educational programs of this country, through grade school, high school and then college, what you find is that education is a subversion, an indoctrination into a materialistic mindset where what should be evident and plausible becomes increasingly implausible, so that in the end, if you go through this education and buy it, you will not accept that there is design in the world. What you will accept is just material forces.

That is what happened to Michael Shermer. He used to be an evangelical Christian, but he got a good dose of Darwin and he is now entirely smitten by Darwin. In fact, if you look at the back cover of his books you will see a picture of a smiling Shermer with a bust of Darwin and books by Darwin behind him.

Giving Glory to God

So what is the bottom line? What is the tangible benefit of Intelligent Design for the Christian community? I think minimally it is that it will prevent our young people from being swept away by this materialist ideology. But beyond that, and I think this is what really is the driving force for me, it gives us the truth of creation. I am wholly committed to the fundamental truth that God, by wisdom, created the world. It is only in acknowledging that that God will get proper glory for his creation. It would be a travesty and an insult if you met some wonderful artist, a Michelangelo or a Leonardo da Vinci or a Rembrandt, and they had their life's masterpiece beside them, and you came along and said, "You just threw this together. There is nothing to it. I could do that."

Now take it further. That is what we do when we take the marvelous designs that God has built into the world, things that far exceed anything by Michelangelo, and we do not just say, "I could have done that," but we attribute them to some blind, stupid, material process. It is just galling to me when I see the nature programs on PBS where "nature did this" and "natural selection did that." Where is God in all of this? He is dispensable. I think that is the real problem with naturalism and materialism.

There are the Dawkinses who are rabid in their atheism, but for the most part these materialists rarely come out and say, "There is no God." It is not that there is an outright denial of God, it is just that God is not necessary. Instead of a heated denial it is benign neglect. And I think we are seeing that more and more. But I think Intelligent Design is going to turn this around. I think we are going to see the whole level of rhetoric and controversy ratcheted up more and more in coming days.

Just last December, Oxford University Press published two books, a total of seven hundred pages, against Intelligent Design. One of them, by Barbara Forrest and Paul Gross, is Creationism's Trojan Horse, subtitled The Wedge of Intelligent Design. Another is a book by Niall Shanks, God, the Devil and Darwin, and then Prometheus Press put out Unintelligent Design, another four hundred pages

there. So a lot of people are making their reputations and even getting tenure for dealing with this. It is an interesting time.

March 2004
Mark J. Nielsen
The Wonder of the Creation
Ensign Article

I awoke before sunrise, as I always do when camping. My wife and I and two friends were camped at the base of one of the many mountain ranges in the western Utah desert. It was late spring, and sunrises came early, but the waiting adventures of the new day drew me from the warmth of my sleeping bag. Unable to coax anyone to join me, I walked alone a short distance from camp to the top of a rocky knoll. The area was remote: the nearest paved road was more than 20 miles away, the nearest settlement more than 50. From where I stood, all that was visible was untouched by human hands. Around me, sharp-edged white boulders were interspersed with juniper and occasional blossoms of cacti and globe mallow. Ahead of me, a serene shadowed valley gave way to ridge after purple ridge of mountains stretching toward the growing dawn. Directly behind me, a towering peak of white rock caught the orange blush of sunrise.

There was a certain timelessness to that moment—waiting for the sun to clear the distant crest of the Wasatch Plateau. I could imagine a time even more ancient—a time when no mortal eye had viewed that scene—when perhaps even the hosts of heaven surveyed the landscapes of the newly prepared earth with gratitude, wonderment, and awe. I thought of these words in Genesis: "God saw every thing that he had made, and, behold, it was very good" (Gen. 1:31). I wondered if it might have been at such a time "when the morning stars sang together, and all the sons of God shouted for joy" (Job 38:7). As I reflected on those verses, my spirit confirmed that "all things which [God] had made were very good" (Moses 2:31).

That sunrise was, for me, an intensely religious experience. I was dressed only in blue jeans and a sweatshirt, covered with the dust of the previous day's rockhounding and saturated with the smell of the previous night's campfire—not the usual setting for a spiritual experience. But the feeling of wonder for the gift of this earth I derived from that experience is one I will never forget. Since that time I have tried to renew that feeling by reflecting again on those verses, on the beauties of our world, and on the kindness of its Creator.

Of course, we need not travel to the desert to gain such a perspective. As we read and discuss the Creation story, we may also experience feelings of reverent awe as we give thoughtful consideration to what the gift of the Creation means to us and to what the Creator would have us learn from it.

Scriptural Symbols
Many features found on earth give rise to powerful scriptural symbols. The wildernesses of Jared (see Ether 2:6), Moses (see Ex. 16), and Lehi (see 1 Ne. 2) symbolize the testing of faith. The thorns and thistles that came after the Fall (see Gen. 3:18) typify the trials of mortal life. These symbols teach us about the nature and purpose of mortality, but they do not teach us that we should think negatively of the earth. After all, the Lord Himself has declared the earth to be good. Features of the earth used symbolically need not detract from our appreciation of the reality of nature's beauty. There can be appreciation for sunsets, snapdragons, and streams—and the joy we feel in experiencing them—alongside the thorns, thistles, and thunderstorms.
Testimony to a Creator

We can draw three lessons from nature's grandeur: first, God exists; second, God is powerful; and third, God loves us. One way we can feel a surety of the Creator's existence is to observe His handiwork. While it is the Holy Spirit that conveys such a testimony to our hearts, we may first prepare our hearts to receive it. A marvelous way to do this is to gaze into a star-filled sky on a moonless night or at the intricate patterns on the back of a single maple leaf. As Alma taught, "All things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator" (Alma 30:44).

The same things that prepare our hearts for the knowledge of God's existence teach us of His power. The Lord Himself has stated:

"The earth rolls upon her wings, and the sun giveth his light by day, and the moon giveth her light by night, and the stars also give their light, as they roll upon their wings in their glory, in the midst of the power of God.

"Unto what shall I liken these kingdoms, that ye may understand?

"Behold, all these are kingdoms, and any man who hath seen any or the least of these hath seen God moving in his majesty and power" (D&C 88:45–47).

We are keenly aware of God's majesty and power when we see His handiwork in motion. Next time you stand at the foot of a roaring waterfall or at the toe of a mighty glacier, reflect on the power of the Creator.

Along with teaching us that God exists and that He is powerful, the very existence of this earth impresses upon us the reality that God loves us. God's manifest power in the universe leads us to say, as did David, "When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained;

"What is man, that thou art mindful of him?" (Ps. 8:3–4).

Our answer may be found in asking another question: how important must mankind be to God, seeing that He has created all of this for us? We are surrounded by signs of God's love for us. The beauty of Creation itself is "love which from our birth over and around us lies" ("For the Beauty of the Earth," Hymns, no. 92).

The teachings of the restored gospel heighten our realization of how the very Creation of the earth is a manifestation of God's love for us. Modern revelation teaches that life is a blessing—an opportunity to prove ourselves, gain a physical body, and further our eternal progress. We were present at the Creation, singing with joy for the opportunities this earth would afford us. Though we don't remember that event now, the beauty around us is a constant reminder of our Heavenly Father's love and concern for His children.

Attendant Responsibilities

There are other fundamental lessons to draw from the Creation—lessons of what the Creator might expect from us. It seems to me that by virtue of living upon the earth we shoulder two responsibilities. The first is to care for our beautiful home. At the Creation of the world God placed Adam and Eve as caretakers, with dominion over "every living thing that moveth upon the earth," and gave them instructions to "replenish the earth, and subdue it" (Abr. 4:28). The earth, then,

was created for us and given into our care. It is within our power to do with it what we like, but since it is God who entrusted it to us, it is to Him we shall answer for what we choose to do.

Words that come to mind from the story of the Creation in Genesis chapter 1 are dominion and subdue. Sometimes these words conjure up images of an ultimate rule over powerless subjects. But no gift or station granted to us by God comes without responsibilities and expectations. Proper dominion over nature requires us to use the earth's resources wisely. They are here for our benefit, and it is pleasing to God when they are used well. "The earth is full," the Lord tells us, "and there is enough and to spare" (D&C 104:17). Any shortcomings of earth's resources needed to support mankind are not due to a lack of proper preparation of the earth. Consider how the verse concludes: "I prepared all things, and have given unto the children of men to be agents unto themselves." Thoughtful, righteous dominion is what God expects of us; any other kind of dominion is likely to cause shortages and suffering among mankind.

Humanity as a whole is doing a poor job of caring for the earth. Individually, we can do better. We can, of course, not litter. In fact, we can help pick up after those who do. We can practice conservation of resources where possible. All of our actions can display respect for the creations of God.

A second responsibility man owes, it seems to me, is gratitude. Gratitude is an essential ingredient in accepting any gift from God, and failing to show gratitude for the gift of the earth risks offense to its Creator. Indeed, our most well-known scripture commanding us to give thanks to God applies specifically to the Creation. After giving a description of the goodness of the earth in section 59 of the Doctrine and Covenants, the Lord closes with these words:

"And it pleaseth God that he hath given all these things unto man; for unto this end were they made to be used, with judgment, not to excess, neither by extortion.

"And in nothing doth man offend God, or against none is his wrath kindled, save those who confess not his hand in all things, and obey not his commandments" (D&C 59:20–21).

When I was a teenager, a good brother in our ward whom I admired pronounced a blessing on his new baby daughter. This man had a tremendous appreciation for the creations of God. I remember that the blessing he gave was quite unusual, and several thoughts from it stuck in my mind. He blessed his infant with a sense of wonder for the natural beauty that would surround her in this life—to "find wisdom in the trident leaf of the sage." Now, many years later, through experiences like the sunrise in the desert, I have come to appreciate the value of that blessing. That daughter is by now a young woman. I hope she treasures the gifts pronounced by her father in that blessing. I would wish the same blessing on us all: to find wisdom in the beauty of nature and to glean from each part of Creation that which it would teach us about its Creator.

2004
Stephen C. Meyer
DNA and the Origin of Life: Information, Specification, and Explanation
Paper at Discovery Institute

Theories about the origin of life necessarily presuppose knowledge of the attributes of living cells. As historian of biology Harmke Kamminga has observed, "At the heart of the problem of the origin of life lies a fundamental question: What is it exactly that we are trying to explain the origin of?"1 Or as the pioneering chemical evolutionary theorist Alexander Oparin put it, "The problem of the nature of life and the problem of its origin have become inseparable."2 Origin-of-life researchers

want to explain the origin of the first and presumably simplest—or, at least, minimally complex—living cell. As a result, developments in fields that explicate the nature of unicellular life have historically defined the questions that originof-life scenarios must answer.

Since the late 1950s and 1960s, origin-of-life researchers have increasingly recognized the complex and specific nature of unicellular life and the biomacromolecules on which such systems depend. Further, molecular biologists and origin-of-life researchers have characterized this complexity and specificity in informational terms. Molecular biologists routinely refer to DNA, RNA, and proteins as carriers or repositories of "information."3 Many origin-of-life researchers now regard the origin of the information in these biomacromolecules as the central question facing their research. As Bernd-Olaf Kuppers has stated, "The problem of the origin of life is clearly basically equivalent to the problem of the origin of biological information."4

This essay will evaluate competing explanations for the origin of the information necessary to build the first living cell. To do so will require determining what biologists have meant by the term information as it has been applied to biomacromolecules. As many have noted, "information" can denote several theoretically distinct concepts. This essay will attempt to eliminate this ambiguity and to determine precisely what type of information origin-of-life researchers must explain "the origin of." What follows will first seek to characterize the information in DNA, RNA, and proteins as an explanandum (a fact in need of explanation) and, second, to evaluate the efficacy of competing classes of explanation for the origin of biological information (that is, the competing explanans).

Part I will seek to show that molecular biologists have used the term information consistently to refer to the joint properties of complexity and functional specificity or specification. Biological usage of the term will be contrasted with its classical information-theoretic usage to show that "biological information" entails a richer sense of information than the classical mathematical theory of Shannon and Wiener. Part I will also argue against attempts to treat biological "information" as a metaphor lacking empirical content and/or ontological status.5 It will show that the term biological information refers to two real features of living systems, complexity and specificity, features that jointly do require explanation.

Part II will evaluate competing types of explanation for the origin of the specified biological information necessary to produce the first living system. The categories of "chance" and "necessity" will provide a helpful heuristic for understanding the recent history of origin-of-life research. From the 1920s to the mid-1960s, origin-of-life researchers relied heavily on theories emphasizing the creative role of random events—"chance"— often in tandem with some form of prebiotic natural selection. Since the late 1960s, theorists have instead emphasized deterministic self-organizational laws or properties—that is, physical-chemical "necessity."

Part II will critique the causal adequacy of chemical evolutionary theories based on "chance," "necessity," and the combination of the two.

A concluding part III will suggest that the phenomenon of information understood as specified complexity requires a radically different explanatory approach. In particular, I will argue that our present knowledge of causal powers suggests intelligent design as a better, more causally

adequate explanation for the origin of the specified complexity (the information so defined) present in large biomolecules such as DNA, RNA, and proteins.

I.

A. Simple to Complex: Defining the Biological Explanandum

After Darwin published the Origin of Species in 1859, many scientists began to think about a problem that Darwin had not addressed.6 Although Darwin's theory purported to explain how life could have grown gradually more complex starting from "one or a few simple forms," it did not explain, or attempt to explain, how life had first originated. Yet in the 1870s and 1880s, evolutionary biologists like Ernst Haeckel and Thomas Huxley assumed that devising an explanation for the origin of life would be fairly easy, in large part because Haeckel and Huxley assumed that life was, in its essence, a chemically simple substance called "protoplasm" that could easily be constructed by combining and recombining simple chemicals such as carbon dioxide, oxygen, and nitrogen.

Over the next sixty years, biologists and biochemists gradually revised their view of the nature of life. During the 1860s and 1870s, biologists tended to see the cell, in Haeckel's words, as an undifferentiated and "homogeneous globule of plasm." By the 1930s, however, most biologists had come to see the cell as a complex metabolic system.7 Origin-of-life theories reflected this increasing appreciation of cellular complexity. Whereas nineteenth-century theories of abiogenesis envisioned life arising almost instantaneously via a one- or two-step process of chemical "autogeny," early twentieth-century theories, such as Oparin's theory of evolutionary abiogenesis, envisioned a multibillion-year process of transformation from simple chemicals to a complex metabolic system.8 Even so, most scientists during the 1920s and 1930s still vastly underestimated the complexity and specificity of the cell and its key functional components—as developments in molecular biology would soon make clear.

B. The Complexity and Specificity of Proteins

During the first half of the twentieth century, biochemists had come to recognize the centrality of proteins to the maintenance of life. Although many mistakenly believed that proteins also contained the source of heredity information, biologists repeatedly underestimated the complexity of proteins.

For example, during the 1930s, English X-ray crystallographer William Astbury elucidated the molecular structure of certain fibrous proteins, such as keratin, the key structural protein in hair and skin.9 Keratin exhibits a relatively simple, repetitive structure, and Astbury was convinced that all proteins, including the mysterious globular proteins so important to life, represented variations on the same primal and regular pattern. Similarly, biochemists Max Bergmann and Carl Niemann of the Rockefeller Institute argued in 1937 that the amino acids in proteins occurred in regular, mathematically expressible proportions. Other biologists imagined that insulin and hemoglobin proteins, for example, "consisted of bundles of parallel rods."10

Beginning in the 1950s, however, a series of discoveries caused this simplistic view of proteins to change. From 1949 to 1955, biochemist Fred Sanger determined the structure of the protein molecule, insulin. Sanger showed that insulin consisted of a long and irregular sequence of the various amino acids, rather like a string of differently colored beads arranged without any discernible pattern. His work showed for a single protein what subsequent work in molecular biology would establish as a norm: The amino acid sequence in functional proteins generally defies expression by any simple rule and is characterized instead by aperiodicity or complexity.11 Later in the 1950s, work by John Kendrew on the structure of the protein myoglobin showed that proteins also exhibit a surprising three-dimensional complexity. Far from the simple structures that biologists had imagined earlier, an extraordinarily complex and irregular three-dimensional shape was revealed: a twisting, turning, tangle of amino acids. As Kendrew explained in 1958, "The big surprise was that it was so irregular . . . the arrangement seems to be almost totally lacking in the kind of regularity one instinctively anticipates, and it is more complicated than has been predicted by any theory of protein structure."12

By the mid-1950s, biochemists recognized that proteins possess another remarkable property. In addition to their complexity, proteins also exhibit specificity, both as one-dimensional arrays and three-dimensional structures. Whereas proteins are built from chemically rather simple amino acid "building blocks," their function (whether as enzymes, signal transducers, or structural components in the cell) depends crucially on a complex but specific arrangement of those building blocks.13 In particular, the specific sequence of amino acids in a chain and the resultant chemical interactions between amino acids largely determine the specific three-dimensional structure that the chain as a whole will adopt. Those structures or shapes in turn determine what function, if any, the amino acid chain can perform in the cell.

For a functioning protein, its three-dimensional shape gives it a handin-glove fit with other molecules, enabling it to catalyze specific chemical reactions or to build specific structures within the cell. Because of its three-dimensional specificity, one protein can usually no more substitute for another than one tool can substitute for another. A topoisomerase can no more perform the job of a polymerase than a hatchet can perform the function of a soldering iron. Instead, proteins perform functions only by virtue of their three-dimensional specificity of fit, either with other equally specified and complex molecules or with simpler substrates within the cell. Moreover, the three-dimensional specificity derives in large part from the one-dimensional sequence specificity in the arrangement of the amino acids that form proteins. Even slight alterations in sequence often result in the loss of protein function.

C. The Complexity and Sequence Specificity of DNA

During the early part of the twentieth century, researchers also vastly underestimated the complexity (and significance) of nucleic acids such as DNA and RNA. By then, scientists knew the chemical composition of DNA. Biologists and chemists knew that in addition to sugars (and later phosphates), DNA was composed of four different nucleotide bases, called adenine, thymine, cytosine, and guanine. In 1909, chemist P. A. Levene showed (incorrectly as it later turned out) that the four different nucleotide bases always occurred in equal quantities within the DNA molecule.14 He formulated what he called the "tetranucleotide hypothesis" to account for that putative fact. According to that hypothesis, the four nucleotide bases in DNA linked together in repeating sequences of the same four chemicals in the same sequential order. Since Levene envisioned those sequential arrangements of nucleotides as repetitive and invariant, their potential for expressing any genetic diversity seemed inherently limited. To account for the heritable differences between species, biologists needed to discover some source of variable or irregular specificity, some source of information, within the germ lines of different organisms. Yet insofar as DNA was seen as an uninterestingly repetitive molecule, many biologists assumed that DNA could play little if any role in the transmission of heredity.

That view began to change in the mid-1940s for several reasons. First, Oswald Avery's famous experiments on virulent and nonvirulent strains of Pneumococcus identified DNA as the key factor in accounting for heritable differences between different bacterial strains.15 Second, work by Erwin Chargaff of Columbia University in the late 1940s undermined the "tetranucleotide hypothesis." Chargaff showed, contradicting Levene's earlier work, that nucleotide frequencies actually do differ between species, even if they often hold constant within the same species or within the same organs or tissues of a single organism.16 More important, Chargaff recognized that even for nucleic acids of exactly "the same analytical composition"—meaning those with the same relative proportions of the four bases (abbreviated A, T, C, and G)—"enormous" numbers of variations in sequence were possible. As he put it, different DNA molecules or parts of DNA molecules might "differ from each other . . . in the sequence, [though] not the proportion, of their constituents." As he realized, for a nucleic acid consisting of 2,500 nucleotides (roughly the length of a long gene) the number of sequences "exhibiting the same molar proportions of individual purines [A, G] and pyrimidines [T, C] . . . is not far from 101500."17 Thus, Chargaff showed that, contrary to the

tetranucleotide hypothesis, base sequencing in DNA might well display the high degree of variability and aperiodicity required by any potential carrier of heredity.

Third, elucidation of the three-dimensional structure of DNA by Watson and Crick in 1953 made clear that DNA could function as a carrier of hereditary information.18 The model proposed by Watson and Crick envisioned a double-helix structure to explain the Maltese-cross pattern derived from X-ray crystallographic studies of DNA by Franklin, Wilkins, and Bragg in the early 1950s. According to the now well-known Watson and Crick model, the two strands of the helix were made of sugar and phosphate molecules linked by phosphodiester bonds. Nucleotide bases were linked horizontally to the sugars on each strand of the helix and to a complementary base on the other strand to form an internal "rung" on a twisting "ladder." For geometric reasons, their model required the pairing (across the helix) of adenine with thymine and cytosine with guanine. That complementary pairing helped to explain a significant regularity in composition ratios discovered by Chargaff. Though Chargaff had shown that none of the four nucleotide bases appears with the same frequency as all the other three, he did discover that the molar proportions of adenine and thymine, on the one hand, and cytosine and guanine, on the other, do consistently equal each other.19 Watson and Crick's model explained the regularity Chargaff had expressed in his famous "ratios."

The Watson-Crick model made clear that DNA might possess an impressive chemical and structural complexity. The double-helix structure for DNA presupposed an extremely long and high-molecular-weight structure, possessing an impressive potential for variability and complexity in sequence. As Watson and Crick explained, "The sugar-phosphate backbone in our model is completely regular but any sequence of base pairs can fit into the structure. It follows that in a long molecule many different permutations are possible, and it, therefore, seems likely that the precise sequence of bases is the code which carries genetic information."20

As with proteins, subsequent discoveries soon showed that DNA sequences were not only complex but also highly specific relative to the requirements of biological function. Discovery of the complexity and specificity of proteins had led researchers to suspect a functionally specific role for DNA. Molecular biologists, working in the wake of Sanger's results, assumed that proteins were much too complex (and yet also functionally specific) to arise by chance in vivo. Moreover, given their irregularity, it seemed unlikely that a general chemical law or regularity could explain their assembly. Instead, as Jacques Monod has recalled, molecular biologists began to look for some source of information or "specificity" within the cell that could direct the construction of such highly specific and complex structures. To explain the presence of the specificity and complexity in the protein, as Monod would later insist, "you absolutely needed a code."21

The structure of DNA as elucidated by Watson and Crick suggested a means by which information or "specificity" might be encoded along the spine of DNA's sugar-phosphate backbone.22 Their model suggested that variations in sequence of the nucleotide bases might find expression in the sequence of the amino acids that form proteins. In 1955, Crick proposed this idea as the so-called sequence hypothesis. According to Crick's hypothesis, the specificity of arrangement of amino acids in proteins derives from the specific arrangement of the nucleotide bases on the DNA molecule.23 The sequence hypothesis suggested that the nucleotide bases in DNA functioned like letters in an alphabet or characters in a machine code. Just as alphabetic letters in a written language may perform a communication function depending on their sequence, so, too, might the nucleotide bases in DNA result in the production of a functional protein molecule depending on their precise sequential arrangement. In both cases, function depends crucially on sequence. The sequence hypothesis implied not only the complexity but also the functional specificity of DNA base sequences.

By the early 1960s, a series of experiments had confirmed that DNA base sequences play a critical role in determining amino acid sequence during protein synthesis.24 By that time, the processes and mechanisms by which DNA sequences determine key stages of the process were known (at least in outline). Protein synthesis or "gene expression" proceeds as long chains of nucleotide bases are first copied during a process known as transcription. The resulting copy, a "transcript" made of single-stranded "messenger RNA," now contains a sequence of RNA bases precisely reflecting the sequence of bases on the original DNA strand. The transcript is then transported to a complex organelle called a ribosome. At the ribosome, the transcript is "translated" with the aid of highly specific adaptor molecules (called transfer-RNAs) and specific enzymes (called amino-acyl tRNA synthetases) to produce a growing amino acid chain (figure 1).25 Whereas the function of the protein molecule derives from the specific arrangement of twenty different types of amino acids, the function of DNA depends on the arrangement of just four kinds of bases. This lack of a one-to-one correspondence means that a group of three DNA nucleotides (a triplet) is needed to specify a single amino acid. In any case, the sequential arrangement of the nucleotide bases determines (in large part) the one-dimensional sequential arrangement of amino acids during protein synthesis.26 Since protein function depends critically on amino acid sequence and amino acid sequence depends critically on DNA base sequence, the sequences in the coding regions of DNA themselves possess a high degree of specificity relative to the requirements of protein (and cellular) function.

D. Information Theory and Molecular Biology

From the beginning of the molecular biological revolution, biologists have ascribed information-bearing properties to DNA, RNA, and proteins. In the parlance of molecular biology, DNA base sequences contain the "genetic information" or the "assembly instructions" necessary to direct protein synthesis. Yet the term information can denote several theoretically distinct concepts. Thus, one must ask which sense of "information" applies to these large biomacromolecules. We shall see that molecular biologists employ both a stronger conception of information than that of mathematicians and information-theorists and a slightly weaker conception of the term than that of linguists and ordinary users.

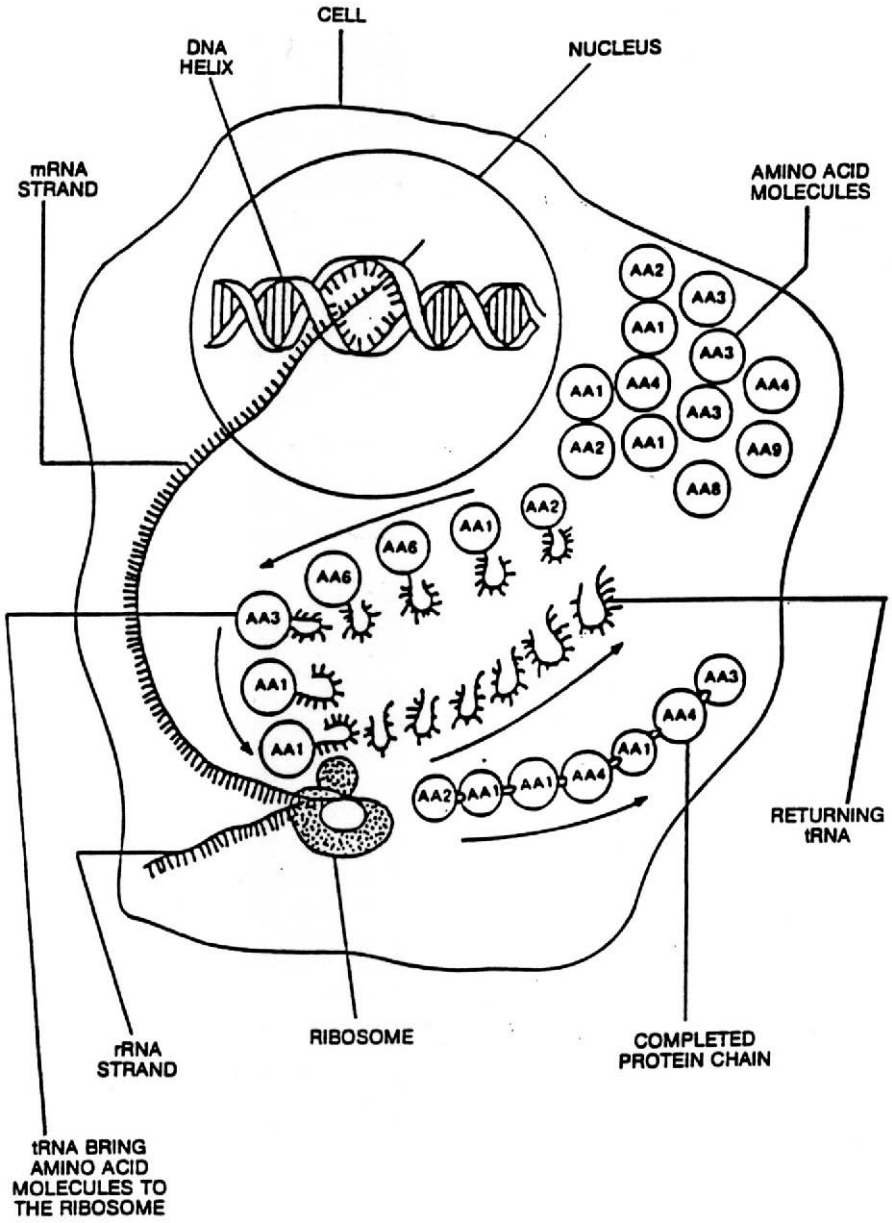

FIGURE 1. The intricate machinery of protein synthesis. The genetic messages encoded on the DNA molecule are copied and then transported by messenger RNA to the ribosome complex. There the genetic message is "read" and translated with the aid of other large biomolecules (transfer-RNA and specific enzyme) to produce a growing amino acid chain. Courtesy of I. L. Cohen of New Research Publications.

During the 1940s, Claude Shannon at Bell Laboratories developed a mathematical theory of information.27 His theory equated the amount of information transmitted with the amount of uncertainty reduced or eliminated by a series of symbols or characters.28 For example, before one rolls a six-sided die, there are six possible outcomes. Before one flips a coin, there are two. Rolling a die will thus eliminate more uncertainty and, on Shannon's theory, will convey more information than flipping a coin. Equating information with the reduction of uncertainty implied a mathematical relationship between information and probability (or its inverse, complexity). Note that for a die each possible outcome has only a one in six chance of occurring, compared to a one in two chance for each side of the coin. Thus, in Shannon's theory the occurrence of the more improbable event

conveys more information. Shannon generalized this relationship by stating that the amount of information conveyed by an event is inversely proportional to the prior probability of its occurrence. The greater the number of possibilities, the greater the improbability of any one being actualized, and thus more information is transmitted when a particular possibility occurs.

Moreover, information increases as improbabilities multiply. The probability of getting four heads in a row when flipping a fair coin is 1/2 × 1/2 × 1/2 × 1/2, or (1/2)4. Thus, the probability of attaining a specific sequence of heads and/or tails decreases exponentially as the number of trials increases. The quantity of information increases correspondingly. Even so, information theorists found it convenient to measure information additively rather than multiplicatively. Thus, the common mathematical expression (I =–log2p) for calculating information converts probability values into informational measures through a negative logarithmic function, where the negative sign expresses an inverse relationship between information and probability.29

Shannon's theory applies most easily to sequences of alphabetic symbols or characters that function as such. Within any given alphabet of x possible characters, the placement of a specific character eliminates x-1 other possibilities and thus a corresponding amount of uncertainty. Or put differently, within any given alphabet or ensemble of x possible characters (where each character has an equi-probable chance of occurring), the probability of any one character occurring is 1/x. The larger the value of x, the greater the amount of information that is conveyed by the occurrence of a specific character in a sequence. In systems where the value of x can be known (or estimated), as in a code or language, mathematicians can easily generate quantitative estimates of information-carrying capacity. The greater the number of possible characters at each site and the longer the sequence of characters, the greater is the information-carrying capacity—or Shannon information—associated with the sequence.

The essentially digital character of the nucleotide bases in DNA and of the amino acid residues in proteins enabled molecular biologists to calculate the information-carrying capacity (or syntactic information) of those molecules using the new formalism of Shannon's theory. Because at every site in a growing amino acid chain, for example, the chain may receive any one of twenty amino acids, placement of a single amino acid in the chain eliminates a quantifiable amount of uncertainty and increases the Shannon or syntactic information of a polypeptide by a corresponding amount. Similarly, since at any given site along the DNA backbone any one of four nucleotide bases may occur with equal probability, the p value for the occurrence of a specific nucleotide at that site equals 1/4, or .25.30 The information-carrying capacity of a sequence of a specific length n can then be calculated using Shannon's familiar expression (I =–log2p) once one computes a p value for the occurrence of a particular sequence n nucleotides long where p = (1/4)n. The p value thus yields a corresponding measure of information-carrying capacity or syntactic information for a sequence of n nucleotide bases.31

E. Complexity, Specificity, and Biological Information

Though Shannon's theory and equations provided a powerful way to measure the amount of information that could be transmitted across a communication channel, it had important limits. In particular, it did not and could not distinguish merely improbable sequences of symbols from those that conveyed a message. As Warren Weaver made clear in 1949, "The word information in this theory is used in a special mathematical sense that must not be confused with its ordinary usage. In particular, information must not be confused with meaning."32 Information theory could measure the information-carrying capacity or the syntactic information of a given sequence of symbols but could not distinguish the presence of a meaningful or functional arrangement of symbols from a random sequence (for example, "we hold these truths to be self-evident" versus "ntnyhiznl-hteqkhgdsjh"). Thus, Shannon information theory could quantify the amount of functional or

meaningful information that might be present in a given sequence of symbols or characters, but it could not distinguish the

status of a functional or message-bearing text from random gibberish. Thus, paradoxically, random sequences of letters often have more syntactic information (or information-carrying capacity), as measured by classical information theory, than do meaningful or functional sequences that happen to contain a certain amount of intentional redundancy or repetition.

In essence, therefore, Shannon's theory remains silent on the important question of whether a sequence of symbols is functionally specific or meaningful. Nevertheless, in its application to molecular biology, Shannon information theory did succeed in rendering rough quantitative measures of the information-carrying capacity or syntactic information (where those terms correspond to measures of brute complexity).33 As such, information theory did help to refine biologists' understanding of one important feature of the crucial biomolecular components on which life depends: DNA and proteins are highly complex, and quantifiably so. Yet the theory by itself could not establish whether base sequences in DNA or amino acid sequences in proteins possessed the property of functional specificity. Information theory helped establish that DNA and proteins could carry large amounts of functional information; it could not establish whether they did.

The ease with which information theory applied to molecular biology (to measure information-carrying capacity) has created considerable confusion about the sense in which DNA and proteins contain "information." Information theory strongly suggested that such molecules possess vast information-carrying capacities or large amounts of syntactic information, as defined by Shannon's theory. When molecular biologists have described DNA as the carrier of hereditary information, however, they have meant much more than the technically limited term information. Instead, as Sahotra Sarkar points out, leading molecular biologists defined biological information so as to incorporate the notion of specificity of function (as well as complexity) as early as 1958.34 Molecular biologists such as Monod and Crick understood biological information—the information stored in DNA and proteins—as something more than mere complexity (or improbability). Their notion of information did associate both biochemical contingency and combinatorial complexity with DNA sequences (allowing DNA's carrying capacity to be calculated), but they also recognized that sequences of nucleotides and amino acids in functioning biomacromolecules possessed a high degree of specificity relative to the maintenance of cellular function. As Crick explained in 1958, "By information I mean the specification of the amino acid sequence in protein. . . . Information means here

the precise determination of sequence, either of bases in the nucleic acid or on amino acid residues in the protein."35

Since the late 1950s, biologists have equated the "precise determination of sequence" with the extra-information-theoretic property of specificity or specification. Biologists have defined specificity tacitly as "necessary to achieve or maintain function." They have determined that DNA base sequences, for example, are specified not by applying information theory but by making experimental assessments of the function of those sequences within the overall apparatus of gene expression.36 Similar experimental considerations established the functional specificity of proteins.

Further, developments in complexity theory have now made possible a fully general theoretical account of specification, one that applies readily to biological systems. In particular, recent work by mathematician William Dembski has employed the notion of a rejection region from statistics to provide a formal complexity-theoretic account of specification. According to Dembski, a specification occurs when an event or object (a) falls within an independently given pattern or

domain, (b) “matches” or exemplifies a conditionally independent pattern, or (c) meets a conditionally independent set of functional requirements.37

To illustrate Dembski’s notion of specification, consider these two strings of characters:

“iuinsdysk]idfawqnzkl,mfdifhs” “Time and tide wait for no man.”

Given the number of possible ways of arranging the letters and punctuation marks of the English language for sequences of this length, both of these two sequences constitute highly improbable arrangements of characters. Thus, both have a considerable and quantifiable information-carrying capacity. Nevertheless, only the second of the two sequences exhibits a specification on Dembski’s account. To see why, consider the following. Within the set of combinatorially possible sequences, only a very few will convey meaning. This smaller set of meaningful sequences, therefore, delimits a domain or pattern within the larger set of the totality of possibilities. Moreover, this set constitutes a “conditionally independent” pattern. Roughly speaking, a conditionally independent pattern corresponds to a preexisting pattern or set of functional requirements, not one contrived after the fact of observing the event in question—specifically, in this case, the event of observing the two sequences above.38 Since the smaller domain distinguishes functional from nonfunctional English sequences and the functionality of alphabetic sequences depends on the preexisting or independently given conventions of English vocabulary and grammar, the smaller set or domain qualifies as a conditionally independent pattern.39 Since the second string of characters (“Time and tide wait . . .”) falls within this smaller conditionally independent domain (or “matches” one of the possible meaningful sentences that fall within it), the second sequence exhibits a specification according to Dembski’s complexity-theoretic account. That sequence therefore exhibits the joint properties of complexity and specification and possesses not just information-carrying capacity but both “specified” and, in this case, “semantic” information.

Biological organisms also exhibit specifications, though not necessarily semantic or subjectively “meaningful” ones. The nucleotide base sequences in the coding regions of DNA are highly specific relative to the independent functional requirements of protein function, protein synthesis, and cellular life. To maintain viability, the cell must regulate its metabolism, pass materials back and forth across its membranes, destroy waste materials, and do many other specific tasks. Each of these functional requirements in turn necessitates specific molecular constituents, machines, or systems (usually made of proteins) to accomplish these tasks. Building these proteins with their specific three-dimensional shapes requires specific arrangements of nucleotide bases on the DNA molecule.

Since the chemical properties of DNA allow a vast ensemble of combinatorially possible arrangements of nucleotide bases, any particular sequence will necessarily be highly improbable and rich in Shannon information or information-carrying capacity. Yet within that set of possible sequences a very few will, given the multimolecular system of gene expression within the cell, produce functional proteins.40 Those that do are thus not only improbable but also functionally “specified” or “specific,” as molecular biologists use the terms. Indeed, the smaller set of functionally efficacious sequences again delimits a domain or pattern within a larger set of combinatorial possibilities. Moreover, this smaller domain constitutes a conditionally independent pattern, since (as with the English sequences above) it distinguishes functional from nonfunctional sequences, and the functionality of nucleotide base sequences depends on the independent requirements of protein function. Thus, any actual nucleotide sequence that falls within this domain (or “matches” one of the possible functional sequences that fall within it) exhibits a specification. Put differently, any nucleotide base sequence that produces a functional protein clearly meets certain independent functional requirements, in particular, those of protein function. Thus, any sequence that meets such requirements (or “falls within the smaller subset of functional

sequences") is again not only highly improbable but also specified relative to that independent pattern or domain. Thus, the nucleotide sequences in the coding regions of DNA possess both syntactic information and "specified" information.

A note of definitional clarity must be offered about the relationship between "specified" information and "semantic" information. Though natural languages and DNA base sequences are both specified, only natural language conveys meaning. If one defines "semantic information" as "subjectively meaningful information that is conveyed syntactically (as a string of phonemes or characters) and is understood by a conscious agent," then clearly the information in DNA does not qualify as semantic. Unlike a written or spoken natural language, DNA does not convey "meaning" to a conscious agent.

Rather, the coding regions of DNA function in much the same way as a software program or machine code, directing operations within a complex material system via highly complex yet specified sequences of characters. As Richard Dawkins has noted, "The machine code of the genes is uncannily computer-like."41 Or as software developer Bill Gates has noted, "DNA is like a computer program, but far, far more advanced than any software we've ever created."42 Just as the specific arrangement of two symbols (0 and 1) in a software program can perform a function within a machine environment, so, too, can the precise sequencing of the four nucleotide bases in DNA perform a function within the cell.

Though DNA sequences do not convey "meaning," they do exhibit specificity or specification. Moreover, as in a machine code, the sequence specificity of DNA occurs within a syntactic (or functionally alphabetic) domain. Thus, DNA possesses both syntactic and specified information. In any case, since the late 1950s, the concept of information as employed by molecular biologists has conjoined the notions of complexity (or improbability) and specificity of function. The crucial biomolecular constituents of living organisms possess not only Shannon or syntactic information but also "specified information" or "specified complexity."43 Biological information so defined, therefore, constitutes a salient feature of living systems that any origin-of-life scenario must explain "the origin of." Further, as we will see below, all naturalistic chemical evolutionary theories have encountered difficulty explaining the origin of such functionally "specified" biological information.

F. Information as Metaphor: Nothing to Explain?

Though most molecular biologists would see nothing controversial in characterizing DNA and proteins as "information-bearing" molecules, some historians and philosophers of biology have recently challenged that description. Before evaluating competing types of explanation for the origin of biological information, this challenge must be addressed. In 2000, the late historian of science Lily Kay characterized the application of information theory to biology as a failure, in particular because classical information theory could not capture the idea of meaning. She suggests, therefore, that the term information as used in biology constitutes nothing more than a metaphor. Since, in Kay's view, the term does not designate anything real, it follows that the origin of "biological information" does not require explanation. Instead, only the origin of the use of the term information within biology requires explanation. As a social constructivist, Kay explained this usage as the result of various social forces operating within the "Cold War Technoculture."44 In a different but related vein, Sarkar has argued that the concept of information has little theoretical significance in biology because it lacks predictive or explanatory power.45 He, like Kay, seems to regard the concept of information as a superfluous metaphor lacking empirical reference and ontological status.

Of course, insofar as the term information connotes semantic meaning, it does function as a metaphor within biology. That does not mean, however, that the term functions only

metaphorically or that origin-of-life biologists have nothing to explain. Though information theory has a limited application in describing biological systems, it has succeeded in rendering quantitative assessments of the complexity of biomacromolecules. Further, experimental work established the functional specificity of the sequences of monomers in DNA and proteins. Thus, the term information as used in biology does refer to two real and contingent properties of living systems: complexity and specificity. Indeed, since scientists began to think seriously about what would be required to explain the phenomenon of heredity, they have recognized the need for some feature or substance in living organisms possessing precisely these two properties together. Thus, Schrödinger envisioned an "aperiodic crystal"; Chargaff perceived DNA's capacity for "complex sequencing"; Watson and Crick equated complex sequences with "information," which Crick in turn equated with "specificity"; Monod equated irregular specificity in proteins with the need for "a code"; and Orgel characterized life as a "specified complexity."46 Further, Davies has recently argued that the "specific randomness" of DNA base sequences constitutes the central mystery surrounding the origin of life.47 Whatever the terminology, scientists have recognized the need for, and now know the location of, a source of complex specificity in the cell in order to transmit heredity and maintain biological function. The incorrigibility of these descriptive concepts suggests that complexity and specificity constitute real properties of biomacromolecules—indeed, properties that could be otherwise but only to the detriment of cellular life. As Orgel notes: "Living organisms are distinguished by their specified complexity. Crystals . . . fail to qualify as living because they lack complexity; mixtures of random polymers fail to qualify because they lack specificity."48

The origin of specificity and complexity (in combination), to which the term information in biology commonly refers, therefore does require explanation, even if the concept of information connotes only complexity in classical information theory and even if it has no explanatory or predictive value in itself. Instead, as a descriptive (rather than as an explanatory or predictive) concept, the term information helps to define (either in conjunction with the notion of "specificity" or by subsuming it) the effect that origin-of-life researchers must explain "the origin of." Thus, only where information connotes subjective meaning does it function as a metaphor in biology. Where it refers to an analog of meaning, namely, functional specificity, it defines an essential feature of living systems.

II.

A. Naturalistic Explanations for the Origin of Specified Biological Information

The discoveries of molecular biologists during the 1950s and 1960s raised the question of the ultimate origin of the specified complexity or specified information in both DNA and proteins. Since at least the mid-1960s, many scientists have regarded the origin of information (so defined) as the central question facing origin-of-life biology.49 Accordingly, origin-of-life researchers have proposed three broad types of naturalistic explanation to explain the origin of specified genetic information: those emphasizing chance, necessity, or the combination of the two.

B. Beyond the Reach of Chance

Perhaps the most common popular naturalistic view about the origin of life is that it happened exclusively by chance. A few serious scientists have also voiced support for this view, at least, at various points in their careers. In 1954, biochemist George Wald, for example, argued for the causal efficacy of chance in conjunction with vast expanses of time. As he explained, "Time is in fact the hero of the plot. . . . Given so much time, the impossible becomes possible, the possible probable, and the probable virtually certain."50 Later, in 1968, Francis Crick would suggest that the origin of the genetic code—that is, the translation system—might be a "frozen accident."51 Other theories have invoked chance as an explanation for the origin of genetic information, though often in conjunction with prebiotic natural selection (see part C below).

Almost all serious origin-of-life researchers now consider “chance” an inadequate causal explanation for the origin of biological information.52 Since molecular biologists began to appreciate the sequence specificity of proteins and nucleic acids in the 1950s and 1960s, many calculations have been made to determine the probability of formulating functional proteins and nucleic acids at random. Various methods of calculating probabilities have been offered by Morowitz, Hoyle and Wickramasinghe, Cairns-Smith, Prigogine, Yockey, and, more recently, Robert Sauer.53 For the sake of argument, these calculations have often assumed extremely favorable prebiotic conditions (whether realistic or not), much more time than was actually available on the early earth, and theoretically maximal reaction rates among constituent monomers (that is, the constituent parts of proteins, DNA, or RNA). Such calculations have invariably shown that the probability of obtaining functionally sequenced biomacromolecules at random is, in Prigogine’s words, “vanishingly small . . . even on the scale of . . . billions of years.”54 As Cairns-Smith wrote in 1971: “Blind chance . . . is very limited. Low-levels of cooperation he [blind chance] can produce exceedingly easily (the equivalent of letters and small words), but he becomes very quickly incompetent as the amount of organization increases. Very soon indeed long waiting periods and massive material resources become irrelevant.”55

Consider the probabilistic hurdles that must be overcome to construct even one short protein molecule of 100 amino acids in length. (A typical protein consists of about 300 amino acid residues, and many crucial proteins are much longer.)

First, all amino acids must form a chemical bond known as a peptide bond when joining with other amino acids in the protein chain. Yet in nature many other types of chemical bonds are possible between amino acids; in fact, peptide and nonpeptide bonds occur with roughly equal probability. Thus, at any given site along a growing amino acid chain, the probability of having a peptide bond is roughly 1/2. The probability of attaining four peptide bonds is (1/2 × 1/× 1/2 × 1/2) = 1/16, or (1/2)4. The probability of building a chain of 2 100 amino acids in which all linkages involve peptide linkages is (1/2)99, or roughly 1 chance in 1030.

Second, in nature, every amino acid found in proteins (with one exception) has a distinct mirror image of itself, one left-handed version, or L-form, and one right-handed version, or D-form. These mirror-image forms are called optical isomers. Functioning proteins tolerate only left-handed amino acids, yet the right-handed and left-handed isomers are produced in (amino acid–producing) chemical reactions with roughly equal frequency. Taking this “chirality” into consideration compounds the improbability of attaining a biologically functioning protein. The probability of attaining at random only L-amino acids in a hypothetical peptide chain 100 amino acids long is (1/2)100 or again roughly 1 chance in 1030. Starting from mixtures of DL- forms, the probability of building a 100-amino-acid-length chain at random in which all bonds are peptide bonds and all amino acids are L-form is, therefore, roughly 1 chance in 1060.

Functioning proteins have a third independent requirement, the most important of all; their amino acids must link up in a specific sequential arrangement just as the letters in a meaningful sentence must. In some cases, changing even one amino acid at a given site results in loss of protein function. Moreover, because there are twenty biologically occurring amino acids, the probability of getting a specific amino acid at a given site is small—1/20. (Actually the probability is even lower because in nature there are also many nonprotein-forming amino acids.) On the assumption that all sites in a protein chain require one particular amino acid, the probability of attaining a particular protein 100 amino acids long would be (1/, or roughly 1 chance in 10130. We know now, however, that some sites along the chain do tolerate several of the twenty amino acids commonly found in proteins, though others do not. Biochemist Robert Sauer of MIT has used a technique known as “cassette mutagenesis” to determine how much variance among amino acids can be tolerated at any given site in several proteins. His results imply that, even taking the possibility of variance into

account, the probability of achieving a functional sequence of amino acids in several known (roughly 100 residue) proteins at random is still "vanishingly small," about 1 chance in 1065.56 (There are 1065 atoms in our galaxy).57 Recently, Douglas Axe of Cambridge University has used a refined mutagenesis technique to measure the sequence specificity of the protein barnase, a bacterial RNase. Axe's work suggests that previous mutagenesis experiments actually underestimated the functional sensitivity of proteins to amino acid sequence change because they presupposed (incorrectly) the context independence of individual residue changes.58 If, in addition to the improbability of attaining a proper sequence, one considers the need for proper bonding and homochirality, the probability of constructing a rather short functional protein at random becomes so small (no more than 1 chance in 10125) as to appear absurd on the chance hypothesis. As Dawkins has said, "We can accept a certain amount of luck in our explanations, but not too much."59

Of course, Dawkins's assertion begs a quantitative question, namely, "How improbable does an event, sequence, or system have to be before the chance hypothesis can be reasonably eliminated?" That question has recently received a formal answer. William Dembski, following and refining the work of earlier probabilists such as Emile Borel, has shown that chance can be eliminated as a plausible explanation for specified systems of small probability whenever the complexity of a specified event or sequence exceeds available probabilistic resources.60 He then calculates a conservative estimate for the "universal probability bound" of 1 in 10150 corresponding to the probabilistic resources of the known universe. This number provides a theoretical basis for excluding appeals to chance as the best explanation

× 10150

for specified events of probability less than 1/2 . Dembski thus answers the question of how much luck is—for any case—too much to invoke in an explanation.

Significantly, the improbability of assembling and sequencing even a short functional protein approaches this universal probability bound—the point at which appeals to chance become absurd given the "probabilistic resources" of the entire universe.61 Further, making the same kind of calculation for even moderately longer proteins pushes these measures of improbability well beyond the limit. For example, the probability of generating a protein of only 150 amino acids in length (using the same method as above) is less than 1 chance in 10180, well beyond the most conservative estimates of the probability bound, given our multibillion year old universe.62 Thus, given the complexity of proteins, it is extremely unlikely that a random search through the space of combinatorially possible amino acid sequences could generate even a single relatively short functional protein in the time available since the beginning of the universe (let alone the time available on the early earth). Conversely, to have a reasonable chance of finding a short functional protein in a random search of combinatorial space would require vastly more time than either cosmology or geology allows.

More realistic calculations (taking into account the probable presence of nonproteineous amino acids, the need for much longer proteins to perform specific functions such as polymerization, and the need for hundreds of proteins working in coordination to produce a functioning cell) only compound these improbabilities, almost beyond computability. For example, recent theoretical and experimental work on the so-called minimal complexity required to sustain the simplest possible living organism suggests a lower bound of some 250 to 400 genes and their corresponding proteins.63 The nucleotide sequence-space corresponding to such a system of proteins exceeds 4300,000. The improbability corresponding to this measure of molecular complexity again vastly exceeds 1 chance in 10150 and thus the "probabilistic resources" of the entire universe.64 When one considers the full complement of functional biomolecules required to maintain minimal cell

function and vitality, one can see why chance-based theories of the origin of life have been abandoned. What Mora said in 1963 still holds: “Statistical considerations, probability, complexity, etc., followed to their logical implications suggest that the origin and continuance of life is not controlled by such principles. An admission of this is the use of a period of practically infinite time to obtain the derived result. Using such logic, however, we can prove anything.”65

Though the probability of assembling a functioning biomolecule or cell by chance alone is exceedingly small, it is important to emphasize that scientists have not generally rejected the chance hypothesis merely because of the vast improbabilities associated with such events. Very improbable things do occur by chance. Any hand of cards or any series of rolled dice will represent a highly improbable occurrence. Observers often justifiably attribute such events to chance alone. What justifies the elimination of chance is not just the occurrence of a highly improbable event but also the occurrence of an improbable event that also conforms to a discernible pattern (that is, to a conditionally independent pattern; see part I, section E). If someone repeatedly rolls two dice and turns up a sequence such as 9, 4, 11, 2, 6, 8, 5, 12, 9, 2, 6, 8, 9, 3, 7, 10, 11, 4, 8, and 4, no one will suspect anything but the interplay of random forces, though this sequence does represent a very improbable event given the number of combinatorial possibilities that correspond to a sequence of this length. Yet rolling 20 (or certainly 200) consecutive sevens will justifiably arouse suspicion that something more than chance is in play. Statisticians have long used a method for determining when to eliminate the chance hypothesis; the method requires prespecifying a pattern or “rejection region.”66 In the dice example above, one could prespecify the repeated occurrence of seven as such a pattern in order to detect the use of loaded dice, for example. Dembski has generalized this method to show how the presence of any conditionally independent pattern, whether temporally prior to the observation of an event or not, can help (in conjunction with a small probability event) to justify rejecting the chance hypothesis.67

Origin-of-life researchers have tacitly, and sometimes explicitly, employed this kind of statistical reasoning to justify the elimination of scenarios relying heavily on chance. Christian de Duve, for example, has made the logic explicit in order to explain why chance fails as an explanation for the origin of life: “A single, freak, highly improbable event can conceivably happen. Many highly improbable events—drawing a winning lottery number or the distribution of playing cards in a hand of bridge—happen all the time. But a string of improbable events—drawing the same lottery number twice, or the same bridge hand twice in a row—does not happen naturally.”68

De Duve and other origin-of-life researchers have long recognized that the cell represents not only a highly improbable but also a functionally specified system. For this reason, by the mid-1960s most researchers had eliminated chance as a plausible explanation for the origin of the specified information necessary to build a cell.69 Many have instead sought other types of naturalistic explanations.

C. Prebiotic Natural Selection: A Contradiction in Terms

Of course, even many early theories of chemical evolution did not rely exclusively on chance as a causal mechanism. For example, Oparin’s original theory of evolutionary abiogenesis first published in the 1920s and 1930s invoked prebiotic natural selection as a complement to chance interactions. Oparin’s theory envisioned a series of chemical reactions that he thought would enable a complex cell to assemble itself gradually and naturalistically from simple chemical precursors.

For the first stage of chemical evolution, Oparin proposed that simple gases such as ammonia (NH_3), methane (CH_4), water vapor (H_2O), carbon dioxide (CO_2), and hydrogen (H_2)would have existed in contact with the early oceans and with metallic compounds extruded from the core of the earth.70 With the aid of ultraviolet radiation from the sun, the ensuing reactions would have produced energy-rich hydrocarbon compounds. They in turn would have combined and recombined

with various other compounds to make amino acids, sugars, and other “building blocks” of complex molecules such as proteins necessary to living cells. These constituents would eventually arrange themselves by chance into primitive metabolic systems within simple cell-like enclosures that Oparin called coacervates. Oparin then proposed a kind of Darwinian competition for survival among his coacervates. Those that, by chance, developed increasingly complex molecules and metabolic processes would have survived to grow more complex and efficient. Those that did not would have dissolved.71 Thus, Oparin invoked differential survival or natural selection as a mechanism for preserving complexity-increasing events, thus allegedly helping to overcome the difficulties attendant to pure-chance hypotheses.

Developments in molecular biology during the 1950s cast doubt on Oparin’s scenario. Oparin originally invoked natural selection to explain how cells refined primitive metabolism once it had arisen. His scenario relied heavily on chance to explain the initial formation of the constituent biomacromolecules on which even primitive cellular metabolism would depend. Discovery during the 1950s of the extreme complexity and specificity of such molecules undermined the plausibility of his claim. For that and other reasons, Oparin published a revised version of his theory in 1968 that envisioned a role for natural selection earlier in the process of abiogenesis. His new theory claimed that natural selection acted on random polymers as they formed and changed within his coacervate protocells.72 As more complex and efficient molecules accumulated, they would have survived and reproduced more prolifically.

Even so, Oparin’s concept of prebiotic natural selection acting on initially unspecified biomacromolecules remained problematic. For one thing, it seemed to presuppose a preexisting mechanism of self-replication. Yet self-replication in all extant cells depends on functional and, therefore, (to a high degree) sequence-specific proteins and nucleic acids. Yet the origin of specificity in these molecules is precisely what Oparin needed to explain. As Christian de Duve has stated, theories of prebiotic natural selection “need information which implies they have to presuppose what is to be explained in the first place.”73 Oparin attempted to circumvent the problem by claiming that the first polymers need not have been highly sequence-specific. But that claim raised doubts about whether an accurate mechanism of self-replication (and thus natural selection) could have functioned at all. Oparin’s latter scenario did not reckon on a phenomenon known as error catastrophe, in which small errors, or deviations from functionally necessary sequences, are quickly amplified in successive replications.74

Thus, the need to explain the origin of specified information created an intractable dilemma for Oparin. On the one hand, if he invoked natural selection late in his scenario, he would need to rely on chance alone to produce the highly complex and specified biomolecules necessary to self-replication. On the other hand, if Oparin invoked natural selection earlier in the process of chemical evolution, before functional specificity in biomacromolecules would have arisen, he could give no account of how such prebiotic natural selection could even function (given the phenomenon of error-catastrophe). Natural selection presupposes a self-replication system, but self-replication requires functioning nucleic acids and proteins (or molecules approaching their complexity)—the very entities that Oparin needed to explain. Thus, Dobzhansky would insist that, “prebiological natural selection is a contradiction in terms.”75

Although some rejected the hypothesis of prebiotic natural selection as question-begging, others dismissed it as indistinguishable from implausible chance-based hypotheses.76 The work of mathematician John von Neumann supported that judgment. During the 1960s, von Neumann showed that any system capable of self-replication would require subsystems that were functionally equivalent to the information storage, replicating, and processing systems found in extant cells.77 His calculations established a very high minimal threshold of biological function, as would later experimental work.78 These minimal-complexity requirements pose a fundamental difficulty for

natural selection. Natural selection selects for functional advantage. It can play no role, therefore, until random variations produce some biologically advantageous arrangement of matter. Yet von Neumann's calculations and similar ones by Wigner, Landsberg, and Morowitz showed that in all probability (to understate the case) random fluctuations of molecules would not produce the minimal complexity needed for even a primitive replication system.79 As noted above, the improbability of developing a functionally integrated replication system vastly exceeds the improbability of developing the protein or DNA components of such a system. Given the huge improbability and the high functional threshold it implies, many origin-of-life researchers came to regard prebiotic natural selection as both inadequate and essentially indistinguishable from appeals to chance.

Nevertheless, during the 1980s, Richard Dawkins and Bernd-Olaf Kuppers attempted to resuscitate prebiotic natural selection as an explanation for the origin of biological information.80 Both accept the futility of naked appeals to chance and invoke what Kuppers calls a "Darwinian optimization principle." Both use computers to demonstrate the efficacy of prebiotic natural selection. Each selects a target sequence to represent a desired functional polymer. After creating a crop of randomly constructed sequences and generating variations among them at random, their computers select those sequences that match the target sequence most closely. The computers then amplify the production of those sequences, eliminate the others (to simulate differential reproduction), and repeat the process. As Kuppers puts it, "Every mutant sequence that agrees one bit better with the meaningful or reference sequence . . . will be allowed to reproduce more rapidly."81 In his case, after a mere thirty-five generations, his computer succeeded in spelling his target sequence, "NATURAL SELECTION."

Despite superficially impressive results, such "simulations" conceal an obvious flaw: Molecules in situ do not have a target sequence "in mind." Nor will they confer any selective advantage on a cell, and thus differentially reproduce, until they combine in a functionally advantageous arrangement. Thus, nothing in nature corresponds to the role that the computer plays in selecting functionally nonadvantageous sequences that happen to agree "one bit better" than others with a target sequence. The sequence NORMAL ELECTION may agree more with NATURAL SELECTION than does the sequence MISTRESS DEFECTION, but neither of the two yields any advantage in communication over the other in trying to communicate something about NATURAL SELECTION. If that is the goal, both are equally ineffectual. Even more to the point, a completely nonfunctional polypeptide would confer no selective advantage on a hypothetical protocell, even if its sequence happened to agree "one bit better" with an unrealized target protein than some other nonfunctional polypeptide.

Both Kuppers's and Dawkins's published results of their simulations show the early generations of variant phrases awash in nonfunctional gibberish.82 In Dawkins's simulation, not a single functional English word appears until after the tenth iteration (unlike the more generous example above that starts with actual, albeit incorrect, words). Yet to make distinctions on the basis of function among sequences that have no function is entirely unrealistic. Such determinations can be made only if considerations of proximity to possible future function are allowed, but that requires foresight, which natural selection does not have. A computer, programmed by a human being, can perform such functions. To imply that molecules can do so as well illicitly personifies nature. Thus, if these computer simulations demonstrate anything, they subtly demonstrate the need for intelligent agents to elect some options and exclude others—that is, to create information.

D. Self-Organizational Scenarios

Because of the difficulties with chance-based theories, including those relying on prebiotic natural selection, most origin-of-life theorists after the mid1960s attempted to address the problem of the origin of biological information in a completely different way. Researchers began to look for self-

organizational laws and properties of chemical attraction that might explain the origin of the specified information in DNA and proteins. Rather than invoking chance, such theories invoked necessity. If neither chance nor prebiotic natural selection acting on chance explains the origin of specified biological information, then those committed to finding a naturalistic explanation for the origin of life must necessarily rely on physical or chemical necessity. Given a limited number of broad explanatory categories, the inadequacy of chance (with or without prebiotic natural selection) has, in the minds of many researchers, left only one option. Christian de Duve articulates the logic: "a string of improbable events—drawing the same lottery number twice, or the same bridge hand twice in a row—does not happen naturally. All of which lead me to conclude that life is an obligatory manifestation of matter, bound to arise where conditions are appropriate."83

When origin-of-life biologists began considering the self-organizational perspective that de Duve describes, several researchers proposed that deterministic forces (stereochemical "necessity") made the origin of life not just probable but inevitable. Some suggested that simple chemicals possessed "self-ordering properties" capable of organizing the constituent parts of proteins, DNA, and RNA into the specific arrangements they now possess.84 Steinman and Cole, for example, suggested that differential bonding affinities or forces of chemical attraction between certain amino acids might account for the origin of the sequence specificity of proteins.85 Just as electrostatic forces draw sodium (Na^+) and chloride (Cl^-) ions together into highly ordered patterns within a crystal of salt (NaCl), so, too, might amino acids with special affinities for each other arrange themselves to form proteins. In 1969, Kenyon and Steinman developed that idea in a book entitled Biochemical Predestination. They argued that life might have been "biochemically predestined" by the properties of attraction existing between its constituent chemical parts, particularly among the amino acids in proteins.86

In 1977, another self-organizational theory was proposed by Prigogine and Nicolis based on a thermodynamic characterization of living organisms. In Self Organization in Nonequilibrium Systems, Prigogine and Nicolis classified living organisms as open, nonequilibrium systems capable of "dissipating" large quantities of energy and matter into the environment.87 They observed that open systems driven far from equilibrium often display self-ordering tendencies. For example, gravitational energy will produce highly ordered vortices in a draining bathtub; thermal energy flowing through a heat sink will generate distinctive convection currents or "spiral wave activity." Prigogine and Nicolis argued that the organized structures observed in living systems might have similarly "self-originated" with the aid of an energy source. In essence, they conceded the improbability of simple building blocks arranging themselves into highly ordered structures under normal equilibrium conditions. But they suggested that, under non-equilibrium conditions, where an external source of energy is supplied, biochemical building blocks might arrange themselves into highly ordered patterns.

More recently, Kauffman and de Duve have proposed self-organizational theories with somewhat less specificity, at least with regard to the problem of the origin of specified genetic information.88 Kauffman invokes so-called autocatalytic properties to generate metabolism directly from simple molecules. He envisions such autocatalysis occurring once very particular configurations of molecules have arisen in a rich "chemical minestrone." De Duve also envisions protometabolism emerging first with genetic information arising later as a byproduct of simple metabolic activity.

E. Order versus Information

For many current origin-of-life scientists, self-organizational models now seem to offer the most promising approach to explaining the origin of specified biological information. Nevertheless, critics have called into question both the plausibility and the relevance of self-organizational models. Ironically, a prominent early advocate of self-organization, Dean Kenyon, has now explicitly

repudiated such theories as both incompatible with empirical findings and theoretically incoherent.89

First, empirical studies have shown that some differential affinities do exist between various amino acids (that is, certain amino acids do form linkages more readily with some amino acids than with others).90 Nevertheless,

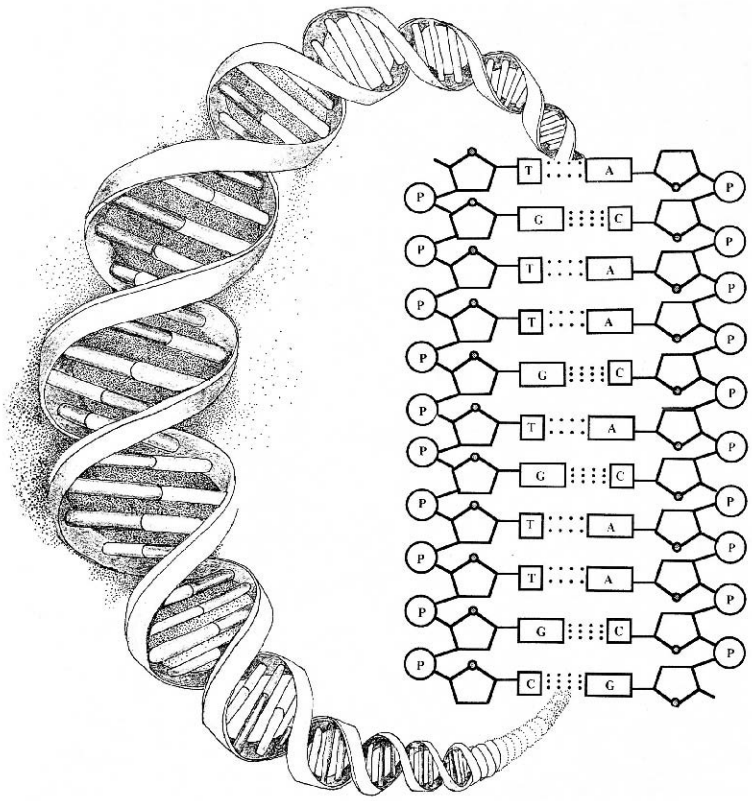

FIGURE 2. The bonding relationship between the chemical constituents of the DNA molecule. Sugars (designated by the pentagons) and phosphates (designated by the circled Ps) are linked chemically. Nucleotide bases (A's, T's, G's and C's) are bonded to the sugar-phosphate backbones. Nucleotide bases are linked by hydrogen bonds (designated by dotted double or triple lines) across the double helix. But no chemical bonds exist between the nucleotide bases along the message-bearing spine of the helix. Courtesy of Fred Heeren, Day Star publications.

such differences do not correlate to actual sequences in large classes of known proteins.91 In short, differing chemical affinities do not explain the multiplicity of amino acid sequences existing in naturally occurring proteins or the sequential arrangement of amino acids in any particular protein.

In the case of DNA, this point can be made more dramatically. Figure 2 shows that the structure of DNA depends on several chemical bonds. There are bonds, for example, between the sugar and the phosphate molecules forming the two twisting backbones of the DNA molecule. There are bonds fixing individual (nucleotide) bases to the sugar-phosphate backbones on each side of the molecule. There are also hydrogen bonds stretching horizontally across the molecule between nucleotide bases, making so-called complementary pairs. The individually weak hydrogen bonds, which in concert hold two complementary copies of the DNA message text together, make replication of the

genetic instructions possible. It is important to note, however, that there are no chemical bonds between the bases along the longitudinal axis in the center of the helix. Yet it is precisely along this axis of the DNA molecule that the genetic information is stored.

Further, just as magnetic letters can be combined and recombined in any way to form various sequences on a metal surface, so, too, can each of the four bases—A, T, G, and C—attach to any site on the DNA backbone with equal facility, making all sequences equally probable (or improbable). Indeed, there are no significant differential affinities between any of the four bases and the binding sites along the sugar-phosphate backbone. The same type of N-glycosidic bond occurs between the base and the backbone regardless of which base attaches. All four bases are acceptable; none is chemically favored. As Kuppers has noted, "The properties of nucleic acids indicate that all the combinatorially possible nucleotide patterns of a DNA are, from a chemical point of view, equivalent."92 Thus, "self-organizing" bonding affinities cannot explain the sequentially specific arrangement of nucleotide bases in DNA because (1) there are no bonds between bases along the information-bearing axis of the molecule, and (2) there are no differential affinities between the backbone and the specific bases that could account for variations in sequence. Because the same holds for RNA molecules, researchers who speculate that life began in an RNA world have also failed to solve the sequence specificity problem—that is, the problem of explaining how information in functioning RNA molecules could have arisen in the first place.

For those who want to explain the origin of life as the result of self-organizing properties intrinsic to the material constituents of living systems, these rather elementary facts of molecular biology have decisive implications. The most obvious place to look for self-organizing properties to explain the origin of genetic information is in the constituent parts of the molecules that carry that information. But biochemistry and molecular biology make clear that forces of attraction between the constituents in DNA, RNA, and proteins do not explain the sequence specificity of these large, information-bearing biomolecules.

The properties of the monomers constituting nucleic acids and proteins simply do not make a particular gene, let alone life as we know it, inevitable. (We know this, in addition to the reasons already stated, because of the many variant polypeptides and gene sequences that exist in nature and that have been synthesized in the laboratory.) Yet if self-organizational scenarios for the origin of biological information are to have any theoretical import, they must claim just the opposite. And that claim is often made, albeit without much specificity. As de Duve has put it, "the processes that generated life" were "highly deterministic," making life as we know it "inevitable" given "the conditions that existed on the prebiotic earth."93 Yet imagine the most favorable prebiotic conditions. Imagine a pool of all four DNA bases and all necessary sugars and phosphates; would any particular genetic sequence inevitably arise? Given all necessary monomers, would any particular functional protein or gene, let alone a specific genetic code, replication system, or signal transduction circuitry, inevitably arise? Clearly not.

In the parlance of origin-of-life research, monomers are "building blocks," and building blocks can be arranged and rearranged in innumerable ways. The properties of stone blocks do not determine their own arrangement in the construction of buildings. Similarly, the properties of biological building blocks do not determine the arrangement of functional polymers. Instead, the chemical properties of the monomers allow a vast ensemble of possible configurations, the overwhelming majority of which have no biological function whatsoever. Functional genes or proteins are no more inevitable, given the properties of their "building blocks," than, for example, the Palace of Versailles was inevitable, given the properties of the stone blocks that were used to construct it. To anthropomorphize, neither bricks and stone, nor letters in a written text, nor nucleotide bases "care" how they are arranged. In each case, the properties of the constituents remain largely

indifferent to the many specific configurations or sequences they may adopt, nor do they make any specific structures "inevitable" as self-organizationalists must claim.

Significantly, information theory makes clear that there is a good reason for this. If chemical affinities between the constituents in the DNA determined the arrangement of the bases, such affinities would dramatically diminish the capacity of DNA to carry information. Recall that classical information theory equates the reduction of uncertainty with the transmission of information, whether specified or unspecified. The transmission of information, therefore, requires physical-chemical contingency. As Robert Stalnaker has noted, "[information] content requires contingency."94 If, therefore, forces of chemical necessity completely determine the arrangement of constituents in a system, that arrangement will not exhibit complexity or convey information.

Consider, for example, what would happen if the individual nucleotide bases (A, C, G, and T) in the DNA molecule did interact by chemical necessity (along the information-bearing axis of DNA). Suppose that every time adenine (A) occurred in a growing genetic sequence, it attracted cytosine (C) to it.95 Suppose every time guanine (G) appeared, thymine (T) followed. If this were the case, the longitudinal axis of DNA would be peppered with repetitive sequences in which A followed C and T followed by G. Rather than a genetic molecule capable of virtually unlimited novelty and characterized by unpredictable and aperiodic sequences, DNA would contain sequences awash in repetition or redundancy—much like the arrangement of atoms in crystals. In a crystal, the forces of mutual chemical attraction do determine, to a very considerable extent, the sequential arrangement of its constituent parts. Hence, sequencing in crystals is highly ordered and repetitive but neither complex nor informative. In DNA, however, where any nucleotide can follow any other, a vast array of novel sequences is possible, corresponding to a multiplicity of possible amino acid sequences and protein functions.

The forces of chemical necessity produce redundancy (roughly, law- or rule-generated repetition) or monotonous order but reduce the capacity to convey information and express novelty. Thus, as chemist Michael Polanyi noted:

> Suppose that the actual structure of a DNA molecule were due to the fact that the bindings of its bases were much stronger than the bindings would be for any other distribution of bases, then such a DNA molecule would have no information content. Its code-like character would be effaced by an overwhelming redundancy. . . . Whatever may be the origin of a DNA configuration, it can function as a code only if its order is not due to the forces of potential energy. It must be as physically indeterminate as the sequence of words is on a printed page [emphasis added].96

In other words, if chemists had found that bonding affinities between the nucleotides in DNA produced nucleotide sequencing, they also would have found that they had been mistaken about DNA's information-bearing properties. Or, to put the point quantitatively, to the extent that forces of attraction between constituents in a sequence determine the arrangement of the sequence, to that extent will the information-carrying capacity of the system be diminished or effaced by redundancy.97 As Dretske has explained: "As p(si) [the probability of a condition or state of affairs] approaches 1, the amount of information associated with the occurrence of si goes to 0. In the limiting case when the probability of a condition or state of affairs is unity [p(si) = 1], no information is associated with, or generated by, the occurrence of si. This is merely another way to say that no information is generated by the occurrence of events for which there are no possible alternatives."98

Bonding affinities, to the extent they exist, inhibit the maximization of information because they determine that specific outcomes will follow specific conditions with high probability.99 Yet

information-carrying capacity is maximized when just the opposite situation obtains, namely, when antecedent conditions allow many improbable outcomes.

Of course, as noted in part I, section D, the base sequences in DNA do more than possess information-carrying capacity (or syntactic information) as measured by classical Shannon information theory. These sequences store functionally specified information—that is, they are specified as well as complex. Clearly, however, a sequence cannot be both specified and complex if it is not at least complex. Therefore, self-organizational forces of chemical necessity, which produce redundant order and preclude complexity, also preclude the generation of specified complexity (or specified information) as well. Chemical affinities do not generate complex sequences. Thus, they cannot be invoked to explain the origin of information, whether specified or otherwise.

A tendency to conflate the qualitative distinctions between "order" and "complexity" has characterized self-organizational scenarios—whether those that invoke internal properties of chemical attraction or an external organizing force or source of energy. That tendency calls into question the relevance of these scenarios of the origin of life. As Yockey has argued, the accumulation of structural or chemical order does not explain the origin of biological complexity or genetic information. He concedes that energy flowing through a system may produce highly ordered patterns. Strong winds form swirling tornados and the "eyes" of hurricanes; Prigogine's thermal baths do develop interesting convection currents; and chemical elements do coalesce to form crystals. Self-organizational theorists explain well what does not need explaining. What needs explaining in biology is not the origin of order (defined as symmetry or repetition) but the specified information—the highly complex, aperiodic, and specified sequences that make biological function possible. As Yockey warns: "Attempts to relate the idea of order . . . with biological organization or specificity must be regarded as a play on words that cannot stand careful scrutiny. Informational macromolecules can code genetic messages and therefore can carry information because the sequence of bases or residues is affected very little, if at all, by [self-organizing] physicochemical factors."100

In the face of these difficulties, some self-organizational theorists have claimed that we must await the discovery of new natural laws to explain the origin of biological information. As Manfred Eigen has argued, "our task is to find an algorithm, a natural law, that leads to the origin of information."101 Such a suggestion betrays confusion on two counts. First, scientific laws don't generally produce or cause natural phenomena, they describe them. For example, Newton's law of gravitation described, but did not cause or explain, the attraction between planetary bodies. Second, laws necessarily describe highly deterministic or predictable relationships between antecedent conditions and consequent events. Laws describe highly repetitive patterns in which the probability of each successive event (given the previous event) approaches unity. Yet information sequences are complex, not repetitive—information mounts as improbabilities multiply. Thus, to say that scientific laws can produce information is essentially a contradiction in terms. Instead, scientific laws describe (almost by definition) highly predictable and regular phenomena—that is, redundant order, not complexity (whether specified or otherwise).

Though the patterns that natural laws describe display a high degree of regularity, and thus lack the complexity that characterizes information-rich systems, one could argue that we might someday discover a very particular configuration of initial conditions that routinely generates high informational states. Thus, while we cannot hope to find a law that describes an information-rich relationship between antecedent and consequent variables, we might find a law that describes how a very particular set of initial conditions routinely generates a high information state. Yet even the statement of this hypothetical seems itself to beg the question of the ultimate origin of information, since "a very particular set of initial conditions" sounds precisely like an information-

rich—a highly complex and specified—state. In any case, everything we know experientially suggests that the amount of specified information present in a set of antecedent conditions necessarily equals or exceeds that of any system produced from those conditions.

F. Other Scenarios and the Displacement of the Information Problem

In addition to the general categories of explanation already examined, origin-of-life researchers have proposed many more specific scenarios, each emphasizing random variations (chance), self-organizational laws (necessity), or both. Some of those scenarios purport to address the information problem; others attempt to bypass it altogether. Yet on closer examination, even scenarios that appear to alleviate the problem of the origin of specified biological information merely shift the problem elsewhere. Genetic algorithms can "solve" the information problem, but only if programmers provide informative target sequences and selection criteria. Simulation experiments can produce biologically relevant precursors and sequences, but only if experimentalists manipulate initial conditions or select and guide outcomes—that is, only if they add information themselves. Origin-of-life theories can leapfrog the problem altogether, but only by presupposing the presence of information in some other preexisting form.

Any number of theoretical models for the origin of life have fallen prey to this difficulty. For example, in 1964, Henry Quastler, an early pioneer in the application of information theory to molecular biology, proposed a DNA-first model for the origin of life. He envisioned the initial emergence of a system of unspecified polynucleotides capable of primitive self-replication via the mechanisms of complementary base-pairing. The polymers in his system would have, on Quastler's account, initially lacked specificity (which he equated with information).102 Only later, when his system of polynucleotides had come into association with a fully functional set of proteins and ribosomes, would the specific nucleotide sequences in the polymers take on any functional significance. He likened that process to the random selection of a combination for a lock in which the combination would only later acquire functional significance once particular tumblers had been set to allow the combination to open the lock. In both the biological and the mechanical case, the surrounding context would confer functional specificity on an initially unspecified sequence. Thus, Quastler characterized the origin of information in polynucleotides as an "accidental choice remembered."

Although Quastler's way of conceiving of the origin of specified biological information did allow "a chain of nucleotides [to] become a [functional] system of genes without necessarily suffering any change in structure," it did have an overriding difficulty. It did not account for the origin of the complexity and specificity of the system of molecules whose association with the initial sequence gave the initial sequence functional significance. In Quastler's combination-lock example, conscious agents chose the tumbler settings that made the initial combination functionally significant. Yet Quastler expressly precluded conscious design as a possibility for explaining the origin of life.103 Instead, he seemed to suggest that the origin of the biological context—that is, the complete set of functionally specific proteins (and the translation system) necessary to create a "symbiotic association" between polynucleotides and proteins—would arise by chance. He even offered some rough calculations to show that the origin of such a multimolecular context, though improbable, would have been probable enough to expect it to occur by chance in the prebiotic soup. Quastler's calculations now seem extremely implausible in light of the discussion of minimal complexity in part II, section B.104 More significantly, Quastler "solved" the problem of the origin of complex specificity in nucleic acids only by transferring the problem to an equally complex and specified system of proteins and ribosomes. Whereas, admittedly, any polynucleotide sequence would suffice initially, the subsequent proteins and ribosomal material constituting the translation system would have to possess an extreme specificity relative to the initial polynucleotide sequence and relative to any protocellular functional requirements. Thus, Quastler's attempt to bypass the sequence specificity problem merely shifted it elsewhere.

Self-organizational models have encountered similar difficulties. For example, chemist J. C. Walton has argued (echoing earlier articles by Mora) that the self-organizational patterns produced in Prigogine-style convection currents do not exceed the organization or structural information represented by the experimental apparatus used to create the currents.105 Similarly, Maynard-Smith, Dyson, and Shapiro have shown that Eigen's so-called hypercycle model for generating biological information actually shows how information tends to degrade over time.106 Eigen's hypercycles presuppose a large initial contribution of information in the form of a long RNA molecule and some forty specific proteins and thus do not attempt to explain the ultimate origin of biological information. Moreover, because hypercycles lack an error-free mechanism of self-replication, the proposed mechanism succumbs to various "error-catastrophes" that ultimately diminish, not increase, the (specified) information content of the system over time.

Stuart Kauffman's self-organizational theory also subtly transfers the problem of the origin of information. In The Origins of Order, Kauffman attempts to leapfrog the sequence-specificity problem by proposing a means by which a self-reproducing and metabolic system might emerge directly from a set of "low specificity" catalytic peptides and RNA molecules in a prebiotic soup or "chemical minestrone." Kauffman envisions, as Iris Frey puts it, "a set of catalytic polymers in which no single molecule reproduces itself, but the system as a whole does."107 Kauffman argues that once a sufficiently diverse set of catalytic molecules had assembled (in which the different peptides performed enough different catalytic functions) the ensemble of individual molecules would spontaneously undergo a kind of phase transition resulting in a self-reproducing metabolic system. Thus, Kauffman argues that metabolism can arise directly without genetic information encoded in DNA.108

Nevertheless, Kauffman's scenario does not solve, or bypass, the problem of the origin of biological information. Instead, it either presupposes the existence of unexplained sequence-specificity or it transfers such needed specificity out of view. Kauffman claims that an ensemble of relatively short and low specificity catalytic peptides and RNA molecules would suffice jointly to establish a metabolic system. He defends the biochemical plausibility of his scenario on the grounds that some proteins can perform enzymic functions with low specificity and complexity. He cites proteases such as trypsin that cleave peptide bonds at single amino acid sites and proteins in the clotting cascade that "cleave essentially single target polypeptides" to support his claim.109

Yet Kauffman's argument has two problems. First, it does not follow, nor is it the case biochemically, that just because some enzymes might function with low specificity, that all the catalytic peptides (or enzymes) needed to establish a self-reproducing metabolic cycle could function with similarly low levels of specificity and complexity. Instead, modern biochemistry shows that at least some, and probably many, of the molecules in a closed interdependent system of the type that Kauffman envisions would require high complexity and specificity proteins. Enzymatic catalysis (which his scenario would surely necessitate) invariably requires molecules long enough (at least 50-mers) to form tertiary structures (whether in polynucleotides or polypeptides). Further, these long polymers invariably require very specific three-dimensional geometries (which can in turn derive from sequence-specific arrangements of monomers) in order to catalyze necessary reactions. How do these molecules acquire their specificity of sequencing? Kauffman does not address this question because his illustration incorrectly suggests that he need not do so.

Secondly, it turns out that even the allegedly low specificity molecules that Kauffman cites to illustrate the plausibility of his scenario do not themselves manifest low complexity and specificity. Instead, Kauffman has confused the specificity and complexity of the parts of the polypeptides upon which the proteases act with the specificity and complexity of the proteins (the proteases) that do the enzymatic acting. Though trypsin, for example, acts upon (cleaves) peptide bonds at a

relatively simple target (the carboxyl end of two separate amino acids, argenine, and lysine), trypsin itself is a highly complex and specifically-sequenced molecule. Indeed, trypsin is a non-repeating 200+ residue protein that possesses significant sequence-specificity as a condition of its function.110 Further, it has to manifest significant three-dimensional (geometric) specificity to recognize the specific amino acids argenine and lysine—sites at which it cleaves peptide bonds. By equivocating in his discussion of specificity, Kauffman obscures from view the considerable specificity and complexity requirement of even the proteases he cites to justify his claim that low specificity catalytic peptides will suffice to establish a metabolic cycle. Thus, Kauffman's own illustration properly understood (that is, without equivocating about the relevant locus of specificity), shows that for his scenario to have biochemical plausibility it must presuppose the existence of many high complexity and specificity polypeptides and polynucleotides. Where does this information in these molecules come from? Kauffman, again, does not say.

Further, Kauffman must acknowledge (as he seems to in places),111 that for autocatalysis (for which there is as yet no experimental evidence) to occur, the molecules in the "chemical minestrone" must be held in a very specific spatial-temporal relationship to one another. In other words, for the direct autocatalysis of integrated metabolic complexity to occur, a system of catalytic peptide molecules must first achieve a very specific molecular configuration, or a low configurational entropy state.112 Yet this requirement is isomorphic with the requirement that the system must start with a highly specified complexity. Thus, to explain the origin of specified biological complexity at the systems level, Kauffman must presuppose the existence of highly specific and complex (i.e., information-rich) molecules as well as a highly specific arrangement of those molecules at the molecular level. Therefore, his work—if it has any relevance to the actual behavior of molecules—presupposes or transfers, rather than explains, the ultimate origin of specified complexity or information.

Others have claimed that the RNA-world scenario offers a promising approach to the origin-of-life problem and with it, presumably, the problem of the origin of the first genetic information. The RNA world was proposed as an explanation for the origin of the interdependence of nucleic acids and proteins in the cell's information-processing system. In extant cells, building proteins requires genetic information from DNA, but information on DNA cannot be processed without many specific proteins and protein complexes. This poses a chicken-or-egg problem. The discovery that RNA (a nucleic acid) possesses some limited catalytic properties similar to those of proteins suggested a way to solve that problem. "RNA-first" advocates proposed an early state in which RNA performed both the enzymatic functions of modern proteins and the information-storage function of modern DNA, thus allegedly making the interdependence of DNA and proteins unnecessary in the earliest living system.

Nevertheless, many fundamental difficulties with the RNA-world scenario have emerged. First, synthesizing (and/or maintaining) many essential building blocks of RNA molecules under realistic conditions has proven either difficult or impossible.113 Further, the chemical conditions required for the synthesis of ribose sugars are decidedly incompatible with the conditions required for synthesizing nucleotide bases.114 Yet both are necessary constituents of RNA. Second, naturally occurring RNA possesses very few of the specific enzymatic properties of proteins necessary to extant cells. Third, RNA-world advocates offer no plausible explanation for how primitive RNA replicators might have evolved into modern cells that do rely almost exclusively on proteins to process genetic information and regulate metabolism.115 Fourth, attempts to enhance the limited catalytic properties of RNA molecules in so-called ribozyme engineering experiments have inevitably required extensive investigator manipulation, thus simulating, if anything, the need for intelligent design, not the efficacy of an undirected chemical evolutionary process.116

Most important for our present considerations, the RNA-world hypothesis presupposes, but does not explain, the origin of sequence specificity or information in the original functional RNA molecules. Indeed, the RNA-world scenario was proposed as an explanation for the functional interdependence problem, not the information problem. Even so, some RNA-world advocates seem to envision leapfrogging the sequence-specificity problem. They imagine oligomers of RNA arising by chance on the prebiotic earth and then later acquiring an ability to polymerize copies of themselves—that is, to self-replicate. In such a scenario, the capacity to self-replicate would favor the survival of those RNA molecules that could do so and would thus favor the specific sequences that the first self-replicating molecules happened to have. Thus, sequences that originally arose by chance would subsequently acquire a functional significance as "an accidental choice remembered."

Like Quastler's DNA-first model, however, this suggestion merely shifts the specificity problem out of view. First, for strands of RNA to perform enzymatic functions (including enzymatically mediated self-replication), they must, like proteins, have very specific arrangements of constituent building blocks (nucleotides in the RNA case). Further, the strands must be long enough to fold into complex three-dimensional shapes (to form so-called tertiary structures). Thus, any RNA molecule capable of enzymatic function must have the properties of complexity and specificity exhibited by DNA and proteins. Hence, such molecules must possess considerable (specified) information content. And yet explaining how the building blocks of RNA might have arranged themselves into functionally specified sequences has proven no easier than explaining how the constituent parts of DNA might have done so, especially given the high probability of destructive cross-reactions between desirable and undesirable molecules in any realistic prebiotic soup. As de Duve has noted in a critique of the RNA-world hypothesis, "hitching the components together in the right manner raises additional problems of such magnitude that no one has yet attempted to do so in a prebiotic context."117

Second, for a single-stranded RNA catalyst to self-replicate (the only function that could be selected in a prebiotic environment), it must find another catalytic RNA molecule in close vicinity to function as a template, since a single-stranded RNA cannot function as both enzyme and template. Thus, even if an originally unspecified RNA sequence might later acquire functional significance by chance, it could perform a function only if another RNA molecule—that is, one with a highly specific sequence relative to the original—arose in close vicinity to it. Thus, the attempt to bypass the need for specific sequencing in an original catalytic RNA only shifts the specificity problem elsewhere, namely, to a second and necessarily highly specific RNA sequence. Put differently, in addition to the specificity required to give the first RNA molecule self-replicating capability, a second RNA molecule with an extremely specific sequence—one with essentially the same sequence as the original—would also have to arise. Yet RNA-world theorists do not explain the origin of the requisite specificity in either the original molecule or its twin. Joyce and Orgel have calculated that to have a reasonable chance of finding two identical RNA molecules of a length sufficient to perform enzymatic functions would require an RNA library of some 1054 RNA molecules.118 The mass of such a library vastly exceeds the mass of the earth, suggesting the extreme implausibility of the chance origin of a primitive replicator system. Yet one cannot invoke natural selection to explain the origin of such primitive replicators, since natural selection only ensues once self-replication has arisen. Further, RNA bases, like DNA bases, do not manifest self-organizational bonding affinities that could explain their specific sequencing. In short, the same kind of evidentiary and theoretical problems emerge whether one proposes that genetic information arose first in RNA or DNA molecules. The attempt to leapfrog the sequencing problem by starting with RNA replicators only shifts the problem to the specific sequences that would make such replication possible.

III.

A. The Return of the Design Hypothesis

If attempts to solve the information problem only relocate it, and if neither chance nor physical-chemical necessity, nor the two acting in combination, explains the ultimate origin of specified biological information, what does? Do we know of any entity that has the causal powers to create large amounts of specified information? We do. As Henry Quastler recognized, the "creation of new information is habitually associated with conscious activity."119

Experience affirms that specified complexity or information (defined hereafter as specified complexity) routinely arises from the activity of intelligent agents. A computer user who traces the information on a screen back to its source invariably comes to a mind, that of a software engineer or programmer. Similarly, the information in a book or newspaper column ultimately derives from a writer—from a mental, rather than a strictly material, cause.

Further, our experience-based knowledge of information-flow confirms that systems with large amounts of specified complexity or information (especially codes and languages) invariably originate from an intelligent source—that is, from a mind or a personal agent.120 Moreover, this generalization holds not only for the semantically specified information present in natural languages but also for other forms of information or specified complexity whether present in machine codes, machines, or works of art.

Like the letters in a section of meaningful text, the parts in a working engine represent a highly improbable yet functionally specified configuration. Similarly, the highly improbable shapes in the rock on Mount Rushmore conform to an independently given pattern: the faces of American presidents known from books and paintings. Thus, both systems have a large amount of specified complexity or information so defined. Not coincidentally, they also originated by intelligent design, not by chance and/or physical-chemical necessity.

This generalization—that intelligence is the only known cause of specified complexity or information (at least, starting from a nonbiological source)—has received support from origin-of-life research itself. During the last forty years, every naturalistic model proposed has failed to explain the origin of the specified genetic information required to build a living cell.121 Thus, mind or intelligence, or what philosophers call "agent causation," now stands as the only cause known to be capable of generating large amounts of information starting from a nonliving state.122 As a result, the presence of specified information-rich sequences in even the simplest living systems would seem to imply intelligent design.123

Recently, a formal theoretical account of design reasoning has been developed that supports this conclusion. In The Design Inference, mathematician and probability theorist William Dembski notes that rational agents often infer or detect the prior activity of other minds by the character of the effects they leave behind. Archaeologists assume, for example, that rational agents produced the inscriptions on the Rosetta stone; insurance-fraud investigators detect certain "cheating patterns" that suggest intentional manipulation of circumstances rather than "natural" disasters; cryptographers distinguish between random signals and those that carry encoded messages. Dembski's work shows that recognizing the activity of intelligent agents constitutes a common and fully rational mode of inference.124

More important, Dembski identifies two criteria that typically enable human observers to recognize intelligent activity and to distinguish the effects of such activity from the effects of strictly material causes. He notes that we invariably attribute systems, sequences, or events that have the joint properties of "high complexity" (or low probability) and "specification" (see part I, section E) to intelligent causes—to design—not to chance or physical-chemical laws.125 By contrast, he notes that we typically attribute to chance those low or intermediate probability events that do not con-

form to discernable patterns. We attribute to necessity highly probable events that repeatedly recur in a regular or lawlike way.

These inference patterns reflect our knowledge of the way the world works. Since experience teaches, for example, that complex and specified events or systems invariably arise from intelligent causes, we can infer intelligent design from events that exhibit the joint properties of complexity and specificity. Dembski's work suggests a comparative evaluation process for deciding between natural and intelligent causes based on the probabilistic features or "signatures" they leave behind.126 This evaluation process constitutes, in effect, a scientific method for detecting the activity of intelligence in the echo of its effects.

A homespun example illustrates Dembski's method and criteria of design detection. When visitors first enter Victoria Harbor in Canada from the sea, they notice a hillside awash in red and yellow flowers. As they get closer, they reflexively, and correctly, infer design. Why? Observers quickly recognize a complex and specified pattern, an arrangement of flowers spelling "Welcome to Victoria." They infer the past activity of an intelligent cause—in this case, the careful planning of gardeners. Had the flowers been more haphazardly scattered so as to defy pattern-recognition, observers might have justifiably attributed the arrangement to chance—for example, to random gusts of wind scattering the seed. Had the colors been segregated by elevation, the pattern might have been explained by some natural necessity, such as certain types of plants requiring particular environments or soil types. But since the arrangement exhibits both complexity (the specific arrangement of flowers is highly improbable given the space of possible arrangements) and specificity (the pattern of flowers conforms to the independent requirements of English grammar and vocabulary), observers naturally infer intelligent design. As it turns out, these twin criteria are equivalent (or isomorphic, see part I, section E) with the notion of information as used in molecular biology. Thus, Dembski's theory, when applied to molecular biology, implies that intelligent design played a role in the origin of (specified) biological information.

The logical calculus underlying this inference follows a valid and well-established method used in all historical and forensic sciences. In historical sciences, knowledge of the present causal powers of various entities and processes enables scientists to make inferences about possible causes in the past. When a thorough study of various possible causes turns up only a single adequate cause for a given effect, historical or forensic scientists can make definitive inferences about the past.127

The Martian landscape, for example, displays erosional features— trenches and rills—that resemble those produced on Earth by moving water. Though Mars at present has no significant liquid water on its surface, some planetary scientists have nevertheless inferred that Mars did have a significant amount of water on its surface in the past. Why? Geologists and planetologists have not observed any cause other than moving water that can produce the kind of erosional features that we observe on Mars today. Since in our experience water alone produces erosional trenches and rills, the presence of these features on Mars allows planetologists to infer the past action of water on the surface of the red planet.

Or consider another example. Several years ago one of the forensic pathologists from the original Warren Commission that investigated the assassination of President Kennedy spoke out to quash rumors about a second gunman firing from in front of the motorcade. The bullet hole in the back of President Kennedy's skull apparently evidenced a distinctive beveling pattern that clearly indicated that it had entered his skull from the rear. The pathologist called the beveling pattern a "distinctive diagnostic" because the pattern indicated a single possible direction of entry. Since a rear entry was necessary to cause the beveling pattern in the back of the president's skull, the pattern allowed the forensic pathologists to diagnose the trajectory of the bullet.128

Logically, one can infer a cause from its effect (or an antecedent from a consequent) when the cause (or antecedent) is known to be necessary to produce the effect in question. If it's true that "where there's smoke there's fire," then the presence of smoke billowing over a hillside allows us to infer a fire beyond our view. Inferences based on knowledge of empirically necessary conditions or causes ("distinctive diagnostics") are common in historical and forensic sciences and often lead to the detection of intelligent as well as natural causes and events. Since criminal X's fingers are the only known cause of criminal X's fingerprints, X's prints on the murder weapon incriminate him with a high degree of certainty. Similarly, since intelligent design is the only known cause of large amounts of specified complexity or information, the presence of such information implies an intelligent source.

Indeed, since experience affirms mind or intelligent design as a necessary condition (and necessary cause) of information, one can detect (or retrodict) the past action of an intelligence from an information-rich effect—even if the cause itself cannot be directly observed.129 Thus, the pattern of flowers spelling "Welcome to Victoria" allows visitors to infer the activity of intelligent agents even if they did not see the flowers planted or arranged. Similarly, the specified and complex arrangement of nucleotide sequences—the information—in DNA implies the past action of an intelligence, even if such mental activity cannot be directly observed.

Scientists in many fields recognize the connection between intelligence and information and make inferences accordingly. Archaeologists assume that a scribe produced the inscriptions on the Rosetta stone; evolutionary anthropologists establish the intelligence of early hominids from chipped flints that are too improbably specified in form (and function) to have been produced by natural causes; NASA's search for extraterrestrial intelligence (SETI) presupposes that any information embedded in electromagnetic signals coming from space would indicate an intelligent source.130 As yet, however, radio-astronomers have not found any such information-bearing signals. But closer to home, molecular biologists have identified information-rich sequences and systems in the cell, suggesting, by the same logic, an intelligent cause for those effects.

B. Argument from Ignorance? Or Inference to the Best Explanation?

Some would object that any such argument to design constitutes an argument from ignorance. Objectors charge that design advocates use our present ignorance of any sufficient natural cause of information as the sole basis for inferring an intelligent cause of the information present in the cell. Since we don't yet know how biological information could have arisen, we invoke the mysterious notion of intelligent design. On this view, intelligent design functions not as an explanation but as a placeholder for ignorance.

Although the inference to design from the presence of information in DNA does not qualify as a deductively certain proof of intelligent design (empirically based arguments in science rarely do), it does not constitute a fallacious argument from ignorance. Arguments from ignorance occur when evidence against a proposition X is offered as the sole (and conclusive) grounds for accepting some alternative proposition Y.

The inference to design as sketched above (see part III, section A) does not commit this fallacy. True, the previous section of this essay (see part II, sections A-F) argued that at present all types of natural causes and mechanisms fail to account for the origin of biological information from a prebiotic state. And clearly, this lack of knowledge of any adequate natural cause does provide part of the grounds for inferring design from information in the cell. (Though one could just as easily argue that even this "absence of knowledge" actually constitutes a knowledge of absence.) In any case, our "ignorance" of any sufficient natural cause is only part of the basis inferring design. We also know that intelligent agents can and do produce information-rich systems: we have positive experience-based knowledge of an alternative cause that is sufficient, namely, intelligence.

For this reason, the design inference defended here does not constitute an argument from ignorance but an inference to the best explanation.131 Inferences to the best explanation do not assert the adequacy of one causal explanation merely on the basis of the inadequacy of some other causal explanation. Instead, they compare the explanatory power of many competing hypotheses to determine which hypothesis would, if true, provide the best explanation for some set of relevant data. Recent work on the method of "inference to the best explanation" suggests that determining which among a set of competing possible explanations constitutes the best depends on knowledge of the causal powers of competing explanatory entities.132

For example, both an earthquake and a bomb could explain the destruction of the building, but only a bomb could explain the presence of charring and shrapnel at the scene of the rubble. Earthquakes do not produce shrapnel, nor do they cause charring, at least not on their own. Thus, the bomb best explains the pattern of destruction at the building site. Entities, conditions, or processes that have the capability (or causal powers) to produce the evidence in question constitute better explanations of that evidence than those that do not.

It follows that the process of determining the best explanation often involves generating a list of possible hypotheses, comparing their known (or theoretically plausible) causal powers with respect to the relevant data, and then progressively eliminating potential but inadequate explanations, and finally, in the best case, electing the one remaining causally adequate explanation.

This essay has followed precisely this method to make a case for intelligent design as the best explanation for the origin of biological information. It has evaluated and compared the causal efficacy of four broad categories of explanation—chance, necessity, the combination of those two, and intelligent design—with respect to their ability to produce large amounts of specified complexity or information. As we have seen, neither scenarios based on chance nor those based on necessity (nor those that combine the two) can explain the origin of specified biological information in a prebiotic context. That result comports with our uniform human experience. Natural processes do not produce information-rich structures starting from purely physical or chemical antecedents. Nor does matter, whether acting at random or under the force of physical-chemical necessity, arrange itself into complex, information-rich sequences.

Nevertheless, it is not correct to say that we do not know how information arises. We know from experience that conscious intelligent agents can create informational sequences and systems. To quote Quastler again, the "creation of new information is habitually associated with conscious activity."133 Further, experience teaches that whenever large amounts of specified complexity or information are present in an artifact or entity whose causal story is known, invariably creative intelligence—intelligent design— played a causal role in the origin of that entity. Thus, when we encounter such information in the biomacromolecules necessary to life, we may infer—based on our knowledge of established cause-effect relationships— that an intelligent cause operated in the past to produce the specified complexity or information necessary to the origin of life.

As formulated, this inference to design employs the same method of argumentation and reasoning that historical scientists use generally. Indeed, in the Origin of Species, Darwin himself developed his argument for universal common ancestry as an inference to the best explanation. As he explained in a letter to Asa Gray:

> I . . . test this hypothesis [common descent] by comparison with as many general and pretty well-established propositions as I can find—in geographical distribution, geological history, affinities &c., &c. And it seems to me that, supposing that such a hypothesis were to explain

> such general propositions, we ought, in accordance with the common way of following all sciences, to admit it till some better hypothesis be found out [emphasis added].134

Moreover, as formulated, the argument to design from the information in DNA also adheres to the standard uniformitarian canons of method employed within the historical sciences. The principle of uniformitarianism states that "the present is the key to the past." In particular, the principle specifies that our knowledge of present cause-effect relationships should govern our assessment of the plausibility of the inferences that we make about the remote causal past. Yet it is precisely such knowledge of cause-effect relationships that informs the inference to intelligent design. Since we know that intelligent agents do produce large amounts of information, and since all known natural processes do not (or cannot), we can infer design as the best explanation of the origin of information in the cell. Recent developments in the information sciences (such as Dembski's work in The Design Inference) help to define and formalize knowledge of such cause-effect relationships, allowing us to make inferences about the causal histories of various artifacts, entities, or events based on the complexity and information-theoretic signatures they exhibit.135

In any case, the inference to design depends on present knowledge of the demonstrated causal powers of natural entities and intelligent agency, respectively. It no more constitutes an argument from ignorance than any other well-grounded inference in geology, archaeology, or paleontology—where present knowledge of cause-effect relationships guides the inferences that scientists make about the causal past.

Objectors might still deny the legitimacy of inferring intelligent design (even as a best explanation) because we are ignorant of what future inquiry may uncover about the causal powers of other materialistic entities or processes. Some would characterize the design inference presented here as invalid or unscientific because it depends on a negative generalization— that is, "purely physical and chemical causes do not generate large amounts of specified information"—which future discoveries may later falsify. We should "never say never," they say.

Yet science often says "never," even if it can't say so for sure. Negative or proscriptive generalizations often play an important role in science. As many scientists and philosophers of science have pointed out, scientific laws often tell us not only what does happen but also what does not happen.136 The conservation laws in thermodynamics, for example, proscribe certain outcomes. The first law tells us that energy is never created or destroyed. The second tells us that the entropy of a closed system will never decrease over time. Those who claim that such "proscriptive laws" do not constitute knowledge, because they are based on past but not future experience, will not get very far if they try to use their skepticism to justify funding for research on, say, perpetual motion machines.

Further, without proscriptive generalizations, without knowledge about what various possible causes cannot or do not produce, historical scientists could not make determinations about the past. Reconstructing the past requires making abductive inferences from present effects back to past causal events.137 Making such inferences requires a progressive elimination of competing causal hypotheses. Deciding which causes can be eliminated from consideration requires knowing what effects a given cause can—and cannot—produce. If historical scientists could never say that particular entities lack particular causal powers, they could never eliminate them, even provisionally, from consideration. Thus, they could never infer that a specific cause had acted in the past. Yet historical and forensic scientists make such inferences all the time.

Moreover, Dembski's examples of design inferences—from fields such as archaeology, cryptography, fraud-detection, and criminal forensics—show that we often infer the past activity of an intelligent cause and do so, evidently, without worrying about committing fallacious arguments from ig-

norance. And we do so for good reason. A vast amount of human experience shows that intelligent agents have unique causal powers that matter (especially nonliving matter) does not. When we observe features or effects that we know from experience only agents produce, we rightly infer the prior activity of intelligence.

To determine the best explanation, scientists do not need to say "never" with absolute certainty. They need only say that a postulated cause is best, given what we know at present about the demonstrated causal powers of competing entities or agencies. That cause C can produce effect E makes it a better explanation of E than some cause D that has never produced E (especially if D seems incapable of doing so on theoretical grounds), even if D might later demonstrate causal powers of which we are presently ignorant.138

Thus, the objection that the design inference constitutes an argument from ignorance reduces in essence to a restatement of the problem of induction. Yet one could make the same objection against any scientific law or explanation or against any historical inference that takes present, but not future, knowledge of natural laws and causal powers into account. As Barrow and Tipler have noted, to criticize design arguments, as Hume did, simply because they assume the uniformity and (normative character) of natural law cuts just as deeply against "the rational basis of any form of scientific inquiry."139 Our knowledge of what can and cannot produce large amounts of specified information may later have to be revised, but so might the laws of thermodynamics. Inferences to design may later prove incorrect, as may other inferences implicating various natural causes. Such possibilities do not stop scientists from making generalizations about the causal powers of various entities or from using those generalizations to identify probable or most plausible causes in particular cases.

Inferences based on past and present experience constitute knowledge (albeit provisional), not ignorance. Those who object to such inferences object to science as much as they object to a particular science-based hypothesis of design.

C. But Is It Science?

Of course, many simply refuse to consider the design hypothesis on grounds that it does not qualify as "scientific." Such critics affirm an extra-evidential principle known as methodological naturalism.140 Methodological naturalism asserts that, as a matter of definition, for a hypothesis, theory, or explanation to qualify as "scientific," it must invoke only naturalistic or materialistic entities. On that definition, critics say, the intelligent design hypothesis does not qualify. Yet, even if one grants this definition, it does not follow that some nonscientific (as defined by methodological naturalism) or metaphysical hypothesis may not constitute a better, more causally adequate, explanation. This essay has argued that, whatever its classification, the design hypothesis does constitute a better explanation than its materialistic or naturalistic rivals for the origin of specified biological information. Surely, simply classifying an argument as metaphysical does not refute it.

In any case, methodological naturalism now lacks justification as a normative definition of science. First, attempts to justify methodological naturalism by reference to metaphysically neutral (that is, non-questionbegging) demarcation criteria have failed.141 Second, to assert methodological naturalism as a normative principle for all of science has a negative effect on the practice of certain scientific disciplines, especially the historical sciences. In origin-of-life research, for example, methodological naturalism artificially restricts inquiry and prevents scientists from seeking some hypotheses that might provide the best, most causally adequate explanations. To be a truth-seeking endeavor, the question that origin-of-life research must address is not "Which materialistic scenario seems most adequate?" but rather "What actually caused life to arise on Earth?" Clearly, one possible answer to that latter question is this one: "Life was designed by an

intelligent agent that existed before the advent of humans." If one accepts methodological naturalism as normative, however, scientists may never consider the design hypothesis as possibly true. Such an exclusionary logic diminishes the significance of any claim of theoretical superiority for any remaining hypothesis and raises the possibility that the best "scientific" explanation (as defined by methodological naturalism) may not be the best in fact.

As many historians and philosophers of science now recognize, scientific theory-evaluation is an inherently comparative enterprise. Theories that gain acceptance in artificially constrained competitions can claim to be neither "most probably true" nor "most empirically adequate." At best, such theories can be considered the "most probably true or adequate among an artificially limited set of options." Openness to the design hypothesis would seem necessary, therefore, to any fully rational historical biology—that is, to one that seeks the truth, "no holds barred."142 A historical biology committed to following the evidence wherever it leads will not exclude hypotheses a priori on metaphysical grounds. Instead, it will employ only metaphysically neutral criteria—such as explanatory power and causal adequacy—to evaluate competing hypotheses. Yet this more open (and seemingly rational) approach to scientific theory evaluation would now suggest the theory of intelligent design as the best, most causally adequate, explanation for the origin of the information necessary to build the first living organism.

Notes

1. Harmke Kamminga, "Protoplasm and the Gene," in Clay Minerals and the Origin of Life, ed. A. G. Cairns-Smith and H. Hartman (Cambridge: Cambridge University Press, 1986), 1.
2. Alexander Oparin, Genesis and Evolutionary Development of Life (New York: Academic Press, 1968), 7.
3. F. Crick and J. Watson, "A Structure for Deoxyribose Nucleic Acid," Nature 171 (1953): 737–38; F. Crick and J. Watson, "Genetical Implications of the Structure of Deoxyribose Nucleic Acid," Nature 171 (1953): 964–67, esp. 964; T. D. Schneider, "Information Content of Individual Genetic Sequences," Journal of Theoretical Biology 189 (1997): 427–41; W. R. Loewenstein, The Touchstone of Life: Molecular Information, Cell Communication, and the Foundations of Life (New York: Oxford University Press, 1999).
4. Bernd-Olaf Kuppers, Information and the Origin of Life (Cambridge: MIT Press, 1990), 170–72.
5. L. E. Kay, "Who Wrote the Book of Life? Information and the Transformation of Molecular Biology," Science in Context 8 (1994): 601–34;
L. E. Kay, "Cybernetics, Information, Life: The Emergence of Scriptural Representations of Heredity," Configurations 5 (1999): 23–91; L.
E. Kay, Who Wrote the Book of Life? (Stanford, Calif.: Stanford University Press, 2000), xv–xix.
6. Darwin's only speculation on the origin of life is found in an unpublished 1871 letter to Joseph Hooker. In it, he sketched the outlines of the chemical evolutionary idea, namely, that life could have first
evolved from a series of chemical reactions. As he envisioned it, "if (and oh! what a big if!) we could conceive in some warm little pond, with all sorts of ammonia and phosphoric salts, light, heat, electricity, etc., that a proteine compound was chemically formed ready to undergo still more complex changes." Cambridge University Library, Manuscripts Room, Darwin Archives, courtesy Peter Gautrey.
7. E. Haeckel, The Wonders of Life, trans. J. McCabe (London: Watts, 1905), 111; T. H. Huxley, "On the Physical Basis of Life," Fortnightly Review 5 (1869): 129–45.
8. A. I. Oparin, The Origin of Life, trans. S. Morgulis (New York: Macmillan, 1938); S. C. Meyer, "Of Clues and Causes: A Methodological Interpretation of Origin of Life Studies" (Ph.D. diss., Cambridge University, 1991).
9. W. T. Astbury and A. Street, "X-Ray Studies of the Structure of Hair, Wool and Related Fibers," Philosophical Transactions of the Royal Society of London A 230 (1932): 75–101; H. Judson, Eighth

Day of Creation (New York: Simon and Schuster, 1979), 80; R. Olby, The Path to the Double Helix (London: Macmillan, 1974), 63. 10. Olby, Path to the Double Helix, 7, 265.
11. Judson, Eighth Day, 213, 229–35, 255–61, 304, 334–35, 562–63; F. Sanger and E. O. P. Thompson, "The Amino Acid Sequence in the Glycyl Chain of Insulin," parts 1 and 2, Biochemical Journal 53 (1953): 353–66, 366–74.
12. Judson, Eighth Day, 562–63; J. C. Kendrew, G. Bodo, H. M. Dintzis, R.
G. Parrish, and H. Wyckoff, "A Three-Dimensional Model of the Myoglobin Molecule Obtained by X-Ray Analysis," Nature 181 (1958): 662–66, esp. 664.
13. B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts, and J. D. Watson, Molecular Biology of the Cell (New York: Garland, 1983), 111–12, 127–31.
14. Judson, Eighth Day, 30.
15. Ibid., 30–31, 33–41, 609–10; Oswald T. Avery, C. M. MacCleod, and
M. McCarty, "Induction of Transformation by a Deoxyribonucleic Acid Fraction Isolated from Pneumococcus Type III," Journal of Experimental Medicine 79 (1944): 137–58.
16. Judson, Eighth Day, 95–96; E. Chargaff, Essays on Nucleic Acids (Amsterdam: Elsevier, 1963), 21.
17. Chargaff, Essays, 21.
18. Crick and Watson, "Structure."

19. Judson, Eighth Day, 96.
20. Crick and Watson, "Genetical Implications," 964–67.
21. Judson, Eighth Day, 611.
22. Crick and Watson, "Structure"; Crick and Watson, "Genetical Implications."
23. Judson, Eighth Day, 245–46, 335–36.
24. Ibid., 470–89; J. H. Matthei and M. W. Nirenberg, "Characteristics and Stabilization of DNAase-Sensitive Protein Synthesis in E. coli Extracts," Proceedings of the National Academy of Sciences, USA 47 (1961): 1580–88; J. H. Matthei and M. W. Nirenberg, "The Dependence of Cell-Free Protein Synthesis in E. coli upon Naturally Occurring or Synthetic Polyribonucleotides," Proceedings of the National Academy of Sciences, USA 47 (1961): 1588–1602.
25. Alberts et al., Molecular Biology, 106–8; S. L. Wolfe, Molecular and Cellular Biology (Belmont, Calif.: Wadsworth, 1993), 639–48.
26. We now know, of course, that in addition to the process of gene expression, specific enzymes must often modify amino acid chains after translation in order to achieve the precise sequencing necessary to allow correct folding into a functional protein. The amino acid chains produced by gene expression may also undergo further modification in sequence at the endoplasmic reticulum. Finally, even well-modified amino acid chains may require preexisting protein "chaperons" to help them fold into a functional three-dimensional configuration. All these factors make it impossible to predict a protein's final sequence from its corresponding gene sequence alone. See S. Sarkar, "Biological Information: A Skeptical Look at Some Central Dogmas of Molecular Biology," in The Philosophy and History of Molecular Biology: New Perspectives, ed. S. Sarkar (Dordrecht, Netherlands: Boston Studies in Philosophy of Science, 1996), 196, 199–202. Nevertheless, this unpredictability in no way undermines the claim that DNA exhibits the property of "sequence specificity," or the isomorphic claim that it contains "specified information" as argued in part I, section E. Sarkar argues, for example, that the absence of such predictability renders the concept of information theoretically superfluous for molecular biology. Instead, this unpredictability shows that the sequence specificity of DNA base sequences constitutes a necessary, though not sufficient, condition of attaining proper protein folding—that is, DNA does contain specified information (part I, section E), but not enough to determine protein folding by itself. Instead, the presence of both post-translation processes of modification and pretranscriptional genomic editing (through exonucleases, endonucleases, spliceosomes, and other editing enzymes) only underscores the need for other preexisting, information-rich biomolecules in order to process genomic information in the cell. The presence of a complex and functionally integrated information-processing system does

suggest that the information on the DNA molecule is insufficient to produce proteins. It does not show that such information is unnecessary to produce proteins, nor does it invalidate the claim that DNA, therefore, stores and transmits specified genetic information.
27. C. Shannon, “A Mathematical Theory of Communication,” Bell System Technical Journal 27 (1948): 379–423, 623–56.
28. F. Dretske, Knowledge and the Flow of Information (Cambridge: MIT Press, 1981), 6–10.
29. Ibid.; Shannon, “A Mathematical Theory.”
30. B. Kuppers, “On the Prior Probability of the Existence of Life,” in The Probabilistic Revolution, ed. Lorenz Kruger et al. (Cambridge: MIT Press, 1987), 355–69.
31. Schneider, “Information Content”; see also H. P. Yockey, Information Theory and Molecular Biology (Cambridge: Cambridge University Press, 1992), 246–58, for important refinements in the method of calculating the information-carrying capacity of proteins and DNA.
32. C. Shannon and W. Weaver, The Mathematical Theory of Communication (Urbana: University of Illinois Press, 1949), 8.
33. Schneider, “Information Content,” 58–177; Yockey, Information Theory, 58–177.
34. See note 26. Sarkar, “Biological Information,” 199–202, esp. 196; F. Crick, “On Protein Synthesis,” Symposium for the Society of Experimental Biology 12 (1958): 138–63, esp. 144, 153.
35. Crick, “On Protein Synthesis,” 144, 153.
36. Recall that the determination of the genetic code depended, for example, on observed correlations between changes in nucleotide base sequences and amino acid production in “cell-free systems.” See Judson, Eighth Day, 470–87.
37. W. A. Dembski, The Design Inference: Eliminating Chance Through Small Probabilities (Cambridge: Cambridge University Press, 1998), 1–35, 136–74.
38. Ibid., 136–74.

39. Of the two sequences, only the second meets an independent set of functional requirements. To convey meaning in English one must employ preexisting (or independent) conventions of vocabulary (associations of symbol sequences with particular objects, concepts, or ideas) and existing conventions of syntax and grammar (such as “every sentence requires a subject and a verb”). When arrangements of symbols “match” or utilize these vocabulary and grammatical conventions (that is, functional requirements), meaningful communication can occur in English. The second sequence (“Time and tide wait for no man”) clearly exhibits such a match between itself and preexisting requirements of vocabulary and grammar. The second sequence has employed these conventions to express a meaningful idea. It also, therefore, falls within the smaller (and conditionally independent) pattern delimiting the domain of all meaningful sentences in English and thus, again, exhibits a “specification.”
40. J. Bowie and R. Sauer, “Identifying Determinants of Folding and Activity for a Protein of Unknown Sequences: Tolerance to Amino Acid Substitution,” Proceedings of the National Academy of Sciences, USA 86 (1989): 2152–56; J. Reidhaar-Olson and R. Sauer, “Functionally Acceptable Solutions in Two Alpha-Helical Regions of Lambda Repressor,” Proteins, Structure, Function, and Genetics 7 (1990): 306–10.
41. R. Dawkins, River out of Eden (New York: Basic Books, 1995), 11.
42. B. Gates, The Road Ahead (Boulder, Colo.: Blue Penguin, 1996), 228.
43. L. E. Orgel, The Origins of Life on Earth (New York: John Wiley, 1973),
189.
44. See note 5. Kay, “Who Wrote,” 611–12, 629; Kay, “Cybernetics”; Kay,
Who Wrote.
45. Sarkar, “Biological Information,” 199–202.
46. E. Schrödinger, What Is Life? And Mind and Matter (Cambridge: Cambridge University Press, 1967), 82; Alberts et al., Molecular Biology, 21; Crick and Watson, “A Structure”; Crick and Watson, “Genetical Implications”; Crick, “On Protein”; Judson, Eighth Day, 611; Orgel, Origins of Life, 189.
47. P. Davies, The Fifth Miracle (New York: Simon and Schuster, 1998),

120.
48. Orgel, Origins of Life, 189.
49. Loewenstein, Touchstone; Davies, Fifth Miracle; Schneider, “Information Content”; C. Thaxton and W. Bradley, “Information and the Origin of Life,” in The Creation Hypothesis: Scientific Evidence for an Intelligent
Designer, ed. J. P. Moreland (Downers Grove, Ill.: InterVarsity Press, 1994), 173–210, esp. 190; S. Kauffman, The Origins of Order (Oxford: Oxford University Press, 1993), 287–340; Yockey, Information Theory, 178–293; Kuppers, Information and Origin, 170–72; F. Crick, Life Itself (New York: Simon and Schuster, 1981), 59–60, 88; J. Monod, Chance and Necessity (New York: Vintage Books, 1971), 97–98, 143; Orgel, Origins, 189; D. Kenyon and G. Steinman, Biochemical Predestination (New York: McGraw-Hill, 1969), 199–211, 263–66; Oparin, Genesis, 146–47;

H. Quastler, The Emergence of Biological Organization (New Haven, Conn.: Yale University Press, 1964).
50. G. Wald, “The Origin of Life,” Scientific American 191 (August 1954): 44–53; R. Shapiro, Origins: A Skeptic’s Guide to the Creation of Life on Earth (New York: Summit Books, 1986), 121.
51. F. Crick, “The Origin of the Genetic Code,” Journal of Molecular Biology 38 (1968): 367–79; H. Kamminga, “Studies in the History of Ideas on the Origin of Life” (Ph.D. diss., University of London 1980), 303–4.
52. C. de Duve, “The Constraints of Chance,” Scientific American (Jan. 1996): 112; Crick, Life Itself, 89–93; Quastler, Emergence, 7.
53. H. J. Morowitz, Energy Flow in Biology (New York: Academic Press, 1968), 5–12; F. Hoyle and C. Wickramasinghe, Evolution from Space (London: J. M. Dent, 1981), 24–27; A. G. Cairns-Smith, The Life Puzzle (Edinburgh: Oliver and Boyd, 1971), 91–96; I. Prigogine, G. Nicolis, and A. Babloyantz, “Thermodynamics of Evolution,” Physics Today (23 Nov. 1972); Yockey, Information Theory, 246–58; H. P. Yockey, “Self-Organization, Origin of Life Scenarios and Information Theory,” Journal of Theoretical Biology 91 (1981): 13–31; Bowie and Sauer, “Identifying Determinants”; Reidhaar-Olson et al., Proteins; Shapiro, Origins, 117–31.
54. Prigogine, “Thermodynamics.”
55. Cairns-Smith, Life Puzzle, 95.
56. Reidhaar-Olson and Sauer, “Functionally Acceptable”; D. D. Axe, “Biological Function Places Unexpectedly Tight Constraints on Protein Sequences,” Journal of Molecular Biology 301, no. 3: 585–96; M. Behe, “Experimental Support for Regarding Functional Classes of Proteins to Be Highly Isolated from Each Other,” in Darwinism: Science or Philosophy? ed. J. Buell and V. Hearn (Richardson, Tex.: Foundation for Thought and Ethics, 1994), 60–71; Yockey, Information Theory, 246–58. Actually, Sauer counted sequences that folded into stable three-dimensional configurations as functional, though many sequences
that fold are not functional. Thus, his results actually underestimate the probabilistic difficulty.
57. Behe, “Experimental Support.”
58. Axe, “Biological Function.”
59. Dawkins, Blind Watchmaker, 54, 139.
60. Dembski, Design Inference, 175–223; E. Borel, Probabilities and Life, trans. M. Baudin (New York: Dover, 1962), 28. Dembski’s universal probability bound actually reflects the “specificational” resources, not the probabilistic resources in the universe. Dembski’s calculation determines the number of specifications possible in finite time. It nevertheless has the effect of limiting the “probabilistic resources” available to explain the origin of any specified event of small probability. Since living systems are precisely specified systems of small probability, the universal probability bound effectively limits the probabilistic resources available to explain the origin of specified biological information.
61. Dembski, Design Inference, 175–223. Cassette mutagenesis experiments have usually been performed on proteins of about 100 amino acids in length. Yet extrapolations from these results can generate reasonable estimates for the improbability of longer protein molecules. For example,

Sauer's results on the proteins lambda repressor and arc repressor suggest that, on average, the probability at each site of finding an amino acid that will maintain functional sequencing (or, more accurately, that will produce folding) is less than 1 in 4 (1 in 4.4). Multiplying 1/4 by itself 150 times (for a protein 150 amino acids in length) yields a probability of roughly 1 chance in 1091. For a protein of that length, the probability of attaining both exclusive peptide bonding and homochirality is also about 1 chance in 1091. Thus, the probability of achieving all the necessary conditions of function for a protein 150 amino acids in length exceeds 1 chance in 10180.
62. Dembski, Design Inference, 67–91, 175–214; Borel, Probabilities, 28.
63. E. Pennisi, "Seeking Life's Bare Genetic Necessities," Science 272 (1996): 1098–99; A. Mushegian and E. Koonin, "A Minimal Gene Set for Cellular Life Derived by Comparison of Complete Bacterial Genomes," Proceedings of the National Academy of Sciences, USA 93 (1996): 10268–73; C. Bult et al., "Complete Genome Sequence of the Methanogenic Archaeon, Methanococcus jannaschi," Science 273 (1996): 1058–72.
64. Dembski, Design Inference, 67–91, 175–223, 209–10.

65. P. T. Mora, "Urge and Molecular Biology," Nature 199 (1963): 212–19.
66. I. Hacking, The Logic of Statistical Inference (Cambridge: Cambridge University Press, 1965), 74–75.
67. Dembski, Design Inference, 47–55.
68. C. de Duve, "The Beginnings of Life on Earth," American Scientist 83 (1995): 437.
69. Quastler, Emergence, 7.
70. Oparin, Origin of Life, 64–103; Meyer, Of Clues, 174–79, 194–98, 211–12.
71. Oparin, Origin of Life, 107–8, 133–35, 148–59, 195–96.
72. Oparin, Genesis, 146–47.
73. C. de Duve, Blueprint for a Cell: The Nature and Origin of Life (Burlington, N.C.: Neil Patterson, 1991), 187.
74. G. Joyce and L. Orgel, "Prospects for Understanding the Origin of the RNA World," in RNA World, ed. R. F. Gesteland and J. J. Atkins (Cold Spring Harbor, N.Y.: Cold Spring Harbor Laboratory Press, 1993), 1–25, esp. 8–13.
75. T. Dobzhansky, "Discussion of G. Schramm's Paper," in The Origins of Prebiological Systems and of Their Molecular Matrices, ed. S. W. Fox (New York: Academic Press, 1965), 310; H. H. Pattee, "The Problem of Biological Hierarchy," in Toward a Theoretical Biology, ed. C. H. Waddington, vol. 3 (Edinburgh: Edinburgh University Press, 1970), 123.
76. P. T. Mora, "The Folly of Probability," in Fox, Origins, 311–12; L. V. Bertalanffy, Robots, Men and Minds (New York: George Braziller, 1967),
82.
77. J. Von Neumann, Theory of Self-reproducing Automata, completed and edited by A. Berks (Urbana: University of Illinois Press, 1966).
78. Pennisi, "Seeking"; Mushegian and Koonin, "Minimal Gene Set"; Bult et al., "Complete Genome Sequence."
79. E. Wigner, "The Probability of the Existence of a Self-reproducing Unit," in The Logic of Personal Knowledge, ed. E. Shils (London: Kegan and Paul, 1961), 231–35; P. T. Landsberg, "Does Quantum Mechanics Exclude Life?" Nature 203 (1964): 928–30; H. J. Morowitz, "The Minimum Size of the Cell," in Principles of Biomolecular Organization, ed. M. O'Connor and G. E. W. Wolstenholme (London: J. A. Churchill, 1966), 446–59; Morowitz, Energy Flow, 10–11.
80. Dawkins, Blind Watchmaker, 47–49; Kuppers, "On the Prior Probability."
81. Kuppers, "On the Prior Probability," 366.

82. Dawkins, Blind Watchmaker, 47–49; P. Nelson, "Anatomy of a Still-Born Analogy," Origins and Design 17 (3) (1996): 12.
83. de Duve, "Beginnings of Life," 437.
84. Morowitz, Energy Flow, 5–12.

85. G. Steinman and M. N. Cole, “Synthesis of Biologically Pertinent Peptides Under Possible Primordial Conditions,” Proceedings of the National Academy of Sciences, USA 58 (1967): 735–41; G. Steinman, “Sequence Generation in Prebiological Peptide Synthesis,” Archives of Biochemistry and Biophysics 121 (1967): 533–39; R. A. Kok, J. A. Taylor, and W. L. Bradley, “A Statistical Examination of Self-Ordering of Amino Acids in Proteins,” Origins of Life and Evolution of the Biosphere 18 (1988): 135–42.
86. Kenyon and Steinman, Biochemical Predestination, 199–211, 263–66.
87. I. Prigogine and G. Nicolis, Self-Organization in NonEquilibrium Systems (New York: John Wiley, 1977), 339–53, 429–47.
88. Kauffman, Origins of Order, 285–341; de Duve, “Beginnings of Life”; C. de Duve, Vital Dust: Life as a Cosmic Imperative (New York: Basic Books, 1995).
89. C. Thaxton, W. Bradley, and R. Olsen, The Mystery of Life’s Origin: Reassessing Current Theories (Dallas: Lewis and Stanley, 1992), v–viii; D. Kenyon and G. Mills, “The RNA World: A Critique,” Origins and Design 17, no. 1 (1996): 9–16; D. Kenyon and P. W. Davis, Of Pandas and People: The Central Question of Biological Origins (Dallas: Haughton, 1993);
S. C. Meyer, “A Scopes Trial for the ’90’s,” Wall Street Journal, 6 Dec. 1993; Kok et al., “Statistical Examination.”
90. Steinman and Cole, “Synthesis”; Steinman, “Sequence Generation.”
91. Kok et al., “Statistical Examination”; B.J. Strait and G. T. Dewey, “The Shannon Information Entropy of Biologically Pertinent Peptides,” Biophysical Journal 71: 148–155.
92. Kuppers, “On the Prior Probability,” 64.
93. de Duve, “Beginnings of Life,” 437.
94. R. Stalnaker, Inquiry (Cambridge: MIT Press, 1984), 85.
95. This, in fact, happens where adenine and thymine do interact chemically in the complementary base-pairing across the information-bearing axis of the DNA molecule. Along the message bearing axis, however, there are no chemical bonds or differential bonding affinities that determine sequencing.
96. M. Polanyi, “Life’s Irreducible Structure,” Science 160 (1968): 1308–12, esp. 1309.
97. As noted in part I, section D, the information-carrying capacity of any symbol in a sequence is inversely related to the probability of its occurrence. The informational capacity of a sequence as a whole is inversely proportional to the product of the individual probabilities of each member in the sequence. Since chemical affinities between constituents (“symbols”) increase the probability of the occurrence of one, given another (i.e., necessity increases probability), such affinities decrease the information-carrying capacity of a system in proportion to the strength and relative frequency of such affinities within the system.

98. Dretske, Knowledge and the Flow, 12.

99. Yockey, “Self-Organization,” 18.

100. H. P. Yockey, “A Calculation of the Probability of Spontaneous Biogenesis by Information Theory,” Journal of Theoretical Biology 67 (1977): 377–98, esp. 380.

101. M. Eigen, Steps Toward Life (Oxford: Oxford University Press, 1992),

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102. Quastler, Emergence, ix.

103. Ibid., 1, 47.

104. Yockey, Information Theory, 247.

105. J. C. Walton, “Organization and the Origin of Life,” Origins 4 (1977): 16–35.

106. J. M. Smith, “Hypercycles and the Origin of Life,” Nature 280 (1979): 445–46; F. Dyson, Origins of Life (Cambridge: Cambridge University Press, 1985), 9–11, 35–39, 65–66, 78; Shapiro, Origins, 161.

107. Iris Fry, The Emergence of Life on Earth (New Brunswick, N.J.: Rutgers University Press, 2000), 158.

108. Kauffman, Origins of Order, 285–341.

109. Ibid., 299.

110. See Protein Databank at http://www.rcsb.org/pdb.

111. Kauffman, Origins of Order, 298.

112. Thaxton, et al., Mystery of Life’s Origin, 127–43.

113. R. Shapiro, “Prebiotic Cytosine Synthesis: A Critical Analysis and Implications for the Origin of Life,” Proceedings of the National Academy of Sciences, USA 96 (1999): 4396–4401; M. M. Waldrop, “Did Life Really Start Out in an RNA World?” Science 246 (1989): 1248–49.

114. R. Shapiro, “Prebiotic Ribose Synthesis: A Critical Analysis,” Origins of Life and Evolution of the Biosphere 18 (1988): 71–85; Kenyon and Mills, “RNA World.” 115. G. F. Joyce, “RNA Evolution and the Origins of Life,” Nature 338 (1989): 217–24.
116. A. J. Hager, J. D. Polland Jr., and J. W. Szostak, “Ribozymes: Aiming at RNA Replication and Protein Synthesis,” Chemistry and Biology 3 (1996): 717–25.
117. de Duve, Vital Dust, 23.
118. Joyce and Orgel, “Prospects for Understanding,” 1–25, esp. 11.
119. Quastler, Emergence, 16.
120. A possible exception to this generalization might occur in biological evolution. If the Darwinian mechanism of natural selection acting on random variation can account for the emergence of all complex life, then a mechanism does exist that can produce large amounts of information—assuming, of course, a large amount of preexisting biological information in a self-replicating living system. Thus, even if one assumes that the selection/variation mechanism can produce all the information required for the macroevolution of complex life from simpler life, that mechanism will not suffice to account for the origin of the information necessary to produce life from nonliving chemicals. As we have seen, appeals to prebiotic natural selection only beg the question of the origin of specified information. Thus, based on experience, we can affirm the following generalization: “for all nonbiological systems, large amounts [note 118 below] of specified complexity or information originate only from mental agency, conscious activity, or intelligent design.” Strictly speaking, experience may even affirm a less qualified generalization (such as “large amounts of specified invariably originate from an intelligent source”), since the claim that natural selection acting on random mutations can produce large amounts of novel genetic information depends on debatable theoretical arguments and extrapolation from observations of small-scale microevolutionary changes that do not themselves manifest large gains in biological information. Later in this volume (in “The Cambrian Explosion: Biology’s Big Bang”), Meyer, Ross, Nelson, and Chien argue that neither the neo-Darwinian mechanism nor any other current naturalistic mechanism adequately accounts for the origin of the information required to build the novel proteins and body plans that arise in the Cambrian explosion. In any case, the more qualified

empirical generalization (stated above in this endnote) is sufficient to support the argument presented here, since this essay seeks only to establish intelligent design as the best explanation for
origin of the specified information necessary to the origin of the first life.
121. K. Dose, "The Origin of Life: More Questions Than Answers," Interdisciplinary Science Reviews 13 (1988): 348–56; Yockey, Information Theory, 259–93; Thaxton et al., Mystery, 42–172; Thaxton and Bradley, "Information and the Origin," 193–97; Shapiro, Origins.
122. Of course, the phrase "large amounts of specified information" again begs a quantitative question, namely, "How much specified information or complexity would the minimally complex cell have to have before it implied design?" Recall that Dembski has calculated a universal probability bound of 1/10150 corresponding to the probabilistic/specificational resources of the known universe. Recall further that probability is inversely related to information by a logarithmic function. Thus, the universal small probability bound of 1/10150 translates into roughly 500 bits of information. Chance alone, therefore, does not constitute a sufficient explanation for the de novo origin of any specified sequence or system containing more than 500 bits of (specified) information. Further, since systems characterized by complexity (a lack of redundant order) defy explanation by self-organizational laws and since appeals to prebiotic natural selection presuppose but do not explain the origin of the specified information necessary to a minimally complex self-replicating system, intelligent design best explains the origin of the more than 500 bits of specified information required to produce the first minimally complex living system. Thus, assuming a nonbiological starting point (note 116 above), the de novo emergence of 500 or more bits of specified information will reliably indicate design.
123. Again, this claim applies at least in cases where the competing causal entities or conditions are nonbiological—or where the mechanism of natural selection can be safely eliminated as an inadequate means of producing requisite specified information.
124. Dembski, Design Inference, 1–35.
125. Ibid., 1–35, 136–223.
126. Ibid., 36–66.
127. Ibid.; E. Sober, Reconstructing the Past (Cambridge, Mass.: MIT Press, 1988), 4–5; M. Scriven, "Causes, Connections, and Conditions in History," in Philosophical Analysis and History, ed. W. Dray (New York: Harper and Row, 1966), 238–64, esp. 249–50.
128. McNeil-Lehrer News Hour, Transcript 19 (May 1992).

129. Meyer, Of Clues, 77–140.
130. Less exotic (and more successful) design-detection occurs routinely in both science and industry. Fraud-detection, forensic science, and cryptography all depend on the application of probabilistic or information theoretic criteria of intelligent design. Dembski, Design Inference, 1–35. Many would admit that we may justifiably infer a past human intelligence operating (within the scope of human history) from an information-rich artifact or event, but only because we already know that human minds exist. But, they argue, since we do not know whether an intelligent agent(s) existed prior to humans, inferring the action of a designing agent that antedates humans cannot be justified, even if we observe an information-rich effect. Note, however, that SETI scientists do not already know whether an extraterrestrial intelligence exists. Yet they assume that the presence of a large amount of specified information (such as the first 100 prime numbers in sequence) would definitively establish the existence of one. Indeed, SETI seeks precisely to establish the existence of other intelligences in an unknown domain. Similarly, anthropologists have often revised their estimates for the beginning of human history or civilization because they discovered information-rich artifacts dating from times that antedate their previous estimates. Most inferences to design establish the existence or activity of a mental agent operating in a time or place where the presence of such agency was previously unknown. Thus, to infer the activity of a designing intelligence from a time prior to the advent of humans on Earth does not have a qualitatively different epistemological status than other design inferences that critics already accept as

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Chapter 8: Giving The Devil His Due - Teleological Arguments After Hume
James D. Madden

Among David Hume's many confrontations with natural theology his criticisms of the argument from design, or the teleological argument, may well be the most influential. Even today when one encounters the difficulties of using the arrangement of the natural world as evidence for the existence of God, one finds that it is Hume's original objections to such an enterprise that pose the greatest challenge. Suffice it to say that Hume, rivaled only by Darwin, has done the most to undermine in principle our confidence in arguments from design among all figures in the Western intellectual tradition.'

Despite Hume's powerful critique, there may be grounds for guarded optimism on the part of the theist. However, such optimism must not be purchased at the price of ignoring the original force of Hume's objections. To do so would be intellectually dishonest and would rob the theist's position of its real value. Therefore, this chapter contains both a discussion of the claims of some historically

significant teleological arguments and a presentation of criticisms that originate with Hume and remain salient today. With those discussions in place we may then turn our attention to whether a plausible response to Humean objections can be made in light of recent work in the philosophy of religion.

We begin with a discussion of the classical expression of the teleological argument found in the writings of William Paley and St. Thomas Aquinas. Hume subjected this argument to a criticism that to this day calls classical teleological arguments into question. Although the fate of the classical teleological argument has not been sealed, I take Hume's criticism as an occasion to examine a modern version of the teleological argument that is constructed to sidestep the problems of the classical attempts at an argument from design. Nevertheless, we will see that the modern teleological argument is itself subject to a further Humean objection. We then turn to a consideration of contemporary work on the problem of evil and ultimately to principles taken from G. W. Leibniz to find a plausible strategy for defending the modem teleological argument against its Humean critics.

Classical Teleological Arguments

Among what are known as teleological arguments we find many different and varied attempts to prove the existence of a designer of the universe.2 Not only do they vary both in the evidence they cite and the strength of their proposed conclusions, but their proponents argue from disparate philosophical presuppositions. For example, proponents of classical versions of the argument can be found in Aquinas and later Thomists, as well as in William Paley and the nineteenth-century natural theologians, who argue from a decidedly non-Aristotelian perspective. We can also point to examples of contemporary scientifically informed writers who claim that teleological arguments for the existence of a designer need to be taken seriously. In this section we will discuss the teleological argument in its classical form.

The teleological argument most familiar to philosophers in the Anglo-American tradition is offered by William Paley in his 1803 treatise Natural Theology.3 Paley imagines finding a functioning watch while strolling along a heath. Unlike many objects one might encounter during an afternoon's stroll (Paley's example is a stone), the watch seems to be resistant to an explanation in terms of mere chance or coincidence. Paley argues that we need a special explanation in the case of the watch, but not in the case of a stone, because "when we come to inspect the watch, we perceive (what we could not discover in the stone) that its several parts are framed and put together for a purpose. "4 In other words, the watch, unlike the stone, has working parts that are intricately arranged so as to serve an obvious purpose. (I will hereafter refer to such collections of purposively arranged working parts as "teleological systems.") Paley's point is that when one encounters a teleological system it is only reasonable to conclude that one has encountered a genuine artifact and not the product of mere chance.

Paley next asks us to consider the structures we commonly encounter in nature, and he has in mind here the complex working parts of organisms and the law-governed phenomena observed by the astronomer. These phenomena, for Paley, are evidence of an intelligent designer of the universe to "a degree that exceeds all computation." He arrives at this conclusion by way of a supposed analogy between artifacts and natural phenomena: since the teleological structuring of the watch leads any reasonable person to infer the existence of a craftsman who has designed and assembled it, likewise the seemingly purposive arrangement of nature should lead us to infer the existence of nature's designer. As Paley puts it, our tendency to affirm the existence of a designer of the found watch is an expression of our acceptance of the principle that "there cannot be design without a designer; contrivance without a contriver; order without choice; arrangement, without anything capable of arranging; subserviency and relation to a purpose, without that which could intend a purpose." Therefore, the evidence of intricate teleological systems we find in nature strongly

supports "the presence of intelligence and mind." In short, since all teleological systems that we have encountered in the past—watches, mills, etc.—have been the product of design, the weight of human experience should lead us to conclude that natural teleological systems are likewise the products of intelligent design. The intelligent designer of nature's teleological systems is, for Paley, the God of orthodox theism, that is the unique omnipotent, omniscient and perfectly good person who is worshiped in the great Western religions.

Well before Paley, St. Thomas Aquinas offered a teleological argument that does not rely on an analogy between artifacts and natural structures. In the last of his famous Five Ways, Aquinas offers the following argument:

The fifth way is taken from the governance of the world. We see that things which lack knowledge, such as natural bodies, act for an end and this is evident from their acting always, or nearly always, in the same way, so as to obtain the best result. Hence it is plain that they achieve their end, not fortuitously, but designedly. Now whatever lacks knowledge cannot move towards an end, unless it be directed by some being endowed with knowledge and intelligence; as the arrow is directed by the archer. Therefore some intelligent being exists by whom all natural things are directed to their end; and this being is God. (ST 1.2.3)

Some contemporary commentators take this argument as an earlier version of Paley's project.5 But Aquinas is up to something quite different. His point is not that the structured complexity of natural systems is analogous to teleological systems built by human contrivance. Rather, Aquinas has in mind the Aristotelian principle that a teleological element must operate in all instances of change in the natural world. For the Aristotelian there must be a goal or final cause that determines or guides every natural change; without this purpose for action, the Aristotelian argues, there would be no causality at all. In changes that involve intelligent beings exercising their rational capacity, the final cause is not very difficult to account for—the agent simply acts according to an intention. In the case of "things which lack knowledge" the final cause is more difficult to explain. Aquinas believes that nonrational beings have a natural disposition to their end but, given the fact that the behaviors of such beings for the most part aim toward their good; he concludes that this inclination is not the result of mere chance. Thus, Aquinas concludes, there must be some intelligence that ultimately directs natural beings to their ends by endowing them with proper dispositions, and that being is the God of orthodox theism 6

Paley and Aquinas both argue that the existence of the God of orthodox theism is supported strongly by the premises they cite, so we may fairly represent both of their arguments with the same schema, what we will call the "classical teleological argument" (CTA):

1. Certain natural phenomena clearly have feature F (e.g., teleological ordering or intrinsic finality).

2. It is highly improbable that F be caused by something other than the God of orthodox theism.'

3. Therefore, it is highly probable that the God of orthodox theism exists.

Although Paley's and Aquinas's arguments can both be placed under the rubric of CTA, there are important differences between their approaches. The feature that Aquinas cites in the first premise (the ubiquity of Aristotelian final causality in nature) is quite different from what Paley has in mind (teleological systems in nature). Moreover, the arguments that each thinker appeals to in defense of the second premise are quite distinct; Paley refers us to the analogy between mechanical artifacts and teleological systems in nature, whereas Aquinas would point out the metaphysical problems that arise for the Aristotelian when one tries to use either chance or efficient causality

alone to explain the occurrence of regularities in nature. Nevertheless, both Paley and Aquinas do attempt to establish the existence of the God of orthodox theism by using an argument of the form presented in CTA.

Hume's Objection To CTA

David Hume is likely the most influential critic of natural theology in the Western philosophical tradition.8 Hume's attacks on arguments for God's existence in his Dialogues Concerning Natural Religion, his Enquiry Concerning Human Understanding and his Natural History of Religion have served as the precedents for much of the case for unbelief made during the subsequent centuries (the "Humean legacy" on which this volume is focused). Indeed, Hume's influence can still be seen among many contemporary philosophers of religion. J. J. C. Smart, Michael Martin, J. L. Mackie and a number of other prominent nontheists all employ criticisms whose historical origin can be found in Humean insights.9

The teleological argument is certainly not spared Hume's critical attack; indeed the greatest share of Hume's attention to natural theology in the Dialogues and the Enquiry is given to it. Typical of his doctrines regarding other theistic arguments, Hume's criticism of the teleological argument is held in high esteem by many contemporaries. Bernard Williams, for instance, tells us that Hume's attack on the teleological argument is so compelling that "after it there did not need to be another."10 Hume makes trouble for the proponent of the teleological argument on a number of fronts, but for the moment I will deal with one of his criticisms that seems to have enjoyed the greatest polemical staying power.

In his discussion of the teleological argument in the Enquiry, Hume provides us with the following principle: "[W]hen we infer any particular cause from an effect, we must proportion the one to the other, and can never be allowed to ascribe to the cause any qualities but what are exactly sufficient to produce the effect."11 In other words, when we argue from a purported effect to a postulation of its cause, we must tailor our hypothesis strictly to the properties of the effect for which we hope to account; we may assume that a purported cause has only those powers that are strictly necessary to bring about the phenomena to be explained. Any discrepancy between the powers of the cause and the properties of the effect is unwarranted by the relevant evidence. Hume's criticism here is really a straightforward application of the commonsense principle known to philosophers as Ockham's razor, that is, all things being equal, we should posit only those entities that are strictly necessary to explain the phenomena being investigated.

This Humean criticism presents a particular difficulty for the proponent of CTA because it is unclear that the evidence cited requires a single, omnipotent, omniscient and perfectly good being to act as its cause. It is logically possible that some combination of lesser designers, or even a single being lacking perfect competence, have acted to produce the range of phenomena considered by Paley and Aquinas.12 Since Hume's point is that the evidence provided by the proponent of CTA is insufficient to justify the theistic hypothesis, let's call this criticism the "insufficient evidence objection" (IEO).

It is not only agnostics and atheists who have voiced this Humean objection. No less a theist than Alvin Plantings raises the difficulty IEO poses for the proponents of teleological arguments as follows:

In believing that God exists, the theist believes a proposition logically equivalent to a conjunction. Among the conjuncts we should find at least the following:

a. The universe is designed.

b. The universe is designed by exactly one person.

c. The universe was created ex nihilo.

d. The universe was created by the person who designed it.

e. The creator of the universe is omniscient, omnipotent and perfectly good.

f. The creator of the universe is an eternal spirit, without body, and in no way dependent upon physical objects.

Now, we can put the objection as follows. Perhaps the teleological argument gives us a smidgen of evidence for (a), but it does nothing for (b) through (f).13

In other words, even if we admit that there is sufficient evidence to support a design hypothesis (Plantinga's [a]), such evidence is not sufficient to underwrite belief in the existence of a being that fits the description of the deity that is the center of orthodox theism (Plantinga's [b] through [f]). At most we may conclude that such a being is sufficiently powerful to produce the complex teleological systems we encounter in this world. We have no reason to think that it has the power to produce a universe significantly different from the actual world, much less that the designer is omnipotent. We can, so the argument goes, make similar arguments for the other powers ascribed to the God of orthodox theism. The Humean point is that there are a great many equally plausible hypotheses that may explain the evidence of design, none of which require the positing of a perfect being. The evidence, strictly speaking, does not require the positing of such a being, so the theist must produce an independent reason for the supposition of God's existence beyond the evidence cited in classical teleological arguments. This result robs the teleological argument of its force; as Hume puts it in section 11 of n. the Enquiry, IEO shows that the proponent of the classical teleological arguments relies on "the assistance of exaggeration and flattery to supply the defects of argument and reasoning."

Many theists have averred a response to IEO, usually by appealing to the virtues of theoretical simplicity and elegance that, it is supposed, the theistic hypothesis enjoys. That is to say, even though the existence of a unique, all-powerful, all-knowing and perfectly good designer is not strictly implied by the evidence for design, the theistic hypothesis is simpler and more elegant than any other explanatory hypothesis available. Thus, we are within our rights to believe that the evidence of CTA supports the theistic hypothesis. Such a defense of CTA is certainly not without force.14 Nevertheless, the claim that the theistic hypothesis is the simplest and most elegant explanation of the order of nature is controversial.

Even if we grant the greater simplicity of theism, it is unclear whether or not it is, on the whole, the most elegant alternative. That is to say, it is an open question whether or not theism solves as many problems as it raises. There is a long history of trying to make some sense of the notion of omnipotence, and the relation between an infinitely knowledgeable creator and the free actions of some of his creatures is certainly not easily explained. Moreover, the problem of reconciling the occurrence of horrendous evil with the God of orthodox theism continues to occupy the attention of theists. One might easily charge that the theistic hypothesis complicates as much as it simplifies. Of course these problems might be solvable, but it is incumbent on anyone who appeals to the theistic hypothesis to provide a way to quell these worries, and we must not beg any questions. Intellectual honesty requires us to admit that at this stage of philosophical progress these questions have not received final answers, although many of us are sanguine about particular avenues for their eventual resolution.15

For this reason I take it that, even if we grant the greater simplicity of theism, it is an open question whether God is the most elegant explanation of the relevant data. This is not to say that the case for CTA is a dead issue. However, given this serious problem, we do well to consider other versions of the teleological argument that may be insulated against IEO.

The Modern Teleological Argument

A modem version of the teleological argument has recently been developed by members of the contemporary intelligent design movement, including William Dembski, Michael Denton, Stephen Meyer and others.16 I will use Michael Behe as an example. Behe is a biochemist who doubts whether Darwinian principles alone are sufficient to explain the complexity of life at its most fundamental levels. In his controversial book, Darwin's Black Box, Behe cites the problem of explaining the formation of the flagellum of a bacterium as one of a number of cases that call the viability of Darwinian explanation into question.17 This biological propulsion system has hundreds of working parts, none of which serves any known purpose integral to the organism's survival distinct from its function within the flagellum—a characteristic Behe labels "irreducible complexity." Yet each of these parts is necessary to the operation of the flagellum. If Behe is correct, then none of the parts of the flagellum would have been preserved by natural selection. Therefore, so the argument goes, this particular system resists explanation in terms of a standard Darwinian model. If a Darwinian explanation is unavailable, then we must conclude either that the flagellum is the product of intelligent design or that this complex system came together all at once through the operation of pure chance alone, possibly by mutation.18 The likelihood of all of the parts of the flagellum coming together by chance are so astronomically slim as to be functionally zero; nobody may reasonably argue that the hundreds of integral parts of the flagellum came together by pure chance. Thus, given that neither natural selection nor mere chance is a plausible explanation in this case, Behe concludes that the best explanation is intelligent design.

There is an important difference between Behe's argument and classical attempts to prove God's existence based on the evidence of teleology in nature. Behe's conclusion is much less ambitious than that of Aquinas and Paley. Behe makes this point clear when he tells us that his "argument is limited to design itself; I strongly emphasize that it is not an argument for the existence of a benevolent God, as Paley's was," and "questions about whether the designer is omnipotent, or even especially competent, do not arise in my argument as they did in Paley's."19 Behe does not claim that the God of orthodox theism can be derived directly from the evidence he cites in favor of design. All that he claims is that certain facts of biochemistry are sufficient to tip the evidential scale in favor of the design hypothesis. Whether the designer can be shown to be the unique, perfectly good, omnipotent and omniscient being worshiped by the Western religious traditions is a question that Behe is willing to leave to philosophers and theologians.20 Indeed, Behe is not alone in this interpretation of the implications of the contemporary argument for intelligent design. For example, William Dembski, the foremost figure in the intelligent design movement, explicitly claims that arguments such as Behe's are not works of natural theology.21

We may represent the structure of the modern teleological argument (MTA) as follows:

1. Certain natural phenomena clearly have feature F.

2. It is highly improbable that F be caused by something other than an intelligent designer.

3. Therefore, it is highly probable that there exists an intelligent designer of such phenomena.

As noted above, Behe's project is much less ambitious than the classic versions of the teleological argument. He simply argues that a designer or designers, with unknown capacities and moral

dispositions, is the best explanation of phenomena observed at the biochemical level. Other teleological arguments with less ambitious pretensions will also likely take this form. Furthermore, it should be clear that the parsimony of the conclusion of MTA insulates it from IEO. Behe does not, nor does any other major member of the intelligent design movement, claim to prove the existence of the God of orthodox theism. Rather, all we are shown is that nature or some systems within nature are products of design. As such the Humean may not assert that the proponent of such an argument has overstepped what can be strictly derived from the empirical evidence.

Although MTA successfully sidesteps IEO, one may wonder what good it does the theist: If the argument does not strongly support the theistic hypothesis, how does it help the cause of belief? The answer is that such an argument may play a role in a cumulative case for God's existence. In order to illustrate what is meant by a cumulative case, take the example of a detective investigating the theft of a large sum of money from a bank. Suppose if Smith had perpetrated the crime we would expect (1) he would have been in the vicinity of the bank at the time of the crime, (2) he had recently come into a large sum of money that cannot otherwise be explained, and (3) he had ample motive for taking the money. If our detective can only prove that it is probable that Smith meets any one of these criteria, he has not given us good reason to believe that Smith is guilty; for example, there were probably plenty of people in the vicinity of the bank who did not steal the money. However, if the detective can show that it is probable that Smith meets all three of these descriptions, then there is very good reason to suspect that Smith is indeed the thief. Thus, even though an argument that shows it is highly probable that Smith was in the vicinity of the bank at the time of the robbery is independently insufficient to show that he was likely the thief, the combination of such an argument with other arguments that show he probably meets the other criteria will lead us to be rightfully suspicious of Smith. The combining of separate arguments, each of which is insufficient to prove a particular hypothesis independently, into a single argument for that hypothesis is what is meant here by a cumulative case.

If the God of theism exists, we would expect to find intelligent design in his creation, and the modern teleological argument shows that this expectation has been met. Nevertheless, as we have discussed above, this conclusion alone is not enough to make the theistic God's existence more probable than not. But just as in the case of our suspected thief, if further arguments can show that many of the other expectations we have for a universe created by God have been met, the combination of this evidence may be sufficient to show that we have very good reason to believe that God exists. MTA ca assist a cumulative case for God's existence by showing that one of our ex pectations for what would obtain should God exist has been met. MT leaves us with more work to do (we still need to determine whether any o our other expectations have been met), but it does provide one very impor tant piece of the puzzle. However, before we may finally settle the issue of MTA, we need to address a further Humean criticism that may rob suc an effort even of its role in a cumulative case.

The Counterevidence Objection

Let us now turn to a second classic Humean criticism, one which we wil see raise some trouble for MTA. In the Dialogues Philo notes that

> [t]here are many inexplicable difficulties in the works of Nature, which, if we allow a perfect author to be proved a priori, are easily solved, and become only seeming difficulties, from the narrow capacity of man, who cannot trace infinite relations. But according to your method of reasoning, these difficulties become all real; and perhaps will be insisted on, as new instances of likeness to human art and contrivance. At least, you must acknowledge that it is impossible for us to tell, from our limited views, whether this system contains any great faults or deserves any considerable praise, if compared to other possible, and even real systems.23

Hume's point here is that nature is full of apparent flaws, which should count as counterevidence to the orthodox theist's hypothesis, and one might say that turnabout is fair play. Hume grants that one can explain away the apparent flaws in nature more easily if one is a proponent of cosmological or ontological arguments. Such theists do not typically cite the arrangement of nature to support their particular views regarding the power and character of the creator, so they gain greater credibility when they shrug off the apparent inconsistency between God's perfection and infelicities in the natural order. According to Hume, the theist who appeals to the arrangement of nature as evidence of God's existence may not make such a move. The proponent of the teleological argument is committed to the view that the arrangement of nature is evidence of the character of its cause. Therefore, the arrangement of nature that a theist may see as evidence for God's existence requires us also to recognize a great deal of evidence that should lead to the opposite conclusion. It is unclear, at least on the face of the matter, which side is better supported by the evidence provided by nature. Thus, MTA undermines itself, if one accepts the strength of the evidence for the theist's conclusion, then one must accept equally strong counterevidence, and any theistic conclusion is thereby compromised. Let's call this criticism the "counterevidence objection" (CO).

CO is also employed by contemporary critics of teleological arguments. David Myers has recently followed such a line and concluded that "there is nothing in the new natural theology, based on the findings of contemporary science, that gives us any new compelling reason to think that, even if there is a cosmic designer, this designer possesses all three attributes of the God of traditional theism.,24 Myers's argument is a good representative of the ba sic Humean approach inspired by CO, so I will flesh it out in some detail. His strategy is to cite evidence that the natural order is not the product of the creative effort of a perfect being, and then claim that the sort of evidence cited by Behe and company does nothing to resolve these doubts.

The counterevidence we are concerned with is said to undermine the omnipotence and omniscience of the creator. Myers claims that omniscience implies knowledge of how best to design things to achieve any particular purpose, and omnipotence implies power to instantiate any such design. On the assumption of the theistic hypothesis, Myers believes that we should "expect a designed structure or system to be such that we cannot imagine how it could be improved.,25 Given this principle, even if we grant that the universe is designed, we may not conclude that the designer is both omnipotent and omniscient if there are ways in which we can envision its having been better designed.

Examples of apparent design flaws in nature are notoriously easy to produce. For instance, the neural wiring of the human eye is such that it creates a natural blind spot, and the structure of the human trachea allows swallowing to interfere with breathing, which gives rise to a considerable risk of choking. One cannot deny that the human eye and trachea would perform better if they lacked these flaws. On the basis of such examples, and they can be multiplied,26 Myers concludes that, even if we grant that there is complexity at the biochemical level that supports strongly the existence of a supernatural designer, obvious facts of anatomy preclude the conclusion that the designer is both omnipotent and omniscient.

One may be inclined to argue that a perfect creator might have motives unknown to us that are sufficient to justify these apparent design flaws. Myers replies to such an objection that it just seems implausible to claim that any good can come from a blind spot or any of the other defects in nature he cites.27 Furthermore, I might add that an appeal to ends beyond our ken is a poor strategy for the theist to follow, for it not only asks us to believe in a perfect creator but also to believe that such an artificer has unknown and possibly counterintuitive motivations. This addition to the theistic hypothesis could only weaken the case made by any design argument because the

more content we build into a hypothesis, the less confirmation it receives by any piece of evidence.28

That the classical teleological argument is particularly troubled by CO should be clear. The proponent of such an argument is committed to the claim that we can read the existence and character of God directly from the evidence we encounter in nature. However, as a host of skeptical philosophers have pointed out over the millennia, there seems to be as much evidence in nature to speak against a perfectly competent creator as there is evidence that speaks in favor of the theistic hypothesis. Thus, we may take this Humean objection as good reason once again to temper our enthusiasm for CTA.

However, one might be inclined to believe that CO does not really pose a problem for MTA. We have discussed earlier that such an argument is proposed as part of a cumulative case for God's existence. Proponents of MTA merely claim that part of what we expect on the assumption of God's existence does obtain, namely, there is evidence of design in the universe. One then might conclude that CO is not a worry for the proponent of MTA simply because this argument does not claim to give us independent reason to believe the designer is particularly powerful or knowledgeable. Nevertheless, the systems taken as evidence in MTA clearly call for an explanation in terms of intelligent agency. This modest conclusion, one might say, is all that is necessary in order for MTA to make its contribution to a cumulative case for God's existence.

We should not be so quick to assume that there are no troubles posed for MTA by CO. We must keep in mind that MTA is useful to the theist only as part of a cumulative case for the existence of God. The conclusion that such a cumulative case is supposed to support is the notion that God is the creator, designer and sustainer of the universe, and this claim is usually taken to imply that God is intimately involved with the whole of his creation, such that he is responsible for the existence and nature of everything in the universe.29

The basic claims of theism then provide us with two points relevant to the plausibility of MTA: (1) It is inconsistent with the basic claims of theism that design be a local phenomenon. Since the whole of the universe is supposed to be a product of God's activity, we should expect that all systems in nature would reflect his creative plan. Theism requires a universe that is well designed from head to toe; it is not just this or that natural system that God is supposed to have designed, but the entirety of nature. (2) Therefore, in order for a well-confirmed design hypothesis to be helpful to the theist, the overall structure and arrangement of the systems of nature must be at least consistent with the work of a perfect designer. Furthermore, even though there is quite a bit of evidence of well-designed systems in nature, if there are equally as many poorly designed systems to found, then the overall probability of the universe's being designed by God has not been shown to be greater.

Thus, if Hume is correct, any positive contribution MTA makes to a cumulative case for God's existence could easily be nullified by a skeptic who points out the all-too-common presence of apparent design flaws. We may grant that systems such as bacterium's flagellum are indeed well crafted enough to support the hypothesis of a perfect designer. On the other hand, we must also admit that something like the human spine, which we all know is quite prone to problems, is not exactly what we would expect of omniscience and omnipotence. Likewise, if one points out the incredible complexity and elegance of the human immune system as evidence of a perfect designer, one must also recognize the evidence against this hypothesis provided by the propensity of the human body to produce cancers. When taken in isolation, the immune system and the flagellum may very well show that it is probable that there is an intelligent designer. As such, the evidence provided by these systems may contribute positively to a cumulative case for God's existence.

However, the theistic hypothesis requires that God is responsible for all mechanisms in nature, and therefore the occurrence of frequent spinal injuries and cancer cannot be ignored.

The Humean's point is that this counterevidence to design cancels out the evidence provided by flagellum and the immune system. We could expect that the entire universe created by God would be perfectly designed, but, given the prevalence of apparent design flaws, it is at best a 50 percent probability that God has designed nature.30 That is, MTA shows that it is neither more nor less likely that God is the designer of the universe. If the Humean is correct on this score, it is difficult to see how MTA can be used to raise the overall probability of God's existence, and this particular piece of the puzzle has not been provided. Thus, one should worry whether MTA has anything to offer even a cumulative case for the existence of the God of orthodox theism.31

The task then for the MTA proponent is to counter CO by showing that the apparent design flaws we find in nature are actually consistent with the theistic hypothesis. In the following section we will discuss how a strategy taken from the contemporary debate over the problem of evil may be helpful to this end.

Defending MTA Against CO: The Basic Strategy

We have seen above that one should expect the Humean to argue that the supposed imperfections in creation are incompatible with the design of an omnipotent and omniscient creator. Therefore MTA would have no role to play in a cumulative case for God's existence; by drawing evidence for God's existence from nature one is forced to accept equally compelling evidence in favor of the opposite conclusion.

One of the most influential theistic strategies32 in the debate regarding the problem of evil employed in recent years comes to us in the form of Stephen Wykstra's condition of reasonable epistemic access (CORNEA), which he summarizes as follows:

On the basis of cognized situation s, human His entitled to claim "It appears that p" only if it is reasonable for Hto believe that, given her cognitive faculties and the use she has made of them, if p were not the case, s would likely be different than it is in some way discernable by her.33

In other words, if one is going to believe reasonably that some state of affairs obtains on the evidence provided by a particular set of data, she must be able to point out what difference in the evidence we would expect to find if that state of affairs did not obtain. For example, if I were to claim after inspecting a crowded room that Mr. Jones is not in the room, I must be able to say exactly what would be different about the appearance of the room if Mr. Jones were in the room. In this case, I would simply need to point out that the appearance of the room would be different in that it would include the appearance of Mr. Jones.

The skeptic in the debate over the problem evil claims that there is no good that could justify certain instances of intense suffering. As such, so the skeptic argues, the evidence of suffering makes it unreasonable to assume the existence of God. However, if we take CORNEA seriously, then it is incumbent on the skeptic to give an account of how the relevant data would be different if there were such a justifying good. Specifically, the skeptic needs to point out how the amount or intensity of suffering in the world would be different were theism true.

The skeptic's task in this case is a difficult undertaking. One may concede both that we would expect all suffering in a world created by God to lead to a greater good and that there is no known good, the achievement of which would justify the horrible suffering that occurs with regularity in the current state of the universe. On this much the theist and the skeptic may agree. However, if we admit that there are goods beyond our ken—good states of affairs that human beings in their

current state are unable to recognize as being good—then it remains possible that the horrible suffering in the world does indeed serve some end that justifies God's allowing it to happen. We are then unable to say exactly what the relevant difference between our world and a world created by God would be. In other words, if we have reason to believe that there are unknown goods sufficient to justify apparently gratuitous suffering, then it seems the atheist may not reasonably claim

that a certain state of affairs that obtains in the actual world would not obtain in a world created by God because there is no apparent good that comes of it. It is always possible, perhaps even to be expected, that the suffering is justified by a good beyond our ken.34 Thus, it is unclear exactly what the skeptic expects to be different in a world created by God.35

It is not difficult to see how CORNEA can be useful to the proponent of MTA. When pressed with CO, the proponent of MTA should ask his critic to specify how the data provided by the natural order would be different if there were an omniscient and omnipotent designer. The critic's likely response is that, if God existed, we would not expect the prevalence of apparent design flaws. But the proponent of MTA may appeal to CORNEA to point out that the current state of the world is no different from what we might expect on the assumption that God is responsible for the natural order. As long as there are ends of design beyond our ken, it always remains possible that an apparent design flaw is the product of impeccable principles of engineering that are unknown to us. Thus, once again the skeptic is unable to articulate just how creation would be different under the assumption that God exists.

CORNEA provides a promising strategy for the proponent of MTA, but its typical application will not serve that end. By appealing to goods beyond our ken, the theist increases the content of his hypothesis. We are asked not only to believe in an omnipotent, omniscient and perfectly good being that has all the properties associated with the God of orthodox theism, but also we must accept a certain theory of goodness implying that there are goods (for the present, at least) unknowable by the human intellect. Such a claim of unknowability in principle is controversial and lowers the overall probability of the theist's position. The mere fact that the unknowability claim is conjoined with the assertion of God's existence lowers the probability of the entire conjunction. Although there are philosophers, namely, G. E. Moore in Principia Ethica, who have held (for independent reasons) that there may be goods of which we have no knowledge, one may worry that appeal to such a theory of goodness is quite ad hoc on the theist's part; there is nothing in the basic theistic hypothesis that requires the existence of good beyond our ken. As a rule of thumb one should attempt to employ a CORNEA strategy only by appealing to goods that are both within our grasp and consequences of the minimal claims of orthodox theism.

The task of the proponent of MTA, then, is to articulate principles that are plausible components of the basic claims of orthodox theism and which would lead us to expect the occurrence of apparent design flaws. We now turn to G. W. Leibniz for a presentation of two such goods that can serve us well in defense of MTA against the Humean attack.

A Leibnizian Application Of CORNEA: The Principle Of Simplicity

G. W. Leibniz, a (mainly) seventeenth-century metaphysician, theologian, political thinker and mathematician, is better known for his cosmological and ontological arguments, although he does offer a version of CTA. However, we will not need to enter into a discussion of his particular arguments for God's existence. Rather, Leibniz's more general theological views contain insights into the constraints a perfect creator might operate under, and these constraints show that apparent design flaws are consistent with a natural order that is the product of divine artifice. Leibniz's thought on divine creation and his sustained program of theodicy give rise to various vexing philosophical problems (most famously his claim that the actual world is the best of all possible worlds), and I cannot defend his views here. Nevertheless, there is at least one doctrine

central to Leibniz's project that is certainly consistent with the basic theistic hypothesis, which we shall address in what follows.37

We should reemphasize at the onset that we need not make any strong claims in favor of these Leibnizian principles. All that is needed for our purposes is the indication of principles that are both consistent with the theistic hypothesis and sufficient to justify the occurrence of design flaws. Thus, we do not need to claim that Leibniz's principles are necessitated by theism, nor do we need to show that these principles would likely be accepted by most theists. As long as God's pursuit of such principles is possible and these principles are sufficient to justify apparent design flaws, then the Humean will be unable to point out a difference in the relevant data set that must obtain if God exists.

Leibniz's views about the perfection of a world created by God are as famous as they are controversial: "Since all possible things have a claim to existence in God's understanding in proportion to their perfections, the result of all these claims must be the most perfect actual world which is possible."38 Despite the way his optimism has been infamously satirized by later critics such as Voltaire and Schopenhauer, Leibniz is certainly well aware of the occurrence of apparent flaws in creation that are prima facie inconsistent with ours being the best of all possible worlds. At times when Leibniz addresses these worries he seems to employ something along the lines of CORNEA by appealing to goods beyond our grasp. For example, in one of his most seminal attempts at justifying the order of creation in his Discourse on Metaphysics, Leibniz claims that "to understand the reasons in particular which have moved [God] to choose this order of the universe ... surpasses the power of the finite mind."39 On the face of the matter, one might believe that Leibniz is apt to appeal to goods beyond our ken—i.e., "the reasons in particular which have moved" God to create—in order to justify the apparently infelicitous arrangement of nature. These remarks then give all the appearance of an application of CORNEA that makes use of an unknown principle to justify God's allowance of apparent design flaws. As such, it would then seem that Leibniz is taking us beyond the requirements of basic theism, and thus offers little help to the proponent of MTA.

We should not be too quick to accept this simple interpretation of Leibniz's theodicy in the Discourse. Leibniz goes on to claim in the same section that, although we cannot know all of God's ultimate ends for creation, "some general remarks can be made, however, about the ways of providence in the government of affairs."40 In other words, no mortal can know all of what motivates God for any single divine act, but we can rationally discern certain guidelines that a perfect being would follow when creating a world. These principles may in turn, according to Leibniz, reveal why it is that certain apparent infelicities actually are quite consistent with the perfection of the best of all possible worlds.

One such guideline is what I call Leibniz's "principle of efficiency" (PE). Leibniz begins to articulate this principle when he claims that the "simplicity of the ways of God ... is shown especially in the means which he uses, whereas the variety, opulence, and abundance appears in regard to the ends or results. '41 Leibniz's point here is not that the work of a perfect creator would not exhibit stunning complexity; rather his claim regards the proportion between means and results that is the mark of the competence of a designer. This point can be fleshed out well with an example:

> It can be said, then that he who acts perfectly is like an excellent geometrician who knows how to find the best construction of a problem; or a good architect who makes the most advantageous use of the space and the capital intend for a building, leaving nothing which offended or which lacks the beauty of which it is capable; or a good family head who makes such use of his holding that there is nothing uncultivated and barren; or a skilled machinist

> who produces his work by the easiest process that can be chosen; or a learned author who includes the greatest number of subjects in the smallest volume 42

Leibniz's point is that one sign of true expertise is one's ability to bring about a great number of desired effects with limited resources. Given vast resources, even a mediocre designer may be able to craft a product of great value. However, the most skilled architect is the one who can build something magnificent on a small budget, and the expert engineer is somebody who can produce an intricate and highly effective machine through an efficient process. In short, the ability to produce a grand product through a very small set of resources is evidence of a designer of very high proficiency. PE is not the only mark of sound design, but it is certainly part of what we expect from an artificer of great skill. As such, one mark of a world created by a perfect designer is that a vast number of phenomena are produced with limited resources. We may then conclude that we would expect to find a perfect economy of means and ends in a world designed by a perfect being.

An objection looms here. Certainly it is a mark of great skill when a designer with limited resources is able to craft a highly valuable artifact, but it is unclear that God would have limited resources available when creating a universe. The architect has a certain budget for a building project imposed on him, and therefore the range of possibilities for pursing his end is restricted. The wisdom of the architect is then demonstrated if he does not expend any of these resources needlessly; he uses every bit of his capital in the most efficient way available to bring about a building of high value. Since God is omnipotent, all possible plans for design are open to him. No possible plan of design is any more or less difficult for God to execute. There then seems to be no sense in which God must operate on limited resources when designing the universe. As long as God's ultimate ends are met he does not evidence his wisdom by choosing any particular route to his goal, because all such routes are equally easy for him to pursue. There then seems to be no sense in which God can be any more or less efficient. Thus, we might worry that PE is simply not applicable to God.

Leibniz is aware of this concern when he notes that it is "true that nothing costs God anything." Nonetheless, Leibniz goes no to say, "l]here wisdom is concerned, decrees or hypotheses are comparable to expenditures, in the degree to which they are independent of each other, for reason demands that we avoid multiplying hypotheses or principles, somewhat as the simplest system is always preferred in astronomy."43 The possibilities for creation are not limited for God; there are infinitely many ways in which his ends could be met. However, God could produce a needlessly complicated universe. God might create a universe that operates according to more natural laws, what Leibniz calls "principles," than are absolutely necessary to bring about the phenomena he wants to establish. These natural principles, according to Leibniz, are God's "means" for bringing about his ends; God fulfills his plan for creation by instantiating a certain set of natural laws that govern creation. If any principles of nature obtain that are not absolutely necessary for God's creative plan, then he is not operating with the highest efficiency. Such a principle would be a needless intellectual "expenditure" on God's part. Thus, God satisfies PE by producing a universe in which there is a perfect ratio between the principles of nature (God's "means") and the phenomena they govern. The degree to which fewer principles subsume a greater number of phenomena is one determining factor in the overall perfection of the universe, and therefore an indication of the perfection of its designer.

PE enables us to respond to the Humean proponent of CO using a revised CORNEA strategy. As we discussed earlier, the Humean critic cites such familiar phenomena as the faulty human spine and the frequency of cancer in mammals as counterevidence to MTA. PE shows that this supposed counterevidence is consistent with the work of a perfect designer. Leibniz would not deny that God could produce a system of nature that is free of cancer and faulty spinal columns. Nevertheless, it

remains possible that elimination of these apparent errors would decrease the overall perfection of the created order by multiplying the number of natural principles. Thus, we need not take the occurrence of apparent design flaws to reflect badly on either the power or wisdom of the creator. It is possible that these infelicities are allowed to occur in the interest of maintaining the best possible proportion between natural principles and the phenomena they govern. One might even say that it is not surprising to see apparent flaws in a world that is guided by a principle of efficiency for, as long as the means available are constrained by considerations of the efficiency of means, the end product may appear less perfect than another world that was governed in an ad hoc manner. (Of course, for Leibniz, this is only an apparent lack of perfection, for the world that is governed by a principle of simplicity really is more perfect.)

If the occurrence of apparent design flaws is consistent with the work of a perfect designer, as PE shows, then CORNEA may be effectively utilized. It is incumbent on the Humean critic to point out exactly how the world would be different from its current state if it were God's work. The claim that it would not contain any particular apparent design flaw is inadequate, since under PE this is at best an open question. Leibniz has shown us that any such appearance is perfectly consistent with the theistic hypothesis. Thus, the evidence cited in MTA supports the theistic hypothesis and the supposed Humean counterevidence is actually consistent with the work of a perfect designer. In short, PE coupled with CORNEA show that Hume's supposed counterevidence is not counterevidence at all.

Unlike appeals to unknown goods, PE will not cost the proponent of MTA anything in terms of the plausibility of the theistic hypothesis. Leibniz does not indulge any special pleading by appealing to principles that remain in principle beyond our grasp. Rather, he points out a readily grasped principle. Indeed, as Leibniz's examples show, we presuppose PE in our everyday evaluation of the expertise of practical designers. Moreover, the fact that PE is consistent with, even suggested by, the theistic hypothesis is readily apparent. We would not expect that God would employ principles that are unnecessary to the creation of a universe that meets his ends." The theist may then help herself to PE without adding to the weight of her hypothesis. Therefore, Leibniz gives us good reason to believe that well-designed systems may coexist in nature with apparently flawed systems and still raise the probability of the existence of an omniscient and omnipotent designer.45

Conclusion

Although we have seen that Hume's IEO gives us good reason to be cautious about CTA, MTA is immune to this criticism. And although Hume's CO enjoys some initial promise as an objection to MTA, CORNEA offers hope of overcoming this difficulty. However, CORNEA in its typical application requires an appeal to goods beyond our ken, which itself may make the theistic hypothesis ad hoc. Leibniz's PE indicates known goods that are sufficient to justify the appearance of design flaws and is entirely consistent with the basic theistic hypothesis. As such Leibnizian considerations provide us with a means of defending MTA against Humean concerns about apparent design flaws in nature.46

Notes

1 Darwin likely has had a greater direct influence on Western culture in general than has Hume, and Darwinism may be the more frequent reason cited for one's rejection of a particular teleological argument. Nevertheless, the Darwinian case against the soundness of the teleological argument does not give us reason in principle to reject the possibility of constructing a sound version of such an argument. Darwin simply gives us a way of explaining the supposed evidence of design without appealing to a designer. If one could produce evidence that cannot be so explained, the Darwinian objection would not have much force. Hume's objections call the entire enterprise of giving a teleological argument for God's existence into question. Hume does not merely offer an alternative explanation of the phenomena appealed to by the proponent of a teleological argument, but instead argues that no such proof of God's existence is plausible. For Hume's anticipation of the

Darwinian notion of evolution via unguided adaptation, see David O'Connor, Hume on Religion (New York: Routledge, 2001), chap. 7, esp. pp. 130-31.
2 For the purposes of this chapter I treat neither arguments from consciousness nor fine-tuning arguments as teleological arguments. My task is to assess the legacy of Hume's classic criticism of teleological arguments, and these traditional Humean concerns are not directed specifically toward the key issues in the fine-tuning and consciousness arguments. For a treatment of the fine-tuning argument see Robin Collins's chapter 9 of this volume. For a treatment of the argument from consciousness, see J. P. Moreland's chapter 13 of this volume.
3 For a more detailed introduction to Paley's argument, its strengths and weaknesses, see Stephen Davis, God, Reason and Theistic Proofs (Grand Rapids: Eerdmans, 1997), chap. 6. '
4 William Paley, "The Evidence of Design," in Natural Theology (London: Faulder, 1805). All quotations from Paley are taken from William Rowe and William Wainwright, eds., Philosophy of Religion: Selected Readings, 3rd ed. (Fort Worth: Harcourt Brace, 1998), pp. 155-62.
5 Anthony Kenny at times seems to take a similar line in his interpretation of the fifth way. lee The Five Ways: St. Thomas Aquinas' Proofs for God's Existence (London: Rutledge & Kegan Paul, 1969), pp. 97-98. For a good discussion of why it is best not to read the fifth way in such a manner, see John F. Wipple, The Metaphysical Thought of Thomas Aquinas (Washington, D.C.: Catholic University of America Press, 2000), pp. 480-85.
6 There is great debate regarding whether Aquinas believes that any one of his Five Ways is individually sufficient to establish the existence of the God of orthodox theism. Many thinkers argue that Aquinas sees the Five Ways as working in conjunction to produce a cumulative case for the existence of God. For a discussion of all sides of this debate see Wipple, Metaphysical Thought of Aquinas, pp. 497-501. Since Aquinas explicitly mentions the existence of God as the conclusion of his argument, I will assume for the purposes of this chapter that he believed the fifth way to be sufficient to prove orthodox theism.
7 It is unclear whether Aquinas intends his teleological argument to be deductive or inductive. Since teleological proofs are generally considered as specimens of inductive reasoning, I will assume for the sake of argument that Aquinas would be satisfied by this premise, which is stated probabilistically.
8 There is some debate among Hume scholars regarding whether Hume himself was an unbeliever. Although the standard view is certainly that Hume's voice in the Dialogues is that of the atheist Philo, a minority of scholars, most notably Nicholas Capaldi, have argued that there is reason to believe that Cleanthes, a somewhat mitigated believer, may actually speak for Hume. See Nicholas Capaldi, "Hume's Philosophy of Religion: God Without Ethics," International Journal of Philosophy of Religion 1 (1970): 233-40. For a recent argument (though somewhat attenuated) for the primacy of Philo as the voice of Hume, see O'Connor, Hume on Religion, pp. 214-16.
9 See J. L. Mackie, The Miracle of Theism (New York: Oxford University Press, 1982); John Haldane and J. J. C. Smart, Atheism. and Theism (Malden, Mass.: Blackwell, 1996); and Michael Martin, Atheism: A Philosophical Justification (Philadelphia: Temple University Press, 1992). 10B. 10 A. O. Williams, "Hume on Religion," in David Hume: A Symposium, ed. D. F. Pears (New York: St. Martin's, 1963), p. 85. Williams also claims that, in the wake of Hume's attack, "little seems to be left of the Argument from Design, or indeed of the Christian conception of God" (p. 87).
11 David Hume, Enquiry Concerning Human Understanding, sec. 11.
12 Hume's point here is basically to cite the fallacy Todd Furman calls "jumping the gun" in chapter 3 of this volume.
13 A1vin Plantinga, God, Freedom and Evil (Grand Rapids: Eerdmans, 1974), PP• 83-84.
14 for a recent attempt at such a defense of CTA see Richard Swinburne, "cosmological and Teleological Arguments," in The Rationality of Theism, ed. Adolfo Garcia de la Sienra (Amsterdam: Rodopi, 2000), P. 112.
15 Also pertinent when considering the limits of any teleological argument is the employment of a cumulative case argument strategy. This approach will be discussed in several places in this

chapter. See also R. Douglas Geivett's treatment of the cumulative case argument in chapter 14 of this volume.
16 See William Dembski, Intelligent Design (Downers Grove, Ill.: InterVarsity Press, 1999), and Michael Denton, Darwinism: A Theory in Crisis (Bethesda, Md.: Adler and Adler, 1986). For a good summary of the views of the intelligent design movement in general, see Michael Behe et al., Science and Evidence for Design in the Universe (San Francisco: Ignatius, 2000).
17 Michael Behe, Darwin's Black Box: The Biochemical Challenge to Evolution (New York: Free Press. 1996). chap. 3.
18 The dilemma between design and pure chance may be a false dichotomy in such cases. Some biologists and philosophers argue that one may appeal to nonselection-based processes, such as coadaptation or genetic drift, in order to account for complexity without resorting to chance or design. For an accessible summary of these views and their critical relevance to Behe's argument, see Michael Ruse, Can a Darwinian Be a Christian? The Relationship Between Science and Religion (New York: Cambridge University Press, 2001), pp. 115-22. Since my goal is not to evaluate the scientific status of design arguments, I will leave this issue aside in what follows. For further scientific objections to Behe's position, I also direct the reader to Kenneth R. Miller, Finding Darwin's God: A Scientist's Search for Common Ground Between God and Evolution (New York: Cliff Street Books, 1999). Behe's reply to Miller is found in 'Ihe Modern Intelligent Design Hypothesis: Breaking Rules," Philosophia Christi, n.s. 3 (2001): 165-79. A helpful overview of design arguments in general is Michael Ruse, Darwin and Design (Cambridge, Mass.: Harvard University Press, 2003). Chapter 15 contains an aseessment of the debate surrounding the intelligent design movement in light of philosophical, theological and scientific considerations.
19 Behe, "Modem Intelligent Design Hypothesis," pp. 165-66.
20 Ibid., p. 165.
21 See Dembski, Intelligent Design, pp. 105-9.
22 An example of a cumulative approach to proving God's existence is provided by Richard Swinburne in The existence of God, rev. ed. (New York: Oxford University Press, 1991). Swill burne also provides a less technical version of this case in Is There a God? (New York: Oxfor~ University Press, 1996). See Douglas Geivett's contribution in chapter 14 of this volume fa
an in-depth dis..
23 David Hume, Dialogues Concerning Natural Religion, in David Hume: Writings on Religion, ed. Anthony Flew (Peru, Ill.: Open Court, 1992), p. 228.
24 David Myers, New Design Arguments: Old Millian Objections," Religious Studies 36 (2000): 146.
25 Ibid., p. 147.
26 The proponent of CO will also likely point out the weakness of the spine, the narrowness of
the birth canal and the presence of the infection-prone appendix. ""Myers, "New Design Arguments," p. 151.
27 The problem is discussed in greater detail in the following section, "Defending MTA Against Co."
28 At this point a theist in the biblical tradition may interject that many of the apparent flaws in design may be accounted for by the Fall. God's original creation was flawless, but the introduction of sin into the universe, which was not by God's design, has caused aspects of creation to go off course. While one may accept this explanation as part of an overall theological understanding of the current state of the universe, it is not a good strategy for the theist when doing natural theology. Appealing to the Fall requires one to pack more information into the theistic hypothesis. This increase in the scope of the hypothesis lowers its overall probability.
29 Thus, appeal to the Fall will make it more difficult for the theist to prove her case. I discuss this strategy in greater detail in the next section of this chapter. For a view divergent from my own that takes the Fall as playing a core role in Christian theism, and therefore does not lower the overall probability of the theistic hypothesis, see Cornelius G. Hunter, Darwin s God. Evolution and the Problem of Evil (Grand Rapids: Brazos, 2001). Also helpful on this point is James Sennett, "The Inscrutable Evil Defense Against the Inductive Argument from Evil," Faith and philosophy 10 (1993): 220-29.

30 I am assuming for the sake of argument that there are (approximately) equally as many apparently well-designed as apparently poorly designed systems in nature.
31 This objection has no traction if the proponent of MTA does not intend to use his case to help prove God's existence. The occurrence of well-designed systems is perfectly compatible with the occurrence of poorly designed systems. In this way, the MTA could still be a naturalism defeater without contributing significantly to a case for God's existence. For a discussion of how MTA may fulfill this role, see Mark A. Discher and James D. Madden, "What ID Does and Does Not Imply," Perspectives on Science and Christian Faitb 56, no. 4 (2004): 286-91.
32 This particular strategy is often referred to as "skeptical theism." For a detailed discussion of the role skeptical theism has played in recent philosophy of religion, see David O'Connor, God and Inscrutable Evil: In Defense of Theism and Atheism (New York: Rowman & Littlefield, 1998), chap. 10.
33 Stephen J. Wykstra, "The Humean Obstacle to Evidential Arguments from Suffering: On Avoiding the Evils of 'Appearance,'" International journal of Philosophy of Religion 16 (1984): 85. For a more recent treatment, see Stephen J. Wykstra, "Rowe's Noseeum Arguments from Evil," in The Evidential Argument from Evil, ed. Daniel Howard-Snyder (Bloomington: Indiana University Press, 1996), pp. 126-50.
34 For an explication of some reasons why this might be expected, see Sennett, "The Inscrutable Evil Defense."
35 For a response to skeptical theism from a "friendly atheist," see William Rowe, "The Evidential Argument from Evil: A Second Look," in The Evidential Argument from Evil, pp. 262-85.
36 For a good introduction to Leibniz's well-known cosmological and ontological arguments, see David Blumenfeld, "Leibniz's Ontological and Cosmological Arguments," in The Cambridge Companion to Leibniz, ed. Nicholas Jolley (New York: Cambridge University Press, 1995), PP. 353-81.
37 Leibniz offers a famous argument for a version of idealism in which all of reality is reducible to immaterial atoms, what he calls monads. Moreover, Leibniz accepts a form of essentialism in which all of the nonrelational properties of any substance are absolutely necessary to it. In short, much of what Leibniz has to say in his metaphysics is quite controversial. Nevertheless, the Leibnizian claims we will rely on in this chapter can be separated from Leibniz's more tendentious metaphysical doctrines. Indeed, the Leibnizian resources we shall draw on in what follows are all taken from section 5 of his Discourse on Metaphysics (see note below), which may be understood in isolation from his more controversial claims. In short, one need not accept idealism or essentialism in order to employ a Leibnizian defense of MTA.
38 G. W. Leibniz, Discourse on Metaphysics, in Philosophical Papers and Letters, Second Edition, ed. and trans. L. E. Loemker (Dordrecht, The Netherlands: Kluwer, 1989), p. 369.
39 Ibid., p. 305.
40 lbid.
41 Ibid., p. 306.
42 ibid., PP. 305-6. It is unclear that God would have limited resources available when creating a universe. The architect has a certain budget for a building project imposed on him, and therefore the range of possibilities for pursing his end is restricted. The wisdom of the architect is then demonstrated if he does not expend any of these resources needlessly; he uses every bit of his capital in the most efficient way available to bring about a building of high value. Since God is omnipotent, all possible plans for design are open to him. No possible plan of design is any more or less difficult for God to execute. There then seems to be no sense in which God must operate on limited resources when designing the universe. As long as God's ultimate ends are met he does not evidence his wisdom by choosing any particular route to his goal, because all such routes are equally easy for him to pursue. There then seems to be no sense in which God can be any more or less efficient. Thus, we might worry that PE is simply not applicable to God.
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comparable to expenditures, in the degree to which they are independent of each other, for reason demands that we avoid multiplying hypotheses or principles, somewhat as the simplest system is always preferred in astronomy."43 The possibilities for creation are not limited for God; there are infinitely many ways in which his ends could be met. However, God could produce a needlessly complicated universe. God might create a universe that operates according to more natural laws, what Leibniz calls "principles," than are absolutely necessary to bring about the phenomena he wants to establish. These natural principles, according to Leibniz, are God's "means" for bringing about his ends; God fulfills his plan for creation by instantiating a certain set of natural laws that govern creation. If any principles of nature obtain that are not absolutely necessary for God's creative plan, then he is not operating with the highest efficiency. Such a principle would be a needless intellectual "expenditure" on God's part. Thus, God satisfies PE by producing a universe in which there is a perfect ratio between the principles of nature (God's "means") and the phenomena they govern. The degree to which fewer principles subsume a greater number of phenomena is one determining factor in the overall perfection of the universe, and therefore an indication of the perfection of its designer.

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If the occurrence of apparent design flaws is consistent with the work of a perfect designer, as PE shows, then CORNEA may be effectively utilized. It is incumbent on the Humean critic to point out exactly how the world would be different from its current state if it were God's work. The claim that it would not contain any particular apparent design flaw is inadequate, since under PE this is at best an open question. Leibniz has shown us that any such appearance is perfectly consistent with the theistic hypothesis. Thus, the evidence cited in MTA supports the theistic hypothesis and the supposed Humean counterevidence is actually consistent with the work of a perfect designer. In short, PE coupled with CORNEA show that Hume's supposed counterevidence is not counterevidence at all.

Unlike appeals to unknown goods, PE will not cost the proponent of MTA anything in terms of the plausibility of the theistic hypothesis. Leibniz does not indulge any special pleading by appealing to principles that remain in principle beyond our grasp. Rather, he points out a readily grasped principle. Indeed, as Leibniz's examples show, we presuppose PE in our everyday evaluation of the expertise of practical designers. Moreover, the fact that PE is consistent with, even suggested by, the theistic hypothesis is readily ap

43 Ibid., p. 306.

44 Leibniz would likely prefer a stronger claim here. In his view PE is not merely consistent with the theistic hypothesis, but is logically implied by God4s perfection. However, for our purposes, it is ample that PE only be consistent with theism, and therefore there is no need to saddle the theist with the claim that theism necessitates it.

45 One may object that things may not be so simple for the theist on this score. If there is some reason to believe that the proportion between the laws of nature and the phenomena they govern

in the natural world is less than parsimonious, then the appeal to PE is blocked. However, recent optimism by many physicists regarding the eventual discovery of a single formula that can ultimately account for all physical phenomena (the fabled "Theory of Everything") may bode well for PE. Such a formula would show that all natural occurrences are subsumed under a single natural law, which a Leibnizian would interpret as evidence of the perfect simplicity of God's means.
46 I owe a great deal of gratitude to Martin Curd and James Sennett for their careful reading and generous comments on earlier drafts of this chapter. I have done my best to take their criticisms into account, although some of our differences still remain. Gordon Barnes, Mark A. Discher, Douglas Groothuis and Bryan O'Neal also made helpful recommendations. Thanks to all. I of course take sole responsibility for the weaknesses and errors contained in this work.

Chapter 9: Hume, Fine-Tuning And The "Who Designed God?" Objection
Robin Collins

Elsewhere I have argued that the discoveries in physics and cosmology, along with developments in philosophy, particularly in the logic of inference, have significantly bolstered the traditional teleological argument, or argument from design.' Today, I contend, the evidence from physics and cosmology offers us significant, well-formulated reasons for believing in theism. In this chapter I will show how, if properly formulated, the argument from fine-tuning can largely circumvent David Hume's major objections to the teleological argument. I will devote the second half of this chapter to addressing Hume's most important and often-raised objection to the design argument, what could be called the "Who Designed God?" objection. Before considering these objections to the fine-tuning design argument, however, we will need to review the argument briefly.

Review Of The Fine-Tuning Argument
The fine-tuning of the laws of nature and the initial conditions of the universe for intelligent life (or conscious observers) has been one of the most widely discussed bodies of cosmological evidence for design, although other aspects of the laws of nature, such as their beauty, elegance and intelligibility also suggest design. The fine-tuning of the cosmos for intelligent life refers to the fact that many of the fundamental parameters of physics and the initial conditions of the universe are balanced on a razor's edge for intelligent life to occur. For example, if these parameters were slightly different, life of comparable intelligence to our own would not exist, or would at least be much less likely. The first major claim along these lines was in 1956--that the resonance states of carbon and oxygen had to fall within a narrow range for significant quantities of both carbon and oxygen to be produced in stars. Without enough carbon and oxygen, the existence of carbon-based life would be seriously inhibited.

Many other instances of cosmic fine-tuning have been advanced since then, and much work is continuing. One of the most impressive and widely discussed cases of fine-tuning is that of the "cosmological constant," a term in Einstein's equation of general relativity that governs the rate at which space expands. For the universe to be hospitable to life, this constant must be fine-tuned to at least one part in 10 to the 53rd power—that is, one part in one hundred million, billion, billion, billion, billion, billion—of what physicists consider its natural range of values. To get an idea of how precise this is, it would be like throwing a dart at the surface of the earth from the moon and hitting a bull's-eye one trillionth of a trillionth of an inch in diameter—less than the size of an atom!

Elsewhere I have presented the evidence for fine-tuning and developed one version of the argument from the fine-tuning in detail, including addressing various objections to the argument.2 Here I can only briefly summarize the main features of the argument. I first distinguish between what I call the "atheistic single-universe hypothesis" and the "many-universes hypothesis."3 According to the former, there is only one universe, and it is ultimately an inexplicable, "brute" fact that the universe exists and is fine-tuned. Many atheists, however, advocate the latter—sometimes also

called the "many-worlds hypothesis." According to the most popular version of this hypothesis, there exists some physical process that imaginatively could be thought of as a "universe generator" that produces a very large or infinite number of universes, with each universe having a randomly selected set of initial conditions and values for the constants of physics. Because this generator produces so many universes, it will eventually—and strictly by chance—produce one that is set just right for intelligent life to occur.

I argue that fine-tuning strongly supports theism over the atheistic single-universe hypothesis and then separately argue that there are reasons to prefer the theistic explanation of fine-tuning over the atheistic version of the many-universes explanation.4 The argument that the evidence of fine-tuning strongly supports theism over the atheistic single-universe hypothesis is our main concern in this chapter.5

Although the fine-tuning argument can be cast in several different forms—such as inference to the best explanation—I believe the most rigorous way of formulating the argument is in terms of what I will call the "prime principle of confirmation" (PPC), a version of the principle that Rudolf Car-nap has called the "increase in firmness" principle, and others have simply called the "likelihood principle.,6 The prime principle can be stated as follows: For any two competing hypotheses H1 and H2, an observation counts as evidence in favor of H1 over H2 if the observation is more probable under H1 than H2. Put symbolically, evidence E counts in favor of H1 over H2 if P(E/H1) > P(E/H2), where "P(E/H1)" and "P(E/H2)" represent the conditional epistemic probability of E on H1 and H2, respectively. (The notion of epistemic probability will be explained below.) Moreover, the degree to which the evidence counts in favor of one hypothesis over another is proportional to the degree to which the observation is more probable under the one hypothesis than the other.'

To avoid certain potential counterexamples, however, we will restrict the principle to apply only to those cases in which H1 was not merely constructed to account for E being considered: for example, H1 has some independent plausibility apart from E, or was at least widely considered viable apart from E.8 I call this the restricted prime principle. The motivation for restricting the principle can be seen by considering the following example. Suppose that I roll a die twenty times and it comes up some apparently random sequence of numbers—say 2, 6, 4, 3, 1, 5, 6, 4, 3, 2, 1, 6, 2, 4, 4, 1, 3, 6, 6, 1. The probability is one in 3.6 x 1015, or about one in a million billion. To explain the die coming up in this sequence, suppose I invented an hypothesis that there is a demon whose favorite number is just the above sequence of numbers, and that this demon had a strong desire for that sequence to turn up when I rolled the die. Now, if this demon hypothesis were true, then the fact that the die came up in this sequence would be expected--that is, it would not be epistemically improbable. Consequently, by the unrestricted prime principle of confirmation, the occurrence of this sequence would strongly confirm the demon hypothesis over the chance hypothesis. But this seems counterintuitive: given a sort of commonsense notion of confirmation, it does not seem that the demon hypothesis is confirmed. Or consider another example. Suppose that Jane Doe wins the lottery. Under the chance hypothesis this is very unlikely—say one in a million—but under the hypothesis that the lottery was rigged in her favor, it is not improbable at all. Thus, contrary to what we might think intuitively, it follows from the unrestricted version of the prime principle that Jane's winning the lottery strongly confirms that it was rigged in her favor.

Now consider a modification of the demon case in which, prior to my rolling the die, a group of occultists claimed to have a religious experience of a demon they called Goodal, who they claimed revealed that her favorite number was the number above and that she strongly desired that number be realized in some continuous sequence of die rolls in the near future. Suppose they wrote this all down in front of many reliable witnesses days before I rolled the die. Certainly, it seems, the sequence of the rolls would count as evidence in favor of their "Goodal" hypothesis over the chance hypothesis. Of course, in this circumstance, the Goodal hypothesis was already advocated prior to

the rolling of the die, and thus the restricted prime principle implies that the sequence of die rolls confirms the "Goodal" hypothesis. Thus, the restricted version of the principle gives the right results in this case. Similarly, if we already suspected that the lottery was rigged in Jane's favor, we would consider the fact that she won the lottery strong evidence in favor of the rigging hypothesis .9

The core of my version of the fine-tuning argument begins by more carefully defining what we mean by fine-tuning. In the literature, "fine-tuning" typically refers to the conjunction of the following two claims: (1) the claim that the range of life-permitting values for the constants of physics is small compared to some properly chosen comparison range R for those values;10 and (2) the claim that the values of the constants actually fall within the life-permitting range." I will refer to claim 1 as the claim that the constants are fine-tuned, and to claim 2 as the claim that the constants have life-permitting values. Given this distinction, the fine-tuning argument can be stated as follows:

P1: The existence of life-permitting values for the constants of physics is not epistemically improbable under theism.

P2: Because of the fine-tuning, the existence of life-permitting values for the constants is epistemically very improbable under the atheistic single-universe hypothesis.

C: Since both theism and the atheistic single-universe hypothesis were clearly not constructed merely to account for the fine-tuning data, it follows from premises 1 and 2 and the restricted prime principle that the fine-tuning data provide strong evidence in favor of the design hypothesis over the atheistic single-universe hypothesis.

Note several features of this argument. First, the argument does not say that the fine-tuning evidence proves that the universe was designed, or even that it is likely that the universe was designed. Indeed, of itself it does not even show that we are epistemically warranted in believing in theism over the atheistic single-universe hypothesis. In order to justify these sorts of claims, we would have to look at the full range of evidence both for and against the theistic hypothesis, something we are not doing in this chapter. Rather, the argument merely concludes that fine-tuning strongly supports theism over the atheistic single-universe hypothesis.

In this way, the evidence of the fine-tuning argument is much like fingerprints found on a gun: although they can provide strong evidence that the defendant committed the murder, one could not conclude merely from them alone that the defendant is guilty; one would also have to look at all the other evidence offered. Suppose ten reliable witnesses claimed to see the defendant at a party at the time of the shooting. In this case, the fingerprints would still count as significant evidence of guilt, but this evidence would be counterbalanced by the testimony of the witnesses. Similarly the evidence of fine-tuning strongly supports theism over the atheistic single-universe hypothesis, though it does not itself show that theism is the most plausible explanation of the world, all things considered.

The second feature of the argument we should note is that the type of probability is epistemic. Roughly, the conditional epistemic probability of a proposition R on another proposition S can be defined as the degree to which S of itself should rationally lead us to expect that R is true. It is important to stress here that, under the atheistic single-universe hypothesis, there is no statistical probability that a universe will exist that has life-permitting values for its constants. A statistical probability could only exist relative to some model in which the universe was produced by some physical process that churned out life-permitting universes with a certain relative frequency. The whole point of the atheistic single-universe hypothesis, however, is that there is no such universe generator. Rather, the universe exists as a brute, inexplicable fact. Thus, the probabilities in this

case should not be understood as statistical probabilities, but rather as measures of rational degrees of support of one proposition or another." The claim essentially boils down to the claim that, because the life-permitting range of a parameter of physics is very small compared to a properly chosen comparison range R, the atheistic single-universe hypothesis, of itself, should strongly lead us to expect that a parameter of physics would not fall into the (intelligent-)life-permitting range. Furthermore, the expectations here are not expectations relative to our total background information—which already includes the information that the values are life-permitting. Rather it is relative to a reduced set of background information in which the fact that a particular parameter has life-permitting values is "subtracted-out."13

The third feature of the argument we should note is that, given the truth of the prime principle of confirmation, the conclusion of the argument follows from the premises. Specifically, if the premises of the argument are true, then we are guaranteed that the conclusion is true, that is, the argument is what philosophers call valid.

One major argument in support of P1 is that, since God is an all-good being and it is good for intelligent, conscious, embodied beings to exist, it is not surprising or improbable that God would create a world that could support embodied intelligent life. Thus, given fine-tuning, the existence of life-permitting cosmic conditions is not improbable under theism, as P1 asserts.

One might object that, because of the existence of evil, we do not know that the existence of embodied, conscious, intelligent beings is a good thing as the argument seems to assume. To address this objection, let E represent the claim that embodied, conscious beings exist and let E' represent the claim that embodied conscious beings exist in the universe and that their embodied existence is a positive good (that is, something that increases the overall value of reality). Then, it follows from the above argument that claim E' is not highly improbable under theism. But, E' entails E and if one claim R entails another claim S, then the probability of S is greater than or equal to that of R. Hence, if E' is not highly improbable under theism, then it follows that E isn't either.

In defense of P2 an appeal is often made to some sort of an analogy, such as the improbability of a randomly tossed dart hitting a very small bull's-eye. It is helpful, however, to have a more principled justification of this claim. To do so, we must appeal to some principle that allows us to move from the fact that the life-permitting range of the parameters of physics is very small to the claim that it is improbable that the parameters of physics would fall into the life-permitting range under the atheistic single-universe hypothesis. I do this by appealing to a version of the probabilistic principle of indifference, what I will call the restricted principle of indifference. Applied to the case at hand, this principle could be roughly stated as follows: When we have no reason to prefer any one value of a parameter over another, we should assign equal probabilities to equal ranges of the parameter, given that the parameter in question directly corresponds to some pbyslcal magnitude (or occurs in the simplest way of writing the fundamental theories in the relevant domain)14

Specifically, if the comparison range (that is, the range allowed by the relevant background theories) of such a parameter is R and the life-permitting range is r, then the epistemic probability is r/R (r divided by R). Suppose, for instance, that the comparison range, R, of values for the strength of gravity runs from zero to the strength of the strong nuclear force, that is, 0 to 1040G0 (where Go represents the current value for the strength of gravity). I have argued elsewhere that the life-permitting range r for the strength of gravity is at most 0 to 109G0, and probably closer to 0 to 103G0.15 Now, of itself (specifically, apart from the knowledge that we exist), the atheistic single-universe hypothesis gives us no reason to think that the strength of gravity would fall into the life-permitting range instead of any other part of the comparison range. Thus, assuming the strength of gravity constitutes a real physical magnitude or occurs in the simplest way of writing

the relevant theories, the restricted principle of indifference would state that equal ranges of this force should be given equal probabilities, and hence the probability of the strength of gravity falling into the life-permitting range would be at most r/R = 109/1040 = 1/10 to the 31st power—an astronomically unlikely probability.16

Hume's Objections Answered

Objections to analogy. The first of Hume's objections is with the argument for design from analogy, which is the way the argument was typically formulated in Hume's day, before careful work was done on the logic of inference. This version of the argument rests on the principle that similar effects have similar causes.17 It is then argued that the universe is similar in the relevant respects to a human contrivance, such as a work of art or a watch, and thus has a similar cause. Thus, since human contrivances are products of intelligent design, if the universe is analogous to a human contrivance in the relevant respects, then by the above principle we should infer that the universe is a product of a similar cause, namely, an intelligent agent.

This version of the argument faces at least two major types of objections, which Hume elaborated. The first derives from the principle that the more similar the effect, the more similar the cause. Thus, the more the universe seems to be like a human artifact, the more we should claim that the cause of the world is like a human being, just much more powerful (e.g., an alien with a brain and a body who created the universe in a lab). But this is not what the argument from design is supposed to show.

The second objection is that the analogy between human artifacts and the features of the universe that supposedly exhibit design are tenuous. The fact that the values of the constants of physics are in an extremely narrow life-permitting range, for instance, might be enough to suggest design, but in many ways it is disanalogous to the "fine-tuning" characteristic of a human artifact. No actual human artifact has fundamental physical constants that are adjusted just right; rather, it has certain material parts that are configured in the way needed to achieve some end. One must therefore interpret the falling of the parameters of physics within some narrow range as relevantly similar to the material parts of an artifact being in some narrow range of positions. Although such a subjective interpretation might be enough to suggest design, it clearly does not provide a sufficient basis for a rigorous development of the fine-tuning argument. In any case, whatever the merits of this analogical version of the fine-tuning argument, it is not the argument I have developed. My version of the fine-tuning argument is not an argument from analogy at all and is therefore not subject to either of these Humean objections.

The alternative explanation objection. Another objection that Hume, raised to the design argument was that one cannot infer the God of theism from fine-tuning, since there are many alternative explanations (DNR 35-38). For example, perhaps our world is the result of a committee of gods, or some finite deity (or, again, a powerful alien who has discovered how to create universes in a lab). Of course, a theist might respond that hypothesizing such beings simply pushes the design problem up one level, to who or what designed the minds of these gods or alien intelligences. To this, an atheist can respond that the same problem confronts the theistic hypothesis. If we invoke God as an explanation of the fine-tuning, haven't we just pushed the issue of design up one level to who or what designed God? As mentioned in the introduction, this is probably the most common objection to the design argument, whether the fine-tuning version or some other version. We will address this objection extensively in the latter part of this chapter. There we will see that the God hypothesis avoids this objection, whereas the many gods and finite god hypotheses do not.

For now we can simply observe that, as I have formulated the argument, it circumvents this issue. It merely says that the evidence of fine-tuning strongly confirms theism over the atheistic single-universe hypothesis. That is, if theism and the atheistic single-universe hypothesis are the main

contenders, then the evidence of fine-tuning should significantly raise confidence in theism and lower confidence in the truth of the atheistic single-universe hypothesis in comparison with what such confidences would otherwise be. Although this does not establish everything we might want, it does establish something of great significance (provided my version of the fine-tuning argument is sound).18 Of course, other explanations—such as the many-gods hypothesis—are also confirmed over the atheistic single-universe hypothesis. So, at the end of the day, if one is interested in which hypothesis to believe, one would have to provide other reasons for preferring the theistic explanation—arguments such as the cosmological argument, the moral argument, the argument from religious experience, or considerations based on simplicity, as Richard Swinburne does.19 But this is a task beyond the scope of the design argument.20

Of itself, the primary focus of the fine-tuning design argument is to provide us good reason for preferring theism over the atheistic single-universe hypothesis, which is historically the leading contender to theism among Western intellectuals. Other considerations can then be offered for preferring theism to other leading contenders, particularly what I call the many-universes generator hypothesis (see above) and the appeal to a grand unified theory (which speculates that the values of the constants of physics are a consequence of the ultimate laws and physical principles underlying the universe) to explain fine-tuning. For example, one of the major objections that can be offered to both the many-universe generator hypothesis and the appeal to a grand unified theory is that they simply move the design problem up one level. To the many-universes generator hypothesis, one can argue that the physical process that produces the many-universes must have just the right laws and processes to produce life-sustaining universes.21 And, with regard to a grand-unified-theory explanation, one would have to have just the right ("well-designed") set of laws to yield life-permitting values for the constants. As astrophysicists Bernard Carr and Martin Rees note, "Even if all apparently anthropic coincidences could be explained [in terms of some grand unified theory], it would still be remarkable that the relationships dictated by physical theory happened also to be those propitious for life.,22 Given that these hypotheses transfer the design problem up one level, we can then use a variation of the kind of reasoning used above in the case of the atheistic single-universe hypothesis to show that the evidence of fine-tuning confirms theism over the atheistic versions of these hypotheses.

The problem of evil objection. Another objection to the fine-tuning argument raised by Hume is that since there is so much evil in the world, the teleological argument only allows one to infer to a morally apathetic creator (DNR 66-68). To understand Hume's objection, let's briefly reconstruct his argument. One way of understanding Hume is that he looks at two collections of data: the existence of evil and the appearance of design. He then argues that the theistic God is not necessarily the best explanation for these two collections taken together. Rather, a designer who is morally neutral (or incompetent) is at least as good an explanation, if not better.

One problem with Hume's line of argument is that, if we are going to add other things we know about the world to the data of design, then to avoid arbitrariness we should add everything else we know about the world. This would include features such as religious experiences, our sense of morality and the like. But once these features are added, it is no longer clear that a morally neutral designer is as good a hypothesis as the theistic God. For example, both religious experiences and our sense of morality point to a non-apathetic deity, one who is at least good. And once one ascribes goodness to the designer, it seems less arbitrary to ascribe perfect goodness. Again, one could also argue with Swinburne that the theistic hypothesis is simpler than these other hypotheses and thus constitutes a better explanation.23

Another way of reading Hume here is simply as saying that, taken alone, the data of apparent design cannot allow one to infer to an all good deity. One response is simply to grant Hume's claim, and then point out that the design argument as I have developed it does not try to infer to an all

good deity. Rather, as elaborated above, our version of the fine-tuning argument only shows that the existence of life-permitting values for the constants of physics strongly confirms theism over the atheistic single-universe hypothesis. This would be true even if a morally apathetic deity, or even an evil deity, would offer at least as good an explanation of the existence of a life-permitting universe. From this point of view, whether at the end of the day we should infer to the all good deity of theism will rest on considerations of all the evidence both for and against theism.

However, a more interesting line of response is to call into question the claim that a morally apathetic or evil deity is not significantly confirmed by the fine-tuning argument. To see this, note that, in the argument above, our main reason for claiming that the existence of a life-permitting universe is not improbable under theism appealed to God's goodness, since God's goodness gives God a reason to create such a universe. Thus, one could argue, at the very least, that a morally apathetic being would have less reason to bring about a universe with conscious life in it than one who is perfectly good, and therefore everything else being equal the design argument gives preference to a perfectly good being over a morally apathetic being.

The Who Designed God?" Objection

Perhaps the most common objection that atheists raise to the argument from design is that postulating the existence of God does not solve the problem of design, but just transfers it up one level. This objection was hinted at by Hume:

For aught we can know a priori, matter may contain the source or spring of order originally within itself, as well as mind does; and there is no more difficulty conceiving that the several elements, from an internal unknown cause, may fall into the most exquisite arrangement, than to conceive that their ideas, in the great universal mind, from a like unknown cause, fall into that arrangement. (DNR 17-18)

This same sort of objection has been repeated in various forms by a host of atheist philosophers and thinkers, such as by J. L. Mackie, George Smith, J. J. C. Smart, Richard Dawkins and Colin McGinn.24 Here are a few representative quotations showing the different forms this argument takes:

The argument for design, therefore, can be sustained only with the help of a supposedly a priori double-barreled principle, that mental order (at least in a god) is self-explanatory, but that all material order not only is not self-explanatory, but is positively improbable and in need of further explanation.25

If the universe is wonderfully designed, surely God is even more wonderfully designed. He must, therefore, have had a designer even more wonderful than He is. If God did not require a designer, then there is no reason why such a relatively less wonderful thing as the universe needed one.26

If we want to postulate a deity capable of engineering all the organized complexity in the world ... that deity must already have been vastly complex in the first place.... If we are going to allow ourselves the luxury of postulating organized complexity without offering an explanation, we might as well make a job of it and simply postulate the existence of life as we know it!27

If we postulate God in addition to the created universe we increase the complexity of our hypothesis. We have all the complexity of the universe itself, and we have in addition the at least equal complexity of God. (The designer of an artifact must be at least as complex as the designed artifact.) ... If the theist can show the atheist that postulating God actually reduces the complexity of one's total world view, then the atheist should be a theist."

The above quotations show that the claim that If the universe needs a designer, so does God, is a standard atheist objection to design arguments for theism. Therefore, if the fine-tuning argument is really going to be convincing, we must directly address this objection. Many of the responses I give, however, will apply to any version of the design argument.

The first response to the above atheist objection is to point out that neither Hume, Mackie, Smith, Dawkins, Smart nor McGinn offer any argument for the central premise of their objection, namely, that the designer of an artifact must be at least as complex as the designed artifact. Moreover, their claim is certainly not self-evident. But I do believe that their claim has some initial intuitive plausibility. For example, in the world we experience, organized complexity seems only to be produced by systems that already possess it, such as the human brain/mind, a factory or an organism's biological parent. However, this intuitive plausibility may not be much help. Atheists will not wish to infer a general principle from these cases, since this would force them into denying the adequacy of evolution based on unguided chance plus natural selection to account for the organized complexity of life, and instead would force them into hypothesizing some cause of this complexity that was itself as complex as life. As one of the leading atheist evolutionary biologists Richard Dawkins states, the explanatory force of Darwin's theory is that it can purportedly explain the generation of organized complexity where there was none before.'

A second response is to point out that, at most, this objection only works against a version of the design argument that claims that all organized com plexity needs an explanation, and that God is the best explanation of the organized complexity found in the world. The version of the argument I presented against the atheistic single-universe hypothesis, however, only required that the fine-tuning be more epistemically probable under theism than under the atheistic-single-universe hypothesis. But this requirement is still met even if God exhibits tremendous internal complexity, far exceeding that of the universe. Thus, even if we grant the atheist assumption that the designer of an artifact must be as complex as the artifact, the fine-tuning would still give us strong reasons to prefer theism over the atheistic single-universe hypothesis.

To illustrate, suppose we discovered a complex domed structure on Mars with all the right configurations of metal and other substances to maintain an oxygen/nitrogen/carbon dioxide atmosphere that could support life. By the restricted prime principle of confirmation, the existence of such a "biosphere" would still give us strong reasons for believing that intelligent, extraterrestrial life had once been on Mars, even though that alien life would most likely have to be much more complex than the biosphere itself. After all, we would reason, such a structure would be enormously unlikely to occur by chance—say by some series of volcanic eruptions—but not unlikely to occur if Mars was once inhabited by some alien race. And this would be true even if we had no account (such as the theory of evolution) of how complex, intelligent life could come into being. Of course, this inference works because the extraterrestrial hypothesis is not completely ad hoc: it already was considered by many to have some viability apart from the evidence in question. Or, for those who want to employ the idea, the prior epistemic probability of the extraterrestrial hypothesis does not seem nearly as low as the probability of the structure coming into existence by chance. Hence, given the existence of the biosphere, it follows from Bayes's theorem30 that the extraterrestrial hypothesis is more likely than the chance hypothesis.

In reply, the atheist could claim that the existence of a God with the necessary sort of internal complexity is more improbable than the existence of a life-permitting universe. If this were the case, then even though the fine-tuning would still significantly support theism over the atheistic single-universe hypothesis, it could never raise theism's probability enough to make it more probable than atheism, since theism would have been so improbable to begin with.31 To illustrate, suppose a group of New Age cultists tried to explain the existence of the Martian biosphere by claiming that it was built by Martian robots who, the cultists asserted, simply spontaneously formed

on Mars from various volcanic eruptions. Although the existence of the biosphere would raise the probability of the robot hypothesis, it never could of itself make this hypothesis more likely than the hypothesis that the biosphere itself spontaneously formed by chance. Why? Because the spontaneous formation of these robots is at least as improbable as the spontaneous formation of the biosphere.

I see no reason for thinking that the existence of the God of classical theism would be extremely epistemically improbable apart from the evidence of fine-tuning or other "design-like" features of the universe.32 First, we have plausible, independent reasons for believing in God—for example, religious experience and the cosmological argument. Thus, God's existence is not extremely improbable on our background information, as this atheist reply requires. Second, even if God must exhibit great internal order, that in itself does not necessarily make God's existence a priori improbable, since we have no good reason to think that the existence of order is a priori improbable. Indeed, atheists themselves often claim that the existence of an orderly physical world is not a priori unlikely.33 In contrast to order in and of itself, the reason the order exhibited by the fine-tuning seems extremely improbable is that (1) there seems to be a vast range of other theoretically possible values for the constants of physics, the initial conditions of the universe and even the laws of physics themselves; and (2) the values needed for life seem to be tiny in proportion to all the theoretically possible values. But no such line of reasoning can be applied to the case of God's mind. For example, we have no basis for thinking that there is a vast number of possible types of order that a supermind such as God's could exhibit, of which the relevant order in God's mind constitutes a tiny proportion.34

Moreover, theists have traditionally considered it plausible, independent from the argument. from design, to hold that God necessarily exists, and hence that the existence of God, along with any mental order in God, is self-explanatory. Of course, if the theist says that God necessarily exists, the atheist can claim the same thing about the universe itself. This reply, however, is weak in the case of fine-tuning. First, the claim that God exists necessarily is not ad hoc, since theists have traditionally believed this for reasons independent of the design argument. But typically atheists have not claimed this about the universe, and thus their reply is at least to some extent ad hoc. Second, and more important, it seems highly implausible to most people to think that the laws, constants and initial conditions of the universe must have been fine-tuned to just those range of values that would allow for life to occur, even though there seems to be an enormous range of other possible values they could have had. If there is some principle of necessity requiring that the constants and initial conditions of the universe fall within some range of values, it seems extraordinarily surprising that this principle would be one which required that the values be just those needed for intelligent life to exist. So the atheist's reply along these lines just seems to transfer the improbability or surprise up one level.35

The only exception to this is if the principle has some sort of intuitive viability in and of itself. One possibility is the Neo-Platonic principle promoted by philosopher John Leslie: of necessity, what ought to exist does exist.36 Since a reality in which a universe with conscious observers exists is better than a reality without such a universe, Leslie argues that it follows from this principle that a life-permitting universe would exist. Leslie points out, however, that his Neo-Platonic principle is compatible with theism, and might even entail theism, since God is a being of supreme value, and consequently, a reality with God would be better than a reality without God. Thus, even if we adopt Leslie's hypothesis, this would not necessarily provide an alternative to the theistic explanation of the fine-tuning of the universe.37

Finally, although I believe the above theistic responses to the "Who Designed God" objection are strong, an atheist could reply that they rest partly on ignorance of what the order in God might be like. If we only understood the complex order that God's existence requires, they could contend,

we would see how improbable it is. Although I consider this reply weak, I nonetheless address it in the next section by developing an independently plausible model that explicitly shows how postulating the existence of a mind like God's radically reduces the total amount of unexplained complexity in the world.

The Model

My model begins by noting that a mind has the ability to "search" through the realm of possibilities and then select that possibility that appears best to meet its goal. When engineers develop a car, for instance, they consider many different configurations of elements, not only for the car as a whole but for various parts of the car, and then select one of them. An engineer working on the carburetor might mentally consider a whole series of carburetor configurations and eventually select the one that she judges to function the best given the other constraints on the car.

Of course, since God is omniscient, this process of examining various possibilities and then selecting one of them cannot be thought of as occurring in some temporal sequence, such as God's first looking at one possibility, then a moment later considering another and so on. Rather, all possibilities would be present to the divine mind in a single instant. Depending on God's relation to time, this "selecting" among the various possibilities could then be thought of as occurring timelessly or from "all eternity" or even temporally following God's considering the possibilities. Whatever view one holds regarding God's relation to time, the process of considering the possibilities and selecting among them could arguably be considered in some sense logically analogous to the way human minds make selections. For example, God's willing one possibility over another could be thought of as logically dependent on the act of God's considering the various possibilities and thus logically posterior to it, even though it is not temporally posterior to it.

Clearly, this model of the mind producing order is very similar to the Darwinian picture of the origin of biological complexity, the main difference being that selection is occurring intentionally instead of through the impersonal mechanism of natural selection. Indeed, all three major explanations of the origin of organized complexity—intelligent design, the many-universes hypothesis and Darwinian evolution—explain the existence of organized complexity by some sort of selection mechanism. In the case of intelligent design, this selection mechanism is the purposes of the designing agent (for example, the desires flowing out of God's goodness). In the case of the many-universes hypothesis, a sort of self-selection occurs, since the only universes that intelligent beings find themselves in are fine-tuned. And in the case of Darwinian evolution, it is natural selection. So, if atheists claim that Darwinian evolution can produce organized complexity from where it was lacking, as almost all of them do, then they should admit the same thing for the mind, given that the above model is correct.

But, one might object, don't those complex possihle design plans that an engineer considers already have to exist somewhere? So, applied to God, aren't we back to hypothesizing a preexisting complex order (consisting of possible design plans in God's mind) that is as much in need of explanation as the organized complexity of the universe?

The first reply to this objection is that this same problem arises for Darwinians: their evolutionary model seems to presuppose a realm of preexisting possihle organism configurations through which the organism travels (for example, Dawkins's "biomorph" space)." The second response begins by noting that, since God is in the business of creating whole worlds, the "possible design plans" that God would be considering are nothing less than what philosophers call "possible worlds," and the existence of possible worlds is thought to be self-explanatory. Possible worlds can be thought of as a complete representation, including every detail, of a possible way things could be. These descriptions can be thought of as something like complete novels that not only describe a possible way the world could be, but fill in every single detail and are logically consistent. Of course, unlike

real novels, these representations are not representations in any human language; rather, a possible world can be defined as a maximal set of propositions or states of affairs. These would exist even if there were not any human beings. Now, one might wonder why someone would think that possible worlds really exist. The reasons are many and varied, and almost all independent of the argument from design. All that I will say here is that the reasons are powerful enough to have convinced a large percentage of philosophers, both atheists and theists, that possible worlds exist.39 Moreover, almost all philosophers—both atheists and theists—who believe in possible worlds hold that they exist necessarily: that is, it is absolutely impossible for a possible world not to exist.40

What exists necessarily, however, is self-explanatory, for the only time we need to explain why something is a certain way is when it is possible for it to be another way. Hence, since it is impossible for possible worlds not to exist, their existence is self-explanatory, even if in some sense they contain complex internal structure.

To intuitively understand why anything that necessarily exists is self-explanatory, consider the following two analogies. Suppose I were in the weight room bench-pressing one hundred pounds and someone asked me why I'm only lifting one hundred pounds instead of, say, three hundred pounds. I would most likely reply that I cannot lift more than one hundred pounds and I would consider this fact an adequate explanation of why I was not lifting three hundred pounds. That is, given that there are only two alternatives (lifting one hundred pounds or lifting three hundred pounds), we would consider the fact that one alternative (lifting three hundred pounds) is impossible to be an adequate explanation of why the other alternative (lifting one hundred pounds) occurred. Or consider another illustration. Suppose someone asked you why there are no objects in the world that are both perfect cubes and perfect spheres. You would not answer by claiming, for instance, that the factory designed to produce these objects went bankrupt. Rather, you would say that the reason there are no such objects is that it is impossible for there to exist an object that is a perfect cube and a perfect sphere at the same time. The fact that the existence of these objects is impossihle explains why they do not exist. Thus by analogy, in the case of something that necessarily exists, such as a possible world, the fact that the alternative of nonexistence is impossible explains why the other alternative, that of existence, is the case.

In sum, then, given this model, one can respond to the "Who designed God?" objection as follows: God's mind selects among possible worlds, and even though these passible worlds can be thought of as highly structured, we have independent reasons, accepted both hy theists and nontheists, to believe that they exist and that their existence is self-explanatory. Consequently, God does not exhibit a complex order that is as much in need of explanation as that of the universe. Insofar as there is preexisting complex order, it exists as part of the structure of possible worlds, and the existence of these are considered by theists and atheists alike not to be in need of explanation. Although I haven't proved the key premise of this response, namely, that these possible worlds exist, many philosophers hold that they exist for reasons entirely independent of theism. Thus, what I have shown so far is that the theist has a plausible response to the "Who designed God?" objection, and a plausible account of the ultimate origin of order and complexity.41

Some further objections. But, the skeptic might object at this point: just as the human mind needs a highly organized brain to function, doesn't God's mind need to contain some other type of order that accounts for God's ability to grasp possible worlds and then bring those possible worlds into being? So, even under this account, don't we have to postulate that God exhibits internal, unexplained complexity at least as great as the universe? I see no reason to think this. First, consider the human analogy. If we gave some human being enough time, it seems possible that she could create artifacts the sum of whose complexity eventually surpassed the human brain itself. At the very least, there is no obvious argument that this is not the case. Thus, contrary to Smart, the

complexity of designed artifacts, taken together, could surpass that of the designer. Thus, even if God's mind requires an incredible amount of complexity, its complexity could be far less than that of the universe. It is still possible to think, therefore, that hypothesizing God reduces the total amount of unexplained order.

Second, and more importantly, we have metaphysical reasons for thinking that minds do not, by their inherent nature, require high levels of internal complexity, and this is true even though all the minds we are familiar with require the organized complexity of the brain to operate. To begin with, there are significant philosophical reasons based on considerations of the unity of consciousness for thinking that consciousness (or the soul) is simple and without internal complexity, as Plato, Descartes and mind/body dualists have traditionally thought. Perhaps the strongest argument for this thesis is that we normally experience our own conscious self as a single, unified center that is aware of the world and can act in the world. For example, I am currently simultaneously aware of the hum of the air conditioner, the sound of my hands typing and the letters on my computer screen. I cannot explain this experience by supposing that my self has three parts and that one part is experiencing the hum, the other my typing, and the other is seeing letters on the computer screen, for then there would be three separate experiencers, one corresponding to each part. But there seems to be only one experiencer—I—that perceives all three things. Thus, it seems that I must suppose there is one unified experiencer that cannot be reduced to a bunch of parts. (Compare this to a red and green striped ball: although we say that the ball, as a single entity, is striped, this can be explicated in terms of various parts of the ball being colored either red or green.)42

Now that we have argued it is plausible to think that the conscious, thinking self is inherently simple, we need to argue that hypothesizing that it has the ability to grasp possible worlds and bring them into existence does not introduce further complexity or contingency. First, as George Bealer argues, the ability to grasp abstract objects, of which possible worlds are one species, seems to be an essential, even defining, feature of the mind and consciousness.43 So hypothesizing that a mind has this ability does not add any complexity to it since it is already part of its essential nature. Moreover, the other feature of God's mind that my model needs—the ability to actualize possible worlds—also does not seem to require a well-designed internal structure. Indeed, if one thinks that the "I"—that thing behind the scenes that is conscious, that does the thinking and the like—is simple, as we have been suggesting, then it follows that a person's power to perform what philosophers call hasic actions must be simple and thus without any further structure. One could think of a person's power to act as analogous to the most fundamental causal powers of the basic constituents of matter; these powers must be simple for otherwise they could be further analyzed and hence they would not be fundamental. Therefore, based on the above considerations, it is plausible to think that minds do not necessarily require great internal complexity.

But an atheist might further object at this point that my explanation merely transfers the problem of design up one level. After all, I must assume that God has the desire to create a world with intelligent, embodied beings. But why would God have any more desire to create this sort of world than any of the other possible worlds that exist? So isn't God's having this desire as improbable as the fine-tuning itself? The answer to this objection is to appeal to God's goodness. If God is good, then it is not extremely improbable that God would create a world with intelligent beings because the existence of such beings is good. Moreover, assuming that a being who had the power and knowledge to design the universe would be good is in and of itself quite plausible. For, as Swinburne has argued, if one assumes a moral order to reality, then it seems likely that any sufficiently intelligent and powerful being would come to grasp that order, and upon grasping it act in accordance with it." The reason is that, because God is omnipotent, God would not be subject to the sort of internal or external forces that distort our judgment and impel us to do things against

our most deeply held values. The only motive for God's actions, Swinburne argues, would be God's perception of ethical and other kinds of value 45

Conclusion

I end by suggesting two merits my model has over and above answering atheists such as Mackie and Dawkins. First, if my line of argument is correct, then design arguments can be put on even surer philosophical footing, since the basic principle invoked above—that we should infer to those hypotheses that reduce the total amount of unexplained organized complexity—is widely held by philosophers, both theists and atheists. Second, this line of argument provides an important reason for preferring theism over some of the other major alternative hypotheses, such as the many-universe generator hypothesis or the many-gods hypothesis, as an explanation of the fine-tuning of the universe. Further, as I have argued elsewhere, 6 we have good reasons to believe that the many-universes generator must itself have significant organized complexity of a kind that requires fine-tuning to produce life-sustaining universes. Thus, since we have solid metaphysical reasons for thinking God does not have significant unexplained organized complexity, the atheist's own principle provides strong additional reasons for preferring theism over the atheistic version of the many-universes generator hypothesis. Of course, the atheist could simply hypothesize that the universe generator either lacks complex internal order or that its complex internal order necessarily exists. But such a hypothesis is surely ad hoc apart from some metaphysical account of how this could be the case. Similarly, the many-gods hypothesis seems to involve a higher level of unexplained organized complexity than the theistic hypothesis, since there would have to be some account of how the many gods interrelate with each other. If one responded that these interrelations exist of necessity, then one is likely to simply be advocating something like the much discussed social concept of the Trinity (with perhaps more than three persons) and thus not really advocating a nontheistic view. The finite-god hypothesis also seems to involve an increase in organized complexity since some account would have to be given for why such a god had whatever specific finite limits on power, knowledge, etc., it had instead of some other set of limits. These are potentially fruitful lines of argument that I cannot explore here.

I conclude by recalling the words of noted atheist philosopher J. J. C. Smart, quoted earlier in this chapter: "If the theist can show the atheist that postulating God actually reduces the complexity of one's total world view, then the atheist should be a theist." I hope that atheists who read this chapter take such Smart advice.

Notes

1 For example, see Robin Collins, "The Teleological Argument," in The Rationality of Theism, ed. Paul Copan and Paul Moser (New York: Routledge, 2003).

2 A careful presentation of six good cases of fine-tuning is presented in Robin Collins, "The Evidence for Fine-Tuning," in God and Design: The Teleological Argument and Modern Science, ed. Neil Manson (New York: Routledge, 2003). An up-to-date rendition of the argument is presented in Robin Collins, "God, Design, and Fine-Tuning," in God Matters: Readings in the Philosophy of Religion, ed. Raymond Martin and Christopher Bernard (New York: Longman, 2002), and Collins, "The Teleological Argument" (2003). Further information and updates can be found at <www.fine-tuning.org>.

3 1n this chapter, I take atheism as more than simply the denial of the God of traditional theism, but as also involving the denial of any overall intelligence that could be considered responsible for the existence or apparent design of the universe.

4 It should be noted that theism is not of itself incompatible with the many-universes hypothesis, since, for example, God could have created a life-permitting universe indirectly by creating a physical process that generated multiple universes with different values for the basic parameters of physics.

5 For an extended treatment of the many-universes hypothesis, see Robin Collins, "The Argument from Design and the Many-Worlds Hypothesis," in Philosophy of Religion: A Reader and Guide, ed. William lane Craig (New Brunswick, NJ.: Rutgers University Press, 2002).
6 See Rudolf Carnap, The Logical Foundations of Probability (Chicago: University of Chicago, 1962). For a basic, but somewhat dated, introduction to confirmation theory and the prime principle of confirmation, see Richard Swinburne, An Introduction to Confirmation Theory (London: Methuen, 1973). For literature specifically discussing the likelihood principle, see A. W. F. Edwards, Likelihood (Baltimore: Johns Hopkins University, 1992) and Elliot Sober, "Bayesianism—Its Scope and Limits," in Bayes's Theorem, ed. Richard Swinburne (Oxford: Oxford University Press, 2002), pp. 21-38.
7 For those familiar with the probability calculus, a precise statement of the degree to which evidence counts in favor of one hypothesis over another can be given in terms of the odds form of Bayes's theorem: that is, f(H1/E)/P(H2/E) - [P(Hl)/P(H2)] x (P(E/H1)/P(E/H2)], where P(x/y) represents the conditional epistemic probability of one proposition x on another y. The general version of the PPC stated here, however, does not require the applicability or truth of Bayes's theorem.
8 Often, the prime principle is stated without this restriction.
9 The restricted prime principle is not the only way of addressing such counterexamples. A more common way is to argue that the prior probability of the hypothesis in question is so low that the confirmation offered cannot be sufficient to make the hypothesis likely. Although I agree that this latter response is successful, it commits one to the notion of prior probabilities which I prefer to avoid.
10 The comparison range/region will effectively be that local range/volume in parameter space around the life-permitting region such that we can make determinations as to whether or not a parameter is life-permitting—what I call the epistemically illuminated region. Generally this range/region will be very large, but finite. For more on this, see my website <www.fine _tuning.org>.
11 For the balance of this chapter, the expression "life-permitting values" should be understood as "intelligent life-permitting values."
12 This is an error made by Keith Parsons when he objects that fine-tuning could not be probable or improbable under the atheistic single-universe hypothesis: "If the universe is the ultimate brute fact, it is neither likely nor unlikely, probable or improbable; it simply is." Keith Parsons, "Is there a Case for Christian Theism?" in Does God Exist? A Debate Between Theists and Atheists, ed. J. P. Moreland and Kai Nielsen (New York: Prometheus, 1993), p. 182.
13 This is one way of addressing the standard problem of "old evidence," of which this version of the fine-tuning argument is an instance. The issue of how to subtract the evidence in question unambiguously is beyond the scope of this chapter. See Collins, "How to Rigorously Define fine-Tuning," Pbllosopbia Christi, forthcoming.
14 As an example of what it means to directly correspond to some physical magnitude, consider the mass of an object. A physical parameter m that designates the mass directly corresponds to a physical quantity, whereas a physical parameter u that designates that mass squared Cu - m2) does not directly correspond to a physical quantity but to an artificial variable. When conflicting parameters arise—e.g., two equally simple ways of writing a theory with different sets of parameters functionally related to each other—then one should take the probability as being given by the range of probability values formed by applying the restricted principle to each parameter separately. A full statement and defense of this principle may be found at my website <www.fine-tuning.org>.
15 Collins, "The Evidence for Fine-Tuning."
16 A full-scale, rigorous justification of the restricted principle of indifference, and of P2, is be
yond the scope of this chapter. A sketch of how such a justification would proceed is presented in the appendix of Collins, "The Fine-Tuning Design Argument," and to a lesser extent in Collins, "God, Design, and Fine-Tuning." In those papers I explain how certain well-known objections to the

principle of indifference, such as the Bertrand Paradoxes, can be circumvented. I hope to present a full-scale justification of the principle in a book, currently in progress and tentatively titled The Well-Tempered Universe: God, Fine-Tuning, and the laws of Nature. The important point in the present text is that, by providing a principled justification of P2, the fine-tuning argument can get beyond merely being an argument from analogy. See also <www.fine-tuning.org>.17 David Hume, Dialogues Concerning Natural Religion and the Posthumous Essays, ed. Richard Popkin (Indianapolis: Hackett, 1980), pp. 15. Hereafter references will be given in the text with DNR and page numbers.
18 for example, I argue in "The Fine-Tuning Design Argument" that the fine-tuning offers a stronger and more solid argument for theism (versus the atheistic single-universe hypothesis) than the probabilistic version of the argument from evil offers against theism.
19 Richard Swinburne, The Existence of God (Oxford: Clarendon, 1979), pp. 102-6.
20 For an additional reason, based on the Who Designed God?" objection, for rejecting these alternative hypotheses, see the end of this chapter.
21 Collins, "God, Design, and Fine-Tuning" and "The Argument from Design and the Many-Worlds Hypothesis." In the latter article, I also critique what I call the metaphysical many-universes hypothesis, according to which all possible universes exist out of some sort of metaphysical necessity.
22 B J. Carr and M. J. Rees, "The Anthropic cosmological Principle and the Structure of the Physical World," Mature 278 (1979): 612.
23 Swinburne, The Existence of God, pp. 102-6.
24 Colin McGinn, The Mysterious Flame: Conscious Minds in a Material World (New York: Basic Books, 1999), p. 86. Other references are given below.
25 J. L. Mackie, The Miracle of Theism (Oxford: Clarendon, 1982), p. 144.
26 George Smith, "deism: The Case Against God," in An Anthology of Atheism and Rationalism, ed. Gordon Stein Amherst N.Y.: Prometheus, 1980), p. 56.
27 Richard Dawkins, The Blind Watchmaker (New York: Norton, 1986), p. 316.
28 J. J. C. Smart, "Laws of Nature and Cosmic Coincidence," The Philosophical Quarterly 35 (1985): 275-76; emphasis mine.
29 Dawkins, Blind Watchmaker, p. 316.
30 See note 7 above
31 If we adopt the Bayesian form of the prime principle of confirmation in note 7, one can easily show this; otherwise, one can show this by looking at other relevantly similar cases of confirmation.
32 1 am here assuming that certain classic objections to theism, such as the problem of evil, the paradoxes of divine omnipotence, etc., can be adequately answered.
33 Bertrand Russell argued along these lines in his well-known essay "Why I Am Not a Christian," in Bertrand Russell, Why I Am Not a Christian: And Other Essays on Religion and Related Subjects (New York: Touchstone Books, 1967).
33 Michael Tooley's and David Armstrong's metaphysical theories of natural laws also imply that it is likely that nature would turn out orderly. Michael Tooley, Causation. A Realist Approach (Oxford: Oxford University Press, 1988) and David Armstrong, What Is a Law of Nature? (Cambridge: Cambridge University Press, 1983).
37 It should be noted, however, that Leslie has more recently argued for a pantheistic conception of God based on this principle and other considerations. See John Leslie, Infinite Minds: A Philosophical Cosmology (Oxford: Clarendon, 2001). For a critique of this book (and Leslie's response), see Robin Collins, "Theism or Pantheism? A Review Essay on John Leslie's Infinite Minds," and John Leslie, "fantheism and Platonic Creation: A Reply to Robin Collins," both in Philosophia Christi, n.s. 5 (2003): 563-74; 575-80.
38 Dawkins, Blind Watchmaker, chap. 4.
39 Indeed, one major reason some philosophers deny the existence of possible worlds is that they cannot see where they could exist. Theists, going all the way back to St. Augustine, have often claimed that they exist as conceptualizations in the mind of God, though considerable metaphysical work is necessary to work this proposal out in detail. See, for example, Christopher Menzel and

Thomas V. Morris, "Absolute Creation," American Philosophical Quarterly 23 (1986): 353-62; Christopher Menzel, "Theism, Platonism, and the Metaphysics of Mathematics," Faith and Philosophy 4 (1987): 365-82; and Brian Leftow, God and Necessity (Oxford: Oxford University Press, forthcoming) for some recent work on this issue.
40 Many standard metaphysics textbooks have discussions of the case for and against the existence of possible worlds and other abstract objects. Good places to start are Michael Jubien, Contemporary Metaphysics: An Introduction (Maiden, Mass.: Blackwell, 1997); Michael Loux, Metaphysics: A Contemporary Introduction (New York: Routledge, 2002); and Michael Loux, ed., The Possihle and the Actual.. Readings in the Metaphysics of Modality (Ithaca, N.Y.: Cornell University Press, 1979).
41 Although many theistic philosophers think that these possible worlds, and other abstract objects, are thoughts or conceptualizations in the mind of God, the same arguments for thinking that abstract objects exist out of metaphysical necessity, and hence are self-explanatory, still apply.
42 For further discussion of this argument, see William Hasker, "Emergentism," Religious Studies 18 (1982): 473-88; fhilip Quinn, "Tiny Selves: Chisholm on the Simplicity of the Soul," in The Philosophy of Rodrick Chisholm, ed. Lewis Edwin Hahn, Library of Living Philosophers 25 (Chicago: Open Court, 1997); and Stuart Goetz, "Substance Dualism," in In Search of the Souk Four Views of the Mind-Body Problem, ed. Joel Green and Stuart Palmer (Downers Grove, Ill.: InterVarsity Press, 2005).
43 George Beater, Quality and Concept (Oxford: Clarendon, 1982)
44 Swlnburne, The Existence of God, pp. 97-102.
45 'The reasoning here is independent of whether one thinks that the moral order exists in or outside God.
46 E.g., Collins, "The Argument from Design and the Many-Worlds Hypothesis."

2005
Dyson Freeman, Physicist
Almost As Though The Universe Knew We Were Coming
Templeton Prize Address

It is both an honour and a pleasure for me to deliver my acceptance address for the 1995 Templeton Prize to such a distinguished audience in this world-famous Abbey, just a few metres from the remains of Isaac Newton. Along with Einstein and Darwin, Newton is one of the few scientists known to almost every member of the population. He is one of the great heroes of my own discipline, physics, even if his career as a civil servant left a lot to be desired.

It was Newton, Galileo and their contemporaries who created science as we know it, three centuries ago. Today we take the scientific method of enquiry so much for granted that few people stop to think how astonishing it is that science works.

I was fascinated to learn that one of the judges for the Prize was Baroness Thatcher. This is in fact the second time she has been involved in giving me a prize. The first occasion was in 1962, at the Speech Day of Woodhouse Grammar School in North Finchley, when she presented me with a copy of Norton's Star Atlas for doing well in my O level exams. I doubt if her Ladyship recalls the encounter, but I can trace my own decision to become a scientist to more or less that event.

Like all school pupils, I learned science as a set of procedures that would reveal how nature works, but I never questioned why we were able to do this thing called science so successfully. It was only after a long career of research and scholarship that I began to appreciate just how deep scientific knowledge is, and how incredibly privileged we human beings are to be able to unlock the secrets of nature in such a powerful way.

Of course, science didn't spring ready-made into the minds of Newton and his colleagues. They were strongly influenced by two longstanding traditions that pervaded European thought. The first was Greek philosophy. Most ancient cultures were aware that the universe is not completely chaotic and capricious: there is a definite order in nature. The Greeks believed that this order could be understood, at least in part, by the application of human reasoning. They maintained that physical existence was not absurd, but rational and logical, and therefore in principle intelligible to us. They discovered that some physical processes had a hidden mathematical basis, and they sought to build a model of reality based on arithmetical and geometrical principles.

The second great tradition was the Judaic world view, according to which the universe was created by God at some definite moment in the past and ordered according to a fixed set of laws. The Jews taught that the universe unfolds in a unidirectional sequence - what we now call linear time - according to a definite historical process: creation, evolution and dissolution. This notion of linear time - in which the story of the universe has a beginning, a middle and an end - stands in marked contrast to the concept of cosmic cyclicity, the pervading mythology of almost all ancient cultures. Cyclic time - the myth of the eternal return - springs from mankind's close association with the cycles and rhythms of nature, and remains a key component in the belief systems of many cultures today. It also lurks just beneath the surface of the Western mind, erupting occasionally to infuse our art, our folklore and our literature.

A world freely created by God, and ordered in a particular, felicitous way at the origin of a linear time, constitutes a powerful set of beliefs, and was taken up by both Christianity and Islam. An essential element of this belief system is that the universe does not have to be as it is: it could have been otherwise. Einstein once said that the thing which most interested him is whether God had any choice in his creation. According to the Judaeo-Islamic-Christian tradition, the answer is a resounding yes.

Although not conventionally religious, Einstein often spoke of God, and expressed a sentiment shared, I believe, by many scientists, including professed atheists. It is a sentiment best described as a reverence for nature and a deep fascination for the natural order of the cosmos. If the universe did not have to be as it is, of necessity - if, to paraphrase Einstein, God did have a choice - then the fact that nature is so fruitful, that the universe is so full of richness, diversity and novelty, is profoundly significant.

Some scientists have tried to argue that if only we knew enough about the laws of physics, if we were to discover a final theory that united all the fundamental forces and particles of nature into a single mathematical scheme, then we would find that this superlaw, or theory of everything, would describe the only logically consistent world. In other words, the nature of the physical world would be entirely a consequence of logical and mathematical necessity. There would be no choice about it. I think this is demonstrably wrong. There is not a shred of evidence that the universe is logically necessary. Indeed, as a theoretical physicist I find it rather easy to imagine alternative universes that are logically consistent, and therefore equal contenders for reality.

It was from the intellectual ferment brought about by the merging of Greek philosophy and Judaeo-Islamic-Christian thought, that modern science emerged, with its unidirectional linear time, its insistence on nature's rationality, and its emphasis on mathematical principles. All the early scientists such as Newton were religious in one way or another. They saw their science as a means of uncovering traces of God's handiwork in the universe. What we now call the laws of physics they regarded as God's abstract creation: thoughts, so to speak, in the mind of God. So in doing science, they supposed, one might be able to glimpse the mind of God. What an exhilarating and audacious claim!

In the ensuing three hundred years, the theological dimension of science has faded. People take it for granted that the physical world is both ordered and intelligible. The underlying order in nature - the laws of physics - are simply accepted as given, as brute facts. Nobody asks where they come from; at least they don't in polite company. However, even the most atheistic scientist accepts as an act of faith the existence of a lawlike order in nature that is at least in part comprehensible to us. So science can proceed only if the scientist adopts an essentially theological world view.

It has become fashionable in some circles to argue that science is ultimately a sham, that we scientists read order into nature, not out of nature, and that the laws of physics are our laws, not nature's. I believe this is arrant nonsense. You'd be hard-pressed to convince a physicist that Newton 's inverse square law of gravitation is a purely cultural concoction. The laws of physics, I submit, really exist in the world out there, and the job of the scientist is to uncover them, not invent them. True, at any given time, the laws you find in the textbooks are tentative and approximate, but they mirror, albeit imperfectly, a really-existing order in the physical world. Of course, many scientists don't recognize that in accepting the reality of an order in nature - the existence of laws "out there" - they are adopting a theological world view. Ironically, one of the staunchest defenders of the reality of the laws of physics is the American physicist Steven Weinberg, a sort of apologetic atheist who, though able to wax lyrical about the mathematical elegance of nature, nevertheless felt compelled to pen the notorious words: "The more the universe seems comprehensible, the more it also seems pointless."

Let us accept, then, that nature really is ordered in a mathematical way - that "the book of nature", to quote Galileo, "is written in mathematical language". Even so, it is easy to imagine an ordered universe which nevertheless remains utterly beyond human comprehension, due to its complexity and subtlety. For me, the magic of science is that we can understand at least part of nature - perhaps in principle all of it - using the scientific method of enquiry. How utterly astonishing that we human beings can do this! Why should the rules on which the universe runs be accessible to humans?

The mystery is all the greater when one takes into account the cryptic character of the laws of nature. When Newton saw the apple fall, he saw a falling apple. He didn't see a set of differential equations that link the motion of the apple to the motion of the moon. The mathematical laws that underlie physical phenomena are not apparent to us through direct observation; they have to be painstakingly extracted from nature using arcane procedures of laboratory experiment and mathematical theory. The laws of nature are hidden from us, and are revealed only after much labour. The late Heinz Pagels - another atheistic physicist - described this by saying that the laws of nature are written in a sort of cosmic code, and that the job of the scientist is to crack the code and reveal the message - nature's message, God's message, take your choice, but not our message. The extraordinary thing is that human beings have evolved such a fantastic code-breaking talent. This is the wonder and the magnificence of science; we can use it to decode nature and discover the secret laws that make the universe tick!

Many people want to find God in the creation of the universe, in the big bang that started it all off. They imagine a superbeing who deliberates for all eternity, then presses a metaphysical button and produces a huge explosion. I believe this image is entirely misconceived. Einstein showed us that space and time are part of the physical universe, not a pre-existing arena in which the universe happens. Cosmologists are convinced that the big bang was the coming-into-being, not just of matter and energy, but of space and time as well. Time itself began with the big bang. If this sounds baffling, it is by no means new. Already in the fifth century St. Augustine proclaimed that "the world was made with time, not in time". According to James Hartle and Stephen Hawking, this coming-into-being of the universe need not be a supernatural process, but could occur entirely

naturally, in accordance with the laws of quantum physics, which permit the occurrence of genuinely spontaneous events.

The origin of the universe, however, is hardly the end of the story. The evidence suggests that in its primordial phase the universe was in a highly simple, almost featureless state: perhaps a uniform soup of subatomic particles, or even just expanding empty space. All the richness and diversity of matter and energy we observe today has emerged since the beginning in a long and complicated sequence of self-organizing physical processes. What an incredible thing these laws of physics are! Not only do they permit a universe to originate spontaneously; they encourage it to self-organize and self-complexify to the point where conscious beings emerge, and can look back on the great cosmic drama and reflect on what it all means.

Now you may think I have written God entirely out of the picture. Who needs a God when the laws of physics can do such a splendid job? But we are bound to return to that burning question: Where do the laws of physics come from? And why those laws rather than some other set? Most especially: Why a set of laws that drives the searing, featureless gases coughed out of the big bang, towards life and consciousness and intelligence and cultural activities such as religion, art, mathematics and science?

If there is a meaning or purpose to existence, as I believe there is, we are wrong to dwell too much on the originating event. The big bang is sometimes referred to as "the creation", but in truth nature has never ceased to be creative. This ongoing creativity, which manifests itself in the spontaneous emergence of novelty and complexity, and organization of physical systems, is permitted through, or guided by, the underlying mathematical laws that scientists are so busy discovering.

Now the laws of which I speak have the status of timeless eternal truths, in contrast to the physical states of the universe which change with time, and bring forth the genuinely new. So we here confront in physics a re-emergence of the oldest of all philosophical and theological debates: the paradoxical conjunction of the eternal and the temporal. Early Christian thinkers wrestled with the problem of time: is God within the stream of time, or outside of it? How can a truly timeless God relate in any way to temporal beings such as ourselves? But how can a God who relates to a changing universe be considered eternal and unchangingly perfect?

Well, physics has its own variations on this theme. In our century, Einstein showed us that time is not simply "there" as a universal and absolute backdrop to existence, it is intimately interwoven with space and matter. As I have mentioned, time is revealed to be an integral part of the physical universe; indeed, it can be warped by motion and gravitation. Clearly something that can be changed in this manner is not absolute, but a contingent part of the physical world.

In my own field of research - called quantum gravity - a lot of attention has been devoted to understanding how time itself could have come into existence in the big bang. We know that matter can be created by quantum processes. There is now a general acceptance among physicists and cosmologists that spacetime can also originate in a quantum process. According to the latest thinking, time might not be a primitive concept at all, but something that has "congealed" from the fuzzy quantum ferment of the big bang, a relic, so to speak, of a particular state that froze out of the fiery cosmic birth.

If it is the case that time is a contingent property of the physical world rather than a necessary consequence of existence, then any attempt to trace the ultimate purpose or design of nature to a temporal Being or Principle seems doomed to failure. While I do not wish to claim that physics has solved the riddle of time - far from it - I do believe that our advancing scientific understanding of

time has illuminated the ancient theological debate in important ways. I cite this topic as just one example of the lively dialogue that is continuing between science and theology.

A lot of people are hostile to science because it demystifies nature. They prefer the mystery. They would rather live in ignorance of the way the world works and our place within it. For me, the beauty of science is precisely the demystification, because it reveals just how truly wonderful the physical universe really is. It is impossible to be a scientist working at the frontier without being awed by the elegance, ingenuity and harmony of the lawlike order in nature. In my attempts to popularize science, I'm driven by the desire to share my own sense of excitement and awe with the wider community; I want to tell people the good news. The fact that we are able to do science, that we can comprehend the hidden laws of nature, I regard as a gift of immense significance. Science, properly conducted, is a wonderfully enriching and humanizing enterprise. I cannot believe that using this gift called science - using it wisely, of course - is wrong. It is good that we should know.

So where is God in this story? Not especially in the big bang that starts the universe off, nor meddling fitfully in the physical processes that generate life and consciousness. I would rather that nature can take care of itself. The idea of a God who is just another force or agency at work in nature, moving atoms here and there in competition with physical forces, is profoundly uninspiring. To me, the true miracle of nature is to be found in the ingenious and unswerving lawfulness of the cosmos, a lawfulness that permits complex order to emerge from chaos, life to emerge from inanimate matter, and consciousness to emerge from life, without the need for the occasional supernatural prod; a lawfulness that produces beings who not only ask great questions of existence, but who, through science and other methods of enquiry, are even beginning to find answers.

You might be tempted to suppose that any old rag-bag of laws would produce a complex universe of some sort, with attendant inhabitants convinced of their own specialness. Not so. It turns out that randomly-selected laws lead almost inevitably either to unrelieved chaos or boring and uneventful simplicity. Our own universe is poised exquisitely between these unpalatable alternatives, offering a potent mix of freedom and discipline, a sort of restrained creativity. The laws do not tie down physical systems so rigidly that they can accomplish little, nor are they a recipe for cosmic anarchy. Instead, they encourage matter and energy to develop along pathways of evolution that lead to novel variety, what Freeman Dyson has called the principle of maximum diversity: that in some sense we live in the most interesting possible universe.

Scientists have recently identified a regime dubbed "the edge of chaos", a description that certainly characterises living organisms, where innovation and novelty combine with coherence and cooperation. The edge of chaos seems to imply the sort of lawful freedom I have just described. Mathematical studies suggest that to engineer such a state of affairs requires laws of a very special form. If we could twiddle a knob and change the existing laws, even very slightly, the chances are that the universe as we know it would fall apart, descending into chaos. Certainly the existence of life as we know it, and even of less elaborate systems such as stable stars, would be threatened by just the tiniest change in the strengths of the fundamental forces, for example. The laws that characterize our actual universe, as opposed to an infinite number of alternative possible universes, seem almost contrived - fine-tuned some commentators have claimed - so that life and consciousness may emerge. To quote Dyson again: it is almost as if "the universe knew we were coming". I can't prove to you that that is design, but whatever it is it is certainly very clever!

Now some of my colleagues embrace the same scientific facts as I, but deny any deeper significance. They shrug aside the breathtaking ingenuity of the laws of physics, the extraordinary felicity of nature, and the surprising intelligibility of the physical world, accepting these things as a package of marvels that just happens to be. But I cannot do this. To me, the contrived nature of

physical existence is just too fantastic for me to take on board as simply "given". It points forcefully to a deeper underlying meaning to existence. Some call it purpose, some design. These loaded words, which derive from human categories, capture only imperfectly what it is that the universe is about . But, that it is about something, I have absolutely no doubt.

Where do we human beings fit into this great cosmic scheme? Can we gaze out into the cosmos, as did our remote ancestors, and declare: "God made all this for us!" Well, I think not. Are we then but an accident of nature, the freakish outcome of blind and purposeless forces, an incidental by-product of a mindless, mechanistic universe? I reject that too. The emergence of life and consciousness, I maintain, are written into the laws of the universe in a very basic way. True, the actual physical form and general mental make-up of homo sapiens contains many accidental features of no particular significance. If the universe were re-run a second time, there would be no solar system, no Earth and no people. But the emergence of life and consciousness somewhere and somewhen in the cosmos is, I believe, assured by the underlying laws of nature. The origin of life and consciousness were not interventionist miracles, but nor were they stupendously improbable accidents. They were, I believe, part of the natural outworking of the laws of nature, and as such our existence as conscious enquiring beings springs ultimately from the bedrock of physical existence - those ingenious, felicitous laws. That is the sense in which I have written in my book The Mind of God: "We are truly meant to be here". I mean "we" in the sense of conscious beings, not homo sapiens specifically. Thus although we are not at the centre of the universe, human existence does have a powerful wider significance. Whatever the universe as a whole may be about, the scientific evidence suggests that we, in some limited yet ultimately still profound way, are an integral part of its purpose.

How can we test these ideas scientifically? One of the great challenges to science is to understand the nature of consciousness in general and human consciousness in particular. We still haven't a clue how mind and matter are related, nor what process led to the emergence of mind from matter in the first place. This is an area of research that is attracting considerable attention at present, and for my part I intend to pursue my own research in this field. I expect that when we do come to understand how consciousness fits into the physical universe, my contention that mind is an emergent and in principle predictable product of the laws of the universe will be borne out.

Secondly, if I am right that the universe is fundamentally creative in a pervasive and continuing manner, and that the laws of nature encourage matter and energy to self-organize and self-complexify to the point that life and consciousness emerge naturally, then there will be a universal trend or directionality towards the emergence of greater complexity and diversity. We might then expect life and consciousness to exist throughout the universe. That is why I attach such importance to the search for extraterrestrial organisms, be they bacteria on Mars, or advanced technological communities on the other side of the galaxy. The search may prove hopeless - the distances and numbers are certainly daunting - but it is a glorious quest. If we are alone in the universe, if the Earth is the only life-bearing planet among countless trillions, then the choice is stark. Either we are the product of a unique supernatural event in a universe of profligate overprovision, or else an accident of mind-numbing improbability and irrelevance. On the other hand, if life and mind are universal phenomena, if they are written into nature at its deepest level, then the case for an ultimate purpose to existence would be compelling.

Finally, let me turn to the theme of the Templeton Prize itself: progress in religion. It is often pointed out that people are increasingly turning away from the established religions. However, it remains as true as ever that ordinary men and women yearn for some sort of deeper meaning to their lives. Our secular age has led many people to feel demoralised and disillusioned, alienated from nature, regarding their existence as a pointless charade in an indifferent, even hostile, universe, a meaningless three score years and ten on a remote planet wandering amid the vastness

of an uncaring cosmos. Many of our social ills can be traced to the bleak world view that three hundred years of mechanistic thought have imposed on us, a world view in which human beings are presented as irrelevant observers of nature rather than an integral part of the natural order. Some may indeed recoil from this philosophy and find comfort in ancient wisdom and revered texts that place mankind at the pinnacle of creation and the centre of the universe. Others choose to put their faith in so-called New Age mysticism.

I would like to suggest an alternative. We have to find a framework of ideas that provides people with some broader context to their lives than just the daily round, a framework that links them to each other, to nature and to the wider universe in a meaningful way, that yields a common set of principles around which peoples of all cultures can make ethical decisions, yet remains honest in the face of scientific knowledge; indeed, that celebrates that knowledge alongside other human insights and inspirations. The scientific enterprise as I have presented it to you today may not return human beings to the centre of the universe, it may reject the notion of miracles other than the miracle of nature itself, but it doesn't make human beings irrelevant either. A universe in which the emergence of life and consciousness is seen, not as a freak set of events, but fundamental to its lawlike workings, is a universe that can truly be called our home.

I believe that mainstream science, if we are brave enough to embrace it, offers the most reliable path to knowledge about the physical world. I am certainly not saying that scientists are infallible, nor am I suggesting that science should be turned into a latter-day religion. But I do think that if religion is to make real progress, as Sir John Templeton so passionately advocates, it cannot ignore the scientific culture; nor should it be afraid to do so, for as I have argued, science reveals just what a marvel the universe is.

Sir John Templeton recognizes that if religion is to progress it must confront modern scientific thought. Many religious leaders also accept this, and over the years I have enjoyed fruitful discussions on science and religion with theologians of varying persuasions - behind closed doors. What has most impressed me about my encounters with these theologians has been their open-mindedness and willingness to accept the conclusions of modern science. While the interpretation of the scientific account of the world may be contentious, the scientific facts are rarely questioned. Basic notions like the big bang theory, the origin of life and consciousness by natural physical processes, and Darwinian evolution, seem to cause these theologians little difficulty.

Yet among the general population there is a widespread belief that science and theology are for ever at loggerheads, that every scientific discovery pushes God further and further out of the picture. It is clear that many religious people still cling to an image of a God-of-the-gaps, a cosmic magician invoked to explain all those mysteries about nature that currently have the scientists stumped. It is a dangerous position, for as science advances, so the God-of-the-gaps retreats, perhaps to be pushed off the edge of space and time altogether, and into redundancy.

The position I have presented to you today is radically different. It is one that regards the universe, not as the plaything of a capricious Deity, but as a coherent, rational, elegant and harmonious expression of a deep and purposeful meaning. I believe the time has now come for those theologians who share this vision to join me and my scientific colleagues to take the message to the people!

2005
John Polkinghorne, Physicist and Theologian
Beyond Darwin
Article

John Polkinghorne is a physicist and an Anglican priest. This article is excerpted from Exploring Reality: The Intertwining of Science and Religion, © 2005 Yale University Press, New Haven, Connecticut. This article appeared in The Christian Century, (November 15, 2005, pp. 25-28) Copyright by The Christian Century Foundation: used by permission.

The attempt to force classical Darwinian thinking into the role of an explanatory principle of almost universal scope has proved singularly unconvincing. It seeks to inflate an assembly of half-truths into a theory of everything. Sober evaluation of the adequacy of the insights being proffered soon pricks this explanatory bubble.

Humans' increasing ability to process information coming from the environment is clearly an advantage in the struggle for survival, but this does not explain why it has been accompanied by the trait of conscious awareness. Indeed, one might suppose that the latter, with its limited focus of attention and no more than a peripheral openness to signals coming from other possible directions, might be more a hazard than a help.

Evolutionary epistemology has attempted to explain and validate the human power to attain reliable knowledge as something originating through Darwinian development. Once again one encounters a half-truth. Of course, being able to make sense of everyday experience is a vital survival asset. If one could not figure out that stepping off a high cliff was a dangerous thing to do, life would soon be imperiled. Yet when Isaac Newton recognized that the same force that makes the high cliff dangerous is also the force that holds the moon in its orbit around the earth and the earth in its orbit around the sun, thereby going on to discover universal gravity, something happened that went far beyond anything needed for survival.

When Sherlock Holmes and Dr. Watson first meet, the great investigator feigns not to know whether the earth goes round the sun or the sun around the earth. He defends his apparent ignorance simply by asking what it matters for his daily work as a detective. Of course, it does not matter at all, but human beings know many things that neither bear relation to mundane necessities nor could plausibly be considered simply as spin-offs from the exercise of rational skills developed to cope with those necessities.

This point was reinforced about 200 years after Newton when Albert Einstein's discovery of general relativity produced the modern theory of gravity -- capable of explaining not only the behavior of our little local solar system but also the structure of the whole cosmos. In both relativity theory and quantum theory, modes of thought are required that are totally different from those appropriate to everyday affairs. The human mind has proved capable of comprehending the counterintuitive world of subatomic physics and the cosmic realms of curved spacetime.

It has turned out that it is our mathematical abilities that have furnished the key to unlock deep secrets of the physical universe. Once more one encounters a mystery impenetrable by conventional evolutionary thinking. Survival needs would seem to require no more than a little arithmetic, some elementary Euclidean geometry and the ability to make certain kinds of simple logical association. Whence then comes the human ability to explore non-commutative algebras, prove Fermat's last theorem and discover the Mandelbrot set? These rational feats go far beyond anything susceptible to Darwinian explanation.

The ability to use the experience of yesterday as a guide to coping with the challenges of today is clearly a significant aid to survival. But does this fact alone give us sufficient license to trust in human ability to reconstruct from fragmentary evidence the history of a past extending over many millions of years? Darwin himself felt some doubts on this score, writing in old age to a friend that

"'with me the horrid doubt arises whether the convictions of man's mind, which has been developed from the mind of lower animals, are of any value or are trustworthy."'

There is something touching in the spectacle of this great scientist poised with rational saw in hand and tempted to sever the epistemic branch on which he had sat while making his great discoveries. Surely his doubts were unjustified. The cumulative power of scientific thinking has vindicated itself many times over in the course of human investigations into reality. Why science is possible in this deep way is a question which, if pursued, would take us well beyond science itself. I believe that ultimately it is a reflection of the theological fact that human beings are creatures who are made in the image of their Creator (Gen. 1:26-27).

Sociobiology seeks to explain human ethical intuitions in terms of inherited patterns of behavior favoring the propagation of at least some of an individual's genes. Once again, one may acknowledge a source of partial insight. No doubt ideas of kin altruism (the mutual support extended between those who share in the family gene pool) and reciprocal altruism (favors done in the expectation of favors later to be received) shed some Darwinian light on aspects of human behavior. Models of behavioral strategies that optimize probable returns in given circumstances -- such as "tit for tat": respond in the same manner that your opponent has displayed to you -- give some insight into the nature of prudent decision making. But sociobiology tells too banal a story to be able to account for radical altruism -- the ethical imperative that leads a person to risk his or her own life in the attempt to save an unknown and unrelated stranger from the danger of death. Love of that incalculable kind eludes Darwinian explanation.

Equally elusive to evolutionary explanation are many human aesthetic experiences. What survival value has Mozart's music given us, however profoundly it enriches our lives in other ways?

The proper response to all this is not to adopt a Procrustean technique of chopping down the range of human experience until it fits into a narrow Darwinian bed, nor is it to abandon evolutionary thinking altogether. Rather, it is to release that thinking from the poverty of its neo-Darwinian captivity. This requires two steps. One is an enrichment of the concept of the environment within which hominid evolution has taken place. The other is an enhancement of our understanding of the processes that have been at work. When these steps have been taken, we shall be freed from being driven to the construction of implausible just-so stories, alleging that human capacities of which we have basic experience are totally different in character from what we, in fact, know them to be.

One way of enhancing understanding of the actual scope and character of the human environment can be provided by thinking about the nature of mathematics. Most mathematicians are convinced that their subject is concerned with discovery and not with mere construction. They are not involved in playing amusing intellectual games of their own contrivance, but are privileged to explore an already existing realm of mentally accessed reality. In other words, as far as their subject is concerned, mathematicians are instinctive Platonists. They believe that the object of their study is an everlasting noetic world which contains the rationally beautiful structures that they investigate. Benoit Mandelbrot did not invent his celebrated set; he discovered it. Acknowledgment of the existence of this rational dimension of reality is vital to the possibility of understanding the origin of human mathematical powers.

At some stage of hominid development, our ancestors acquired a brain structure that afforded them access to the mental world of mathematics. It then became as much a part of their environment as were the grasslands over which they roamed. At first this noetic encounter must have been limited to a utilitarian style of mundane thinking, involving just an engagement with simple arithmetical and geometrical ideas. However, once that intellectual traffic had started it could not be limited to such elementary matters. Our ancestors were beguiled into further

exploration of noetic richness which, once begun, continued with an ever-increasing fruitfulness. What drew them into this exploratory process was not a Darwinian drive to the enhanced propagation of their genes, but an entirely different mechanism.

The kinds of considerations in the case of mathematical experience that lead us to take seriously an enriched human environment apply equally to other distinctive forms of human ability. Human ethical intuitions indicate the existence of a moral dimension of reality open to our exploration. Our conviction that torturing children is wrong is not some curiously veiled strategy for successful genetic propagation, nor is it merely a convention adopted arbitrarily by society. It is a fact about the nature of reality to which our ancestors gained access at some stage of hominid development. Similarly, human aesthetic experiences gain their authenticity and value from their being encounters with yet another aspect of the multidimensional reality that encompasses humanity Experiences of beauty are much more than emotion recalled in tranquillity; they are engagements with the everlasting truth of being.

Once one accepts the enrichment beyond the merely material of the context within which human life is lived, one is no longer restricted to the notion of Darwinian survival necessity as providing the sole engine driving hominid development. In these noetic realms of rational skill, moral imperative and aesthetic delight -- of encounter with the true, the good and the beautiful -- other forces are at work to draw out and enhance distinctive human potentialities. Survival is replaced by something that one may call satisfaction, the deep contentment of understanding and the joyful delight that draws on inquirers and elicits the growth of their capacities. No doubt the neural ground for the possibility of psychosomatic beings like ourselves to be able to develop aptitudes in this way was afforded by the plasticity of the hominid brain. Much of the vast web of neural networking within our skulls is not genetically predetermined, but it grows epigenetically, in response to learning experiences. It is formed by our actual encounters with reality.

The era of these developments was the time when human culture. emerged, generating a language-based Lamarckian ability to transfer information from one generation to the next through a process whose efficiency vastly exceeded the slow and uncertain Darwinian method of differential propagation. It is in these ways that a recognition of the many-layered character of reality, and the variety of modes of response to it, make intelligible the rapid development of the remarkable distinctiveness of human nature.

Hominid evolution inaugurated the exercise of these new creaturely capacities here on planet Earth, but it did not bring into being the reality to which these nascent abilities gave access. What emerged were mathematicians, not mathematics. The latter was always "there," even if unrecognized by creatures during billions of years of cosmic history. The rational, moral and aesthetic contexts within which hominid capacities began to develop are essential and abiding dimensions of created reality. From the point of view of dual-aspect monism, these realities exist at the extreme mental pole of the complementary duality involved, just as sticks and stones exist at the far physical pole.

One should go on to ask what is the origin of these many diverse but interrelated aspects of reality. For the religious believer, the source of these dimensions lies in the unifying will of the Creator, a fundamental insight that makes it intelligible not only that the universe is transparent to our scientific enquiry, but also that it is the arena of moral decision and the carrier of beauty. Those dimensions of reality, the understanding of whose character lies beyond the narrow explanatory horizon of natural science, are not epiphenomenal froth on the surface of a fundamentally material world, but are gifts expressive of the nature of this world’s Creator. Thus moral insights are intuitions of God’s good and perfect will, and aesthetic delight is a sharing in the Creator’s joy in creation, just as the wonderful cosmic order discovered by science is truly a reflection of the mind

of God. Thinking about human experience in this way affords the possibility of a satisfyingly unified account of multi-layered reality. Theology can lay just claim to being the true Theory of Everything.

2005
Jeff Lindsey, LDS Blogger
Tuesday, May 03, 2005
Intelligent Design: Not Just a Matter of Faith

> On February 7, 2005, the New York Times ran an op-ed piece, "Design for Living" by Michael J. Behe (also available at Discovery.org and other unusual sites. The author makes the point that the concept of intelligent design has been widely misrepresented and does not depend on religious faith.
>
> Michael Behe is a biochemist at Lehigh University in Bethlehem, Pennsylvania, and a senior fellow at the Discovery Institute's Center for Science and Culture, a Seattle-based organization that supports the intelligent-design movement. Here is an excerpt from his article:
>
> Rather, the contemporary argument for intelligent design is based on physical evidence and a straightforward application of logic. The argument for it consists of four linked claims.
>
> The first claim is uncontroversial: we can often recognize the effects of design in nature. For example, unintelligent physical forces like plate tectonics and erosion seem quite sufficient to account for the origin of the Rocky Mountains. Yet they are not enough to explain Mount Rushmore.
>
> Of course, we know who is responsible for Mount Rushmore, but even someone who had never heard of the monument could recognize it as designed.
>
> Which leads to the second claim of the intelligent design argument: the physical marks of design are visible in aspects of biology. This is uncontroversial, too. . . .
>
> The next claim in the argument for design is that we have no good explanation for the foundation of life that doesn't involve intelligence. Here is where thoughtful people part company.
>
> Darwinists assert that their theory can explain the appearance of design in life as the result of random mutation and natural selection acting over immense stretches of time.
>
> Some scientists, however, think the Darwinists' confidence is unjustified. They note that although natural selection can explain some aspects of biology, there are no research studies indicating that Darwinian processes can make molecular machines of the complexity we find in the cell.
>
> Scientists skeptical of Darwinian claims include many who have no truck with ideas of intelligent design, like those who advocate an idea called complexity theory, which envisions life self-organizing in roughly the same way that a hurricane does, and ones who think organisms in some sense can design themselves.

> The fourth claim in the design argument is also controversial: in the absence of any convincing non-design explanation, we are justified in thinking that real intelligent design was involved in life. . . .

Interesting comments.

Personally, I find the intricacies of life and the universe to be so clever and even inspiring that it is difficult to escape the natural testimony of a design. Yes, there is a Designer - and He's awfully good at what He does.

November 2005
Elder Douglas L. Callister
Our God Is God
Brigham Young University–Idaho Devotional

My dear young students: I keenly feel my responsibility to testify of truths which will strengthen your growing faith. That desire has driven me to my knees many times in preparation of my message.

More than a year ago, half a world away in the city of Moscow, Russia, a young sister about your age spoke to me of her friendship with a troubled non-member boy. He had been raised in a Communist home. He frequently inquired of her, "Where is God?"

Especially during university years, that question will often be asked of young people by those whose wisdom is self-appointed. If faith in God's existence and your relationship with Him is lost while you acquire an education, you will also lose your testimony that you are His child and have the potential to become like Him.

In moments of extremity, men and women of all generations have asked where God is. The Prophet Joseph did so from Liberty Jail in the familiar language of Section 121 of the Doctrine and Covenants: "O God, where art thou? And where is the pavilion that covereth thy hiding place?" (Doctrine and Covenants 121:1)

God often had to counsel the suffering Saints, "Be still and know that I am God" (Doctrine and Covenants 101:16). Even Christ in the concluding hours of His atoning sacrifice cried out, "My God, my God, why hast thou forsaken me?" (Matthew 27:46)

More than a century ago Robert G. Ingersoll, an American agnostic, pursued this question in the following words:

Each nation has created a god, and the god has always resembled his creators. He hated and loved what they hated and loved. Each nation made its gods…speak its language and put in their mouths the same mistakes of history, geography, astronomy and matters of fact generally… No god was ever in advance of the nation that created him.

[Africans] represented their deities with black skins and curly hair. The Mongolian gave to his a yellow complexion and dark, almond-shaped eyes… Zeus was a perfect Greek, and Jove looked as though a member of the Roman Senate.

The gods of the northern countries were represented warmly clad in robes of fur; those of the tropics were naked. The gods of India were often mounted upon elephants; those of the islanders were great swimmers, and the deities of the Arctic zone were passionately fond of whale's blubber.

Few nations have been so poor as to have but one god. Gods were made so easily, and the raw materials cost so little that generally the god market was fairly glutted with these phantoms (The Works of Robert G. Ingersoll, Vol. 1 [1900], 7, 10, 23, 24).

In paraphrasing a famous quotation from Alexander Pope, Ingersoll irreverently concluded: "An honest god is the noblest work of man" (Ibid 7).

People of all ages have delighted in pitting the strength or wisdom of their gods against that of their neighbors' gods. Two of the most interesting and consequential contests are recorded in the Old Testament.

One took place over 2500 years ago on Mount Carmel between the Lord God of Israel, represented by his prophet Elijah, and the Phoenician god Baal, represented in turn by his 450 prophets. How piercing was Elijah's challenge, "How long halt ye between two opinions? If the Lord be God, follow him: but if Baal, then follow him."

The heavens silently ignored the incantations and pleading to Baal's dumb and brazen idols. Elijah mocked, "Cry aloud: for he is a god; either he is talking, or he is pursuing, or he is in a journey, or peradventure he sleepeth, and must be awakened." Man-made gods never fared well in the presence of real deity.

When it was Elijah's turn he prayed openly: "Lord God of Abraham, Isaac, and of Israel, let it be known this day that thou art God in Israel, and that I am thy servant…"

Then the fire of the Lord fell, and consumed the burnt sacrifice, and the wood, and the stones, and the dust, and licked up the water that was in the trench. The people fell on their faces and proclaimed: "The Lord, he is...God; the Lord, he is...God" (1 Kings 18:21, 27, 36, 38-39).

No less impressive in story or message was the contest between Moses and the magicians of Pharaoh. Moses pled: "Let my people go" (Exodus 5:1). But the heart of Ramses was as stone. Moses transformed a rod into a serpent. He smote the waters of Egypt that they turned to blood, and the fish died and the waters stank. He inflicted the land with frogs and with lice and swarms of flies, and a plague upon the cattle of Egypt, and boils, and blains, and hail, and fire, and locusts, and thick darkness. But the heart of Pharaoh would not soften. His magicians could duplicate some of the miracles, but not all – and even they pled for the release of Israel when Israel's God smote their firstborn sons. Stubborn Pharaoh finally discovered life's greatest truth when the message was brought to him of the destruction of his army by the crashing waters of the Red Sea.

As portrayed by Cecil B. DeMille on the motion picture screen, we can imagine Pharaoh upon his throne pondering, then muttering in eloquence: "Moses' God is God" (Motion Picture: The Ten Commandments).

In their preoccupation to worship a powerful and respectable god, ancient civilizations often fashioned multiple deities as the objects of their reverence. It never occurred to them to have no god. That sin was left to our more sophisticated society.

William Jennings Bryan, eloquent speaker of a generation past, and once the United States Secretary of State, penned these words in response to Charles Darwin's Origin of the Species:

How does the evolutionist explain the eye when he leaves God out?

The evolutionist guesses that there was a time when eyes were unknown. And since the eye is a universal possession among living things the evolutionist guesses that it came into being – not by design or by act of God – but just happened, and how did it happen? A piece of pigment, or, as some say, a freckle appeared upon the skin of an animal that had no eyes. This piece of pigment or freckle converged the rays of the sun upon that spot and when the little animal felt the heat on that spot it turned the spot to the sun to get more heat. The increased heat irritated the skin – so the evolutionists guess, and a nerve came there and out of the nerve came the eye! But this only accounts for one eye; there must have been another piece of pigment or freckle soon afterward and just in the right place in order to give the animal two eyes.

And, according to the evolutionist, there was a time when animals had no legs, and so the leg came by accident. How? Well, the guess is that a little animal without legs was wiggling along on its belly one day when it discovered a wart, and it was in the right place to be used to aid it in locomotion; so, it came to depend upon the wart, and use finally developed it into a leg. And then another wart and another leg, at the proper time – by accident – and accidentally in the proper place.

How long did the "light waves" have to play on the skin before the eyes came out? The evolutionist is very deliberate; he is long on time. He would certainly give the eye thousands of years, if not millions, in which to develop; but how could he be sure that the light waves played all the time in one place or played in the same place generation after generation until the development was complete? And why did the light waves quit playing when two eyes were perfected? Why did they not keep on playing until there were eyes all over the body? Why do they not play today, so that we may see eyes in process of development? And if the light waves created the eyes, why did they not create them strong enough to bear the light? Why did the light waves makes eyes and then make eyelids to keep the light out of the eyes? (William Jennings Bryan, In His Image, [1922] 97-100).

Naturalism's explanations often appear convoluted and grotesque when placed side-by-side with the simple, yet beautiful truths of the revealed word and divine scripture. Joseph Smith said: "A man never has half so much fuss to unlock a door, if he has a key, as though he had not, and had to cut it open with his jackknife" (Joseph Fielding Smith, Teachings of the Prophet Joseph Smith, [1972], 308).

With its 107 million cells, connected to the brain by over one million neurons, the eye is more perfect than any camera ever invented. It caused Charles Darwin to humbly confess "that the eye with all its inimitable controversies… could have been formed by natural selection seems, I freely confess, absurd in the highest degree" (Quoted in Bert Thompson, The Case for the Existence of God [2003]).

In 1860 Darwin wrote a botanist friend: "To this day the eye makes me shudder" (Francis Hitching, Was Darwin Wrong? Quoted in The Neck of the Giraffe). It is small wonder that a much wiser race than Darwin's, that of the ancient Egyptians, chose the eye as their symbol of perfection.

The psalmist wrote: "The fool hath said in his heart, there is no God" (Psalms 53:1). Such a foolish disbeliever ought use those precious eyes to look at his hands. Seventy muscles contribute to hand movements. Much of the rest of the body is devoted to optimizing the complex function of the hand. There are no muscles in the fingers. The sole purpose of the forearm, its muscles and bones, is to move and optimally position the hand.

If you wish to observe a miracle, look at a baby's creasy hand. Its initial movements are uncontrolled. Shortly after birth it will be able to grasp, curl, push, lift, sense hot and cold, respond to pain by withdrawal, heal itself, display great strength or extraordinary sensitivity. These hands will be used thousands of times each day without aforethought.

Your miraculous thumb is controlled by 9 individual muscles and 3 major hand nerves. Sir Isaac Newton said: "In the absence of any other proof, the thumb alone would convince me of God's existence" (Paul Brand and Phillip Yancey, The Scars fo Easter, Christianity Today [April 5, 1985]. Paul Brand, renowned orthopedic hand surgeon, wrote:

We use our hands for the most wonderful activities: art, music, writing, healing, touching. Some people go to concerts and athletic events to watch the performance; I go to watch hands. For me, a piano performance is a ballet of fingers – a glorious flourish of ligaments and joints, tendons, nerves and muscles (Ibid).

Once the infant Son of Man possessed tiny hands. His hands, too, grew to accomplish their intended purposes. He used them to touch and heal the blind and infirm. His hands threw the money-changers out of the temple. His hands reached upward in prayer; outward in blessing; and downward from the cross, penetrated by cruel nails, driven through the palms, then the wrists, by the heavy blow of the mallet.

The fool proclaims in his heart that there is no god, but our eyes and our hands and our hearts and souls unhesitatingly testify to the contrary. The psalmist wrote: "I will praise thee; for I am fearfully and wonderfully made…" (Psalms 139:14).

One of my brothers is a physician. During earlier years in medical school he was assigned to study anatomy in companionship with an agnostic. Their education eventually required that the two of them carefully examine and dissect a cadaver. They studied the incredibly complex, yet harmonious systems of the body: the lymphatic, skeletal, circulatory, waste elimination, reproductive, neurological and immune systems. They noted the body's power to correct its own deficiencies, and to send healing antibodies to the place of injury or infection. They learned of over 150 trillion cells within the body. If set end-to-end, they would encircle the earth over 200 times.

Today they would learn of over one billion miles of DNA in one human body. They learned of a brain bathed in fluid which continually receives signals from 130 million light receptors in the eyes, 24,000 hearing receptors in the ears, 10,000 taste buds, and hundreds of thousands of receptors in the skin, with specialized commission to recognize touch, vibration, cold, heat and pain. My brother and his friend became silent as they contemplated the miracle they were examining. Sensing the moment was right, my brother challenged: "Coincidence is a marvelous thing, isn't it?" The agnostic responded, "You win."

This earth departs from its straight line orbit of the sun by only 1/9 of an inch every 18 miles. If, instead, it changed by 1/10 of an inch every 18 miles we would all freeze to death. If it changed by 1/8 of an inch we would all be incinerated? (Bert Thompson, The Case for the Existence of God [2003]) Did this all happen by accident?

There are, perhaps, 25,000 billion billion (25 sextillion) stars in the one billion galaxies or Milky Ways of which we have knowledge. Our own Milky Way has, perhaps, 100 billion stars. We literally could not tally the stars of one galaxy within the span of a single life. In section 88 of the Doctrine and Covenants the Prophet Joseph was taught the perfect order of this vast universe. "And there are many kingdoms;...And unto every kingdom is given a law;…and any man who hath seen any or

the least of these hath seen God moving in his majesty and power" (Doctrine and Covenants 88:37-38, 47).

Alma spoke to us, as well as to Korihor, in testifying: "[Y]ea, and all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator" (Alma 30:44).

The doubter requires too much of us when he asks us to believe that the miracles of eyes and hands and DNA and order in the universe all happened by chance. The passage of time, even long intervals of time, is not a "cause" and provides no answers without an intelligent designer.

President Ronald Reagan, speaking in Moscow, Russia, during the Soviet period, extemporaneously added to his remarks, "Sometimes when I'm faced with an unbeliever, an atheist, I am tempted to invite him to the greatest gourmet dinner one could ever serve and, when finished eating that magnificent dinner, to ask him if he believes there's a cook" (Paul Kengor, God and Ronald Reagan [2004], 302).

You may be too young to remember the famous American trial of Alger Hiss, tried for treason against the United States. The principal witness against him was Whitaker Chambers, a longtime atheistic Communist, who finally could not escape the reality of God. He speaks of his conversion in these words:

My daughter was in her high chair. I was watching her eat. She was the most miraculous thing that had ever happened in my life. …my eye came to rest on the delicate convolutions of her ear – those intricate, perfect ears. The thought passed through my mind: "No, those ears were not created by any chance coming together of atoms in nature (the communist view). They could have been created only by immense design." The thought was involuntary and unwanted. I crowded it out of my mind. But I never wholly forgot it or the occasion. I had to crowd it out of my mind. If I had completed it, I should have had to say: Design presupposes God. I did not then know that, at that moment, the finger of God was first laid upon my forehead (Whitaker Chambers, Witness, [1952] 16).

The evidence of God's existence is everywhere: in every newborn babe, in every system, part and parcel of the unending, and orderly universe, including our own bodies. He is evidenced in every sunset, work of art and passage of music, all of which He has provided to gladden the heart and bring beauty to our lives. Richard Swinburne said, "God paints with a big brush from a large paint box and he has no need to be stingy with the paint he uses to paint a beautiful universe" (Richard Swinburne, Is There A God? [1996] 63).

It is not possible to contemplate the immeasurable vacuum and purposelessness that would exist in our lives if God were "not there." A cloud or pallor of gloom would settle upon us of indescribable proportion. We would regret the passing of every day, and the passing of every loved one, knowing that neither time nor relationships could be extended. We would approach the autumn, and then the winter years of life with crescendoing fear. Every day of our lives we should thank God that He "is there" and that this life is not "all there is." We call this the gift of immortality. In the words of another, we are grateful that death is the "spreading of pinions to soar," not a "folding forever of wings" (Ingersolls Lectures [1877] 356). Because God exists we rejoice in the unendingness of time.

Yet, some ask where God is because there is pain on this earth and God does not hasten to intervene. This is known as the philosophical problem of evil. One flippantly approached this issue by sophomorically suggesting that God ought to have made "good health catching rather than

disease" (The Works of Robert G. Ingersoll, Vol. 1 [1900] 11). However, such thinking misses the whole point of our mortal existence, which is probationary rather than paradisiacal in nature.

During my years in law practice I became acquainted with a fine Jewish client. As a teenager he lived as a Hasidic Jew in German-occupied France during the Second World War. He was apprehended by the Gestapo. Tattooed numbers were placed on his arm labeling him as undesirable and he was sent to a German concentration camp. He lived only because he was young and strong, able to help with the required daily chores. As a result of his suffering he said in his heart "there is no god."

One day I asked him, for conversation sake, to imagine there is a god. "Would you have had this god intervene and prevent the death of six million Jews during the Second World War?" I inquired. He answered, "Most certainly."

I then referred to others over the centuries, not necessarily of Jewish ancestry, who had also lost their lives through barbarous acts. "Should God have intervened and stopped this?" "Yes," he affirmed.

I then spoke of yet others of ages past and present who died through cruel diseases, not the inhumanity of man. "Should God have precluded this, also?" His avowal was consistent.

Then I spoke of yet others who, short of death, had suffered much from physical – or emotional – or familial – or financial woes. My friend could not turn from his chosen course. He would have God intervene and eliminate every burden of man. He was uncomfortable in his answer but did not know where to draw the line once his imaginary god hastened to remove the very challenges that are the purpose and necessity of our probationary estate. I told him I did not like his god, even if only imaginary, for he kept me from passing the tests of faith for which I was sent to this earth.

In his marvelous message entitled Tragedy or Destiny? President Spencer W. Kimball rhetorically inquires what disservice we would offer to God's plan, if we had uncontrolled power, yet limited vision. He wrote:

With such uncontrolled power, I surely would have felt to protect Christ from the agony in Gethsemane, the insults, the thorny crown, the indignities in the court, the physical injuries. I would have administered to his wounds and healed them, giving him cooling water instead of vinegar. I might have saved him from suffering and death, and lost to the world his atoning sacrifice (Spencer W. Kimball, Faith Precedes the Miracle, [1972] 99).

If little babies could talk, and could remember their pre-earthly estate, their first utterances might express, "You came here to be tested. You agreed to that. The tests will be hard, in part because they are seldom the tests you anticipated. This is a closed book test in that you will not remember your pre-mortal estate. God will not intervene and remove the tests until the close of the examination or probationary period." That God does not hasten to intervene does not mean He is not there or does not love us. He has infinite respect for our agency and the purposes of earth life.

Elder Melvin J. Ballard stirs us with this example:

> I remember a good sister out in the Northwest whose husband was stricken with paralysis until he was unable to move, and lay day after day in the hospital. She said, "He can't die. He must not die or my faith will be broken." God knows how much we can stand and He recognizes this. I said to that woman, "God will not take your husband until you ask Him to: She said, "I will never ask Him."

> The man became so weak he could only speak in the slightest whisper. One day, months having passed, the woman came to the mission office and said, "I never thought I would live to reach the place I am today. You told me he would never be taken until the Lord was asked to take him. I come now seeking his death. Please come and ask the Lord to take him. I surrender him and give him up. I can't endure his suffering longer." We went to the hospital and asked the Lord for that blessing, and in one hour he was gone (Melvin R. Ballard, Melvin J. Ballard, Crusader of Righteousness [1966] 278).

Agency is not just the right to select among good alternatives. When God granted agency, He necessarily contemplated the possibility of wrong choices. Because God knows best and esteems so highly our precious agency, He does not answer every prayer just as it is uttered, nor does He always punish transgressors before there has been an opportunity or a space for repentance. The Divine hesitancy is to our advantage.

The same God who brings such order to the universe, and inspired the prophets, designated the time, place and circumstances of your birth. He chose your ancestors and your posterity. To the Prophet Joseph the Lord said, "Thy days are known, and thy years shall not be numbered less…" (Doctrine and Covenants 122:9). God's love for you and awareness of your circumstances is of equal measure. He foreordained you to perform a mission. Nothing will bring you greater sorrow than to have Father say when you return home: "You didn't complete your work. I had to give part of your mission to someone else."

You satisfy only part of your obligation to God by acknowledging the order of His universe. You must do more than confess His existence. Our relationship with God is not that of Creator and created-thing. It is of personal Father and child.

In March of 1997, I had the privilege of being present when President Hinckley was interviewed by the 17 senior editors of the Los Angeles Times. An editor inquired as to the rapid growth of the Church. President Hinckley chose to respond, instead, by emphasizing the miraculous transformation in life of each individual who joins the Church. He spoke of a girl in Australia who was employed serving ice cream. She seemed inattentive to the message of the missionaries until one of them said, "Do you know that you are a child of God?" She replied, "Nobody has ever said that to me before. I had no idea that I might be a child of God." Thereafter she went to her room, got down on her knees, and inquired, "Are you there? Am I your child? Please let me know." Then she said, "There came into me a surge of feeling that brought me the conviction that was the case." She joined the Church.

Two weeks later she was asked to give a talk in a Church meeting. Her first impulse was to run from it. Then she thought, "If I am a child of God I can do anything." With this enlarged vision of who she was she became a stalwart member of the Church.

Our entire perspective of ourselves, our worth and what we can make of our lives is altered for good when we come to understand that we are God's children, and we can become like Him. Everything we know and understand about God and our relationship with Him is a result of the Prophet Joseph Smith and the Restoration.

Someday, when memory is refreshed and all things are drawn "to [our] remembrance" (John 14:26) we will recall what we did and knew in the glorious pre-mortal estate. Undoubtedly we understood there the foundation principles of the gospel. President Joseph F. Smith said:

Can we know anything here that we did not know before we came? [Christ] no doubt possessed a foreknowledge of all the vicissitudes through which he would have to pass in the mortal tabernacle…He is our example. If Christ knew beforehand, so did we. But in coming here, we forgot all, that our agency might be free indeed, to choose good or evil (Joseph F. Smith, Gospel Doctrine [1970] 13).

We may have prayed countless times that when we found the truth on this earth – or it found us – we would not be casual in living our religion. We must have urged that we would, in the fullest measure, complete the mission to which we were foreordained, that our work would not be given to others. Perhaps we prayed a thousand times ten thousand times that on this earth we would never lose our faith or virtue, or our ability to remain as living tools in the hands of the Lord in accomplishing His work. It would serve us well if our present prayers included the same supplications. Every morning and night we should plead with the Lord on our knees that we never lose our faith or virtue.

The Book of Daniel includes the remarkable story of the three princes of Judah: Shadrach, Meshach and Abed-nego. They were cast into the midst of a burning, fiery furnace, heated seven times more than it was wont to be heated, because they would only worship the true and living God.

Nebuchadnezzar, the king, then said to his counselors: Did not we cast three men, bound into the midst of the fire?
Lo, I see four men loose, walking in the midst of the fire, and they have no hurt; and the form of the fourth is like the Son of God.

The king's counselors [then] saw these men, …upon whose bodies the fire had no power, nor was a hair of their head singed, neither were their coats changed, nor the smell of fire had passed on them.

Then Nebuchadnezzar spake, and said, Blessed be the God of Shadrach, Meshach and Abed-nego, who hath sent his angel, and delivered his servants that trusted in him, and have changed the king's word, and yielded their bodies, that they might not serve nor worship any god, except their own God.

…there is no other God that can deliver after this sort. (Daniel 3:24-25, 27-29)

Thereby all learned that our God is God.

This is the true answer to the query of the young lad in Moscow, who asked: "Where is God?"

Many of the promises of God resting upon you are conditional. They are dependent upon individual covenant-keeping and fulfillment of your appointed mission as a child of God in the exercise of your agency.

But the promises of God resting upon this Church, and its appointed destiny are unconditional. When Peter and John stood before the Sanhedrin and boldly testified in the name of Christ, Gamaliel said to his fellow Sanhedrists in reference to the missions of Peter and John: "Refrain from these men, and let them alone: for if this counsel or this work be of men, it will come to naught: But if it be of God, ye cannot overthrow it; lest haply ye be found even to fight against God" (Acts 5:38-39).

I have a testimony that this is true. I know that our God is God, and that He lives. I know He is our personal Father with an appointed mission for each of us to perform. I pray that we will never lose

our faith, testimonies or virtue, that we may be worthy to receive the blessings of immortality and eternal life, in the name of Jesus Christ, amen.

2006
The Goldilocks Enigma - Why Is The Universe Just Right For Life?
Paul Davies
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Chapter 1 - The Big Questions

Confronting the Mystery of Existence
FOR THOUSANDS OF YEARS, human beings have contemplated the world about them and asked the great questions of existence: Why are we here? How did the universe begin? How will it end? How is the world put together? Why is it the way it is? For all of recorded human history, people have sought answers to such "ultimate" questions in religion and philosophy or declared them to be completely beyond human comprehension. Today, however, many of these big questions are part of science, and some scientists claim that they may be on the verge of providing answers.

Two major developments have bolstered scientists' confidence that the answers lie within their grasp. The first is the enormous progress made in cosmology — the study of the large-scale structure and evolution of the universe. Observations made using satellites, the Hubble Space Telescope, and sophisticated ground-based instruments have combined to transform our view of the universe and the place of human beings within it. The second development is the growing understanding of the microscopic world within the atom — the subject known as high-energy particle physics. It is mostly carried out with giant particle accelerator machines (what were once called "atom smashers") of the sort found at Fermilab near Chicago and the CERN Laboratory just outside Geneva. Combining these two subjects — the science of the very large and the science of the very small — provides tantalizing clues that deep and previously unsuspected linkages bind the micro-world to the macro-world. Cosmologists are fond of saying that the big bang, which gave birth to the universe billions of years ago, was the greatest ever particle physics experiment. These spectacular advances hint at a much grander synthesis: nothing less than a complete and unified description of nature, a final "theory of everything" in which a flawless account of the entire physical world is encompassed within a single explanatory scheme.

The Universe Is Bio-Friendly
One of the most significant facts — arguably the most significant fact — about the universe is that we are part of it. I should say right at the outset that a great many scientists and philosophers fervently disagree with this statement: that is, they do not think that either life or consciousness is even remotely significant in the great cosmic scheme of things. My position, however, is that I take life and mind (that is, consciousness) seriously, for reasons I shall explain in due course. At first sight life seems to be irrelevant to the subject of cosmology. To be sure, the surface of the Earth has been modified by life, but in the grand sweep of the cosmos our planet is but an infinitesimal dot. There is an indirect sense, however, in which the existence of life in the universe is an important cosmological fact. For life to emerge, and then to evolve into conscious beings like ourselves, certain conditions have to be satisfied. Among the many prerequisites for life — at least, for life as we know it — is a good supply of the various chemical elements needed to make biomass. Carbon is the key life-giving element, but oxygen, hydrogen, nitrogen, sulfur, and phosphorus are crucial too. Liquid water is another essential ingredient. Life also requires an energy source and a stable environment, which in our case are provided by the sun. For life to evolve past the level of simple microbes, this life encouraging setting has to remain benign for a very long time; it took billions of years for life on Earth to reach the point of intelligence.

On a larger scale, the universe must be sufficiently old and cool to permit complex chemistry. It has to be orderly enough to allow the untrammeled formation of galaxies and stars. There have to be the right sorts of forces acting between particles of matter to make stable atoms, complex molecules, planets, and stars. If almost any of the basic features of the universe, from the properties of atoms to the distribution of the galaxies, were different, life would very probably be impossible.' Now, it happens that to meet these various requirements, certain stringent conditions must be satisfied in the underlying laws of physics that regulate the universe, so stringent in fact that a bio-friendly universe looks like a fix — or a "put-up job," to use the pithy description of the late British cosmologist Fred Hoyle.

It appeared to Hoyle as if a super-intellect had been "monkeying" with the laws of physics.2 He was right in his impression. On the face of it, the universe does look as if it has been designed by an intelligent creator expressly for the purpose of spawning sentient beings. Like the porridge in the tale of Goldilocks and the three bears, the universe seems to be "just right" for life, in many intriguing ways. No scientific explanation for the universe can be deemed complete unless it accounts for this appearance of judicious design.

Until recently, "the Goldilocks factor" was almost completely ignored by scientists. Now, that is changing fast. As I shall discuss in the following chapters, science is at last coming to grips with the enigma of why the universe is so uncannily fit for life. The explanation entails understanding how the universe began and evolved into its present form and knowing what matter is made of and how it is shaped and structured by the different forces of nature. Above all, it requires us to probe the very nature of physical laws.

The Cosmic Code

Throughout history, prominent thinkers have been convinced that the everyday world observed through our senses represents only the surface manifestation of a deeper hidden reality, where the answers to the great questions of existence should be sought. So compelling has been this belief that entire societies have been shaped by it. Truth seekers have practiced complex rituals and rites, used drugs and meditation to enter trancelike states, and consulted shamans, mystics and priests in an attempt to lift the veil on a shadowy world that lies beneath the one we perceive. The word occult originally meant "knowledge of concealed truth," and seeking a gateway to the occult domain has been a major preoccupation of all cultures, ranging from the Dreaming of Aboriginal Australians to the myth of Adam and Eve tasting the forbidden fruit of the tree of knowledge.

The advent of reasoned argument and logic did nothing to dispel the beguiling notion of a hidden reality. The ancient Greek philosopher Plato compared the world of appearances to a shadow playing on the wall of a cave. Followers of Pythagoras were convinced that numbers possess mystical significance. The Bible is also replete with numerology, for example, the frequent appearances of 7 and 40, or the association of 666 with Satan. The power of numbers led to a belief that certain integers, geometrical shapes, and formulas could invoke contact with a supernatural plane and that obscure codes known only to initiates might unlock momentous cosmic secrets. Remnants of ancient numerology survive today: some superstitious people still believe that numbers such as 8 and 13 are lucky or unlucky.

Attempts to gain useful information about the world through magic, mysticism, and secret mathematical codes mostly led nowhere. But about 350 years ago, the greatest magician who ever lived finally stumbled on the key to the universe — a cosmic code that would open the floodgates of knowledge. This was Isaac Newton — mystic, theologian, and alchemist — and in spite of his mystical leanings, he did more than anyone to change the age of magic into the age of science. Newton, together with a small number of other scientific luminaries who included Nicolaus

Copernicus, Johannes Kepler, and Galileo Galilei, gave birth to the modern scientific age. The word science is derived from the Latin scientia, simply meaning "knowledge." Originally it was just one of many arcane methods used to probe beyond the limitations of our senses in the hope of accessing an unseen reality. The particular brand of "magic" employed by the early scientists involved hitherto unfamiliar and specialized procedures, such as manipulating mathematical symbols on pieces of paper and coaxing matter to behave in strange ways. Today we take such practices for granted and call them scientific theory and experiment. No longer is the scientific method of inquiry regarded as a branch of magic, the obscure dabbling of a closed and privileged priesthood. But familiarity breeds contempt, and these days the significance of the scientific process is often underappreciated. In particular, people show little surprise that science actually works and that we really are in possession of the key to the universe. The ancients were right: beneath the surface complexity of nature lies a hidden subtext, written in a subtle mathematical code. This cosmic code contains the secret rules on which the universe runs. Newton, Galileo, and other early scientists treated their investigations as a religious quest. They thought that by exposing the patterns woven into the processes of nature they truly were glimpsing the mind of God., Modern scientists are mostly not religious, yet they still accept that an intelligible script underlies the workings of nature, for to believe otherwise would undermine the very motivation for doing research, which is to uncover something meaningful about the world that we don't already know.

Finding the key to the universe was by no means inevitable. For a start, there is no logical reason why nature should have a mathematical subtext in the first place. And even if it does, there is no obvious reason why humans should be capable of comprehending it. You would never guess by looking at the physical world that beneath the surface hubbub of natural phenomena lies an abstract order, an order that can't be seen or heard or felt, but deduced. Even the wisest mind couldn't tell merely from daily experience that the diverse physical systems making up the cosmos are linked, deep down, by a network of coded mathematical relationships. Yet science has uncovered the existence of this concealed mathematical domain. We human beings have been made privy to the deepest workings of the universe. Other animals observe the same natural phenomena as we do, but alone among the creatures on this planet, Homo sapiens can also explain them.

How has this come about? Somehow the universe has engineered, not just its own awareness, but also its own comprehension. Mindless, blundering atoms have conspired to make not just life, not just mind, but understanding. The evolving cosmos has spawned beings who are able not merely to watch the show, but to unravel the plot. What is it that enables something as small and delicate and adapted to terrestrial life as the human brain to engage with the totality of the cosmos and the silent mathematical tune to which it dances? For all we know, this is the first and only time anywhere in the universe that minds have glimpsed the cosmic code. If humans are snuffed out in the twinkling of a cosmic eye, it may never happen again. The universe may endure for a trillion years, shrouded in total mystery, save for a fleeting pulse of enlightenment on one small planet around one average star in one unexceptional galaxy, 13.7 billion years after it all began.

Could it just be a fluke? Might the fact that the deepest level of reality has connected to a quirky natural phenomenon we call "the human mind" represent nothing but a bizarre and temporary aberration in an absurd and pointless universe? Or is there an even deeper sub-plot at work?

The Concept of Laws

I may have given the impression that Newton belonged to a small sect that conjured science out of the blue as a result of mystical investigation. This wasn't so. Their work did not take place in a cultural vacuum: it was the product of many ancient traditions. One of these was Greek philosophy, which encouraged the belief that the

world could be explained by logic, reasoning, and mathematics. Another was agriculture, from which people learned about order and chaos by observing the cycles and rhythms of nature, punctuated by sudden and unpredictable disasters. And then there were religions, especially monotheistic faiths, which encouraged belief in a created world order. The founding assumption of science is that the physical universe is neither arbitrary nor absurd; it is not just a meaningless jumble of objects and phenomena haphazardly juxtaposed. Rather, there is a coherent scheme of things. This is often expressed by the simple aphorism that there is order in nature. But scientists have gone beyond this vague notion to formulate a system of well-defined laws.

The existence of laws of nature is the starting point of this book, and indeed it is the starting point of science itself. But right at the outset we encounter an obvious and profound enigma:

Where do the laws of nature come from?
As I have remarked, Galileo, Newton, and their contemporaries regarded the laws as thoughts in the mind of God, and their elegant mathematical form as a manifestation of God's rational plan for the universe. Few scientists today would describe the laws of nature using such quaint language. Yet the questions remain of what these laws are and why they have the form that they do. If they aren't the product of divine providence, how can they be explained?

Historically, laws of nature were discussed by analogy to civil law, which arose as a means of regulating human society. Civil law is a concept that dates back to the time of the first settled communities, when some form of authority was needed to prevent social disorder. Typically, a despotic leader would concoct a set of rules and exhort the populace to comply with them. Since one person's rules can be another person's problem, rulers would often appeal to divine authority to buttress their power. A city's god might be literally a stone statue in the town square, and a priest would be appointed to interpret the god's commandments. The notion of turning to a higher, nonmaterial authority as justification for civil law underpins the Ten Commandments and was refined in the Jewish Torah. Remnants of this notion survived into the modern era as the concept of the divine right of kings.

Appeal was also made to an invisible higher power in support of laws of nature. In the fourth century BCE the Stoic philosopher Cleanthes described "Universal Nature, piloting all things according to Law." The order of nature was perhaps clearest in the heavens — the very domain of the gods. Indeed, the word astronomy means "law of the stars." The first-century BCE Roman poet Lucretius referred to the way in which nature requires "each thing to abide by the law that governs its creation.", In the first century CE, Marcus Manilius was explicit about the source of nature's order, writing that "God brought the whole universe under law." It was a position wholeheartedly embraced by the monotheistic religions: God the Creator was also God the Lawmaker, who ordered nature according to his divine purposes. Thus the early Christian theologian Augustine of Hippo wrote that "the ordinary course of nature in the whole of creation has certain natural laws."9

By the thirteenth century, European theologians and scholars such as Roger Bacon had arrived at the conclusion that laws of nature possess a mathematical basis, a notion that dates back to the Pythagoreans. Oxford University became the center for scholars who applied mathematical philosophy to the study of nature. One of these so-called Oxford Calculators was Thomas Bradwardine (1295-1349), later to become archbishop of Canterbury. Bradwardine has been credited with the first scientific work to announce a general mathematical law of physics in the modern sense. Given this background, it is no surprise that when modern science emerged in Christian Europe in the sixteenth and seventeenth centuries, it was perfectly natural for the early scientists to believe that the laws they were discovering in the heavens and on Earth were the mathematical manifestations of God's ingenious handiwork.

The Special Status of the Laws of Physics

Today, the laws of physics occupy the central position in science; indeed, they have assumed an almost deistic status themselves, often cited as the bedrock of physical reality. Let me give an everyday example. If you go to Pisa in Italy, you can see the famous leaning tower (now restored to a safe inclination by engineering works). Tradition says that Galileo dropped balls from the top of the tower to demonstrate how they fall under gravity. Whether or not this is true, he certainly did carry out some careful experiments with falling bodies, which is how he came to discover the following law. If you drop a ball from the top of a tall building and measure how far it falls in one second, then repeat the experiment for two seconds, three seconds, and so on, you will find that the distance the ball travels increases as the square of the time. The ball will fall four times as far in two seconds as in one, nine times as far in three seconds, and so on. Schoolchildren learn about this law as "a fact of nature" and normally move on without giving it much further thought. But I want to stop right there and ask the question, Why? Why is there such a mathematical rule at work on falling bodies? Where does the rule come from? And why that rule and not some other?

Let me give another example of a law of physics, one that made a big impression on me in my school days. It concerns the way magnets lose their grip on each other with separation. Line them up side by side and measure the force as the distance between them increases. You will find that the force diminishes with the cube of the distance, which is to say that if we double the distance between the magnets, the force falls to one eighth, treble it and the force will be one twenty-seventh, and so on. Again, I am prompted to ask the question, Why?

Some laws of physics bear the name of their discoverer, such as Boyle's law for gases, which tells you that if you double the volume of a fixed mass of gas while keeping the temperature constant, its pressure is halved. Or Kepler's laws of planetary motion, one of which says that the square of the period of an orbit is proportional to the cube of the orbit's radius. Perhaps the best-known laws are Newton's laws of motion and gravitation, the latter supposedly inspired by an apple falling from a tree. It states that the force of gravity diminishes with distance as the square of the separation between the two bodies. That is, the force that binds the Earth to the sun, and prevents it from flying off alone across the galaxy, would fall to only one quarter the strength if the Earth's orbit were twice as big. This is known as an inverse square law. I have drawn a graph depicting it in Figure 1.

The fact that the physical world conforms to mathematical laws led Galileo to make a famous remark. "The great book of nature," he wrote, "can be read only by those who know the language in which it was written. And this language is mathematics.") The same point was made more bluntly three centuries later by the English astronomer James Jeans: "The universe appears to have been designed by a pure mathematician. "H It is the mathematical aspect that makes possible what physicists mean by the much-misunderstood word theory. Theoretical physics entails writing down equations that capture (or model, as scientists say) the real world of experience in a mathematical world of numbers and algebraic formulas. Then, by manipulating the mathematical symbols, one can work out what will happen in the real world, without actually carrying out the observation. That is, by applying the equations that express the laws relevant to the problem of interest, the theoretical physicist can predict the answer. For example, by using Newton's laws of motion and gravitation, engineers can figure out when a spacecraft launched from Earth will reach Mars. They can also calculate the required mass of fuel, the most favorable orbit, and a host of other factors in advance of the mission. And it works! The mathematical model faithfully describes what actually happens in the real world. (Of course, in practice one may have to simplify the model to save time and cost of the analysis, making the predictions good only to a certain level of approximation, but that is not the fault of the laws.)

When I was at school I took a fancy to a young lady in my class named Lindsay. I didn't see much of her because she was studying mainly the arts and I was studying the sciences and mathematics. But we did meet up in the school library from time to time. On one occasion I was busy doing a calculation. I even remember what it was. If you throw a ball in the air at a certain speed and angle, Newton's laws let you work out how far it will travel before it hits the ground. The equations tell you that to achieve maximum range you should throw the ball at 45° to the horizontal. If the ground on which you are standing slopes upward, however, the angle needs to be greater; by how much depends on the amount of slope. I was deeply engrossed in calculating the maximum range up an inclined plane when Lindsay looked up and asked what I was doing. I explained. She seemed puzzled and skeptical. "How can you possibly know what a ball will do by writing things on a sheet of paper?" she asked. At the time I dismissed her question as silly — after all, this was what we had been taught to do! But over the years I came to see that her impulsive response precisely captures one of the deepest mysteries of science: Why is nature shadowed by a mathematical reality? Why does theoretical physics work?

How Many Laws Are There?

As scientists have probed deeper and deeper into the workings of nature, all sorts of laws have come to light that are not at all obvious from a casual inspection of the world, for example, laws that regulate the internal components of atoms or the structure of stars. The multiplicity of laws raises another challenging question: How long would a complete list of laws be? Would it include ten? twenty? two hundred? Might the list even be infinitely long?

Not all the laws are independent of one another. It wasn't long after Galileo, Kepler, Newton, and Boyle began discovering laws of physics that scientists found links between them. For example, Newton's laws of gravitation and motion explain Kepler's three laws of planetary motion and so are in some sense deeper and more powerful. Newton's laws of motion also explain Boyle's law of gases when they are applied in a statistical way to a large collection of chaotically moving molecules.

In the four centuries that have passed since the first laws of physics were discovered, more and more have come to light, but more and more links have been spotted too. The laws of electricity, for example, were found to be connected to the laws of magnetism, which in turn explained the laws of light. These interconnections led to a certain amount of confusion about which laws were "primary" and which could be derived from others. Physicists began talking about "fundamental" laws and "secondary" laws, with the implication that the latter were formulated for convenience only. Sometimes physicists call these "effective laws" to distinguish them from the "true" underlying fundamental laws, within which, at least in principle, the effective, or secondary, laws can all be subsumed. In this respect, the laws of physics differ markedly from the laws of civil society, which are an untidy hodgepodge of statutes expanding without limit. To take an extreme case, the tax laws in most countries run to millions of words of text. By comparison, the Great Rule Book of Nature (at least as it is currently understood) would fit comfortably onto a single page. This streamlining and repackaging process — finding links between laws and reducing them to ever more fundamental laws — continues apace, and it's tempting to believe that, at rock bottom, there is just a handful of truly fundamental laws, possibly even a single super-law, from which all the other laws derive.

Given that the laws of physics underpin the entire scientific enterprise, it is curious that very few scientists bother to ask what these laws actually mean. Speak to physicists, and most of them will talk as if the laws are real things — not physical objects, of course, but abstract relationships between physical entities. Importantly, though, they are relationships that really exist "out there" in the world and not just in our heads.

For brevity I have been a bit cavalier with my terminology. If you confront a physicist and say, "Show me the laws of physics," you will be referred to a collection of textbooks — on mechanics, gravitation, electromagnetism, nuclear physics, and so on. But a pertinent question is whether the laws you find in the books are actually the laws of physics or just somebody's best stab at them. Few physicists would claim that a law found in a book in print today is the last word on the subject; all the textbook laws are probably just some sort of

approximation of the real ones. Most physicists nevertheless believe that as science advances, the textbook laws will converge on the Real Thing.'

Are the Laws Real?

There is a subtlety buried in all this that will turn out to be of paramount importance when I come to discuss the origin of the laws. The idea of laws began as a way of formalizing patterns in nature that connect physical events. Physicists became so familiar with the laws that somewhere along the way the laws themselves — as opposed to the events they describe — became promoted to reality. The laws took on a life of their own. It is hard for nonscientists to grasp the significance of this step. One analogy might be made with the world of finance. Money in the pocket means coins and notes — real physical things that get exchanged for real physical goods or services. But money in the abstract has also taken on a life of its own. Investors can grow (or shrink, in my case) money without ever buying or selling physical stuff. For example, there are rules for manipulating different currencies that are at best tenuously connected to the actual purchasing function in your local corner shop. In fact, there is far more "money" in circulation, much of it swirling around cyberspace via the Internet, than can ever be accumulated as coins and notes. In a similar vein, the laws of physics are said to inhabit an abstract realm and touch the physical world only when they "act." It's almost as if the laws are lying in wait, ready to seize control of a physical process and compel it to comply, just as the rules of monetary conversion are "in place" even when nobody is actually converting anything. This "prescriptive" view of physical laws as having power over nature is not without its detractors (namely, philosophers who prefer a "descriptive" view). But most physicists working on fundamental topics inhabit the prescriptive camp, even if they won't own up to it explicitly.

So we have this image of really existing laws of physics ensconced in a transcendent aerie, lording it over lowly matter. One reason for this way of thinking about the laws concerns the role of mathematics. Numbers began as a way of labeling and tallying physical things such as beads or sheep. As the subject of mathematics developed, and extended from simple arithmetic into geometry, algebra, calculus, and so forth, so these mathematical objects and relationships came to assume an independent existence. Mathematicians believe that statements such as "3 x 5 = 15" and "11 is a prime number" are inherently true — in some absolute and general sense — without being restricted to "three sheep" or "eleven beads."

Plato considered the status of mathematical objects and chose to locate numbers and idealized geometrical shapes in an abstract realm of perfect forms. In this Platonic heaven there would be found, for example, perfect circles — as opposed to the circles we encounter in the real world, which will always be flawed approximations to the ideal. Many modern mathematicians are Platonists (at least on weekends). They believe that mathematical objects have real existence yet are not situated in the physical universe. Theoretical physicists, who are steeped in the Platonic tradition, also find it natural to locate the mathematical laws of physics in a Platonic realm. I have depicted this arrangement diagrammatically in Figure 2. In the final chapter I shall take a critical look at the nature of physical laws and ask whether the Platonic view has become an unwelcome fixation in the drive to understand the mathematical underpinnings of the universe.

Goodbye God?

Religion was the first systematic attempt to explain the universe comprehensively. It presented the world as a product of mind or minds, of supernatural agents who could order or disorder nature at will. In Hinduism, Brahma is creator and Shiva destroyer. In Judaism, Yahweh is both creator and destroyer. For the traditional Aboriginal people of the Kimberley in Australia, two creator beings acted in synergy. Wallanganda, a male space being, sprinkled water on Wunngud, a female snake coiled in jelly, to make Yorro Yorro — the world as we see it's In these sorts of schemes, things are as they are because a god (or gods) decided they should be so. The major world religions devoted centuries of scholarship in attempts to make these theistic explanations cogent and consistent. Even today, millions of people base their worldview on a religious interpretation of nature.

Science was the second great attempt to explain the world. This time, explanations were cast in terms of impersonal forces and natural, physical processes rather than the activities of purposive supernatural agents. When scientific explanations conflicted with religious explanations, religion invariably lost the battle. Mostly, theologians retreated to concentrate on social and ethical matters such as spiritual enlightenment, content to leave interpreting the physical universe to the scientists. There are still people who believe that rain is made by rain gods rather than by atmospheric processes, but I wouldn't rate their chances in a debate with a meteorologist. When it comes to actual physical phenomena, science wins hands down against gods and miracles. That is not to say that science has explained everything. There remain some pretty big gaps: for example, scientists don't know how life began, and they are almost totally baffled by consciousness. Even some familiar phenomena, such as turbulent fluids, are not completely understood. But this doesn't mean that one needs to appeal to magic or miracles to plug the gaps; what is needed are advances in scientific understanding. This is a topic I shall address in detail in Chapter 10

When it comes to metaphysical questions such as "Why are there laws of nature?" the situation is less clear. These sorts of questions are not much affected by specific scientific discoveries: many of the really big questions have remained unchanged since the birth of civilization and still vex us today. The various faith traditions have had hundreds of years to ponder them carefully. Religious scholars such as Anselm and Thomas Aquinas were not pious simpletons, but the intellectual heavyweights of their age.

Many scientists who are struggling to construct a fully comprehensive theory of the physical universe openly admit that part of the motivation is to finally get rid of God, whom they view as a dangerous and infantile delusion. And not only God, but any vestige of God-talk, such as "meaning" or "purpose" or "design" in nature. These scientists see religion as so fraudulent and sinister that nothing less than total theological cleansing will do. They concede no middle ground and regard science and religion as two implacably opposed worldviews. Victory is assumed to be the inevitable outcome of science's intellectual ascendancy and powerful methodology.

But will God go quietly? Even within the world of organized religion, the concept of God means many different things to different people. At the level of popular, Sunday-school Christianity, God is portrayed simplistically as a sort of Cosmic Magician, conjuring the world into being from nothing and from time to time working miracles to fix problems. Such a being is obviously in flagrant contradiction to the scientific view of the world. The God of scholarly theology, by contrast, is cast in the role of a wise Cosmic Architect whose existence is manifested through the rational order of the cosmos, an order that is in fact revealed by science. That sort of God is largely immune to scientific attack.

Is the Universe Pointless?

Even atheistic scientists will wax lyrical about the scale, the majesty, the harmony, the elegance, the sheer ingenuity of the universe of which they form so small and fragile a part. As the great cosmic drama unfolds before us, it begins to look as though there is a "script" — a scheme of things

— that its evolution is following. We are then bound to ask, Who or what wrote the script? Or did the script somehow, miraculously, write itself? Is the great cosmic text laid down once and for all, or is the universe, or the invisible author, making it up as it goes along? Is this the only drama being staged, or is our universe just one of many shows in town?

The fact that the universe conforms to an orderly scheme, and is not an arbitrary muddle of events, prompts one to wonder — God or no God — whether there is some sort of meaning or purpose behind it all. Many scientists are quick to pour scorn even on this weaker suggestion, however. Richard Feynman, arguably the finest theoretical physicist of the mid-twentieth century, thought that "the great accumulation of understanding as to how the physical world behaves only convinces one that this behavior has a kind of meaninglessness about it." This sentiment is echoed by the theoretical physicist and cosmologist Steven Weinberg: "The more the universe seems comprehensible the more it also seems pointless." Weinberg came in for some flak from his colleagues for writing this comment — not because he denied that the universe had a point, but for even suggesting that it could have a point.

To be sure, concepts like meaning and purpose are categories devised by humans, and we must take care when attempting to project them onto the physical universe. But all attempts to describe the universe scientifically draw on human concepts: science proceeds precisely by taking concepts that humans have thought up, often from everyday experience, and applying them to nature. Doing science means figuring out what is going on in the world — what the universe is "up to," what it is "about." If it isn't "about" anything, there would be no good reason to embark on the scientific quest in the first place, because we would have no rational basis for believing that we could thereby uncover additional coherent and meaningful facts about the world. So we might justifiably invert Weinberg's dictum and say that the more the universe seems pointless, the more it also seems incomprehensible. Of course, scientists might be deluded in their belief that they are finding systematic and coherent truth in the workings of nature. It could be we who weave a tapestry of dazzling intellectual elegance from what is nothing more than a banality. Ultimately there may be no reason at all for why things are the way they are. But that would make the universe a fiendishly clever bit of trickery. Can a truly absurd universe so convincingly mimic a meaningful one? This is the biggest of the big questions of existence that we will confront as we embark on our investigation of life, the universe, and everything.

Key Points

- Many big questions of existence are now on the scientific agenda.
- A really big question is why the universe is fit for life; it looks "fixed up."
- The universe obeys mathematical laws; they are like a hidden subtext in nature. To appreciate this book you have to be comfortable with that idea.
- The mathematical laws of physics underlie everything. Many physicists think they are real and that they inhabit a transcendent Platonic realm.
- Science reveals that there is a coherent scheme of things, but scientists do not necessarily interpret that as evidence for meaning or purpose in the universe. Most, but by no means all, scientists are atheists or agnostics.
- Somehow I am supposed to explain all this.

Chapter 7 - A Universe Fit for Life

The Role of Observers

A LANDMARK in the history of science — arguably the very birth of science itself — was the posthumous publication of Nicolaus Copernicus's book De revolutionibus orbium coelestium in 1543. In this tract the Polish astronomer set out his model of the solar system, with the sun at the center and Earth and the other planets orbiting around it: "Finally we shall place the Sun himself at the center of the Universe. All this is suggested by the systematic procession of events and the harmony of the whole Universe, if only we face the facts, as they say, 'with both eyes open.'"

The new view of the cosmos that Copernicus advocated, with Earth revolving around the sun, so shook the Western world that it resulted in the word revolution being adopted in a broad political and social context, too. In the sixteenth century, Europe was in thrall to the Roman Church, which clung to the ancient Ptolemaic view that the Earth lay at the center of the universe and — the natural corollary — that humankind represented the pinnacle of God's creation. By demoting our planet from the pivotal cosmic position, Copernicus initiated a trend — a principle of mediocrity — that continued for four centuries. When Galileo turned the newly invented telescope on the sky in 1609 he saw that the Milky Way consisted of a vast. aggregation of faint stars. Astronomers gradually came to realize that the sun is just one unexceptional star among many. Today we know that the Milky Way galaxy contains over a hundred billion stars, many of them similar to the sun. In the twentieth century, large telescopes were able to resolve stars in the Andromeda galaxy and beyond, revealing that even the Milky Way doesn't occupy a special location in the universe. Systematic surveys of the galaxies established the cosmological principle, which proceeds from the basis that the universe is uniform on a large scale.

Any attempt to explain the universe can claim success only if it accounts for this "mediocratic progression." As we have seen, the inflationary universe scenario offers a natural explanation for the large-scale cosmic uniformity. The theory of how galaxies form from primordial irregularities goes some way toward explaining the ubiquity of systems like the Milky Way, while the theory of how stars and planets form from clouds of gas and dust likewise accounts for our apparently run-of-the-mill solar system. But uniformity and mediocrity are by no means the only features of the universe that must be explained. There is one aspect that often gets left off the list of observed properties, and this is the fact that there are observers to observe them.

The role of "the observer" in science is a peculiar one and makes many scientists a little queasy. After all, it is the task of science to replace a subjective view of nature with an objective one. A scientific claim is taken seriously only if it can be tested by others in a disinterested (not uninterested!) way. If I asserted that the Earth goes round the sun because it is towed by a giant spacecraft that I alone can see, nobody would believe me — and rightly so. Einstein's theory of relativity elevates objectivity to a central principle. The very word relativity implies that the view of the world is always the view of a given observer, and the theory provides the necessary transformation rules to reconcile one observer's experiences with another's. In this way the "objective essence" of nature can be extracted from the specific experiences of individual observers. Einstein made it a founding tenet of the theory of relativity that the laws of physics must be the same for all observers, no matter how they move or where they are located. No observer is privileged. For this reason the laws of physics can make no reference to the speed of an object through space, for example. If it did, it would single out a certain class of observers — stationary ones — who experienced the world differently.

Given this history, it is no surprise that an explanation of the existence of observers has not been a priority requirement among cosmologists for a successful theory of the universe. But more and more of them are now convinced that this is a serious omission. Take our location in the universe —

just how typical is it? Well, there is a very obvious sense in which it is extremely atypical. Most of the universe is near-empty space, but humans live on the surface of a planet.

There is a good reason for this. Life is most unlikely to emerge in outer space, and even if it did, organisms with big brains wouldn't be very successful there. Human observers find themselves living on a planet because they could hardly have evolved anywhere else.

This rather trivial example is a pointer to more weighty considerations. Observers — at least in our experience so far — are living organisms, and life is a delicate and complex phenomenon that has many special requirements. It will emerge in the universe only if the circumstances are right. If those circumstances were not universal, then our view of the cosmos would not be typical: it would reflect our situation in a special, life-encouraging cosmic locale.

Nobody can be at all surprised by this simple tautology. It merely says that observers will find themselves located only where life can exist. It could hardly be otherwise. Nevertheless, in spite of the incontestable nature of the statement, it should not be dismissed as mere wordplay. For a start, the conditions necessary for life could be very restrictive. To be sure, Earth may be a typical planet near a typical star in a typical galaxy as far as its geological and astronomical circumstances are concerned, but it may be highly atypical — even unique — from the point of view of its biological circumstances. If there were just one place in the universe where life was able to form, Earth would be it, because that is where we find ourselves located. This point, while glaringly obvious, is in direct contradiction with the principle of mediocrity and has become known as the anthropic principle. The term is an unfortunate misnomer, because anthropic derives from the same Greek root as man, and nobody is suggesting that the principle has anything to do with humans per se (though human beings are undeniably one example of life). The British astrophysicist Brandon Carter, who first used the word in this context, once remarked that had he known the trouble it would cause, he would have suggested something else — the "biophilic" principle, perhaps. But we seem to be stuck with "anthropic," so I shall continue to use that term.

Are We Alone in the Universe?

What can be said about the possibilities for life beyond Earth? In spite of the huge growth in the subject of astrobiology, there is still no direct evidence for any extraterrestrial life. In the event that life is discovered elsewhere in the solar system, for example, on Mars, then the most likely explanation will be that it did not originate there but was transplanted from Earth in rocks ejected from our planet by comet and asteroid impacts. We know that Earth and Mars trade rocks, and it seems very probable that microbes have hitched a ride many times throughout the solar system's long 4.5 billion-year history. So finding life on Mars would not in itself prove that it has formed from scratch more than once. To draw that stronger conclusion, it would be necessary to demonstrate that Mars life and Earth life were sufficiently different to have had independent origins.

The question of whether or not we are alone in the universe is one of the great unsolved puzzles of science. The answer hinges on whether the origin of life was a stupendous chemical fluke that may have happened only once in the observable universe, or was the expected outcome of intrinsically bio-friendly laws that facilitate the emergence of life wherever Earthlike conditions prevail. For both points of view there are distinguished scientists who will argue the case, but in the absence of any hard evidence it is impossible to say either way. The stuff of life is certainly widespread in the universe. Life (at least as we know it) is based on carbon, one of the most common elements. It also uses hydrogen — the most common element of all — as well as nitrogen, oxygen, sulfur, and phosphorus, all of which are reasonably abundant. Some of the building blocks of life, organic molecules such as formaldehyde and urea, are found in interstellar clouds. Water — another indispensable requirement for terrestrial biology — is extremely common in the solar system and in

other star systems and gas clouds. Accumulating evidence therefore suggests that life-encouraging substances — organics and water — are found throughout the universe. Nevertheless, it is a long road from simple building blocks to even the most primitive living organism. Whereas organics and water are certainly necessary prerequisites for life, they are far from sufficient. It isn't possible to conclude, merely from the commonplace nature of life's building blocks, that life itself is commonplace. But as far as we can tell, life could have formed almost anywhere in the observed universe. If life turns out to be restricted to Earth, that is probably just a historical accident rather than an indicator that there is something exceptional about the solar system's biological suitability.

To permit life in at least one place in the universe, three very basic requirements must be satisfied:

- The laws of physics should permit stable complex structures to form.
- The universe should possess the sort of substances, such as carbon, that biology uses.
- An appropriate setting must exist in which the vital components come together in the appropriate way.

Even these three requirements impose very stringent restrictions on physics and cosmology, so stringent that they strike some scientists as nothing short of a fix — a "put-up job," to repeat Fred Hoyle's colorful term. In this chapter I shall give some examples of these striking "cosmic coincidences," beginning with the one that so astonished Hoyle.

The Origin of the Chemical Elements

Chemists have identified over a hundred chemical elements, which are neatly marshaled into rows and columns in the famous periodic table originated by Dmitri Mendeleev in the nineteenth century. Some elements, such as carbon and iron, are common, while others, such as gold and lanthanum, are rare. In the universe as a whole, 99 percent of ordinary (as opposed to dark) matter is in the form of hydrogen and helium, the helium having been made during the first few minutes after the big bang. One of the challenges to astrophysical theory is to account for the relative abundances of the remaining elements. For a long time their origin was a mystery, but by the 1940s it had become clear that stars are deeply implicated. A star is a gigantic nuclear reactor, hot enough to synthesize heavier elements from lighter ones.

The first stars began to form when hydrogen and helium gas left over from the big bang aggregated into dense clouds. This took several hundred million years because the cosmic background radiation was initially too fierce to allow the gases to settle. Eventually, under the pull of gravity, the condensing clouds fragmented into proto-stars — balls of gas that grew hotter as they shrank. Once the center of a ball of gas reaches a temperature of a few million degrees, nuclear reactions are triggered. A true star is born when this heat creates enough internal pressure to arrest the contraction. Thus stabilized, a star will burn happily for millions or even billions of years, depending on its mass. Low-mass stars are relatively cool, so they consume their nuclear fuel slowly and live for a long time. Massive stars gobble up their fuel quickly and soon burn out.

Stars derive most of their energy from the conversion of hydrogen into helium by nuclear fusion. In the big bang, this transmutation was fast and easy because the universe was born with a plentiful supply of free neutrons. (Helium, remember, has a nucleus containing two protons and two neutrons. A hydrogen nucleus consists of a single proton.) But neutrons are unstable in isolation, so there weren't any on the loose by the time stars began to form. Another, much slower route to helium had to be found, using just protons. Protons repel one another because they all carry a positive electric charge, but at high temperatures they can move so fast that they can be brought into close proximity. If the speed is great enough, as it is in the hot core of a star, two protons can

approach each other to within the range of the strong nuclear force, opening the way to nuclear transformations. Remember that the strong force falls sharply to zero beyond about a ten-trillionth of a centimeter, which is roughly the size of an atomic nucleus, so only by getting very close will protons come under its influence. When they do, the nuclear force is strong enough to overwhelm the longer-ranged electrical repulsion. The details don't need to be spelled out here; suffice it to say that in the process of forming one helium nucleus from four protons, two of the protons must turn into neutrons. Although it is the strong nuclear force that is responsible for the prodigious energy released by fusion reactions, the crucial transmutation from protons into neutrons is controlled by the weak nuclear force. Because the latter force is so weak, it greatly slows down the entire helium production process — compared, that is, with the rate of the primordial synthesis of helium just after the big bang. This is fortunate because it permits the great majority of stars to burn steadily for an immense duration; in the case of the sun, for long enough to permit the formation of life and to nurture the evolution of complex organisms.

When a star's supply of hydrogen runs low, it faces an energy crisis. Stars of small and medium mass can't generate any more heat from nuclear processes. They shrink to form white dwarfs, which glow only with remnant heat. Higher-mass stars, however, can call upon further nuclear fusion reactions to keep them shining because they can reach higher internal temperatures (up to hundreds of millions of degrees). So what is the next step after hydrogen fusion? The direct way ahead would be to add another proton to helium to make lithium. However, this reaction won't work because a lithium nucleus with three protons and two neutrons is unstable; lithium normally has either three or four neutrons. What about the fusion of two helium nuclei to make the isotope beryllium, a nucleus with four protons and four neutrons? No good either, because that nucleus is also highly unstable, disintegrating almost as soon as it forms. The stable isotope of beryllium found in nature has five neutrons, not four. So the star is confronted with a serious nuclear bottleneck.

How the Universe Made Carbon, the Life-Giving Element

After beryllium, carbon is the next-heaviest element. It has six protons and six neutrons. Could it be that stars have found a way to vault over lithium and beryllium and go straight from helium to carbon? This would require three helium nuclei to come together at the same moment. The proton and neutron arithmetic (3 x 2 x 2 = 6 + 6) works out correctly, and the end product would be stable carbon nuclei. Because more protons are involved in a triple nuclear encounter than in the original hydrogen fusion, the electrical repulsion is correspondingly greater, so the temperature must be higher to overcome it and allow the nuclei to get close enough for the short-range strong nuclear force to act. That isn't a problem: by further contracting, a star's core can raise the temperature to a high enough level. There is, however, a fundamental difficulty with the reaction itself. The likelihood of three helium nuclei coming together at the same place and the same time is tiny. To be sure, they don't have to arrive at exactly the same moment; two helium nuclei could first form a very unstable nucleus of beryllium, and before it fell apart a third helium nucleus might slam into it. But at first sight the numbers look very unfavorable, with a typical beryllium nucleus disintegrating too quickly to give a third helium nucleus a decent chance to hit it. On the face of it, then, that route to carbon seems to be blocked too.

That was the situation as it presented itself to astrophysicists in the early 1950s. Fred Hoyle, then a relatively unknown English astronomer, took an interest in this enigma. He reasoned that carbon-based sentient beings in general, and Fred Hoyle in particular, would not exist if the synthesis of the elements had become stuck at helium. Well, it's obvious enough that something must have happened to make carbon, presumably something inside stars. And if a general consideration of nuclear physics fails to account for carbon, then perhaps something unusual is responsible.

Which gets us to the heart of the matter: In science, one tries to avoid appealing to flukes. Occam's razor entreats us to try the simple and obvious explanations first. But sometimes simple and

obvious explanations just won't work, and we are forced to invoke something out of the ordinary. As Sherlock Holmes remarked, when you have eliminated the impossible, then what remains, however improbable, must be the truth. On the whole, sticking to the simple and the obvious is the best strategy, but there is one topic where even extraordinary flukes can enter into a legitimate scientific explanation — and that topic is life.

To get what I am driving at, consider this: not one of your ancestors died childless. In the history of humanity, infant mortality has mostly been very high. There have been huge numbers of children who have died before they reached puberty. Now imagine your pre-human ancestors, stretching back hundreds of millions of years. A long time ago. your ancestors were fish. Think how fish spawn countless eggs, and imagine the tiny, tiny fraction that survive and mature. Nevertheless, not one of your ancestors — not a single one — was a failed fish. What are the odds against this sequence of lucky accidents extending unbroken over billions of years, generation after generation? No human lottery would dare to offer such adverse odds. But here you are — a winner in the great Darwinian game of chance! Does this mean that there is something miraculous in the history of your ancestry? Not at all. If your very existence depends on a concatenation of freak events, then such events may become part of a perfectly valid scientific explanation. Scientists call this an observer selection effect. By looking at the world through the eyes of an observer, the world you see will have to encompass whatever it takes for you, the observer, to be seeing it. This "anthropic" reasoning was applied by Hoyle to the problem of carbon synthesis in stars by appealing not to a freak sequence of events as with our ancestors, but to an unexpected and fluky property of atomic nuclei.

Here's how it happens. The rate at which nuclear reactions proceed depends on the energy of the participating particles. Mostly the variation in the rate is a gentle rise or fall in efficiency, but occasionally there is a sharp spike in the rate. Physicists call this abrupt amplification a resonance. The name stems from the way that quantum mechanics enters the picture. Quantum theory ascribes a wave aspect to particles (see Box 4, p. 63), including atomic nuclei, and waves famously display resonances. For example, some opera singers can deliver a high-frequency note that resonates with a wineglass, enough to shatter it. A more mundane example of resonance comes from tuning a radio to receive the signal from a particular station.

When the frequency of the circuits in the radio matches the frequency of the radio waves from the station, the waves resonate with the circuit and the signal is greatly amplified. Quantum waves can also resonate, thereby boosting the rate of an atomic or nuclear process.

Hoyle felt that resonance held the key to an explanation for carbon production. The mass of a normal carbon nucleus is rather less than the masses of the three helium nuclei that it was supposed might collide to form it, because of the mass-energy released when the carbon is made. But nuclei can exist in excited states too, so Hoyle deduced that a carbon nucleus must have an excited state a little bit above the combined mass-energies of three helium nuclei. The helium-beryllium system could then resonate at this mass-energy if the small deficit were made up by the kinetic energy of the particles rushing about inside the hot star. The resonance would have the effect of greatly prolonging the unstable beryllium nucleus, giving a third helium nucleus a decent chance of hitting it. The way would then lie open to forming abundant carbon, against the apparent odds. Hoyle calculated what the energy of the resonance should be.

This was in 1951. Very little was known about the excitation of nuclei, although an experimental program had been developed in World War II for the purposes of the Manhattan atomic bomb project. Hoyle was visiting Caltech at the time, and he confronted a group of American nuclear physicists, including Willy Fowler (who would go on to win a Nobel Prize for related work), with his prediction of a carbon nuclear resonance. The physicists were incredulous that a little-known British astronomer could breeze in unannounced and claim to know more about carbon nuclei than

a leading group of U.S. nuclear experts. But Hoyle pestered Fowler's colleagues so persistently that they agreed to undertake an experiment to check his idea. After some modifications to their equipment, the nuclear physicists were able to announce that, indeed, Hoyle's guess hit the mark. There is a resonance in carbon, and at just the right energy for stars to manufacture abundant quantities of this element by the triple-helium process. The experiments confirm that the resonance will prolong the lifetime of the unstable beryllium nucleus to something approaching a hundred billion-billionths of a second — long enough for the triple-helium reaction to proceed. And once the carbon is made, the rest is smooth sailing. There are no more bottlenecks. Oxygen forms next, then neon, then magnesium, and so on up the periodic table of elements as far as iron. That pretty much covers all the stuff life needs to get going. Elements heavier than iron are also produced by stars, but only during explosive outbursts, when more energy is available.9

The carbon story left a deep impression on Hoyle. He realized that if it weren't for the coincidence that a nuclear resonance exists at just the right energy, there would be next to no carbon in the universe, and probably no life. The energy at which the carbon resonance occurs is determined by the interplay between the strong nuclear force and the electromagnetic force. If the strong force were slightly stronger or slightly weaker (by maybe as little as 1 percent),,° then the binding energies of the nuclei would change and the arithmetic of the resonance wouldn't add up; the universe might very well be devoid of life and go unobserved.

What are we to make of this? When Hoyle drew attention to this issue, the orthodox view was that the strength of the nuclear force is simply "given" — it is a "free parameter," the value of which is not determined by any theory but must be measured by experiment. A common response was to shrug the matter aside with the comment "The value it has is the value it has, and if it had been different, we wouldn't be here to worry about it." But that attitude seems a bit unsatisfactory. We can certainly imagine a universe in which the form of the strong force law is the same but the actual strength of the force is different, just as we can imagine a world in which gravity is a little stronger or weaker but otherwise obeys the same laws. The fact that the value of the strong and electromagnetic forces in atomic nuclei are "just right" for life (like Goldilocks' porridge) cries out for explanation.

George Gamow, who was responsible for putting the hot big bang model of the universe on the scientific map in the early 1950s, composed the following witty account of the significance of Hoyle's discovery, which he called "New Genesis":

> In the beginning God created Radiation and Ylem. And the Ylem was without shape or number, and the nucleons were rushing madly upon the face of the deep.
>
> And God said: "Let there be mass two." And there was mass two. And God saw deuterium, and it was good.
>
> And God said: "Let there be mass three." And there was mass three. And God saw tritium, and it was good.
>
> And God continued to call numbers until He came to the trans-uranium elements. But when He looked back on his work, He saw that it was not good. In the excitement of counting, He had missed calling for mass five, and so, naturally, no heavier elements could have been formed.
>
> God was very disappointed by that slip and wanted to contract the universe again and start everything from the beginning. But that would be much too simple. Instead, being Almighty, God decided to make heavy elements in the most impossible way.

And so God said: "Let there be Hoyle." And there was Hoyle. And God saw Hoyle and told him to make heavy elements in any way he pleased.

And so Hoyle decided to make heavy elements in stars, and to spread them around by means of supernova explosions. But in doing so, he had to obtain the same abundance curve which would have resulted from nucleo-synthesis in Ylem, if God would not have forgotten to call for mass five.

And so, with the help of God, Hoyle made heavy elements in this way, but it was so complicated that nowadays neither Hoyle, nor God, nor anybody else can figure out exactly how it was done.

Amen.

The Weak Force — Another "Put-Up job"?

Of course, that isn't the end of the story. But before taking it further I want to run through some other "coincidences" of a similar nature. Hoyle's "put-up job" turned out to be the first of many instances in which seemingly small changes in some basic parameters of physics would prove lethal. A good way to think about this is to imagine playing God and setting out to design a universe. Suppose you had already settled on the basic laws of physics, but you still had some free parameters at your disposal. The values of these parameters could be set by twiddling the knobs of a Designer Machine (see Figure 23). Turn one knob and the electron gets a bit heavier, turn another and the strong force becomes a bit weaker, and so on. You could do this and see what happened to the universe. When would it make a big difference, and when would it scarcely matter? Although physicists can't actually carry out the experiment (at least not yet!), they can perform simple calculations to see what — all else being equal — such changes would do to the prospects for life. The qualification "all else being equal" is important here because we have no idea whether the various parameters of interest are actually free and independent, or whether they will turn out to be linked by a more comprehensive theory, or possibly even determined completely by such a theory. Maybe you can't raise the mass of the electron and lower the strength of the strong nuclear force together because these two properties of nature are connected in some deep way that forbids it. From our present knowledge, however, that wouldn't seem to be the case.

So let's play with the Designer Machine and see what happens. I have discussed the strong nuclear force. What about the weak one — the one responsible for such things as radioactive decay and the transmutation of neutrons into protons? The situation here is less critical but still interesting. The weak force is implicated in the carbon story, not only in manufacturing the carbon but also in disseminating it. The carbon atoms in your body were forged inside a star somewhere, billions of years ago. How did they end upon Earth? A good way for a star to divest itself of carbon is by exploding. Massive stars typically end their lives catastrophically as supernovas. What happens is that the core of the star runs out of nuclear fuel and can no longer sustain the enormous pressure needed to hold it up against the weight of its material. A critical juncture is reached at which the core abruptly gives up and implodes catastrophically to form either a black hole or a neutron star (depending on its initial mass). The overlying material plunges inward, following the collapsing core, but rebounds and explodes spectacularly, spewing gas into interstellar space. Stellar cataclysms like this erupt on average two or three times per century per galaxy and release so much energy that for a few days the stricken star can rival an entire galaxy in its brightness.

A major factor in the rebound mechanism involves the weak nuclear force. When the core of a massive star implodes, its protons and electrons are violently compressed together. Under the action of the weak force, the protons turn into neutrons, and each sacrificed proton releases a

neutrino in the process. Thus a vast tide of neutrinos suddenly belches from the imploding core. This is not just theory: in 1987 an underground experiment in Japan devised to look for proton decay picked up a pulse of neutrinos at the same time as a supernova was seen to go off in the Large Magellanic Cloud. To the extent that neutrinos interact at all with ordinary matter, it is via the weak nuclear force. In normal circumstances this interaction is too feeble to make much difference, but the circumstances inside an imploding star are anything but normal. The nuclear material of the star collapses to a density of almost a billion tons per cubic centimeter — so dense that even neutrinos have a tough job plowing through it. As they stream away from the stellar interior, they exert a powerful outward pressure, and this helps to turn around the material plunging onto the collapsing core, blasting it back into space. If the weak force were weaker, the neutrinos would lack the punch to create this explosion. If it were stronger, the neutrinos would react more vigorously with the stellar core and wouldn't escape to deliver their blow to the outer layers. Either way, the dissemination of carbon and other heavy elements needed for life via this process would be compromised.

The Weak Force in the Early Universe

The weak force is important in another aspect of the life story, by controlling the amount of helium synthesized in the hot early universe. In Chapter 3, I explained how the relative abundances of hydrogen and helium depend on the ratio of neutrons to protons in the primordial material about one second after the big bang. This is how the weak force affects things. An isolated neutron is unstable, with a half-life of 615 seconds, and decays into a proton. This decay process results from the action of the weak force. But it took about 100 seconds for the universe to cool enough to allow deuterium to start forming, so this was a rather close-run thing. Had the weak force been a bit stronger, the primordial neutrons would have decayed faster, reducing the total amount of helium produced, which in turn would reduce the quantity of life-encouraging carbon production in stars. On the other hand, if the weak force had been a bit weaker, a different problem would have arisen. The primordial cosmic material was a thorough mix of protons, neutrons, electrons, and neutrinos. Before about one second, the different particle species were maintained at a common temperature (that is, they were in thermodynamic equilibrium) by various interactions. Neutrinos played the determining role in maintaining the equilibrium between protons and neutrons because these particles can transmute into each other by emitting and absorbing neutrinos (and antineutrinos). However, the ability of the neutrinos to distribute the heat energy democratically between protons and neutrons hinges on whether the transmutations take place fast enough to keep pace with the rapidly falling temperature. The race to keep up gets harder and harder because the expansion of the universe dilutes both the energies and the densities of the participating particles, so reducing the reaction rate. Eventually the time comes when the struggle is lost. The poor neutrinos, armed only with the weak force, can't keep up, and they rather abruptly drop out of the game. This "decoupling" event happens at a little less than one second. At that point thermodynamic equilibrium between protons and neutrons is lost because there is no longer a mechanism to redistribute the available energy between their relative populations.

Neutrons are about 0.1 percent heavier than protons, so the principle of democracy means that if they are to be limited to their fair share of the available heat energy, there will be fewer of them than there are protons (because it takes more energy to make a slightly heavier neutron than a proton). The degree to which this mass difference between neutrons and protons translates into a numerical advantage for the protons depends very critically on the temperature. A microsecond after the big bang, when the temperature was a trillion degrees, the 0.1 percent mass difference was almost irrelevant (compared with the huge thermal energy available), so the ratio of neutrons to protons was nearly one to one. But as the temperature plummeted and less and less thermal energy was available to share out, the balance of advantage favoring the lighter protons grew dramatically: the ratio of neutrons to protons sank inexorably from nearly one to one down to

about six to one (six protons for every neutron). At this stage the neutrinos opted out, and the proto-to-neutron ratio remained stuck at a little more than six to one.

So now we can see what would have happened if the weak force had been weaker. The neutrinos would have given up the struggle sooner, when the universe was hotter and when the numerical advantage given to the lighter protons by the democracy principle was less. That would have meant more neutrons and fewer protons in the final mix. Because the excess protons went on to make hydrogen, there would have been less hydrogen in the universe and more helium. Had the freeze-out ratio been exactly one to one, all of the material would have ended up as helium. Less hydrogen would have had dire consequences for life. Stable, long-lived stars like our sun are hydrogen reactors. Without an abundant supply of this raw material they would be starved of fuel and would have very different properties. Also, hydrogen combines with oxygen to make water, a vital part of the life story at all stages. For example, life probably began in a watery "primeval soup," and for the greater part of its history life on Earth has been confined to the oceans. Even land animals like us contain about 75 percent water. Without abundant water, the chances of life forming and flourishing are slim.

The upshot of these various nuclear considerations, then, is that had the weak force been either somewhat stronger or very slightly weaker, the chemical makeup of the universe would be very different, with much poorer prospects for life.

Fine-Tuning in the Other Forces

Let me now turn to the other two forces of nature, gravitation and electromagnetism. How vital are their properties to the life story? It is easy to see why changing their strengths too much would threaten biology. If gravity were stronger, stars would burn faster and die younger: if by some magic we could make gravitation twice as strong, say, then the sun would shine more than a hundred times as brightly. Its lifetime as a stable star would fall from 10 illion to less than 100 million years, which is probably too short for life to emerge and certainly too short for intelligent observers to evolve. If electromagnetism were stronger, the electrical repulsion between protons would be greater, threatening the stability of atomic nuclei.

One of the striking things about electromagnetism and gravitation is the vast disparity in their relative strengths. In a normal hydrogen atom, the single electron is bound to the single proton by electrical attraction. But another source of attraction is at work here too — gravitation. It is easy to calculate the relative strengths of these two forms of attraction. It turns out that the electrical force is about 10 to the 40^{th} power times stronger than the gravitational force. Clearly, then, gravity is extraordinarily weak compared with electromagnetism.

That isn't how we experience these forces, though. We feel Earth's gravity a lot, whereas everyday electrical forces seem insignificant by comparison. The reason for this disparity is gravitation's cumulative effect: the more matter there is, the stronger is its gravity. The situation with electric charges is different because they come in both negative and positive varieties. Accumulate a lot of positive charge somewhere, and it will attract negative charge from its environment, thus reducing the net force. In this way electric charge has a natural self-limiting property. Not so with gravitation: the more matter there is in one place, the more it drags in additional material and the stronger the combined gravitational force becomes. Gravitation is therefore inherently self-amplifying, so that in spite of its extreme weakness it can add up to become dominant, as happens when a star collapses.

Years ago, Brandon Carter found an amazing relationship between the unexplained ratio 10 to the 40^{th} power and the properties of stars. Every star must transport heat from the nuclear furnace in its core to the surface, where it radiates into space. Heat can flow in two ways: by radiation, in

which photons convey the energy, and by convection, in which hot gas from deep down rises to the surface, bringing heat with it. Our sun has a convective outer layer, and through a telescope its surface looks like a boiling maelstrom. Astronomers think that this convective motion plays a role in forming planets, although it is far from clear how (the process of planet formation is still poorly understood). Larger stars rely on radiative transfer of heat rather than convection, and this is thought to be important in creating the conditions that lead to supernova explosions. Because both planets and supernovas are a major part of the life story, it is important for the universe to contain a selection of both radiative and convective stars. Carter discovered from the theory of stellar structure that to get both sorts of stars, the ratio of the strengths of the electromagnetic and gravitational forces needs to be very close to the observed value of 10 to the 40^{th} power. If gravity were a bit stronger, all stars would be radio-active and planets might not form; if gravity were somewhat weaker, all stars would be convective and supernovas might never happen. Either way, the prospects for life would be diminished.

More Fine-Tuning Marvels

As if what I have already described isn't enough, there are many more "convenient coincidences" in basic physics that make the universe bio-friendly. Other examples are the masses of the various subatomic particles. Physicists produce tables of these, and the numbers are fascinating but on the face of it almost totally meaningless. I receive lots of unsolicited manuscripts from mystically minded amateur scientists convinced that they have spotted subtle patterns in the numerical values of these masses. Sadly, such schemes are all bogus. Maybe one day theorists will be able to derive these numbers from some deep mathematical principles tied to a proper physical theory, but that is a distant prospect. Meanwhile, we can take the numbers as given, stare at them, and ask what they imply for life.

To give you a feeling for what I am talking about, the ratio of the mass of the proton to that of the electron is 1,836.1526675 — an utterly mundane number. The neutron-to-proton mass ratio is 1.00137841870, which looks equally uninspiring. Physically, it means that the proton has very nearly the same mass as the neutron, which, as we have already seen, is about 0.1 percent heavier. Is this important? Indeed it is, and not just in determining the ratio of hydrogen to helium in the universe. The fact that the neutron's mass is coincidentally just a little bit more than the combined mass of the proton, electron, and neutrino is what enables free neutrons to decay. If the neutron were even very slightly lighter, it could not decay without an energy input of some sort. If the neutron were lighter still, yet only by a fraction of 1 percent, it would have less mass than the proton, and the tables would be turned: isolated protons, rather than neutrons, would be unstable. Then protons would decay into neutrons and positrons, with disastrous consequences for life, because without protons there could be no atoms and no chemistry.

Cosmology provides more remarkable examples of fine-tuning. As I have discussed, the cosmic microwave background radiation is embellished with all-important ripples or perturbations, echoes of the seeds of the large-scale structure of the universe. These seeds, remember, are thought to originate in quantum fluctuations during inflation. Numerically, the variations are small: about one part in a hundred thousand, a quantity that cosmologists denote by the letter Q. Now, if Q were smaller than one hundred-thousandth — say, one millionth — this would severely inhibit the formation of galaxies and stars. Conversely, if Q were bigger — one part in ten thousand or more — galaxies would be denser, leading to lots of planet-disrupting stellar collisions. Make Q too big and you'd form giant black holes rather than clusters of stars. Either way, Q needs to sit in a rather narrow range to make possible the formation of abundant, stable, long-lived stars accompanied by planetary systems of the type we inhabit.

Returning to my Designer Machine metaphor, the collection of felicitous "coincidences" in physics and cosmology implies that the Great Designer had better set the knobs carefully, or the universe

would be a very inhospitable place. How many knobs are there? The Standard Model of particle physics has about twenty undetermined parameters, while cosmology has about ten. All told, there are over thirty "knobs." As I have cautioned already, not all the parameters are necessarily independent of the others, and not all require exceptional fine-tuning for life to be possible But several certainly do: some of the examples I have given demand "knob settings" that must be fine-tuned to an accuracy of less than 1 percent to make a universe fit for life. But even this sensitivity pales into insignificance compared with the biggest fine-tuning riddle of all: dark energy.

The Biggest Fix in the Universe

I have described dark energy as a cosmic repulsion, or antigravity force, which drives the galaxies apart at an accelerating rate. But actually this is a bit misleading because the antigravity still acts when no ordinary matter is present at all. As I mentioned briefly in Chapter 3, if the cosmic repulsion force is included, then a completely empty universe will expand "exponentially," doubling in volume in successive fixed intervals of time. To recap, one can think of empty space as being filled with invisible dark energy and its associated negative pressure, a combination that creates antigravity.

Why should empty space possess dark energy? Why isn't it simply empty, with no energy whatsoever? One reason, which I alluded to in Chapter 3, is that space would possess dark energy if it were permeated by an invisible scalar field, such as the inflation field. We wouldn't be able to see or touch this field, but it would still generate antigravity, as it is supposed to do with a vengeance during the inflationary phase of the very early universe. But there is another reason too, provided by quantum mechanics, which predicts that even apparently empty space is teeming with virtual particles (see Box 4, p. 63). Virtual particles, like real particles, possess energy, and it turns out that they also possess exactly the requisite negative pressure to generate a cosmic repulsion force of the sort that Einstein proposed.

I have already pointed out that when Einstein introduced the cosmic repulsive force "by hand" into his general theory of relativity, the theory itself couldn't pin down its value. He was free to choose any number he wanted to multiply the antigravity term and thereby set the overall strength of the cosmic repulsion force. In the event, he used astronomical data to calculate a plausible value that would permit a static universe — his favored model. When he later changed his mind about a static universe, it was just a simple matter of adjusting the number multiplying the cosmic repulsion term to zero, thus eliminating that term from the equations altogether. Such a fast-and-loose approach to cosmic repulsion, or dark energy, might be justified if one is restricting the analysis to gravitation only, but when quantum mechanics comes in, it simply won't do.

About thirty years ago, several theoretical physicists, myself included, decided to work out how much dark energy would be provided by all the virtual particles that inhabit the quantum vacuum (see Box 7 for more details). One can consider, say, the electromagnetic field and determine how much quantum energy resides in a given volume of "empty" space (that is, with no "real" photons present). The calculation isn't hard: a rough answer can be worked out on the back of an envelope. The answer, unfortunately, is unbelievable. Converted into mass density, it comes out at about 10 to the 93rd power grams per cubic centimeter, implying that a thimbleful of empty space should contain a million trillion trillion trillion trillion trillion trillion trillion tons! Stephen Hawking once quipped that this must be the biggest failure of physical theory in history. How could we get it so wrong?

Faced with such a serious embarrassment, physicists scrambled for an explanation. Perhaps some sort of cancellation mechanism might be at work. The electromagnetic field is only one of many fields in nature, and some of the others contribute negative dark energy. Perhaps there is a deep symmetry that causes the pluses and minuses to neutralize each other exactly. And in fact such a

symmetry exists: it is super-symmetry. The trouble is, we know that super-symmetry is broken in the real world, and unless the symmetry is exact, the positives and negatives won't cancel out. Many

other ideas were tried, but they all looked contrived. Nevertheless, it was possible to believe — and was believed by most physicists and cosmologists — that some physical mechanism drove the value of dark energy (or cosmic repulsion) to precisely zero.

Such hopes were thoroughly dashed when astronomers discovered that dark energy is actually not zero after all. This came as a complete shock. The value of the dark energy mass density measured by astronomers is some 120 powers of ten less than the "natural" value obtained by applying quantum theory to the virtual particles in a vacuum (see Box 7). When the value of dark energy seemed to be zero, it was at least plausible that some yet-to-be discovered mechanism might operate to force an exact cancellation. But, as Leonard Susskind has stressed, a mechanism that cancels to one part in 120 powers of ten, and then fails to cancel after that, is something else entirely. To give the reader some idea of just how much of a fix this almost-cancellation is, let me write out the number 10 to the 120^{th} power in its full glory:

> 1,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,
> 000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000

So the big fix somehow works brilliantly (if mysteriously) for 119 powers of ten, but fails at the 120th.

Whatever dark energy may be — and it may just be the "natural" energy of empty space — it is dangerous. In fact, it could be the most dangerous stuff known to science. About twenty years ago Steven Weinberg pointed out that if the magnitude of the dark energy were only moderately larger than the observed value, it would have frustrated the formation of galaxies. Galaxies form by the slow aggregation of matter under the action of attractive gravitation. If this tendency were opposed by a strong enough cosmic repulsion force, galaxies would be unable to grow properly. And as I have already remarked, without galaxies there would probably be no stars or planets or life. So our existence depends on the dark energy's not being too large. A factor of ten would suffice to preclude life: if space contained ten times as much dark energy as it actually does, the universe would fly apart too fast for galaxies to form. A factor of ten may seem like a wide margin, but one power of ten on a scale of 120 is a pretty close call. The cliché that "life is balanced on a knife-edge" is a staggering understatement in this case: no knife in the universe could have an edge that fine.

Logically, it is possible that the laws of physics conspire to create an almost but not quite perfect cancellation. But then it would be an extraordinary coincidence that that level of cancellation — 119 powers of ten, after all — just happened by chance to be what is needed to bring about a universe fit for life. How much chance can we buy in scientific explanation? One measure of what is involved can be given in terms of coin flipping: odds of 10 to the 120th to one is like getting heads no fewer than four hundred times in a row. If the existence of life in the universe is completely independent of the big fix mechanism — if it's just a coincidence — then those are the odds against our being here. That level of flukiness seems too much to swallow.

But what is the alternative? There is indeed another way to explain the minuscule value of the dark energy, and perhaps all the other convenient "coincidences" in physics and cosmology, but it represents a huge departure from the way we normally do science, and many scientists are aghast at it. But, as we shall see in the next chapter, it may be the only answer.

Key Points

- The existence of life as we know it depends delicately on many seemingly fortuitous features of the laws of physics and the structure of the universe.
- A famous early example of how the laws of physics seem to be fine-tuned for life is the production of carbon in stars, which requires a numerical "coincidence" to produce a nuclear resonance at just the right energy.
- All four forces of nature are implicated in the life story. Changing the strength of any one of them, even by a small amount, could render the universe sterile.
- The masses of some fundamental particles could not be very different without compromising the habitability of the universe.
- The measured value of dark energy is 120 powers of ten less than its natural value, for reasons that remain completely mysterious. If it were 119 rather than 120 powers of ten less, the consequences would be lethal.

Chapter 9 - Intelligent and Not-So-Intelligent Design

The Watchmaker Argument

EVERYONE AGREES that the universe looks as if it was designed for life. Well, perhaps it is designed for life. Perhaps there is a Designer? This is hardly groundbreaking reasoning — the design argument for the existence of God goes back hundreds of years. Augustine expressed the basic idea clearly when he wrote that "The very order, disposition, beauty, change and motion of the world and of all visible; things silently proclaim that it could only have been made by God." In the thirteenth century, Thomas Aquinas chose evidence from design as his "Fifth Way." The argument was popularized in the eighteenth century by an English clergyman named William Paley, who' famously used an analogy between a watch and the wonders of the:natural world.

Paley invited us to imagine that by chance we came upon a watch lying on the ground. Even without knowing precisely what it was, he suggested, we would soon deduce that it was an artifact designed for a purpose:

> When we come to inspect the watch, we perceive ... that its several parts are framed and put together for a purpose e.g. that they are so formed and adjusted as to produce motion, and that motion so regulated as to point out the hour of the day; that if the different parts had been differently shaped from what they are, or placed after any other manner or in any other order than that in which they are placed, either no motion at all would have been carried on in the machine, or none which would have answered the use that is now served by it ... the inference we think is inevitable, that the watch must have had a maker — that there must have existed, at some time and at some place or other, an artificer or artificers who formed it for the purpose which we find it actually to answer, who comprehended its construction and designed its use.

Paley went on to discuss "the contrivances of nature" that are vastly more complex and design-like than watches; The marks of design are too strong to be got over. Design must have had a designer. That designer must have been a person. That person is GOD." In presenting evidence for a designer-God, Paley considered two types of natural system: astronomical and biological. The astronomical comes closest to the theme of this book, but the biological is better known and of some current interest, so I shall deal with that first.

Biological organisms are immensely complex — far more complex than Paley could have realized. To a physicist they look nothing short of miraculous. The many and diverse components function together in a coherent and amazingly orchestrated manner. The living cell contains minuscule pumps, levers, motors, rotors, turbines, propellers, scissors, and many other instruments familiar

from a human workshop, all of them exquisite examples of nanotechnology. The entire assemblage runs itself with great efficiency, sometimes autonomously, sometimes in collaboration with other cells through a sophisticated network of intercellular communication based on chemical signaling. The command and control functions of the cell are encoded in its DNA database, which implements instructions through intermediary molecules using an optimal mathematical code to convert software instructions into hardware products with customized functionality. And this is just one cell. In a larger organism, vastly many cells get together and cooperate to form organs such as eyes, ears, brains, livers, and kidneys, many of them immensely elaborate in their structure and function. The human brain alone has more cells than there are stars in the Milky Way galaxy. So it all adds up to a package of marvels that boggles the mind.

The appearance of design is one of the defining hallmarks of life. The question before us is whether living organisms actually were designed, or whether natural processes can mimic design well enough to explain what biologists observe. Darwin's theory of evolution, published in 1859, owes its success precisely to its ability to account for the appearance of design without invoking a designer the so-called blind watchmaker argument lucidly popularized by Richard Dawkins)! The theory is simple and has been so thoroughly discussed in the literature that it needs only the briefest summary here.

So:

Organisms produce offspring with slight variations — taller shorter, darker, lighter, slower, faster . Sometimes circumstances are such that one of these features is favored (for example, better to be faster if the name of the game is to escape predators), and organisms possessing that quality will have a greater chance of survival and of passing on theft favored genes to the next generation.. As Dawkins graphically expresses it, good genes end up inside descendants, and bad genes end up in the stomachs of predators. So nature acts as a sieve, filtering out maladapted genes and rewarding good genes with duplicates. In this way, incrementally, favorable traits become amplified and unfavorable ones eventually eliminated. Amplification of different traits in different circumstances leads to diversity, and when the divergence between similar organisms exceeds the threshold beyond which interbreeding can happen, they are considered to be separate species.

The only assumption made in framing this theory is that there will be variation, inheritance, and selection. Selection operating in the struggle for survival is obvious to us all, but these days scientists understand how inheritance and genetic variation come about too, in terms of the molecular basis of life. Notice that although variations may be random, selection is far from random, so that it is not true to say, as is sometimes quipped, that Darwinism attributes the organized complexity of the biosphere to nothing more than random chance. It is obvious that chance alone would be no more likely to produce a living cell than (to use Fred Hoyle's famous analogy) a whirlwind blowing through a junkyard would produce a Boeing 747. But chance was not alone in fashioning the biosphere.

There is actually a fourth essential ingredient in Darwin's theory, and that is time. Selection can work only generation by generation, so changes tend to be slow and accumulate over immense durations. Billions of years are needed for life to evolve from a handful of simple microbes to the diversity of the biosphere we see today. But that's all right: Earth is over 4.5 billion years old. The fossil record, patchy though it inevitably is, provides overwhelming support for the fact that life has indeed evolved over at least 3.5 billion years from its humble origins in the form of simple microbes.

God-of-the-Gaps Makes a Comeback

After some early skirmishes, most theologians came to accept Darwin's theory of evolution. They contented themselves with the belief that God could achieve his purposes by working (albeit slowly) through the evolutionary mechanism rather than against it. They conceded that although Paley's argument was right, his conclusion was flawed: God did not design and create the different species of living organisms one by one from scratch. Rather, they evolved gradually and incrementally as a result of variation and selection. Nevertheless, some critics of Darwin's theory pointed to certain organs, or organisms, which they considered to be so complex and so well organized that it seemed incredible that their existence could be accounted for by mere variation and selection.

A favorite example was the human eye, an organ that Darwin himself found baffling. The eye was held up as an illustration of irreducible complexity. The point here is not just that the human eye is a complicated organ but that it contains many interconnecting and cooperating components, for example, a lens, a light-sensitive surface, and a pupil to control the influx of light. Remove just one of these components and the eye would be severely compromised. The puzzle seemed to be how the several parts, each of which individually is of limited use, could nevertheless come to be assembled in such an efficiently collaborative way. Since it is the essence of Darwinian evolution that selection acts gradually and incrementally to fashion new organs, and that each intermediate stage must have some selective advantage at the time, the eye seemed to provide a good example of a gap in the Darwinian account. Many other apparent gaps were identified.

The fossil record in Darwin's day was very patchy, which encouraged the belief in some quarters that God still had a role to play, presumably by popping up from time to time in evolutionary history, like a conjurer, to fix an unsatisfactory job: rearranging a few atoms here tweaking a gene there. Many theologians, however, were not comfortable with this idea, as is well captured in the following remark by Henry Drummond, made over a century ago:

Those who yield to the temptation to reserve a point here and there for special divine interposition are apt to forget that this virtually excludes God from the rest of the process. If God appears periodically, He disappears periodically. If He comes upon the scene at special crises, He is absent from the scene in the intervals. Whether is all-God or occasional-God the nobler theory? Positively, the idea of an immanent God, which is the God of Evolution, is infinitely grander than the occasional Wonder-worker, who is the God of an old theology.'

So strongly did some theologians object to the idea of God as part-time biological tinkerer that they invented the derisory term “God-of-the-gaps" to describe it.° The main objection to a God-of-the-gaps is not so much the happy-go-lucky — indeed, less than compelling _ nature of this style of designer, but rather the ever-present likelihood that scientific advances would systematically close the gaps, 5:44.4...4 God into smaller and smaller interstices, perhaps to be distinct), together in due course. A God who lurks in the dark corners of man’s ignorance is a God who must make a slow and excruciating retreat as science progresses.

And many gaps have indeed been plugged. One of these is the eye, the favorite example of irreducible complexity throughout the nineteenth century. It is easy to say that half an eye is?Ades,. st that simply isn't true, as partially sighted people will testify, any sort of light sensitivity is better than none, and on that bait a. It also has been possible to reconstruct a plausible evolutionary history it eye, starting with nothing more complicated than a light-sensitive patch and requiring that each incremental adaptation offers something as a selective advantage over the previous setup. In fact, eyes have evolved many times, using many different "designs," which suggests that it is actually not that hard for random variation and selection to do the job step by step, ratchetlike, accumulating many small improvements. Darwinian explanation is further

bolstered by the fact that each of the intermediate stages in the development of complexity actually exist in the animal kingdom: there are creatures out there; look at them!

Intelligent Design in Biology Is Magic, Not Science

In spite of the gap-closing that has been continuing for the past century and a half, supporters of a God-of-the-gaps simply move the goal-posts and seek other gaps. A current favorite with the so-called Intelligent Design movement in the United States is the bacterial flagellum, an ingenious-looking device that propels the cell by a rotary action using a little motor. This system is claimed to have irreducible complexity. Exactly why the bacterial flagellum is more "irreducibly complex" than the eye isn't clear, and one would have thought that the lesson had been learned by now. Although a blow-by-blow account of the way in which the flagellum evolved is currently beyond us, an outline is known, including how some of the components might have been used originally for other purposes and co-opted to make the flagellum motor.

The study of biology makes it clear that living organisms are contraptions cobbled together from odds and ends as circumstances dictate. Although many bits operate beautifully, a lot of the "design" has a make-do air about it. In evolution, it is sufficient that organisms get by; they don't all have to be biological Rolls-Royces. Many features of the human body contain design flaws, such as the dangerous convergence of food and air pathways in the throat and the inadequate robustness of the spine. If there is a designer, then this being is clearly not micromanaging the process very well.

The weak point in the "gaps" argument of the Intelligent Design movement is that there is no reason why biologists should immediately have all the answers anyway. Just because something can't be explained in detail at this particular time doesn't mean that it has no natural explanation: it's just that we don't know what it is yet. Life is very complicated and unraveling the minutiae of the evolutionary story in detail is an immense undertaking. Actually, in some cases we may never know the full story. Because evolution is a process that operates over billions of years, it is entirely likely that the records of many design-like features have been completely erased. But that is no excuse for invoking magic to fill in the gaps.

One of the confusions surrounding the Intelligent Design movement's propaganda is a failure to distinguish between the fact of evolution and the mechanism of evolution. Design proponents often cite squabbles among biologists as signs that "Darwinism is in trouble." Even if it was, that doesn't mean that life hasn't evolved over billions of years. Darwinism proposes a specific physical mechanism. Other possible mechanisms may exist to drive evolution. For example, jeanBaptiste Lamarck offered a theory of evolution based on the idea of inheriting acquired characteristics. That is to say, an organism's lifetime experiences can, according to this theory, be passed on to its offspring; so, for example, the son of a man who becomes a bodybuilding fanatic should have bigger-than-average muscles. Sadly for Lamarck, his theory has been refuted — more or less. The point, however, is that the theory has clearly defined and testable consequences, which qualifies it as being a scientific theory; the same cannot be said for intelligent design. Those who think that alternatives to Darwinism should be taught in schools would do well to consider Lamarck's theory of evolution for this purpose. It is not inconceivable and it is certainly scientifically possible) that some subtle version of Lamarckian evolution might be at work here and there, augmenting the Darwinian mechanism.

Another possible evolutionary mechanism is self-organization. Many nonliving systems evolve complex patterns and organizational structure from featureless beginnings. They do this entirely spontaneously, without variation or selection in the Darwinian sense. For example, snowflakes form distinctive elaborate hexagonal patterns. Nobody suggests that there are genes for a snowflake, but nobody suggests that they are made by an intelligent designer either. They spontaneously self-

organize and self-assemble, in accordance with definite mathematical rules and physical laws. Non-Darwinian evolution by self-organization is found in physics, chemistry, astronomy, earth sciences, and even in networks such as the World Wide I Web. It would be surprising if it didn't happen here and there in biology too, but I may be wrong.9 Even if I am right, that doesn't mean that Darwinism is disproved, just that it may be only a partial account of the evolutionary mechanism. But the missing bit is not some cosmic magician; it is a natural process complying with some yet-to-be elucidated principle of organization deriving from physical laws.

Further confusion in the intelligent design discussion often arises from a failure to distinguish between the evolution of life and the emergence of life — how life got started in the first place. Darwin himself pointedly omitted any reference to life's origin: "One might as well speculate about the origin of matter," he said (a problem that, incidentally, has now effectively been solved — see p. 105. It has to be admitted that the origin of life remains a deep mystery. But that cannot be used as an argument against Darwinian evolution because biogenesis is not part of evolutionary theory. Clearly, we can discuss the evolution of life only on the basis that life already exists. So could it be that life's murky beginning is one of those "irreducible" gaps in which the actions of an intelligent designer might lie? I don't think so. Let me repeat my warning. Just because we can't explain how life began doesn't make it a miracle. Nor does it mean that we will never be able to explain it — just that it's a hard and complicated problem about an event that happened a long time ago and left no known trace. But I for one am confident that we will figure out how it happened in the not-too-distant future.

In spite of the curious resurgence of the God-of-the-gaps argument in the United States, it remains true that Paley's biological design argument for the existence of God was blown out of the water by Darwin's theory of evolution and its refinements. But what about Paley's astronomical arguments? Here the situation is much more subtle.

Laws by Design Versus Anthropic Selection in a Multiverse

In astronomy and cosmology, the appearance of design enters most strikingly when it comes to the laws of physics and the overall organization of the universe, especially in relation to the fine-tuning and bio-friendliness I have been discussing throughout this book. Here the design argument is largely immune to Darwinian attack. The Darwinian mechanism of variation, inheritance, and selection cannot easily be adapted to cosmology.'" There is no battle for survival, with universes slugging it out, red in tooth and claw, passing on their successful traits to baby universes, and no competition for resources or a "universe-to-universe" struggle. It could be said that in the eternal inflation version of the multiverse, victory goes to the empty, featureless regions between the bubble universes, where inflation hasn't ceased — if by "victory" one means gaining the biggest volume of space. But clearly, Darwinism is not an appropriate framework for explaining the appearance of design in cosmology.

There is, however, the possibility of anthropic selection rather than Darwinian selection. In the previous chapter I discussed how the multiverse theory combined with anthropic selection constituted a serious attempt to explain the appearance of design. This multiverse/anthropic challenge to intelligent design has already attracted the attention of the Roman Catholic Church. Christoph Schönborn, the cardinal of Vienna, recently wrote in the New York Times:

> Now at the beginning of the 21st century, faced with scientific claims like Neo-Darwinism and the multiverse hypothesis in cosmology invented to avoid the overwhelming evidence for purpose and design found in modern science, the Catholic Church will again defend human reason by proclaiming that the immanent design evident in nature is real. Scientific theories that try to explain away the appearance of design as the result of "chance and

> necessity" are not scientific at all, but, as [Pope John Paul] put it, an abdication of human intelligence.

The take-home message from the cardinal is that invoking a multiverse is an attempt to "explain away" design rather than explain it and that God s a better, simpler, and more credible explanation.

So let's take a look at the hypothesis that the appearance of design in the universe is the result of a designer-creator. Although by definition this is not a scientific explanation (since it appeals to a supernatural cause), it is still a rational explanation. The question is, how good is it? We can crudely caricature an intelligent designer as a being who contemplates a shopping list of possible universes, figures out one that will contain life and observers, and then sets to work creating it, discarding the alternatives. There is no doubt that, even in this crude form, the hypothesis of an intelligent designer applied to the laws of nature is far superior than the designer considered in the previous section, who violates the laws of nature from time to time by working miracles in evolutionary history. Design-by-laws is incomparably more intelligent than design-by-miracles. If I were an omnipotent being who wanted to make an inhabited universe like ours, and I could achieve this simply by conjuring up what I wanted when I wanted it, I wouldn't regard my activities as very clever. But to select a set of laws that, without any periodic fixing up and micromanagement, can bring a universe into being and bring about self-organization, self complexification, and self-assembly of life and consciousness — well, that looks very clever indeed! So the "intelligent" design beloved of the Intelligent Design movement strikes me as not very intelligent at all, in contrast to a designer of laws of nature that by themselves have such astonishing creative ability without the need for intervention and miracles.

Intelligent design of the laws does not conflict with science because it accepts that the whole universe runs itself according to physical laws and that everything that happens in the universe has a natural explanation. There are no miracles other than the miracle of nature itself. You don't even need a miracle to bring the universe into existence in the first place because the big bang may be brought within the scope of physical laws too, either by using quantum cosmology to explain the origin of the universe from nothing or by assuming something like eternal inflation.

The designer-of-laws is responsible for the universe, and might be thought of as upholding its existence at every moment, but does not tinker with its day-to-day operation. The type of God I am describing comes close, I think, to what many scholarly theologians — and for that matter quite a few scientists — profess to believe in. Yet even this "no miracles" version of an intelligent designer is not without its critics. The central objection to invoking such a being to account for the ingenious form of the universe is the completely ad hoc nature of the explanation. Unless there is already some other reason to believe in the existence of the Great Designer, then merely declaring, "God did it!" tells us nothing at all. It simply plugs one gap the mystery of cosmic bio-friendliness — with another—the mystery of an unknown intelligent designer. So we are no further forward.

A Cosmic Designer Must Lie Outside Time

There is also the very considerable problem of time. Time is part of the physical universe, inseparable from space and matter. Any designer-creator of the universe must therefore transcend time as well as space and matter. That is, God must he outside time if God is to be the designer and creator of time. Augustine was well aware of this and began a school of thought that asserts that God is a timeless being, not just in the sense of living forever but of being outside time altogether." (As I have explained, time itself can have a beginning and an end. Most theologians would not want God to come into being at the beginning of time and cease to exist if it should come to an end.) The difficulty with a timeless designer, however, is in making sense of the concept of design. What does it mean to design something "timelessly"? In human experience, a

designer is a being who thinks through in advance the consequences of certain choices and then selects a judicious one. But "thinking" and "in advance" are inescapably temporal descriptions.

Even if some more abstract notion of "timeless design" is accepted, a further difficulty arises with the specifics of the designer's choice. Could the designer have chosen a different universe or chosen not to make a universe at all? If the answer is no, then God had no alternative but to create this universe and plays no role at all in the explanation — and so does not merit the title "designer." Nature is reduced to a subset of the divine being rather than a creation of this being — in fact, we might as well do away with the notion of a designer altogether. Christians, however, traditionally believe something quite different. They believe that God created this particular universe as a free act: that is, God was free to not make this universe. But this comes with its own set of difficulties because we can ask why it was that God chose to make this universe, as opposed to a lifeless one, or one with maximum suffering. If the reply is "It's unfathomable," then the chain of explanation peters out. If the answer is that the choice was blind, then again the element of design is lost, because if the selection was purely whimsical, then the universe is reduced to a divine plaything. But if the answer is that the decision to make the universe was a profound and considered one that proceeded from God's nature, then one is prompted to ask about the source of this nature. In other words, who designed the designer? This is a variant of the old "who made God?" conundrum.

Speculations (Some of Them Wild) About a Natural God

One way of evading the creator's creator difficulty comes from an imaginative suggestion by the cosmologist Edward Harrison, made in the context of the multiverse theory." If one accepts that there are many universes and that universes can be created by natural processes with different laws, constants, and initial conditions, it is but a small step to the speculation that our universe is the engineered product of an intelligent designer who evolved naturally in an earlier universe. Harrison envisages a random ensemble of universes in which some pocket universes give rise to life and intelligence purely by chance. One of these universes develops a super-intelligence so technologically advanced that it becomes capable of creating baby universes to order (for example, by gaining control over the universe-generating mechanism). These baby universes are deliberately made to optimize life and observers. Our universe would then be the product of a natural god who evolved by good old Darwinian processes in a preceding universe. Such a being has a long tradition in the history of religious philosophy and is usually referred to as a demiurge. Plato's demiurge was a powerful creator of the world we see but nevertheless had to work within the resources and laws available. The demiurge is not omnipotent, as is the monotheistic God. Harrison's god is however, a super-demiurge because it can choose both the form of matter and the laws of low-energy physics by, for example, nucleating a universe in the appropriate region of the string theory landscape. Nevertheless, this god is still bound by the laws of string/M theory (or whatever unified theory one envisages) and the physics of the universe-generating mechanism.

Harrison's speculation carries echoes of Hoyle's "super-intelligence," who has deliberately "monkeyed with the laws of physics," and of the Star Maker in Olaf Stapledon's famous novel Hoyle disliked the traditional Christian deity who makes the universe as a free choice because it implies a lopsidedness of creator and creation: creation depends on God, but God remains unaffected by creation. If God has no need to create the world and s unaffected by it, why did God bother to do so? This "logical morass is avoided," Hoyle points our if God exists only by virtue of the support received from the Universe." y this, Hoyle meant that God exists within the universe (or multiverse) rather than transcending it.

Similar ideas have been espoused by Andrei Linde in a curious paper informally entitled The Hard Art of Universe Creation" in which he discusses a super-civilization manipulating temperature, pressure, and external fields so as to configure the birth of a universe with life-encouraging low-energy physics, "to send a message to those who will live in the universe." The "message in a bottle"

universe was also a theme taken up by Heinz Pagels, who wondered whether the ingenious, life-encouraging laws of physics — what he termed the cosmic code" — might be a message from a demiurge:

Scientists in discovering this code are deciphering the Demiurge's hidden message, the tricks he used in creating the universe. No human mind could have arranged for any message so flawlessly coherent, so strangely imaginative, and sometimes downright bizarre. It must be the work of an Alien Intelligence.

Pagels took pains to point out that his demiurge, his "Alien Intelligence," was just an interesting thought experiment and that the said being had somehow "written himself out of the code." The science writer James Gardner has adapted the same general concept into what he terms "the selfish bio-cosm." His thesis is that the universe is a self-organizing, self-replicating system in which life and intelligence emerge to create new universes with life and intelligence, with the "knobs of the designer machine" suitably fine-tuned. "Under the theory," he writes, "the laws and constants are life-friendly precisely because they were deliberately engineered by advanced intelligent life forms in a prior cosmic cycle to endow our universe with the capability for life-mediated reproduction."

It is now time to take a reality check. In our search for an explanation of cosmic bio-friendliness we have encountered a heady mix of speculation, ranging from the intriguing to the seriously flaky. Some of the ideas have included fake universes designed by fake gods, multiverses that feature absolutely everything conceivable, and now super-intelligent, godlike beings who evolve naturally but then go on to create or manipulate entire universes for theft own purposes. All these fanciful theories provide excellent material for entertaining science fiction, but the realm of professional science has been left far behind. If it were not for the fact that the speculators include some scientists of great distinction, the discussion could probably be dismissed without further ado. The fact that some great minds have been driven to explore such wild ideas is testimony to the intractable nature of the problems being confronted. Somehow we have to understand how life and cosmology connect (unless we are to dismiss the link as illusory). But even if we are prepared to suspend disbelief and go along with a natural god as a working hypothesis, the job is only half-done.

God as a Necessary Being

A major shortcoming of invoking demiurges and natural gods is that they do not address the ultimate explanation of existence. One has to assume that some sort of universe or multiverse already exists before the god or gods can emerge. Professional theologians are unlikely to be impressed by that. They argue for the existence of a transcendent eternal deity who is outside, and responsible for, all universes at all times. Theologians have confronted the "who-made-God" argument for centuries and have had plenty of time to come up with interesting answers. The conventional Christian doctrine is that God had no maker. Instead, God is a necessary being — a being whose existence needs no explanation in terms of something outside itself. In other words, it is logically impossible for God to not exist; a state of "no God" is deemed to be meaningless.

It is far from clear to me whether such a conclusion is logically valid or conceptually coherent (even professional philosophers continue to squabble about it), but even if it is, we are not done. Christians, like all monotheists, believe in one God. So they need to show not only that God exists necessarily, but also that this being is necessarily unique — otherwise there could be countless necessary beings making countless universes. Even if all of this can be sorted out, we are still confronted with the problem that, in spite of God's necessary existence and nature, God did not necessarily create the universe as it is, but instead merely chose to do so. But now the alarm bells ring. Can a necessary being act in a manner that is not necessary? Does that make sense? On the face of it, it doesn't. If God is necessarily as God is, then God's choices are necessarily as they are,

and the freedom of choice evaporates?? Nevertheless, there is a long history of attempts to get round this obstacle and to reconcile a necessary God with a contingent universe.

Confused? I certainly am. I am not an accomplished enough philosopher to evaluate these explanations, which become very technical. The arguments are abstract, subtle, and convoluted, and the question inevitably arises of whether something like the multiverse/ anthropic explanation isn't easier to grasp and altogether more plausible. If only that were true.

Who Designed the Multiverse?

If the concept of God runs into a logical and existential quagmire, then the multiverse fares little better. Just as one can mischievously ask who made God or who designed the designer, so one can equally well ask why the multiverse exists and who or what designed it. Although a strong motivation for introducing the multiverse concept is to get rid of the need for design this bid is only partially successful. Like the proverbial bump in the carpet, the popular multiverse models merely shift the problem elsewhere — up a level from universe to multiverse. To appreciate this one only has to list the many assumptions that underpin the multiverse theory.

First, there has to be a universe-generating mechanism, such as eternal inflation. This mechanism is supposed to involve a natural, law-like process — in the case of eternal inflation, a quantum "nucleation" of pocket universes, to be precise. But that raises the obvious question of the source of the quantum laws (not to mention the laws of gravitation, including the causal structure of space-time on which those laws depend) that permit inflation. In the standard multiverse theory, the universe-generating laws are just accepted as given: they don't come out of the multiverse theory. Second, one has to assume that although different pocket universes have different laws, perhaps distributed randomly, nevertheless laws of some sort exist in every universe. Moreover, these laws are very specific in form: they are described by mathematical equations (as opposed to, say, ethical or aesthetic principles). Indeed, the entire subject is based on the assumption that the multiverse can be captured by (a rather restricted subset of) mathematics.

Furthermore, if we accept that the multiverse is predicted by string/M theory, then that theory, with its specific mathematical form, also has to be accepted as given — as existing without need for explanation. One could imagine a different unified theory — N theory, say — also with a dense landscape of possibilities. There is no limit to the number of possible unified theories one could concoct: 0 theory, P theory, Q theory . . . Yet one of these is assumed to be "the right one" — without explanation. Now it may be argued that a decent theory of everything would spring from some deeper level of reasoning, containing natural and elegant mathematical objects that already commend themselves to pure mathematicians for their exquisite properties. It would — dare one say it? — display a sense of ingenious design. (Certainly the theoretical physicists who construct such theories consider their work to be designed with ingenuity.) In the past, mathematical beauty and depth have been a reliable guide to truth. Physicists have been drawn to elegant mathematical relationships that bind the subject together with economy and style, melding disparate qualities in subtle and harmonious ways. But this is to import a new factor into the argument — questions of aesthetics and taste. We are then on shaky ground indeed. It may be that M theory looks beautiful to its creators, but ugly to N theorists, who think that their theory's the most elegant. But then the 0 theorists disagree with both groups.

It There Were a Unique Final Theory, God Would Be Redundant

Let me now turn to the main scientific alternative to the multiverse: the possible existence of a unique final theory of everything, a theory that permits only one universe. Remember that many scientists, including some prominent string theorists such as David Gross, are scathing about the multiverse, regarding those who espouse it as "giving up." They are convinced that a unique theory describing a unique world, with all laws and parameters completely fixed by the theory, will

eventually emerge — maybe one day soon. Einstein once remarked that what interested him most was whether "God had any choice in the creation of the world." If Gross is right, the answer is no: the universe has to be as it is. There is only one mathematically self-consistent universe possible. And if there were no choice, then there need be no Chooser. God would have nothing to do because the universe would necessarily be as it is.

Intriguing though the idea of a "no-free-parameters" theory may seem, there is a snag. If it were correct, it would leave the peculiar bio-friendliness of the universe hanging as a complete coincidence. Here is a hypothetical unique theory that just happens, obligingly, to permit life and mind. How very convenient! To get some idea of what we are being invited to believe, consider an analogy. The number PI, defined as the ratio of the circumference to the diameter of a circle, was discovered by geometers in ancient Greece. It arises, however, in many contexts in the natural world, ranging from the motions of the planets to the patterns made by waves. One might say that Z. is built into the very structure of the physical universe. Now a cannot be expressed as a ratio of whole numbers (it is irrational, to use the technical term); rather, it must be expanded as an infinite decimal: 3.141592 ..., without any end to the sequence of digits. It can also be expressed as an unending binary sequence, in terms of l's and O's. These strings of numbers, both decimal and binary, appear from statistical tests to be completely random. Knowing the first million digits of "pi" gives no clue at all to the million-and-first digit.

Imagine next that the unending binary expression of is displayed on a computer monitor in simple pictorial form, by making I correspond to a bright pixel and 0 to a dark pixel, starting with the first digit and continuing indefinitely. Being random, the sequence will generate screen after screen of uninteresting "snow." It is, however, a feature of randomness that, sooner or later, anything that is possible will happen. In this case, the implication is that somewhere deep in the binary expansion of n there will be a screen containing a coherent shape — a circle, say. It is easy to work out that the probability of this happening is so low that a computer could display a fresh screen showing the continuing binary expansion of PI every second for a lifetime and you would still have a negligible chance of seeing a circle. Nevertheless, there is a nonzero probability that it could happen. The same logic applies to more complicated shapes, such as pictures of faces, but the more elaborate the image, the lower the probability of ever seeing it.

Now imagine that this experiment is performed, and after only two minutes a smiling face appears on the screen! What would one make of it? To say that one would be astonished is an understatement; some sort of trickery would be very strongly suspected. And yet the binary expression of it is uniquely fixed by the rules of mathematics. There are no free parameters to fiddle with to "make a face." If a face is there, it is there by the iron logic of real numbers: we need provide no further explanation. The same is true of the unique, no-free-parameter theory of everything, which, purely as a fortuitous consequence of its internal mathematical logic, describes a life-permitting universe (if this theory indeed exists). Of course, if you don't think that life and mind are anything very special, the digits of it analogy won't cut much ice. But in my opinion, life and mind are special, for reasons I shall explain in the next chapter. It seems to me that a unique mathematical theory that makes no reference to life, but that nevertheless yields life, is as unbelievable as seeing a face leap out from among the early digits of a.

A Unique Final Theory Seems to Be Falsified Already

There is another, more direct argument against the idea of a unique final theory. The job of the theoretical physicist is to construct possible mathematical models of the world. These are often what are playfully called toy models: clearly too far removed from reality to qualify as serious descriptions of nature. Physicists construct them sometimes as an experiment, to test the consistency of certain mathematical techniques, but usually because the toy model accurately captures some limited aspect of the real world in spite of being hopelessly inadequate about the

rest. The attraction is that such slimmed-down world models may be easy to explore mathematically, and the solutions can be a useful guide to the real world, even if the model is obviously unrealistic overall.

A good example of a toy model is one used to solve a problem in fewer than the usual three dimensions of space. I did a lot of this myself in the 1970s. I was interested in the behavior of quantum fields propagating in curved space-time, and it was sometimes possible to solve the equations exactly by pretending that space had only one dimension rather than three. For some real-world situations the two extra dimensions I omitted play an unimportant role, so my one-dimensional calculations provided a useful guide. Such toy models are a description not of the real world, but of impoverished alternatives. Nevertheless, they describe possible worlds. Anyone who wanted to argue that there can be only one truly self-consistent theory of the universe would have to give a reason why these countless mathematical models that populate the pages of theoretical physics and mathematics journals were somehow unacceptable descriptions of logically possible worlds.

It's not necessary to consider radically different universes to make the foregoing point. Let's start with the universe as we know it and change something by fiat: for example, make the electron heavier and leave everything else alone. Would this arrangement not describe a possible universe, yet one that is different from our universe? "Hold on," cries the no-free-parameters proponent. "You can't just fix the constants of nature willy-nilly and declare that you have a theory of everything! There is much more to a theory than a dry list of numbers. There has to be a unifying mathematical framework from which these numbers emerge as only a small part of the story." That is true. But I can always fit a finite set of parameters to a limitless number of mathematical structures, by trial and error if necessary. Of course, these mathematical structures may well be ugly and complicated, but that is an aesthetic judgment, not a logical one. So there is clearly no unique theory of everything if one is prepared to entertain other possible universes and ugly mathematics.

While the argument I have just given seems to be incontestable, many physicists would be content to settle for a weaker claim than the assertion that the universe cannot possibly have been other than it is. To be sure, there may exist legions of self-consistent mathematical "theories of everything" describing universes different from ours, but when it comes to this universe, perhaps there is only one self-consistent theory. Maybe if we knew enough about unifying theories, we would find that only one knob setting of the Designer Machine (that is, only one theory) fits all the known facts about the world — not just the values of the constants of nature, but such things as the existence of life and observers. That would certainly be something! It could be that there are many possible no-free-parameters theories describing many possible single universes, but only one of those theories fits all the observed facts about this universe. Surely this imaginary Holy Grail of a theory solves the Goldilocks enigma without invoking either intelligent design or a multiverse?

Unfortunately it would not, because one would still be left with the puzzle of why that theory — the one that permits a life-giving universe — is "the chosen one." Stephen Hawking has expressed this more eloquently: "What is it that breathes fire into the equations and makes a universe for them to describe?" Who, or what, does the choosing? Who or what, promotes the "merely possible" to the "actually existing"? This question is the analogue of the problem of "who made God" or "who designed the Designer." We still have to accept as "given," without explanation, one particular theory, one specific mathematical description, drawn from a limitless number of possibilities. And the universes described by almost all the other theories would be barren.

Perhaps there is no reason at all why "the chosen one" is chosen. Perhaps it is arbitrary. If so, we are left still with the Goldilocks puzzle. What are the chances that a randomly chosen theory of everything would describe a life-permitting universe? Negligible. There are many locked knob

settings on the Designer Machine representing logically possible single, no-free-parameters, mathematically ugly, sterile universes. If any one of these infinitely many possibilities had been the one to have "fire breathed into it" by a Designer with poor taste perhaps?), we wouldn't know about it because it would have gone unobserved and uncelebrated. So it remains a complete mystery as to why this universe, with life and mind, is "the one."

My conclusion is that both the multiverse theory and the putative no-free-parameters theory might go a long way to explaining the nature of the physical universe, but nevertheless they would not, and cannot, provide a complete and final explanation of why the universe is fit for life, or why it exists at all.

What Exists and What Doesn't: Who or What Gets to Decide?
We have now reached the core of this entire discussion, the problem that has tantalized philosophers, theologians, and scientists for millennia:

What is it that determines what exists?

Among the big questions I listed at the beginning of this book, this is one of the Really Big ones. The physical world contains certain objects — stars, planets, atoms, living organisms, for example. Why do those things exist rather than others? Why isn't the universe filled with, say, pulsating green jelly, or interwoven chains, or disembodied thoughts ...? The possibilities are limited only by our imagination. The same sort of conundrum arises when we contemplate the laws of physics. Why does gravity obey an inverse square law rather than, for example, an inverse cube law? Why are there two varieties of electric charge (+ and –j instead of four? And so on. Invoking a multiverse merely pushes the problem back to "why that multiverse." Resorting to a no-free-parameters single universe described by a unified theory invites the retort "Why that theory?"

Is there a way out? There is, but it is pretty drastic. There are only two of what one might term "natural" states of affairs, by which I mean states of affairs that require no additional justification, no Chooser and no Designer, and are not arbitrary and reasonless. The first is that nothing exists. This state of affairs is certainly simple, and I suppose it could be described as elegant in an austere sort of way, but it is clearly wrong. We can confidently rule it out by observation. The second natural state of affairs is that everything exists. By this I mean that everything that can exist does exist. Now that contention is much harder to knock down. We can't observe everything in the universe, and absence of evidence is not the same as evidence of absence. We cannot be sure that any particular thing we might care to imagine?" doesn't exist somewhere, perhaps beyond the reach of our most powerful instruments or in some parallel universe.

Could It Be That Everything Exists?
An enthusiastic proponent of this extravagant hypothesis is Max Tegmark. He was contemplating the "fire-breathing" conundrum I discussed above (allegedly over a few beers in a pub). "If the universe is inherently mathematical, then why was only one of the many mathematical structures singled out to describe a universe?" he wondered. "A fundamental asymmetry appears to be built into the heart of reality." To restore the symmetry completely and eliminate the need for a Cosmic Selector, Tegmark proposed that "every mathematical structure corresponds to a parallel universe." So this is a multiverse with a vengeance. On top of the "standard" multiverse I have already described, consisting of other bubbles in space with other laws of physics, there would be much more: "The elements of this [extended) multiverse do not reside in the same space but exist outside of space and time. Most of them are probably devoid of observers."

Tegmark gives an illustration of the other mathematical structures he has in mind. "How about time that comes in discrete steps, as for computers, instead of being continuous? How about a universe

that is simply an empty dodecahedron?" He also considers fractals — mathematical structures that have fractional dimensionality for example, dimension and are infinitely irregular. There would also be sparse universes that would be just sets of points with no connectivity and others containing objects that could be counted, but for which 3 x 4 would not be the same as 4 x 3. Some universes might allow for "hyper-computation" — the ability to solve mathematical problems that would take an infinite number of steps in our universe. Mathematicians consider these sorts of systems all the time and write papers about them as branches of mathematical theory. Tegmark suggests that they also correspond to physical reality — somewhere.

A knee-jerk reaction to Tegmark's "anything goes" multiverse is that it is stupefyingly complex and in flagrant breach of the most basic rule of science, which is Occam's razor. But Tegmark points out that everything is actually simpler than something. That is, the whole can often be defined more economically than any of its parts. A concrete example is provided by an infinite crystal. A perfect infinite crystal consists of a regular and uniform lattice of atoms without any boundary. Its structure may be described completely by simply specifying the spacing between neighboring atoms, the overall orientation, and the statement that the lattice has no boundary. Now imagine removing from the perfect infinite crystal a random set of atoms and separately retaining the three-dimensional arrangements of both the removed set and the remainder. In this manner the original set of atoms has been divided into two randomly specified subsets. Now, by definition a random set cannot be described by a smaller number of bits of information than the set itself contains. For example, if you remove one million atoms at random, you must specify one million bits of information to identify the process. So each subset is a complicated object needing a lot of information to describe it. But put the two subsets back together again and you get something very simple and easy to describe.

Beguiling though Tegmark's proposal may seem, it is not without problems. The notion of "everything" is a slippery one in mathematics because of the possibility of self-referential sets. These relate to the well-known problems that lurk within the logical foundations of mathematics, such as Bertrand Russell's barber paradox. The village barber shaves all the men who don't shave themselves. Then who shaves the barber? If the barber shaves himself, he belongs to the set of men who are not shaved by the barber, so he doesn't shave himself. But if he doesn't shave himself, then he is shaved by the barber! Either way, one gets contradictory nonsense. This little puzzle is more than just an amusing diversion: it strikes at the very roots of mathematical consistency and negates any simple attempt to define mathematics in terms of sets of objects obeying sets of rules. Even basic arithmetic is compromised.

A second objection to Tegmark's idea is that it is framed in terms of mathematics. This is, of course, hardly surprising of a theory constructed by a mathematical physicist, and it is supported by the discovery that nature is indeed mathematical in form. But if we are in "anything goes" territory, there is no reason at all to restrict ourselves to mathematics. To do so invites the question of why the multiverse is mathematical: who decided that? We can certainly imagine multiverses that are defined in other ways. For example, the set of all aesthetically pleasing universes, the set of all good universes or evil universes, the set of all deities, the set of all virtual realities. Even within the general domain of mathematics, one can question the standard rules of logic on which mathematical statements are based and contemplate a multiverse with the set of all objects deriving from all possible forms of logic. If you really believe that everything exists, then all these other multiverses should be out there too.

Maybe they are? Very few people, however, would want to go whole hog with Tegmark. Most scientists, even those who believe in some sort of multiverse, stop short of supposing that literally everything exists. Which brings us right back to the basic problem we confronted at the outset of this section: what decides what exists?

The Origin of the Rule That Separates What Exists from What Doesn't

If not everything exists, there must be a description or a rule that specifies how to separate "the actual" from "the possible-but-in-fact-non-existent." The inevitable questions then arise: What is the rule that divides them? What, exactly, determines that-which-exists and separates it from that-which-might-have-existed-but-doesn't? From the bottomless pit of possible entities, something plucks out a subset and bestows upon its members the privilege of existing. Something "breathes fire into the equations" and makes a universe or a multiverse for them to describe. And the puzzle doesn't stop there. Not only do we need to identify a "fire-breathing actualizer" to promote the merely possible to the actually existing, but we also need to think about the origin of the rule itself — the rule that decides what gets fire breathed into it and what doesn't. Where did that rule come from? And why does that rule apply rather than some other rule? In short, how did the right stuff get selected? Are we not back with some version of a Designer/Creator/Selector entity, a necessary being who chooses "the Rule" and "breathes fire" into it?

These deliberations are summarized in Figure 26, which shows three sets separated by two boundaries, A and B. The lightest region, enclosed within boundary A. is the set of all things that all possible observers can in principle observe. This set can be a part — a subset — of all that exists, which is encompassed by boundary B. Excluded from the lightest-colored subset, but still contained within boundary B, are, for example, universes that possess no life and observers. The dark region on the other side of boundary B is the set of things that could in principle have existed but in fact do not exist. The union of these three sets forms the set of all that is logically possible — that is, all that could in principle exist.

Let's see how the three attempts to explain the universe relate to these sets. First consider the no-free-parameters theory of everything. Its advocates declare, quite simply, that boundary A does not exist: that there is just one universe — the observed universe (see Figure 27). They have no truck with the notion of "other universes" that go unseen on account of being lifeless, so A is abolished. Unfortunately there is still boundary B. The theory of everything has nothing to say about B: it is left as a mystery.

How does the multiverse theory fare? Its advocates agree that there is a boundary A, and they invoke the anthropic principle, or the observer selection effect, to explain its size and shape!whatever they might be — we don't know yet). Once again, however, this theory cannot help us chart the boundary of the second set, boundary B — the dividing line between the set of all that does exist and the set of all that can exist but doesn't. Boundary B is beyond the reach of anthropic reasoning. The multiverse/anthropic theory can perhaps explain why the universe is bio-friendly, but it is absolutely not a complete theory of the universe, however much that claim may be made. It still leaves a lot unexplained. For one thing, we still need to know who, or what, drew boundary B. Now according to Tegmark, boundary B does not exist: by his reasoning, the set of all that exists is the same as the set of all that can exist (see Figure 28). But how many people are really prepared to go that far? When it comes to the existence business, most people think that some things got left out. But what? And why those things?

The third theory is that some sort of divine selection operates. In crude terms, this theory says that God, or a set of gods, determines both boundaries A and B. In Christian theology, God either transcends the set of existing things or embeds it as a subset. But now there is a further mystery and another boundary: the boundary between the actually existing God and the set of all possible gods.

Turtle Power

There is a famous story (attributed by some to Bertrand Russell, by others to the nineteenth-century American philosopher William James) about a lecture on the nature of the universe. Partway through the talk a woman at the back stands up and denounces the lecturer, claiming that she knows how the universe is put together: the Earth rests on the back of a giant elephant that stands on the back of a giant turtle. The bewildered lecturer responds by asking what the turtle is standing on. "You may be very clever, young man," the woman shoots back, "but you can't fool me. It's turtles all the way down!" (see Figure 29).

This lighthearted anecdote illustrates a seemingly unavoidable problem that confronts attempts to give a complete account of reality: how to terminate the chain of explanation. In order to "explain" something, in the everyday sense, you have to start somewhere. To avoid an infinite regress — a bottomless tower of turtles — you have at some point to accept something as "given," something that other people can acknowledge as true without further justification. In proving a geometrical theorem, for example, one begins with the axioms of geometry, which are accepted as self-evidently true and are then used to deduce the theorem in a step-by-step logical argument. Sticking to the herpetological metaphor, the axioms of geometry represent a levitating super-turtle, a turtle that holds itself up without the need for additional support (see Figure 30). The same general argument applies to the search for an ultimate explanation of physical existence.

The trouble is, one man's super-turtle is another man's laughingstock. Scientists who crave a theory of everything with no free parameters are happy to accept the equations of that theory for example, M theory) as their levitating super-turtle. That is their starting point. The equations must be accepted as "given" and used as the unexplained foundation upon which an account of all physical existence is erected. Multiverse devotees (apart perhaps from Tegmark) accept a package of wonders, including a universe-generating mechanism, quantum mechanics, relativity, and a host of other technical prerequisites as their super-turtle. Monotheistic theologians cast a necessary God in the role of super-turtle. All three camps denounce the other's super-turtles in equally derisory measure. But there can be no reasoned resolution of this debate because at the end of the day one super-turtle or another has to be taken on faith (or at least provisionally accepted as a working hypothesis), and a decision about which one to pick will inevitably reflect the cultural prejudices of the devotee." You can't use science to disprove the existence of a supernatural God, and you can't use religion to disprove the existence of self-supporting physical laws.

Many People Think the Universe Absurd

The root of the turtle trouble can be traced to the orthodox nature of reasoned argument. The entire scientific enterprise is predicated on the assumption that there are reasons for why things are as they are. A scientific explanation of a phenomenon is a rational argument that links the phenomenon to something deeper and simpler. That, in turn, may be linked to something yet deeper, and so on. For example, the changing shape of the moon from crescent to full and back again is explained by the motions of the bodies in the solar system, which are explained by Newton's laws, which are subsumed in Einstein's general theory of relativity, which it is to be hoped) will emerge one day from a theory of quantum gravity such as string theory. Following the chain of explanation back (or the turtles down), we see that there are indeed rational reasons for why the moon changes shape, but when we reach the putative final theory — the super-turtle what then? One can ask: Why that unified theory rather than some other? Why a unified theory that permits a moon? Why a unified theory that permits sentient beings who can observe the moon? One answer you may be given is that there is no reason: the unified theory must simply be treated as "the right one," and its consistency with the existence of a moon, or of living observers, is dismissed as an inconsequential fluke. If that is so, then the unified theory — the very basis for all physical reality — itself exists for no reason at all. Anything that exists reasonlessly is by definition absurd. So we are asked to accept that the mighty edifice of scientific rationality — indeed, the very

mathematical order of the universe — is ultimately rooted in absurdity! There is no reason at all for the scientific super-turtle's amazing levitating power.

A different response to such questions comes from the multiverse theory. Its starting point is not a single, arbitrary set of monolithic laws, with fluky, unexplained bio-friendliness, but a vast array of laws, with the life factor accounted for by observer selection. But unless one opts for the Tegmark "anything goes" extreme, then there is still an unexplained super-turtle in the guise of a particular form of multiverse based on a particular universe-generating mechanism and all the other paraphernalia. So the multiverse likewise retains an element of arbitrariness and absurdity. Its super-turtle also levitates for no reason, so that theory too is ultimately absurd.

Monotheistic theologians, for whom God plays the role of super turtle, have had longer to think about this problem. They believe, or at least some do, that the threat of ultimate absurdity is countered by positing that God is a necessary being. As I explained earlier in this chapter, this is an attempt and one that is not obviously successful) at describing a "self-levitation" mechanism — God explains God's own existence — without which we would be right back to arbitrariness, reasonlessness, and absurdity: if God exists reasonlessly, then the theistic explanation is also absurd. Whatever the dubiousness of the notion of a necessary being at least the theologians have had a serious go at explaining how their super-turtle levitates rather than claiming that it happens for no reason.

The Ultimate Explanation of the Universe Should Be Simple

It would appear that each of the three positions I have discussed threatens to be ultimately absurd and requires us to accept a starting point based on faith: a set of mathematical laws, a multiverse with bylaws, or God. How are we to decide between them? At this point, "the argument from simplicity" is often invoked. Martin Gardner uses simplicity to argue for God over the multiverse: "Surely the conjecture that there is just one universe and its Creator is infinitely simpler and easier to believe than that there are countless billions upon billions of worlds."" The theologian Richard Swinburne has also argued that an infinite rational God is a simpler starting point than either an unexplained multiverse or a single ordered universe and therefore constitutes a preferable starting point in the chain of reasoning. However, Richard Dawkins has used the simplicity criterion to argue precisely the reverse, declaring that "you can't get much more complex than an Almighty God!" On the face of it, Dawkins has a point: an infinite mind (that is, the traditional monotheistic God) looks to be infinitely complex and not simple at all. But the same criticism can be leveled at an infinite multiverse, which requires an infinite amount of unverifiable information to specify it.' If it boils down to a choice between an infinite unseen God or an infinite collection of unseen universes, which explanation is the simpler? It seems to me that the traditional God of monotheism and the standard model of the multiverse are about equally complex in this regard. The hands-down winner in this "simpler-than-thou" three-way contest would be the unique-universe, no-free-parameters theory — if such a theory exists, and if (it's a big if) it turns out to be the hoped-for simple and elegant description and not an unholy mishmash of complex mathematics.

It should be clear from this chapter that all three attempts to explain the world completely — two scientific and one theological — eventually hit a wall, and demand that something truly huge be accepted on faith alone. So is that as far as we can go? Have we reached the final limits of reasoning, with no clear answer in sight? I don't think so. I set out in this book to address the question of why the universe is bio-friendly. I now want to take a deeper look at the "bio" part. In the discussion so far, life and observers have been cast in a purely passive role. In the multiverse theory, for example, they exist in some universes and not in others, and therefore (without doing anything other than what they normally do — that is, living and observing) they allegedly explain cosmic bio-friendliness. So long as life and mind are treated in this manner, as simply an incidental byproduct of nature, then the mystery of existence will remain forever that — a mystery. But there

is another avenue we can explore, one in which life and mind are not just carried along for the ride but play an active role in explaining existence.

Key Points

- This chapter contains more of the author's personal opinions than the earlier chapters.
- In some respects, such as its strange fitness for life, the universe appears designed. Some people suggest that it is. Invoking a supernatural designer, however, opens up its own as-yet-unsolved philosophical issues about the designer's nature, origin, uniqueness, necessity, and relationship to time.
- It is important to distinguish between design in the laws of physics and design in objects or in systems such as biological organisms. The appearance of design in organisms has a testable scientific explanation based on Darwin's theory of evolution.
- The appearance of design in the laws might be explained by hypothesizing a multiverse with "anthropic" selection. However, a multiverse is not a complete explanation of existence because it still requires some unexplained physical laws.
- Some scientists pin their hopes on a complete "theory of everything" that would explain the universe without invoking observer selection effects. If such a theory were correct, the bio-friendliness of the universe would be a lucky coincidence. However, the existence of a unique final theory is very doubtful.
- Unless everything that can exist does exist, something still unexplained must separate what exists from what doesn't.
- To avoid an infinite regress of tower of turtles, something must be accepted on faith, even in scientific accounts, but that something should be as simple as possible.
- We are not finished yet!

2006
Matt Evans
The planets which move in their regular form
Times and Seasons Blog

Do all things denote there is a God? Do the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form, witness that there is a Supreme Creator?

Or is the argument for Intelligent Design bunk?

Yes, the lead is deliberately provocative. The central premise of intelligent design is the same teleological argument used by Alma: the complexity and order of life and universe prove the existence of a Supreme Creator / Intelligent Designer. What are we to make of Alma's claim? What seems especially striking about Korihor's confrontation with Alma is that he seems to cement his demise by rejecting Alma's testimony, and it doesn't seem fair to have his eternal spiritual welfare hinge on his accepting a fallacious claim. It also seems hard to deny that Alma is inspired when he testifies on behalf of intelligent design, as he strikes Korihor dumb in God's name moments later, leading even Korihor to acknowledge that "nothing save it were the power of God could bring this [curse] upon me." Finally, Alma invokes the teleological argument as deducing God's presence without relying solely on faith, suggesting that Korihor can only deny the soundness of the observable evidence of God's existence by stubbornly and categorically refusing to acknowledge God.

I understand the arguments against the teleological argument (nature *is*, it has no purpose; infinite regression of designers), but I tend to think that God reveals his fingerprints in the plain-reading of his creation. He's found and understood by children better than learned men who think they are wise. For that reason I wonder if our spirits, by nature, so to speak, recognize nature's divine purpose and order, and wonder if we lose that capacity only through intense indoctrination in the theories of men, theories which lead most to imagine that the mysteries are punctured by scattered discoveries of proximate causes.

So getting back to the beginning, in a less-than-orderly fashion, does the motion of the earth and planets denote there is a God?

This entry was posted on Wednesday, January 4th, 2006 at 12:02 am and is filed under Cornucopia and is tagged with LDS. You can follow any responses to this entry through the RSS 2.0 feed.
59 Responses to "The planets which move in their regular form"

1.
sarebear
1/4/2006 at 12:27 am

I believe, and feel, deeply in my soul and entire being, that yes, nature does indeed testify of God.

It is one of the few, or maybe even ONLY, things, experiences, sights, wonders, what-have-you, that can, within half a minute or so, calm everything whirling about inside me.

Now, if I only lived outside 24/7, then I guess my diagnoses wouldn't be much of a problem! I need to go out more, I stay inside like a hermit too much!

I love, love, LOVE the outdoors, nature, the splendor thereof, the FEELING in my heart, my bones, my SPIRIT; the feeling in the ESSENCE of who I am, that I feel God's signature everywhere . . . .

Even in places some might deem ugly, like the expanse of desert and dry, brown mountains and hills between St. George and Las Vegas; I feel Him there.

A simple sit out on the front steps in the sunshine on a fall day, with the faintest tang of fall chill and scent in the air, and the tips of the leaves just teasing with a drop of color; the whisper of a breeze holding autumn's promise, with the quiet warmth of the sun entering my soul . . . . . even this alone speaks to me of God's marvels.

The grandeur of the Tetons and Yellowstone country, to the sere dusty lakebeds along the desert drive to California, to the forests of the Hudson River Valley, to the spread of plain stretching beyond horizons in Kansas, I feel Him everywhere. My heart and soul beat in rythym with the waves upon the seashore, and the pounding rythyms of Niagara's falls; He is glory, and these things testify to me of it.

Thank you for this post. It has reminded me of the soulful peace and sensations that are but a step outside my door.

2.
sarebear
1/4/2006 at 12:33 am

Woops! I guess I didn't really speak to the earth and planets thing, but DEFINITELY. Here is a post I wrote, that pulls together in one place some fantastic images from the spacecraft Cassini, of Saturn and it's moons, with some unusual perspectives.

To me, the motions of the planets, stars, and galaxies; the images of nebulae such as the one I posted about and included re: Christmas; to me, this dance of elegance, fury, and magnificence is also a testimony of our Creator. (Scroll up and down to get the top of the post to show; stupid template often screws up with photos).

3.
sarebear
1/4/2006 at 12:34 am

Arg. its, not it's. (Pet peeve).

4.
Ariel
1/4/2006 at 1:09 am

Does the complexity of creation prove that there is a god? No.

Does it testify of God, and give one an opportunity to invite the Spirit into one's heart, and know for certain through that proof? Yes.

5.
DHofmann
1/4/2006 at 1:35 am

"…the complexity and order of life and universe prove the existence of a Supreme Creator / Intelligent Designer."

"Anyone can make the simple complicated. Creativity is making the complicated simple." –Charles Mingus

So no, I don't think a truly Supreme Creator would make anything complex. Maybe it just takes a bigger mind than yours or mine to comprehend the simplicity of the universe.

But to answer the question at hand, does the universe prove the existence of a Supreme Creator? It could be that, or it could be the Big Bang. It's hard to tell, but I'm pretty sure it's one of the two.

6.
Otto
1/4/2006 at 9:28 am

Matt,

I think the problem with your provocation, and with the entire thrust of the I.D. argument, is that it insists a mutual exclusivity between "creation" and "proximate causes." Would Alma have been crestfallen if someone had explained to him the "proximate causes" of heavenly motion — mechanics of gravity and orbits? Mormons, of all people, should be interested in "proximate causes," believing, as we do, and as Jim F. so poignantly put it once, that "God exists in the world in something like the way we do." We believe God's creative power resides in him mastery and

accumulation of “proximate causes,” not his transcendence of them. The thing that turns me off to the I.D. movement, even though nature certainly does denote to me that there is a God, is that it treats belief in God like a belief in Santa Claus: be careful, because if you think too hard about the mechanics, you’ll realize the implausibility. Evolution has no interest in disproving God, but, to the religious person, explaining his methods. It can accommodate a religious worldview without insisting upon it.

Also, applying “I.D.” to astronomy has much different ramifications than it does in the realm of biological evolution, since, at least in the post-Galileo era, the hermeneutics of the heavens aren’t so religiously and politically volatile as the hermeneutics of Darwinianism. I think it’s a little disingenuous to recruit Alma to the current I.D. cause.

7.
Julie in Austin
1/4/2006 at 9:28 am

I think the reason that I dislike ID (while, with Alma, essentially thinking it is true) is because ID is a trojan horse designed to sneak creationism into a place where it has been (rightfully) kicked out. Satan’s favorite trick is mixing truth and error, and here he’s done it in spades with ID by combining a basically true idea with a nasty, grasping, politically-motivated agenda. Those who accept ID’s agenda take their truth with a chaser of guile and those who reject it because of the guile often end up rejecting the truth it contains without consciously articulating why.

8.
enochville
1/4/2006 at 9:51 am

Matt – I do believe that God created the heavens and the earth and life upon the earth, etc. And I especially believe in Ariel’s statement. Perhaps, I am misinterpreting your comment, but it seems to me that you are equating the belief that God created the planets, stars, and life with the theory of Intelligent Design. If that is what you did, nothing could be further from the truth. I believe that the earth was designed intelligently by the Gods before the physical creation started, but I wholeheartedly reject the theory of Intelligent Design. If that seems incomprehensible to you, then I don’t think you are familiar enough with the theory of I.D.

“Intelligent Design” has an intelligent Designer intervening / interfering with the natural process of evolution at several critical junctures. There are many reasons for people who believe that God is the Creator to reject I.D. Some may because they reject evolution entirely. Others may because they believe God used natural laws to start creation and then let it take its course without having to interfere. I feel that I.D. was cooked up by religious people who are trying to “steady the Ark”. God can fight his own battles, he does not need his believers to claim he created the world someway that he has not revealed. When I.D. is demonstrated to be incorrect it will make believers in God look like idiots needlessly because God never claimed he performed the creation the way the theory of ID puts it.

It is fun to speculate how creation was done. I do it to. But, we need to remember to not confuse the theory of Intelligent Design with the belief that God created the heavens and the earth. And we need not consider Intelligent Design a science or teach it in a science class (you did not suggest that, but I live in Kansas and I am tired of the IDer’s forcing their theory into our state’s science curriculum). Here is a link to interesting attempts to reconcile LDS scriptures with scientific discoveries in the origin of life on earth:
http://www.nauvoo.com/ubb/forum/ultimatebb.php?ubb=get_topic;f=4;t=000736

9.
Jared
1/4/2006 at 10:17 am

I believe that all things testify of him (other scriptures make that point), but what is the content of that testimony?

Interestingly, the Lectures on Faith say:

"…it is necessary to go back and show the evidences which mankind has had, and the foundation on which these evidences are, or were, based since the creation, to believe in the existence of a God. We do not mean those evidences which are manifested by the works of creation which we daily behold with our natural eyes. We are sensible that after a revelation of Jesus Christ, the works of creation throughout their vast forms and varieties, clearly exhibit his eternal power and Godhead." (Lecture II, emphasis added)

This is different from how we usually think of it. But even in the confrontation between Alma and Korihor, Alma cites the testimony of the scriptures and the prophets before invoking "all things."

10.
Otto
1/4/2006 at 11:00 am

Fantastic quote, Jared. I'm filing that one away for future use…

11.
Christian Y. Cardall
1/4/2006 at 11:08 am

Manual trackback to this post, since Blogger lacks trackbacks. There are questions as to whether Alma's argument is consistent with Joseph Smith's mature views on the nature of God, and also with the ancient Hebrew worldview from which Nephite culture sprang.

12.
Matt Evans
1/4/2006 at 11:10 am

Thanks for everyone's comments. I don't have much time for blogging today, but wanted to quickly answer some questions.

Ariel, I like your formulation. If the natural order does not prove but testifies of God's existence, what is the nature of that gap separating them?

Otto, I have a different perspective of ID. Rather than reassure believers that God's work couldn't be done by man, it warns non-believers not to foolishly think that their finding a few proximate causes means no one with "mastery and accumulation of proximate causes," as you put it, is guiding the whole process. (By including his testimony that "all things upon the face of [the earth]" denote a God, I don't think we can distance Alma from the biology-focused teleological argument ID rests upon.)

Julie, is it Alma or Darwinians that "combin[es] a basically true idea with a nasty, grasping, politically-motivated agenda"? (Which combination appeals to those convinced the world would be better without religion?) I fail to see how Alma's, or ID's, insistence that the natural order testifies of a Supreme Creator or Intelligent Designer, is "nasty" or "grasping."

Enochville, Alma doesn't say he "believes" God created the universe, he says that the nature of the universe, and life on earth, *denotes* *witnesses* and is a *sign* of God's existence in the same way the scriptures and prophets do. One can reject the testimony of the scriptures, prophets and nature, but it doesn't mean they aren't speaking clearly.

Jared, that's an interesting quote. Can you post it in its entirety, because from this part it appears that the speaker and hearer assume there are "evidences" for God from natural observations. The sentence you emphasize seems to say that once one has a testimony of Christ and recognizes him as Creator, the variety of the natural world is evidence of his great power, and not that one needs a testimony to see evidence for God in nature. (Hopefully the entire quote will shed light on this distinction.) Regarding the ordering of Alma's chain of testimony, I read him to be ending his argument with the evidence of earth as a way of emphasis, "Heck, you don't even need to accept the human-based witnesses of prophets and scriptures, who can lie. *Even* earth and space, for crying out loud, say exactly the same thing." (My reading is based on his introducing the clause with "even the earth . . . ")

13.
Otto
1/4/2006 at 11:46 am

Matt,

[I.D.] warns non-believers not to foolishly think that their finding a few proximate causes means no one with " mastery and accumulation of proximate causes," as you put it, is guiding the whole process.

I find it amusing that the advocates of ID have been trying so very hard to distance themselves from the rhetoric you're using–i.e., the "foolishness" of "non-believers." Non-believers in what? The I.D. folks won't even say the G word, in order to come across as scientific and objective.

By including his testimony that "all things upon the face of [the earth]" denote a God, I don't think we can distance Alma from the biology-focused teleological argument ID rests upon.

Fair enough. But if all things denote there is a God, it would seem that uncovering more "proximate causes" would result in more evidence of his existence. In other words, the hermeneutics of nature would do their testifying by themselves, without help from the I.D.ers, who take the opposite tack: pointing at the gaps in scientific knowledge as evidence of God.

This strategy would seem to me to undermine God's purposes and His work. If belief in God is too dependent on the mystery of his methods, that belief unravels when those methods become demystified. For example, if I believe that God, in some mysterious and unfathomable and unquantifiable way, keeps the earth in rotation around the sun, and my belief rests on the idea that only God can account for the mysterious, unfathomable, and unquantifiable, and that's what makes him worth believing in, what happens when I learn about gravity and orbits, etc.? Seems to me that Creation's power to testify comes from a sense of _aesthetic_ wonder, not from science's (ever-decreasing) inability to provide explanations about methods — or, as you say, "proximate causes."

When the school board in Kansas recently reworded their science curriculum, they changed their fundamental definition of science. They removed the phrase describing science as "searching for natural explanations of observed phenomena." Which, one can only assume, means that they want to leave the door open for "supernatural explanations." I.D. encourages sloppy science. That doesn't do God any good. He doesn't need that kind of help.

And that's where I think I.D. fails in general, and fails Mormons in particular. As people who profess a belief that God is embodied and that spirit is a refined kind of matter, we don't really have a place for the "supernatural" in our theology, but rather a place for the "yet-to-be-explained." And the consensus, from the brethren (not to mention from the science faculty at BYU, who have lobbied strongly against I.D. to the Utah legislature), seems to be to step back and let the scientists work on the explaining. There's no reason that has to interfere with people finding the divine through the microscope or telescope, after the manner of Alma. And the idea of taking a teleological argument (i.e., the universe was designed by a Designer with a Purpose) and turning that into the teleological methodology of I.D. (i.e., science should be designed to give God due credit for Creation) threatens to weaken the scientific enterprise. Steadying the ark indeed.

14.
JWL
1/4/2006 at 11:49 am

You're mixing apples and kumquats. The so-called "Intelligent Design" theory is a counter-attack on biological evolutionary theory which argues that there are aspects of life so complex that they could not have risen from natural selection alone. Alma's argument does not really mention the complexity of life which is the focus of the evolution vs. ID debate. He is going to a deeper level — his point is that that there is life at all denotes that there is a God ("ALL things that are upon the face of [the earth]"). The idea that God got life started and then let evolution run its course would be compatible with Alma's argument but not with modern ID theory. Alma then turns to astronomical phenomena, which also goes beyond the scope of modern anti-evolution ID theory.

Interestingly, modern cosmology has discovered a large number of fundamental physical constants in the universe. The values of these constants seem to be quite arbitrary, they do not follow necessarily from any understanding we have of physics. However, if these constants varied by even minute degrees, our life-bearing universe would be impossible. For example, if the balance between the force of gravity and the electromagnetic force were to vary by even one part in a million neither atoms or galaxies could exist, let alone life. Nor would "all the planets … move in their regular form." One can not say that these PROVE that there is a deistic influence in the universe's creation, but they certainly make the cosmological argument credible as one WITNESS of God's presence in the universe, which is how Alma uses the cosmological argument. Many scientists acknowledge the wonder of this apparent "fine tuning" of the universe necessary to the appearance of life (e.g. Stephen Hawking) who wouldn't give a half second's notice to the pseudo-scientific phumpherings of the ID opponents of biological evolution. Alma (and we) are in a much stronger and more sophisticated position in opposing modern korihorism than the Intelligent Design lobbyists.

15.
Todd
1/4/2006 at 11:49 am

A few thoughts–I hope not too tangential:
I reject ID because it is attempting to prove a Designer–prove God…which to me is a violation of the faith premise for the test of mortality.

I appreciate Jared's quote–I tend to agree. For most of science–true believers see the wonder of it all and feel more at one with God. Non-believers marvel at the complexity, but are more in awe of man's ability to figure it out rather than it testifying of some supreme being. For the so-called believers, evolution is an exception to this for much of sectarian Christianity–but there are those who are not in any fundamental conflict over it. For LDS members, it's maybe easier–I appreciate the comment that we will learn things that "no man had supposed" during the Millennium. Maybe evolution will be shown to be false, or maybe it will be devastatingly, disturbingly correct to an extent that shakes us. I'm sure I will be surprised about the actual answer, regardless.
As for me, the wondrous complexity does testify of a supreme being, without adding explicit proof. And man's ability to figure it out is both a testimony of Divine Provenance and the fact that we are the offspring of God.

16.
Jared
1/4/2006 at 11:53 am

(hat-tip to Jeff Gilliam, who pointed out this quote to me.)

I took the text from here.

[Lec 2:1] Having shown in our previous lecture "faith itself – what it is," we shall proceed to show secondly the object on which it rests.
[Lec 2:2a] We here observe that God is the only supreme governor and independent being in whom all fullness and perfection dwells;
[Lec 2:2b] who is omnipotent, omnipresent, and omniscient;
[Lec 2:2c] without beginning of days or end of life;
[Lec 2:2d] and that in him every good gift, and every good principle dwells;
[Lec 2:2e] and that he is the Father of lights.
[Lec 2:2f] In him the principle of faith dwells independently;
[Lec 2:2g] and he is the object in whom the faith of all other rational and accountable beings centers for life and salvation.

[Lec 2:3a] In order to present this part of the subject in a clear and conspicuous point of light, it is necessary to go back and show the evidences which mankind has had,
[Lec 2:3b] and the foundation on which these evidences are, or were, based since the creation, to believe in the existence of a God.
[Lec 2:4a] We do not mean those evidences which are manifested by the works of creation which we daily behold with our natural eyes.
[Lec 2:4b] We are sensible that after a revelation of Jesus Christ, the works of creation throughout their vast forms and varieties, clearly exhibit his eternal power and Godhead.
[Lec 2:4c] Romans 1:20, "For the invisible things of him from the creation of the world are clearly seen, being understood by the things that are made, even his eternal power and Godhead."
[Lec 2:4d] But we mean those evidences by which the first thoughts were suggested to the minds of men that there was a God who created all things.

The lecture goes on to establish that it was God's interaction with Adam and the transmitting of that knowledge from parent to child that gave man a knowledge of God. I think it could be read a couple of ways–I tend to agree with your first suggestion. It is not as strong as "you can't see evidence of God in nature until you have a testimony," but it sure does not put nature first in regard to the initial idea that God exists. But ID proponents make just that argument–that in the absence of any idea that a designer exists, his/her/its existence can be inferred by examining certain aspects of nature.

17.
Otto
1/4/2006 at 12:01 pm

JWL: I would like to take this opportunity to thank you for introducing me to the word "phumphering."

Todd: I agree with your comment except for the phrase "Non-believers marvel at the complexity, but are more in awe of man's ability to figure it out rather than it testifying of some supreme being." The non-believer scientists I know aren't "more in awe of man's ability to figure it out"–they truly wonder at nature, in a way I think not entirely unlike Alma. I detect in their wonder at creation something vaguely religious and spiritual, although they might not call it that. The difference is that their awe simply doesn't translate into a desire to assign credit to someone–neither to God, for creating, nor to man, for deciphering. To be sure, there's professional admiration, just like in any field, but I don't think the epiphany of a non-believer squinting through a telescope has anything to do with that.

18.
Matt Evans
1/4/2006 at 12:08 pm

Christian,

Thanks for your extended comment at your site. Quickly, I don't think there's need to argue that Alma's statement is another Book of Mormon anachronism. (From your argument that Joseph was speaking and not Alma, I assume that you don't believe the BoM is a historical record and is a narrative expressing Joseph's ideas, or God's ideas through Joseph? (Though if you think Alma's statement is incorrect and represents Joseph's immature thinking, that rules out Joseph's introducing God's ideas into the story.))

More importantly, I believe it's wrong to assume that the Mormon doctrine positing God's being subject to laws to mean that he's subject to the laws of *our* universe. I believe he used laws from his sphere to create the laws in ours.

19.
Rob
1/4/2006 at 12:35 pm

I was an anthropology undergrad at BYU, and managed to get through my entire experience there, including a class on human evolution, as a non-believer in evolution. However, after getting out of school, I wanted to look at evolution in more depth. I read a lot. I dug up dinosaurs and worked in the Smithsonian. I enrolled in some post-bac classes in evolution, genetics, and ecology at another school. Then I went to grad school. Through all this close evaluation of the evidence, I finally got what I didn't get in Sunday School–a clear and overwhelming vision of how the earth came to be. I find attacks on evolutionary theory to be sad, and wish everyone would take a couple years to study evolution before attacking it. It is as amazing as the starry skies that inspired Alma.

For me, I find that all things help confirm that there is a God. That means quantum physics, astrophysics, evolutionary ecology, etc. They don't prove to me that there is a God–I take personal and modern-day revelations as my evidence for that. But they do help me get closer to God and to appreciate the nature of the world that He has set up for us to participate in. I still have lots of

unanswered questions, but I have no trouble affirming a belief in God and an appreciation for an ancient earth and long lines of family history that include non-human ancestors.

I think that we Mormons are in a great position to reconcile belief in God with modern scientific understanding. I'm glad we have more evidence for how the earth came to be than did the ancient biblical writers, and more info on other dimensions of reality than some modern scientific researchers. I cringe whenever I hear someone in Sunday School say we didn't come from no monkeys, just as I'd cringe if I ever heard one getting caught up in the ID debate. As Hugh Nibley liked to point out, we have much more info and are in a much better position in regards to evolution and creation than our more Evangelical neighbors.

I have seen the entire universe in a baby turtle's eye…including the hand of the Almighty.

20.
Matt Evans
1/4/2006 at 12:36 pm

Otto (Comment 13), the understood object of the common words "believer" and "non-believer" is God, no one's trying to pretend otherwise! And it's undeniable that many people who have concluded that their ability to learned evolutionary theory means they are wise enough to reject God's counsels, and that is, indeed, foolishness.

I don't believe there's a difference between our "yet-to-be-explained" and the common use of "miracles" or "supernatural." Mormons don't believe science can discover the ways of God, and I don't believe any Mormon scientist claims that his methods could someday explain how God hears and answers prayers. Nor do I believe any evangelicals believe that God's ways could never be explained, even by God. They believe God's power has reasons for it's being, even if we don't yet understand them.

JWL, I'm more interested in the teleological argument, which Alma makes, than I am in its incarnation as ID. I don't know much about ID, and don't really have any interest defending it. I do know enough, however, to know that is rooted in the teleological argument, and I'd bet dollars-to-donuts that ID advocates welcome arguments like yours from cosmology. (And I don't understand why you find compelling a God of the gaps in cosmology but not biology. What difference does it make what branch of science we're studying when we attribute the unexplainable to God?)

Jared, thanks for the providing the whole quote. (It seems Christian's attack on Alma 30 applies here, given that it describes God as an "omnipotent" and "independent being" — ideas incompatible with Christian's conception of Joseph's refined views of a God constrained by laws.)

21.
Matt Evans
1/4/2006 at 12:40 pm

Rob,

Just to clarify, I believe and accept evolution generally. What I'm most interested in here is whether Alma was right to argue that all things denote their is a God, i.e., have you really seen the hand of God in the eye of a turtle, or were you just projecting your religious worldview onto something that simply *is*.

22.

Rob
1/4/2006 at 12:58 pm

Matt,
I'm not sure that this question is answerable. Surely, for the believer, all things denote that there is a God. For the nonbeliever, there be no such evidence. For me, I sense that there are aspects and dimensions to reality that I can't easily see, taste, hear, or smell. The revealed gospel helps me sense these, and I sense additional confirmation through my experience with the natural world. Without the revelations, without the revelation of Christ mentioned in the Lectures on Faith, I might not have the same experience.

23.
Rob
1/4/2006 at 1:09 pm

BTW, I got a program for my Palm a couple months ago that plots the planets and all the stars of the night sky for any place and time. I've also studied Ancient Mayan cosmology, in which the regular movement of the planets were very, very important to their understanding of the universe. Like sarebare (#1 and 2), I wonder if our modern inside-all-day-and-night lives are distancing us from God. I love reading the anthropological works that give insight into how other people experience nature and spirit. In my own limited way I hope to live Brigham Young's injunction to seek out all the knowledge of the world and bring it back to its foundation in the gospel of Christ. Without that foundation, that revelation, it is just interesting information. With it, all things find their proper place, and denote that there is a God.

For us LDS, God is a material reality that we can interact with. Just as it may take hundreds of millions of dollars to create a super collider to enable us to interact with the traces of subatomic particles, it may take a similar high price in personal righteousness to be able to interact meaningfully with God. But just as we can interact with everything made up of subatomic particles without knowing they are there or building a super collider, we can interact with the world God created, and knowing He is there, come to a greater understanding of the universe and our place in it.

24.
Otto
1/4/2006 at 1:12 pm

the understood object of the common words "believer" and "non-believer" is God, no one's trying to pretend otherwise!

I'm sorry, Matt, but the ID movement goes to great lengths to pretend otherwise, and that's one of the reasons I find it so disingenuous. It has a collusion of plausible deniability going on with the Christian far-right. ID assumes the role of pointing out a gap in modern science, but claims to do so under the guide of "objectivity" not faith. It uses the rhetoric of "design detection," but tries to maintain science cred by avoiding speculation on who/what the Designer might be. It then turns its back and whistles innocently while the evangelicals in Kansas and elsewhere jump in and fill the gap with God.

Go to http://www.intelligentdesignnetwork.org/. Do a page search for "God." You won't find him. To quote from the page: "ID proponents believe science should be conducted objectively, without regard to the implications of its findings." In other words, it sneaks religion into science by saying

that it's anti-God ideology that has sullied science's objectivity (as part of their effort to bend science with pro-God ideology), and it's "objective" science that points up the inexplicable gaps.

Mormons don't believe science can discover the ways of God.

Maybe not all of them. But if we don't believe science can discover _some_ of the ways of God, what is it exactly that we think scientists do discover? To whom do we (as Mormons) attribute the things science reveals? Have you read Eric Robert Paul's _Science, Religion, and Mormon Cosmology_? The book suggests that for Mormons science is inherently a spiritual undertaking (and the implication that I take from that is that for many if not most Mormon scientists, that inherent spiritual content obviates the need to dress science in religious rhetoric or bend it to religious ends). The frontispiece of the book says it all. It reads "And God said…" followed by a page's worth of mathematical formula, ending with "And there was light."

If, as you said to JWL, you're more interested in "the teleological argument" than defending I.D., this thread could go in an entirely different direction. But by aligning yourself and Mormon scripture with I.D. in the original post you've assumed a lot of very problematic baggage from the I.D. movement.

The problem with the ID "God in the Gaps"

25.
Otto
1/4/2006 at 1:20 pm

woops…

As I was saying… the problem with "God in the Gaps" is twofold: 1) it carries an inherent injunction to avoid filling in the gaps — otherwise where will God go?; and 2) it suggests that the only place God can inhabit is the gaps in science — rather than Creation as a whole, humanly fathomed or otherwise. It relies, essentially, on the idea of an unembodied God — flexible and immaterial enough to serve as the mortar in the tesselations of terrestrial science.

Alma didn't see God in the heavenly motions because he was at a loss to explain them otherwise, Alma saw God there because they're beautiful.

26.
will
1/4/2006 at 1:31 pm

Otto, I think it's pretty likely that Alma was at a loss to explain them otherwise, since:

A) He offered them as evidence of God
B) There was no other explanation available back then

27.
Jack
1/4/2006 at 2:15 pm

Matt,

I think we need to remember that Korihor, after he was struck dumb, did acknowledge that he always knew there was a God. This seems to indicate (to me) that the knowledge of God was not forced upon him by Alma's appeal to "ID," or what have you. The simple truth was that Korihor was a liar. Alma knew that Korihor had been instructed in the ways of God and, therefore, in some measure, possessed an understanding similar to his own regarding the creation.

28.
sarebear
1/4/2006 at 2:57 pm

I don't really know what the theory of I.D. entails, but for myself, I believe that God uses natural processes to accomplish his works; nature itself is in harmony with the purposes of God. It serves to glorify Him, as well, I believe, and it does so in part because it works as it "naturally" does. And that the very nature of Nature, is, I think, well, words just failed me know. Concepts, even. And heck, the hubris of my even trying to sum up the nature of Nature, and how it relates to God, in one sentence.

Well, perhaps not hubris, but one little ant trying to "see" the whole of a canteloupe. Just couldn't do it.

Hrm. Now I feel REALLY, really small. Lol!

I think Nature works with God (not how an artist works with clay, but rather, how a system, a network, works with those whom directed its assembly, its purpose, its focus. The world around us works to the dictates of Nature, and Nature is the conductor of the symphony. God is the patron of the Nature symphony; he provides the funding, he gets the ball rolling, and the ball, or Nature, works according to its own nature, which is in harmony with the purposes with which God has in mind for it, because I feel the very definition of any tool or process that or of which God uses and chooses to use, means that it is perfectly suited to His need and use. The purposes for which Nature works to its own ends, it thus works to God's ends. God works with Nature, and Nature works with God, but God is the source, the benefactor, the contributing funder, the beginner of all things.

I'm not necessarily saying that he just said, "Begin", and left it at that, but at the same time there is a certain beauty in Him knowing that the processes were suited to what He required of them . . . . it is, of course, for Him to do however and whatever He sees fit; and I have no problem with the idea that He might stir the pot from time to time, or add a dash of this or that. Or bring the "this or that" together, so that they would then combine in the ways that Nature does.

Anyway, I don't know if this makes any sense to y'all. I've never really crystallized my thinking on this (these) issue(s) before! Interesting discussion.

29.
Ryan
1/4/2006 at 4:32 pm

"I don't believe any Mormon scientist claims that his methods could someday explain how God hears and answers prayers"

I will say this: Having communication tools such as cell phones and the internet and their associated technologies certainly makes the answer to whether he possibly could hear and answer prayers much less of a faith based proposition (at least for me anyway) than it would have been 200 years

ago. Perhaps this little parcel may serve as a micro-example of our current comprehensive knowledges of the cosmos and the hand of God in such.

30.
enochville
1/4/2006 at 4:33 pm

Here is the quote we are discussing: “all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator (Alma 30:44).

I believe that all things denote that there is a God to those who have faith to see it. To those who don’t have faith, they denote nothing to them one way or the other. However, since the earth and the planets were in reality created by God, they will always stand as a witness of God. But, since alternative explanations can be created for their existence, their witness is not conclusive.

31.
sarebear
1/4/2006 at 4:38 pm

I agree, enochville.

Heck, even if an angel came down and told people, it wouldn’t convince some. Look at Laman and Lemuel, when they saw an angel. Didn’t affect them much, lol!

32.
Todd
1/4/2006 at 4:44 pm

Otto: Point taken, I was think more like a research engineer (which I just about am) and less like a natural scientist. I stand in awe at nature but also at the ingeniousness of solving a complex problem.

Matt (w/Otto’s comments): “Mormons don’t believe science can discover the ways of God.”
I think many Mormons do secretly hope that, or possibly that they can find proof of God….but my reading of the doctrine is that God does not desire to be discovered via methods of normal scientific inquiry… e.g. hypothesis, logic, repeatable experiments. There is no “God Particle”…to borrow a book’s title.

That said, I think there’s a pretty good scientific case for deducing that the most plausible scenario for the origins of the Book of Mormon are exactly what Joseph Smith says it was. Occham’s razor…when all the facts we know today are taken into account, Joseph’s is actually the simplest. And that is an interesting anomaly…a mind puzzle of sorts.

33.
Christian Y. Cardall
1/4/2006 at 4:59 pm

Matt, I hope this doesn’t become a threadjack, but by way of answering your direct question in #18: I’m not settled about the historicity of the Book of Mormon. I think there are some nontrivial questions. From Jed Woodworth’s interview of Bushman at M*, it seems that not even Bushman thinks it a settled issue. As for the implications, I will say I don’t think an inspired fiction model in

which the Book of Mormon is historically fictional—while still being inspired by God—would be viable. I tend to think it either must have a real historical basis, or be a purely human production.

34.
danithew
1/4/2006 at 5:08 pm

Yes and yes again.

35.
Jack
1/4/2006 at 5:11 pm

Then it must be historical because, as much as I would like to let myself off the mormon the hook, I just can't seem to attribute the writing of the BoM solely to the creative genius of mere mortals.

36.
Otto
1/4/2006 at 5:19 pm

Will said:

Otto, I think it's pretty likely that Alma was at a loss to explain them otherwise, since:

A) He offered them as evidence of God
B) There was no other explanation available back then

You missed my point. I wasn't asserting that Alma did have scientific explanations, I was suggesting that it would be erroneous to consider that lack of explanation synonymous with Alma's reverence for Creation.

After all, there were probably some pretty horrible things that Alma encountered in his life that he didn't have rational explanations for–things that he probably wouldn't attribute to God or see as evidences of God's goodness.

Again, I think Alma's wonder had more to do with aesthetics than with scientific befuddlement. Standing in awe at the beauty of a painting is much different than standing in awe at the skill of a painter. When a painter A learns how painter B created a particular effect with a particular brush stroke or color combination, that demystification of process doesn't lessen A's esteem for B. Appreciation isn't dependent on mystery.

I think at the heart of the I.D. movement is a crisis of relevance that, ironically, betrays a fundamental lack of faith: a worry that Nietzsche was right, that God's power is inversely proportional to the understanding of his methods, and that the expansion of scientific knowledge entails a colonization of the heavens rather than an understanding of the heavens.

Mormonism, it would seem to me, would be resistant to this crisis: in our cosmology God's power isn't diminished by our understanding of his methods; in fact, in the eternal scheme of things, it's His goal to teach us those methods, not to leave us forever mystified about them.

37.
danithew

1/4/2006 at 5:26 pm

By the way, my yes answers above were in answer to the posted question: “Do all things denote there is a God?”

38.
Matt Evans
1/4/2006 at 5:58 pm

Otto,

Like I said earlier, I don’t know much about ID, but I don’t believe you’re characterizing it fairly. For example, fundamentalists aren’t any different from Mormons in their appraisal of scientific progress, believing, like us, that scientists discover laws of God’s creation. (What else would they be discovering?) You write as though there are evangelical scientists or ID advocates who dispute the veracity of e=mc^2 because it marginalizes God, fearing that we’re losing God to science. They know, like we know, that God isn’t going anywhere. The concern is that many people are deceived by their learning, foolishly coming to believe that by identifying proximate causes, like organic evolution, they have solved the mysteries of God, when all they’ve really done is move the ball of mystery. I don’t think evangelical scientists warrant your negative apprisal, and I think you’d be hard pressed to find a single one of them who doesn’t share the Mormon belief that God could express his power as a scientific equation. They too know that God’s mysteries aren’t mysterious to Him.

39.
Jack
1/4/2006 at 6:30 pm

Is there really a difference between Alma’s experience and that of anyone today who will give a little thought to the cosmos–that is, if we’re talking strictly about aesthetics? No matter how deep we dig there will always be something to wonder at. The problem is that it’s been difficult for us (collectively speaking) to let our religious texts take a back seat to the book of nature when dealing with things created–which is an unfortunate dilema caused by the polarization of science and religion (which polarization is the real root of the problem!). Religious texts need not lose their importance because science is able to cast a knew light on creation. In fact, it ought to enhance our understanding of the scriptures by causing us to think differently about them.

40.
Otto
1/4/2006 at 6:38 pm

Matt, I still think your admitted lack of in-depth knowledge about the I.D. movement leads you to be generous in your assessment of their goals and claims. I think fundamentalists _do_ think about scientific progress differently than Mormons do. If it’s any indication, the fundamentalist scientists who support I.D. think quite differently than do the Mormon scientists at BYU who oppose the I.D. movement. And I think that there are many scientists who would say that the fundamentalists’ problems with Darwinian evolution aren’t categorically different than a rejection of e=mc^2. And in everyday discussions by lay people, in LDS meetings and elsewhere, the “losing God to science” rhetoric is certainly present.

I think you’d be hard pressed to find a single one of them who doesn’t share the Mormon belief that God could express his power as a scientific equation.

If God were to express his power as an equation, presumably it would be sound enough that there wouldn't be a "God constant" somewhere in there, which would be the equivalent of the "gap" that I.D.ers put God in. Thus, if he can express his power in an equation that doesn't include his own mysterious self in there somewhere, Creation is ultimately, if dauntingly, quantifable. Why, then, should science seek to put him there instead of undertaking the work of deciphering His methods? Likewise, why should we expect all scientists to see God in nature in the way Alma does, unless they arrive at that belief through other, spiritual means first? I.D. relies on the idea that some things in nature are just too complex to ever explain scientifically. That's why the Kansas school board took out the "seeking natural explanations" wording.

If the real concern is that people are "deceived by their learning," that simply means that preachers need to start preaching differently, not that scientists need to start sciencing differently. It's simply not the scientists' job to predict how people will react to their findings and frame their results in order to shape the outcome. If society heads in the direction that the IDers want to push the country, the discovery of new "proximate causes" will be more likely to shake a believer's faith because that faith will rely on mystification. If, on the other hand, religion is more embracing of scientific endeavor, more people of faith will be moved by "proximate causes" to marvel at nature, like Alma.

41.
sarebear
1/4/2006 at 6:52 pm

Re: #34: oh my, that was VERY Funny! (sides hurt from laughing . . . .)

40: "not that scientists need to start sciencing differently"

sciencing! That's the coolest new made-up word I've heard in awhile. (And I make up new versions of words all the time, in this manner, because it suits the need.)

42.
Kingsley
1/4/2006 at 7:03 pm

Otto, is there anything to the claim that along with "sciencing" you often get preaching as vigorous as dogmatic as that of the evangelicals, but from a godless point of view?

43.
Otto
1/4/2006 at 7:23 pm

Kingsley,

I don't think there is much to that claim, frankly. I suppose there are a very few outspoken public intellectuals who who preach the doctrine of atheism and cite science in their sermons, but I don't think "often" would be a fair characterization. Most scientists who oppose I.D. do so not because they think people should stop believing in God, but because they think scientists work better when they don't impose upon science religiously-derived preconditions and presumptions. So, I suppose, in that sense, it is "godless" — but of course there are many devoutly religious scientists who think science should remain "godless" as far as methodology and theory go, even if they personally see science within a broader hermenuetic of godly cosmology.

Beyond that, no, I can't think of a secular equivalent to Pat Robertson on the 700 Club calling down calamity upon the heathens of Dover, PA.

44.
Matt Evans
1/4/2006 at 7:31 pm

I like your explanation in your last paragraph, Otto, and agree that this is the problem. I think that there is an agenda behind ID and it's to put a dose of God into what they see as the hostile secular world of public education, and I don't begrudge them that. There are millions of people, most of the western world, probably, that are convinced science has ended their need to accept the counsel of God, so I think religious leaders are right to fear they are losing this ideological battle. Just on this thread, several commenters (you may have been one of them, I don't remember) have suggested that Alma wouldn't have attributed the marvels of nature to God had he possessed their knowledge of astronomy, and that, it seems to me, is the crucial question. Why do people, even Mormons, think identifying a proximate cause ends the mystery?

You may be right that I'm too generous in my assessment of ID, but I still have a hard time believing that "I.D. relies on the idea that some things in nature are just too complex to ever explain scientifically." I thought they teach the more modest claim that some things are too complex to have been achieved through natural selection, and that therefore natural selection isn't the sole mechanism.

45.
Otto
1/4/2006 at 8:04 pm

Matt,

I don't think I made that claim about Alma (and I don't recall comments by others that make that claim). I certainly didn't mean that. I think I asked, rhetorically, if Alma would have been less moved had he had a better grasp of science–but I meant to suggest that the answer to that rhetorical question was a resounding no. I was simply arguing that Alma's wonder didn't rely on mystification, even if his wonder was inevitably accompanied by a lack of sophisticated scientific knowledge. I firmly believe that Alma would have still seen God in the cosmos even if he were gazing at them from the console of a state-of-the-art observatory.

I agree with you that there is an unfortunate perceived polarization between science and religion in America, but I think that's religion's fault as much as science's. Frankly, churchgoers through the centuries don't have a very good track record when it comes to dealing with scientific paradigm shifts, and it's no wonder that the scientific community in the post-Scopes era feels threatened by the religious right. Throughout history, it seems to me, it's been the religious folks that have felt threatened by the looming demystification of "proximate causes." I also dispute your claim that "most of Europe and blue America" think "God has ended." In a Zogby poll in Feb. 2004 64 percent of democrats said religion was "very important" in their daily lives, while only 10% it was "not at all important." The numbers for Republicans weren't that different: 70/7.

I also think that polarity is due in part to the perception by the Christian right that removing God from the classroom is "hostile," while scientists and others (including many religious people) feel that keeping God out of the classroom is just a matter of letting things operate in their appropriate spheres.

46.
Julie M. Smith
1/4/2006 at 10:19 pm

Re #12–

Matt, did you read the part where I said that I agreed completely with Alma?

47.
ed
1/5/2006 at 11:13 am

I don't think science leads people away from religion just because it explains the previously unexplainable. It leads them away when it offers explanations that *contradict* the explanations given by religion. For example, science contradicts the idea of a young earth, a global flood, etc. That's why I don't think Newton was seen as a threat to religion nearly as much as Darwin. Both explained new things, but only Darwin overturned religious dogma.

48.
Otto
1/5/2006 at 11:43 am

Ed,

Science… leads them away when it offers explanations that *contradict* the explanations given by religion.

But if the explanations given by religion are based on faulty interpretation of scripture, we can hardly label the scientists godless heretics just for being loyal to truth as they observe it. That Galileo's heliocentrism offended the Roman Church indicated fault on the part of the Church, not Galileo. Eventually, the Church had to change, not science. (We Mormons dont' have to share the shame of that, however, since BoM astronomy is heliocentric). Darwin was hardly the only scientist ever to "overturn religious dogma" by honestly following the results of his science into realms religion was unequipped at the time to accommodate.

49.
JWL
1/5/2006 at 1:30 pm

Let's go back to the text. First of all, natural phenomena are presented as the third of three items which show the existence of God, the other being scripture and the spiritual witness of one's own contemporaries ("ye have the testimony of all these thy brethren, and also all the holy prophets"). Second, the word used regarding the natural phenomena in the BoM is "denotes." What it might have been in the original Nephite we have no clue. From this I would suggest that:

(1) Alma was not relying exclusively on natural phenomena to show the existence of God, rather that they were part of the mix with spiritual witnesses.

(2) That word "denotes" could mean "suggest" as easily as it could mean "proves." Both the teleological argument and ID theory present themselves as logical proofs of the existence of conscious design. I think Alma can be read as using the wonder of natural phenomena less

strenuously — that the wonders of the natural world make it reasonable to incline one to accept the spiritual witnesses.

(3) Some above have suggested that the natural world is faith-promoting largely in an aesthetic sense. This view is compatible with the understanding in #2 above.

(4) However, if we take Alma's point more rigorously, we have to make another distinction. We are dealing here with a brief phrase, a fragment of a phrase. As I suggested in #1 with respect to the word "denotes," I think we have to cautious in reading modern science and philosophy into these few words. Is Alma really "testifying on behalf of intelligent design"? Your use of the term "intelligent design" carries a lot of later Western intellectual baggage that may have been meaningless to both Alma and Korihor. Other understandings are possible. One is the aesthetic. Another is that he is simply saying that that there is something rather than nothing is suggestive of some higher power without intending to go any deeper.

(5) Obviously Alma's few words are suggestive to the modern mind of the teleological argument and it is certainly legitimate to use them as a point of departure to discuss the position of that issue in the modern restored gospel. No one is suggesting that Alma understood cosmological arguments based on quantum mechanics, but if we are going to freight him with the philosophical baggage of the teleological argument, I think he should have the benefit of relevant modern scientific developments as well.

(6) The "fine-tuning" arguments from cosmology are far more powerful than arguments from biology because the "gaps" in cosmology are orders of magnitude more profound and significant than in biology. There is no explanation for the values even suggested by modern physics, whereas contra the ID'ers some Darwinian explanation for any living phenomenon can be postulated. More importantly, the existence of these cosmological constants is really as fundamental as our science can go. Life on Earth is very much a micro-phenomenon in comparision. And even more importantly, even the most atheist cosmologists acknowledge that there is indeed a point where this science becomes irreducible — when you do have a theory of everything, why is that theory the way it is? Cosmology acknowledges that there is indeed a point where one may run out of proximate causes. At least based on our current understanding of the science, it is an unsupportable and premature judgement to call Alma's statement a "fallacious claim."

(7) What is unsupportable is to claim that this is a conclusive proof of the existence of God. The most one can say is that it makes it at least statistically plausible that there is some deliberateness behind the "fine-tuned" constants as opposed to them arising by chance. One is then left to fall back on one's underlying philosophical assumptions. If they are materialist, one can certainly propose non-theistic explanations. One of these is that there are multiple universes with different physical constants and we just happen to live in the universe where they came out right for us to exist. However, if one is willing to presuppose the possibility of some conscious control of the universe, these phenomena can make one more comfortable in accepting spiritual witnesses. More than that that one can not argue, which is why I prefer to read "denotes" as "suggest" or "are consonant with" rather than "irrefutably prove."

50.
sam brown
1/5/2006 at 1:48 pm

I've thought about this a fair bit too. I'll admit to being somewhat taken by the book I am currently reading, which I have mentioned I believe in a prior post. It's Elijah Lovejoy's _Great Chain of Being_ a collection of lectures given in the 1930s and representing the standard treatment of a

longstanding idea that there is a “chain” or “scale” of being which encompasses all created beings and fills all of empty space.

It has occurred to me in reading the book and in reading this thread that there is another aspect to this discussion that we don’t talk much about. In a sense these debates about how to interpret the physical universe are more debates about how to interpret ourselves. We are the ones who are responding to the “immensity” of space, it is our sensuous and (ir)rational experience that denotes the universe as “simple” or “complex,” and we are the ones who determine whether something is beautiful or not.

In many cases (not all), we are focusing on our sense experience, our pleasure, our sense of a place in creation or of stewardship over other created beings/things.

The threat of Darwinism (social and biological) is not that the world isn’t glorious, beautiful, inspiring, or even that there is no God (only in a false dichotomy can you erase God if you believe in Darwinism). It is that we aren’t God’s special creations (or children/nurtured intelligences in Mormon parlance).

In alternate phrasing evolution doesn’t dethrone God, it dethrones us.

Lovejoy argues that this was inherent in the Great Chain of Being from the start, and that in this sense evolution was not a huge change, although that is not how we have in retrospect understood this philosophical shift.

Though you would think I’m denigrating this anthropocentric view of the universe, I find it both comforting and liberating. It leaves me free to delight in the rich complexity of the universe and–because I believe in God for other reasons–to experience it as his kind gift to me. I don’t have to decide the ID debate or frankly take much interest in it. By focusing on my experience of beauty and vastness, I can, without too much philosophical dithering, love God and feel his love for me in a wide variety of natural environments.

51.
Kingsley
1/5/2006 at 1:55 pm

Otto, my exposure to the debate has come primarily from Time and CNN and so forth, where both sides seem cut from the same cloth. Thanks for the response.

52.
sam brown
1/5/2006 at 1:56 pm

A separate idea hence a separate post.

I think this also is about the interface between finitude and infinity. There’s a great line in Speak, Memory (Nabokov’s juggernaut of a memoir) that talks about the dizzy juxtaposition of a finite mind and the great infinity of a parent’s love for a child.

This experience that Alma and others talk about, this sense that the vast, orderly complexity of the universe bespeaks the existence of God, in a large part is about our encounter with infinity. How wonderful and reassuring that instead of the nihilist’s abyss that great potential void is filled with an orderly creation of an infinite God.

I think that's why astronomic objects (I was going to say astrologic but worried the historical reference would be too obscure), mountains, weather, and the oceans are some of the most familiar tropes for this encounter. They are the times that we seem to be encountering objects of infinite vastness or infinite temporal expanse. They represent God's infinity.

That's another reason I think we're so taken with these arguments, and another reason that I am delighted to comprehend nature as an expression of God's infinite love.

53.
sam brown
1/5/2006 at 1:59 pm

Final isolated thought.

Re: this idea that no one intelligent would make something complex

a) I think that people are surprised that it seems to "work" whatever that means, and they anticipate that a perfect designer would be required to make a complex system "work."
b) there is an emphasis on the orderliness of everything, which does appear to be fairly simple.
c) historically complexity was seen as an indication of God's grace and power, specifically that he was capable of filling every possible miniscule nook both in physical space AND in taxonomic space with subtly graduated variations. People weren't claiming that he was an uber-engineer, they were claiming that his power and goodness were so overwhelming that he gladly created every possible thing. (Lovejoy has a great summary of this)

54.
Jack
1/5/2006 at 2:17 pm

I envy you, sam brown. How I long to be delivered (for a moment, at least) from the precepts of academia when it comes to experiencing truth and beauty. My pure sensibilities have given way to a feverish dithering–a storm of mad girations on multiple axis bereft of any concept of zenith. Oh, to be a child again; to love what I love without the culturally imposed need for an acredited someone to tell me what I should love.

55.
Otto
1/5/2006 at 11:12 pm

I know this thread is trailing off a bit, but I thought this recent profile of Norman Tolk, a professor of physics at Vanderbilt University, might be of interest.

One particularly pertinent paragraph:

"If there is an apparent conflict between science and religion, it is simply because we either don't understand enough about the science, or we don't understand enough about the religion." He gives an example of a colleague and fellow Mormon that he knew in New York. "I had a friend at Columbia who was a Mormon bishop at the time, and whose work should have won him the Nobel Prize. When he was leaving to study physics in college, he asked his father â€˜What about religion?' His father said â€˜Son, you only have an obligation to believe that which is true.' I've never forgotten that."

56.
Rob
1/6/2006 at 6:15 pm

Otto, thanks for that quote. Going far enough in both science and religion to get past the most apparent descrepancies is not an easy task, and can lead down some lonely paths. But the views can be breathtaking!

57.
a random John
1/9/2006 at 12:46 pm

At least Mormonism allows for an infinite regression of designers. Others have a bigger problem here.

58.
Digger
1/11/2006 at 6:49 am

How does an infinite regression of Designers help, other than to obscure origins?

59.
Joseph Stanford
1/16/2006 at 2:46 pm

I have heard a quote attributed to Albert Einstein that says that one can approach life in one of two ways: either believing that nothing is a miracle or believing that everything is. I don't know if Einstein really said this, but I think it is accurate in the sense that understanding proximate causes isn't the main issue. The main issue is our underlying assumptions, which may include or exclude God. Science as a way of knowing still occurs in the context of our underlying assumptions.

March 2006
Creation by Evolution?
Frank B. Salisbury
A review of "Evolution and Mormonism: A Quest for Understanding" by Trent D. Stephens, D. Jeffrey Meldrum, with Forrest B. Peterson
FARMS Review: Volume - 18, Issue - 1, Pages: 313-319, Provo, Utah: Maxwell Institute, 2006

Review of Trent D. Stephens, D. Jeffrey Meldrum, with Forrest B. Peterson. Evolution and Mormonism: A Quest for Understanding. Salt Lake City: Signature Books, 2001. xxii + 238 pp., with index. $19.95.

This is a book by two Latter-day Saint evolutionary biologists who are highly committed to both their faith and their biology. Helped by a movie producer/writer, they present strong arguments for evolution as the mechanism of creation, including humans as well as all other living things. Before embarking on reading the entire book, I first checked to see what references they had made to my own writing; in one such reference, the authors seemed to completely miss the point I was trying to make. Hence I began examining the book further with a bit of skepticism—I was looking for more

errors. But as I got into the volume, my attitude toward it became increasingly positive. This is not to say that I agree with everything they say, but the book presents a strong case for evolution in creation and perhaps, above all, provides much food for religious thought. As far as I know, some ideas are truly unique to these authors.

Stephens and Meldrum are well qualified to discuss evolution in the light of the restored gospel. Both are professors at Idaho State University in Pocatello, and both are engaged in research and teach classes directly related to evolution. Stephens was a bishop at the time the book was published, and Meldrum was a priesthood instructor. Peterson, who is also an active Latter-day Saint, provided perspective from a nonspecialist's viewpoint. The list of acknowledgments is impressive. The authors have discussed the topic of their book with dozens of others, including Professor Duane Jeffery at Brigham Young University, who wrote the foreword.

The authors discuss the three official statements from First Presidencies on the origin of man, and these are reproduced in an appendix (pp. 209—18). The statements do not necessarily or categorically reject a role for evolution in creation. Other Latter-day Saint authors are also quoted, and while some support evolution, others oppose such a view.

Stephens and Meldrum review the history of the idea that man is not an animal, an idea that might be held by some church members, and then they present rather detailed anatomical, physiological, and psychological evidence that humans have all the characteristics of other animals and are easily classified as primates. Having always believed that humans are anatomically and physiologically part of the animal kingdom, I am weary of this discussion. Do all animals have all the same psychological (mental) abilities of humans, only in lesser degree, as Stephens and Meldrum argue? Well, yes, some animals use tools, exhibit the rudiments of language (e.g., can be taught sign language), and even have some degree of self-awareness and compassion, but what other animal could write a book like this one? Other animals may have creative intelligence (i.e., can solve problems), but the gap between that and human intelligence seems huge. Stephens and Meldrum note that humans truly are unique in one sense because "man, as a spirit, was begotten and born of heavenly parents" (p. 125, quoting the 1909 First Presidency statement).

Another topic to which the authors repeatedly return is the idea that there was no death of any living thing before the fall of Adam and Eve. This old sectarian doctrine does still need much attention. The idea goes back to the period before the restoration of the gospel; Stephens and Meldrum suggest John Milton's Paradise Lost as the possible origin of the doctrine (pp. 183—84). Yet it has been preached by some prominent Latter-day Saint General Authorities, including Orson Pratt, Joseph Fielding Smith (though not when he was president), and Bruce R. McConkie.1 With such backing for the idea, it is not surprising that it has sometimes been taught in seminaries and institutes, as well as in some gospel doctrine classes.

Stephens and Meldrum point out that nowhere in scripture does it say that Adam and Eve—let alone all other living things—were created in an immortal state. Rather, after the fall, the tree of life was guarded so that Adam and Eve could not partake of its fruit and live forever—that is, be immortal (Genesis 3:22—24; Moses 4:28—31). If they were to partake of the fruit of the tree of life while they were in the garden, in some way that we do not understand the fruit would have made their bodies capable of living forever. We may not understand how a fruit could produce "eternal youth" in two special people, but we can at least imagine it. But it is impossible for a biologist or paleontologist to imagine how all organisms could avoid death until after the fall. As Adam and Eve ate of the fruit of every tree of the garden, the cells in that fruit would die. And the idea of there being no death also means no reproduction, but fruits are reproductive organs that produce seed. And in the creation story, the Lord commands all living things to bring forth of their own kind—clearly a command to reproduce (e.g., Moses 2:11—12, 20—22, 24—25, 28—30).

The fossils in the earth's sedimentary rocks are the remains of organisms that lived and died on the earth. If there were no death of any organisms until after the fall, all of these fossils must have been produced in the Noachian flood—and that is what some people during the Middle Ages believed. This idea can be found now among the young-earth creationists. This would mean that all those organisms—for example, dinosaurs and humans—were living on earth at the same time. The ordering of the strata in the earth's crust just does not fit this picture. No traces of humans have ever been found in the same strata as dinosaur bones, for example. I see large quantities of the remains of living organisms that testify to an ancient earth: coal, limestones, dolomites, and diatomaceous earth represent such remains. The diatomaceous earth, for example, consists of microscopic shells of diatoms laid down one cell at a time, a process that would require millions of years to produce the known strata thicknesses (1,500 feet in one location).

But what about that statement in 2 Nephi 2:22 that says that if Adam had not fallen, "all things which were created must have remained in the same state in which they were after they were created; and they must have remained forever, and had no end"? This is the key scripture quoted by proponents of the no-death-before-the-fall doctrine. It is the only scripture that seems to support the doctrine (no scripture in Genesis, Moses, or Abraham does), but that support depends on one's interpretation of the word state. Was this a state of immortality as some have taught? Or was it some kind of ecological state, perhaps with no development of human civilizations? To assume that state means immortality goes against all the things mentioned above as well as against other ideas, as Stephens and Meldrum point out.

I was very excited by Stephens and Meldrum's idea that Adam and Eve were not placed on earth as immortal beings but gained their immortality from eating of the tree of life (see pp. 181—83). As far as I know, this idea is unique with these authors. Stephens and Meldrum's views on the fall and its consequences provide great insight to me.

A strong impression gained from reading the book is that Stephens and Meldrum are convinced that creation involved evolution. Their summary of the principles of evolution by natural selection of random mutations is excellent and convincing. They answer many objections to evolutionary theory such as no transitional forms in the fossil record (many such "missing links" are now known). I see some problems at the level of genes and enzymes (are mutations really sufficient to account for the needed variability?), but it does seem that evolution has occurred over past eons on the earth's surface.

One question concerns the extent to which God intervened in his creations. For Stephens and Meldrum, the extent of intervention must be very limited. Natural selection is capable of handling creation almost by itself, they imply, so how can man be created in the likeness and image of God? Stephens and Meldrum present preliminary data (drawn from some of Stephens's research) that suggest that there are "constraints" during development—that is, evolution may not be as random as many evolutionists have claimed but is rather directional instead, leading to man. I was not convinced by this argument, although I am taking a wait-and-see attitude.

Stephens and Meldrum seem to be saying that God wound things up and then let them play out without his intervention until humans were the result, at which time Adam's spirit could be introduced into his body. Pushed to its ultimate, this is the doctrine of deism, which says that God started things going, after which the universe ran and now runs like clockwork and will run for the rest of eternity. This philosophy of a clockwork universe (i.e., a purely mechanistic universe) became popular after Newton and others formulated the basic laws of physics. Several of our founding fathers taught it, and Charles Darwin finished The Origin of Species with a paragraph based on this approach. (The paragraph includes: "Life . . . having been originally breathed by the

Creator into a few forms or into one . . . [from which] endless forms . . . have been, and are being evolved.")2 Modern physics, especially quantum mechanics, rejects a mechanistic universe, and Stephens and Meldrum would of course agree that God can and did intervene in creation whenever it fulfilled his purposes, but their chapter does smack of deism.

A final short chapter summarizes the Latter-day Saint doctrine of eternal progression as a kind of evolution. It may be a nice analogy, but it can be misleading to someone who thinks that some individual near-ape ancestor itself changed into a human. That is not what the theory of evolution says—only that an individual might differ slightly from its parents such that it had a somewhat better chance of surviving and reproducing than its parents did. As these small changes accumulated over thousands of generations, new species could gradually be distinguished. (Always, any set of parents produces only its own "kind.") But "eternal evolution," as Stephens and Meldrum call it, is a change in individuals from intelligences, to spirit children of God, to mortals, back to spirits, and finally to resurrected beings. This is not evolution based upon mutations and natural selection.

The book is remarkably free of errors, but I did notice a very few. For example, Darwin did not present Wallace's paper in 1858 (p. 96). Darwin had just buried an infant and did not attend the meeting at the Linnean Society. I was also surprised that there is no mention of intelligent-design creationists, only the flood-geology, young-earth creationists. Intelligent-design creationism started in the mid-1990s, but it was not well known until more recently, which might be why Stephens and Meldrum do not discuss it.

About the authors' misunderstanding of my writing, which I mentioned at the beginning of this review: I was trying to make the point that similarity in form does not prove genetic descent of one form from the other.3 There are, as Stephens and Meldrum point out, by now thousands of fossil hominids that could be human ancestors. The logical thing to do is to try to arrange them into "trees" that show how one might have descended from the other (with many generations between the two, of course). But the fact that they have similarities and that the trees may appear "logical" does not prove that the trees actually represent descent through time. Actually, the trees have been changing with almost every new discovery during the past century and a half. But that is another story. I went on to say that if similarity proved descent, then "we would have to conclude that Fords and Chevrolets are genetically related and that 1976 Fords descended from 1975 Fords."4 "A little reflection," according to Stephens and Meldrum, "reveals the fundamental flaw in this analogy, which incorrectly equates cars, that cannot pass on traits, with biological organisms capable of reproduction and transmission of genetic information from one generation to the next" (p. 143). But that was my whole point! I assumed that it was obvious to anyone that cars don't reproduce! I even noted that "each automobile is the product of an act of special creation" (i.e., in a factory).5 Still, cars can and often do resemble each other, but since it is obvious that they do not reproduce, resemblance is not enough to prove genetic descent.

Paleontologists have no choice but to try to arrange fossils according to similarities in form, but they can never prove that the results of their arrangements really represent what happened. And it doesn't really matter. The important thing is that arrangements can logically be made, whether the exact arrangements represent history or not. The overall arrangement shows the simplest organisms in the oldest strata and the most complex fossils in the youngest strata. That is what evolutionary theory predicts.

This little story merits discussion because it illustrates what is perhaps a minor problem with Stephens and Meldrum's book as a whole—they are so busy defending evolutionary theory that it never seems to occur to them that there might still be problems with the theory. Perhaps that is the result of creationist attacks on evolution, especially during the past decade or so. It has put the

evolutionists so much on the defensive that they tend to ignore any questioning of proposed evolutionary mechanisms. I agree with the authors that the case for evolution is so strong that many aspects are now well established, but it is shortsighted to imply that all the problems have been solved—and to suggest to young Latter-day Saint students that all the answers are in and that those answers include an evolutionary creation by a deist God.

On balance, Stephens and Meldrum have done a wonderful job of telling the story of evolution in a way that can make much sense to Latter-day Saint readers—even providing thoughtful insights into the restored gospel scriptures. Because of the amazing progress of science during the past thirty years, if I were writing my 1976 book now, it would come much closer to the book written by Stephens and Meldrum—I would take a much less favorable view of the creationist literature than I did then, but I would still point out some problems.

Notes:
1. See Orson Pratt, Masterful Discourses and Writings of Orson Pratt (Salt Lake City: Bookcraft, 1962), 356—57; Joseph Fielding Smith, Doctrines of Salvation (Salt Lake City: Bookcraft, 1999), 1:108; and Bruce R. McConkie, Mormon Doctrine, 2nd ed. (Salt Lake City: Bookcraft, 1966), 185.
2. Charles R. Darwin, The Origin of Species by Means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life, 6th ed. (1859; London: Collier Books, 1962 [1969 printing]), 484—85.
3. Frank B. Salisbury, The Creation (Salt Lake City: Deseret Book, 1976), 225.
4. Salisbury, Creation, 225.
5. Salisbury, Creation, 225.

March 2006
The Church and Evolution: A Brief History of Official Statements
Frank B. Salisbury
FARMS Review: Volume - 18, Issue - 1, Pages: 307-311
A review of "Mormonism and Evolution: The Authoritative LDS Statements" by William E. Evenson and Duane E. Jeffery
Provo, Utah: Maxwell Institute, 2006

The authors/compilers of this slim volume say that they had only one purpose in mind: to assemble under one cover all the official statements of the First Presidencies of the Church of Jesus Christ of Latter-day Saints regarding evolution and the origin of man, augmented by some other statements (those known to them) made by others but with First Presidency permission. They further state that they do not express their own opinions regarding these topics. The book does not strive for "balance" of views held by church members but is a sourcebook based on official statements only. Evenson and Jeffery achieve their stated purposes well.

After an introduction and a preface, the contents of a thirty-page packet assembled in 1992 to be given to students at Brigham Young University is reproduced. Different professors were handing out various materials relevant to evolution and the origin of man, so Evenson, who was then dean of the College of Physical and Mathematical Sciences and who had prepared the article on evolution for the Encyclopedia of Mormonism, was asked by University Provost Bruce C. Hafen to assemble a packet that could be handed out to students. If they desired, professors could add their own materials to this packet. Evenson provided various documents, including some that Jeffery had already assembled for placement in the library. These materials were then submitted to the BYU Board of Trustees, including the First Presidency and seven apostles.

This packet of essays begins with a cover letter from the Board of Trustees, which is followed by three statements of First Presidencies (in 1909 and 1910 under Joseph F. Smith and in 1925 under Heber J. Grant). The entry "Evolution" from the Encyclopedia of Mormonism is the final document. It is included because it "had material input from the First Presidency" (p. 34). Each document is preceded by a brief introduction that provides its historical context.

Following the "BYU Evolution Packet" (pp. 9—38) is an appendix called "Other Authoritative Materials." It consists of twelve documents that were sponsored or approved by the First Presidency or that were published over a president's signature alone (pp. 39—114). Some of the documents in this book are very short, even less than a page, but three are rather extensive statements that are of considerable importance. The first is the statement of the First Presidency in 1909 (document 1 in the "BYU Evolution Packet"), which includes a review of scriptural statements on the origin and preexistence of man, the literal likeness of both preexistent spirits and their temporal bodies to our Father in Heaven and his Son Jesus Christ, and the reality of Adam as a real person and progenitor of the human race.

Some members then (as even now) used the statement to claim that the church rejects the theory of evolution. Hence, a year later, the First Presidency, in their regular column in the Improvement Era, "Priesthood Quorums' Table," stated the following: "Whether the mortal bodies of man evolved in natural processes to present perfection, through the direction and power of God; whether the first parents of our generations, Adam and Eve, were transplanted from another sphere, with immortal tabernacles, which became corrupted through sin and the partaking of natural foods, in the process of time; whether they were born here in mortality, as other mortals have been, are questions not fully answered in the revealed word of God" (pp. 43—44, document A, appendix). Clearly, if the 1909 statement is mentioned, the 1910 clarification should also be quoted. Subsequent statements agree with the ideas presented in these two documents.

The second extensive document (pp. 54—67, document C, appendix) is a memo from the First Presidency dated 5 April 1931 and addressed to the Council of the Twelve, the First Council of Seventy, and the Presiding Bishopric. It responds to a controversy that had erupted between the young apostle Joseph Fielding Smith, B. H. Roberts (the presiding president of the Seventy), and other members of the Twelve. The memo reviews the background of the controversy. Elder Smith had given a sermon to the Genealogical Society on 5 April 1930; the speech was published in the Utah Genealogical and Historical Magazine and also as a pamphlet. Elder Smith had proclaimed that evolution was a fraud, that the earth was very young, as implied in the Genesis account of creation, and that there was "no death upon the earth, either vegetable, insect or animal, prior to the fall of man, and that human life did not exist upon the earth prior to Adam" (p. 55). Although Evenson and Jeffery do not mention it, Elder Smith had become acquainted with the teachings of the Seventh-day Adventist creationist George McCready Price and had corresponded with him.1

In response to Elder Smith's sermon, B. H. Roberts had written a letter to the First Presidency taking strong issue with the ideas presented by Elder Smith, especially the concept of no death before the fall. (I have personally wondered what happens to "vegetables" when eaten by "insect, or animal." Do they die? And if there is no death before the fall, then all coal, limestone, diatomaceous earth, and all the fossils are younger than Adam, perhaps trapped in the Noachian flood!) The matter was discussed at length in meetings of the Twelve, and Elder Roberts was asked to defend his viewpoint, which he did with a fifty-page manuscript. Elder Smith responded a few weeks later with his own fifty-eight-page manuscript. The memo from the First Presidency in 1931 requested that the Brethren set this argument aside because it seemed to have no resolution and did not affect the basic teachings of the church.

Some of the Twelve noted that, because Elder Smith's sermon had been widely disseminated, while Elder Roberts's views had not been made public, members of the church might conclude that Elder Smith's sermon represented the official doctrine of the church. And many have concluded just that, based not only on the sermon but also on Elder Smith's book entitled Man: His Origin and Destiny.2 It was concluded that James E. Talmage of the Twelve should give a sermon expressing his viewpoint and also encompassing that of others who sided with him and Elder Roberts. The Talmage speech was given in the Tabernacle in August 1931, and, after some resistance from Elder Smith but with the blessing of the First Presidency, it was published first in the Church News and then by the church as a pamphlet. In the speech, Elder Talmage (a geologist by training) strongly emphasized that countless organisms had lived and died for millions of years before the fall of Adam, some small portion of them becoming fossils. He also quoted scripture and expressed his conviction that Adam was indeed the first member of the human race, that we existed previously in heaven, and that we were created in the image of God (pp. 68—70).

Because the First Presidency had encouraged and supported Elder Talmage's talk, Evenson and Jeffery include it in their collection (pp. 71—94, document D, appendix). It is the third long document mentioned above, and it is a very valuable source. The other, shorter documents are also of interest, with statements by Presidents Heber J. Grant, David O. McKay, Spencer W. Kimball, and Gordon B. Hinckley. These brief statements reiterate the ideas put forth in the official statements of 1909 and 1910.

Reviewing all these documents and the history that goes with them, I was sorry that the compilers had set standards that eliminated inclusion of the sermon of Joseph Fielding Smith, the complete letter of B. H. Roberts, his manuscript to the Twelve, and Elder Smith's response. It would be useful to read these documents in the context of the others, although several excerpts are included in the Presidency's memo of 1931. The compilation and comments of Evenson and Jeffery have provided a valuable source for those who are interested in the evolution controversy, and they also make highly interesting reading.

Notes
1. Ronald L. Numbers, The Creationists: The Evolution of Scientific Creationism (Berkeley: University of California Press, 1992), 309—10.
2. Joseph Fielding Smith, Man: His Origin and Destiny (Salt Lake City: Deseret Book, 1954).

June 2006
Frank B. Salisbury, Ph.D.
The Case for Divine Design: Cells, Complexity, and Creation
Book

Introduction
The title of my book is a little bit (but not very!) misleading. It was suggested by my publisher, who didn’t like An Intelligent Creation? or Cells, Complexity, and Creation. As the title now stands, it suggests that this book is right in the midst of the many books that argue for the existence of God on the basis of Intelligent Design. But I don’t see nature’s complexity as proof of God.

For one thing, evolutionists can make a very strong case for the development of complexity through evolution by natural selection. And they are certainly not stupid. These atheistic biologists are convinced that intelligent intervention in creation is not necessary to explain the complexity that we see around us and in ourselves.

I can't prove that they are wrong although for several reasons that I describe in the book, my gut feeling is that their explanation has serious problems. At the same time, all that complexity is certainly compatible with an intervention in creation by an Intelligent Creator. We can't prove such an intervention scientifically, but we also can't prove that there was not such an intervention.

So why do I believe in God and in some kind of Intelligent Creation? The question is a serious one for me because there is no way that I can understand how such a Creation might have occurred—or even the extent to which a Creator might have been directly involved (in an on-going evolutionary process, for which there is overwhelming evidence). The best I can do is to make some wild guesses about it.

Still, for me, there are good, solid reasons to believe in God, as I explain in Chapter 1. My faith is not a blind one. But the reasons are highly personal. My conviction is that every individual must find God on his or her own. I can't see anything in the findings of science that disproves God's existence—nor do I see anything that proves the existence of God.

Nevertheless, if one does believe in God (i.e., has found God), and believes that a Creator some way applied intelligence in directing creation, modern biology can be viewed as a marvelous and supremely beautiful insight into the results of that intelligence. In the past half century or so (to my amazement, within my life time!), application of the scientific method has opened to our gaze a level of living complexity that could not have been dreamed about at the time when I was born!

It simply blows my mind! Thus, a goal of this book is to share some of that wonder with those who are not biologists. I outline the strong evidences for evolution, try with all my might to explain molecular and cellular biology (but sadly, many readers tell me that this where they hang up!), emphasize the fundamental importance of sequences in the order of amino acids in proteins and of nucleotides in nucleic acids, and then outline some of the problems encountered in accounting for the origin of life.

It amazes me that everyone seems to take it for granted that life will originate if water, minerals, and an energy source are present on some young planet. To take that for granted is an act of supreme faith! Scientists working in the field are well aware of the problems, but the public seems to think that it is just a matter of conditions and sufficient time.

After these forays into modern science, I get a bit philosophical in the final two chapters, pointing out how some very knowledgeable people reject God while others take an opposite view—again bringing home the idea that science can neither prove nor disprove God's existence.

There are four appendices that seem highly important to me: a discussion of current creationist viewpoints, a presentation of William Paley's 1802 analogy of the watch in the path (which is often greatly oversimplified by contemporary atheists), a closer look at photosynthesis and the ATP synthase motor (the most incredible example of molecular complexity known to me—and, as far as we know, present in virtually every living cell!), and finally a brief summary of how scholars of my Church of Jesus Christ of Latter-Day Saints (Mormon) have viewed evolution and creation, some defending young-earth creationism and others rejecting such views and defending evolution by natural selection.

Frank B. Salisbury

Reviews
Not by natural selection and random mutation alone. . ., October 6, 2008
By Elaine Douglass (Moab, Utah) -

Before I read The Case for Divine Design, I had hardly an idea of the mind-boggling complexity of cellular processes, hardly realized that the mechanism of evolution of these processes has not been plausibly described. Nor did I fully understand science has not explained the origin of life on earth. It's not about gaps in the fossil record. It's about showing how the thousands of chemicals essential to the existence of life, chemicals composed of huge molecules that are constantly being synthesized in living tissue, could have arisen solely by natural selection acting on spontaneous random genetic changes--which is the core mechanism science today uses to explain the manifest characteristics of the life forms present on earth.

I love the idea of evolution. But what the author of this book showed me is that to embrace evolution as the sole mechanism accounting for life is indeed an act of faith, just as religion is a faith, belief in God is a faith.

The author of this book, Frank Salisbury, PhD, is a leading American scientist, with a 43-year career spent in academia, the last 31 years at Utah State University. Salisbury is a plant physiologist, a botanist if you will, who, until his retirement, led an American/Russian team that grew wheat in the Russian Space Station, Mir. The many other research projects in his career included plant flowering, alpine ecology, and plant responses to gravity. His fame among other botanists was largely based on his textbooks, including a basic plant physiology text that went through four editions. So nobody can say Frank Salisbury doesn't understand modern biological science.

If you took God out of this book, you would be left with a critique of modern biological science for its failure to explain how life arose from inert matter and how cellular processes achieved the dizzying complexity they now manifest. Nor can biological science dispute it has failed to explain these fundamental scientific questions. That became evident to me as Salisbury reviewed the work of numerous contemporary biologists who obviously have thrown the full weight of their brilliant intellects at these questions and come up wanting.

Reflect, I had to reflect. Darwin lived around the time of the Civil War. Watson and Crick defined the double helix in the 1950s. So it's been only about 150 years we've had any ideas other than the Bible to work with to explain the living world. I'd say it's going to take another 200 years to work these problems out, IF they are worked out. And I gather Dr. Frank Salisbury would be fairly overjoyed if, say, the origin of life were satisfactorily explained scientifically.

That's what makes this book unique among creationist works. The author does not insist on an interventionary God, he merely posits it, gently, persistently, as a possibility, while all the while illuminating the reader as to the profound mysteries confronting biological science and delineating the inadequacy of natural selection as the sole theoretical basis for resolving those mysteries. I strongly recommend this book!

8 of 8 people found the following review helpful:
5.0 out of 5 stars One of the best books on ID, September 24, 2006

By The Professor5.0 out of 5 stars>
The Case for Divine Design is a must read for anyone interested in the Intelligent Design (ID) controversy. I was attracted to the book because the author wrote a college level botany text I once used and has authored several leading college textbooks in this area with major textbook publishers. The author has a PhD in plant physiology from Cal Tech and is a leading researcher in the field. Salisbury was also department head at Utah State University for many years. He reviews a great deal of cell biology and biochemistry in this 258 page well illustrated book and does an excellent job, showing that the case for Intelligent Design is very strong and this is one major reason for the opposition to the idea today. Opponents see it as clear competition to classical Neo-

Darwinism, although in articles critical of ID the authors try to imply the opposite. He also does a good job answering many of the common objections to ID. No one can claim to be informed about this issue without reading this well documented book which should become a classic in the field. He has much good material on irreducible complexity, showing that everything is irreducibly complex except quarks and leptons and they may not be fundamental particles either! If 2 or more parts are required for something to function, it is irreducibly complex.

5 of 5 people found the following review helpful:
5.0 out of 5 stars Objective Discussion of Intelligent Design, October 21, 2006
By Stewart E.Greene
This book provides an objective review of the cases supporting and opposing intelligent design. The author discusses the strengths and weaknesses of each case. It brings sanity in an area of study where emotional retaliation seems to be the predominant response.

It is also very informative in discussing the progress in the study of biology for the lay reader.

March 2006 (From an April 1988 general conference address)
The Message: The Handiwork of God
M. Russell Ballard, Quorum of the Twelve Apostles
New Era Article

“Then sings my soul, my Savior God, to thee, How great thou art! How great thou art!”
Image

This is a beautiful time of year with spring beginning to burst forth in many parts of the world, bringing all of its colors, scents, and cheerful sounds. The miracle of the changing seasons, with the reawakening and rebirth in nature, inspires feelings of love and reverence within us for God’s marvelous, creative handiwork.

The Easter season is a good time for people everywhere to appreciate the wonders of nature and give thanks to the Creator of this beautiful world. Think of what would happen if all of us took time to look carefully at the wonders of nature that surround us and devoted ourselves to learning more about this world that God created for us!

My family and I had a simple but impressive experience with one of God’s creations. I gave my wife, Barbara, a dozen roses as a valentine. They were a delicate shade of peach in color and had a rich scent. Barbara put them in a vase and placed them on the table in our family room. As the days passed, the family watched the blossoms unfold from buds to full flower.

As I watched this miracle, I became curious about roses. I was amazed to learn from a botanist friend that there are thousands of different varieties of roses. Inside each rose is a giant storehouse of genetic coding that develops a seed or a slip into roots, stems, thorns, leaves, colors, and blooms.

Each rose is a compact chemical-processing factory. Using sunlight, the green leaves take carbon dioxide from the air and replace it with oxygen, which we breathe. When other chemicals within the plant react with sunlight, it produces starch that becomes food. As you know, this process is called photosynthesis, and without it the earth’s atmosphere would soon be devoid of oxygen, and most living things would disappear from the earth.

This experience led me to consider the myriad forms of plant and animal life that thrive in astounding balance upon the earth. My esteem for our little roses took on an element of wonder and reverence. I pondered the power of the Creative Genius who lovingly provided such marvels for His children. I thought then how important it is for every human soul to see and appreciate the glory and grandeur of God in everything about us. Into my mind came the words and message of a beautiful hymn:

When thru the woods and forest glades I wander,
And hear the birds sing sweetly in the trees,
When I look down from lofty mountain grandeur
And hear the brook and feel the gentle breeze,
Then sings my soul, my Savior God, to thee,
How great thou art! How great thou art!
("How Great Thou Art," Hymns, no. 86)

I felt a deep reverence for both the creation and the Creator. Reverence may be defined as a profound respect mingled with love and awe. Other words that add to our understanding of reverence include gratitude, honor, veneration, and admiration. The root word revere also implies an element of fear. Thus, reverence might be understood to mean an attitude of profound respect and love with a desire to honor and show gratitude, with a fear of breaking faith or offending.
All Things Bear Record

In the book of Moses we read, "And behold, all things have their likeness, and all things are created and made to bear record of me, both things which are temporal, and things which are spiritual; things which are in the heavens above, and things which are on the earth, and things which are in the earth, and things which are under the earth, both above and beneath: all things bear record of me" (Moses 6:63).

Truly, the heavens and the earth and all things in them evidence the handiwork of God, their Creator. In the Book of Mormon we learn of Korihor, an anti-Christ who was brought to the Prophet Alma. He asked for a sign of God's existence before he would believe. "But Alma said unto him: Thou hast had signs enough; will ye tempt your God? Will ye say, Show unto me a sign, when ye have the testimony of all these thy brethren, and also all the holy prophets? The scriptures are laid before thee, yea, and all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator" (Alma 30:44). These eternal evidences continue to testify to us today.

Astronauts viewing the earth from space have stated how incredibly beautiful it is and how alive it appears. United States Senator Jake Garn wrote of his experience in space: "It is impossible for me to describe the beauty of the earth. It is a breathtaking, awe-inspiring, spiritual experience to view the earth from space while traveling at twenty-five times the speed of sound. I could also look into the blackness of the vacuum of space and see billions of stars and galaxies millions of light-years away. The universe is so vast as to be impossible to comprehend. But I did comprehend the hand of God in all things. I felt His presence throughout my seven days in space. I know that God created this earth and the universe. I know that we are His children wherever we live on the earth, without regard to our nationality or the color of our skin. Most important, I know that God lives and is the Creator of us all" (letter to M. Russell Ballard, March 3, 1988).

Again, the words of the hymn came to mind:

O Lord my God, when I in awesome wonder

Consider all the worlds thy hands have made,
I see the stars, I hear the rolling thunder,
Thy pow'r thruout the universe displayed;
Then sings my soul, my Savior God, to thee,
How great thou art! How great thou art!
(Hymns, no. 86)
The Gift of Life

The psalmist wrote, "When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained;

"What is man, that thou art mindful of him? and the son of man, that thou visitest him?

"For thou hast made him a little lower than the angels, and hast crowned him with glory and honour" (Ps. 8:3–5).

The Lord gave an answer to the psalmist's question; it is recorded in the book of Moses: "For mine own purpose have I made these things. …

"And by the word of my power, have I created them. …

"For behold, this is my work and my glory—to bring to pass the immortality and eternal life of man" (Moses 1:31–32, 39).

When we look to see the evidence of Creation all around us, from a grain of sand to the majestic planets, we begin to realize that we are the greatest of all God's creations; we are created in His image. God created the earth in all its magnificent glory, not as an end in itself, but for us, His children. Indeed, we are His children, His offspring, and He is the Father of our spirits.

We sometimes feel great respect and reverence for creative genius as expressed in great art or music. How much more should we revere the power and majesty of our Divine Creator? We may stand in awe of man's creations of beautiful buildings or bridges. But remember the Apostle Paul's words to the Hebrews: "He who hath builded the house hath more honour than the house.

"For every house is builded by some man; but he that built all things is God" (Heb. 3:3–4).

Those who feel no reverence for the creations and the divine attributes of God likely will have little appreciation for other sacred things. Such a lack of respect for God's creations may diminish until a person becomes totally insensitive to the feelings of others. This, I am afraid, is the condition in some parts of the world.

When we consider people who are irreverent, we may think of those who lack manners, sensitivity, and courtesy, and who show little or no respect for the finer things or for sacred things. Perhaps some lack reverence for life and for their fellow men because they do not understand who they are and what they have the potential to become.

M
God expresses His love for us by providing the guidance we need to progress and reach our potential. Perhaps a simple story will illustrate this point. Recently, a young man purchased a used computer but could not get it to work properly. Soon he became discouraged. His temper grew short, and he threatened the inanimate object with painful destruction unless its performance improved. A wise father intervened and took his son to a local vendor, where they obtained an

instruction manual. After all, who would know more about a complex computer than the person or company that created it? Who would know most about its capacity and potential? Who would better know the safeguards required to avoid damaging or ruining this fine instrument? Soon the boy enjoyed the full potential of his computer by working within the guidelines given in the instruction book provided by its creator.

Likewise in our lives, He who knows most about us, our potential, and our eternal possibilities has given us divine counsel and commandments in His instruction manuals—the holy scriptures. When we understand and follow these instructions, our lives have purpose and meaning. We learn that our Maker loves us and desires our happiness. In an incomparable manifestation of this divine love for us, He sent His Only Begotten Son, Jesus Christ.

“For God so loved the world, that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life.

“For God sent not his Son into the world to condemn the world; but that the world through him might be saved” (John 3:16–17).

Jesus was born into mortality. He led a perfect life and, in so doing, marked the path for us to follow. He taught His disciples: “I am the light of the world: he that followeth me shall not walk in darkness, but shall have the light of life” (John 8:12).

Love One Another

His gospel is a gospel of love—love for God and love for one another. He directs us to follow His example. Our discipleship is measured by how well we comply.

“A new commandment I give unto you, That ye love one another; as I have loved you, that ye also love one another.

“By this shall all men know that ye are my disciples, if ye have love one to another” (John 13:34–35).

Can you imagine what an impact following this instruction would have on society today?

Many people, I fear, never come to understand that the commandments of God are for our benefit and that as we sow, so shall we reap.

Our return to our Heavenly Father is through His Son, Jesus Christ. Jesus told His disciples, “I am the way, the truth, and the life: no man cometh unto the Father, but by me” (John 14:6). He instructed us to keep His commandments if we love Him (see John 14:15). He taught further that “he that hath my commandments, and keepeth them, he it is that loveth me: and he that loveth me shall be loved of my Father, and I will love him, and will manifest myself to him” (John 14:21).

In the Atonement and the Resurrection of Jesus Christ, we can glimpse the reality of His divine mission to redeem all who will come unto Him and will honor and reverence God, our Eternal Father.

We may begin to understand the depths of Christ’s love for us when we consider that He was willing to atone and suffer the pain for our sins, “which suffering caused [Him], even God, the greatest of all, to tremble because of pain, and to bleed at every pore, and to suffer both body and spirit”

(D&C 19:18). Nevertheless, He gave glory to His Father and partook and finished His preparations unto the children of men (see D&C 19:19).

The crowning words of the inspired hymn continue:

And when I think that God, his Son not sparing,
Sent him to die, I scarce can take it in,
That on the cross, my burden gladly bearing,
He bled and died to take away my sin,
Then sings my soul, my Savior God, to thee,
How great thou art! How great thou art!
(Hymns, no. 86)

Let us give special thanks to God for the Atonement and Resurrection of His Beloved Son, Jesus Christ. For in Him, by Him, and through Him, this temporary mortal condition can be made into a permanent, perfect existence, for which words cannot express our joy.

To truly reverence the Creator, we must appreciate His creations. We need to plan to take time to observe the marvels of nature. Today, we can easily become surrounded by brick buildings and asphalt surfaces that shelter us from real life around us. Plan to share with your family the miracle of buds changing to fragrant blossoms. Take time to sit on a hillside and feel the tranquillity of the evening, when the sun casts its last golden glow over the horizon. Take time to smell the roses.

All the marvels of nature are glimpses of the Lord's divine power and expressions of His love. Yet the greatest of all miracles awaits us. It will occur when, by His power, we will come forth from death and the grave to a new world that will not pass away, where, if we are worthy, we will be with Him and our Father in Heaven forever and ever.

2006
John C. Polkinghorne, Physicist and Theologian
Natural Theology
Book – Science and Creation – The Search for Understanding

Chapter 1 - Natural Theology

A scientist of even quite modest attainments will find, from time to time, that he receives unsolicited contributions from the general public proposing solutions to the riddle of the physical universe. His correspondents may need a little help with the mathematics or a testimonial to facilitate the publication of their ideas, but they are confident that they have made an important advance. I am sorry to have to say that such items of this character that have come my way have, without exception, proved valueless. Many have not been sufficiently articulate even to attain the status of being wrong. Nor does some kinship with science prove any help in the matter; some of my most persistent and wrong-headed correspondents have been electrical engineers.

This thought crosses my mind as I, a theoretical physicist by profession, take up my pen to write on matters theological. To be sure, I received some grounding in theology during my preparation for ordination, and the subject remains among the principal interests which direct my reading; but it is also true that electrical engineers are taught a bit of physics, and no doubt they read more about it after graduation. So how can I have the temerity to attempt the present task? I certainly cannot pretend to write as a professional theologian, but only as a scientist deeply interested in the understanding of religion.

I believe that the justification for the enterprise lies in the nature of theology. If it is to lay claim again to its medieval title of the Queen of the Sciences, that will not be because it is in a position to prescribe the answers to the questions discussed by other disciplines. Rather, it will be because it must avail itself of their answers in the conduct of its own inquiry, thereby setting them within the most profound context available. Theology's regal status lies in its commitment to seek the deepest possible level of understanding. In the course of that endeavor, it needs to take into account all other forms of knowledge, while in no way attempting to assert hegemony over them. A theological view of the world is a total view of the world. Every form of human understanding must make its contribution to it. The offering of the physical sciences to that end must be made, at least partly, by those who work in them. Theology cannot just be left to the theologians, as is made clear by the recent spectacle of a distinguished theologian writing more than 300 pages on God in creation with only an occasional and cursory reference to scientific insight.' It is as idle to suppose that one can satisfactorily speak about the doctrine of creation without taking into account the actual nature of the world, as it would be to think that the significance of the world could be exhaustively conveyed in the scientific description of its physical processes. There must be a degree of consonance between the assertions of science and theology if the latter are to make sense. Hence there is an urgent need for dialogue between the two disciplines. The arena for their interaction is natural theology.

Natural theology may be defined as the search for the knowledge of God by the exercise of reason and the inspection of the world. There are, of course, those who would deny the possibility of such knowledge. They are by no means all of an atheist or agnostic persuasion. People of religious belief have sometimes been so impressed by the transcendent otherness of God that they have asserted that He is only to be encountered in His gracious and specific acts of self-disclosure. He can condescend to us, but we are powerless to reach out to Him. The leading proponent of this point of view in our century has been Karl Barth, who wrote of the God of whom the Christian creeds speak:

> He cannot be known by the powers of human knowledge, but is apprehensible and apprehended solely because of His own freedom, decision and action. What man can know by his own power according to the measure of his natural powers, his understanding, his feeling, will be at most something like a supreme being, an absolute nature, the idea of an utterly free power, of a being towering over everything. This absolute and supreme being, the ultimate and most profound, this "thing in itself' has nothing to do with God.2

That "nothing" seems like something of an overstatement. We can acknowledge that natural theology, whose source of insight is by definition limited to the generalities of experience, will not tell us all about God that is humanly accessible. The individual encounter with Him, both our own and that of the spiritual masters preserved in the tradition, will surely be of the highest importance. Yet the world is not just a neutral theater in which these individual revelatory acts take place. Rather, it is itself, if theism is true, the creation of God and so potentially a vehicle also for His self-disclosure. God is to be found in the general as well as in the particular. Natural theology may only be able to help us to discern "something like a supreme being, an absolute nature:' and it is certainly powerless by itself to bring us to know the God and Father of our Lord Jesus Christ, but its insights are not for that reason to be despised. There is a great deal more to the structure of matter than chemistry can tell us, with its talk of 92 elements, but it would be foolish to refuse its assistance in an inquiry into what the physical world is made of. Similarly, natural theology can provide valuable help in an inquiry about whether the process of the world is the carrier of significance and the expression of purpose. This role is of special relevance today when so many people find it difficult to see theism as a credible and coherent possibility. Natural theology may be for them a necessary starting point. I agree with Hugh Montefiore when he writes about the relationship of the intellectual quest for God through natural theology to the personal

commitment of faith, that while it is true that cold intellectual thinking can never bring anyone into a warm personal relationship with God, it is also true that, while a subjective commitment to God may be satisfying to the self, it lacks credibility to others unless it can be shown that there are good reasons for the actual existence of the God to whom commitment has been given.3

The contention that natural theology is important is supported by a consideration of the history of religious thought. I shall attempt a survey to show that it has had a continuing role within the Judeo-Christian tradition.

At first sight, no one could seem to be less concerned with such matters than ancient Israel. Belief that there is a God is absolutely axiomatic in the Old Testament (as it is in the New Testament). There is no attempt to reason the matter, no apologetic argument for God's existence. The priests proclaim that He is known in the worship He has ordained and the laws that He has promulgated. The prophets declare Him to be found in His saving and judgmental acts in history. Yet, even in Israel, there were those who also sought Him in the everyday circumstances of life, or who at least tried to make sense of humdrum experience in the light of their faith in Yahweh. The fruit of their labor is recorded for us in the wisdom literature of the Old Testament and Apocrypha. One of its characteristic forms of expression is the proverb, a sort of refinement of the folk adage. By this means, the wise men sought to discern an order in the chaotic flux of events. Von Rad said the teachers of wisdom "stood in the forward line of experiential knowledge:'4 Their observation is often deadpan, without overt moralizing:

> A poor man is odious even to his friend; the rich have friends in plenty.'

They are men of patient observation rather than charismatic enlightenment, so a certain calm level-headedness attracts their praise:

> Experience uses few words; discernment keeps a cool head.6

One feels that they would thoroughly approve of the motto of the Royal Society: Nullius in verba (freely translated—"no mere talking"). An anchorage in the way things are, acting as a restraint on speculative fancy, is of particular importance for theology. One is sometimes astonished at the confidence with which the fathers or the medieval theologians will discuss such ineffable subjects as the nature of angels or the inner life of the Holy Trinity. The wise men encourage the asking of the question, instinctive to the scientist, How do you know? They look at the world with an openness to the hard facts of its reality and resist the temptation, endemic in religious thought, to confine themselves to the way they would like things to be or hope that things will eventually come to be. Yet in pursuit of knowledge, the wise men were willing to recognize their own limitations as part of what actually is the case. Von Rad says that they were "aware that the area a man can grasp with his rational powers and tell out with his being is really small:"7 Rational exploration did not decoy them into rational overconfidence:

> Face to face with the Lord,
> wisdom, understanding, counsel go for nothing.$

Since the wisdom writers' special concern is with knowledge of God derived from general rather than particular experience, there is a universal character to their thought. The founding figure of the tradition was said to be Solomon, and one can readily imagine such a warily appraising attitude arising in the cosmopolitan brilliance of his court. He is compared with the wise men from the East and from Egypt, admittedly to his advantage but in terms that suggest that like is being set beside like,9 a comparison with other nations unthinkable for Israel in the spheres of priest or prophet. Part of the Book of Proverbs (22:17-24:22) is a transcription from the Egyptian writings of

Amenemope. There is an accessible character to natural theology that helps it to cross cultic frontiers. Nevertheless, in the end, it must seek its integration with the totality of the experience of God and of thought about Him. The later wisdom writings are set in a more explicitly Yahwehistic context than their predecessors.'°

As part of the wise men's cool observation of the world there was regard for what we would call nature (a concept itself unknown to Hebrew). Thus at the end of the Book of Job, God's answer to the complaints of the innocent sufferer is a catalogue of the wonders of the physical world (Job 38, 39) and an injunction to consider the hippopotamus and the crocodile, albeit exalted to mythic proportions (Job 40, 41). They are reminders to Job that the Lord has other concerns beyond those with men: "Behold, Behemoth, which I made as I made you:"11 It is characteristic of natural theology that it delivers us from a narrow anthropocentricity. Moltmann is surely right to say, "No theological doctrine of creation must be allowed to reduce the understanding of belief in creation to the existential self-understanding of the person. If God is not the Creator of the world, he cannot be my Creator either."1'

At a humbler level, the enumeration sayings in Proverbs, such as:

> Three things are too wonderful for me; four I do not understand:
> the way of an eagle in the sky,
> the way of a serpent on a rock,
> the way of a ship on the high seas,
> and the way of a man with a maiden.13

show a concern with the physical world at the level of natural history, the encyclopedic collection of "for instances." The Hebrews were unable to proceed beyond this to develop a scientific point of view concerned with a pattern of cause and effect. They lacked the necessary concepts. In particular, despite experience of exile in Babylon (an ancient center of some degree of sophistication in calculation and astronomy), they made no progress with mathematics. Nevertheless, the post-exilic wisdom writers did take one remarkable step: They personified wisdom, speaking of her as the beginning of God's works, antedating the material world," His agent in creation,15 and His consort in its enjoyment.16 This astonishing figure is a challenge to exegetes. Von Rad says that the wisdom imagery shows that God "had at his service a quite different means, besides prophets and priests, whereby he could reach men, namely the voice of primeval order."" Thus it was that natural theology found voice in the Old Testament.

Wisdom is one of the many concepts which constellate round the Logos, the Word, so powerfully proclaimed as being in the beginning with God and equal to God, in the prologue to St. Johns Gospel.18 Ideas come together here which are both Greek and Hebrew in origin. The Stoic notion of the logos is concerned with the rational order of the world, while the Hebrew dabar (which means both word and deed) focuses on activity, that word of the Lord by which the heavens were made19 and which came to the prophets as the message of God's purpose at work in history. The twin discernment of both pattern and process in the workings of the world, of being and becoming, lies at the heart of any attempt to construct a natural theology in true accord with the way things are. There has been a perpetual temptation in religious thought to concentrate on one pole or the other of this dialectic—the static perfection of the God of the philosophers, in all His remoteness; the living God of Abraham, Isaac and Jacob, in all His dangerous anthropomorphism. A true account will hold the two in balance. It is interesting that a similar complementarity of being and becoming is necessary in the scientific story of the world, as we shall see in chapter 3.

Before Johns prologue is completed, he has moved from the generalities of form to the particularity of expression in making the quintessential Christian assertion that the Word became flesh and dwelt

among us. The Epistle to the Colossians declares of the Christ so made known that "he is before all things, and in him all things hold together:'20 Such consistency as we may find in the coherence of the world will never of itself lead us to the cosmic Christ of Colossians, but that cosmic Christ would not be believable if the universe were at root a chaos rather than a cosmos. There must be a congruence between the claims of revelation and the perceptions of a rational inquiry into the world. That necessity alone is sufficient to make natural theology an indispensable part of the theological endeavor.

The urban Christians who wrote the New Testament show less concern with the natural world than do the writers of the Old Testament, whose style of life made them more in touch with nature. The New Testament writers are so seized by the thought of God's great act in Christ, by which they have been encountered, that the generalities of human experience play only a small part in their thought. Nevertheless, it is Paul whose words provide the classic text to which natural theologians are wont to appeal in search of scriptural warrant for their activities. Writing to the Romans, he held that no man can excuse himself on the grounds that he did not know that there is a God, for, "Ever since the creation of the world his invisible nature, namely his power and deity, has been clearly perceived in the things that have been made."21 We might feel that the clarity of the case is somewhat exaggerated by Paul, but his words certainly encourage the attempt to pursue a natural theology. God is the elusive hidden one, not overpowering us by His unveiled presence, but it would surely be disconcerting if there were no signs of Him to be found in His creation.

The Greek Fathers of the Church made use of the idea of the Logos, particularly in the second century, as "the answer to the problem of how God could be both a changeless self-contained being and at the same time the active Creator God:'22 Their concern was with the dialectic of being and becoming, but concentrating on the question of how God is related to the world in a "descending" movement, opposite to the "ascending" flow of natural theology seeking to move from the world to God. As the Fathers continued their wrestling with the mysteries of the incarnation and the Holy Trinity, in an effort to do justice to the particular experiences of revelation, the Logos faded out as a useful category of thought. In the Western Church, Augustine's great influence militated against the exercise of reason and the inspection of the world as routes to God. He wrote: "Understanding is the reward of faith. Therefore do not seek to understand in order to believe but believe in order that you may understand"23 The one-sided emphasis is ironic in one who was the greatest intellect that the Latin Church produced and whose powers of introspection into the polarities of the human psyche provided him with the basis for the most penetrating discussion yet written concerning the doctrine of the Holy Trinity.

The link between belief and understanding is a root concern of this essay. They cohere in mutual interaction, which requires a balance in which neither is afforded an overriding primacy. The dialogue between them is analogous to that between theory, and experiment in science. Without the insight of theory experiment would have no significance. The behaviors and registrations of laboratory apparatus are not of interest in themselves but only for what they are understood to signify. In a similar way, an act of faith, a commitment to some belief, is necessary in the search for wider understanding. On the other hand, no theory can survive which does not find some confirmation in experiment. A physical idea, however intrinsically beautiful, will only remain of interest if it proves capable of illuminating physical fact. In a similar way, faith is not unmotivated. It must be congruent with the way things are and corrigible by them. There is an analogy between this dialectic of faith and understanding and the interrelationship of divine grace and human response in the life of the spirit, another balance that Augustine did not succeed in maintaining.

The Middle Ages saw the first great flowering of natural theology. Its mode was largely the appeal to reason, its purest form the ontological argument of St. Anselm. The latter offers the dazzling prospect of Something for nothing, the deduction of the existence of God (defined as "that than

which no greater can be conceived") simply from an analysis of the implications of that definition. The claim is that what exists is greater than what does not exist, so such a being must, in order to attain his maximal status, include existence among his attributes. The instinct that this is too clever to be true was confirmed when Kant pointed out the illegitimacy of treating existence as a defining predicate. Its logical status is quite different, namely, the assertion that there is an instance of what is defined by the true predicates (in this case, the predicates of omnipotence, omniscience, etc). Thus the ontological argument fails in its logically coercive intent. The existence of God cannot be smuggled into the divine definition, and so it remains a logically open question. This conclusion survives ingenious attempts to get round it by claiming that aseity (that is to say, the property of necessary being as opposed to merely contingent being) is a predicate required for maximal status. There is a distinction to be maintained between internal logical necessity, given a definition, and actual necessity (that is, necessity of an instance of the definition). If "that than which no greater can be conceived" rightly has aseity among His attributes, all that enables us impeccably to deduce is that, if there is a God, then He exists necessarily in the same way that we can deduce that there are numbers greater than 999 if we accept Peano's axioms for arithmetic. But, just as we can conceive of mathematical systems with a limited number of integers,24 so we can conceive of worlds in which God does not exist without committing any logical impropriety." Atheism is not an incoherent possibility.

St. Thomas Aquinas never accepted Anselm's reasoning. However, in the Five Ways,26 he sets out his own natural arguments for the existence of God. They are less austerely abstract than Anselm's, for they take account of certain facts about the world and are not exclusively logical in character. However, the facts appealed to are mostly very general, such as the existence of the world and of change within it, so that the emphasis is still very much on the exercise of reason. In summary, we might say that the Five Ways appeal to (1) the existence of change, so there has to be a first originator of change; (2) the existence of causation, so there has to be a first cause; (3) the existence of coming to be and ceasing to be, so the world's actual continuance requires an unchanging ground of its existence; (4) the existence of gradations of qualities, so there has to be one whose perfection is the ground of all partial qualities; (5) the existence of purpose in the world, so there is the necessity of an intelligence directing it. In each case, the conclusion leads to the postulation of a being of whom it can be said "and all understand that this is God:' Only the last of the Five Ways appeals to a rather specific aspect of the world.

The Five Ways are variations on two grand themes of argument for God's existence, namely, the cosmological theme (the fact of the world requires an explanation: as Leibniz's great question puts it, Why does something exist, rather than nothing?) and the theme of design (the pattern and process of the world exhibits a fruitfulness which speaks of purpose, rather than blind chance). In terms of intellectual compulsion, the Five Ways are no more coercive than the ontological argument. Hume was to have a lot of shrewd fun at their expense. Of course, there has to be some rock-bottom starting point in our account of the world, but "why may not the material universe be the necessary existent.. . for aught we can affirm it [matter] may contain some qualities which, were they known, would make non-existence appear as great a contradiction as that twice two is five."27 Physics has explored the possibility of a self-sustaining role for matter in a way that escaped the notice even of Hume's audacious intellect. This is the notion of the bootstrap,28 a self-consciously constructed counter to the orthodox physical view that matter is composed of identifiable constituents. To the bootstrapper, there are no basic elementary particles; rather, everything is made out of everything else. That breathtaking possibility—that the world has lifted itself into existence by its own bootstraps, so to speak—is conceivable in modern physics where particles are made out of other particles by a force holding them together and where that force is itself due to the exchange of particles between particles. This double role of particles—as carriers of force and as consequences of force—enables us to think of the possibility of particles making themselves out of themselves in a recursively self-consistent way that identifies carrier and

consequence. One of the proponents of this idea, Geoffrey Chew, rather charmingly called it "nuclear democracy"—nothing is more elementary than anything else.

The bootstrap enables us to think of such a possibility; but I must add that no one has ever succeeded in constructing a theory that did more than approximate in a crude and unsatisfactory way to the idea. Moreover, there is good reason to believe that there is an elite of elementary particles, the quarks and the gluons, out of which matter is in fact constructed, rather than a democratic egalitarianism holding sway. As a physically realized idea, therefore, the bootstrap seems dead—but as an enlarger of the intellectual imagination, it continues to tease our thoughts. It also serves to contradict the assertion of the classical logicians that cause and effect must be distinct from each other.

As for Hume's views on design, he points out that the perfection of the world is very questionable: "This world for aught [one] knows is very faulty and imperfect, compared to a superior standard, and was only the first rude essay of some infant deity"29 One must acknowledge that the world often presents an ambiguous face when we seek in it to discern signs of benevolent design. Religious believers are sometimes prone to take too facile a view of its perfection. Many years ago, there were two sets of films in circulation concerned with the character of the living world. One set, made by the Moody Institute of Science as items of Christian apologetic, concentrated on comfortable aspects of the remarkable way in which life is adapted to its environment. The other set, made by the Disney Organization without any metaphysical axe to grind, while not oblivious of the benevolent side of nature, portrayed also its more ruthless aspect. The roles of predators and disease were not overlooked. That would have come as no shock to the biblical writers. The psalmists, in particular, are open to the whole range of experience:

> The young lions roar for their prey, seeking their food from God.30
>
> For my loins are filled with burning,
> and there is no soundness in my flesh. I am utterly spent and crushed;
> I groan because of the tumult of my heart 31

Continued sifting of the arguments from both existence and design has confirmed their shakiness in regard to proof.32 However, that should occasion neither surprise nor dismay. Outside of mathematics, there is very little that enjoys such an incontrovertible degree of certainty (and even there Gödel's theorem indicates that an act of faith is necessary concerning the consistency of the system being considered). There is no infallible way of demonstrating the error of the man who claims that the world came into existence five minutes ago. He is logically invulnerable in his preposterous position, and much good may it do him! Whatever Aquinas himself may have thought to be the character of his arguments, their true nature is not that of knockdown demonstration. It is something subtler than that.

Commentators on Aquinas agree that, when he speaks of a "first" cause, and so on, his concern is with logical hierarchy rather than temporal priority. It is not that God is an originating cause in the remote past (like the fiery explosion of the big bang in physical cosmology) but that He is the fundamental cause in and of the present. In other words, the search for a first cause is a search for the deepest possible understanding of what comes to be, as it comes to be, and a similar search for understanding can be said to characterize the rest of the Five Ways. They are pointers to the divine as the only totally adequate ground of intelligibility. Aquinas's rejection of the possibility of an infinite regress—so strange to us who think naturally of infinite series—is the assertion that there is an attainable comprehensible understanding of all that is. If that is so, it would not seem inappropriate that all should "understand that this is God." Thus conceived, the aim of natural theology is not demonstration of the divine beyond a peradventure, but rather an understanding of

the world through and through, at the most profound level of explanation. The themes of cosmology and design are not proofs but insights.

Perhaps the unconscious recognition of natural theology as a search for understanding is why its second great flowering could occur in the late eighteenth and early nineteenth centuries, despite the severe contemporary criticisms of Hume and Kant. This movement had the character of a whole-hearted appeal to the inspection of the world, in particular to the evidence of design, which its intricate and marvelously apt structure was held to reveal. Its leading figure was Archdeacon Paley, whose Natural Theology was long considered the outstanding English work of apologetic for theism. A later manifestation was provided by the Bridgewater Treatises, founded by a bequest by the eighth Earl of Bridgewater for books devoted to exhibiting "the Power, Wisdom and Goodness of God, as manifested in the Creation;' and with titles such as The Hand, as Evincing Design. After all, the fitness of men and animals for life in their environments is a striking feature of the world that certainly cries out for explanation. Whatever logical caviling might come from the philosophers, the apparent signs of widespread design were persuasive of the need for a Designer. The precariousness of the quest for insight, arising from our limited powers of imagination of how things can come to be, was never more remarkably illustrated than when Darwin proposed an alternative mechanism, whereby the differential selection of random variations, effected by means of the struggle for survival, could lead to the appearance of design without the need for the intervention of a Designer. It was the offering of an alternative insight, rather than detailed philosophical criticism, which dealt a mortal blow to the natural theology of that day. Natural selection made sense, in broad terms, of the fossil record and also of the existence of small differences between species in mutually isolated environments, such as the different types of finch found in the separate islands of the Galapagos archipelago, which otherwise would seem to be acts of superabundant prodigality if they were special creations of the Creator.

The subsequent advance of knowledge has made less and less plausible the invocation of "the God of the Gaps;' that shadowy deity whose only role was to explain the currently scientifically inexplicable. There are certainly many things that we do not understand. There is no agreement about whether the development of life is straightforwardly to be expected, given the right conditions of chemical environment, temperature and radiation,33 or whether it is so unlikely that we must invoke the rather desperate remedy of supposing it to have arrived on Earth from somewhere else (what one might call "the Space Being of the Gaps" theory of Francis Crick).34 Yet we have no reason to think that scientifically state-able questions will not prove in the end to have scientifically state-able answers, however hard they may be to find and by however much they may turn out to require more knowledge than we have at our present disposal.

The God of the Gaps is dead, and with him has died the old-style natural theology of Paley and the Bridgewater Treatises. No theologian need weep for them, for the God of the Gaps, hovering at the periphery of the known world, was far from being someone of whom it could be said that "all understand that this is God:' He was proposed as a sort of demiurge, a cause among the other competing causes of the world. When Aquinas spoke of God as "first cause:' he did not consider Him thus as a jostling participant among the many efficient causes of the cosmic process. Rather, He is the ground of all that is in the world and not to be identified with any part of its process. He is the author and producer of the play, not a particularly striking actor upon the stage.

Torrance has made the interesting observation that the two great periods of natural theology's flourishing were also periods characterized by strongly dualistic thought about the world." The Middle Ages discriminated between the sensible world of brute perception and the intelligible world of spiritual apprehension. They drew a line between nature and super-nature. In the eighteenth century, Cartesian dualism proclaimed a division between the extended substance of matter and the thinking substance of mind, while the deists sharply differentiated a detached God from the

world that he had launched upon its way. The appeal of natural theology in both of these ages lay in its ability to act as a logical bridge across the imposed gulf. It provided a way from one side to the other, as the grand scheme of the Summa Theologiae clearly illustrates.

Torrance emphatically rejects this idea that natural theology is just a prior preparation for revealed theology, a warming-up exercise before the real action starts. Rather, it is an integral part of the whole theological endeavor:

> If we reject a deistic disjunction between God and the world, which we are bound to do, natural theology cannot be pursued in its traditional abstractive form, as a prior conceptual system on its own, but must be brought within the body of positive theology and be pursued in indissoluble unity with it. No longer extrinsic but intrinsic to the knowledge of God, it will function as a necessary infra-structure of theological science.36

He calls natural theology the "epistemological `geometry" of revealed theology. In that somewhat curious phrase, he has in mind the analogy of the integration of geometry and mechanics that Einstein's General Theory of Relativity brought about. The classical Newtonian view of the question was that space was the given container in which particles of matter executed their mechanical interactions. In this view, geometry was a priori to physics. It described the stage on which the dynamical play was to be performed. Just as the scene-setters in a theater can get on with their work in the absence of the actors, so geometrical thought was capable of being pursued in isolation from the consideration of the mechanics of matter. Euclid had his job to do, which Newton could then take over for his purposes.

In General Relativity, this is not the case. Space and matter, geometry and physics, impinge upon each other. What we think of as the force of gravity is due to the curvature of space, which is itself due to the distribution of matter. While it may at times be profitable to concentrate one's attention on geometry and at times on matter, one is always conscious that they together form an integrated whole. It is Torrance's contention that the same is true of natural and revealed theology. His view is congenial to those of us who believe in the unity of knowledge and who consequently think that theology must take account of all that we know about the world in the course of its inquiry. It is also consonant with the history of thought, for when we are seeking an understanding through and through, areas of experience interact with each other and place mutual limitations on the interpretations which are conceivable. One has only to think of the modification of the tone of theological discourse that resulted from the transition from the three-decker universe of the world of antiquity to the vast universe discerned by modern cosmology, to get the point. Taking a contrary position is to risk relegating theology to an intellectual ghetto. Pannenberg has warned of the "danger of distorting the historical revelation into a gnostic knowledge of secrets;' which follows from an "understanding that puts revelation in contrast to, or even in conflict with, natural knowledge.

In this view, natural theology is an essential study, not just an optional extra for those so inclined. The Darwinian debacle has had the effect of largely discrediting its pursuit for a century. Nevertheless, it is undergoing a welcome revival in our own time. This is occurring not so much at the hands of the theologians (whose nerve, with some honorable exceptions, has not yet returned) but at the hands of the scientists. There has grown up a widespread feeling, especially among those who study fundamental physics, that there is more to the world than meets the eye. Science seems to throw up questions that point beyond itself and transcend its power to answer. They arise from recognizing the potentiality inherent in the structure of the world, its interlocking tightly knit character, and, indeed, its very intelligibility which makes it open to our inquiry. Thus a physicist such as Paul Davies, who is notably unsympathetic to conventional religion, can nevertheless write, "It may be bizarre but in my opinion science offers a surer road to God than religion."38

We are concerned not only with a revived natural theology but also with a revised natural theology. It points to law and circumstance (the assumed data of science and so not open to scientific inquiry) rather than to particular occurrences (such as the coming-to-be of life or of the eye). These latter questions are legitimate subjects for scientific investigation and the attempt to capture them, for theology is just the error of the God of the Gaps. On the other hand, the former matters of law and circumstance are part of the founding faith of science, which it has to assume as the basis of its inquiry. They bring us back to the themes of cosmology and design, pursued at a deeper level than the scientific, in a search for the fullest possible understanding of the world.39 The insights thus obtained must find their integration within the totality of theological thinking. These are the tasks to which we must address ourselves in the chapters that follow. The purpose of this chapter has been to show that this intellectual quest is a continuation of a long and fruitful tradition of religious thought.

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Anthony Flew, Former Atheist and Now Deist
There is a God – How the World's Most Notorious Atheist Changed His Mind
Book

Chapter 4 - A Pilgrimage

Let us begin with a parable. Imagine that a satellite phone is washed ashore on a remote island inhabited by a tribe that has never had contact with modem civilization. The natives play with the numbers on the dial pad and hear different voices upon hitting certain sequences. They assume first that it's the device that makes these noises. Some of the cleverer natives, the scientists of the tribe, assemble an exact replica and hit the numbers again. They hear the voices again. The conclusion seems obvious to them. This particular combination of crystals and metals and chemicals produces what seems like human voices, and this means that the voices are simply properties of the device.

But the tribal sage summons the scientists for a discussion. He has thought long and hard on the matter and has reached the following conclusion: the voices coming through the instrument must be coming from people like of a greater understanding of the world beyond the island inhabited by the tribe.

Now it often seems to people who are not atheists as if there is no conceivable piece of evidence that would be admitted by apparently scientific-minded dogmatic atheists to be a sufficient reason for conceding "There might be a God after all." I therefore put to my former fellow-atheists the simple central question: "What would have to occur or to have occurred to constitute for you a reason to at least consider the existence of a superior Mind?"

Laying The Cards On The Table

Moving on now from the parable, it's time for me to lay my cards on the table, to set out my own views and the reasons that support them. I now believe that the universe was brought into existence by an infinite Intelligence. I believe that this universe's intricate laws manifest what scientists have called the Mind of God. I believe that life and reproduction originate in a divine Source.

Why do I believe this, given that I expounded and defended atheism for more than a half century? The short answer is this: this is the world picture, as I see it, that has emerged from modern science. Science spotlights three dimensions of nature that point to God. The first is the fact that

nature obeys laws. The second is the dimension of life, of intelligently organized and purpose-driven beings, which arose from matter. The third is the very existence of nature. But it is not science alone that has guided me. I have also been helped by a renewed study of the classical philosophical arguments.

My departure from atheism was not occasioned by any new phenomenon or argument. Over the last two decades, my whole framework of thought has been in a state of migration. This was a consequence of my continuing assessment of the evidence of nature. When I finally came to recognize the existence of a God, it was not a paradigm shift, because my paradigm remains, as Plato in his Republic scripted his Socrates to insist: "We must follow the argument wherever it leads."

You might ask how I, a philosopher, could speak to issues treated by scientists. The best way to answer this is with another question. Are we engaging in science or philosophy here? When you study the interaction of two physical bodies, for instance, two subatomic particles, you are engaged in science. When you ask how it is that those subatomic particles—or anything physical—could exist and why, you are engaged in philosophy. When you draw philosophical conclusions from scientific data, then you are thinking as a philosopher.

A Recovery Of Wisdom

As for my new position on the classical philosophical debates about God, in this area I was persuaded above all by the philosopher David Conway's argument for God's existence in his book The Recovery of Wisdom: From Here to Antiquity in Quest of Sophia. Conway is a distinguished British philosopher at Middlesex University who is equally at home with classical and modern philosophy.

The God whose existence is defended by Conway and myself is the God of Aristotle. Conway writes:

> In sum, to the Being whom he considered to be the explanation of the world and its broad form, Aristotle ascribed the following attributes: immutability, immateriality, omnipotence, omniscience, oneness or indivisibility, perfect goodness and necessary existence. There is an impressive correspondence between this set of attributes and those traditionally ascribed to God within the Judaeo-Christian tradition. It is one that fully justifies us in viewing Aristotle as having had the same Divine Being in mind as the cause of the world that is the object of worship of these two religions.2

As Conway sees it, then, the God of the monotheistic religions has the same attributes as the God of Aristotle.

In his book, Conway attempts to defend what he describes as the "classical conception of philosophy." That conception is "the view that the explanation of the world and its broad form is that it is the creation of a supreme t, omnipotent and omniscient intelligence, more commonly referred to as God, who created it in order to bring into existence and sustain rational beings."3 God created the world so as to bring into being a race of rational creatures. Conway believes, and I concur, that it is possible to learn of the existence and nature of this Aristotelian God by the exercise of unaided human reason.

I must stress that my discovery of the Divine has proceeded on a purely natural level, without any reference to supernatural phenomena. It has been an exercise in what is traditionally called natural theology. It has had no connection with any of the revealed religions. Nor do I claim to have had any personal experience of God or any experience that may be called supernatural or miraculous. In short, my discovery of the Divine has been a pilgrimage of reason and not of faith.

Chapter 5 - Who Wrote The Laws Of Nature?

Perhaps the most popular and intuitively plausible argument for God's existence is the so-called argument from design. According to this argument, the design that is apparent in nature suggests the existence of a cosmic Designer. I have often stressed that this is actually an argument to design from order, as such arguments proceed from the perceived order in nature to show evidence of design and, thus, a Designer. Although I was once sharply critical of the argument to design, I have since come to see that, when correctly formulated, this argument constitutes a persuasive case for the existence of God. Developments in two areas in particular have led to this conclusion. The first is the question of the origin of the laws of nature and the related insights of eminent modern scientists. The second is the question of the origin of life and reproduction.

What do I mean by the laws of nature? By law, I simply mean a regularity or symmetry in nature.

Some common textbook examples should show what I mean:

Boyle's law stipulates that, given constant temperature, the product of the volume and pressure of a fixed quantity of an ideal gas is constant.

According to Newton's first law of motion, an object at rest will remain at rest unless acted upon by an external and unbalanced force; an object in motion will remain in motion unless acted upon by an external and unbalanced force.

According to the law of the conservation of energy, the total amount of energy in an isolated system remains constant.

The important point is not merely that there are regularities in nature, but that these regularities are mathematically precise, universal, and "tied together." Einstein spoke of them as "reason incarnate." The question we should ask is how nature came packaged in this fashion. This is certainly the question that scientists from Newton to Einstein to Heisenberg have asked—and answered. Their answer was the Mind of God.

Now, this way of thinking is not something found only in well-known premodern theistic scientists like Isaac Newton and James Maxwell. On the contrary, many prominent scientists of the modern era have regarded the laws of nature as thoughts of the Mind of God. Stephen Hawking ends his best-selling A Brief History of Time with this passage:

> If we discover a complete theory, it should in time be understandable by everyone, not just by a few scientists. Then we shall all, philosophers, scientists and just ordinary people, be able to take part in the discussion of the question of why it is that we and the universe exist. If we find the answer to that, it would be the ultimate triumph of human reason—for then we should know the mind of God.

On the previous page he asked: "Even if there is only one possible unified theory, it is just a set of rules and equations. What is it that breathes fire into the equations and makes a universe for them to describe?"

Hawking had more to say on this in later interviews: "The overwhelming impression is one of order. The more we discover about the universe, the more we find that it is governed by rational laws." And, "You still have the question: why does the universe bother to exist? If you like, you can define God to be the answer to that question."2

Who Wrote All Those Books?
Long before Hawking, Einstein had used similar language: "I want to know how God created this world.... I want to know His thoughts, the rest are details." 3 In my book God and Philosophy, I had said we cannot make too much of these sorts of passages, since Einstein had said that he believed in Spinoza's God. 4 Since for Baruch Spinoza the words God and nature were synonymous, it could be said that Einstein, in the eyes of Judaism, Christianity, and Islam, was unequivocally an atheist and that he was "a spiritual father of all atheists."

But the recent book Einstein and Religion, by one of Einstein's friends, Max Jammer, paints a very different picture of the influence of Spinoza and also of Einstein's own beliefs. Jammer shows that Einstein's knowledge of Spinoza was quite limited; he had read only Spinoza's Ethics and turned down repeated requests to write about Spinoza's philosophy. In response to one request, he replied, "I do not have the professional knowledge to write a scholarly article about Spinoza." 5 Although Einstein shared Spinoza's belief in determinism, Jammer holds that it "is artificial and unwarranted" to assume that Spinoza's thought influenced Einstein's science.6 Jammer notes too that "Einstein felt akin to Spinoza because he realized that they shared a need for solitude as well as the fate of having been reared within the Jewish heritage but having become subsequently alienated from its religious heritage."?

While drawing attention to Spinoza's pantheism, Einstein, in fact, expressly denied being either an atheist or a pantheist:

> I'm not an atheist, and I don't think I can call myself a pantheist. We are in the position of a little child entering a huge library filled with books in many languages. The child knows someone must have written those books. It does not know how. It does not understand the languages in which they are written. The child dimly suspects a mysterious order in the arrangement of the books but doesn't know what it is. That, it seems to me, is the attitude of even the most intelligent human being toward God. We see the universe marvelously arranged and obeying certain laws but only dimly understand these laws. Our limited minds grasp the mysterious force that moves the constellations. [Emphasis added.]$

In his book The God Delusion, Richard Dawkins propounds my old position that Einstein was an atheist. In doing so, Dawkins ignores Einstein's categorical statement above that he was neither an atheist nor a pantheist. This is puzzling because Dawkins cites Jammer on occasion, but leaves out numerous statements by Jammer and Einstein that are fatal to his own case. Jammer observes, for instance, that "Einstein always protested against being regarded as an atheist. In a conversation with Prince Hubertus of Lowenstein, for example, he declared, `What really makes me angry is that they [people who say there is no God] quote me for support of their views.' Einstein renounced atheism because he never considered his denial of a personal God as a denial of God."9

Einstein, of course, did not believe in a personal God. But he said:

> It is a different question whether belief in a personal God should be contested. Freud endorsed this view in his latest publication. I myself would never engage in such a task. For such a belief seems to me preferable to any lack of any transcendental outlook of life, and I wonder whether one can ever successfully render to the majority of mankind a more sublime means in order to satisfy its metaphysical needs.'°

"To sum up," concludes Jammer, "Einstein, like Maimonides and Spinoza, categorically rejected any anthropomorphism in religious thought." But unlike Spinoza, who saw the only logical consequence of the denial of a personal God in an identification of God with nature, Einstein maintained that

God manifests himself "in the laws of the universe as a spirit vastly superior to that of man, and one in the face of which we with our modest powers must feel humble." Einstein agreed with Spinoza that he who knows nature knows God, but not because nature is God, but because the pursuit of science in studying nature leads to religion."

Einstein's "Superior Mind"

Einstein clearly believed in a transcendent source of the rationality of the world that he variously called "superior mind," "illimitable superior spirit," "superior reasoning force," and "mysterious force that moves the constellations." This is evident in several of his statements:

> I have never found a better expression than "religious" for this trust in the rational nature of reality and of its peculiar accessibility to the human mind. Where this trust is lacking science degenerates into an uninspired procedure. Let the devil care if the priests make capital out of this. There is no remedy for that."
>
> Whoever has undergone the intense experience of successful advances in this domain [science] is moved by profound reverence for the rationality made manifest in existence ... the grandeur of reason incarnate in existence.13
>
> Certain it is that a conviction, akin to religious feeling, of the rationality or intelligibility of the world lies behind all scientific work of a higher order.... This firm belief, a belief bound up with deep feeling, in a superior mind that reveals itself in the world of experience, represents my conception of God.14
>
> Every one who is seriously engaged in the pursuit of science becomes convinced that the laws of nature manifest the existence of a spirit vastly superior to that of men, and one in the face of which we with our modest powers must feel humble.1S
>
> My religiosity consists of a humble admiration of the infinitely superior spirit who reveals himself in the slight details we are able to perceive with our frail and feeble minds. That deeply emotional conviction of the presence of a superior reasoning power, which is revealed in the incomprehensible universe, forms my idea of God.16

Quantum Leaps Toward God

Einstein, the discoverer of relativity, was not the only great scientist who saw a connection between the laws of nature and the Mind of God. The progenitors of quantum physics, the other great scientific discovery of modern times, Max Planck, Werner Heisenberg, Erwin Schrodinger, and Paul Dirac, have all made similar statements,'? and I reproduce a few of these below.

Werner Heisenberg, famous for Heisenberg's uncertainty principle and matrix mechanics, said, "In the course of my life I have repeatedly been compelled to ponder on the relationship of these two regions of thought [science and religion], for I have never been able to doubt the reality of that to which they point."8 On another occasion he said:

Wolfgang [Pauli] asked me quite unexpectedly: "Do you believe in a personal God?"... "May I rephrase your question?" I asked. "I myself should prefer the following formulation: Can you, or anyone else, reach the central order of things or events, whose existence seems beyond doubt, as directly as you can reach the soul of another human being. I am using the term `soul' quite deliberately so as not to be misunderstood. If you put your question like that, I would say yes.... If the magnetic force that has guided this particular compass—and what else was its source but the central order?—should ever become extinguished, terrible things may happen to mankind, far more terrible even than concentration camps and atom bombs."

Another quantum pioneer, Erwin Schrodinger, who developed wave mechanics, stated:

> The scientific picture of the world around me is very deficient. It gives me a lot of factual information, puts all our experience in a magnificently consistent order, but is ghastly silent about all that is really near to our heart, that really matters to us. It cannot tell a word about the sensation of red and blue, bitter and sweet, feelings of delight and sorrow. It knows nothing of beauty and ugly, good or bad, God and eternity. Science sometimes pretends to answer questions in these domains, but the answers are very often so silly that we are not inclined to take them seriously.
>
> Science is reticent too when it is a question of the great g Unity of which we somehow form a part, to which we belong. The most popular name for it in our time is God, with a capital "G." Science is, very usually, branded as being atheistic. After what we have said this is not astonishing. If its world picture does not even contain beauty, delight, sorrow, if personality is cut out of it by agreement, how should it contain the most sublime idea that presents itself to the human mind.20

Max Planck, who first introduced the quantum hypothesis, unambiguously held that science complements religion, contending, "There can never be any real opposition between religion and science; for the one is the complement of the other."21 He also said, "Religion and natural science are fighting a joint battle in an incessant, never relaxing crusade against skepticism and against dogmatism, against unbelief and superstition ... [and therefore] On to God!'"22

Paul A. M. Dirac, who complemented Heisenberg and Schrodinger with a third formulation of quantum theory, observed that "God is a mathematician of a very high order and He used advanced mathematics in constructing the universe. "23

Generations before any of these scientists, Charles Darwin had already expressed a similar view:

> [Reason tells me of the] extreme difficulty or rather impossibility of conceiving this immense and wonderful universe, including man with his capability of looking far backwards and far into futurity, as the result of blind chance or necessity. When thus reflecting I feel compelled to look to a First Cause having an intelligent mind in some degree analogous to that of man; and I deserve to be called a Theist 24

This train of thought has been kept alive in the present time in the writings of many of today's leading expositors of science. These range from scientists like Paul Davies, John Barrow, John Polkinghorne, Freeman Dyson, Francis Collins, Owen Gingerich, and Roger Penrose to philosophers of science like Richard Swinburne and John Leslie.

Davies and Barrow, in particular, have further developed the insights of Einstein, Heisenberg, and other scientists into theories about the relationship between the rationality of nature and the Mind of God. Both have received the Templeton Prize for their contributions to this exploration.

Their works correct many common misconceptions while shedding light on the issues discussed here.

Whose Laws?

In his Templeton address, Paul Davies makes the point that "science can proceed only if the scientist adopts an essentially theological worldview." Nobody asks where the laws of physics come from, but "even the most atheistic scientist accepts as an act of faith the existence of a Jawlike

order in nature that is at least in part comprehensible to us." Davies rejects two common misconceptions. He says the idea that a theory of everything would show that this is the only logically consistent world is "demonstrably wrong," because there is no evidence at all that the universe is logically necessary, and in fact it is possible to imagine alternative universes that are logically consistent. Second, he says it is "arrant nonsense" to suppose that the laws of physics are our laws and not nature's. Physicists will not believe that Newton's inverse law of gravitation is a cultural creation. He holds that the laws of physics "really exist," and scientists' job is to uncover and not invent them.

Davies draws attention to the fact that the laws of nature underlying phenomena are not found through direct observation, but extracted through experiment and mathematical theory. The laws are written in a cosmic code that scientists must crack in order to reveal the message that is "nature's message, God's message, take your choice, but not our message."

The burning question, he says, is threefold:

Where do the laws of physics come from?

Why is it that we have these laws instead of some other set?

How is that we have a set of laws that drives featureless gases to life, consciousness and intelligence?

These laws "seem almost contrived—fine-tuned, some commentators have claimed—so that life and consciousness may emerge." He concludes that this "contrived nature of physical existence is just too fantastic for me to take on board as simply `given.' It points to a deeper underlying meaning to existence." Such words as purpose and design, he says, only capture imperfectly what the universe is about. "But, that it is about something, I have absolutely no doubt."25

John Barrow, in his Templeton address, observes that the unending complexity and exquisite structure of the universe are governed by a few simple laws that are symmetrical and intelligible. In fact, "there are mathematical equations, little squiggles on pieces of paper, that tell us how whole universes behave." Like Davies, he dismisses the idea that the order of the universe is imposed by our minds. Moreover, "natural selection requires no understanding of quarks and black holes for our survival and multiplication."

Barrow observes that in the history of science new theories extend and subsume old ones. Although Newton's theory of mechanics and gravity has been superseded by Einstein's and will be succeeded by some other theory in the future, a thousand years from now engineers will still rely on Newton's theories. Likewise, he says, religious conceptions of the universe also use approximations and analogies to help in grasping ultimate things. "They are not the whole truth, but this does not stop them being a part of the truth. "26

The Divine Lawmaker

A few philosophers have also written about the divine provenance of the laws of nature. In his book The Divine Lawmaker: Lectures on Induction, Laws of Nature and the Existence of God, Oxford philosopher John Foster contends that regularities in nature, however you describe them, can be best explained by a divine Mind. If you accept the fact that there are laws, then something must impose that regularity on the universe. What agent (or agents) brings this about? He contends that the theistic option is the only serious option as the source, so that "we shall be rationally warranted in concluding that it is God—the God of the theistic account—who creates the laws by imposing the

regularities on the world as regularities." Even if you deny the existence of laws, he argues, "there is a strong case for explaining the regularities by appealing to the agency of God."27

Swinburne makes a related point in a response to Dawkins's critique of his argument to design:

> What is a law of nature? (This is not an issue faced by any of my critics.) To say that it is a law of nature that all bodies behave in a certain way (e.g., attract each other in accord with a certain formula) is, I suggest, just to say that each body of physical necessity behaves in that way (e.g., attracts each body in that way). And it is simpler to suppose that this uniformity arises from the action of one substance which causes them all to behave in the same way, rather than to suppose that all bodies behaving in the same uniform way is an ultimate brute fact.28

Swinburne's central argument is that a personal God with the traditional properties best explains the operation of the laws of nature.

Richard Dawkins has rejected this argument on the grounds that God is too complex a solution for explaining the universe and its laws. This strikes me as a bizarre thing to say about the concept of an omnipotent spiritual Being. What is complex about the idea of an omnipotent and omniscient Spirit, an idea so simple that it is understood by all the adherents of the three great monotheistic religions—Judaism, Christianity, and Islam? Commenting on Dawkins, Alvin Plantinga recently pointed out that, by Dawkins's own definition, God is simple—not complex—because God is a spirit, not a material object, and hence does not have parts.

Returning to my parable of the satellite phone in the previous chapter, the laws of nature pose a problem for atheists because they are a voice of rationality heard through the mechanisms of matter. "Science is based on the assumption that the universe is thoroughly rational and logical at all levels," writes Paul Davies, arguably the most influential contemporary expositor of modern science. "Atheists claim that the laws [of nature] exist reasonlessly and that the universe is ultimately absurd. As a scientist, I find this hard to accept. There must be an unchanging rational ground in which the logical, orderly nature of the universe is rooted."29

Those scientists who point to the Mind of God do not merely advance a series of arguments or a process of syllogistic reasoning. Rather, they propound a vision of reality that emerges from the conceptual heart of modern science and imposes itself on the rational mind. It is a vision that I personally find compelling and irrefutable.

Chapter 6 - Did The Universe Know We Were Coming?

Imagine entering a hotel room on your next vacation. The CD player on the bedside table is softly playing a track from your favorite recording. The framed print over the bed is identical to the image that hangs over the fireplace at home. The room is scented with your favorite fragrance. You shake your head in amazement and drop your bags on the floor.

You're suddenly very alert. You step over to the minibar, open the door, and stare in wonder at the contents. Your favorite beverages. Your favorite cookies and candy. Even the brand of bottled water you prefer.

You turn from the minibar, then, and gaze around the room. You notice the book on the desk: it's the latest volume by your favorite author. You glance into the bathroom, where personal care and grooming products are lined up on the counter, each one as if it was chosen specifically for you. You switch on the television; it is tuned to your favorite channel.

Chances are, with each new discovery about your hospitable new environment, you would be less inclined to think it was all a mere coincidence, right? You might wonder how the hotel managers acquired such detailed information about you. You might marvel at their meticulous preparation. You might even double-check what all this is going to cost you. But you would certainly be inclined to believe that someone knew you were coming.

Our Finely Tuned Universe

That vacation scenario is a clumsy, limited parallel to the so-called fine-tuning argument. The recent popularity of this argument has highlighted a new dimension of the laws of nature. "The more I examine the universe and study the details of its architecture," writes physicist Freeman Dyson, "the more evidence I find that the universe in some sense knew we were coming." In other words, the laws of nature seem to have been crafted so as to move the universe toward the emergence and sustenance of life. This is the anthropic principle, popularized by such thinkers as Martin Rees, John Barrow, and John Leslie.

Let's take the most basic laws of physics. It has been calculated that if the value of even one of the fundamental constants—the speed of light or the mass of an electron, for instance—had been to the slightest degree different, then no planet capable of permitting the evolution of human life could have formed.

This fine tuning has been explained in two ways. Some scientists have said the fine tuning is evidence for divine design; many others have speculated that our universe is one of multiple others—a "multiverse"—with the difference that ours happened to have the right conditions for life. Virtually no major scientist today claims that the fine tuning was purely a result of chance factors at work in a single universe.

In his book Infinite Minds, John Leslie, a leading anthropic theorist, argues that fine tuning is best explained by divine design. He says that he is impressed not by particular arguments for instances of fine tuning, but by the fact that these arguments exist in such profusion. "If, then, there were aspects of nature's workings that appeared very fortunate and also entirely fundamental," he writes, "then these might well be seen as evidence specially favoring belief in God."2 He cites examples of such "fortunate" and "fundamental" aspects of nature's workings:

> 1 The principle of special relativity ensures that forces such as electromagnetism have an invariable effect regardless of whether they act at right angles to a system's direction of travel. This enables genetic codes to work and planets to hold together when rotating.
>
> 2 Quantum laws prevent electrons from spiraling into atomic nuclei.
>
> 3 Electromagnetism has one-force strength, which enables multiple key processes to take place: it allows stars to burn steadily for billions of years; it enables carbon synthesis in stars; it ensures that leptons do not replace quarks, which would have made atoms impossible; it is responsible for protons not decaying too fast or repelling each other too strongly, which would have made chemistry impossible. How is it possible for the same one-force strength to satisfy so many different requirements, when it seems that different strengths would be required for each one of these processes?3

Across The Multiverse

Opposed to the idea of divine design is the theory of the multiverse. (I shall argue, however, that the existence of a multiverse still does not eliminate the question of a divine Source.) One of the most prominent proponents of the multiverse is cosmologist Martin Rees. Rees observes:

> Any universe hospitable to life—what we might call a biophilic universe—has to be "adjusted" in a particular way. The prerequisites for any life of the kind we know about—long-lived stable stars, stable atoms such as carbon, oxygen and silicon, able to combine into complex molecules, etc.—are sensitive to the physical laws and to the size, expansion rate and contents of the universe.4

This could be explained, he says, by the hypothesis that there are many "universes" with different laws and physical constants, and ours happens to be one belonging to a subset of universes that are conducive to the appearance of complexity and consciousness. If this is the case, fine tuning would not be surprising.

Rees mentions the most influential variations of the multiverse idea. In the "eternal inflationary" idea of cosmologists Andrei Linde and Alex Vilenkin, universes emerge from individual big bangs with space-time dimensions entirely different from those of the universe we know. The black hole thesis of Alan Guth, David Harrison, and Lee Smolin holds that universes materialize from black holes in mutually inaccessible space-time domains. Finally, Lisa Randall and Raman Sundrum propose that there are universes in different spatial dimensions that may or may not interact gravitationally with each other. Rees points out that these multiverse ideas are "highly speculative" and require a theory that consistently describes the physics of ultrahigh densities, the configuration of structures on extra dimensions, and so forth. He notes that only one of them can be right. And, in fact, he adds, "Quite possibly none is: there are alternative theories that would lead just to one universe."5

A Blunderbuss Theory

Both Paul Davies and Richard Swinburne reject the multi-verse idea. Davies, a physicist and cosmologist, writes that "it is trivially true that, in an infinite universe, anything that can happen will happen." But this is not an explanation at all. If we are trying to understand why the universe is bio-friendly, we are not helped by being told that all possible universes exist. "Like a blunderbuss, it explains everything and nothing." By this he means that it is a vacuous claim. If we say that the world and everything in it came into being five minutes ago complete with our memories of living for many years and evidence of events occurring thousands of years ago, then our claim cannot be refuted. It explains everything and yet nothing.

A true scientific explanation, says Davies, is like a single well-aimed bullet. The idea of a multiverse replaces the rationally ordered real world with an infinitely complex, charade and makes the whole idea of "explanation" meaningless.6 Swinburne is just as strong in his disdain for the multiverse explanation: "It is crazy to postulate a trillion (causally unconnected) universes to explain the features of one universe, when postulating one entity (God) will do the job."7

Three things might be said concerning the arguments about fine tuning.

First, it is a hard fact that we live in a universe with certain laws and constants, and life would not have been possible if some of these laws and constants had been different.

Second, the fact that the existing laws and constants allow the survival of life does not answer the question of the origin of life. This is a very different question, as I will try to show; these conditions are necessary for life to arise, but not sufficient.

Third, the fact that it is logically possible that there are multiple universes with their own laws of nature does not show that such universes do exist. There is currently no evidence in support of a multiverse. It remains a speculative idea.

What is especially important here is the fact that the existence of a multiverse does not explain the origin of the laws of nature. Martin Rees suggests that the existence of different universes with their own laws raises the question of the laws governing the entire multiverse, the overarching theory governing the ensemble. "The underlying laws governing the entire multiverse may allow variety among the universes," he writes. "Some of what we call `laws of nature' may in this grander perspective be local bylaws, consistent with some overarching theory governing the ensemble, but not uniquely fixed by that theory.'"

To ask how the laws governing the multiverse originated is the same as asking for the origin of the laws of nature in general. Paul Davies notes:

> Multiverse proponents are often vague about how the parameter values are chosen across the defined ensemble. If there is a "law of laws" describing how parameter values are assigned as one slips from one universe to the next, then we have only shifted the problem of cosmic biophilicity up one level. Why? First, because we need to explain where the law of laws comes from.9

Some have said that the laws of nature are simply accidental results of the way the universe cooled after the big bang. But, as Rees has pointed out, even such accidents can be regarded as secondary manifestations of deeper laws governing the ensemble of universes. Again, even the evolution of the laws of nature and changes to the constants follow certain laws. "We're still left with the question of how these `deeper' laws originated. No matter how far you push back the properties of the universe as somehow `emergent,' their very emergence has to follow certain prior laws."10

So multiverse or not, we still have to come to terms with the origin of the laws of nature. And the only viable explanation here is the divine Mind.

Chapter 7 -

How Did Life Go Live?

When the mass media first reported the change in my view of the world, I was quoted as saying that biologists' investigation of DNA has shown, by the almost unbelievable complexity of the arrangements needed to produce life, that intelligence must have been involved. I had previously written that there was room for a new argument to design in explaining the first emergence of living from nonliving matter—especially where this first living matter already possessed the capacity to reproduce itself genetically. I maintained that there was no satisfactory naturalistic explanation for such a phenomenon.

These statements provoked an outcry from critics who claimed that I was not familiar with the latest work in abiogenesis. Richard Dawkins claimed that I was appealing to a "god of the gaps." In my new introduction to the 2005 edition of God and Philosophy, I said, "I am myself delighted to be assured by biological-scientist friends that protobiologists are now well able to produce theories of the evolution of the first living matter and that several of these theories are consistent with all the so-far-confirmed scientific evidence." But to this I must add the caveat that the latest work I have seen shows that the present physicists' view of the age of the universe gives too little time for these theories of abiogenesis to get the job done.

A far more important consideration is the philosophical challenge facing origin-of-life studies. Most studies on the origin of life are carried out by scientists who rarely attend to the philosophical dimension of their findings. Philosophers, on the other hand, have said little on the nature and origin of life. The philosophical question that has not been answered in origin-of-life studies is this:

How can a universe of mindless matter produce beings with intrinsic ends, self-replication capabilities, and "coded chemistry"? Here we are not dealing with biology, but an entirely different category of problem.

The Purpose-Driven Organism

Let us first look at the nature of life from a philosophical standpoint. Living matter possesses an inherent goal or end-centered organization that is nowhere present in the matter that preceded it. In one of the few recent philosophical works on life, Richard Cameron has presented a useful analysis of this directedness of living beings.

Something that is alive, says Cameron, will also be teleological—that is, it will possess intrinsic ends, goals, or purposes. "Contemporary biologists, philosophers of biology, and workers in the field of `artificial life," he writes, "have yet to produce a satisfying account of what it is to be alive, and I defend the view that Aristotle can help us fill this gap.... Aristotle did not hold life and teleology to be coextensive simply by chance, but defined life in teleological terms, holding that teleology is essential to the life of living things."2

The origin of self-reproduction is a second key problem. Distinguished philosopher John Haldane notes that origin-of-life theories "do not provide a sufficient explanation, since they presuppose the existence at an early stage of self-reproduction, and it has not been shown that this can arise by natural means from a material base."3

David Conway summarizes these two philosophical quandaries in responding to David Hume's contention that the life-sustaining order of the universe was not designed by any form of intelligence. The first challenge is to produce a materialistic explanation for "the very first emergence of living matter from non-living matter. In being alive, living matter possesses a teleological organization that is wholly absent from everything that preceded it." The second challenge is to produce an equally materialist explanation for "the emergence, from the very earliest life-forms which were incapable of reproducing themselves, of life-forms with a capacity for reproducing themselves. Without the existence of such a capacity, it would not have been possible for different species to emerge through random mutation and natural selection. Accordingly, such mechanism cannot be invoked in any explanation of how life-forms with this capacity first `evolved' from those that lacked it." Conway concludes that these biological phenomena "provide us with reason for doubting that it is possible to account for existent life-forms in purely materialistic terms and without recourse to design."4

A Deep Conceptual Challenge

A third philosophical dimension to the origin of life relates to the origin of the coding and information processing that is central to all life-forms. This is well described by the mathematician David Berlinski, who points out that there is a rich narrative drama surrounding our current understanding of the cell.

The genetic message in DNA is duplicated in replication and then copied from DNA to RNA in transcription. Following this there is translation whereby the message from RNA is conveyed to the amino acids, and finally the amino acids are assembled into proteins. The cell's two fundamentally different structures of information manage ment and chemical activity are coordinated by the universal genetic code.

The remarkable nature of this phenomenon becomes apparent when we highlight the word code. Berlinski writes:

> By itself, a code is familiar enough, an arbitrary mapping or a system of linkages between two discrete combinatorial objects. The Morse code, to take a familiar example, coordinates dashes and dots with letters of the alphabet. To note that codes are arbitrary is to note the distinction between a code and a purely physical connection between two objects. To note that codes embody mappings is to embed the concept of a code in mathematical language. To note that codes reflect a linkage of some sort is to return the concept of a code to its human uses.
>
> This in turn leads to the big question: "Can the origins of a system of coded chemistry be explained in a way that makes no appeal whatever to the kinds of facts that we otherwise invoke to explain codes and languages, systems of communication, the impress of ordinary words on the world of matter?"5

Carl Woese, a leader in origin-of-life studies, draws attention to the philosophically puzzling nature of this phenomenon. Writing in the journal RNA, he says: "The coding, mechanistic, and evolutionary facets of the problem now became separate issues. The idea that gene expression, like gene replication, was underlain by some fundamental physical principle was gone." Not only is there no underlying physical principle, but the very existence of a code is a mystery. "The coding rules (the dictionary of codon assignments) are known. Yet they provide no clue as to why the code exists and why the mechanism of translation is what it is." He frankly admits that we do not know anything about the origin of such a system. "The origins of translation, that is before it became a true decoding mechanism, are for now lost in the dimness of the past, and I don't wish to engage here in hand-waving speculations as to what polymerization processes might have preceded and given rise to it, or to speculate on the origins of tRNA, tRNA charging systems or the genetic code."6

Paul Davies highlights the same problem. He observes that most theories of biogenesis have concentrated on the chemistry of life, but "life is more than just complex chemical reactions. The cell is also an information storing, processing and replicating system. We need to explain the origin of this information, and the way in which the information processing machinery came to exist." He emphasizes the fact that a gene is nothing but a set of coded instructions with a precise recipe for manufacturing proteins. Most important, these genetic instructions are not the kind of information you find in thermodynamics and statistical mechanics; rather, they constitute semantic information. In other words, they have a specific mean(; ing. These instructions can be effective only in a molecular environment capable of interpreting the meaning in the genetic code. The origin question rises to the top at this point. "The problem of how meaningful or semantic information can emerge spontaneously from a collection of mindless molecules subject to blind and purposeless forces presents a deep conceptual challenge."?

Through A Glass Darkly

It is true that protobiologists do have theories of the evolution of the first living matter, but they are dealing with a different category of problem. They are dealing with the interaction of chemicals, whereas our questions have to do with how something can be intrinsically purpose-driven and how matter can be managed by symbol processing. But even at their own level, the protobiologists are still a long way from any definitive conclusions. This is highlighted by two prominent origin-of-life researchers.

Andy Knoll, a professor of biology at Harvard and author of Life on a Young Planet: The First Three Billion Years of Life, notes:

> If we try to summarize by just saying what, at the end of the day, we do know about the deep history of life on Earth, about its origin, about its formative stages that gave rise to the biology we see around us today, I think we have to admit that we're looking through a

> glass darkly here. We don't know how life started on this planet. We don't know exactly when it started, we don't know under what circumstances.8

Antonio Lazcano, the president of the International Society for the Study of the Origin of Life, reports: "One feature of life, though, remains certain: Life could not have evolved without a genetic mechanism—one able to store, replicate, and transmit to its progeny information that can change with time.... Precisely how the first genetic machinery evolved also persists as an unresolved issue." In fact, he says, "The exact pathway for life's origin may never be known."9

As for the origin of reproduction, John Maddox, the editor emeritus of Nature, writes, "The overriding question is when (and then how) sexual reproduction itself evolved. Despite decades of speculation, we do not know "10 Finally, scientist Gerald Schroeder points out that the existence of conditions favorable to life still does not explain how life itself originated. Life was able to survive only because of favorable conditions on our planet. But there is no law of nature that instructs matter to produce end-directed, self-replicating entities.

So how do we account for the origin of life? The Nobel Prize–winning physiologist George Wald once famously argued that "we choose to believe the impossible: that life arose spontaneously by chance." In later years, he concluded that a preexisting mind, which he posits as the matrix of physical reality, composed a physical universe that breeds life:

> How is it that, with so many other apparent options, we are in a universe that possesses just that peculiar nexus of properties that breeds life? It has occurred to me lately—I must confess with some shock at first to my scientific sensibilities—that both questions might be brought into some degree of congruence. This is with the assumption that. mind, rather than emerging as a late outgrowth in the evolution of life, has existed always as the matrix, the source and condition of physical reality—that the stuff of which physical reality is constructed is mind-stuff.
>
> It is mind that has composed a physical universe that breeds life, and so eventually evolves creatures that know and create: science-, art-, and technology-making creatures."

This, too, is my conclusion. The only satisfactory explanation for the origin of such "end-directed, self-replicating" life as we see on earth is an infinitely intelligent Mind.

May 2007
Stephen C. Meyer, Ph.D. Historian and Philosopher of Science
Intelligent Design: The Origin of Biological Information and the Higher Taxonomic Categories

Proceedings of the Biological Society of Washington, May 18, 2007

On August 4th, 2004 an extensive review essay by Dr. Stephen C. Meyer, Director of Discovery Institute's Center for Science & Culture appeared in the Proceedings of the Biological Society of Washington (volume 117, no. 2, pp. 213-239). The Proceedings is a peer-reviewed biology journal published at the National Museum of Natural History at the Smithsonian Institution in Washington D.C.

In the article, entitled "The Origin of Biological Information and the Higher Taxonomic Categories", Dr. Meyer argues that no current materialistic theory of evolution can account for

the origin of the information necessary to build novel animal forms. He proposes intelligent design as an alternative explanation for the origin of biological information and the higher taxa.

Introduction

In a recent volume of the Vienna Series in a Theoretical Biology (2003), Gerd B. Muller and Stuart Newman argue that what they call the "origination of organismal form" remains an unsolved problem. In making this claim, Muller and Newman (2003:3-10) distinguish two distinct issues, namely, (1) the causes of form generation in the individual organism during embryological development and (2) the causes responsible for the production of novel organismal forms in the first place during the history of life. To distinguish the latter case (phylogeny) from the former (ontogeny), Muller and Newman use the term "origination" to designate the causal processes by which biological form first arose during the evolution of life. They insist that "the molecular mechanisms that bring about biological form in modern day embryos should not be confused" with the causes responsible for the origin (or "origination") of novel biological forms during the history of life (p.3). They further argue that we know more about the causes of ontogenesis, due to advances in molecular biology, molecular genetics and developmental biology, than we do about the causes of phylogenesis--the ultimate origination of new biological forms during the remote past.

In making this claim, Muller and Newman are careful to affirm that evolutionary biology has succeeded in explaining how preexisting forms diversify under the twin influences of natural selection and variation of genetic traits. Sophisticated mathematically-based models of population genetics have proven adequate for mapping and understanding quantitative variability and populational changes in organisms. Yet Muller and Newman insist that population genetics, and thus evolutionary biology, has not identified a specifically causal explanation for the origin of true morphological novelty during the history of life. Central to their concern is what they see as the inadequacy of the variation of genetic traits as a source of new form and structure. They note, following Darwin himself, that the sources of new form and structure must precede the action of natural selection (2003:3)--that selection must act on what already exists. Yet, in their view, the "genocentricity" and "incrementalism" of the neo-Darwinian mechanism has meant that an adequate source of new form and structure has yet to be identified by theoretical biologists. Instead, Muller and Newman see the need to identify epigenetic sources of morphological innovation during the evolution of life. In the meantime, however, they insist neo-Darwinism lacks any "theory of the generative" (p. 7).

As it happens, Muller and Newman are not alone in this judgment. In the last decade or so a host of scientific essays and books have questioned the efficacy of selection and mutation as a mechanism for generating morphological novelty, as even a brief literature survey will establish. Thomson (1992:107) expressed doubt that large-scale morphological changes could accumulate via minor phenotypic changes at the population genetic level. Miklos (1993:29) argued that neo-Darwinism fails to provide a mechanism that can produce large-scale innovations in form and complexity. Gilbert et al. (1996) attempted to develop a new theory of evolutionary mechanisms to supplement classical neo-Darwinism, which, they argued, could not adequately explain macroevolution. As they put it in a memorable summary of the situation: "starting in the 1970s, many biologists began questioning its (neo-Darwinism's) adequacy in explaining evolution. Genetics might be adequate for explaining microevolution, but microevolutionary changes in gene frequency were not seen as able to turn a reptile into a mammal or to convert a fish into an amphibian. Microevolution looks at adaptations that concern the survival of the fittest, not the arrival of the fittest. As Goodwin (1995) points out, 'the origin of species--Darwin's problem--remains unsolved'" (p. 361). Though Gilbert et al. (1996) attempted to solve the problem of the origin of form by proposing a greater role for developmental genetics within an otherwise neo-Darwinian framework,1 numerous recent authors have continued to raise questions about the adequacy of that framework itself or about the

problem of the origination of form generally (Webster & Goodwin 1996; Shubin & Marshall 2000; Erwin 2000; Conway Morris 2000, 2003b; Carroll 2000; Wagner 2001; Becker & Lonnig 2001; Stadler et al. 2001; Lonnig & Saedler 2002; Wagner & Stadler 2003; Valentine 2004:189-194).

What lies behind this skepticism? Is it warranted? Is a new and specifically causal theory needed to explain the origination of biological form?

This review will address these questions. It will do so by analyzing the problem of the origination of organismal form (and the corresponding emergence of higher taxa) from a particular theoretical standpoint. Specifically, it will treat the problem of the origination of the higher taxonomic groups as a manifestation of a deeper problem, namely, the problem of the origin of the information (whether genetic or epigenetic) that, as it will be argued, is necessary to generate morphological novelty.

In order to perform this analysis, and to make it relevant and tractable to systematists and paleontologists, this paper will examine a paradigmatic example of the origin of biological form and information during the history of life: the Cambrian explosion. During the Cambrian, many novel animal forms and body plans (representing new phyla, subphyla and classes) arose in a geologically brief period of time. The following information-based analysis of the Cambrian explosion will support the claim of recent authors such as Muller and Newman that the mechanism of selection and genetic mutation does not constitute an adequate causal explanation of the origination of biological form in the higher taxonomic groups. It will also suggest the need to explore other possible causal factors for the origin of form and information during the evolution of life and will examine some other possibilities that have been proposed.

The Cambrian Explosion

The “Cambrian explosion” refers to the geologically sudden appearance of many new animal body plans about 530 million years ago. At this time, at least nineteen, and perhaps as many as thirty-five phyla of forty total (Meyer et al. 2003), made their first appearance on earth within a narrow five- to ten-million-year window of geologic time (Bowring et al. 1993, 1998a:1, 1998b:40; Kerr 1993; Monastersky 1993; Aris-Brosou & Yang 2003). Many new subphyla, between 32 and 48 of 56 total (Meyer et al. 2003), and classes of animals also arose at this time with representatives of these new higher taxa manifesting significant morphological innovations. The Cambrian explosion thus marked a major episode of morphogenesis in which many new and disparate organismal forms arose in a geologically brief period of time.

To say that the fauna of the Cambrian period appeared in a geologically sudden manner also implies the absence of clear transitional intermediate forms connecting Cambrian animals with simpler pre-Cambrian forms. And, indeed, in almost all cases, the Cambrian animals have no clear morphological antecedents in earlier Vendian or Precambrian fauna (Miklos 1993, Erwin et al. 1997:132, Steiner & Reitner 2001, Conway Morris 2003b:510, Valentine et al. 2003:519-520). Further, several recent discoveries and analyses suggest that these morphological gaps may not be merely an artifact of incomplete sampling of the fossil record (Foote 1997, Foote et al. 1999, Benton & Ayala 2003, Meyer et al. 2003), suggesting that the fossil record is at least approximately reliable (Conway Morris 2003b:505).

As a result, debate now exists about the extent to which this pattern of evidence comports with a strictly monophyletic view of evolution (Conway Morris 1998a, 2003a, 2003b:510; Willmer 1990, 2003). Further, among those who accept a monophyletic view of the history of life, debate exists about whether to privilege fossil or molecular data and analyses. Those who think the fossil data provide a more reliable picture of the origin of the Metazoan tend to think these animals arose

relatively quickly--that the Cambrian explosion had a “short fuse.” (Conway Morris 2003b:505-506, Valentine & Jablonski 2003). Some (Wray et al. 1996), but not all (Ayala et al. 1998), who think that molecular phylogenies establish reliable divergence times from pre-Cambrian ancestors think that the Cambrian animals evolved over a very long period of time--that the Cambrian explosion had a “long fuse.” This review will not address these questions of historical pattern. Instead, it will analyze whether the neo-Darwinian process of mutation and selection, or other processes of evolutionary change, can generate the form and information necessary to produce the animals that arise in the Cambrian. This analysis will, for the most part, 2 therefore, not depend upon assumptions of either a long or short fuse for the Cambrian explosion, or upon a monophyletic or polyphyletic view of the early history of life.

Defining Biological Form and Information

Form, like life itself, is easy to recognize but often hard to define precisely. Yet, a reasonable working definition of form will suffice for our present purposes. Form can be defined as the four-dimensional topological relations of anatomical parts. This means that one can understand form as a unified arrangement of body parts or material components in a distinct shape or pattern (topology)--one that exists in three spatial dimensions and which arises in time during ontogeny.

Insofar as any particular biological form constitutes something like a distinct arrangement of constituent body parts, form can be seen as arising from constraints that limit the possible arrangements of matter. Specifically, organismal form arises (both in phylogeny and ontogeny) as possible arrangements of material parts are constrained to establish a specific or particular arrangement with an identifiable three dimensional topography--one that we would recognize as a particular protein, cell type, organ, body plan or organism. A particular “form,” therefore, represents a highly specific and constrained arrangement of material components (among a much larger set of possible arrangements).

Understanding form in this way suggests a connection to the notion of information in its most theoretically general sense. When Shannon (1948) first developed a mathematical theory of information he equated the amount of information transmitted with the amount of uncertainty reduced or eliminated in a series of symbols or characters. Information, in Shannon's theory, is thus imparted as some options are excluded and others are actualized. The greater the number of options excluded, the greater the amount of information conveyed. Further, constraining a set of possible material arrangements by whatever process or means involves excluding some options and actualizing others. Thus, to constrain a set of possible material states is to generate information in Shannon's sense. It follows that the constraints that produce biological form also imparted information. Or conversely, one might say that producing organismal form by definition requires the generation of information.

In classical Shannon information theory, the amount of information in a system is also inversely related to the probability of the arrangement of constituents in a system or the characters along a communication channel (Shannon 1948). The more improbable (or complex) the arrangement, the more Shannon information, or information-carrying capacity, a string or system possesses.

Since the 1960s, mathematical biologists have realized that Shannon's theory could be applied to the analysis of DNA and proteins to measure the information-carrying capacity of these macromolecules. Since DNA contains the assembly instructions for building proteins, the information-processing system in the cell represents a kind of communication channel (Yockey 1992:110). Further, DNA conveys information via specifically arranged sequences of nucleotide bases. Since each of the four bases has a roughly equal chance of occurring at each site along the

spine of the DNA molecule, biologists can calculate the probability, and thus the information-carrying capacity, of any particular sequence n bases long.

The ease with which information theory applies to molecular biology has created confusion about the type of information that DNA and proteins possess. Sequences of nucleotide bases in DNA, or amino acids in a protein, are highly improbable and thus have large information-carrying capacities. But, like meaningful sentences or lines of computer code, genes and proteins are also specified with respect to function. Just as the meaning of a sentence depends upon the specific arrangement of the letters in a sentence, so too does the function of a gene sequence depend upon the specific arrangement of the nucleotide bases in a gene. Thus, molecular biologists beginning with Crick equated information not only with complexity but also with "specificity," where "specificity" or "specified" has meant "necessary to function" (Crick 1958:144, 153; Sarkar, 1996:191).3 Molecular biologists such as Monod and Crick understood biological information--the information stored in DNA and proteins--as something more than mere complexity (or improbability). Their notion of information associated both biochemical contingency and combinatorial complexity with DNA sequences (allowing DNA's carrying capacity to be calculated), but it also affirmed that sequences of nucleotides and amino acids in functioning macromolecules possessed a high degree of specificity relative to the maintenance of cellular function.

The ease with which information theory applies to molecular biology has also created confusion about the location of information in organisms. Perhaps because the information carrying capacity of the gene could be so easily measured, it has been easy to treat DNA, RNA and proteins as the sole repositories of biological information. Neo-Darwinists in particular have assumed that the origination of biological form could be explained by recourse to processes of genetic variation and mutation alone (Levinton 1988:485). Yet if one understands organismal form as resulting from constraints on the possible arrangements of matter at many levels in the biological hierarchy--from genes and proteins to cell types and tissues to organs and body plans--then clearly biological organisms exhibit many levels of information-rich structure.

Thus, we can pose a question, not only about the origin of genetic information, but also about the origin of the information necessary to generate form and structure at levels higher than that present in individual proteins. We must also ask about the origin of the "specified complexity," as opposed to mere complexity, that characterizes the new genes, proteins, cell types and body plans that arose in the Cambrian explosion. Dembski (2002) has used the term "complex specified information" (CSI) as a synonym for "specified complexity" to help distinguish functional biological information from mere Shannon information--that is, specified complexity from mere complexity. This review will use this term as well.

The Cambrian Information Explosion

The Cambrian explosion represents a remarkable jump in the specified complexity or "complex specified information" (CSI) of the biological world. For over three billions years, the biological realm included little more than bacteria and algae (Brocks et al. 1999). Then, beginning about 570-565 million years ago (mya), the first complex multicellular organisms appeared in the rock strata, including sponges, cnidarians, and the peculiar Ediacaran biota (Grotzinger et al. 1995). Forty million years later, the Cambrian explosion occurred (Bowring et al. 1993). The emergence of the Ediacaran biota (570 mya), and then to a much greater extent the Cambrian explosion (530 mya), represented steep climbs up the biological complexity gradient.

One way to estimate the amount of new CSI that appeared with the Cambrian animals is to count the number of new cell types that emerged with them (Valentine 1995:91-93). Studies of modern animals suggest that the sponges that appeared in the late Precambrian, for example, would have

required five cell types, whereas the more complex animals that appeared in the Cambrian (e.g., arthropods) would have required fifty or more cell types. Functionally more complex animals require more cell types to perform their more diverse functions. New cell types require many new and specialized proteins. New proteins, in turn, require new genetic information. Thus an increase in the number of cell types implies (at a minimum) a considerable increase in the amount of specified genetic information. Molecular biologists have recently estimated that a minimally complex single-celled organism would require between 318 and 562 kilobase pairs of DNA to produce the proteins necessary to maintain life (Koonin 2000). More complex single cells might require upward of a million base pairs. Yet to build the proteins necessary to sustain a complex arthropod such as a trilobite would require orders of magnitude more coding instructions. The genome size of a modern arthropod, the fruitfly Drosophila melanogaster, is approximately 180 million base pairs (Gerhart & Kirschner 1997:121, Adams et al. 2000). Transitions from a single cell to colonies of cells to complex animals represent significant (and, in principle, measurable) increases in CSI.

Building a new animal from a single-celled organism requires a vast amount of new genetic information. It also requires a way of arranging gene products--proteins--into higher levels of organization. New proteins are required to service new cell types. But new proteins must be organized into new systems within the cell; new cell types must be organized into new tissues, organs, and body parts. These, in turn, must be organized to form body plans. New animals, therefore, embody hierarchically organized systems of lower-level parts within a functional whole. Such hierarchical organization itself represents a type of information, since body plans comprise both highly improbable and functionally specified arrangements of lower-level parts. The specified complexity of new body plans requires explanation in any account of the Cambrian explosion.

Can neo-Darwinism explain the discontinuous increase in CSI that appears in the Cambrian explosion--either in the form of new genetic information or in the form of hierarchically organized systems of parts? We will now examine the two parts of this question.

Novel Genes and Proteins

Many scientists and mathematicians have questioned the ability of mutation and selection to generate information in the form of novel genes and proteins. Such skepticism often derives from consideration of the extreme improbability (and specificity) of functional genes and proteins.

A typical gene contains over one thousand precisely arranged bases. For any specific arrangement of four nucleotide bases of length n, there is a corresponding number of possible arrangements of bases, 4n. For any protein, there are 20n possible arrangements of protein-forming amino acids. A gene 999 bases in length represents one of 4999 possible nucleotide sequences; a protein of 333 amino acids is one of 20333 possibilities.

Since the 1960s, some biologists have thought functional proteins to be rare among the set of possible amino acid sequences. Some have used an analogy with human language to illustrate why this should be the case. Denton (1986, 309-311), for example, has shown that meaningful words and sentences are extremely rare among the set of possible combinations of English letters, especially as sequence length grows. (The ratio of meaningful 12-letter words to 12-letter sequences is 1/1014, the ratio of 100-letter sentences to possible 100-letter strings is 1/10100.) Further, Denton shows that most meaningful sentences are highly isolated from one another in the space of possible combinations, so that random substitutions of letters will, after a very few changes, inevitably degrade meaning. Apart from a few closely clustered sentences accessible by random substitution,

the overwhelming majority of meaningful sentences lie, probabilistically speaking, beyond the reach of random search.

Denton (1986:301-324) and others have argued that similar constraints apply to genes and proteins. They have questioned whether an undirected search via mutation and selection would have a reasonable chance of locating new islands of function--representing fundamentally new genes or proteins--within the time available (Eden 1967, Shutzenberger 1967, Lovtrup 1979). Some have also argued that alterations in sequencing would likely result in loss of protein function before fundamentally new function could arise (Eden 1967, Denton 1986). Nevertheless, neither the extent to which genes and proteins are sensitive to functional loss as a result of sequence change, nor the extent to which functional proteins are isolated within sequence space, has been fully known.

Recently, experiments in molecular biology have shed light on these questions. A variety of mutagenesis techniques have shown that proteins (and thus the genes that produce them) are indeed highly specified relative to biological function (Bowie & Sauer 1989, Reidhaar-Olson & Sauer 1990, Taylor et al. 2001). Mutagenesis research tests the sensitivity of proteins (and, by implication, DNA) to functional loss as a result of alterations in sequencing. Studies of proteins have long shown that amino acid residues at many active positions cannot vary without functional loss (Perutz & Lehmann 1968). More recent protein studies (often using mutagenesis experiments) have shown that functional requirements place significant constraints on sequencing even at non-active site positions (Bowie & Sauer 1989, Reidhaar-Olson & Sauer 1990, Chothia et al. 1998, Axe 2000, Taylor et al. 2001). In particular, Axe (2000) has shown that multiple as opposed to single position amino acid substitutions inevitably result in loss of protein function, even when these changes occur at sites that allow variation when altered in isolation. Cumulatively, these constraints imply that proteins are highly sensitive to functional loss as a result of alterations in sequencing, and that functional proteins represent highly isolated and improbable arrangements of amino acids - arrangements that are far more improbable, in fact, than would be likely to arise by chance alone in the time available (Reidhaar-Olson & Sauer 1990; Behe 1992; Kauffman 1995:44; Dembski 1998:175-223; Axe 2000, 2004). (See below the discussion of the neutral theory of evolution for a precise quantitative assessment.)

Of course, neo-Darwinists do not envision a completely random search through the set of all possible nucleotide sequences--so-called “sequence space.” They envision natural selection acting to preserve small advantageous variations in genetic sequences and their corresponding protein products. Dawkins (1996), for example, likens an organism to a high mountain peak. He compares climbing the sheer precipice up the front side of the mountain to building a new organism by chance. He acknowledges that his approach up “Mount Improbable” will not succeed. Nevertheless, he suggests that there is a gradual slope up the backside of the mountain that could be climbed in small incremental steps. In his analogy, the backside climb up “Mount Improbable” corresponds to the process of natural selection acting on random changes in the genetic text. What chance alone cannot accomplish blindly or in one leap, selection (acting on mutations) can accomplish through the cumulative effect of many slight successive steps.

Yet the extreme specificity and complexity of proteins presents a difficulty, not only for the chance origin of specified biological information (i.e., for random mutations acting alone), but also for selection and mutation acting in concert. Indeed, mutagenesis experiments cast doubt on each of the two scenarios by which neo-Darwinists envisioned new information arising from the mutation/selection mechanism (for review, see Lonnig 2001). For neo-Darwinism, new functional genes either arise from non-coding sections in the genome or from preexisting genes. Both scenarios are problematic.

In the first scenario, neo-Darwinists envision new genetic information arising from those sections of the genetic text that can presumably vary freely without consequence to the organism. According to this scenario, non-coding sections of the genome, or duplicated sections of coding regions, can experience a protracted period of "neutral evolution" (Kimura 1983) during which alterations in nucleotide sequences have no discernible effect on the function of the organism. Eventually, however, a new gene sequence will arise that can code for a novel protein. At that point, natural selection can favor the new gene and its functional protein product, thus securing the preservation and heritability of both.

This scenario has the advantage of allowing the genome to vary through many generations, as mutations "search" the space of possible base sequences. The scenario has an overriding problem, however: the size of the combinatorial space (i.e., the number of possible amino acid sequences) and the extreme rarity and isolation of the functional sequences within that space of possibilities. Since natural selection can do nothing to help generate new functional sequences, but rather can only preserve such sequences once they have arisen, chance alone--random variation--must do the work of information generation--that is, of finding the exceedingly rare functional sequences within the set of combinatorial possibilities. Yet the probability of randomly assembling (or "finding," in the previous sense) a functional sequence is extremely small.

Cassette mutagenesis experiments performed during the early 1990s suggest that the probability of attaining (at random) the correct sequencing for a short protein 100 amino acids long is about 1 in 1065 (Reidhaar-Olson & Sauer 1990, Behe 1992:65-69). This result agreed closely with earlier calculations that Yockey (1978) had performed based upon the known sequence variability of cytochrome c in different species and other theoretical considerations. More recent mutagenesis research has provided additional support for the conclusion that functional proteins are exceedingly rare among possible amino acid sequences (Axe 2000, 2004). Axe (2004) has performed site directed mutagenesis experiments on a 150-residue protein-folding domain within a B-lactamase enzyme. His experimental method improves upon earlier mutagenesis techniques and corrects for several sources of possible estimation error inherent in them. On the basis of these experiments, Axe has estimated the ratio of (a) proteins of typical size (150 residues) that perform a specified function via any folded structure to (b) the whole set of possible amino acids sequences of that size. Based on his experiments, Axe has estimated his ratio to be 1 to 1077. Thus, the probability of finding a functional protein among the possible amino acid sequences corresponding to a 150-residue protein is similarly 1 in 1077.

Other considerations imply additional improbabilities. First, new Cambrian animals would require proteins much longer than 100 residues to perform many necessary specialized functions. Ohno (1996) has noted that Cambrian animals would have required complex proteins such as lysyl oxidase in order to support their stout body structures. Lysyl oxidase molecules in extant organisms comprise over 400 amino acids. These molecules are both highly complex (non-repetitive) and functionally specified. Reasonable extrapolation from mutagenesis experiments done on shorter protein molecules suggests that the probability of producing functionally sequenced proteins of this length at random is so small as to make appeals to chance absurd, even granting the duration of the entire universe. (See Dembski 1998:175-223 for a rigorous calculation of this "Universal Probability Bound"; See also Axe 2004.) Yet, second, fossil data (Bowring et al. 1993, 1998a:1, 1998b:40; Kerr 1993; Monatersky 1993), and even molecular analyses supporting deep divergence (Wray et al. 1996), suggest that the duration of the Cambrian explosion (between 5-10 x 106 and, at most, 7 x 107 years) is far smaller than that of the entire universe (1.3-2 x 1010 years). Third, DNA mutation rates are far too low to generate the novel genes and proteins necessary to building the Cambrian animals, given the most probable duration of the explosion as determined by fossil studies (Conway Morris 1998b). As Ohno (1996:8475) notes, even a mutation rate of 10-9 per base pair per year results in only a 1% change in the sequence of a given section of DNA in 10 million years. Thus, he

argues that mutational divergence of preexisting genes cannot explain the origin of the Cambrian forms in that time.4

The selection/mutation mechanism faces another probabilistic obstacle. The animals that arise in the Cambrian exhibit structures that would have required many new types of cells, each of which would have required many novel proteins to perform their specialized functions. Further, new cell types require Asystems of proteins that must, as a condition of functioning, act in close coordination with one another. The unit of selection in such systems ascends to the system as a whole. Natural selection selects for functional advantage. But new cell types require whole systems of proteins to perform their distinctive functions. In such cases, natural selection cannot contribute to the process of information generation until after the information necessary to build the requisite system of proteins has arisen. Thus random variations must, again, do the work of information generation--and now not simply for one protein, but for many proteins arising at nearly the same time. Yet the odds of this occurring by chance alone are, of course, far smaller than the odds of the chance origin of a single gene or protein--so small in fact as to render the chance origin of the genetic information necessary to build a new cell type (a necessary but not sufficient condition of building a new body plan) problematic given even the most optimistic estimates for the duration of the Cambrian explosion.

Dawkins (1986:139) has noted that scientific theories can rely on only so much “luck” before they cease to be credible. The neutral theory of evolution, which, by its own logic, prevents natural selection from playing a role in generating genetic information until after the fact, relies on entirely too much luck. The sensitivity of proteins to functional loss, the need for long proteins to build new cell types and animals, the need for whole new systems of proteins to service new cell types, the probable brevity of the Cambrian explosion relative to mutation rates--all suggest the immense improbability (and implausibility) of any scenario for the origination of Cambrian genetic information that relies upon random variation alone unassisted by natural selection.

Yet the neutral theory requires novel genes and proteins to arise--essentially--by random mutation alone. Adaptive advantage accrues after the generation of new functional genes and proteins. Thus, natural selection cannot play a role until new information-bearing molecules have independently arisen. Thus neutral theorists envisioned the need to scale the steep face of a Dawkins-style precipice of which there is no gradually sloping backside--a situation that, by Dawkins' own logic, is probabilistically untenable.

In the second scenario, neo-Darwinists envisioned novel genes and proteins arising by numerous successive mutations in the preexisting genetic text that codes for proteins. To adapt Dawkins's metaphor, this scenario envisions gradually climbing down one functional peak and then ascending another. Yet mutagenesis experiments again suggest a difficulty. Recent experiments show that, even when exploring a region of sequence space populated by proteins of a single fold and function, most multiple-position changes quickly lead to loss of function (Axe 2000). Yet to turn one protein into another with a completely novel structure and function requires specified changes at many sites. Indeed, the number of changes necessary to produce a new protein greatly exceeds the number of changes that will typically produce functional losses. Given this, the probability of escaping total functional loss during a random search for the changes needed to produce a new function is extremely small--and this probability diminishes exponentially with each additional requisite change (Axe 2000). Thus, Axe's results imply that, in all probability, random searches for novel proteins (through sequence space) will result in functional loss long before any novel functional protein will emerge.

Blanco et al. have come to a similar conclusion. Using directed mutagenesis, they have determined that residues in both the hydrophobic core and on the surface of the protein play essential roles in

determining protein structure. By sampling intermediate sequences between two naturally occurring sequences that adopt different folds, they found that the intermediate sequences "lack a well defined three-dimensional structure." Thus, they conclude that it is unlikely that a new protein fold via a series of folded intermediates sequences (Blanco et al. 1999:741).

Thus, although this second neo-Darwinian scenario has the advantage of starting with functional genes and proteins, it also has a lethal disadvantage: any process of random mutation or rearrangement in the genome would in all probability generate nonfunctional intermediate sequences before fundamentally new functional genes or proteins would arise. Clearly, nonfunctional intermediate sequences confer no survival advantage on their host organisms. Natural selection favors only functional advantage. It cannot select or favor nucleotide sequences or polypeptide chains that do not yet perform biological functions, and still less will it favor sequences that efface or destroy preexisting function.

Evolving genes and proteins will range through a series of nonfunctional intermediate sequences that natural selection will not favor or preserve but will, in all probability, eliminate (Blanco et al. 1999, Axe 2000). When this happens, selection-driven evolution will cease. At this point, neutral evolution of the genome (unhinged from selective pressure) may ensue, but, as we have seen, such a process must overcome immense probabilistic hurdles, even granting cosmic time.

Thus, whether one envisions the evolutionary process beginning with a noncoding region of the genome or a preexisting functional gene, the functional specificity and complexity of proteins impose very stringent limitations on the efficacy of mutation and selection. In the first case, function must arise first, before natural selection can act to favor a novel variation. In the second case, function must be continuously maintained in order to prevent deleterious (or lethal) consequences to the organism and to allow further evolution. Yet the complexity and functional specificity of proteins implies that both these conditions will be extremely difficult to meet. Therefore, the neo-Darwinian mechanism appears to be inadequate to generate the new information present in the novel genes and proteins that arise with the Cambrian animals.

Novel Body Plans

The problems with the neo-Darwinian mechanism run deeper still. In order to explain the origin of the Cambrian animals, one must account not only for new proteins and cell types, but also for the origin of new body plans. Within the past decade, developmental biology has dramatically advanced our understanding of how body plans are built during ontogeny. In the process, it has also uncovered a profound difficulty for neo-Darwinism.

Significant morphological change in organisms requires attention to timing. Mutations in genes that are expressed late in the development of an organism will not affect the body plan. Mutations expressed early in development, however, could conceivably produce significant morphological change (Arthur 1997:21). Thus, events expressed early in the development of organisms have the only realistic chance of producing large-scale macroevolutionary change (Thomson 1992). As John and Miklos (1988:309) explain, macroevolutionary change requires alterations in the very early stages of ontogenesis.

Yet recent studies in developmental biology make clear that mutations expressed early in development typically have deleterious effects (Arthur 1997:21). For example, when early-acting body plan molecules, or morphogens such as bicoid (which helps to set up the anterior-posterior head-to-tail axis in Drosophila), are perturbed, development shuts down (Nusslein-Volhard & Wieschaus 1980, Lawrence & Struhl 1996, Muller & Newman 2003).5 The resulting embryos die. Moreover, there is a good reason for this. If an engineer modifies the length of the piston rods in an

internal combustion engine without modifying the crankshaft accordingly, the engine won't start. Similarly, processes of development are tightly integrated spatially and temporally such that changes early in development will require a host of other coordinated changes in separate but functionally interrelated developmental processes downstream. For this reason, mutations will be much more likely to be deadly if they disrupt a functionally deeply-embedded structure such as a spinal column than if they affect more isolated anatomical features such as fingers (Kauffman 1995:200).

This problem has led to what McDonald (1983) has called “a great Darwinian paradox” (p. 93). McDonald notes that genes that are observed to vary within natural populations do not lead to major adaptive changes, while genes that could cause major changes--the very stuff of macroevolution--apparently do not vary. In other words, mutations of the kind that macroevolution doesn't need (namely, viable genetic mutations in DNA expressed late in development) do occur, but those that it does need (namely, beneficial body plan mutations expressed early in development) apparently don't occur.6 According to Darwin (1859:108) natural selection cannot act until favorable variations arise in a population. Yet there is no evidence from developmental genetics that the kind of variations required by neo-Darwinism--namely, favorable body plan mutations--ever occur.

Developmental biology has raised another formidable problem for the mutation/selection mechanism. Embryological evidence has long shown that DNA does not wholly determine morphological form (Goodwin 1985, Nijhout 1990, Sapp 1987, Muller & Newman 2003), suggesting that mutations in DNA alone cannot account for the morphological changes required to build a new body plan.

DNA helps direct protein synthesis.7 It also helps to regulate the timing and expression of the synthesis of various proteins within cells. Yet, DNA alone does not determine how individual proteins assemble themselves into larger systems of proteins; still less does it solely determine how cell types, tissue types, and organs arrange themselves into body plans (Harold 1995:2774, Moss 2004). Instead, other factors--such as the three-dimensional structure and organization of the cell membrane and cytoskeleton and the spatial architecture of the fertilized egg--play important roles in determining body plan formation during embryogenesis.

For example, the structure and location of the cytoskeleton influence the patterning of embryos. Arrays of microtubules help to distribute the essential proteins used during development to their correct locations in the cell. Of course, microtubules themselves are made of many protein subunits. Nevertheless, like bricks that can be used to assemble many different structures, the tubulin subunits in the cell's microtubules are identical to one another. Thus, neither the tubulin subunits nor the genes that produce them account for the different shape of microtubule arrays that distinguish different kinds of embryos and developmental pathways. Instead, the structure of the microtubule array itself is determined by the location and arrangement of its subunits, not the properties of the subunits themselves. For this reason, it is not possible to predict the structure of the cytoskeleton of the cell from the characteristics of the protein constituents that form that structure (Harold 2001:125).

Two analogies may help further clarify the point. At a building site, builders will make use of many materials: lumber, wires, nails, drywall, piping, and windows. Yet building materials do not determine the floor plan of the house, or the arrangement of houses in a neighborhood. Similarly, electronic circuits are composed of many components, such as resistors, capacitors, and transistors. But such lower-level components do not determine their own arrangement in an integrated circuit. Biological symptoms also depend on hierarchical arrangements of parts. Genes and proteins are made from simple building blocks--nucleotide bases and amino acids--arranged in specific ways.

Cell types are made of, among other things, systems of specialized proteins. Organs are made of specialized arrangements of cell types and tissues. And body plans comprise specific arrangements of specialized organs. Yet, clearly, the properties of individual proteins (or, indeed, the lower-level parts in the hierarchy generally) do not fully determine the organization of the higher-level structures and organizational patterns (Harold 2001:125). It follows that the genetic information that codes for proteins does not determine these higher-level structures either.

These considerations pose another challenge to the sufficiency of the neo-Darwinian mechanism. Neo-Darwinism seeks to explain the origin of new information, form, and structure as a result of selection acting on randomly arising variation at a very low level within the biological hierarchy, namely, within the genetic text. Yet major morphological innovations depend on a specificity of arrangement at a much higher level of the organizational hierarchy, a level that DNA alone does not determine. Yet if DNA is not wholly responsible for body plan morphogenesis, then DNA sequences can mutate indefinitely, without regard to realistic probabilistic limits, and still not produce a new body plan. Thus, the mechanism of natural selection acting on random mutations in DNA cannot in principle generate novel body plans, including those that first arose in the Cambrian explosion.

Of course, it could be argued that, while many single proteins do not by themselves determine cellular structures and/or body plans, proteins acting in concert with other proteins or suites of proteins could determine such higher-level form. For example, it might be pointed out that the tubulin subunits (cited above) are assembled by other helper proteins--gene products--called Microtubule Associated Proteins (MAPS). This might seem to suggest that genes and gene products alone do suffice to determine the development of the three-dimensional structure of the cytoskeleton.

Yet MAPS, and indeed many other necessary proteins, are only part of the story. The location of specified target sites on the interior of the cell membrane also helps to determine the shape of the cytoskeleton. Similarly, so does the position and structure of the centrosome which nucleates the microtubules that form the cytoskeleton. While both the membrane targets and the centrosomes are made of proteins, the location and form of these structures is not wholly determined by the proteins that form them. Indeed, centrosome structure and membrane patterns as a whole convey three-dimensional structural information that helps determine the structure of the cytoskeleton and the location of its subunits (McNiven & Porter 1992:313-329). Moreover, the centrioles that compose the centrosomes replicate independently of DNA replication (Lange et al. 2000:235-249, Marshall & Rosenbaum 2000:187-205). The daughter centriole receives its form from the overall structure of the mother centriole, not from the individual gene products that constitute it (Lange et al. 2000). In ciliates, microsurgery on cell membranes can produce heritable changes in membrane patterns, even though the DNA of the ciliates has not been altered (Sonneborn 1970:1-13, Frankel 1980:607-623; Nanney 1983:163-170). This suggests that membrane patterns (as opposed to membrane constituents) are impressed directly on daughter cells. In both cases, form is transmitted from parent three-dimensional structures to daughter three-dimensional structures directly and is not wholly contained in constituent proteins or genetic information (Moss 2004).

Thus, in each new generation, the form and structure of the cell arises as the result of both gene products and preexisting three-dimensional structure and organization. Cellular structures are built from proteins, but proteins find their way to correct locations in part because of preexisting three-dimensional patterns and organization inherent in cellular structures. Preexisting three-dimensional form present in the preceding generation (whether inherent in the cell membrane, the centrosomes, the cytoskeleton or other features of the fertilized egg) contributes to the production of form in the next generation. Neither structural proteins alone, nor the genes that code for them, are sufficient to determine the three-dimensional shape and structure of the entities they form. Gene products provide necessary, but not sufficient conditions, for the development of three-

dimensional structure within cells, organs and body plans (Harold 1995:2767). But if this is so, then natural selection acting on genetic variation alone cannot produce the new forms that arise in history of life.

Self-Organizational Models

Of course, neo-Darwinism is not the only evolutionary theory for explaining the origin of novel biological form. Kauffman (1995) doubts the efficacy of the mutation/selection mechanism. Nevertheless, he has advanced a self-organizational theory to account for the emergence of new form, and presumably the information necessary to generate it. Whereas neo-Darwinism attempts to explain new form as the consequence of selection acting on random mutation, Kauffman suggests that selection acts, not mainly on random variations, but on emergent patterns of order that self-organize via the laws of nature.

Kauffman (1995:47-92) illustrates how this might work with various model systems in a computer environment. In one, he conceives a system of buttons connected by strings. Buttons represent novel genes or gene products; strings represent the law-like forces of interaction that obtain between gene products-i.e., proteins. Kauffman suggests that when the complexity of the system (as represented by the number of buttons and strings) reaches a critical threshold, new modes of organization can arise in the system “for free”--that is, naturally and spontaneously--after the manner of a phase transition in chemistry.

Another model that Kauffman develops is a system of interconnected lights. Each light can flash in a variety of states--on, off, twinkling, etc. Since there is more than one possible state for each light, and many lights, there are a vast number of possible states that the system can adopt. Further, in his system, rules determine how past states will influence future states. Kauffman asserts that, as a result of these rules, the system will, if properly tuned, eventually produce a kind of order in which a few basic patterns of light activity recur with greater-than-random frequency. Since these actual patterns of light activity represent a small portion of the total number of possible states in which the system can reside, Kauffman seems to imply that self-organizational laws might similarly result in highly improbable biological outcomes--perhaps even sequences (of bases or amino acids) within a much larger sequence space of possibilities.

Do these simulations of self-organizational processes accurately model the origin of novel genetic information? It is hard to think so.

First, in both examples, Kauffman presupposes but does not explain significant sources of preexisting information. In his buttons-and-strings system, the buttons represent proteins, themselves packets of CSI, and the result of preexisting genetic information. Where does this information come from? Kauffman (1995) doesn't say, but the origin of such information is an essential part of what needs to be explained in the history of life. Similarly, in his light system, the order that allegedly arises for “for free” actually arises only if the programmer of the model system “tunes” it in such a way as to keep it from either (a) generating an excessively rigid order or (b) developing into chaos (pp. 86-88). Yet this necessary tuning involves an intelligent programmer selecting certain parameters and excluding others--that is, inputting information.

Second, Kauffman's model systems are not constrained by functional considerations and thus are not analogous to biological systems. A system of interconnected lights governed by pre-programmed rules may well settle into a small number of patterns within a much larger space of possibilities. But because these patterns have no function, and need not meet any functional requirements, they have no specificity analogous to that present in actual organisms. Instead, examination of Kauffman's (1995) model systems shows that they do not produce sequences or systems

characterized by specified complexity, but instead by large amounts of symmetrical order or internal redundancy interspersed with aperiodicity or (mere) complexity (pp. 53, 89, 102). Getting a law-governed system to generate repetitive patterns of flashing lights, even with a certain amount of variation, is clearly interesting, but not biologically relevant. On the other hand, a system of lights flashing the title of a Broadway play would model a biologically relevant self-organizational process, at least if such a meaningful or functionally specified sequence arose without intelligent agents previously programming the system with equivalent amounts of CSI. In any case, Kauffman's systems do not produce specified complexity, and thus do not offer promising models for explaining the new genes and proteins that arose in the Cambrian.

Even so, Kauffman suggests that his self-organizational models can specifically elucidate aspects of the Cambrian explosion. According to Kauffman (1995:199-201), new Cambrian animals emerged as the result of “long jump” mutations that established new body plans in a discrete rather than gradual fashion. He also recognizes that mutations affecting early development are almost inevitably harmful. Thus, he concludes that body plans, once established, will not change, and that any subsequent evolution must occur within an established body plan (Kauffman 1995:201). And indeed, the fossil record does show a curious (from a neo-Darwinian point of view) top-down pattern of appearance, in which higher taxa (and the body plans they represent) appear first, only later to be followed by the multiplication of lower taxa representing variations within those original body designs (Erwin et al. 1987, Lewin 1988, Valentine & Jablonski 2003:518). Further, as Kauffman expects, body plans appear suddenly and persist without significant modification over time.

But here, again, Kauffman begs the most important question, which is: what produces the new Cambrian body plans in the first place? Granted, he invokes “long jump mutations” to explain this, but he identifies no specific self-organizational process that can produce such mutations. Moreover, he concedes a principle that undermines the plausibility of his own proposal. Kauffman acknowledges that mutations that occur early in development are almost inevitably deleterious. Yet developmental biologists know that these are the only kind of mutations that have a realistic chance of producing large-scale evolutionary change--i.e., the big jumps that Kauffman invokes. Though Kauffman repudiates the neo-Darwinian reliance upon random mutations in favor of self-organizing order, in the end, he must invoke the most implausible kind of random mutation in order to provide a self-organizational account of the new Cambrian body plans. Clearly, his model is not sufficient.

Punctuated Equilibrium

Of course, still other causal explanations have been proposed. During the 1970s, the paleontologists Eldredge and Gould (1972) proposed the theory of evolution by punctuated equilibrium in order to account for a pervasive pattern of “sudden appearance” and “stasis” in the fossil record. Though advocates of punctuated equilibrium were mainly seeking to describe the fossil record more accurately than earlier gradualist neo-Darwinian models had done, they did also propose a mechanism--known as species selection--by which the large morphological jumps evident in fossil record might have been produced. According to punctuationalists, natural selection functions more as a mechanism for selecting the fittest species rather than the most-fit individual among a species. Accordingly, on this model, morphological change should occur in larger, more discrete intervals than it would given a traditional neo-Darwinian understanding.

Despite its virtues as a descriptive model of the history of life, punctuated equilibrium has been widely criticized for failing to provide a mechanism sufficient to produce the novel form characteristic of higher taxonomic groups. For one thing, critics have noted that the proposed mechanism of punctuated evolutionary change simply lacked the raw material upon which to work. As Valentine and Erwin (1987) note, the fossil record fails to document a large pool of species prior

to the Cambrian. Yet the proposed mechanism of species selection requires just such a pool of species upon which to act. Thus, they conclude that the mechanism of species selection probably does not resolve the problem of the origin of the higher taxonomic groups (p. 96).8 Further, punctuated equilibrium has not addressed the more specific and fundamental problem of explaining the origin of the new biological information (whether genetic or epigenetic) necessary to produce novel biological form. Advocates of punctuated equilibrium might assume that the new species (upon which natural selection acts) arise by known microevolutionary processes of speciation (such as founder effect, genetic drift or bottleneck effect) that do not necessarily depend upon mutations to produce adaptive changes. But, in that case, the theory lacks an account of how the specifically higher taxa arise. Species selection will only produce more fit species. On the other hand, if punctuationalists assume that processes of genetic mutation can produce more fundamental morphological changes and variations, then their model becomes subject to the same problems as neo-Darwinism (see above). This dilemma is evident in Gould (2002:710) insofar as his attempts to explain adaptive complexity inevitably employ classical neo-Darwinian modes of explanation.9

Structuralism

Another attempt to explain the origin of form has been proposed by the structuralists such as Gerry Webster and Brian Goodwin (1984, 1996). These biologists, drawing on the earlier work of D'Arcy Thompson (1942), view biological form as the result of structural constraints imposed upon matter by morphogenetic rules or laws. For reasons similar to those discussed above, the structuralists have insisted that these generative or morphogenetic rules do not reside in the lower level building materials of organisms, whether in genes or proteins. Webster and Goodwin (1984:510-511) further envisioned morphogenetic rules or laws operating ahistorically, similar to the way in which gravitational or electromagnetic laws operate. For this reason, structuralists see phylogeny as of secondary importance in understanding the origin of the higher taxa, though they think that transformations of form can occur. For structuralists, constraints on the arrangement of matter arise not mainly as the result of historical contingencies--such as environmental changes or genetic mutations--but instead because of the continuous ahistorical operation of fundamental laws of form--laws that organize or inform matter.

While this approach avoids many of the difficulties currently afflicting neo-Darwinism (in particular those associated with its “genocentricity”), critics (such as Maynard Smith 1986) of structuralism have argued that the structuralist explanation of form lacks specificity. They note that structuralists have been unable to say just where laws of form reside--whether in the universe, or in every possible world, or in organisms as a whole, or in just some part of organisms. Further, according to structuralists, morphogenetic laws are mathematical in character. Yet, structuralists have yet to specify the mathematical formulae that determine biological forms.

Others (Yockey 1992; Polanyi 1967, 1968; Meyer 2003) have questioned whether physical laws could in principle generate the kind of complexity that characterizes biological systems. Structuralists envision the existence of biological laws that produce form in much the same way that physical laws produce form. Yet the forms that physicists regard as manifestations of underlying laws are characterized by large amounts of symmetric or redundant order, by relatively simple patterns such as vortices or gravitational fields or magnetic lines of force. Indeed, physical laws are typically expressed as differential equations (or algorithms) that almost by definition describe recurring phenomena--patterns of compressible “order” not “complexity” as defined by algorithmic information theory (Yockey 1992:77-83). Biological forms, by contrast, manifest greater complexity and derive in ontogeny from highly complex initial conditions--i.e., non-redundant sequences of nucleotide bases in the genome and other forms of information expressed in the complex and irregular three-dimensional topography of the organism or the fertilized egg. Thus, the kind of form

that physical laws produce is not analogous to biological form--at least not when compared from the standpoint of (algorithmic) complexity. Further, physical laws lack the information content to specify biology systems. As Polyanyi (1967, 1968) and Yockey (1992:290) have shown, the laws of physics and chemistry allow, but do not determine, distinctively biological modes of organization. In other words, living systems are consistent with, but not deducible, from physical-chemical laws (1992:290).

Of course, biological systems do manifest some reoccurring patterns, processes and behaviors. The same type of organism develops repeatedly from similar ontogenetic processes in the same species. Similar processes of cell division reoccur in many organisms. Thus, one might describe certain biological processes as law-governed. Even so, the existence of such biological regularities does not solve the problem of the origin of form and information, since the recurring processes described by such biological laws (if there be such laws) only occur as the result of preexisting stores of (genetic and/or epigenetic) information and these information-rich initial conditions impose the constraints that produce the recurring behavior in biological systems. (For example, processes of cell division recur with great frequency in organisms, but depend upon information-rich DNA and proteins molecules.) In other words, distinctively biological regularities depend upon preexisting biological information. Thus, appeals to higher-level biological laws presuppose, but do not explain, the origination of the information necessary to morphogenesis.

Thus, structuralism faces a difficult in principle dilemma. On the one hand, physical laws produce very simple redundant patterns that lack the complexity characteristic of biological systems. On the other hand, distinctively biological laws--if there are such laws--depend upon preexisting information-rich structures. In either case, laws are not good candidates for explaining the origination of biological form or the information necessary to produce it.

Cladism: An Artifact of Classification?

Some cladists have advanced another approach to the problem of the origin of form, specifically as it arises in the Cambrian. They have argued that the problem of the origin of the phyla is an artifact of the classification system, and therefore, does not require explanation. Budd and Jensen (2000), for example, argue that the problem of the Cambrian explosion resolves itself if one keeps in mind the cladistic distinction between “stem” and “crown” groups. Since crown groups arise whenever new characters are added to simpler more ancestral stem groups during the evolutionary process, new phyla will inevitably arise once a new stem group has arisen. Thus, for Budd and Jensen what requires explanation is not the crown groups corresponding to the new Cambrian phyla, but the earlier more primitive stem groups that presumably arose deep in the Proterozoic. Yet since these earlier stem groups are by definition less derived, explaining them will be considerably easier than explaining the origin of the Cambrian animals de novo. In any case, for Budd and Jensen the explosion of new phyla in the Cambrian does not require explanation. As they put it, “given that the early branching points of major clades is an inevitable result of clade diversification, the alleged phenomenon of the phyla appearing early and remaining morphologically static is not seen to require particular explanation” (Budd & Jensen 2000:253).

While superficially plausible, perhaps, Budd and Jensen's attempt to explain away the Cambrian explosion begs crucial questions. Granted, as new characters are added to existing forms, novels morphology and greater morphological disparity will likely result. But what causes new characters to arise? And how does the information necessary to produce new characters originate? Budd and Jensen do not specify. Nor can they say how derived the ancestral forms are likely to have been, and what processes, might have been sufficient to produce them. Instead, they simply assume the sufficiency of known neo-Darwinian mechanisms (Budd & Jensen 2000:288). Yet, as shown above,

this assumption is now problematic. In any case, Budd and Jensen do not explain what causes the origination of biological form and information.

Convergence and Teleological Evolution

More recently, Conway Morris (2000, 2003c) has suggested another possible explanation based on the tendency for evolution to converge on the same structural forms during the history of life. Conway Morris cites numerous examples of organisms that possess very similar forms and structures, even though such structures are often built from different material substrates and arise (in ontogeny) by the expression of very different genes. Given the extreme improbability of the same structures arising by random mutation and selection in disparate phylogenies, Conway Morris argues that the pervasiveness of convergent structures suggests that evolution may be in some way "channeled" toward similar functional and/or structural endpoints. Such an end-directed understanding of evolution, he admits, raises the controversial prospect of a teleological or purposive element in the history of life. For this reason, he argues that the phenomenon of convergence has received less attention than it might have otherwise. Nevertheless, he argues that just as physicists have reopened the question of design in their discussions of anthropic fine-tuning, the ubiquity of convergent structures in the history of life has led some biologists (Denton 1998) to consider extending teleological thinking to biology. And, indeed, Conway Morris himself intimates that the evolutionary process might be "underpinned by a purpose" (2000:8, 2003b:511).

Conway Morris, of course, considers this possibility in relation to a very specific aspect of the problem of organismal form, namely, the problem of explaining why the same forms arise repeatedly in so many disparate lines of decent. But this raises a question. Could a similar approach shed explanatory light on the more general causal question that has been addressed in this review? Could the notion of purposive design help provide a more adequate explanation for the origin of organismal form generally? Are there reasons to consider design as an explanation for the origin of the biological information necessary to produce the higher taxa and their corresponding morphological novelty?

The remainder of this review will suggest that there are such reasons. In so doing, it may also help explain why the issue of teleology or design has reemerged within the scientific discussion of biological origins (Denton 1986, 1998; Thaxton et al. 1992; Kenyon & Mills 1996: Behe 1996, 2004; Dembski 1998, 2002, 2004; Conway Morris 2000, 2003a, 2003b, Lonnig 2001; Lonnig & Saedler 2002; Nelson & Wells 2003; Meyer 2003, 2004; Bradley 2004) and why some scientists and philosophers of science have considered teleological explanations for the origin of form and information despite strong methodological prohibitions against design as a scientific hypothesis (Gillespie 1979, Lenior 1982:4).

First, the possibility of design as an explanation follows logically from a consideration of the deficiencies of neo-Darwinism and other current theories as explanations for some of the more striking "appearances of design" in biological systems. Neo-Darwinists such as Ayala (1994:5), Dawkins (1986:1), Mayr (1982:xi-xii) and Lewontin (1978) have long acknowledged that organisms appear to have been designed. Of course, neo-Darwinists assert that what Ayala (1994:5) calls the "obvious design" of living things is only apparent since the selection/mutation mechanism can explain the origin of complex form and organization in living systems without an appeal to a designing agent. Indeed, neo-Darwinists affirm that mutation and selection--and perhaps other similarly undirected mechanisms--are fully sufficient to explain the appearance of design in biology. Self-organizational theorists and punctuationalists modify this claim, but affirm its essential tenet. Self-organization theorists argue that natural selection acting on self organizing order can explain the complexity of living things--again, without any appeal to design.

Punctuationalists similarly envision natural selection acting on newly arising species with no actual design involved.

And clearly, the neo-Darwinian mechanism does explain many appearances of design, such as the adaptation of organisms to specialized environments that attracted the interest of 19th century biologists. More specifically, known microevolutionary processes appear quite sufficient to account for changes in the size of Galapagos finch beaks that have occurred in response to variations in annual rainfall and available food supplies (Weiner 1994, Grant 1999).

But does neo-Darwinism, or any other fully materialistic model, explain all appearances of design in biology, including the body plans and information that characterize living systems? Arguably, biological forms--such as the structure of a chambered nautilus, the organization of a trilobite, the functional integration of parts in an eye or molecular machine--attract our attention in part because the organized complexity of such systems seems reminiscent of our own designs. Yet, this review has argued that neo-Darwinism does not adequately account for the origin of all appearances of design, especially if one considers animal body plans, and the information necessary to construct them, as especially striking examples of the appearance of design in living systems. Indeed, Dawkins (1995:11) and Gates (1996:228) have noted that genetic information bears an uncanny resemblance to computer software or machine code. For this reason, the presence of CSI in living organisms, and the discontinuous increases of CSI that occurred during events such as the Cambrian explosion, appears at least suggestive of design.

Does neo-Darwinism or any other purely materialistic model of morphogenesis account for the origin of the genetic and other forms of CSI necessary to produce novel organismal form? If not, as this review has argued, could the emergence of novel information-rich genes, proteins, cell types and body plans have resulted from actual design, rather than a purposeless process that merely mimics the powers of a designing intelligence? The logic of neo-Darwinism, with its specific claim to have accounted for the appearance of design, would itself seem to open the door to this possibility. Indeed, the historical formulation of Darwinism in dialectical opposition to the design hypothesis (Gillespie 1979), coupled with the neo-Darwinism's inability to account for many salient appearances of design including the emergence of form and information, would seem logically to reopen the possibility of actual (as opposed to apparent) design in the history of life.

A second reason for considering design as an explanation for these phenomena follows from the importance of explanatory power to scientific theory evaluation and from a consideration of the potential explanatory power of the design hypothesis. Studies in the methodology and philosophy of science have shown that many scientific theories, particularly in the historical sciences, are formulated and justified as inferences to the best explanation (Lipton 1991:32-88, Brush 1989:1124-1129, Sober 2000:44). Historical scientists, in particular, assess or test competing hypotheses by evaluating which hypothesis would, if true, provide the best explanation for some set of relevant data (Meyer 1991, 2002; Cleland 2001:987-989, 2002:474-496).10 Those with greater explanatory power are typically judged to be better, more probably true, theories. Darwin (1896:437) used this method of reasoning in defending his theory of universal common descent. Moreover, contemporary studies on the method of “inference to the best explanation” have shown that determining which among a set of competing possible explanations constitutes the best depends upon judgments about the causal adequacy, or “causal powers,” of competing explanatory entities (Lipton 1991:32-88). In the historical sciences, uniformitarian and/or actualistic (Gould 1965, Simpson 1970, Rutten 1971, Hooykaas 1975) canons of method suggest that judgments about causal adequacy should derive from our present knowledge of cause and effect relationships. For historical scientists, “the present is the key to the past” means that present experience-based knowledge of cause and effect relationships typically guides the assessment of the plausibility of proposed causes of past events.

Yet it is precisely for this reason that current advocates of the design hypothesis want to reconsider design as an explanation for the origin of biological form and information. This review, and much of the literature it has surveyed, suggests that four of the most prominent models for explaining the origin of biological form fail to provide adequate causal explanations for the discontinuous increases of CSI that are required to produce novel morphologies. Yet, we have repeated experience of rational and conscious agents--in particular ourselves--generating or causing increases in complex specified information, both in the form of sequence-specific lines of code and in the form of hierarchically arranged systems of parts.

In the first place, intelligent human agents--in virtue of their rationality and consciousness--have demonstrated the power to produce information in the form of linear sequence-specific arrangements of characters. Indeed, experience affirms that information of this type routinely arises from the activity of intelligent agents. A computer user who traces the information on a screen back to its source invariably comes to a mind--that of a software engineer or programmer. The information in a book or inscriptions ultimately derives from a writer or scribe--from a mental, rather than a strictly material, cause. Our experience-based knowledge of information-flow confirms that systems with large amounts of specified complexity (especially codes and languages) invariably originate from an intelligent source from a mind or personal agent. As Quastler (1964) put it, the "creation of new information is habitually associated with conscious activity" (p. 16). Experience teaches this obvious truth.

Further, the highly specified hierarchical arrangements of parts in animal body plans also suggest design, again because of our experience of the kinds of features and systems that designers can and do produce. At every level of the biological hierarchy, organisms require specified and highly improbable arrangements of lower-level constituents in order to maintain their form and function. Genes require specified arrangements of nucleotide bases; proteins require specified arrangements of amino acids; new cell types require specified arrangements of systems of proteins; body plans require specialized arrangements of cell types and organs. Organisms not only contain information-rich components (such as proteins and genes), but they comprise information-rich arrangements of those components and the systems that comprise them. Yet we know, based on our present experience of cause and effect relationships, that design engineers--possessing purposive intelligence and rationality--have the ability to produce information-rich hierarchies in which both individual modules and the arrangements of those modules exhibit complexity and specificity--information so defined. Individual transistors, resistors, and capacitors exhibit considerable complexity and specificity of design; at a higher level of organization, their specific arrangement within an integrated circuit represents additional information and reflects further design. Conscious and rational agents have, as part of their powers of purposive intelligence, the capacity to design information-rich parts and to organize those parts into functional information-rich systems and hierarchies. Further, we know of no other causal entity or process that has this capacity. Clearly, we have good reason to doubt that mutation and selection, self-organizational processes or laws of nature, can produce the information-rich components, systems, and body plans necessary to explain the origination of morphological novelty such as that which arises in the Cambrian period.

There is a third reason to consider purpose or design as an explanation for the origin of biological form and information: purposive agents have just those necessary powers that natural selection lacks as a condition of its causal adequacy. At several points in the previous analysis, we saw that natural selection lacked the ability to generate novel information precisely because it can only act after new functional CSI has arisen. Natural selection can favor new proteins, and genes, but only after they perform some function. The job of generating new functional genes, proteins and systems of proteins therefore falls entirely to random mutations. Yet without functional criteria to guide a search through the space of possible sequences, random variation is probabilistically doomed. What is needed is not just a source of variation (i.e., the freedom to search a space of

possibilities) or a mode of selection that can operate after the fact of a successful search, but instead a means of selection that (a) operates during a search--before success--and that (b) is guided by information about, or knowledge of, a functional target.

Demonstration of this requirement has come from an unlikely quarter: genetic algorithms. Genetic algorithms are programs that allegedly simulate the creative power of mutation and selection. Dawkins and Kuppers, for example, have developed computer programs that putatively simulate the production of genetic information by mutation and natural selection (Dawkins 1986:47-49, Kuppers 1987:355-369). Nevertheless, as shown elsewhere (Meyer 1998:127-128, 2003:247-248), these programs only succeed by the illicit expedient of providing the computer with a "target sequence" and then treating relatively greater proximity to future function (i.e., the target sequence), not actual present function, as a selection criterion. As Berlinski (2000) has argued, genetic algorithms need something akin to a "forward looking memory" in order to succeed. Yet such foresighted selection has no analogue in nature. In biology, where differential survival depends upon maintaining function, selection cannot occur before new functional sequences arise. Natural selection lacks foresight.

What natural selection lacks, intelligent selection--purposive or goal-directed design--provides. Rational agents can arrange both matter and symbols with distant goals in mind. In using language, the human mind routinely "finds" or generates highly improbable linguistic sequences to convey an intended or preconceived idea. In the process of thought, functional objectives precede and constrain the selection of words, sounds and symbols to generate functional (and indeed meaningful) sequences from among a vast ensemble of meaningless alternative combinations of sound or symbol (Denton 1986:309-311). Similarly, the construction of complex technological objects and products, such as bridges, circuit boards, engines and software, result from the application of goal-directed constraints (Polanyi 1967, 1968). Indeed, in all functionally integrated complex systems where the cause is known by experience or observation, design engineers or other intelligent agents applied boundary constraints to limit possibilities in order to produce improbable forms, sequences or structures. Rational agents have repeatedly demonstrated the capacity to constrain the possible to actualize improbable but initially unrealized future functions. Repeated experience affirms that intelligent agents (minds) uniquely possess such causal powers.

Analysis of the problem of the origin of biological information, therefore, exposes a deficiency in the causal powers of natural selection that corresponds precisely to powers that agents are uniquely known to possess. Intelligent agents have foresight. Such agents can select functional goals before they exist. They can devise or select material means to accomplish those ends from among an array of possibilities and then actualize those goals in accord with a preconceived design plan or set of functional requirements. Rational agents can constrain combinatorial space with distant outcomes in mind. The causal powers that natural selection lacks--almost by definition--are associated with the attributes of consciousness and rationality--with purposive intelligence. Thus, by invoking design to explain the origin of new biological information, contemporary design theorists are not positing an arbitrary explanatory element unmotivated by a consideration of the evidence. Instead, they are positing an entity possessing precisely the attributes and causal powers that the phenomenon in question requires as a condition of its production and explanation.

Conclusion

An experience-based analysis of the causal powers of various explanatory hypotheses suggests purposive or intelligent design as a causally adequate--and perhaps the most causally adequate--explanation for the origin of the complex specified information required to build the Cambrian animals and the novel forms they represent. For this reason, recent scientific interest in the design

hypothesis is unlikely to abate as biologists continue to wrestle with the problem of the origination of biological form and the higher taxa.

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David Grandy
Ideology in the Guise of Science: A review of "The God Delusion" by Richard Dawkins
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Years ago while serving as full-time missionaries, my companion and I were invited to talk about our faith to an introductory philosophy class at the University of Missouri at Columbia. Since neither of us knew anything about philosophy, we simply relied on the missionary discussions to make our presentation. Only one member of the class was hostile, stating that we were "intellectual midgets" compared to Freud and Marx. We took that in stride, not knowing Freud and Marx except by name. Afterward, as the professor and several students thanked us, I happened to glance at a book that the professor had in hand and that evidently was being used as a course text. It was Bertrand Russell's Why I Am Not a Christian.1

About a year later, fresh off my mission and at Brigham Young University, I borrowed Russell's book from the library and opened its pages with some trepidation. Before long I realized that I mostly agreed with Russell, but only because he was attacking a crude caricature of the God I believed in. I didn't believe in that caricature either. For all his philosophical learning, Russell had written a shallow, nonthreatening book about religion.

Richard Dawkins, a well-known biologist and critic of religion, has written a similar book—The God Delusion. The book has gotten a lot of advance publicity and is selling well, but for those who keep track of such things, its publication is a bit of a nonevent. Here is another predictable salvo against religion from the world of science. But it is not science: it is ideology poorly disguised as science. Nor does its author grasp the nature of religious experience. Dawkins dismisses religious claims after measuring them against a rather badly misshapen scientific yardstick. This is positivism at its best (or worst): truth is established scientifically or not at all.

Dawkins would have us believe that Darwinian evolution is the omni-explanatory solution to all of life's mysteries. This is an old refrain, one going back to Ernst Haeckel, Thomas Huxley, H. G. Wells, and, in more recent decades, Daniel Dennett. It is not science per se, but the dramatization of science for ideological purposes. Evolutionary biology is a perfectly legitimate theory of science, but like all intellectual constructions, it has its limitations. This fact, readily acknowledged by those familiar with quantum theory and Kurt GË˜del's incompleteness theorems, has never really seemed to register with life science enthusiasts like Dawkins. Their passion for universal explanations harks back to an earlier era when Newtonian science struck many people as evidence that the human race had finally arrived. Dawkins, wholly enamored of Darwinian biology, is a curious throwback to that era; and he, like certain philosophes of the Enlightenment, is eager to throw traditional religion overboard so as to clear the deck of all ideologies but his own.

It is important to note that Dawkins is not writing in a vacuum. He is replying to a crowd of thinkers—scientists, philosophers, and theologians—who in recent decades have tried to harmonize scientific and religious truth. "What indeed has Athens to do with Jerusalem?" asked Tertullian centuries ago.2 Tertullian's reply was "nothing," and Dawkins's is the same, although for vastly different reasons. The goal of harmonizing faith and reason is an old one, but there are pitfalls along the way; and to his credit, Dawkins does a good job of pointing some of them out. If we invest faith in, say, intelligent design, irreducible complexity, or certain versions of the anthropic

principle, all of which lean on God to make sense of things, what happens when persuasive naturalistic explanations emerge?

This is worldview warfare, not science versus religion. Dawkins readily admits he is opposed only to the idea of a God who takes a personal interest in humankind and who therefore strives to bring off our salvation and happiness. His God, if he must use the word, is coincidental with the laws of nature and consequently perfectly oblivious to our being. This outlook is, of course, not original with Dawkins; most notably it is associated with Einstein and Spinoza. But neither Einstein nor Spinoza dogmatically and zealously asserted it. Both took it as a religious preference, not as a weapon with which to attack and destroy other religious preferences. Dawkins, however, is a religious firebrand in scientific guise, and by trying to straitjacket others into his atheistic worldview, he does science a profound disservice.

In the latter part of the book, Dawkins offers an explanation for religion. Believing that only Darwinian evolution can get to the bottom of this matter, he weaves an interesting story. But this is not to say that others, working from different principles, could not weave equally interesting but very different stories. The problem here is one that Karl Popper identified decades ago: theories that explain so much and that seem to be immune to falsification ought to arouse our suspicion.3 A piece of Silly Putty can be easily molded into the shape of an elephant, a dog, a giraffe, virtually anything we can imagine; but that does not mean that Silly Putty is the universal substance from which all the world was created. It is merely a substance that reacts easily to the human imagination.

Dawkins, it seems, fails to grasp this point. He never admits that there might be other ways to persuasively spin the empirical data, to play dot to dot with the events of nature. Rather, he talks as if Darwinian evolution affords a uniquely unbiased vision of the past. Yet anyone who closely attends to his explanations of the past notes that they become obscure just at the critical moment. In this respect The God Delusion is exactly like The Selfish Gene,4 Dawkins's most sustained attempt to deal with our biological origins. The selfish gene, he says, began as a lifeless unit, void of intentionality. Eventually, however, it evolved into a living, purposive, "selfish" thing, though Dawkins never specifies quite how this happened. He can only say that natural selection—the mechanism that drives organic evolution—brought it about. Thus, while straining at the gnat of the selfish gene, Dawkins swallows the miracle of life that he is quick to disavow in religious contexts. After getting past this hitch, however, he is able to talk with great confidence, and his explanations come off as persuasive, albeit for reasons just indicated. Many people, unfortunately, overlook the leap of faith taken at the outset of the explanation (the assertion that natural selection somehow or other brings life into existence) and uncritically take that leap with Dawkins.

This failure to deal with fundamental issues affords Dawkins a great deal of argumentative mileage. A case in point is his claim that natural selection is not a random process. (He concedes the improbability of life originating from purely random processes.) He compares it to a combination lock that noticeably clicks each time one of the key digits is passed, thus allowing the person turning the lock to quickly decipher its code. Elsewhere5 Dawkins puts a similar spin on the old monkey-at-the-typewriter argument by insisting that a monkey could type out a line from Shakespeare in fairly short order: each time the monkey accidentally hits a correct character it gets locked in, while all the incorrect characters are immediately erased. Thus the monkey, completely unaware of what it is accomplishing, never has to start over from scratch—the process itself is self-improving. It retains correct characters, discards those that are incorrect, and, after sufficient iterations, produces a fully coherent sentence.

But for a monkey to do this, its typewriter would have to be programmed, and who or what is the programmer? Dawkins assigns that role to natural selection. So on the one hand natural selection is

blind and mindless, and on the other it is teleological. This is a contradiction that goes back to Darwin's personification of natural selection (he once described nature as "infinitely more sagacious than man" and as an "all-seeing being" that is ever "rigid and scrutinizing"),6 and it cuts so deeply as to shape up as yet another leap of faith. Dawkins might deny this by arguing that each tiny step of the evolutionary process gets locked in by virtue of its survival value, but it is by no means clear that this is always the case. More fundamentally, one wonders whence survival gets its intrinsic value in a cosmos initially devoid of value, which is the kind of cosmos Dawkins posits.

An old adage states that to a man with a hammer everything looks like a nail. This, no doubt, is an overstatement, but certainly to Dawkins any religious belief is something to be pounded on by the ideological hammer of atheistic science. One of his chief complaints against traditional religion is the religious intolerance that flares up in such places as Israel, Iraq, Northern Ireland, and even the United States. Granted, this is lamentable, but Dawkins's own brand of intolerance only exacerbates the problem. What is needed is not diatribe but dialogue and an openness to new ways of thinking and feeling. Religious experience may not make much sense to Dawkins, but, as William James would say, that is because he chooses to stand outside it: "One can never fathom an emotion or divine its dictates by standing outside of it. In the glowing hour of excitement, however, all incomprehensibilities are solved, and what was so enigmatical from without becomes transparently obvious. Each emotion obeys a logic of its own, and makes deductions which no other logic can draw. Piety and charity live in a different universe from worldly lusts and fears, and form another centre of energy altogether."7 Dawkins gives us one universe or thought world, but there are many others.

Footnotes

1. Bertrand Russell, Why I Am Not a Christian: And Other Essays on Religion and Related Subjects (New York: Simon & Schuster, 1957).
2. Tertullian, De Praescriptione Haereticorum 7.9.
3. Karl R. Popper, Conjectures and Refutations: The Growth of Scientific Knowledge (New York: Basic Books, 1962).
4. Richard Dawkins, The Selfish Gene (New York: Oxford University Press, 1976).
5. See Richard Dawkins, The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe Without Design (New York: W. W. Norton & Company, 1996).
6. Charles Darwin and Alfred R. Wallace, Evolution by Natural Selection (Cambridge: Cambridge University Press, 1958), 45—48.
7. William James, The Varieties of Religious Experience (New York: Barnes & Noble, 2004), 286.

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John Barrow, Simon Morris, Stephen Freeland, Charles Harper, Jr., Editors
Fitness of the Cosmos for Life: Biochemistry and Fine Tuning
Book, Cambridge University Press

Chapter 3 - Is fine-tuning remarkable?
John F. Haught

My contribution to this volume is that of a theologian interested in the relationship between science and religion. I will be asking whether what we are calling "fitness for life" and "biochemical fine-tuning" are consistent with, and perhaps even supportive of, the ageless religious convictions that the universe is here for a reason and that life is the intended consequence of divine love, wisdom, and creative power.

Today, it is particularly striking to many scientists that cosmic constants, physical laws, biochemical pathways, and terrestrial conditions are just right for the emergence and flourishing of

life. It is not surprising, of course, that, as life exists, the cosmic and chemical conditions for it had to have been formatted for such an emergence. It would be remarkable, however, if the format could have been otherwise, and hence not right for life. During the universe's history, it now seems that only a very restricted set of physical conditions operative at several major junctures of emergence could have opened the gateways to life (Hogan, 2000). So, what principles lie behind the narrowing of the gateways that allowed only those conditions preparatory to life to flow through while excluding any cosmological principles, physical parameters, and chemical laws that would not have permitted such an outcome?

In the long, unfolding story of nature's development, any conceivable series of physical conditions or constants other than those that would lead to life have been tossed aside. In fact, only the set that permitted life was allowed through a tightly constrictive filtering process. Close calls characterize the story throughout. And in our Big Bang universe, the fine-tuning of the specific trajectory that would lead to life began during the first moment of cosmic process. At that opening instant, all other sets of mathematically and physically conceivable expansion rates, gravitational constants, and densities of matter were put aside, and only a single set, one that would eventually sponsor life, was allowed entry into actuality. Later on, the chemistry that would lead to life had to leave behind conceivable combinations that would prohibit the emergence of cellular and physiological complexity. Only a chemistry that would allow for a limited variety of three-dimensional protein folding, for example, could make way for the specific routes toward complexification that introduced sentience and consciousness into the Big Bang universe (Denton et al., 2002). But can any of this fine-tuning be adequately understood without appealing to the idea of divine cosmic purpose?

Religion and theology cannot be indifferent to the question of whether the physical universe is the embodiment of an overarching meaning and purpose. However, cosmic purpose is not the same as design or fine-tuning, nor is the accumulation of scientific information about fine-tuning absolutely essential to a plausible theological affirmation of purpose in the universe. Theologically speaking, what purpose means, at the very minimum, is "the actualizing of value" — that is, of what appears self-evidently good —not necessarily the instantiation of design, even though design, order, or a pattern may be an aspect of the actualizing of value. Thus, a universe that appears to be in the process of bringing about such value-laden actualities as life, consciousness, freedom, creativity, and beauty, along with beings endowed with a capacity for reasonableness, selfless love, and promise keeping, could be said to have an overarching purpose, provided, of course, that these achievements have been intended.'

However, design and fine-tuning are ideas that are too narrow to capture the way in which careful theological reflection would conceive of divine intention or purposiveness in nature. After Darwin, moreover, it seems especially unwise to endow what is taken to be the Ultimate Source of the world's being exclusively, or even primarily, with the appellation "Designer." Similarly, the scientific cataloging of items suggestive of biochemical fine-tuning does not, by itself, offer much support to a theological argument for cosmic purpose. In fact, I believe it could be fatal for theology to focus only on design and fine-tuning. Such a concentration, after all, would only make the ancient and persistent theodicy question all the more intractable. Why would an allegedly designing deity, one capable of ordering natural processes in the beautiful arrangement of crystals, protein folds, and cellular mechanisms, refrain from arranging the larger world of life in such a way as to prevent disease, pain, and death? The notion that God is essentially an "Intelligent Designer" or "Fine-Tuner" has even led to the demise of natural theologies built too snugly on observation of natural forms of order alone (Buckley, 1987). The God of religious experience, moreover, is as much a disturber as a distributer of design.

The question of divine action

Whether research into biochemical fine-tuning could be theologically consequential inevitably brings up the more fundamental question of how to situate scientific explanations in relationship to theological understanding. In modem times, these two kinds of knowledge have often been seen as conflicting with each other. However, the best of our theologians have never taught that it is necessary to choose between natural and theological explanations. Theological explanations do not pretend to be an alternative to scientific accounts, just as good science does not appeal to supernatural causes.

Unfortunately, though, religious believers today still sometimes fear that as scientific explanations become more and more persuasive—for example, in accounting for the origin, evolution, and fine-tuning of life — the more they threaten to undermine a robust religious sense of the creative or purposive power of God. At the same time, scientists are sometimes apprehensive that the more room theology makes for the notion of divine action in accounting for natural phenomena, the less room will be available for meaningful scientific research (see my discussion of Cziko's 1995 book Without Miracles, below). For instance, the remarkable series of physical occurrences that have taken place in a chemistry attuned to life can be laid out as a fully natural process explicable in physical and chemical terms. So why do we need to invoke the idea of supernatural causation or cosmic purpose as essential anywhere in the unfolding chain of occurrences? Anyway, if a Creator had intended the universe to produce life, why did it take so long for the right chemistry to come along and for life to make its spontaneous debut relatively late in natural history? Science can give good physical explanations of emergent phenomena, and these accounts will surely become more detailed in the future. Thus, we must ask whether the idea of a wise Divine Designer (or Fine-Tuner) would be of much help in our attempts to understand the natural world.

This question is especially appropriate now that the story of nature shows itself to have been strewn not only with what seems to be, in the human scale of understanding, a wasted amount of time, but also a convoluted kind of engineering, such as the complicated stellar creation of carbon (as described, for example, by Burbidge et at, 1957). And this is not to mention the often ruthless Darwinian processes that have shaped the story of life on earth. If the purpose of the universe is to produce life and mind, what do all the delay and Darwinian debris tell us about divine design, fine-tuning, and cosmic purpose? I believe that any research into biochemical fine-tuning — especially if the goal of such research is to shed light on the question of cosmic purpose — must not take place in abstraction from the larger picture of cosmic process and biological evolution. After all, Darwinian accounts of the evolution of life have made the idea of divine design seem increasingly shaky, and one cannot simply ignore this fact when reflecting on the question of fine-tuning (a notion that suggests design), whether at the level of cosmology or biochemistry.

Today, especially because of the apparent success and intellectual appeal of evolutionary explanations, the ideas of divine action in general and divine design in particular seem to have lost their former appeal in attempts to make ultimate sense of the natural world (see, for example, Dawkins, 1986, 1995, 1996; Dennett, 1995). Before Darwin, it was in the world of life and its adaptive complexity that natural theology ascertained the most dazzling displays of divine fine-tuning. The Boyle Lectures and Bridgewater Treatises, for example, sought characteristically to connect the intelligent activity of God to the complexities of life. But now that the idea of natural selection has become for many scientists the ultimate explanation of adaptive design in living beings (Mayr, 1997, pp. 64-78), it is tempting to look elsewhere for the primary evidence of divine action. For example, the physics of the early universe or segments of biochemistry seem to be exposing degrees of design or fine-tuning so improbable as to be suggestive of divine causation (Davies, 1992).

Even as a theologian interested in promoting good relations between science and religion, 1 confess to an uneasiness about this "regionalizing" of research into fine-tuning, especially if the ultimate

objective of such a project is to see whether science is now opening up new areas, after (and perhaps in spite of) Darwin, for invoking the idea of divine action and purposiveness in nature. Concentrating separately on one or two chapters of apparent fine-tuning in the otherwise more ragged unfolding of nature may allow the natural theologian to momentarily ignore the disorder, waste, struggle, suffering, and death that accompany evolution's extravagant creativity. But the tormenting religious questions posed by Darwinian biology will continue to resist all attempts by natural theology to bracket them out. Therefore, speaking theologically, research into biochemical fine-tuning would strike me as artificial, evasive, and inconsequential as long as it gives any appearance of pushing aside the questions about divine action and cosmic purpose raised specifically by Darwinian biology. Such reserve seems especially appropriate because, these days, those most interested in finding evidence of intelligent design and fine-tuning in nature are often vociferous opponents of evolutional}, biology (see, for example, Dembski, 1998, 1999; Wells, 20(X)).

At another extreme, however, it is also a matter of concern to me that much scientific thought has now concluded that the Darwinian notion of natural selection can provide an ultimately satisfying explanation of nearly everything in the world of life (Naught, 2000, 2003). The apparent success of evolutionary explanations of adaptive design has fostered suspicion that scientific enlightenment now renders the ideas of cosmic purpose and divine action altogether superfluous as far as a fundamental understanding of life is concerned. As one among many available examples of this exclusivist naturalism, I would note Gary Cziko's book Without explanations. In a succession of chapters, he labors to show that it is Darwinian mechanisms rather than divine providence that explain any specific feature of life, such as sight, hearing, or intelligence. Hence, as far as Cziko is concerned, one is forced to choose either science or providential action, but not both.

Cziko's explanatory monism (in which only one explanatory slot is available for all) inevitably leads to the conclusion that theological appeals to divine influence are a threat to scientific explanation. Conversely, as mentioned previously, some religious believers — explanatory monists of another stripe — consider a successful scientific search for natural explanations of biochemical fine-tuning to be an implicit threat to the consequentiality of theological explanation. Both varieties of monocausal thinking, of course, raise the fascinating question of what it means to say that "God acts" in nature, an issue that lies at the heart of almost every contemporary controversy involving science and theology. I cannot give sufficient coverage to this discussion here, but I hope at least to demonstrate, by focusing on the topics of fitness for life and biochemical fine-tuning, that theological explanations can, at least in principle, co-exist quite comfortably and non-competitively with scientific explanations. I shall do so, however, only by also keeping in mind the special concerns about divine action raised by Darwinism.

Layered explanation

Theology, of course, does not strive for exactly the same kind of explanation in its own regions of inquiry as science does with respect to natural causes. Theology must take the discoveries of science seriously, but it cannot emulate the objectifying focus of scientific explanation without sacrificing its own substance. God, in other words, cannot become an object of scientific clarification without ceasing to be God. Theology, moreover, can be seen to have explanatory relevance only if it is first able to show that, in principle, a plurality of non-conflicting layers of explanation can exist for any particular set of natural phenomena. Thus, theology would have the role of ultimate explanation in an extended hierarchy of explanations that includes, and does not in any way compete with, scientific accounts. As long as one allows for layered explanation, in other words, theological discourse can be deeply explanatory of the universe without in any way interfering with the more lucid levels of scientific inquiry. Indeed, when it is taken as a deep explanation, theology even supports and promotes the more regional inquiries that physicists, chemists. or biologists undertake at their own proper planes of exploration. And in its refusal to

compete with or intrude into scientific levels of explanation, theology may itself arrive at a more satisfactory understanding of the meaning and location of divine action or cosmic purpose than was possible before the emergence of modem science.

By "layered explanation," I mean that most things allow for more than one level of explanation. For example, if someone asks me to explain why a fire is burning in my backyard, one response might be, "Because the carbon in the wood is chemically combining with oxygen to make carbon dioxide." But another might be, "Because I applied a lit match to wood." And yet another could be, "Because I want to roast hot dogs." Different layers of explanation, in other words, can co-exist without competing with one another, and it would be a mistake to squeeze one kind of explanation into an explanatory groove that is appropriate to another. Explanatory pluralism, additionally, is more likely than monocausal accounting to put the human mind in touch with the full reality of what is being explained.

It would follow, then, that if a beneficent God, for some mysterious reason, freely intended to create a life-bearing universe, we would not look for evidence of this divine intentionality at the level of biochemical fine-tuning or natural selection of reproductively adaptive organisms. This would be like trying to find "I want hot dogs" in the smoke from the burning wood in my backyard. And yet, it is just such direct physical "evidence" that the scientific naturalist and other explanatory monists typically look for in theological accounts of the universe. The scientific naturalist's complaints about theology usually amount to disappointment that the latter is not very good at giving "scientific explanations." One of the clearest examples of this curious expectation is in E. 0. Wilson's book Consilience, in which the noted author expresses his annoyance that by remaining silent on evolution "the biblical authors had missed the most important revelation of all!" (1998, p. 6). The underlying assumption here is that only one explanatory slot is available to all, and since it now belongs to science, no place remains for theology.

My point, though, is that good theology espouses an explanatory pluralism, as distinct from explanatory monism, and this means that a multiplicity of layers of explanation are available to quench the human desire to understand the world. Accordingly, reference to divine action or divine creativity would make sense only if one located it at levels of understanding other than where physical causes are being investigated. This decoupling of explanations is a function of the fact that every explanation is abstracted from the totality of causal factors that bring about any particular outcome. This does not mean that no connection at all exists between and among accounts. But theological explanations would stand in relation to nature—to such occurrences as biochemical fine-tuning, for example — analogously to the way in which "I want hot dogs" stands in relation to a chemical analysis of the burning logs in my backyard. That is, invoking divine creativity and purpose would lie at a distinct level of understanding, incommensurate but not incompatible with those of the sciences. And it could not be mapped directly onto any scientific accounts. Theology claims to explain things at a deeper level than physical causation, and the deeper explanation would simply not show up, nor should one expect it to do so, while one is setting forth, say, biochemical pathways leading to life.

Analogously, if one were to ask why life appeared on earth at all, even the most painstaking analysis of the physical and chemical fine-tuning required for this eventuality would uncover no purposiveness or divine intention at the many levels of scientific inquiry. Science abstracts from questions of purpose or ultimate meaning. Nevertheless, abundant logical space would still exist for a theological explanation at another level of understanding. Life, it could be said without any inconsistency, arose because of the properties of water (Henderson, 1913; Denton, 1998, pp. 22-46), the stellar formation of carbon (Burbidge el al., 1957), precisely tuned cosmic constants (Rees, 2000), physical and chemical peculiarities (Northrop, 1979, pp. 168-205), and also because of the creative power of an Infinite Goodness. Just as it is not incoherent to say — all at the same time —

that the fire is burning in my backyard because of chemical processes, and because it was ignited by a match, and because I want hot dogs, logically speaking plenty of non-competitive room exists, at least in principle, for a theological understanding of life to co-exist comfortably alongside scientific accounts. The only requirement is that the various layers not be logically inconsistent with one another.

Furthermore, contrary to E. 0. Wilson's expectations, for theology to have deep explanatory value, its understanding of life cannot be spelled out in objectifying scientific language any more than "1 want hot dogs" needs to be expressed in the idiom of chemical combustion. Indeed, the language of truly deep explanation must be that of symbol, metaphor, and analogy because it refers to a reality more encompassing than anything that we humans can bring into objectifying focus. Only a narrow commitment to explanatory monism — a contraction that can be justified by no available scientific evidence — would lead to a rejection of the richly layered model of understanding I am proposing here (and which Aristotle and other philosophers have proposed for centuries). Of course, the option to take the road of layered explanation is a fiduciary leap, but it seems to me to be a more reasonable kind of leap than the option for explanatory monism. As it casts a wider net, explanatory pluralism is less likely to leave out essential causal factors than explanatory monism, even if it still leaves the world looking a lot fuzzier at its foundations than a strict reductionist would prefer.

And yet, a theology comfortable with explanatory pluralism will still encourage all the sciences to push their own purely natural, and inevitably reductive, explanations as far as possible at their own appropriate levels of investigation. Good theology avoids any attempt to make room for divine action in the dark regions of yet uncharted scientific levels of inquiry. This is because its sense of layered explanation can, in principle, make ample room for theological explanation at levels more fundamental, metaphysically speaking, than those at which science functions. And so, without in any way contradicting elaborate physical, chemical, or evolutionary accounts of life, theology may be justified in claiming that chemistry is fine-tuned to life ultimately because of the infinite generosity and wisdom of God. But it does not expect to discover the finger of God anywhere in, or even at the temporal beginning of, the series of physical and biochemical causes that seem suggestive of a fine-tuning for life.

That room still exists for a deeper probing by theology after science has detailed the fitness of the cosmos and its complex chemistry for life is suggested by the fact that so many scientists themselves view fine-tuning as remarkable: that is, they have an intuition that something deeper is going on in nature than science itself can bring into focus. In recent years, as a matter of fact, it is scientists more than theologians who have noticed that the universe and earth appear to be remarkably fine-tuned for life. Modern thought, influenced by a mechanistic philosophy of nature, was not ready for this discovery. Up until the 1970s, science had increasingly pictured life as an anomaly in a pervasively lifeless and pointless universe. Jacques Monod's popular book Chance and Necessity (1971) epitomized the long-standing materialist claim that nature is essentially indifferent to life and intelligence. And much modem philosophy, art, and religious thought have taken shape in support of, or reaction to, that assumption.

But now, many scientists working at diverse scales from microphysics to astronomy have noted in a way they never did before that the universe, apparently from the beginning, was put together in a series of close calls that made it just right for the emergence of living and thinking beings (Davies, 1992). Hence, the universe no longer seems essentially lifeless and mindless. And, as other chapters in this volume point out, nature's biochemical details and the terrestrial environment as a whole provide a nest seemingly designed for life. So impressive is the still-accumulating information about the many emergent levels of the world's fine-tuning for life that some scientists can hardly suppress a suspicion that something momentous, perhaps even purposive, is afoot in the cosmos.

But one must be cautious. At what level should the explanation of the fine-tuning for life — in terms of the notion of purpose — be located? And what exactly does it mean to say that it is fine-tuned for life? Few scientists doubt that physics. chemistry, and terrestrial ecology are just right to sponsor the adventure of life. However, as I noted earlier, what is most interesting and most at issue, at least when all the dust clears, is whether nature has been intentionally prepared for life. And, is science as such ever really equipped to answer the deep question of whether intentionality or purpose is involved at any level?

I believe not, especially because the scientific method, as such, deliberately leaves out considerations of purpose. If, in their more popular essays on the implications of science, scientists hold forth on the question of purpose in nature, it is not as scientists, but as (usually amateur) philosophers that they do so. And that they attempt to draw philosophical conclusions directly out of the data of science is sometimes indicative more of a prior commitment to explanatory monism than of a genuine respect for the integrity of science.

And yet, an intriguing sense of the remarkableness of life persists among scientists themselves, including evolutionists. Remarkableness, as much as some scientists try to disown its power, still remains the muse of biology, as well as of all other sciences. In his extensive research on the phenomenon of evolutionary convergence, the paleobiologist Simon Conway Morris, an editor of this volume, has noted that "words like 'remarkable', 'striking', 'extraordinary', or even 'astonishing', and 'uncanny' are commonplace" in the literature (2003, p. 128). In other words, scientists have an incentive to embark on their research programs only if they somehow find nature astonishing. In fact, it was clearly his own experience of the remarkableness of convergence that led Conway Morris to challenge Stephen Jay Gould's conviction that chance was the determining factor in evolution. Gould had claimed that if the "tape" of terrestrial life's evolution were rewound and played again, the results would be completely different next time around (1989, p. 50). This is because, for Gould, the deepest causes of life's various forms were "contingent," or purely accidental events in natural history (such as climatic changes and mass extinctions). Like most evolutionists, Conway Morris gave a place to chance, but he disagreed with Gould's enshrinement of contingency as the ultimate cause of evolutionary outcomes. He tracked numerous instances of convergence, in which independent, ancestrally unrelated lines of evolutionary adaptation have led time and again to similar physiological outcomes. If the tape of evolution were replayed, the results might be different in some details the next time around, Conway Morris allowed, but generally speaking the consequences would be quite similar to what they turned out to be this time. In any case, life is not a simple lottery in which life forms follow no restrictive corridors of development.

It is "remarkable" to Conway Morris, for instance, that more than a dozen mole-like burrowing (fossorial) animals from around the world exhibit closely comparable bodily features, even though they belong to entirely different species (2003, Pp. 139-44). The rapacious teeth of some predatory marsupials are nearly identical in structure to those of certain placental animals, although their respective evolutionary courses unfolded oceans apart. In species that are clearly unrelated, phylogenetically speaking, the eyes, snouts, auditory mechanisms, and other attributes have developed independently any number of times in nearly the same way, following similar biochemical and morphological pathways. Such similarities cannot be due either to sheer coincidence, since the likenesses are so pronounced, or to genetic inheritance, since they occur in unrelated phyla. Biology exhibits so many instances of convergence that something other than sheer accident must be involved; thus, Gould must be wrong. It is almost as though "evolutionary hyper-spaces" — the possible forms in which life can clothe itself — have been laid out in advance, and their number is finite. Clearly, constraints hear on the possible routes one might imagine life having

taken. Organisms can try on any number of virtual outfits, and alterations can be made; but the tailoring is not infinitely malleable.

It is not my place to pass judgment on the accuracy or inaccuracy of Conway Morris' claims. However, it seems appropriate to ask for an explanation of the limits that constrain life to the point of permitting so much convergence. It does not seem sufficient to invoke the idea of adaptation by natural selection exclusively because, by itself, that idea is too wide-ranging to be helpful. No matter what outcomes occur in evolution, the ultra-adaptationist will insist that the explanation must be "natural selection." This may be true in a general sense, but appealing to the idea of selection lies at the same level of vagueness as a meteorologist's claiming that the laws of physics are the cause of this afternoon's thunderstorm.

Life, to those who have no stomach for layered explanation, is generalizable as merely "simplicity masquerading as complexity" (Atkins, 1992). But to those who find life remarkable, a search for a deeper explanation is in order, since explanatory monism seems too shallow and too vague to capture most of what is actually going on in the universe. However, one needs to avoid reaching for theological explanation too early in the search. Layered explanation allows us to avoid a precipitous rush to bring in theological or quasi-theological categories such as Intelligent Design while plenty of room is available for scientific clarification. Correspondingly, if theology is to offer any explanation as far as fine-tuning is concerned, it should not be introduced prematurely or on those levels of methodological self-restriction where scientific research is being carried out. Such an intrusion would be just one more appeal to "God of the gaps" (i.e. God's role is limited to accounting for the "gaps" in scientific explanations of nature).

However, if one takes the approach of layered explanation, theological understanding might be relevant at vertically deeper layers of understanding than those at which the physical and biological sciences normally function. The sense of remarkableness, 1 believe, arises from the fact that the scientist's consciousness, no less than that of other human beings, is somehow already in the grasp of a dimly intuited need for ultimate explanation. But theology cautions science not to be too hasty in identifying or clarifying nature's deepest dimension. It is "better instead to allow the sense of uneasiness that "something more" is involved to remain alive and unresolved as a spur to ever-deeper exploration. I have argued elsewhere that sortie evolutionists prematurely give to the notion of natural selection a metaphysically foundational status, and that this assignment actually inhibits more penetrating inquiry into the depths of nature (Haught, 2003). I would urge the same caution here with respect to the temptation to give exclusively naturalist accounts of fine-tuning, fitness, and convergence. Allowing for theological or metaphysical explanation at deeper levels than those at which science works delivers science from the burden of having to come up with the ultimate explanation.

And yet, scientists are human beings, and it is natural for all of us to look for the ultimate explanation, especially when things seem surprising. The "frequency of adjectival surprise associated with descriptions of convergence," Conway Morris says, "suggests to me that there is almost a feeling of unease in these similarities" (2003, p. 128). He suspects that some biologists "sense the ghost of teleology looking over their shoulders." and he does not consider this to be an "unworthy sentiment" (2003, p. 128). Convergence has an "eeriness" that makes it plain that human inquiry still has a long way to go until it gets to the bottom of evolution (2003, p.128). Something more than chance, selection, or the sheer passage of time must be involved in the outcomes of earth's life processes. What the "something else" might be, however, Conway Morris does not specify, and since other explanatory levels are available outside of science to account in a deeper way for remarkableness, it is not his task as a scientist to do so.

As a scientist, Conway Morris seems quite aware that he is not supposed to dabble in metaphysics. Yet, in his Life's Solution he provides more than a hint of the need for explorations of life by metaphysics and theology. Still, I believe Conway Morris considers these explorations to be supplemental to those of science as such, and he does not conflate religious allusions with his detailed scientific presentation of the evidence for convergence. Knowing that it is not his task to do theology, contrary to the suspicions of some of his critics (e.g. Prothero, 2003), he is not doing violence to science by pointing out, at least by implication, the need for alternative levels of explanation to account fully for life's remarkableness. In fact, by his explicitly allowing for a theology of evolution in addition to the science of evolution, one could make the case that he is safeguarding the integrity of science. By explicitly making room for theological investigation of life at a level distinct from science, he can more easily let science be just science than can some of his critics. Unlike evolutionists such as Gould, Dawkins, and Prothero, all of whom are content to force a materialist ideology into the single explanatory slot of scientific understanding, Conway Morris seems to be aware of the need to decouple strictly scientific work from statements of belief. By at least implicitly allowing for an explanatory pluralism, he can provide scientific inquiry with much more immunity to metaphysics than evolutionists that either unconsciously or deliberately conflate scientific ideas with materialist ideology.

Is fine-tuning remarkable?

How does this discussion of Conway Morris apply to the issue of fine-tuning: the fitness of the cosmos, earth, and chemistry to the emergence of life? Isn't this set of physical factors also "remarkable" enough to suggest that conventional scientific accounts are leaving something out by way of explanation? I believe that we also need to approach this question with an openness to layered explanation. Science alone, after all, has a habit of reducing remarkableness to mere routine at its own levels of inquiry. This reduction, when confined to the scientific method, strictly speaking, does not seem inappropriate. Science rightly tries to bring a largely hidden concatenation of natural causes out of darkness into the light of day, and once the unbroken sequence is exposed, the seemingly supernormal facade pales into bland normality. This is how science works.

However, the stronger claim that, in the end, nothing in nature can still be remarkable after science has done its work is not so much a characteristic of science itself as it is of the belief system known as "scientific naturalism." Scientific naturalists strongly believe that nature is all there is. If nothing else exists besides nature, it follows that nature must be self-originating. Moreover, if the natural world is not rooted in any creative agency beyond itself, there can be no end or goal that would give overarching purpose to the universe. According to scientific naturalists, the whole scheme of things is pointless, even considering local pockets of purely human meaning. Nor is there room for miracles or divine responsiveness to prayer. Finally, with no divine causation, all causes must be purely natural, and every natural event is the consequence of other natural events (Hardwick, 1996). Thus, all phenomena, however astonishing they may at first appear, are ultimately unremarkable — that is, natural. Otherwise, the naturalist belief system would be exposed as incoherent. Accordingly, cognitional satisfaction cannot occur until one has arrived at the cold consequence that nothing is really remarkable after all. "Remarkable" is at most a temporary sticker, to be removed once the purely natural causes of things have become manifest.

In our own time, scientific naturalism is alluring to scientists and philosophers alike. The self-avowed materialist Nicholas Humphrey clearly exemplifies the scientific naturalist's longing to reduce the remarkable to the routine. In his book Leaps of Faith (1996), he tries to show that what may at first seem supernormal, and hence an invitation to adopt a non-materialist understanding of the world, always turns out, on closer inspection, to be completely normal, and therefore just one more defeat for supernormalism. Like James Randi, the famous debunker of Uri Geller's allegedly paranormal feats of magic, Humphrey considers it not only the scientist's but also the philosopher's responsibility to demonstrate that any natural phenomena that seem to exhibit intelligent design

and fine-tuning are really normal or routine. For Humphey, fine-tuning as described in the present volume would be just one of the many "appearances" that, once we see through them, are really not remarkable at all.

Humphrey has a lot of company in the intellectual world today. Owen Flanagan, a well-known philosopher at Duke University, even goes so far as to declare that the main purpose of academic philosophy is to "make the world safe for naturalism" (2002, pp. 167-8). Nevertheless, even the most naturalistic of scientists and philosophers at least begin their inquiries into specific areas of research only when they find certain things remarkable enough to engage their interest. Without the horizon of a yet unknown world stretching out tantalizingly ahead. scientific exploration could not even get started. Nor could it continue unless the summons to explore the unknown keeps reappearing on the horizon with each advance. It is still an open question, therefore, whether all that we find initially remarkable is destined eventually to become routine.

An appropriate question for theology, therefore, is why the world remains continually remarkable and often becomes even more so as science progresses in its understanding. And what, moreover, would make fine-tuning remarkable enough to be both an interesting topic for research and something deserving of ceaseless (theological) amazement? To many scientists, even after they have reduced it scientifically to purely natural processes, fine-tuning remains — again at a deeper level than science alone can reach — no less eerie and astonishing than evolutionary convergence is to the likes of Conway Morris. Otherwise, it would not be drawing so much attention. What is it, then, that arouses the scion-fist's — or, for that matter, anybody's — interest? What is it that invites theological comment?

As mentioned previously, one factor is a sense of contingency, a realization that many outcomes are possible, but that these possibilities are constrained at every step by pruning principles. A sense of contingency arises because the cosmic or biochemical fine-tuning prior to and underlying life might very well not have occurred at all. And the natural events leading up to life did not have to take place exactly the way they did. The scientist's capacity to entertain counterfactual worlds is possible only because of a prior sense that contingency is involved in the Physical unfolding of the world. That is, alternative sets of physical occurrences are theoretically possible, even though most of them would not have led to life. One reason for sensing remarkableness, then, is the apparent lack of inevitability that scientists arc now discerning in the physical prehistory of life.

Contingency means "absence of necessity," and so a contingent event is any occurrence that has actually taken place but did not have to take place. Contingency is inevitably remarkable as it gives rise to the question of why this or that happened if it did not have to happen at all. If one arrives at the point of realizing that something had to happen, and that it had to happen the way it did, then there would be no more room for questioning. Thus, understandably, one important wing of scientific naturalism— let us call it "right-wing naturalism"— tries to eliminate remarkableness by mentally transforming all impressions of contingency into a sense of inevitability. Acknowledging overriding necessity leaves no room for astonishment.

Right-wing naturalists strive to eliminate remarkableness from nature by demonstrating that all natural phenomena, beneath any initial appearance to the contrary, are the consequence of an underlying physical necessity. According to the philosopher Daniel Dennett, for example, the rich display of novelty and living diversity in evolution is really nothing more than the outcome of an algorithmic (mathematically inevitable) process (1995, pp. 48-60). Apparently, it is the vocation of the right-wing scientific naturalist to help us put aside all childish wonder and become resigned to the inherent unremarkableness of nature. In my opinion, however, such a project can be carried out successfully only where a sense of deeply layered explanation has already been suppressed.

Just what motives lie behind the scientific naturalist's often passionate suppression of explanatory pluralism is a topic deserving of a separate study.

However, a left-wing variety of scientific naturalism is also operating in today's world. Looking for a world shorn of abiding wonder, some scientists and philosophers are inclined to enshrine absolute contingency rather than physical necessity in the role of final explanation. In contemporary debates about how to account for evolutionary outcomes, a major issue is whether the ultimate cause of evolutionary change is the rigorous necessity of adaptation by natural selection or perhaps the irrational contingencies in natural history. Gould, to cite the most prominent representative of contingency proponents, claims that it is especially accidental, undirected events such as meteorite impacts, earthquakes, and climatic changes that explain the uniqueness of living organisms and species. Yet he shares with his more deterministic adversaries the same compulsion to eliminate remarkableness at all costs. In Gould's case, the reduction is not so much to routine as to irreducible unintelligibility, but the result is the same: life is no longer remarkable because its absolute origin has now been revealed. In spite of what seem to be irresolvable conflicts between them, the respective devotees of Dawkins and Gould may appreciate that both evolutionists, though taking different routes, end up exorcising any open-ended mystery from the story of life. For both factions, an allegedly scientific category, whether chance or necessity, functions in fact as a metaphysical explanation, rendering theology obsolete.

Conclusion: nature as narrative

I believe that the notions of chance and necessity, however, are both lifeless men . abstractions that fail to do justice in any way to the deeper fact that nature is story that blends contingency, law, and time into something truly remarkable an unrepeatable. It is this narrative aspect of nature that I would want to reflect o if I were in search of something irreducibly remarkable about the universe an evolution. For scientific naturalists, chance and necessity are each apotheosize. ironically not unlike the deities of an ancient mythic pantheon. In fact, "chance' and "necessity" are really abstract terms that have been reified in such a way . to miss altogether the concretely narrative quality of natural reality. On the on. hand, "chance," "accident," and "randomness" are terms that point only obliquely to nature's concrete, contingent openness to indeterminate future outcomes. 0 the other hand, "necessity" is a misleading label for the underlying consistency of lawful constraints that limit possibility. In the real world, "contingent" openness never exists independently of the habitually constraining and lawful consistency (misnamed "necessity") that gives continuity to nature in its narrative passage through time.

What remains indelibly remarkable, therefore, is not so much life's or the environment's fine-tuning, or evolutionary convergence, for that matter, but the delicate blend of openness, constraint, and temporality that clothes the cosmos with drama. It is this combination that most appropriately invites theological comment. What is eerie, astonishing, and amazing — and utterly irreducible to routine — is that nature is narrative to the core, and that the story is not over. Nature is not a state, but a historical genesis, a process of becoming, an epic still being told. And so we will never get to the bottom of fine-tuning and evolution until we have understood why their matrix is narrative and where the story is leading. Contrary to the tenets of naturalism, I doubt that the natural sciences can answer this question at their own levels without also leaving ample room for theological conjecture at its own appropriate level.

Fine-tuning is remarkable, then, primarily because it is situated within the more foundational context of a cosmic story. The tuning, after all, is never really as fine as it initially seems. If it were, necessity and rigidity would have locked life into eternal stasis — a kind of death, in other words. Nature would no longer have a story to tell. Order without novelty is meager monotony. But, blessedly, an openness to possibility still exists (inaptly called "contingency") that pierces through the armored consistency in natural processes. In evolution, this openness consists in part of the

very imperfections inherent in biological adaptations. Nature must be open to the future if it is to avoid metamorphosing into hard-rock necessity. Its imperfections assist in keeping it open to the future. To an earlier and now passé brand of Darwinism, it was a theological scandal that no adaptations were perfect, as imperfection spoiled the idea of an Intelligent, Divine Designer. But the idea of Intelligent Design is itself just another abstract idea originating in our human tendency to disassociate order from the openness that makes nature narrative. As it turns out, the imperfection of organic adaptation is essential if the story is to keep going and to remain interesting. If nature is narrative, we must remark at how fortunate it is that adaptation and design are not comfortably complete.

On the other hand, openness to transformation does not mean absolute indeterminateness, as fine-tuning and biological convergence show. A finite range of possibilities and a channeling aspect to evolution exist and keep life from splashing out all over the place in completely unrestrained "hyperspace." The morphologies assumed by life, whether on earth or elsewhere, seem to be finite in number. Life is open to possibility, but possibility is not limitless. Otherwise, the story would have no continuity. Evolution arises in a narrative matrix, and narrative requires habitualness and redundancy, along with novelty, to keep the life-journey from collapsing at any capricious moment into complete confusion.

Contingency, if one wishes to use this abstract term, is remarkable because it adds historicity and dramatic suspense to recurrent natural processes. Right-wing naturalism looks for the strain of lawful necessity (and hence predictability) in all natural occurrences, and so it is naturally uneasy with contingency. Contingency means uniqueness, singularity, specificity, and unrepeatability, and these all defy sheer generality and reductive simplicity. To fulfill its objective of exposing remarkableness as mere routine, therefore, right-wing scientific naturalism must at least implicitly deny that contingency is anything more than necessity not yet understood.

When it appears in combination with nature's habitualness, contingency is remarkable. But when it is absolutized as an independent and ultimate explanation, Contingency is equivalent to unintelligibility or absurdity. At the point of being thus maximized, contingency, no less than necessity, banishes remarkableness from the world. The typical way of exorcising remarkableness is the right-wing naturalist's reduction of contingency to necessity. but as this objective is unachievable, another way of muffling surprise and awe is found in left-wing naturalism — namely, to exaggerate contingency to the point of making pure chance the ultimate explanation of the most momentous natural occurrences. I have been proposing, however, that both kinds of naturalism, because of their explanatory monism, can thrive only in an illusory and imaginative world of ideas quite cut off from the actual narrative flow of nature itself. And it is this narrative, a story that wends we know not where, that remains forever remarkable and that gives theology a permanent place in the human quest for deep explanation.

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Chapter 4 – Complexity in Context: The Metaphysical Implications of Evolutionary Theory
Edward T. Oaks

> It would he a poor thing to be an atom in a universe without physicists. And physicists are made of atoms. A physicist is the atom's way of knowing about atoms.
> — George Wald, Introduction to Lawrence Henderson's The Fitness of the Environment

> A conscious fruit fly would have to confront exactly the same difficulties, the same kind of insoluble problems, as man.... To defy heredity is to defy billions of years, to defy the first cell.

— E. M. Cioran, The Trouble with Being Born

> We keep forgetting to go right down to the foundations. We don't put our question marks down deep enough.... What a Copernicus or a Darwin really achieved was not the discovery of a true theory but of a fertile new point of view.... A curious analogy could be based on the fact that even the hugest telescope has to have an eye-piece no larger than the human eye.
> — Ludwig Wittgenstein, Culture and Value

Science is the midwife of metaphysics. However much it might protest that it confines itself to physical realities only, science cannot help but provoke metaphysical questions in the human mind. To be sure, when it confines itself to its own specialized sphere, each science is strictly physical, physical both in the scope of its investigation and in the results and data those investigations produce. But science's ultimate import is always metaphysical} This trans-physical import of science

becomes most evident when scientists look up from their desks and seek to explain the technical results of their work to the general public in easy-to-understand terms. It is especially at this popularizing level that we find science, nolens volens, bumping into metaphysics .2

But often enough the bump is not felt as such. For metaphysics is the spectral science, silent and invisible, often slighted and frequently despised. But however contemned, it is always hovering and lurking about the premises; and for that reason it is not much welcome by scientists, most of whom greet metaphysics the way Jane Eyre reacted to the screams she heard emanating from the attic. John Barrow captures this uneasiness of physicists facing metaphysical questions very neatly in a passage that also explains why the inherently philosophical questions won't go away, no matter how uneasy scientists might feel about them:

> [The] tendency of fundamental physics to move towards questions traditionally of interest to philosophers and theologians has developed in parallel with an increased lack of interest amongst physicists in the philosophical questions raised by these developments. To most scientists [the phrase] "philosophical questions' has become a handy label to apply to any collection of vague or apparently unanswerable questions which only become worthy of serious consideration when they become scientific. (Barrow, 1990, p. 2)

Nor is this uneasiness, which sometimes borders on outright contempt, utterly implausible. Even a quick glance at the current state of philosophy will dismay the empirically trained scientist. When indeed has philosophical speculation ever inspired confidence in a scientist? As portrayed by the Polish writer Leszek Kolakowski the contrast between philosophy and science could hardly be starker:

> For centuries philosophy has asserted its legitimacy by asking and answering questions inherited from the Socratics and Pre-Socratics: how to distinguish the real from the unreal, (the from false, good from evil ... There came a point, however, when philosophers had to confront a simple, painfully undeniable fact: that of the questions which have sustained European philosophy for two and a half millennia, not a single one has been answered to general satisfaction. All of them, if not declared invalid by the decree of philosophers, remain controversial. It is just as possible, culturally and intellectually, to be a nominalist or an anti-nominalist today as it was in the twelfth century; no odder now than in ancient Greece to believe or deny that phenomena can he distinguished from essences, no more unusual to hold that the distinction between good and evil is a contingent one, a matter of convention, than to claim that it is embedded in the necessary order of things. Belief and non-belief in God are equally respectable; no norms of our civilization prevent us from

> claiming that language creates reality or the other way around; we shall not be barred from good society because we embrace or reject the semantic conception of truth. (Kolakowski, 2001, pp. 1-2 (emphasis added])

Obviously, scientists cannot endure such methodological and ideological chaos in their chosen specialties. That is also why, by the way. no matter how much postmodern epistemologists hurl challenges at the validity of science, scientists themselves rarely betray any lack of confidence in their work or in the results of their research and experimentation. Leave the death-wishes to philosophers, they seem to be saying, we need to get on with our work.3 And who can blame them? Philosophy seems largely devoted to proclaiming its own death, rather like those theologians of the death-of-God school. But what science ever acts as philosophy does?

For well over a hundred years, a large part of academic philosophy has been devoted to the business of explaining that philosophy is either impossible or useless or both. Thus Philosophy demonstrates that it can happily survive its own death [by keeping] itself busy trying to prove that it has indeed died . There is an immense variety of unconnected philosophical paths, all converging at one point — that of anti-philosophy. The farewell to philosophy, like the "bye-bye" in a famous Laurel and Hardy scene, never ends. The issues that once formed the kernel of philosophical reflection —being and non-being, good and evil, myself and the universe — seem to have been shunted aside, relegated, except as subjects of historical enquiry, to a corner of academia, almost as dark as that occupied by God in schools of Divinity or sex in Victorian conversation. (Kolakowski, 2001, pp. 7-8)

There is also a further worry that needs to be mentioned: metaphysics is often religious in its claims.4 In fact, Aristotle called "metaphysics" (the word itself was a coinage of post-Aristotelian librarians) not only "first philosophy," but more crucially "theology."5 And the episodes of theology dictating to science (or to "natural philosophy," as it used to be called) are long, well antedating Galileo. One notices this in a remark of Moses Maimonides (AD 1135-1204) in his famous Guide for the Perplexed, where he scores this aggressiveness by theology to dictate results and which he detected in some of his Christian and Muslim predecessors:

> It is not our object to criticize things which are peculiar to either creed, or books which were written exclusively in the interest of one community or the other. We merely maintain that the earlier theologians, both of the Greek Christians and of the Muslims, when they laid down their propositions, did not investigate the real properties of things; first of all, they considered what must be the properties of the things which should yield proof for or against a certain creed; and when this was found they asserted that the thing must be endowed with those properties; then they employed the same assertion as a proof for the identical arguments which had led to the assertion, and by which they either supported or refuted a certain opinion!'

Yet, despite both the simultaneous chaos of philosophy and the repeated acts of aggression perpetrated on science by metaphysical theology, I shall be claiming here that metaphysical claims and implications won't go away, no matter how anxious that makes scientists feel.' This uneasiness might seem to be most acute among physicists, for cosmology ineluctably raises question after question that, at least at first blush, seem metaphysical: the place of chance in quantum physics, the nature of space and time as relative to each other, the role of observership in the constitution of reality, the paradoxes of the anthropic principle, and so forth. But even a quick glance at the debates raging inside biology shows how those debates are frequently determined by issues primarily philosophical, not biological -to the palpable unease of many biologists. In the wake of the discovery of the helical structure of DNA, biologists might well feel confident that they have finally expelled such allegedly metaphysical notions as élan vital, soul, and even "life" (as an extra-

biological concept) from their conceptual armory; but uncomfortable issues remain lurking in the attics of the biological sciences.

Take, for example, the pesky problem of teleology. Before publication of Charles Darwin's On the Origin of Species in 1859, it was the common assumption of everyone from Aristotle to William Paley that the neck of the giraffe was -made for" reaching vegetation atop tall trees, that eyes are "made for" seeing, and so forth. And since such complex formations like the eye could hardly have come about by mere chance, they must have been designed by a kind of divine foresight, just as a watch requires a clever watchmaker. However, with the appearance of the Origin, that explanation fell into disarray and lost its hold on the scientific public, or so it is claimed. In fact the situation was far more complex than the received wisdom would have it. Even avid Darwinians were not so sure. For example, Thomas Huxley ("Darwin's bulldog") saw Darwinism as the perfect opportunity to set up a secular religion to rival Christianity, yet he still believed in "saltations" - big leaps in evolution to account for the transition from, say. fox to dog - and even claimed that "there is a wider Teleology, that is not touched by the doctrine of Evolution."8 On the other side of the coin (and ocean), the Harvard botanist Asa Gray rightly recognized that saltations would mean the demise of the theory of natural selection and vigorously defended Darwin in the New World; but he always remained an orthodox Congregationalist. In contrast, his great rival at Harvard, the zoologist Louis Agassiz, attacked the Origin root and branch, but abandoned the Calvinist religion of his Swiss homeland and became a Unitarian while at Harvard.9

These catfights among the Darwinians continue right down to today. In order to drive home the point that evolution has no goal and that humans are a complete fluke, the late Harvard professor Stephen Jay Gould insisted that if we rewound the tape of evolution and started the whole process over again, the chances would be vanishingly small of evolution producing, yet one more time, the same roaches and sharks, tulips and mushrooms, humans and crabs, that we know today. Of course if the outcome of evolution were that much of a fluke, then, as Daniel Dennett points out in Darwin's Dangerous Idea, the search for intelligent life on other planets would be as pointless as a search for extraterrestrial kangaroos (see more on Dennett's point about this below). The whole point of such a search rests on the assumption that evolution will inevitably tease out the potential for intelligence already lurking, however embryonically, in the prebiotic chemical soup of other life-potential planets. But if intelligence is well-nigh inevitable, then does not such inevitability say something about the inherent nature of the universe? If we were so inevitable from the start, why the paroxysms of self-abasement about our fluke emergence, these pseudo-lachrymose sneers at man as an insignificant worm in the cosmic slime?

What makes this debate, at root, a metaphysical one is its reliance on either implicit or openly avowed metaphysical presuppositions. Even to make the claim he did, Gould must have presupposed that it was meaningful to speak of -rewinding the tape of evolution" or that one may meaningfully speak, after the event, of the relative weight that should be given to chance over necessity in the discussion of biological causality. Even to speculate on "what might have been" had tectonic plates arranged themselves differently (would kangaroos ever have evolved if the Australian continent had stayed fused to the Antarctic land mass?) is to enter into a realm of thought determined by modal verbs ("might have." "could have," and so forth); and the role of modal verbs in determining the structure of reality is itself a heated area of metaphysical debate among analytic philosophers. Similarly, the positing of chance and necessity in causal explanation already represents the introduction of metaphysical categories.10

It is the purpose of this chapter to try to explicate these metaphysical implications. above all as they pertain to biological complexity. Complexity leads to perplexity, goes the old saw in Introduction to Epistemology classes. Or more exactly: complexity in things leads to perplexity in the mind. Even arrangements that are not, in and of themselves, terribly complex - such as a circle

of ten stones forming a barrier for a campfire, for example - prompt the human mind almost spontaneously to imagine the presence of design. Let us take the case of Robinson Crusoe; but this time let us not have this shipwrecked survivor, washed ashore on what seems to be an uninhabited island, discovering a human footprint in the sand. Rather let us assume he comes across, in a forest clearing, a circle of stones: just as with the footprint, so too with the stones - Crusoe knows that there is (or was) at least one human besides himself on the island.

But far from resolving his initial perplexity after being washed ashore, the formation of the stones has still not really answered all his questions. For example, the footprint in the sand surely indicates the recent presence of Man Friday on the island (the sand would have obliterated an old footprint). But assuming there is no ash, no burning embers, in the center of the stone formation, Crusoe has no idea when the circle was made or what kind of human, hostile or friendly, made the campfire. All he knows, almost instinctively, as it were, is that such a circle could hardly have formed itself (which means, in modern parlance, that the circle is not just complex but "irreducibly" complex, a term discussed further below), and therefore that a designer must have introduced - or rather, imposed - a mentally conceived form upon the stones scattered about nearby. Anything beyond that, however, leads only to further perplexity.

I have decided to use this primitive example (primitive, obviously, in more ways than one) because it highlights why and how arguments based on design can lead us astray. No one denies that the universe is complex, staggeringly so. Thus it seemed eminently sensible to extrapolate Crusoe's logic to the universe: something as complex as the universe must have been so arranged as to allow not just the formation of stars, but also the chemical presuppositions of life-and adherents of the Intelligent Design (ID) movement go further and insist that the transition from the inorganic to the organic needed another "jump start" (which they call "abiotic infusion") to account for the even greater complexity of life. But in the wake of Charles Darwin's theory of natural selection, this argument from design has been shown to rest on an optical illusion, or rather, on a philosophical category mistake. "Irreducible complexity," in other words, is not necessarily the same thing as what I shall term here "staggering complexity.""

In my opinion, it is the great virtue of the theory of natural selection that it made Clear, for the first time, the distinction between irreducible and staggering complexity. Unfortunately, in too many minds - both Darwinian and anti-Darwinian – that lesson has not been learned. For too long it has been assumed that Darwin had expelled all forms of teleological understanding in biology, but that is going too far.12 Actually, in some ways the theory of natural selection gives new purchase to the teleological mode of understanding. Even Charles Darwin himself (at least in his better moments) knew as much. Try as he sometimes might (in his weaker moments) to expunge teleology from biological thought, he knew it couldn't be done; so he ended up with a rather muddled ambivalence:

> The term "natural selection" is in some respects a bad one, as it seems to imply conscious choice; but this will be disregarded after a little familiarity. No one objects to chemists speaking of "elective affinity"; and certainly an acid has no more choice in combining with a base, than the conditions of life have in determining whether or not a new form be selected or preserved. (Darwin, 1868, Vol. 1, p. 6)

This passage tells us more than even Darwin himself seems to have divined. For what he is highlighting here, perhaps without realizing it and certainly without the technical vocabulary necessary to make the point clear, is that one must distinguish between what ID advocates call "abiotic infusion" and what Aristotle called entelecheia ("entelechy"). Because this term is hardly a household word these days, perhaps the reader will allow me to cite this definition from the standard reference work for Greek philosophical terminology:

> Entelecheia: stale of completion or perfection, actuality. Although Aristotle normally uses entelecheia, which is probably his own coinage, as a synonym for energeia, there is a passage (Metaphysics 1050a) that at least suggests that the two terms, though closely connected, are not perfectly identical.... The state of functioning (energeia) "tends toward" the state of completion (en-telecheia). (Peters, 1967, p. 57)

In other words, entelechy refers not just to an entity's completed state, but more crucially to its tendency to reach that state (whether that final state came to be as a result of chance, necessity, or a combination of the two is irrelevant to the positing of a prior inherent possibility of the initial state to reach a final state). According to standard Aristotelian metaphysics, the assertion of the presence of this so-called entelechy does not require the positing of some extra element (such as "abiotic infusion" or Henri Bergson's élan vital) in the structure. On the contrary, assertions of entelechy are but the recognition, in biological terms, of a prior logical tautology: posse sequitur esse. This phrase from medieval logic means: if something exists, then it was always possible for it to exist; and since a complex biological organism is now before our investigating eyes, it must he based on a prior structure that already had the capability (called "entelechy") of reaching its complex final state.

Chemists might well speak of "elective affinity," but what they mean by that rather anthropomorphic term is what Aristotle more soberly meant by "entelechy": that chemical structures, under the right conditions, have an inherent, innate tendency to actualize themselves into structures of greater complexity. For after all, if they did not have such an innate capacity in the first place, they never would have reached their final, complex stage in the last place. This is what I shall call, without further So, the "metaphysical" structure of natural complexity. But I hasten to add that the term "metaphysical" does not refer to some spooky "extra-physical" entity (like a designing mind, abiotic infusion, vitalistic vapor, élan vital, whatever). Rather, it refers simply to those logical prerequisites we must employ in order to understand change and identity through time, growth, and development. And note as well that these logical presuppositions are operative no matter what position one takes about the likelihood of the emergence of complex formations from simpler elements. Whether the complex organism is quasi-inevitable, as when acorns result in oak trees, or is highly unlikely, as when (by some accounts) carbon molecules first begin to replicate,13 still the fact of later emergence always means there was a prior entelechy to make that later emergence possible.

These logical substructures might seem tritely obvious, and in fact they are. For the only thing that these logical insights do is to highlight the necessary conceptual presuppositions we must use when discussing change, growth, increasing complexity, identity through time in the midst of development, and so forth. But unless we advert to these conceptual substructures inherent in any process of change, we are in danger of letting slip into our arguments false assumptions and faulty logic, such as the elision made by William Paley in the late eighteenth and early nineteenth centuries and by today's ID advocates when they conflate "staggering" complexity with "irreducible" complexity. But an equivalent metaphysical confusion must also reign among contemporary Darwinians, otherwise the debate over the radical contingency of the human species (Gould) against the virtual inevitability of intelligent life emerging (Dennett) could never arise.

Let us look at the actual conduct of the debate between these two men, for it is above all in the specifics of their argument that their metaphysical presuppositions will become clear. As we saw. Gould held that if we were to "rewind the tape of evolution" and start the process all over again, the chances of something like Homo sapiens emerging again are next to infinitesimal. But what exactly does this mean? Let me take the example of bipedalism to show how the argument works in

practice. In his book The Origin of Humankind, Richard Leakey calls the advent of bipedalism not just a major biological, but also a major adaptive, transformation:

> The origin of bipedal locomotion is so significant an adaptation that we are justified in calling all species of bipedal ape "human". This is not to say that the first bipedal ape species possessed a degree of technology, increased intellect, or any of the cultural attributes of humanity. It didn't. My point is that the adoption of bipedalism was so loaded with evolutionary potential—allowing the upper limbs to be free to become manipulative implements one day — that its importance should be recognized in our nomenclature. These humans were not like us, but without the bipedal adaptation they couldn't have become like us. (Leakey, 1994, p. 13)

So far, so good. But what were the conditions that selected for bipedalism? Here is the way Leakey summarizes one scenario:

About 12 million years ago, a continuation of tectonic forces further changed the environment, with the formation of a long, sinuous valley in central Africa], running from north to south, known as the Great Rift Valley. The existence of the Great Rift Valley has had two biological effects: it poses a formidable east-west barrier to animal populations, and it further promotes the development of a rich mosaic of ecological conditions. The French anthropologist Yves Coppens believes the east-west barrier was crucial to the separate evolution of human and apes ... [and] dubs this the "East Side Story." (Leakey, 1994, pp. 15-16)

> Let us assume for the sake of argument here that M. Coppens' East Side Story is the correct one. If it is, then it immediately raises the question: what would have happened if these tectonic plates had not moved in the way they did? Surely the formation of continents, mountain ranges, coastlines, and so forth follows no hard-and-fast rule of inevitability, any more than the weather does. Thus, if we rewound only that one shift of plates, presumably the conditions that led to bipedalism -and thus later to humans-would not have obtained. That in fact is also Leakey's conclusion: "natural selection operates according to immediate circumstances and not toward a long-term goal. Homo sapiens did eventually evolve as a descendant of the first humans, but there was nothing inevitable about it" (Leakey, 1994, p. 20).

Dennett counters this speculation with the retort that if such a view were true. the SETI Project (the once government-funded but now privately funded effort to Search for Extra-Terrestrial Intelligence) would be pointless. Admittedly, that is no slam-dunk refutation, for perhaps such a project is pointless. But the assumption (hope? possibility?) that there is life in the universe besides our own could not even be entertained if one were simultaneously to subscribe, with Leakey, to the Gould rewind-the-tape hypothesis. But, more crucially to the point at issue, Gould elides two kinds of contingency: the contingency of each human being emerging into life, and the contingency of life as such and of its formal properties. Here is Dennett's argument, where the distinction I am attempting to draw is put most lucidly:

> Just what is Gould's claim about contingency? He says that "the most common misunderstanding of evolution, at least in lay culture," is the idea that "our eventual appearance" is "somehow intrinsically inevitable and predictable within the confines of the theory." Our appearance? What does that mean? There is a sliding scale on which Gould neglects to locate his claim about rewinding the tape. If by "us" he meant something very particular—Steve Gould and Dan Dennett, let's say — then we wouldn't need the hypothesis of mass extinction to persuade us how lucky we are to be alive; if our two moms had never met our respective dads, that would suffice to consign us both to Neverland, and of course the same

> counterfactual holds true of every human being alive today. Had such a sad misfortune befallen us, this would not mean, however, that our respective offices at Harvard and Tufts would be unoccupied. It would be astonishing if the Harvard occupant's name in this counterfactual circumstance was "Gould," and I wouldn't bet that its occupant would be a habitué of bowling alleys and Fenway Park, but I would bet that its occupant would know a lot about paleontology, would give lectures and publish articles and spend thousands of hours studying fauna ... If, at the other extreme, by "us" Gould meant something very general, such as "air-breathing, land-inhabiting vertebrates," he would probably he wrong ... So we may well suppose he meant something intermediate, such as "intelligent, language-using, technology-inventing, culture-creating beings." This is an interesting hypothesis. If it is true, then contrary to what many thinkers routinely suppose, the search for extra-terrestrial intelligence is as quixotic as the search for extra-terrestrial kangaroos — it happened once, here, but would probably never happen again. But [Gould's book] Wonderful Life offers no evidence in its favor; even if the decimations of the Burgess Shale fauna were random, whatever lineages happened to survive would, according to standard neo-Darwinian theory, proceed to grope toward the Good Tricks in Design Space. (Bennett, 1995, p.307)14

It cannot be the task of this chapter to adjudicate this Gould-Dennett debate. I am citing their debate only to point out that the issue could never even hope to be adjudicated without appeal to what I have called the "metaphysics of complexity." By that I mean that, unless we have already determined what really constitutes chance, change over time, complexification from simpler elements, inevitability vs. contingency in the emergence of life, and so on, we will never be able to understand, let alone adjudicate, debates among the Darwinians. In fact, most of those debates only arise because prior philosophical confusions have not been acknowledged and resolved.

Now, I would not dream of disputing the claim that the deliverances of the empirical sciences will largely determine the outcome of this debate, but I wish to highlight how much the debate is also-and inevitably-governed by metaphysical presuppositions that often go unnoticed. Just as advocates of ID (in my opinion) make a mistake of philosophical categorization when conflating "staggering complexity" with "irreducible complexity," so too do the ultra-Darwinians when they assume that Darwin expelled all forms of teleology from biology when in fact he only refuted William Paley's version of the argument from design.

To elucidate and expand on what I am driving at with this observation, I would like to add one other point: why can't Dennett be aligned with Gould that intelligence is a "built-in" feature of evolutionary development yet also hold that intelligence is unlikely anywhere else in the universe? Certainly there is nothing inherently impossible, in the logical sense, with asserting both these positions. Such a thesis is, in fact, the gravamen of the recent book in evolutionary theory, Life's Solution, by Simon Conway Morris (2003).15 Perhaps the greatest virtue of this extraordinarily virtuous book is the author's alertness to the massive philosophical muddle of the (his word) "ultra-Darwinists":

> I am driven to observe of the ultra-Darwinists the following features as symptomatic. First, to my eyes, is their almost unbelievable self-assurance, their breezy self-confidence. Second, and far more serious, are particular examples of a sophistry and sleight of hand in the misuse of metaphor, and more importantly a distortion of metaphysics in support of an evolutionary programme. Consider how ultra-Darwinists, having erected a natural istic system that cannot by itself possess any ultimate purpose, still allow a sense of meaning mysteriously to slip back in ... Third, as has often been noted, the pronouncement of the ultra-Darwinists can shake with a religious fervour. Richard Dawkins is arguably England's most pious atheist. Their texts ring with high-minded rhetoric and dire warnings—not least of the unmitigated evils of religion — all to reveal the path of simplicity and straight

> thinking. More than one commentator has noted that ultra-Darwinism has pretensions to a secular religion, but it may be noted that, however heartfelt the practitioners' feelings, it is also without religious or metaphysical foundations. Notwithstanding the quasi-religious enthusiasms of ultra-Darwinists, their own understanding of theology is a combination of ignorance and derision, philosophically limp, drawing on clichés, and happily fuelled by the idiocies of the so-called scientific creationists. It seldom seems to strike the ultra-Darwinists that theology might have its own richness and subtleties, and might — strange thought — actually tell us things about the world that are not only to our real advantage, but will never be revealed by science. In depicting the religious instinct as a mixture of irrational fundamentalism and wish-fulfilment they seem to be simply unaware that theology is not the domain of pop-eyed flat-earthers. (Conway Morris, 2003, pp. 314-16 [emphasis added!)

Philosophical howlers and whoppers as egregious as those perpetrated by the ultra-Darwinians were bound to catch up with their advocates. And the reason is because the ultra-Darwinists are indulging in precisely the kind of metaphysical speculations that they claim they are trying to expel. The case of Charles Darwin is once again relevant here, for the crucial point is that his gradual movement toward agnosticism happened not, as is too widely assumed, because of his theory of natural selection, but for more personal reasons: he could not reconcile the death of his daughter Anne with the Christian doctrine of providence. In other words, theodicy was the real issue that led him to adopt an agnostic stance. But for the longest time. he saw that natural selection could be reconciled with Christian theism by using the medieval doctrine of secondary causality, a metaphysical doctrine that began with the neo-Platonist figure Proclus (AD 410?-85) and was given classical expression by St. Thomas Aquinas (AD 1225-74). As is well known, Darwin concluded the Origin with a paean to secondary causes:

> To my mind it accords better with what we know of the laws impressed on matter by the Creator, that the production and extinction of the past and present inhabitants of the world should have been due to secondary causes, like those determining the birth and death of the individual. When I view all beings not as special creations, but as the lineal descendants of some few beings which lived long before the first bed of the Cambrian system was deposited, they seem to me to become ennobled. (Darwin, 1928, p. 462)

Less well recognized, however, is the philosophical pedigree of this notion of secondary causality and the crucial role it has played in natural theology from the Middle Ages to the present. As the medieval historian of philosophy, Armand Maurer, puts it:

> What is the nature of Darwin's argument for evolution by secondary causes and what is its value? It does not belong to science but to natural theology, for it concerns God the creator and the laws he has implanted in matter. It should more properly be called metaphysical, for the argument turns on the distinction between primary and secondary causes, which are traditionally the concern of metaphysics. (Maurer, 2004, p. 497)16

Although it would be going much too far to say that Darwin's theory of evolution by natural selection helps to establish theism (Darwin's own changing convictions in that regard prove otherwise), it must none the less also be said that in certain ways his theory provides added support for certain schools of natural theology that come out of the Thomist (and Maimonidean) tradition, which holds that God is better praised by attributing natural events to natural causes rather than to God's direct involvement. Previously, both St. Augustine (AD 354-430) and St. Bonaventure (AD 12177-74) had held that secondary causality, at least when taken too far, would denigrate God's role in the world; so they posited something called "seminal powers" (rationes seminales), asserting that nature cannot produce new effects except by awakening the "seeds" God had originally planted in nature. They also subscribed to an epistemological equivalent of this doctrine, by asserting that

there were also seminal powers in the human mind, so that the human mind cannot attain to the truth without a special illumination from God to awaken latent powers, like the sun turning seeds into plants. But Aquinas insisted that created beings do produce new substances by their own powers and do reach (some) truths by the light of reason alone. As the renowned historian of medieval thought, Etienne Gilson, put it so well: "In St. Thomas man receives from God everything he receives [from God in St. Augustine, but not in the same way. In St. Augustine God delegates his gifts in such a way that the very insufficiency of nature constrains it to return toward him; in St. Thomas God delegates His gifts through the mediacy of a stable nature which contains in itself . . . the sufficient reason of all its operations" (quoted in Maurer, 2004, pp. 509-10 [emphasis added])."

Thomas's criticism of the Augustinian version of natural theology is no doubt the reason so many Thomists appreciate Darwin's achievement and even see his theory as confirmation of Thomas's theory of secondary causality." This is also why so many evolutionary biologists who are ardent Christians (or at least theists), such as Ronald Fisher and Theodosius Dobzhansky, explicitly rely on the notion of secondary causality.19 Needless to say, the concept of secondary causality establishes only the possible compatibility of evolution by natural selection with theism, not its actual compatibility. But the crucial point is that a denial of secondary causality must be argued metaphysically, for nothing in evolution itself can imply the implausibility of secondary causes, and still less their impossibility. Darwin himself recognized this as well in his autobiography, where he explicitly linked his constantly shifting opinions on God and Christianity with his gradual despair over the human mind's ability to reach metaphysical truths and not with his conviction of the truth of evolution:

> {I concede] the extreme difficulty or rather impossibility of conceiving this immense and wonderful universe, including man with his capacity of looking far backwards and far into futurity, as the result of blind chance or necessity. When thus reflecting, I feel compelled to look to a First Cause having an intelligent mind in some degree analogous to that of man; and I deserve to be called a Theist. This conclusion was strong in my mind about the time, as far as I can remember, when 1 wrote The Origin of Species, and it is since that time that it has, very gradually with many fluctuations, become weaker. But then arises the doubt—can the mind of man, which has, as I fully believe, been developed from a mind as low as that possessed by the lowest animals, be trusted when it draws such grand conclusions? (Darwin, 1892, p. 66)

On other occasions, Darwin would speak of the human mind's capacity for metaphysics as being impaired by the fact of its origins in the primeval slime of the early earth, so that an evolution-produced mind trying to puzzle out metaphysical truth was like "puzzling at astronomy without mechanics" or like trying to "illuminate the midnight sky with a candle": just as likely are we to expect that we might "throw the light of reason on metaphysics" (Darwin, 1974, p. 71).

I mention these remarks not to subscribe to Darwin's views (to claim that the evolutionary origin of the human mind renders it incapable of attaining metaphysical with requires argument, not mere assertion), but to point out that his variations of opinion in matters of religion were directly related to his fluctuating stance toward metaphysics, not evolution. Moreover, despite such diffidence, he never did succeed very well in expunging metaphysical interests from his mind, any more than skepticism in the history of philosophy has ever managed to expel metaphysical reflection from the human mind, no matter how often it tries. "Lamarck, Plato, flume, and God jostled for attention," says Janet Browne of Darwin's reading after he got back to England after his five-year voyage on the Beagle. "He had no end of theories about humanity occupying his brain: theories about the origin of language, about morality, religion, and race" (Browne, 1995, pp. 364-439).

In a way, it is too bad that in his desultory reading of metaphysics he never sufficiently attended to the idealist tradition, which could have illumined how the environment testifies to the meaning of the emergence of humans as a species. If he had thought through some of the metaphysical implications of his theory, he might not have been so diffident about the human mind's ability to reach metaphysical conclusions. For evolution does not just say something about life, about humans, about struggle, and about the lowly origins of mind from mud. It also says something about the environment, including the metaphysical environment!

To the best of my knowledge, Lawrence Henderson (1878-1942), the American biochemist at Harvard, was the first to shift the terms of the debate among evolutionary biologists from specific biological forms to the testimony natural selection gives regarding the nature of the environment doing the selecting (Henderson, 1913). In what follows, I wish to stress that I am presenting here my own version of Henderson's shift of perspective. Clearly he was right that, in Darwinian terms (not to mention Aristotelian terms), life cannot emerge unless the environment is first fit for life.20 But I shall take his argument one step further and claim that we also live in a metaphysical environment without which rational life would not be possible.

My way of putting this argument is as follows. Because Darwinism gave a new explanation for how and why each organism is so well adapted to its environment, the record of convergence (similar organs, such as eyes and wings, developing independently across many phyla and species) surely must say something as well about the environment. In other words, the fact that so many biological forms developed photosensitive cells and then eyes (or their equivalents) also testifies to the ubiquity of light, just as the fact that wings developed independently on insects, birds, bats, some dinosaurs, and so forth, testifies to the density and viscosity of the atmosphere of the earth. So too with complex brains: to be adaptive, brains have to evolve in response to the environment. Or as I have argued elsewhere (Oakes, 2004, pp. 28-30), if wings evolve against and in response to air, and eyes against and in response to light, then brains must evolve against and in response to something like "mental air." By that admittedly metaphorical term, I mean those a priori ideal structures already part of the universe that make a mathematics-capable brain possible in the first place. In other words, Darwinism not only is compatible with Platonism, but presupposes it.

This perhaps startling point of view is admirably explained and defended by Daniel Dennett in his lucid philosophical meditation on Darwinian theory, Darwin's Dangerous Idea, where he neatly explains the necessity for Platonic thinking by using this intriguing thought experiment:

> Suppose SETI [the Search for Extra-Terrestrial Intelligence] struck it rich, and established communication with intelligent beings on another planet. We would not be surprised to find that they understood and used the same arithmetic that we do. Why not? Because arithmetic is right ... The point is clearly not restricted to arithmetic, but to all "necessary truths"— what philosophers since Plato have called a priori knowledge It has often been pointed out that Plato's curious theory of reincamation and reminiscence, which he offers as an explanation of the source of our a priori knowledge, bears a striking resemblance to Darwin's theory. and this resemblance is particularly striking from our current vantage point. Darwin himself famously noted the resemblance in a remark in one of his notebooks. Commenting on the claim that Plato thought our "necessary ideas" arise from the pre-existence of the soul. Darwin wrote: "read monkeys for pre-existence." (Dentin!, 1995, pp. 129-30)

But this particular thought experiment does not pertain directly to evolutionary theory, even if it does neatly dispatch certain postmodem theories that claim that rules of arithmetic and the law of gravity vary according to the culture that acknowledges them. Another thought experiment,

however, illuminates more directly the role certain ideal a priori structures play in the evolution of humans:

> a thousand meters or so of the surface of the Earth ... Suppose we carefully preserved the body of a seagull and set it off into space (without any accompanying explanation), to be discovered by Martians. If they made the fundamental assumption that the wings were functional, and that their function was flight (which might not he as obvious to them as we, who have seen them do it, think), they could use this assumption to "read off' the implicit information about an environment for which these wings would be well designed. Suppose they then asked themselves how all this aerodynamic theory came to be implicit in the structure, or, in other words: How did all this information get into these wings? The answer must be: By an interaction between the environment and the seagull's ancestors. (Dennett, 1995, pp. 197-8)

All well and good, but what happens when we continue this logic and do some reverse engineering on the human brain? If wings testify to the density and viscosity of the earth's atmosphere, and if the eye (or its equivalent) testifies to the ubiquity of light, to what then does the brain testify? We have already seen that the SETI project presupposes the presence across intergalactic planetary systems of the a priori structures of intelligence, mathematics above all: we will be able to recognize the presence of intelligence on other planets only by seeing that other life forms recognize the same ideal truths that we do. And that is the clue we need: just as we will be able to spot intelligent life on other planets only by the common communication of intelligible truths across vast distances, so too we now realize, with Dennett's reverse-engineering thought experiment, that such mutual recognition of a priori intelligible truth will have been made possible only because the information of mathematics, logic, and so forth, has "selected for" intelligence in two different locations in the universe. In other words, brains evolve over, against, and in response to "mental air," just as eyes evolve over, against, and in response to light, and wings over, against, and in response to atmosphere, physical air. Or to put the matter perhaps less metaphorically, no intelligence without intelligibility, or more exactly, no evolved intelligence without a prior environmental intelligibility.21

I admit that the logic of this argument leads to the dread specter of Idealism (which posits that ideal realities such as number, logic, and forms precede and determine material realities); and Idealism in particular tends to spook out scientists even more than metaphysics does in general.22 In fact, I rather suspect that the reason scientists find metaphysics so disquieting is precisely because it keeps leading to idealist conclusions. But if I am right that science finds itself regularly bumping into metaphysics, and if evolution means that the information of the environment is always being "read into" the organism so that one can "read back" what the environment must have been like, based solely on the information in the organism, then I see no alternative but to hold that reality is first ideal before it is material.

As is well known by now, some cosmologists go further and insist, by using an argument known as the Strong Cosmological Anthropic Argument, that material reality such as atoms (or, more specifically, subatomic particles and therefore a fortiori atoms) cannot exist unless there are knowers to know them. (This paper, which concentrates on biological complexity, has not dealt with that issue and will not so do in its conclusion.23) However, it does seem appropriate to conclude these reflections with a final consideration of what the universe would be like without knowers. At first glance, it would seem that evolutionary theory presupposes the possibility — indeed actuality — of a world without knowers, since the evolution of consciousness came last of all. A more logical objection would ask whether it is even meaningful to speak of a knower-less universe, since the question of such a possibility can arise only in minds already "thrown into" the universe. Yet, leaving this logical conundrum aside, the enigma of consciousness is still a

fundamental datum of the world, and the human mind cannot help hut ask what that means, what it says about the nature of the universe.24

"There is the best of precedents for concluding a long and abstract discussion of difficult philosophical matters with a myth," says Arthur Lovejoy at the conclusion of his Revolt against Dualism, his history of the philosophical attempts to rid the world of Cartesian dualism by naturalizing the mind in the manner that Darwin attempted at the end of his life. After demonstrating in great detail and with marvelous verve that all attempts to regard the mind as entirely a component of natural processes have failed, he ends his book by trying to imagine how Plato might have 'yeast his myth of creation in the Timaeus if he had been writing today, that is, "if he had been enough of an evolutionist to conceive of the production of living creatures as proceeding from lower to higher, and if he had been more definitely mindful of the problem of the character and genesis of natural knowledge" (Lovejoy, 1955, p. 399). In other words, what would the Demiurge have fashioned if he had been a Darwinist working via the process of natural selection?

In this delightful revision of Platonic myth, Lovejoy shows that the Demiurge, if he wanted to let consciousness emerge out of Darwinian processes, would still have to have created space and time. for they remain essential constituents of evolutionary theory no less than of Platonism. He then imagines what the Demiurge would have said after he had fashioned time as the mobile image of eternity and space as the home for all things in the world: with space and time alone, there would still be something missing in the universe. "The creatures," so Lovejoy's Demiurge would say, "confined within the narrow bounds of their separate being, are wholly strangers to one another_ • and the things they suffer and the deeds they do endure hut for an instant and are then lost in the non-being of the Past." A sad outcome for so noble an effort, no? But because time decrees the evanescence of all things temporal, Which not even the Demiurge can countermand, and because space decrees that all extended things be external to each other, nothing can be present in its own time and place and yet located elsewhere at the same time. What is allotted to one can never belong to another. At which point the Demiurge hits upon a solution:

> Let me, then, consider how I may remove this imperfection, as far as the nature of things allows ... What is needful is that the nature which belongs to one region of being shall be not only reproduced in another, not merely, when so reproduced, be beheld by a creature having its existence in that other region, but that it shall be reproduced and beheld as if present in the region in which it first existed, as belonging to a thing which had or has its being there; only so can any creature see another as being another, and the mutual blindness of the parts be in a certain measure overcome ... So considering, the Demiurgus proceeded to add the gift of knowledge to the many other less excellent gifts which he had already distributed amongst the various grades of living things; and he created the animal man to receive and have the custody of this gift. (Lovejoy, 1955, pp. 400-1 [emphasis added])

But what is our gift is also our dilemma, as Blaise Pascal knew so well and explained so unsparingly: "Thinking reed. It is not in space and time that 1- must look for my dignity, but in the organization of my thoughts. I shall have no advantage in owning estates. Through space the universe grasps and engulfs me like a pinpoint; but through thought I can grasp it" (Pascal, 1995, no. 145, p. 36). So E. M. Cioran is right, and one of the epigraphs to this chapter also brings us round to the same conclusion as his aphorism: "A conscious fruit fly would have to confront exactly the same difficulties, the same kind of insoluble problems, as man . .. To defy heredity is to defy billions of years, to defy the first cell" (Cioran, 1973, pp. 5,31). And maybe that fruit fly would come to see what Friedrich Nietzsche meant when he said in The Gay Science: "Even we knowers today, we godless anti-metaphysicians, still take our fire, too, from the flame lit by a faith thousands of years

old - that Christian faith which was also the faith of Plato, that God is the truth, and truth is divine" (Nietzsche, 1974, no. 344).

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Chapter 10 - How biofriendly is the universe?
Christian de Duve

Introduction
We live in a biofriendly world. Were it otherwise, we wouldn't be around. The question is, therefore, how biofriendly is it? Physicists have addressed this question and have come to the conclusion that if any of the fundamental physical constants were a little smaller or a little larger than they are, the universe would be very different from what it is and unable to produce or harbor living organisms. Not everyone, however, subscribes to the concept of "fine-tuning" embodied in the so-called Anthropic Principle, some preferring instead the notion of a "multiverse," in which our universe is only one in trillions of trillions, perhaps the only one that. by mere chance, happened to have the right combination of constants to enable it to serve as our birthplace and abode.

In contrast, biologists and other scientists interested in biology generally take the universe for granted and ask instead to what extent the manifestations of life. including humankind, fit within the existing physical and cosmic framework. Nothing could better illustrate the depth of their ignorance on this subject than the diversity of answers they have given, which cover virtually the whole array of possibilities. Many agree with the late Jacques Monod, who, in his best-seller Chance and Necessity (1971), expressed his skepticism in the oft-quoted sentence: "The Universe was not pregnant with life, nor the biosphere with man." In my Oral Dust (1995), I defended the diametrically opposed view, also shared by many scientists, that life and mind are "cosmic imperatives," likely to exist in many areas of the universe. The recent interest in astrohiology and the SETI (Search for Extra-Terrestrial Intelligence) project rest on this assumption. Some scientists make a distinction between life and mind, but once again in two diametrically opposed versions. in Rare Earth (2000), the geologist Peter Ward and the astronomer Donald Brownlee

have claimed that life is likely to develop very frequently. but that the probability of its giving rise to mind through evolution is exceedingly small, so that we may well be the only conscious, intelligent beings in the universe, even though simpler living organisms may abound. In contrast, the paleontologist Simon Conway Morris. one of the editors of this book, argues in Life's Solution (2003) that life may he very rare, perhaps unique, but that, once arisen, it was bound to give rise to human beings. Humans, he states, are "inevitable in a lonely universe." Both views make us exceptional, but for totally different reasons.

In this chapter, I propose to look at the problem through the eyes of a biochemist. I will first consider the main features that define life as we know it and then ask how such features could have arisen and what environmental conditions would have been necessary for them to appear. Finally, in trying to put these notions within a cosmic perspective, I hope to derive some assessment of the probability of life's origin, a sort of quantitative estimate of the universe's "biofriendliness."

The hallmarks of life
What is Life? This question, the title of a famous book by Erwin Schrodinger (1944), has been answered in many different ways, most often stressing the ability of living organisms to maintain improbable structures with the help of outside energy. reproduce themselves, and undergo evolution. My own answer to the question is simple — many would call it simplistic, even tautological: Life is all that is common to all known living organisms.. This definition, based on concrete facts that are beginning to be well understood, allows a number of key properties to be

singled out as characteristic of life. I will briefly review these properties in the following pages. For additional information, the reader can refer to my previously published books (1984, 1991, 1995, 2002, 2005) and to standard biochemistry textbooks.

Water and minerals
All living organisms contain abundant water and a number of mineral constituents, mostly Na, K, CI, Ca, and Mg, together with various trace elements, such as Fe. Cu, Mn, Zn, Ni, Co, Mo, Si, F, I, and Se, which, although present in very small amounts, often play functional roles of central importance.

Organic building blocks
The bulk of all living matter is constructed with little more than fifty different organic building blocks, mostly sugars, amino acids, nitrogenous bases, fatty acids, and a few more specialized substances, made with only six elements, represented, not very euphonically, by the acronym CHNOPS (carbon, hydrogen, nitrogen, oxygen, phosphorus, sulfur). These building blocks are joined together in different ways to form a number of metabolic intermediates, coenzymes, and other relatively small molecules that are found in many different organisms, sometimes in all. What accounts for the main differences between the great variety of life forms — whether microbes, plants, fungi, animals, or humans — is the ways in which the building blocks are assembled into macromolecules, such as polysaccharides, lipids, and, especially, nucleic acids and proteins.

Catalysis
Of the thousands of chemical reactions that make up metabolism, virtually none would occur without an appropriate catalyst, or enzyme. Even a reaction such as the combination of carbon dioxide with water to form carbonic acid, which has the rare distinction of taking place spontaneously at a significant rate, is catalyzed by an enzyme (carbonic anhydrase), which accelerates the reaction more than a million-fold.

Protein enzymes
Most enzymes are proteins, which owe their unique functional versatility to the number and diversity of their building blocks. The distinctive side chains that characterize the various proteinogenic amino acids include aliphatic and aromatic molecules, which either are unsubstituted and hydrophobic or bear one of a number of different hydrophilic groups exhibiting a great diversity of physical properties, thus allowing a wide variety of possible interactions. In proteins, the amino acids are linked into long polypeptide chains that usually contain several hundred amino acids.

With the exception of structural proteins, which often remain linear, the polypeptide chains of proteins usually fold into complex, three-dimensional conformations. In enzymes, these conformations bring together certain functional groups of amino acids that are distantly located in the chain, so as to delimit specific binding sites and catalytic centers, disposed in such a manner that reaction substrates are fished out from the surrounding medium, immobilized in a particular configuration, and caused to interact. In addition, many enzymes also bear separate sites, called allosteric, which bind regulatory substances that modify the enzyme's functional properties.

More than ninety percent of the chemical reactions catalyzed by enzymes are either group transfers (including hydrolyses, in which water serves as acceptor of the transferred group) or electron transfers. These two types of reaction, as will be seen, both play major roles in energy transactions. Other enzymatic reactions are mostly isomerizations or reversible molecular splittings.

Cofactors

Protein enzymes frequently operate with the help of metal ions and with that of organic cofactors, which either are covalently bound to the enzyme molecule (prosthetic groups) or act in free, soluble form (coenzymes). As is to be expected, these cofactors serve mostly as carriers in transfer reactions. Several are nucleotide derivatives or have a nucleotide-like structure, thus being related to nucleic acid components. Many contain a vitamin in their molecule.

Ribozynies
A few biological catalysts are RNA molecules. Known as ribozytnes, these catalytic RNAs are involved in RNA splicing and other forms of RNA processing. A special ribozyme of central importance is the ribosomal peptidyl transferase, the catalyst in ribosomes responsible for peptidyl transfer in protein synthesis.

Energy

The central role of ATP
Throughout the living world, energy is derived from the environment and used to support life by mechanisms that almost invariably end up depending, directly or indirectly, on the hydrolysis of the terminal pyrophosphate bond of ATP, giving ADP and inorganic phosphate (Pt):

ATP + 1-1,0 ADP +13; (10.1)

This reaction, in which ATP is sometimes replaced by another NTP, which in turn is subsequently regenerated at the expense of ATP, is exergonic. It releases free energy (that is, energy convertible into work, henceforth to be referred to simply as energy) in an amount that, under physiological conditions, is on the order of 14 kcal. or 59 kJ, per gram molecule of ATP split. This value defines the size of the energy packages used in biological energy transactions, what may be seen as the standard bioenergetic currency unit. If ATP hydrolysis takes place freely, the energy released by the reaction is dissipated as heat. Living systems contain a number of transducers that convert this energy into some form of work, including the mechanical work performed in animal motility; the osmotic work of forcing substances into cells, or out of them, against a concentration gradient; the electric work dependent on the active transport of ions and the resulting membrane potentials; the emission of light in bioluminescence; and, especially, the many forms of chemical work involved in the synthesis of natural compounds.

Biosynthetic processes are as varied as their products, but share some key features. One property they have in common is that they rely, in most cases, on the linking together of small molecules with removal of water (dehydrating condensations). Thus, sugars join into polysaccharides; amino acids into proteins; fatty acids and alcohols into lipid esters; bases, pentoses, and phosphate into nucleic acids; and so on. In an aqueous medium, such reactions are always strongly endergonic. They are almost invariably supported by ATP, or by some other ATP-related NTP, by way of sequential group transfer mechanisms. In these mechanisms, one of the reactants accepts a piece of the ATP molecule—inorganic phosphate, AMP, or inorganic pyrophosphate—forming a complex from which the reactant thus activated is transferred to the other reactant. I have detailed these mechanisms elsewhere (1984, 1991, 2000, 2005).

Besides fueling biosynthetic processes, ATP hydrolysis also serves to spark many metabolic reactions. Thus, phosphorylation of substrates — sugars, for example — often initiates their metabolic transformation. In addition, a number of receptor-mediated, regulatory mechanisms depend on the splitting of ATP (or GTP).

Living cells can function only a few seconds on their content of ATP and other NTPs, which need to be continually regenerated at the expense of their split products for life to be maintained.

Exceptionally, this regeneration may take place at the expense of stored, high-energy phosphate compounds, including the phosphagens of animal cells and, especially, a phosphate polymer, or polyphosphate, found in some bacterial cells. These reservoirs, however, can serve only as a buffer and need to be replenished with the help of ATP. Therefore, all the energy expenditures of a cell are ultimately dependent on the regeneration of ATP by energy-yielding metabolic processes. These processes consist almost exclusively of electron transfers.

Electron transfers

In these transactions, electrons—often combined with protons into hydrogen atoms—are transferred from a donor to an acceptor down a difference in energy level, which is measured by the difference between the redox potentials of the two reactants. A very large number of such reactions participate in metabolism. To be able to serve for ATP regeneration, electron transfers must satisfy two conditions: (0 they must release enough energy to power the reversal of Reaction 10.1; and (2) they must be coupled to the reversal of this reaction — that is, constrained in such a way that they can take place only if ADP and inorganic phosphate condense to ATP at the same time.

The energy condition requires the donor and acceptor to be separated by a difference in redox potential of at least (600/n) mV, n being the number of electrons transferred. This value represents the minimum needed to provide 14 kcal, or 59 kJ, per gram molecule, which we have seen is the energy released by Reaction 10.1 and, therefore, the minimum amount of energy required for its reversal. There are essentially two ways in which this difference is created, depending on whether or not light energy is involved. When it is, an electron in the chlorophyll molecule is displaced to a higher energy level with the help of light and allowed to fall back to a lower energy level through a phosphorylating system, to be either similarly recycled (cyclic photophosphorylation) or used for biosynthetic reductions (see below). In all other cases, electrons are provided from the outside at an appropriately high energy level, most often by organic foodstuffs, as in all heterotrophic organisms, hut sometimes also by mineral donors, as in chemotrophic prokaryotes. After powering ATP assembly, the electrons are taken up at a lower level of energy by an outside acceptor. Most often (oxidative phosphorylation), this acceptor is molecular oxygen, which combines with four electrons and four protons to give two molecules of water. In certain prokaryotes, the acceptor is a mineral oxidized substance, for example nitrate or sulfate. Exceptionally, no outside electron acceptor is required: the final acceptor arises metabolically. Such is the case in alcoholic orlactic fermentation. In addition, all organisms can, when deprived of their external energy supply (either light or electron donors), use their stored reserves, of fat or carbohydrate. for example, or even their own substance as a source of high-energy electrons.

Coupling mechanisms

Throughout the living world. the coupling between electron transfer and ATP assembly is mediated predominantly by electrochemical mechanisms dependent on protonmotive force. In these mechanisms, known as carrier-level phosphorylations. electrons travel along complex chains of membrane-embedded carriers organized in such a way that the electrons can move only if protons are translocated at the same time from one side of the membrane to the other, from which they can return only by way of a proton-dependent, ATP-assembling system. In some cases, this machinery may function in reverse, lifting electrons from a lower to a higher energy level with the help of ATP generated at some other site.

A second coupling mechanism, of minor quantitative but immense qualitative importance, involves soluble enzyme systems and intermediates. It concerns the oxidation of a few selected aldehydes and ce-keto-acids, with NMl' serving as electron acceptor. The substrates are oxidized jointly with a thiol (R-SH) in such a manner that a thioester of the acid is formed:

This type of reaction is almost unique in that it couples the donation of electrons to the closure of a chemical bond, the thioester bond. This bond, which is energetically equivalent to the pyrophosphate bonds of ATP, can be used to power ATP assembly by sequential group transfer:

Adding up the two reactions, one finds that the aldehyde is oxidized to the corresponding acid, or that the a-keto-acid is oxidatively decarboxylated to the corresponding acid and CO,, while ATP is assembled, with the thiol playing a catalytic role. This thiol may be a cysteine residue in the enzyme protein; or an enzyme-linked phosphopantetheine molecule; or coenzyme A, a soluble coenzyme in which phosphopantetheine is linked to .3'-phospho-AMP; or lipoic acid, also known as thioctic acid, a molecule that can serve at the same time as electron carrier and as group carrier, a unique distinction.

Reactions of this kind are called substrate-level phosphorylations, as opposed to the protonmotive force-dependent carrier-level phosphorylations mentioned earlier. Substrate-level phosphorylations are involved in only a few processes; but these belong to the most central metabolic systems, the glycolytic chain and the Krebs cycle, making substrate-level phosphorylations both universal and indispensable. In addition, the reactions are readily reversible (especially with aldehydes as substrates). They can serve in the reduction of a carboxyl group (—COOH) to a carbonyl group (----CO) with the help of energy provided by the splitting of ATP. As we will see, this process is of key importance in biosynthetic reductions.

It should he further noted that thioesters, with coenzyme A as carrier, play a key role as donors of aryl groups in the synthesis of lipids and other esters from free acids and alcohols. In such cases, the acid is activated to the corresponding thioester by Reaction 10.3, running from right to left or, more frequently, by the analogous reaction in which ATP is split to AMP and inorganic pyrophosphate.

Biosynthetic reductions

All living organisms carry out some reductive reactions. The conversion of sugars to fatty acids and the formation of deoxyribose from ribose are important examples ' of such reactions. In heterotrophic organisms, these processes are supplied with electrons by foodstuffs and, if needed, with energy by ATP. The importance of biosynthetic reductions is much greater in autotrophic organisms because these organisms manufacture their substance with very simple, oxidized building blocks. mostly H2O, CO2, NO3, and SO42—. They thus need a considerable additional supply of electrons, as well as of energy, as environmental electrons are usually provided at a low energy level.

Chemotrophic autotrophs derive the required electrons from mineral donors, for example hydrogen sulfide (FL S). They lift these electrons to the high energy level needed for the reductions with the help of ATP (or protonmotive force) generated by the downhill transfer of electrons from the same donors to an outside acceptor (most often oxygen). Primitive phototrophic bacteria likewise obtain electrons from mineral donors, but depend largely on light energy for lifting the electrons to a higher energy level. This process is catalyzed by a chlorophyll-dependent system known as photosystem 1. The more advanced phototrophs, which include cyanobacteria, eukaryotic algae, and plants, have a second chlorophyll-dependent system, photosystem II, which withdraws electrons from water, releasing molecular oxygen, and lifts them to an intermediate energy level, with the help of light energy. From this level, the electrons are transferred to photosystem I for further energization and utilization for biosynthetic reductions. In their passage from photosystem 11 to photosystem I, the electrons suffer a partial energy fall coupled with ATP assembly (non-cyclic photophosphorylation).

Interestingly, in the majority of autotrophic organisms, whether chemotrophic or phototrophic, the top energy boost whereby electrons are lifted to the level from which they can serve to reduce carboxyl to carbonyl groups — mostly 3-phosphoglycerate to 3-phosphoglyceraldehyde, as in reverse glycolysis — is accomplished by a thioester-mediated mechanism (reversal of Reactions 10.3 and 10.2), confirming the central importance of this mechanism.

Information
Biological information circulates universally by means of three processes: replication of DNA, transcription of DNA into RNA, and translation of RNA into protein. In addition, viruses with an RNA genome possess an enzyme that catalyzes one of two processes that are not carried out by cells: replication of RNA and reverse transcription of RNA into DNA. These five processes are shown schematically in Figure 10.1.

These processes have two aspects, one involving energy, the other information. I will treat these two aspects separately.

Biosynthetic mechanisms
In essence, biological information-transfer processes all rely on syntheses and, as such, operate by the same kind of ATP-fueled mechanisms that carry out biosyntheses in general. The synthesis of nucleic acids, which underlies all forms of replication and transcription, is special in that a single transfer reaction completes the process. Mononucleotide groups (either dNMPs or NMPs) are transferred to the 3' end of the growing polynucleotide chain from the corresponding dNTPs or NTPs, with release of inorganic pyrophosphate, which is hydrolyzed, thereby ensuring the irreversibility of the process.

Protein assembly involves reactants carried by transfer RNAs (tRNAs). The bond linking amino acids to tRNAs is created by a sequential group-transfer process in which ATP is split into AMP and inorganic pyrophosphate, which is further hydrolyzed, driving the reaction, as above. The two transfer steps of this process are catalyzed by a single enzyme, called aminoacyl-tRNA synthetase. The peptide bond itself is formed at the expense of the ATP-derived aminoacyl-tRNA bond by transfer of the growing peptide chain from its tRNA carrier to the amino group of a tRNA-borne amino acid, yielding a peptide chain lengthened by one amino-acid unit and attached to the tRNA bearing the new amino acid. This reaction takes place on the surface of ribosomes, which are small particles consisting of about fifty percent protein and fifty percent RNA (rRNAs). Interestingly, the peptidyl transferase that catalyzes the reaction is not a protein, but an rRNA. This is one of the rare known instances of involvement of a catalytic RNA, the only one in which the substrate is not an RNA molecule.

Templates
The biosynthetic mechanisms mentioned differ from all others in being guided by a template molecule that dictates which building block is to be added at each step. This template molecule is invariably a nucleic acid, and the mechanism by which it exerts its control relies universally on base pairing, the phenomenon whereby adenine joins specifically with thymine or with uracil, and guanine joins likewise with cytosine. These relationships are summarized by the following cardinal relationships:

A G=> T or U C. C WA)

In the synthesis of nucleic acids, the template is a nucleic acid — of the same kind in replication, of opposite kind in transcription (see Figure 10.1, above) — which imposes, by base pairing, the nature of the mononucleotide to be added at each step. In protein assembly, the template is a messenger RNA molecule (mRNA), derived by transcription (eventually followed by splicing) from the DNA gene

in which the sequence of the protein is encoded. The mRNA dictates, by successive base triplets, or codons, the choice of the amino acid to be added at each step. This phenomenon is mediated by base pairing between the mRNA codons and corn_ plementary base triplets, or anticodons, present in the amino-acid-bearing tRNAs. Translation itself is carried out earlier by the aminoacyl-tRNA synthetases, which ensure, by their specificities, that amino acids and tRNAs are correctly matched. Exactly twenty varieties of such enzymes exist, one for each proteinogenic amino acid.

Base pairing also has an important structural function. It is responsible for the joining of two complementary DNA chains (or, exceptionally, RNA, in certain viruses) into the celebrated double helix. It also causes single polynucleotide chains (mostly RNA) to bundle up into complex. three-dimensional arrangements. This property accounts for the many functions accomplished by RNA molecules, as opposed to DNA, which is essentially inert chemically and has as its sole functions to serve as a repository of genetic information and as a template for the transfer of this information in replication and transcription.

The genetic code

The genetic code is the set of correspondences between amino acids and codons. In it, 61 of the 64 codons represent amino acids, with up to six codons standing for the same amino acid; the remaining three codons serve as stop signals. With very rare exceptions (in some mitochondria, for example, and in a few microorganisms). which arose late in evolution, the genetic code is the same for all living organisms. Workers have long puzzled about the relationships that underlie the code. which have been attributed to anything between a "frozen accident" and a set of strict, chemical complementarities between amino acids and codons or anticodons. The latest answer is that the genetic code is most likely the product of selective optimization. The structure of the code is such that it minimizes the adverse consequences of mutations leading to the replacement of one base by another in a codon. As has long been pointed out, such changes often either do not alter the nature of the coded amino acid or replace it with an amino acid of similar physical properties so that the mutant protein remains functional. Modeling experiments have shown the code to he close to optimal in this respect (Freeland et at,, 2003).

Homochirality

The amino acids used for protein synthesis are all, with the exception of glycine, which is not optically active, chiral molecules of L configuration. Similarly, DNA and RNA are made exclusively with the D isomers of their constitutive pentoses. deoxyribose and ribose, which happen to be levorotatory, like the 1.-amino acids. This peculiarity has been the object of much discussion and speculation. It is viewed by many as one of the most mysterious hallmarks of life.

It should be noted first that the fact that only enantiomers of the same optical rotation sign are found in proteins and nucleic acids—the "homo" part of homochirality — may be viewed as a necessity, most probably a consequence of natural selection. Protein molecules containing both D- and L-amino acids, nucleic acid constructed with the two enantiomers of the pentoses, would lack some of their key biological properties. Life as we know it could not exist with heterochiral proteins or nucleic acids. The alleged mystery thus concerns the chirality part, the actual nature of the enantiomers used: k- rather than D-amino acids, and 1)- rather than k-pentoses.

Much has been written on this topic. Relevant to the subject of this chapter is the fact that there seems to be no compelling cosmic reason — there may be a local one — why life should use one or the other enantiomer. The possibility of life forms similar to those we know, hut functioning with proteins made of 0-amino acids and with nucleic acids constructed with t. pentoses, is not ruled out in the present state of our knowledge. Whether 0-amino acids could be used with D-pentoses, Or the opposite, seems less likely if, as may well have been the case, steric interactions between the two kinds of molecule played an important role in the origin of life.

Membranes
Membranes are indispensable biological constituents. No living cell can exist without at least a peripheral membrane. In addition, many cells contain internal, membrane-bounded structures. Biological membranes consist universally of a lipid fabric within which a number of proteins are embedded.

The fabric of membranes
The basic fabric of all membranes is the lipid bilayer, a bimolecular layer consisting of amphiphilic molecules typically made of a three-carbon core or skeleton to which are attached, on one side, two long, hydrophobic chains made exclusively of carbon and hydrogen and on the other, a hydrophilic head containing a variety of chemical substances that share the property of being electrically charged or polarized:

The three-carbon core of such molecules most often consists of glycerol, with the hydrophobic tails being made of long-chain fatty acids linked to glycerol by ester bonds — except in archaebacteria, where they arc formed by isoprenoid alcohols linked to glycerol (in the chiral configuration opposite to that shown in Scheme 10.5 by ether bonds. Sphingolipids differ from this general scheme in that the long-chain aminoalcohol sphingosine provides both the core and the top hydrophobic chain, the second hydrophobic chain belonging to a long-chain fatty acid attached to sphingosine by an amide bond.

In phospholipids, which are the most important membrane lipids, the hydrophilic head consists of a negatively charged phosphate ester group, often esterified by some positively charged nitrogenous, hydroxylated substance, such as choline, ethanolamine, or serine (which also carries an extra negative group). In glycolipids, a variety of carbohydrate compounds, occasionally associated with a negatively charged acidic group (sialate or sulfate), make up the hydrophilic head.

When mixed with water under certain conditions, molecules with the above configuration spontaneously organize into closed lipid bilayers. In this structure. two monomolecular layers join by their hydrophobic faces, creating an inner, oily film, lined on both sides by the hydrophilic heads in contact with water inside and outside the vesicle:

Biological membranes owe a number of distinctive properties to the physical characteristics of the lipid bilayers with which they are constructed. One such property is flexibility. Because their constituent molecules can readily slide along one another in semi-fluid fashion, the films can adopt a wide variety of shapes, thus allowing membranes to fold and mold themselves around almost any object.

Another important property is self-sealing. Lipid bilayers and the membranes arising from them invariably exist in the form of closed sacs, or vesicles, with a strong, inherent tendency to adopt this shape. This ability accounts for the spontaneous repair of pierced or injured membranes and for the various reorganization phenomena involved in the fission and fusion of vesicles that underlie many fundamental cellular processes, such as endocytosis, exocytosis, and vesicular transport.

In most membranes, the basic lipid bilayer fabric is enriched in various ways. The inner, fatty film of the bilayer often provides shelter for a number of hydrophobic molecules, for example cholesterol, which is an obligatory constituent of the outer membrane of all eukaryotic cells. Most importantly, all biological membranes contain a variety of specialized proteins of crucial importance.

Membrane proteins

Proteins are able to associate with lipid bilayers because several of the amino acids used for protein synthesis have hydrophobic groups. When a large enough number of such amino acids are present close together in a given stretch of the protein chain, they form a short, rod-shaped segment sufficiently hydrophobic to be accommodated by the bilayer. If such a segment ends the chain, it serves as anchor, with the bulk of the molecule hanging from one or the other face of the bilayer. If a hydrophobic segment is situated inside a protein chain, it can form a transmembrane bridge, with the two parts of the molecule separated by the segment protruding on opposite faces of the bilayer. Finally, if, as is often the case, other such segments follow one another along the protein chain, the molecule will snake in and out across the bilayer, with both ends coming out on the same face or on opposite faces of the bilayer, depending on whether the number of hydrophobic segments is even or odd.

Membrane proteins have multiple functions. They comprise enzymes acting on locally concentrated substrates; transport systems of various kinds, including the ionic pumps responsible for bioelectric manifestations; translocators serving in the specific delivery of proteins and other macromolecules across membranes; electron-transfer chains and other components of protonmotive machineries; photosystems and their ancillary cofactors; and a variety of receptors involved in transmembrane signaling.

Cells

Life cannot exist without cells. The minimal cell contains, within a surrounding membrane, a DNA genome, a complete machinery for replicating this genome and expressing it by way of RNA and protein molecules, and a set of enzymes and cofactors capable of building the cell's constituents from surrounding materials and of deriving energy from the outside in a form suitable for the support of all these activities.

Present in the simplest prokaryotes, these attributes are complemented by a variety of additional properties in higher prokaryotes and, especially, in eukaryotic cells, which are distinguished by a fenced-off nucleus and by complex cytomembrane structures. cytoskeletal and motor elements, and endosymbiont-derived organdies.

A key feature of cells is the ability to multiply by division. Initiated by DNA replication — and held in check as long as this process has not taken place — cell division involves a number of steps, different in prokaryotic and eukaryotic cells, hut leading in both to the splitting of the surrounding membrane into two distinct, closed membranes, each enveloping a full copy of the genome and enough of all other cell components to endow each daughter cell with autonomy. Relatively unchecked in prokaryotes, which tend to multiply exponentially as long as enough usable matter and energy are available, cell division is subject to complex regulations in eukaryotic cells, especially those of multicellular organisms, in keeping with the individual requirements and mutual relationships of tissues and organs. Cancer, as is known, is a major harmful consequence of a defect in this control.

The requisites of life

Having reviewed the key features of life on earth, we are now ready to examine the universe's fitness for life. In addressing this question, I will limit myself to life as we know it, ignoring the frequently evoked possibility of other life forms, differing from extant ones by the nature of their organic constituents and/or by the mechanisms whereby they build their own substance, exploit environmental energy sources, or handle information—and perhaps even constructed from elements other than CHNOPS. Such open-minded conjectures, which satisfy the commendable principle of "leaving no stone unturned," have stimulated many valuable, theoretical reflections on the nature of life and the kind of chemistry needed to support it. In practice, however, these conjectures have

drawn attention mostly to the unique fitness of present-day biochemistry as underpinning the main properties of life. I will not consider them further.

Regarding fitness, an important distinction must be made between fitness to harbor life and fitness to generate life. The former question is to some extent trivial. We know from experience that life, once it has taken hold, can adapt to almost any kind of milieu, from freezing polar waters to superheated volcanic jets; from swamps, lakes, and oceans to the deepest of rocks and the driest of deserts; from almost salt-free freshwaters to saturated brine; from pristine springs to the most polluted canals and other sites created by human technology; and across a wide pH range, from biting acids to caustic alkalis. Considering the diversity and, in some cases, simplicity of the environments in which certain forms of life manage to thrive, one is tempted to believe that the universe has countless spots where some kind of living organism would be able to survive.

Fitness to generate life, however, raises an entirely different question, which could be answered only if we knew how life actually originated. Although we don't know this. I will nevertheless attempt to address the question on the basis of what is known of the nature of life and what is suspected of its origin. My account will be brief, and I again refer the reader to my previous publications for additional information and bibliography (1991, 1995, 2002, 2005). In discussing these requisites of life, I will follow the same order as in the first part of this chapter.

Water and minerals

Liquid water is indispensable for life and must have been so for its origin as well. As far as is known, the universe contains plenty of water. The liquid state carries with it a more stringent condition in that its temperature range, although it varies with pressure, remains relatively narrow. Considering the number and diversity of planets, moons, and other celestial bodies that presumably exist in the universe, this condition can hardly be forbidding. It seems most likely that many sites capable of holding liquid water exist, in our galaxy and in others, and that at least a fraction of those actually do contain it. Even in our solar system, earth is probably not the only such site. Liquid water may lie under the permafrost believed to cover parts of Mars and under the ice plates detected on the surface of Jupiter's moon Europa.

As to the various minerals associated with life, they are likely to be present in sufficient amounts in many of the water-containing celestial bodies. It is significant, in this respect, that no element of atomic number higher than 34 is found in living organisms, even in trace amounts. Up to that limit, elements are all relatively abundant in many stars.

Organic building blocks

When, in 1953. Stanley Miller announced that he had observed the formation of amino acids and other biological molecules "under possible primitive Earth conditions," the scientific world (including the media) was thrilled by the possibility, evoked by Miller's historic experiments, that some of the building blocks of life could have arisen spontaneously on our planet. Surprisingly, nothing like the excitement generated by Miller's results or by those of his co-workers and followers greeted the much more astonishing discovery that the building blocks of life actually do arise spontaneously in many parts of the cosmos.

This is the startlingly significant message that extraterrestrial objects of various kinds— interstellar dust particles, neighboring planets and their moons, comets, and, especially, meteorites — have divulged to high-resolution spectroscopic explorations and to direct analyses using instruments borne by spacecraft or applied to materials that have fallen to earth. It is now known that a great variety of organic radicals and molecules exist in many extraterrestrial sites never visited by any living organism (for reviews, see Botta and Bada, 2002; Ehrenfreund et al., 2002)

Because of the extremely rarefied and cold conditions under which it operates, cosmic chemistry is nothing like the kind of chemistry we know. But it obeys the same laws and, like organic chemistry on earth, exploits the unique associative properties of the carbon atom. Dominant among its products are small molecules and radicals consisting of only a few atoms, short aliphatic hydrocarbons believed, for example, to form the seas observed on the surface of the Saturn moon Titan, the ubiquitous polyaromatic hydrocarbons (PAHs), and fullerene-like polycarbon associations. In addition, cosmic chemistry seems indiscriminately to make, in amounts that decrease with molecular size, most of the combinations that can arise from the radicals. These combinations include amino acids, nitrogenous bases, sugars, and other moderately sized molecules that are found in living organisms, but with no obvious bias in favor of those that serve as biological building blocks over those that do not. Chirality could be an exception, revealed by slight excesses of L- over D-amino acids in some meteoritic material. This matter is, however, still the object of much debate. The bias, to the extent that it exists, is most likely secondary and due to asymmetric destruction rather than to synthesis.

Much is still expected from this fruitful research field. Particularly encouraging is the possibility of reproducing in the laboratory some of the events that take place in outer space. Two distinct groups, one American (Bernstein et al., 2002) and the other European (Munoz Caro et al., 2002), have investigated the effects of ultraviolet irradiation, under about the lowest temperature and highest vacuum conditions attainable, on simulated interstellar ice analogs containing water, methanol, and ammonia as the main components with the addition of cyanide in the first research project and carbon monoxide and carbon dioxide in the other. Both groups have observed the formation of a variety of organic compounds, including a number of amino acids.

It is generally accepted that products of cosmic chemistry were showered on the nascent earth and could likewise fall on many other celestial bodies, brought down by comets, meteorites, and cosmic dust. But there is no agreement on the contribution of such products to the origin of life. Some researchers believe that the bulk of the building blocks of life came from outer space, others that they arose in the primitive terrestrial atmosphere by the kinds of process Miller and others have tried to reproduce in the laboratory. Most likely, both sources contributed, but in proportions that remain to be evaluated.

Faced with these facts, one is obviously tempted to assume that the products of cosmic/terrestrial chemistry did, in reality, serve as the building blocks front which life first arose. This view is not unanimously accepted. At least two prominent investigators, the German Gunter Wachtershauser (1998) and the American Harold Morowitz (1999; Chapter 18, this volume), have vigorously defended the theory that life started from scratch in autotrophic fashion. Their proposed schemes differ, but have in common that they attribute a central role to a reverse, reductive Krebs cycle, from which the first amino acids would have arisen by amination of certain intermediates. A recent cladistic analysis has, however, led to the opposite conclusion that Krebs-cycle intermediates arose from amino acids by deamination (Cunchillos and Lecointre, 2002).

On the whole, it would be very surprising if cosmic chemistry had nothing to do with the development of biochemistry. Attributing the many similarities between the two chemistries to a meaningless coincidence strains the boundaries of credibility. If we accept the more plausible view, then the main message of all these discoveries, from the point of view of our discussions, is that the chemical "seeds" of NC ore present throughout the cosmos. This, as far as I know, is the strongest argument yet uncovered in favor of a "biofriendly" universe.

Catalysis

Chemical "seeds" are a necessary, but not a sufficient, condition for the development of life. For the seeds to "germinate," that is, for the building blocks to join into proteins, nucleic acids, and

other key biological constituents, suitable catalysts are indispensable. What is true of present-day life no doubt also applies to emerging life, which, however, could not have had available the enzymes, ribozymes, and coenzymes that are at work today.

Many investigators have searched the mineral world for possible catalysts of biogenic reactions. Suggestive results have been obtained with metal ions, zinc for example (Lohrmann et al., 1980), clays (Cairns-Smith, 1982: Ferris, 1998). double-layer metal hydroxide minerals (Pitsch et al., 1995), pyrite (Wächtershauser, 1998), and iron-sulfur complexes (Cammack, 1983; Wächtershauser, 1998). To what extent such materials may have been crucial to the origin of life on earth is, however, not known. In addition, doubts have often been expressed that mineral catalysts could, alone, have sufficed to launch life.

Much attention has therefore been given to the suggestion that ribozymes may have played a key role in the origin of life in the so-called RNA world (Gilbert, 1986). There are, indeed, strong reasons that favor this possibility. Protein synthesis, for example, almost certainly was developed by interacting RNA molecules. But RNA itself can obviously not have catalyzed its own synthesis nor all the protometabolic reactions that came before it.

For a number of years, I have advocated the view that the first catalysts were short peptides and related compounds that I have called -multimers" (1991). Different from proteins, which they are supposed to have preceded, these substances could have contained D- as well as L-amino acids, some not found in proteins, together with other components, such as hydroxyacids, resembling in this respect a vast group of natural substances of bacterial and fungal origin. Known as non-ribosomal peptides and polyketides, these substances include a number of antibiotics and other biologically active molecules and have in common that they are synthesized by way of the thioesters of their precursor acids (Cane, 1997; Walsh, 2004).

As I have pointed out, substances of this kind would be most likely, because of chemical similarities, to mimic, be it only in rudimentary fashion, some of the catalytic properties of protein enzymes. Such properties have not been described in natural substances, but they could be looked for, both in natural and in artificial compounds (de Duve, 2003). Furthermore, the possibility that such substances could have arisen spontaneously in a prebiotic setting is plausible. Made of building blocks that are abundant among the primary products of cosmic chemistry, the posited multimers could have formed by fairly simple assembly mechanisms, which could even, like their natural counterparts, have involved thioester precursors. As discovered by Wieland even before the biological role of thioesters came to be known, peptides can form spontaneously from the thioesters of amino acids (see survey by Wieland, 1988). Several other investigators have described the synthesis of peptides under plausible prebiotic conditions (see, for example, Huber and Wächtershäuser, 1998). Particularly interesting are the experiments by a group of Japanese workers that have observed amino acid oligomerization in a hot—cold flow reactor designed to simulate a hydrothermal vent (Imai et al., 1999; Ogata et al., 200(l; Yokoyama et al., 2003). This point, together with the hypothetical involvement of thioesters, is of interest with respect to the possibility that life may have started in a volcanic setting (see below).

Substances resembling my multimers could even be formed by cosmic chemistry. There is evidence of the presence of peptides in meteorites, although apparently limited to the simple dipeptide glycyl—glycine (Shimoyama and Ogasawara, 2002). In the simulation experiments reported above (Bernstein et al., 2002; Munoz Caro et al., 2002), free amino acids were obtained in substantial amounts in the products of UV-irradiated interstellar ice analogs only if the material had first been subjected to acid hydrolysis. The possibility that the amino acids may be present in the form of peptides is explicitly raised by the investigators. It is thus conceivable that peptides and analogous

substances accompanied basic building blocks in the cometary showers that are suspected of having delivered chemical seeds of life to the prebiotic earth.

Energy

Any consideration of the energetic underpinning of emerging life must allow a crucial role to ATP and the other NTPs, especially since these compounds also serve to make RNA, most likely the first biological information-bearing substance (see below). It is interesting and possibly significant that inorganic pyrophosphate substitutes for ATP in a few metabolic reactions today. These reactions have been studied in particular detail by the Swedish couple Margaret and Herrick Baltscheffsky (1992), who believe them to go back to a "pyrophosphate world," a hypothetical early stage in the origin of life in which inorganic pyrophosphate was the first bearer of high-energy phosphate bonds. As mentioned above, another inorganic pyrophosphate derivative, polyphosphate, serves as a reservoir of such bonds in certain bacteria.

If inorganic pyrophosphates were essential to the development of life, this fact would put a severe constraint on the type of site where life could start, as pyrophosphates are very rare in the mineral world. Almost the only place where they might be expected to be present is a hot, volcanic setting (pyr means fire in Greek). where they could arise from inorganic phosphates and have indeed been detected in one instance (Yamagata et al., 1991).

Whatever the role of inorganic pyrophosphate, an early development of the organic moieties of NTPs is mandated by the participation of these molecules in RNA synthesis. This problem is still largely unsolved, even though it has engaged a considerable amount of research. Ribose and the various purine and pyrimidine bases that make up natural nucleosides can all arise by relatively simple reactions. Some of these substances could even be among the products of cosmic chemistry, having been detected in trace amounts in meteoritic materials. What remains unknown, however, is how these molecules joined into nucleosides, were phosphorylated, and, especially, emerged to occupy the central position they hold in the scheme of life. It is possible that subsequent selection, at the RNA level, rather than specific chemistry, was responsible for this emergence (de Duve, 2002, 2005).

Thioesters are another group of substances that could have played a key role in primitive energy transactions. We have seen how these substances arc uniquely involved in both group and electron transfers and in phosphorylation processes that are associated with some of the most primordial metabolic reactions and do not, unlike those dependent on protonmotive force, require complex membrane-embedded systems. We have also seen how my hypothetical multimers could have arisen from the thioesters of amino acids (see above). These facts and others have led to my proposal of a "thioester world" (1998).

Thioesters form by condensation between organic acids, which are typical products of cosmic chemistry, and thiols, which are organic derivatives of hydrogen sulfide (H_2S), a characteristic component of volcanic. fumes. Here, therefore, is yet another hint of a volcanic cradle of life.

These considerations raise the question of the actual source of energy whereby nascent life was fueled. Volcanic heat, by way of pyrophosphates and, perhaps, thioesters, is a possible source, although not likely to have, by itself, supported the acidity may have played a role in the development of protonmotive force (de Duve, 1991).

Membranes

Biological membranes, as we have seen, are constructed on lipid bilayers. What were the first amphiphilic molecules capable of associating into bilayers, and how did they arise?

There are several possibilities. As found by the American investigator David Deamer (1998), small amounts of molecules capable of assembling into bilayers, probably medium-length fatty acids, can be extracted from meteorites, suggesting a possible cosmic origin of the first amphiphilic molecules.

Another possibility is that the first membranes arose from phospholipid-like molecules produced by primitive metabolism. Phosphate, with or without additional components, could have provided the hydrophilic heads of the molecules. As to their hydrophobic tails, the French chemist Guy Ourisson has built a strong case in favor of polyisoprenoid molecules, the building blocks of ether lipids, as opposed to long-chain fatty acids, the main constituents of ester lipids (see Ourisson and Nakatani. 1994; Chapter 19, this volume). In nature, isoprenoid chains arise from isopentenyl pyrophosphate, a relatively simple precursor.

Finally, the possible intervention of hydrophobic peptides or other multimers (de Duve, 1991) may deserve consideration, as they might have provided the pores needed for exchanges of matter across the membranes, to be replaced later by proteins.

Amphiphilic molecules with sufficiently bulky tails readily assemble into vesicular lipid bilayers. A whole industry has been built around the production of artificial vesicles of this kind, or liposomes, which are widely used in the cosmetic and drug industries. A condition for the formation of liposomes is vigorous mechanical agitation, which is generally provided by ultrasound. Thus, we may add agitation to our reconstruction of the cradle of life. Pressured jets, such as those that make up hydrothermal vents, could possibly create the necessary turbulence.

Cells

Whether life started with the formation of vesicular structures or became encapsulated at a later stage is still a matter of much debate. What seems likely is that some kind of protocells already existed by the time RNA appeared. This contention is based on the assumption, which looks reasonable, that the RNA molecules that launched the "RNA world" and developed protein synthesis must have emerged by Darwinian selection. A direct selection process, based on the stability and replicability of the molecules themselves, could conceivably have accounted for the early stages of this evolution. But soon, an indirect process, based on the usefulness of the RNA molecules or of their protein products, must perforce have been at work. Competing protocells capable of multiplication are an indispensable condition of such a selective process.

As seen in the preceding subsection, some kind of vesicular structure could have formed spontaneously by agitation as soon as the appropriate amphiphilic molecules were present. But vesicles are not necessarily cells. Two supplementary conditions, at least, had to be fulfilled. First, the membranes hounding the protocells must have had permeability properties such as to keep functional components inside while allowing incoming foodstuffs and exiting waste products to pass through. In addition, the protocells must have been capable of growth and division if they were to participate in a process of Darwinian selection.

How such conditions were fulfilled is not known. In terms of environment, they imply the existence of a milieu capable of accommodating a large number of protocells, of providing them with necessary nutrients, and of disposing of their waste. The calmer surroundings of hydrothermal vents could conceivably have provided such a milieu.

Discussion

In dealing with the question "How biofriendly is the universe?" I have intentionally restricted my analysis to life and the universe as we know them. Conjecturing on possible forms of life obeying a different kind of chemistry seems to me absurd in the absence of any sign that they exist or any

hint of the kind of chemistry on which they could be based. Similarly, speculating on other possible universes as background for an appreciation of the "fine-tuning" and "anthropic" qualities of the one we inhabit is beyond my competence and must he left to physicists, who have given it abundant attention. Within these self-imposed limits, I have addressed the problem Mainly in the light of biochemistry, which is now understood in considerable detail, and of what is known or suspected about the origin of life, a topic still in its infancy but subject to intensive research.

The chemical seeds of life

What is probably the most significant and revealing lesson emerging from the preceding survey comes from outer space: the chemistry of life is written into that of the cosmos. It has long been recognized that living organisms are built with the most abundant elements. Recent findings have now shown that this biofriendlincss extends from atoms to molecules. Organic chemistry, far from being an exclusive entire development of life. Light, which supports most of the biosphere today, has often been envisaged, but does not, in my opinion, qualify as a primitive source of energy. Its utilization depends on complex membrane-linked systems and, especially, requires the ability to continue functioning in periods of darkness. Today, unilluminated phototrophs subsist on their reserves and, if need be, on their own substance, by coupled electron-transfer mechanisms similar to those used by heterotrophs. Most likely, therefore, some primitive electron-transfer reactions were already involved at an early stage, perhaps connecting thioesters and pyrophosphates in a manner presaging today's substrate-level phosphorylations. If so, what were the participants in these early transactions and how do they relate to the nature of the relevant environment?

This question is unresolved. When Miller designed his celebrated experiments, he was much influenced by the theory of his mentor, Harold Urey, who believed the atmosphere of the early earth to have been strongly reducing. This theory has, however, since fallen into disfavor. throwing doubt on the validity of Miller's results, especially since similar experiments performed with a neutral atmosphere yielded negligible quantities of organic material. The controversy is not yet resolved, but it may become irrelevant if cosmic synthesis, rather than atmospheric formation, should tum out to be the main source of life's building blocks. In such an event, oxidative conditions, rather than reducing ones, would be called for to support the first electron-transfer reactions, with preformed building blocks serving as electron donors.

Although molecular oxygen was most likely absent on the prebiotic earth, there was probably no dearth of potential electron acceptors in the mineral world at the time. Sulfate and its reduction product, sulfite, which serve as electron acceptors for some bacteria, are possible acceptors. This is an attractive possibility because sulfite is a common component of volcanic fumes, and its reduction could have yielded hydrogen sulfide.

The matter must remain open, however, since, as mentioned above, some investigators do not believe that early life was fed by products of cosmic chemistry. but propose instead an autotrophic origin of life, thus reinstating the hypothesis of a reducing milieu. In the scheme devised by Wächtershäuser (1998), the necessary electrons are assumed to be supplied by sulfide ions (S^{2-}) condensing into disulfide (Si^{-}). Ferrous iron is taken to drive this reaction thermodynamically h) precipitating the disulfide formed into the highly insoluble FeS_2 constituent of the mineral pyrite, which is also supposed to provide a catalytic surface for the reaction. Experiments have indeed shown that this process can support certain reductions. Interestingly, this "iron-sulfur world," which combines two major participants of biological electron transfers in a suggestive fashion, also presupposes a volcanic setting.

In recent years, the "hot-cradle" theory has been boosted by the discovery of deep-sea hydrothermal vents and of the many strange forms of life that inhabit those dark and seemingly inhospitable recesses. It has been argued against this theory that the fragility of many of the

constituents of life precludes a hot environment and even mandates freezing temperatures (Miller and Bads. 1988). The fact remains that some organisms thrive at temperatures as high as 110 'C. Also, one would expect primitive forms of life to be more robust than their more sophisticated descendants. Certainly, the traces pointing to a volcanic birthplace apparently left in life's most fundamental processes cannot be lightly disregarded.

Information

Information most probably entered nascent life with the appearance of RNA. One need only look at Figure 10.1 to realize that DNA can be dispensed with provided that RNA can be replicated. In such a DNA-free "RNA world," RNA would have served both as the repository of genetic information and as the agent of the expression of this information, first by itself and later by way of its protein translation products. On the other hand, the key functions carried out by RNA molecules in protein synthesis indicate strongly that proteins - defined as special polypeptides made with a distinct set of twenty amino acids - are an "invention" of RNA. It has been proposed, because of the molecular complexity of RNA, that this substance may itself have been preceded by some simpler information-bearing molecule. This hypothesis, however, is unsupported by any evidence.

The problem of RNA formation is a chemical problem. This point is of cardinal importance. The first RNA molecules were the products, probably together with a number of similar compounds, of the early chemistry whereby life was launched; they were not "intended" to serve as information carriers. It was their unique base Composition that, by lending itself to pairing, probably allowed their specific replication and amplification, which, in turn, caused them to emerge and to be molded by selection into the first bearers of genetic information and into the first catalysts of protein synthesis, as well as, perhaps, of other processes (de Duve, 2005).

In light of these considerations, it would seem that the main requirements for the appearance of RNA were the conditions, already briefly referred to, that allowed the formation of its NTP precursors, presumably in connection with primitive energy transfers. Two restrictions may be added. First, there is the problem of assembly, which probably required a special catalyst (possibly later supplemented by RNA molecules). Furthermore, there is the need for sufficient stability of the assembled Molecules. RNA is a fragile substance, especially in an alkaline medium. Thus, a certain degree of acidity may be another quality to be added to our reconstruction of the cradle of life. This point is of interest as adaptation to media of increasing prerogative of living organisms, as its name was intended to signify, is universal. Moreover, some of the products of cosmic chemistry are identical or closely similar to the most central building blocks of life. Chemical seeds of life arise spontaneously in outer space and on many celestial objects.

It is difficult to attribute this fact to a meaningless coincidence. This, however, is what one would have to believe if, as some researchers maintain, life developed in autotrophic fashion from carbon dioxide and very small building blocks, and not from preformed organic molecules (see above). The problem remains open because autotrophy obviously did develop at some stage by mechanisms that must be accounted for. On the other hand, the evidence is very strong that our young planet—or whatever site harbored the origin of earth life — must have been abundantly supplied with amino acids and other biogenic substances delivered by comets, meteorites, and cosmic dust. It seems highly likely that these substances participated significantly in the development of life, whatever the contribution of local syntheses.

The cradle of life

Seeds can germinate only infertile soil. Thus, if, as appears likely, cosmic chemistry did play a role in the origin of life on earth, the key question facing us is: how frequent, or infrequent, in the universe are the conditions that allowed the products of cosmic chemistry to become fruitfully involved in the generation of living cells?

Our knowledge on this topic is still very scanty. All we have are a few indications that life may have originated in a volcanic milieu, perhaps one resembling present-day hydrothermal vents. What seems to be needed, therefore, according to this reconstruction of the cradle of life, is a rocky body containing a magmatic core, pockets of liquid water, and, in between, a fissured crust allowing water to seep through the cracks and resurge in the form of pressured, turbulent, overheated, acidic, sulfurous, metal-laden jets. If this reconstruction is correct, the question raised reduces to estimating the probability of celestial objects elsewhere in the universe that are likely to harbor hydrothermal vents physically and chemically similar to those found on earth.

This question is obviously unanswerable in the present state of our knowledge. In any case, it is not for the biologist to answer. All that can be said is that the present direction of astronomical research favors multiplicity rather than uniqueness. It is already known that planetary systems are far from rare. It is true that only large planets orbiting close to their sun have been detected so far, but this is because of technical limitations that may well be overcome by the advances of tomorrow. The existence of earth-like planets is not excluded; it is seen as likely by many experts.

The very real possibility remains, however, that our reconstruction of the cradle of life is incomplete and that some special condition not included in our assessment has to be fulfilled for life to arise. Perhaps the magnetic field must be just right. Or the planet's orbit must have the right degree of ellipticity, its rotation axis the right tilt. Or there may be a need for a moon of just the right mass circling at just the right distance. With enough rare conditions to be satisfied, planet earth could indeed turn out to be unique in the entire universe, a "cosmic fluke" (Conway Morris, 2003).

On the whole, sheer numbers would seem to argue against rarity. Considering the number of sunlike stars believed to exist in our galaxy (on the order of thirty billion) and the estimated number of galaxies in the universe (about one hundred billion), the odds seem to favor the existence of multiple earth-like planets capable of giving rise to life. Even some defenders of a "rare earth" share this opinion (Ward and Brownlee, 2000).

The probability of life

Sticking to our metaphor, what we have seen so far is that the chemical seeds of life are universally available and that the kind of soil in which the seeds germinated to give rise to present-day life probably exists in other sites in the universe. One question remains: how probable is it that germination will succeed when the seeds fall on the right soil? In other words, given the building blocks and the appropriate environmental conditions, what is the probability that viable cells will actually emerge?

In considering this question, elsewhere I have vigorously defended the view that life was virtually bound to arise under the conditions that prevailed at the site of its birth (1995, 2002, 2005). This opinion rests mainly on the fact that life must have arisen by chemical processes and that chemistry deals with highly deterministic, reproducible mechanisms. To be sure, contingency became added to chemical determinism when replicable molecules, most likely RNA. began to be made. This phenomenon introduced continuity into the course of events, but, also, the risk of its accidental loss by mutation. Many researchers have emphasized the chancy nature of such developments.

As I have pointed out on a number of occasions, the intervention of chance does not necessarily exclude inevitability. What counts is the number of opportunities available for the occurrence of a given event, as compared with the probability of that event. Many instances indicate that, when faced with a large number of distinct chance opportunities, nascent life enjoyed the freedom of exploring the range of possibilities extensively enough to approach selective optimization. Many of

the "hallmarks" singled out in the first part of this chapter may have been the outcome of such a process (de Duve, 2005).

Admittedly, the possibility cannot be ruled out that some rare substance or some improbable chance occurrence played a decisive, non-reproducible role in the appearance of life. Scientific caution commands such reservation, but common sense argues against it. One doesn't readily see how a complex network of interconnected chemical reactions, such as those that must have initiated life, could have rested critically on a single, improbable chance factor. Such a caveat looks more like an ad hoc hypothesis than like a reasonable conjecture.

Nevertheless, the fact remains that attempts at reproducing key events leading to the development of life in the laboratory have met with little success so far. We still have no inkling, for example, of how such central compounds as ATP and the other NTPs may have arisen. Achieving the synthesis of these substances under plausible prebiotic conditions would go far toward accrediting the deterministic theory. Until this happens, the question stays open. In this connection, the indications gathered on the possible conditions under which life arose may be useful guides in the design of experiments. We have seen that this approach has already yielded some interesting results. Success could also depend critically on finding the right catalysts among possible mineral components of the prebiotic environment or, more likely, among the organic products of primitive chemistry (de Duvet, 2003).

All these uncertainties would be dispelled if clear evidence of extraterrestrial life could be obtained. Even then, kinship with earth life would have to be ruled out. Discovering life on Mars, for example, might not be decisive in itself. It is not considered impossible that Martian life could originate from earth, or terrestrial life from Mars, or both from some third site in the solar system. The two forms of life would have to differ in a significant way, for example in the chirality of some key constituent, for their independent origin to be incontrovertibly established.

The concerted effort that is going on at present in the new discipline of astrobiology, sometimes also called exobiology or bioastronomy - a discipline with three names but no known object! - will perhaps lead to the discovery of extraterrestrial life some time in the future. If it does not, however, all one will be able to state is that life is not extremely frequent. Finding no sign of life in the minuscule part of the cosmos accessible to our explorations in no way can serve as proof of the rarity of life, let alone its uniqueness.

Conclusion

In conclusion, we live in a biofriendly universe: hut just how biofriendly is not precisely known. Therefore, the only scientifically valid attimde with respect to the question is prudent agnosticism. II however, some hypothesis is to be favored, as a guide for experimentation, for example, or as a justification for research funding. or, perhaps more importantly, as an inspiration for one's world view, available clues support the assumption that our universe is such that generation of life was obligatory, probably in many sites and at many times. Turning around Monod's famous saying (see above), the universe was, and presumably still is, "pregnant with life."

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Chapter 9 – Fitness Of The Cosmos For The Origin And Evolution Of Life: From Bio-Chemical Fine-Tuning To The Antropic Principle

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The boundaries of philosophy, science, and theology

Some of the deeper questions that humans have raised are not always answerable within the boundaries of science. Instead, philosophers and theologians have approached such questions within their own domains of competence. One such example is provided by the question of purpose in evolution (see the discussion below). Indeed, the concept of purpose in a general sense may be understood as something that one sets before oneself as an object to be attained, an aim to be kept, a plan to be formulated. In attempting to give an answer to the question of "purpose in nature," we should discuss the main components of human knowledge in an integrated way, so as to ask the right questions in the right field of knowledge. This approach should encourage us to provide appropriate answers that are reasonable within philosophy, science, or theology. At this juncture, it may be also argued that the task of a scientist should be independent of that of the other areas of human culture (Russell, 1991: 13). On the other hand, it is surely useful to be aware that this view of the role of science that is "divorced" from both philosophy and natural theology can also be seen from a different point of view (Townes, 1995: 166): Because science and religion are evolving and are similar in their search for truth, convergence of these independent searches for truth may occur in the future.

I wish to address some questions in philosophy and theology that are pertinent to the main subject of this chapter. In order not to go beyond the natural boundaries of either science or theology, I will discuss contemporary attempts to encompass Darwinian evolution in a natural theological context. To meet this objective, we need some definitions to make this chapter self-contained.

First, teleology may be considered in two separate ways: Either it is a doctrine according to which everything in the cosmos has been designed with humans in mind, or it can be interpreted as a theory of purposiveness in the cosmos (namely, phenomena that are to be explained in terms of its purpose, rather than by initial causes). This latter concept is intimately related to the Anthropic Principle, either as employed in physics or in biochemistry. Teleology is also related to various interpretations of fine-tuning in phenomena such as the nuclear reaction of beryllium atoms in the production of carbon, as originally pointed out by Fred Hoyle (Hoyle, 1975: 401-02).

Second, the notion of process dominates the work of three philosophers of the last century: Louis Bergson (1859-1941), Samuel Alexander (1859-1938), and Alfred North Whitehead (1861-1947) (see Ayer, 1982: 208-09). In passing, it is perhaps worth noting that process theology is based on the metaphysics of Whitehead, who rejected Divine Action in terms of causality, proposing that God acts persuasively in all events, but not necessarily in determining their character. Specifically, Whitehead pointed out the incoherence of belief in a lifeless universe.

Elsewhere in this book, Haught has emphasized God as the sole ground for the world's being (see also Haught, 1998: 393-418). This approach to natural theology leads him to explain the world in terms of evolution, as understood within the Darwinian tradition (Russell, 1996: 1-31). Russell focuses on features of process thought. This philosophical system is considered to be particularly helpful in the task of constructing an evolutionary theology that may throw some further light on Darwinism.

A far-reaching implication of the possibility of interpreting the evolutionary aspects of Darwinism within theology is that the evolutionary process begins at the molecular level of biochemistry. In fact, such "chemical" evolution is a time-honored discipline that has been studied extensively in the past, particularly during the last decade of the last century (e.g., Ponnamperuma and Chela-Flores, 1993; Chela-Flores et al., 2001). In this chapter, I endeavor to show that fine-tuning in biochemistry is a well-defined problem. Its evolutionary aspects should, in principle, be able to be integrated into a framework of natural theology, for instance in approaches such as kenotic process theology.

Process philosophy, or "process thought," attempted to provide a common metaphysical basis for discussions of science and religion. Some criticisms have been raised in the past (Polkinghorne, 1996: 28): If physics is to be appropriate for process thought, this school of philosophy has to face an ongoing debate. In particular, continuity seems to be intrinsic to quantum mechanics (for example, the Schrödinger equation is a differential
equation). For Polkinghorne, at least, the mathematics of process thought should be that of "difference" equations, instead of "differential" equations (with their implied underlying continuity).

On the other hand, we should keep in mind deeper issues that are currently under debate as quantum gravity aims to provide a coherent theory of spacetime. Spacetime is a dynamic entity, and as such it would have quantum properties (Rovelli, 2000: 3776-3800). Both current and future developments in theoretical physics have to investigate the concept of discrete excitations of space itself. Thus, process thought, as a philosophical system, cannot be ruled out at present because of an unfinished debate in theoretical physics.

To complete our discussion of contemporary attempts to encompass Darwinism in a natural theological context, we ask whether there is evidence of purpose in the cosmos. If we allow the simultaneous approaches of philosophy, theology, and science, it seems possible to reconsider the question that has been raised in the past: Is there evidence of purpose in the cosmos? And, in particular, Is there any evidence of purpose in biochemistry?

We can consider how the cosmos itself is well-fitted for the origin and evolution of life. I will discuss how the combined approaches of philosophy, science, and ultimately natural theology can help us to begin to discuss the intelligibility of the universe in a rational way. Care is needed in addressing the right questions within their corresponding cultural domain.

First, we consider the origin and evolution of intelligent behavior in the cosmos, examining the case of life on earth. As already pointed out above, investigations of the evolution of life on earth (Darwinism) can be incorporated in natural theology (process theology), at least in principle. The subsequent arguments in this chapter, within the boundaries of science, should, I hope, be useful for their interpretation in terms of theological issues.

Biochemical fine-tuning and fitness of the cosmos for life

Our starting point for studying the fitness of the cosmos for the origin and evolution of life is Lawrence J. Henderson's influential The Fitness of the Environment (1913). As a graduate of and professor at Harvard University, Henderson's main interests ranged widely, and he became a physiologist, chemist, biologist, philosopher, and sociologist. He discussed the question of teleology in biochemistry to give some rationale to the question of the fitness of the environment for the evolution of life. For many chemical compounds, he discussed the difficulties that the evolution of life would have encountered had these compounds not been freely available in the environment. One obvious example used by Henderson was water, the search for which even today is a main objective of our explorations of the solar system, especially Mars, Europa, Titan, and Enceladus (the tiny Saturn moon).

Today, we need to search the roots of Henderson's biocentrism at the molecular level. In fact, fine-tuning in biochemistry is represented by the strength of the chemical bonds that makes the universal genetic code possible. Neither transcription nor translation of the messages encoded in RNA and DNA would be possible if the strength of the bonds had different values. Hence, life, as we understand it today, would not have arisen.

In this chapter, I will argue in favor of the fitness of the cosmos for the origin and evolution of life without touching on the question of teleology. Instead, we approach the subject by considering biological evolution in the universe, as well as the evolution of the structure of the cosmos itself. I will touch on the evolution of solar systems, interstellar matter, and finally various aspects of the cosmos—all in relation to the emergence of life. However, I hasten to point out that arguments based on science can nevertheless be a source of inspiration for reconsidering the bases of natural theology. I will argue that the fitness of the universe for the origin and evolution of life can be best understood not only through convergence in biochemistry, but also through a range of convergences based on observations of phenomena in the space sciences.

The Weak Anthropic Principle in cosmology and biochemistry

In cosmology or biology, we may inquire whether general mechanisms (for instance, natural selection and adaptive radiation), as well as special values of some physical constants, could be interpreted together in natural theology as indications of purpose. The example of "fine-tuning" in physics has led to a weaker and a stronger version of the Anthropic Principle, which is concerned with the question of the bases of life, particularly intelligent life, in the cosmos. I have no difficulty in accepting what has come to be known as the "Weak Anthropic Principle" in physics:

Change the laws (and constants of nature), and the universe that would emerge most likely would not be compatible with life.

Biochemistry offers a clearly analogous statement:

First omit the observed cosmic abundance of the biogenic elements that are favorable to life. Then omit the environments (earth-like planets or Europa-like satellites) that favor evolution and adaptive radiation. The consequence of omitting both factors is that life most likely would not arise.

However, difficulties certainly would arise, both in cosmology as well as in biology, if we allowed some degree of teleology to be brought into the argument. Here, of course, I am referring to formulation of the "Strong Anthropic Principle":

The laws of nature and the physical constants were established so that human beings would arise in the universe.

The distribution of earth-like environments and Europa-like satellites was laid out so that not only life, but at least in certain circumstances human beings, would also arise in the universe.

The general mechanisms of nature, according to the evidence that we can infer from the biota of earth, which by now is at least 3 billion years old, imply that the evolution of intelligent behavior seems inevitable. What is not evident is the inevitability of the emergence of human beings.

The intimately related concepts of the Anthropic Principle and fine-tuning in living systems (Carr and Rees, 2003: 1-8) are topics that would be simpler to understand with knowledge of more than a single instance of emergence of life on earth. On the other hand, our religious traditions go back to Jewish theology: A sole omnipotent God created heaven and earth, and subsequently life on earth. This view of our origins has traditionally been referred to as the "First Genesis." With the emergence of astrobiology (Chela-Flores, 2001), we can start to explore the possibility of the occurrence of a "Second Genesis"—namely, whether the evolution of intelligent behavior is inevitable in an evolving cosmos, given the present laws of cosmology (general relativity) and the general mechanisms of biological evolution (natural selection and adaptive radiation). If we were to change these laws and mechanisms, the arguments supporting the inevitability of the evolution of intelligent behavior would not stand, and thus the evolution of intelligent beings would not necessarily take place. This aspect of evolution has clear implications for the Weak Anthropic Principle.

A first aspect of convergence: cultural convergence

In the search for answers that go beyond the boundaries of a given area of human culture, we should first consider whether the various approaches would ever converge. The concept of convergence enters our discussion in three different contexts. In this section, I consider convergence in different cultural areas (Townes, 1995: 166). The other two aspects that are discussed in the following two sections are (1) convergence at a cosmic level, a subject that is essentially based in the space sciences, and (2) convergence in biology, a topic that is central to understanding Darwinian evolution.

Both science and religion are concerned with the common understanding of life in the universe. Because they largely address the same questions, we would expect that both aspects of human culture should at some point converge. With subsequent progress in philosophy, science, and theology, convergence seems unavoidable, although human culture does not seem to show any evidence of convergence at present. The status of the relationship between these three disciplines—philosophy, science, and theology—has been discussed in the past (John Paul II, 1992:

1). In this chapter, an integrated approach to the questions regarding the fitness of the universe for the origin and evolution of life aims to avoid a splintered culture.

A second aspect of convergence: convergence at the cosmic level

In this section, I will discuss five cases of convergence at the cosmic level. First, from organic chemistry we know that nuclear synthesis is relevant for the generation of the elements of the periodic table beyond hydrogen and helium and, eventually, for the first appearance of life in solar systems. The elements synthesized in stellar interiors are required for making the organic compounds that have been observed in the circumstellar, as well as the interstellar, medium in comets and other small bodies. The same biogenic elements are also needed for synthesis of the biomolecules of life. Moreover, the spontaneous generation of amino acids in the interstellar medium is suggested by general arguments based on biochemical experimentation: The study of amino acids in the room-temperature residue of an interstellar ice analog has yielded 16 amino acids, some of which are also found in meteorites (Muñoz Caro et al., 2002: 403-06; also see Bernstein et al., 2002: 401-03). These factors help us to understand the first steps in the eventual habitability of planets.

On the other hand, the concept of cosmic convergence has a second aspect that may be inferred from what we know about the small bodies, such as the Murchison meteorite. These bodies may even play a role in the origin of life: According to chemical analyses in this particular meteorite, we find basic molecules that are needed for the origin of life such as lipids, nucleotides, and more than 70 amino acids (Cronin and Chang, 1993: 209-58). Most of the amino acids are not relevant to life on earth and may be unique to meteorites.

This demonstrates that those amino acids present in the Murchison meteorite, which also play the role of protein monomers, are indeed of extraterrestrial origin. In addition, chemical analysis has demonstrated the presence of a variety of amino acids in the Ivuna and Orgueil meteorites (Ehrenfreund et al., 2001: 2138-41). If the presence of biomolecules on the early earth is due in part to the bombardment of interplanetary dust particles, comets, and meteorites, then the same phenomenon could be taking place in any other solar system.

Interstellar gas provides yet another illustration of the convergent phenomenon that occurs at a cosmic level. Indeed, solar systems, many of which are now known, originate from interstellar dust that is constituted mainly of the fundamental elements of life, such as C, N, O, S, P, and a few others. Just before a star explodes into a supernova, all the elements that have originated in its interior as a result of thermonuclear reactions are expelled, thus contributing to the interstellar dust. The star itself collapses under its own gravity, compressing its matter to a degenerate state; the laws of microscopic physics eventually stabilize its collapse into a white dwarf. Stellar evolution of stars more massive than the sun is far more interesting: After the star has burnt out its nuclear fuel, a catastrophic explosion follows in which an enormous amount of energy and matter is released. These supernovae explosions are the source of enrichment of the chemical composition of the interstellar medium. This chemical phenomenon, in turn, provides new raw material for subsequent generations of star formation, which leads to the formation of planets. Late in their evolution, stars are still poor in some of the heavier biogenic elements (for instance, magnesium and phosphorus). Such elements are the product of nucleosynthesis triggered in the extreme physical conditions that occur in the supernova event itself. By this means, the newly synthesized elements are disseminated into interstellar space, becoming dust particles after a few generations of star births and deaths.

An additional case that argues in favor of convergence at a cosmic level is emerging from what we are beginning to learn about the origin of planetary systems around stars. Our solar system formed in the midst of a dense interstellar cloud of dust and gas, essentially a circumstellar disk around the

early sun. Some evidence suggests that this event was triggered by the shock wave of a nearby supernova explosion more than five billion years ago. Indeed, some evidence indicates the presence of silicon carbide (carborundum, SiC) grains in the Murchison meteorite, a fact demonstrating that they are matter from a type II supernova (Hoppe et al., 1997: 1314-17). We may now be observing an extrasolar circumstellar disk around a young three-million-year-old sun-like star in the constellation Monoceros (Kerr, 2002: 2312-13). Several earlier examples of circumstellar disks are known, including a significantly narrow one around an eight-million-year-old star. The narrowness of this disk suggests the presence of planets constraining the disk (Schneider et al., 1999: L1217-30). The following additional information further supports the arguments in favor of universal mechanisms of convergence in the formation of solar systems; that is, the matter of the original collapsing interstellar cloud does not coalesce into the star itself, but collapses into the spinning circumstellar disk, where planets are thought to be formed by a process of accretion. Some planetesimals collide and stay together because of the gravitational force. In addition, a variety of small bodies are formed in the disk, prominent among which are comets, asteroids, and meteorites, completing the components that make up a solar system.

Finally, the fifth example of what I have called "cosmic convergence" is provided by the convergent origin of hydrospheres and atmospheres. The earliest preserved geologic period (the lower Archaean) may be considered as representing the tail end of the "heavy bombardment period." During that time, various small bodies, including comets, collided frequently with the early precursors of the biomolecules that eventually ignited the evolutionary process on earth and in its oceans. In addition, comets may be the source of other volatile substances significant to the biosphere, as well as the biochemical elements that were precursors of the biomolecules. Collisions with comets, therefore, are thought to have played a significant role in the formation of the hydrosphere and atmosphere of habitable planets, including earth. The source of comets is the Oort cloud and Kuiper belt. These two components of the outer solar system seem to be common in other solar systems. Hence, in this cosmic sense, we recognize evolutionary convergence.

A third aspect of convergence: the case for convergence in biology

The question of evolutionary convergence in the context of the life sciences has been discussed extensively (Conway Morris, 2003 and this volume; Chela-Flores, 2001: 149-62; 2003: 307-12; 2006, in press; Akindahunsi and Chela-Flores: 2004: 135-38). We are assuming that natural selection is the main driving force of evolution in the universe, a hypothesis made earlier elsewhere (Dawkins, 1983: 403-25). For these reasons, it is relevant to question whether local environments that were favorable for the emergence of life on the early earth were at all unique, occurring exclusively in our own solar system. Another view on the universal validity of biology in the cosmos has been advanced in the context of the basic building blocks (Pace, 2001: 805-08): It seems likely that the basic building blocks of life anywhere will be similar to our own. Amino acids are readily formed from simple organic compounds and occur in extraterrestrial bodies, such as meteorites. Functions that are suggested as being common to life elsewhere in the cosmos serve to capture adequate energy from physical and chemical processes to conduct the chemical transformations that are necessary for life: lithotropy, photosynthesis, and chemosynthesis. Other factors that argue in favor of the universality of biochemistry are physical (temperature, pressure, and volume) and genetic constraints (see below).

In general, we may say that features that become more, rather than less, similar through independent evolution will be called "convergent." In fact, convergence in biology is often associated with similarity of function, as in the evolution of wings in birds and bats. New World cacti and the African spurge family provide an example. Some other examples are the euphorbs, such as Euphorbia stapfii, and some members of the Madagascar Didieraceae (Didiera madagascariensis). These plants are similar in appearance, being succulent, spiny, water storing, and adapted to desert conditions (Tudge, 1991: 67; Nigel-Hepper, 1982: 81). However, they are

classified in separate and distinct families, sharing characteristics that have evolved independently in response to similar environmental challenges. Hence, we may say that this is a typical case of convergence.

When we look at convergence at the biochemical level, we can further document the general question of the evolution in the life sciences. Convergent evolution is manifest at the active sites of enzymes and in whole proteins, as well as in the genome itself:

The northern sea cod (Boreogadus saida) is an economically important marine fish of the family Gadidae found on both sides of the North Atlantic. The distantly related order Perciformes with its suborder Percoidei contains the sea basses, sunfishes, perches, and, more relevant to our interest, the notothenioid fishes from the Antarctic (Dissotichus mawsoni). In spite of their distant relationship with cods, they have evolved the same type of antifreeze proteins, in which the amino acids threonine, alanine, and proline repeat (Chen et al., 1997: 3817-22). These proteins are active in the fish's blood and avoid freezing by preventing the ice crystals from growing. The Antarctic fish protein arose over seven million years ago, while the Arctic cod first appeared about three million years ago (both species arose in different episodes of genetic shuffling).

The blind cavefish Astyanax fasciatus are sensitive to two long-wavelength visual pigments. In humans, the long-wavelength green and red visual pigments diverged about thirty million years ago. The mammalian lineage diverged from fishes about four hundred million years ago, but a recent episode in evolution has provided fish multiple-wavelength-sensitive green and red pigments. Genetic analysis demonstrates that the red pigment in humans and fish evolved independently from the green pigment by a few identical amino acid substitutions (Yokoyama and Yokoyama, 1990: 9315-18), a clear case of evolutionary convergence at the molecular level.

Convergence may also occur when the sequence and structure of molecules are very different, but the mechanisms by which they act are similar. Serine proteases have evolved independently in bacteria (e.g., subtilisin) and vertebrates (e.g., trypsin). Despite their very different sequences and three-dimensional structures, in each the same set of three amino acids form the active site. The catalytic triads are His 57, Asp 102, and Ser 195 (trypsin) and Asp 32, His 64, and Ser 221 (subtilisin) (Doolittle, 1994: 15-18).

Evolutionary convergence in biology has been best documented at the level of animals. The evolutionary biology of the Bivalvia, both at the level of zoology and paleontology, provide multiple examples of convergence and parallel evolution, a fact that makes the interpretation of their evolutionary history difficult (Harper et al.,2000: 1-494). Specific examples of convergence in mollusks have been pointed out in the case of various families of the gastropods (camaenid, helminthoglyptid, and helcid snails). The shells of the camaenid snails from the Philippines and the helminthoglyptid snails from Central America resemble each other and also members of European helcid snails. These distant species, in spite of having quite different internal anatomies, have grown to resemble each other morphologically in response to their environment. In other words, in spite of considerable anatomical diversity, mollusks from these distant families have come to resemble one another in terms of their external calcareous shell (Tucker Abbott, 1989: 7-8).

In addition, we should recall that the Passeriformes (including swallows) may be confused with Apodiformes (including swifts), but are not related to them. Swallows and swifts provide a classical example of evolutionary convergence. Although unrelated, swallows are generally similar to swifts in size, proportion, and aerial habits (Clench and Austin, 1983: 1052-66). Members of these two orders differ widely in anatomy, and their similarities are the result of convergent evolution on

different stocks that have become adapted to the same lifestyles in similar ecosystems for both species.

Can convergent pathways of evolution in the cosmos be foreseen?
Above I have argued that fine-tuning in biochemistry is represented in molecular biological terms by the strength of chemical bonds that make the universal genetic code possible. The messages coded in RNA and DNA would not be possible if the strength of the bonds had different values. Hence, life, as we understand it today, would not have arisen. Subsequent evolutionary stages beyond molecular evolution in biochemistry (i.e., beyond chemical evolution of the building blocks of life) will depend on certain factors that can be documented with further research in the geologic record of hydrothermal vent communities and with the exploration of the solar system. I will review some of them, beginning with the geologic record. Some evidence indicates that once life originates, provided sufficient (geologic) time is available, evolution will provide living organisms with the opportunity to occupy every conceivable environment. This notion further favors the hypothesis that once life appears at a microscopic level on a given planet or satellite, the eventual evolution of intelligent behavior is just a matter of time.

The inevitability of some of the earliest stages of the evolution of life on earth can be illustrated with careful analysis of the geologic record. For instance, Cambrian fauna, such as lamp-shells (inarticulate brachiopods) and primitive mollusks (Monoplacophora), were maintained during Silurian times by microorganisms that lived in hydrothermal vents (Little et al., 1997: 146-48). Many examples of such fossils have been retrieved from the Silurian Yaman Kasy sulfide deposit. This volcanogenic site is located at the Orenburg district (southern Urals, Russia). In modern vent communities, monoplacophorans have been recovered at the Mid-Atlantic Ridge (37o 50' N), and brachiopods from mid-ocean ridges are also recorded. However, taxonomic analysis of Cenozoic fossils suggests that shelly vent taxa are not ancestors of modern vent mollusks or brachiopods (Little et al., 1998: 259-70). We may conclude that modern vent taxa support the hypothesis that the vent environment is not a refuge for evolution.

In fact, evidence exists that since the Paleozoic and through the Mesozoic era, taxonomic groups have moved in and out of vent ecosystems through time—no single taxon has been unable to escape evolutionary pressures. Some independent support for deep-water extinction has also been presented (Jacobs and Lindberg, 1998: 9396-401). These findings rule out the possibility that deep-sea environments are refuges against evolutionary pressures. In other words, the evidence so far does not support the idea that there could be environments where ecosystems might escape biological evolution, even at the apparently unassailable depth of the oceans. This gives considerable support to the hypothesis that any microorganism, in whatever environment on earth or elsewhere, would be inexorably subject to evolutionary pressures.

As I have shown above, fossils from Silurian hydrothermal-vent fauna demonstrate that species have become extinct in locations that at first sight seem to be far removed from the pressures of evolutionary forces. Given that there are no refuges against evolution, we can raise the question whether over geologic time it was inevitable that the most primitive cellular blueprint bloomed into full eukaryogenesis and beyond, along convergent evolutionary pathways, ultimately to organisms displaying intelligent behavior (Chela-Flores, 1998: 79-99).

To investigate beyond the geologic record whether subsequent evolutionary stages lead to the evolution of intelligent behavior, we turn to the exploration of our solar system. In order to investigate, in the short term, whether the evolution of life is subject to convergence throughout the cosmos, we have at least two possibilities. First, we can directly test whether evolution of intelligent behavior has followed a convergent evolutionary pathway elsewhere in the universe by means of the Search for Extraterrestrial Intelligence (SETI) project (Ekers et al., 2002).

Unfortunately, no definite signal that could be interpreted as originating from an advanced civilization has ever been detected.

A second alternative, although much more restricted in scope, is currently in progress. We can test for the possible existence of the lowest stages of the evolutionary pathway within the solar system, namely at the level of microorganisms. One approach is currently being carried out in terms of the search for life on Mars. Another approach, still within the solar system, is to search in due course for life on the Jovian satellite Europa (Chela-Flores, 2003: 307-12; 2006, in press). Even beyond our solar system, scientific research may help us to decide whether environments exist that fulfill conditions favorable to life's origin and evolution. This is due in part to the fact that we are aware of multiple examples of solar systems. In addition, we suppose that stable conditions persist in extrasolar planets. By stable conditions, it should be understood that the planet (or satellite), where life may evolve, is bound to a long-lived star. In other words, the time available for the origin and evolution of life should be sufficient to allow life itself to evolve, before the solar system of the host planet or satellite reaches the final stages of stellar evolution, such as at the red-giant and supernova phases.

It is also assumed that major collisions of large meteorites with a habitable world are infrequent after the solar system has passed through its early period of formation. Under such stable conditions, the gradual action of natural selection would be expected to be the dominant mechanism in evolution. Fortunately, the existence of stable earth-like planetary conditions is an empirical question for which we will be able to give partial answers in the foreseeable future. Reliable observational techniques are currently being provided to image Jupiter-like planets orbiting at several astronomical units from their corresponding stars. Hence, we may conclude that in the not-too-distant future we will be able to address the following question on the evolution of intelligent behavior: Is the evolution of the cosmos "fine-tuned" for the inevitable emergence of intelligent behavior throughout the cosmos? The assumed universality of biological evolution suggests a positive answer to this question, provided that stable planetary conditions are maintained in a given planet, or satellite, over geologic time.

A third factor in favor of the inevitability of the evolution of intelligent behavior in the cosmos is natural selection, which seems to be powerful enough to shape terrestrial organisms to similar ends, independent of historical contingency. Likewise, in view of the assumed universality of biology, we would expect evolutionary processes to take place in the cosmos that are mechanistically similar to those that have driven the evolution of life on earth. I will discuss some examples that support this view. Before approaching the question of convergent evolution, however, we should first recall that the set of factors influencing the relative degree to which earth's biota has been shaped is still a debatable topic. According to the hypothesis of universal Darwinism, life on earth, and possibly elsewhere, may have been shaped either by contingency or by the gradual action of natural selection. It may be possible to document convincingly whether, independent of historical contingency, natural selection is powerful enough for organisms living in similar environments to be shaped to similar ends. For this reason, I highlight the following examples, which suggest that, to a certain extent and in certain conditions, natural selection may be stronger than chance:

Black European fruit flies (Drosophila subobscura) were transported to California more than twenty years ago. This event has provided the possibility of testing the role of natural selection in two different continental environments. Pacific coast D. subobscura (from Santa Barbara to Vancouver) were compared in wing-length with European specimens (from Southern Spain to the middle of Denmark). After half a dozen generations living in similar conditions, the increase in wing length was almost identical (four percent). This is a compelling case in favor of the key role played by natural selection in evolution (Huey et al., 2000: 308-09).

Anole lizards from some Caribbean islands (Anolis spp.) provide another example of evolutionary convergence. In Cuba, Hispaniola (shared by Haiti and the Dominican Republic), Jamaica, and Puerto Rico (the so-called Greater Antilles), the observed phenomenon suggests that in similar environments adaptive radiation can overcome historical contingencies to produce strikingly similar evolutionary outcomes. We could even say that replicated adaptive radiation has occurred in the various islands. In fact, it has been shown that although many species were known to thrive on these islands, some groups of lizards from different islands living in similar environments also look similar (Losos et al., 1998: 2115-18). Genetic analysis has shown that similar traits have evolved in distantly related species for coping with similar environments (such as treetops or ground-dwellings): Anoles that live on the ground have long, strong hind legs, while those living at treetops have large toe-pads and short legs. Repeated evolution of similar groups of species (both morphologically and ecologically) suggests that adaptation is responsible for the predictable evolutionary responses of the anole lizards of the Caribbean. Indeed, we can speak in this case of evolutionary history repeating itself (Vogel, 1998: 2043).

Finally, in order to decide whether the standard laws of physics and biology imply the evolution of intelligent behavior, it is instructive to appreciate the implications of the
existence of several constraints on chance. These constraints are relevant to the question of whether life elsewhere might follow pathways analogous to the ones it has already followed in terrestrial evolution. Christian de Duve has enumerated various examples of constraints on chance (de Duve, 1995: 296-97; 2002; and this volume):

Not all genes are equally significant targets for evolution. The genes involved in significant evolutionary steps are few in number; these are the so-called regulatory genes. In these cases, mutations may be deleterious and consequently are not fixed.

Once a given evolutionary change has been retained by natural selection, future changes are severely constrained; for example, once a multicellular body plan has been introduced, future changes are not totally random, as the viability of the organisms narrows down the possibilities. For instance, once the body plan of mammals has been adopted, mutations such as those that are observed in Drosophila, which exchange major parts of their body, are excluded. Such fruit-fly mutations are impossible in the more advanced mammalian body plan.

Not every genetic change retained by natural selection is equally decisive. Some may tend to increase biodiversity rather than contribute to a significant change in the course of evolution.

Implicit in Darwin's work is chance represented by the randomness of mutations in the genetic patrimony and their necessary filtering by natural selection. However, the novel point of view that astrobiology forces on us is to accept that randomness is built into the fabric of the living process. Yet, contingency, which is represented by the large number of possibilities for evolutionary pathways, is limited by a series of constraints.

Natural selection necessarily seeks solutions for the adaptation of evolving organisms to a relatively limited number of possible environments. From cosmochemistry we know that the elements used by the macromolecules of life are ubiquitous in the cosmos.

To sum up, a finite number of environments force a limited number of options on natural selection for the evolution of organisms. We expect convergent evolution to occur repeatedly, wherever life

arises. Consequently, it makes sense to search for the analogs of the attributes that we have learned to recognize on earth, especially the evolution of intelligent behavior.

Conclusion

Data from the current fleet of space probes that are capable of searching for signs of life in the solar system suggest that extraterrestrial life could be identified sometime in the near future. Thus, if we can settle the question of the occurrence of a Second Genesis elsewhere in the universe, additional information would be available to discuss the question of fine-tuning in biochemistry. Earlier, I extended the meaning of convergence from biology to the space sciences in an effort to provide a solid scientific basis for the concept that the universe is fit for the origin and evolution of life.

Closely related to the issue of extending convergence from the life to the space sciences is the subject of the intelligibility of life in the universe, a significant topic that requires an explanation. In this chapter, two aspects of the intelligibility of life in the universe were discussed in scientific terms, namely, the origin and the evolution of intelligent behavior in the universe. The arguments were centered on whether evolution is dominated by either contingency, or by the gradual action of natural selection. Random gene changes accumulating over time may imply that the course of evolution is generally unpredictable, but constraints on chance, as argued above, put some powerful bounds on the degree of uncertainty.

Other contingent factors are the extinction of species due to asteroid collisions or other calamities, although these uncertainties may affect only the evolution of single lineages. However, such questions are of lesser interest to the larger issues that are relevant to either natural theology, or to science. This is particularly true when the question of fine-tuning is raised in physics, or biochemistry—that is, whether the appearance of biological features such as vision, locomotion, nervous systems, brains, and intelligent behavior is inevitable, rather than the preservation of a given species. I have further argued throughout this chapter that contingency does not contradict a certain repetition of natural history. Evolution allows a certain degree of predictability of the eventual biological properties that are likely to evolve, mainly because of convergence in the life sciences, but especially, as we have stressed repeatedly, because of the useful new concept of convergence in the space sciences.

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2008
The Clockmaker Returns
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A review of "The Case for Divine Design: Cells, Complexity, and Creation" by Frank B. Salisbury
Provo, Utah: Maxwell Institute

For much of the twentieth century, few geologists believed, in spite of evidence to the contrary, that continents could drift. Continental drift was called "geopoetry" because there was no known mechanism to drive continents through the hard oceanic crust. Now continental drift is "geoscience" because the theory of plate tectonics explains the motion. Similarly, cosmology was once considered to be nonscience because there was no way to test hypotheses. Now there is powerful observational evidence and an impressive theoretical base for the science of cosmology.

Observational and experimental evidence for evolution are sufficient to justify the assertion that the origin of living species by evolution from ancient species is as close to being a fact as any historical description can ever be. The theory of evolution (especially with regard to the mechanisms that drive evolution) is very advanced, although not yet complete. But how did life begin in the first place? Is the origin of the first living cells a science? That is one of the major questions explored in Frank Salisbury's book The Case for Divine Design.

Except for religious fundamentalists, including the Creationist[1] community, few informed people doubt that evolution has produced our biological world. This book largely ignores the debate on evolution per se and concentrates on a new version ("intelligent design," or ID) of an old idea (namely, the watchmaker analogy made famous by William Paley in 1802; see appendix B in Salisbury's book).

One of the basic premises of ID is that some essential structures or processes are too complex to have arisen by chance. The concept of "irreducible complexity" has been used by Creationists for a long time. A commonly cited example is the vertebrate eye. A structure or process that requires many different parts, not one of which is functional without all of the others, could not have arisen by sequential addition of the parts, one at a time. In the case of the eye, that argument failed when scientists discovered that each part made the light-detecting apparatus more adaptive, even in the absence of some or all of the other parts. More recently, the supposed irreducible complexity of subcellular processes and structures has attracted a great deal of attention (see examples in appendix C).

The Creationists have eagerly adopted the subcellular version of irreducible complexity in an attempt to force public schools to teach ID in science classes as a way to undermine the teaching of evolution. The one court case to date denied their attempts, ruling that ID is not science. Like nearly all other scientists, Salisbury agrees that ID is not science, since there is no apparent way to support it or refute it by observation or experiment. However, he apparently finds ID to be an attractive possible explanation for the origin of life.

In chapter 1, Salisbury briefly examines the nature of scientific research as a way to discover how the world works. He also discusses the role of scripture, belief, and revelation in discovering religious truth. In several places, he uses the differences in these two approaches to explain why ID is not science. He also makes a good case for why some scientists' statements about the origin of life are not yet science either. He points out that research on the origin of life could become science in the future if someone were to figure out how to do relevant experiments that address the crucial questions. He emphasizes the danger of basing belief in God on ignorance about something that might someday be explained.

In chapter 2 and elsewhere, Salisbury shows that evidence for evolution of living organisms from more primitive forms over vast periods of time is very strong. However, he correctly points out that it cannot be shown that God had no hand in the history of life. Salisbury suggests that perhaps God occasionally tweaked the process to accomplish what he had in mind. Salisbury repeatedly uses a probability argument (especially in chapter 4) to suggest that it is reasonable to infer that a designer occasionally crafted new DNA sequences to produce novel kinds of proteins during the history of life. He does not make the claim that this proves the existence of God, but apparently he finds it a compelling argument that strengthens his own belief. I am not so convinced by this part of the book. Probability arguments are always treacherous since they depend so strongly on assumptions about the nature of things that we do not know and, in many cases, cannot know.[2] I am also troubled by the fact that, so far at least, there is no convincing evidence of directionality, steady progression to an end, in the evolutionary record. Although Homo sapiens is the only species of our genus to survive, there were many other species, now extinct, that diverged from our direct-line ancestors.

Human beings and every other living thing we have looked at carefully are continuing to evolve, and recently mutated genes that make organisms better adapted to their environment have been described. For instance, a mutation appeared in humans in a town in Italy just a few hundred years ago that prevents cholesterol from damaging the arteries of those who have the mutant gene. These people routinely live for about a century.[3]

Chapter 5 may be the most important chapter in the book. Salisbury shows quite convincingly that, with regard to the origin of cellular life, there is no scientific hypothesis that is supported by experiment or observation. Since the book was written, more work has been published, but in my opinion it does not invalidate Salisbury's arguments.[4]

Just as I dislike false claims made by Creationists, I dislike false claims or misstatements made by some scientists and textbook writers who say that we know how life began. In fact, we do not. The claims are made because of the philosophical beliefs of the people who write and adopt the texts and because of pressure from the general scientific community. In my experience, many scientists are atheists or are indifferent to religion.[5] If one believes there is no god, it is obvious that life must have originated spontaneously because there is no other possibility, and it is only a matter of time until we discover how it occurred. It would be much more honest for textbooks to say that while we do not know how life originated, future research may shed light on the matter—and perhaps it will.

There are scientific hypotheses about prebiotic (chemical) evolution, based on experiments showing that complex organic molecules can arise spontaneously, in the laboratory and in nature, from a mixture of simple molecules and a source of energy. The prebiotic hypotheses seem credible and worthy of more research.[6] The origin of living cells is a much more difficult problem. Although the term irreducible complexity has become a red flag to many scientists, it seems appropriate in this context. A cell worthy of the name must have both an information storage mechanism (presumably RNA or DNA) that contains useful information and a translation mechanism to put the information into usable forms. In Salisbury's opinion, and mine, the "RNA world" hypothesis does not solve the problem. The problem is difficult enough that Nobel Prize–winner Francis Crick coauthored a paper with Leslie Orgel suggesting that perhaps the first living cells were carried to earth from some other place.[7] It is also not clear how eukaryotic cells (the kind found in plants, animals, fungi, etc.) could have arisen from the apparently earlier prokaryotic cells (bacteria and Archaea), although there is good evidence that some parts of eukaryotic cells were derived from symbiotic prokaryotes.

Michael Behe, a biochemist at Pennsylvania's Lehigh University, is the foremost spokesman for ID in the scientific community, where his ideas have had a very hostile reception. In chapter 6 Salisbury reviews Behe's ideas and the responses of his critics and then discusses his own views on the matter. Behe continues to publish, and his critics continue to respond.[8] Although Salisbury has a lot of sympathy for Behe's ideas, he makes it very clear that he does not consider ID to be science or to be appropriate for the science classroom.[9]

To be sure, feelings within the scientific community about ID and irreducible complexity are strong. To illustrate, a research paper on the origin of eukaryotic cells[10] provoked a critical letter that, after a technical discussion, ended with this paragraph:

Finally, and most disturbing, if contemporary eukaryotic cells are truly of "irreducible nature," as Kurland et al.'s title declares, then no stepwise evolutionary process could have possibly brought about their origin, and processes other than evolution must be invoked. Is there a hidden message in their paper?[11]

What I find most disturbing about this paragraph is that it sounds very similar to comments made by some Latter-day Saint Creationists about Latter-day Saint scientists who are perceived to be friendly to the theory of evolution. Are scientists justified in being so thin-skinned when it comes to ID? Perhaps they are. The Creationists have been so dishonest, so aggressive, and so single-mindedly antiscience for over a hundred years that scientists generally detest them and all that they stand for. It is not surprising that many scientists (including me) are very wary about anything the Creationists say. Unfortunately, ID per se has come to be seen as guilty by association with Creationist literature. I do not condemn members of the scientific community for their reaction, but I wish they were more aware of the identity of their true enemies.

In chapter 7 and appendix D, Salisbury makes his personal scientific and religious views explicitly clear. They are interesting, and for what it is worth, I feel much the same way.

Salisbury's book is a sound introduction to most of the topics related to the origin of life. It contrasts the possibilities of spontaneous generation of life with a creationist view. It is written for an intelligent reader who is not necessarily well-grounded in science. I strongly recommend the book to anyone who is troubled by the often acrimonious debate concerning evolution and creation.

[1]In this review, the lowercased word creationist refers to anyone who believes that God was involved in some way in the creation of life. When I capitalize the word Creationist, I am referring to members of political groups who have attempted, for the last few decades, to persuade school boards, and subsequently courts, to mandate the inclusion of their religious views about evolution in public school textbooks and other teaching materials, as well as the teaching of those ideas in science classes. The Creationist community has tried to make a case for what they call "creation science" largely by ignoring the discoveries of science, by appealing to magic, or by dismissing those discoveries because they do not agree with an absolutely literal interpretation of the Bible, particularly Genesis. Salisbury briefly reviews some Creationist beliefs in appendix A.

[2]These are post hoc probability arguments. Salisbury calculates the probability that something could have happened, even though we now know that it did happen. Once something has happened, then the probability that it could have happened is 1 (certainty). For instance, roulette wheels have occasionally produced a very long sequence of red (or black). Consider a run of twenty blacks in a row. If we make the slightly simplifying assumption that the probability of black is 0.5, then the probability of twenty in a row is (0.5)20 = 0.00000095, or about one chance in a million. Someone who observes such an unlikely run might conclude that it could not be due to chance, but of course it can be.

One should also be aware that, if the roulette wheel is unbalanced, the chance of such an unlikely run might be much higher (or lower). Is our universe "unbalanced" in that formation of unlikely DNA sequences is more likely than we think?

[3]"A Rare Protein Mutation Offers New Hope for Heart Disease Patients," Berkeley Lab Research News, 17 May 2002, http://www.lbl.gov/Science-Articles/Archive/LSD-Milano-Bielicki.html (accessed 21 August 2008).

[4]These are a few of the more interesting recent articles: Claudia Huber and GŸnter WŠchtershŠuser, "a-Hydroxy and a-Amino Acids Under Possible Hadean, Volcanic Origin-of-Life Conditions," Science 314 (2006): 630–32; Jeffrey L. Bada et al., "Debating Evidence for the Origin of Life on Earth" (letter), Science 315 (2007): 937–38 (see in Science 315 GŸnter WŠchtershŠuser and Claudia Huber's response, 938–39); Irene A. Chen, "The Emergence of Cells During the Origin of Life," Science 314 (2006): 1558–59; W. M. Napier, J. T. Wickramasinghe, and N. C. Wickramasinghe, "The origin of life in comets," International Journal of Astrobiology 6 (2007): 321–23; Philipp Baaske et al., "Extreme accumulation of nucleotides in simulated hydrothermal pore systems," Proceedings of the National Academy of Sciences of the United States of America 104 (2007): 9346–51.

[5]An interesting recent book review discusses several aspects related to this subject: Olle HŠggstršm, review of Irreligion: A Mathematician Explains Why the Arguments for God Just Don't Add Up, by John Allen Paulos, Notices of the American Mathematical Society 55 (2008): 789–91, http://www.ams.org/notices/200807/tx080700789p.pdf (accessed 20 August 2008).

[6]An excellent, short commentary on this work is available on the Internet: Eugene V. Koonin, "An RNA-making reactor for the origin of life," Proceedings of the National Academy of Sciences of the

United States of America 104/22 (2007): 9105–6, http://www.pnas.org/content/104/22/9105 (accessed 20 August 2008).

[7]F. H. C. Crick and L. E. Orgel, "Directed Panspermia," Icarus 19/3 (1973): 341–46.

[8]Michael J. Behe, The Edge of Evolution: The Search for the Limits of Darwinism (New York: Free Press, 2007); Sean B. Carroll, "God as Genetic Engineer," Science 316 (2007): 1427–28; Michael J. Behe, "Addressing Cumulative Selection" (letter), Science 318 (2007): 196 (see in Science 316 Sean B. Carroll's response, 196).

[9]For a current summary of Salisbury's position, see Frank B. Salisbury, "Simple answers to creation" (letter), Deseret News, 2 May 2008, section A14.

[10]C. G. Kurland, L. J. Collins, and D. Penny, "Genomics and the Irreducible Nature of Eukaryote Cells," Science 312 (2006): 1011–14.

[11]William Martin et al., "The Evolution of Eukaryotes" (letter), Science 316 (2007): 542–43 (see in Science 316 C. G. Kurland et al.'s response, though it does not address the quoted paragraph). Both letters are available at http://www.sciencemag.org/cgi/content/full/316/5824/542c (accessed 21 August 2008).

January 2008
Elder Douglas L. Callister
Our God Truly Is God
Ensign, Jan 2008, 64-68

From a devotional address given at Brigham Young University-Idaho on November 8, 2005. For the full text, please visit www.byui.edu/devotionalsandspeeches.

Recognizing the Lord's Hand
Naturalism's explanations of the origins of life and the miracle of our bodies often appear convoluted when placed side by side with the simple truths of the revealed word and divine scripture.

With its 107 million cells, connected to the brain by over 1 million neurons, the eye is more perfect than any camera ever invented. It caused Charles Darwin to humbly admit, "That the eye with all its inimitable contrivances … could have been formed by natural selection, seems, I freely confess, absurd in the highest sense."1

The Psalmist wrote, "The fool hath said in his heart, There is no God" (Psalm 53:1). Such a foolish disbeliever ought to look at his hands. Seventy muscles contribute to hand movements. Much of the rest of the body is devoted to optimizing the complex function of the hand. There are no muscles in the fingers. The sole purpose of the forearm, its muscles and bones, is to move and position the hand.

To observe a miracle, look at a baby's creased hand. Its initial movements are uncontrolled. Shortly after the child's birth, the hand will be able to grasp, curl, push, lift, sense hot and cold, respond to pain by withdrawing, heal itself, and display great strength and extraordinary sensitivity. These hands will be used thousands of times each day without forethought.

Your miraculous thumb is controlled by nine individual muscles and three major hand nerves. Sir Isaac Newton is reported to have said: “In the absence of any other proof, the thumb alone would convince me of God’s existence.”2

Paul Brand, renowned orthopedic hand surgeon, wrote: “We use our hands for the most wonderful activities: art, music, writing, healing, touching. Some people go to concerts and athletic events to watch the performance; I go to watch hands. For me, a piano performance is a ballet of fingers—a glorious flourish of ligaments and joints, tendons, nerves, and muscles.”3

The infant Son of Man once possessed tiny hands. His hands, too, grew to accomplish their intended purposes. He used them to touch and heal the blind and infirm. His hands threw the money changers out of the temple. His hands reached upward in prayer, outward in blessing, and downward from the cross.

The fool proclaims in his heart that there is no God, but our eyes, hands, hearts, and souls unhesitatingly testify to the contrary.

One of my brothers is a physician. During medical school he was assigned to study anatomy in companionship with an agnostic. Their education eventually required that the two of them carefully examine and dissect a cadaver. They studied the incredibly complex yet harmonious systems of the body. They noted the body’s power to correct its own deficiencies and to send healing antibodies to the place of injury or infection. They learned of over 150 trillion cells within the body. If set end-to-end, these cells would encircle the earth more than 200 times. Today medical students learn of more than 1 billion miles (1.6 billion km) of DNA in one human body. My brother and his fellow student learned of a brain that continually receives signals from 130 million light receptors in the eyes, 24,000 hearing receptors in the ears, 10,000 taste buds, and hundreds of thousands of receptors in the skin, with specialized commissions to recognize touch, vibration, cold, heat, and pain. My brother and his friend became silent as they contemplated the miracle they were examining. Sensing the moment was right, my brother challenged: “Coincidence is a marvelous thing, isn’t it?” His agnostic classmate responded, “You win.”

This earth departs from its orbit of the sun by only one-ninth of an inch (2.82 mm) every 18 miles (29 km). If, instead, it changed by one-tenth of an inch (2.54 mm) every 18 miles, we would all freeze to death. If it changed by one-eighth of an inch (3.18 mm), we would all be incinerated.4 Did this all happen by accident?

Alma spoke to us, as well as to Korihor, testifying, “Yea, and all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator” (Alma 30:44).

The doubter requires too much of us when he asks us to believe that the miracles of eyes and hands and DNA and order in the universe all happened by chance. The passage of time, even long intervals of time, is not a “cause” and provides no answers without an intelligent designer.

The evidence of Heavenly Father’s existence is everywhere: in every newborn babe and in every system, part, and parcel of the unending and orderly universe, including our own bodies. He is evidenced in every sunset, work of art, and passage of music, all of which He has provided to gladden the heart and bring beauty to our lives. Richard Swinburne said: “God paints with a big brush from a large paintbox and he has no need to be stingy with the paint he uses to paint a beautiful universe.”5

It is not possible to contemplate the immeasurable vacuum and purposelessness that would exist in our lives if He were not there. We would regret the passing of every day and the passing of every loved one, knowing that neither time nor relationships could be extended. We would approach the autumn and then the winter years of life with crescendoing fear. Every day of our lives we should thank Him that He is there and that this life is not all there is.

Valuing the Agency of Man
Some ask where God is because there is pain on this earth, and He does not usually hasten to intervene. One flippantly approached this issue by suggesting that God ought to have made good health contagious rather than disease.6 However, such thinking misses the whole point of our mortal existence, which is probationary rather than paradisaical in nature.

If babies could talk and could remember their pre-earthly estate, their first utterances might express: “You came here to be tested. You agreed to that. The tests will be hard, in part because they are seldom the tests you anticipated. This is a closed-book test in that you will not remember your premortal estate. God will not intervene and remove the tests until the close of the examination or probationary period.” That Heavenly Father does not hasten to intervene does not mean He is not there or does not love us. He has infinite respect for our agency and the purposes of earth life.

Agency is not just the right to select among good alternatives. When God granted agency, He necessarily contemplated the possibility of wrong choices. Because He knows best and esteems so highly our precious agency, He does not answer every prayer just as it is uttered. Nor does He always punish transgressors before there has been an opportunity or a space for repentance. This Divine hesitancy is to our advantage.

2008
By Orson Scott Card
Intelligent Conversation
Article in The Rhinoceros Times, Greensboro, NC

In a world where a snob like Michael Moore and a smug manipulator like Al Gore can win Oscars for "documentaries" that play fast and loose with the truth, it's ironic that Ben Stein's Expelled: No Intelligence Allowed, which makes a serious effort to tell the truth about a problem that's seriously damaging our civilization, not only won't get nominated for an Oscar but will certainly be attacked as anti-scientific.

This is the opposite of the truth, or very nearly so. Ben Stein's film project was to expose the way rigid insistence on Darwinist dogma is expelling not only brilliant individuals but also truth itself from the public conversation of science.

To do this, he tackles the issue of "intelligent design" (ID), which is detested by atheists -- and many believers -- as an unscientific insistence that what can't yet be explained by science must therefore be the result of a deliberate act by some unidentified intelligence.

Of course, almost all adherents of ID have in mind that the "intelligent designer" is God.

But Expelled is not trying to preach or even defend ID. The technical arguments are far too complicated to explain in a movie. What Ben Stein is trying to do is expose the way anyone who dissents from Darwinist orthodoxy is punished and silenced.

It is the curse of our age. The Left, now that it is in control of our elite institutions, is at least as rigid and inclined to persecute dissenters as the Right was during the 1950s. This is tolerable in English departments ruled by political correctness, where almost nothing is at stake, but it is dangerous when such rigidity is applied in the sciences.

Yet most of those who are actively suppressing ID do so with the idea of protecting science.

Why Intelligent Design Is Wrong
I think Ben Stein's movie deals fairly yet powerfully with a vitally important issue and should be seen by everyone with enough education to make sense of it (which means not your average middle school student).

But let me make it clear from the start that I believe Intelligent Design is wrong and potentially dangerous -- and shouldn't be taught in science classes as if it were a scientific theory, because it is not.

At the same time, ID is not "Creationism." Creationism was a ludicrous attempt to twist the physical evidence collected by geologists, paleontologists, and biologists, and pretend that it did not contradict the seven-days-of-creation model of Genesis.

Intelligent Design is not trying to prove the Bible. It starts from the premise that the facts on the ground are correct: It took billions of years to get from the creation of our solar system to the present state of life on Earth. The believers in ID do not deny the evidence -- they insist on it.

They embrace the idea that life began very simply and progressed through stages to ever-more-complex organisms, including the extraordinary complexity of the human species. They accept the links and bonds between humans and animals and are untroubled by the idea that human beings evolved from less-intelligent predecessor species.

However, they also see that the specific hypotheses of Darwinism do not fit the evidence. In short, evolution obviously happened, but Darwinism is not a sufficient explanation of how and why it happened.

So far, I am in complete agreement with them. Darwinism is grossly inadequate to explain very much of what we see; furthermore, most cutting-edge molecular biologists are keenly aware of the enormous burden that any explanation of evolution must bear at the level of the cell.

The questions raised by critics of Darwinism are fundamental. Darwin's model, even when adjusted by the punctuational model of evolution and other attempted fixes, is simply inadequate. We need a better model in order to make sense of how life persists, changes, adapts, and improves.

Even terms that we once thought we understood -- like "life" and "species" -- are being challenged by the evidence being gathered at the frontiers of biology and paleontology.

The problem with ID Theory is that they make an unwarranted intellectual leap. Just because the Darwinian model is inadequate or even contradicted by the evidence does not mean, imply, or even hint that the best alternative explanation of the evidence is that it was designed by an intelligent creator.

Even when you coyly insist that you don't necessarily refer to God, Darwinism and ID are not the only two conceivable choices, and the assumption of Intelligent Design is counterproductive and antiscientific.

Unfortunately, the opponents of ID are making assumptions that are just as counterproductive and antiscientific -- and they're behaving very badly in the process. And because the Darwinists have all the power in the scientific establishment, their antiscientific behavior is by far the more dangerous problem, because it is causing damage right now, whereas the danger posed by ID is only a potential problem.

Why Science and Faith Don't Mix Well

It is not that science disproves -- or tries to disprove -- the existence of God. The acts of a transcendent creator are simply outside the realm of anything that science can examine.

Science is the process of trying to discover mechanistic causes of publicly observable phenomena. The trouble is that causation cannot be positively proven. Ever. Under any circumstances.

So the best that scientists can do is make guesses (hypetheses) about causation and then conduct experiments designed to prove those guesses wrong. If the experiments don't prove them wrong, then the guess is considered to be a good one, an educated one, and scientists assume that it is true, or true enough, until new evidence emerges to contradict it.

But in science, no answer is ever final. No assumption of cause is beyond question. We never know enough to say, "This subject is now closed."

And that's just on the subject of mechanical cause. When it comes to final cause, which we call "purpose" or "motive," science is simply helpless. It is up to historians and biographers and fiction writers to provide motive and purpose and meaning -- and their work is specifically considered not to be science.

Scientists must therefore conduct their work as if the entire universe were one big machine, in which everything that happens is caused to happen by outside forces that push on each other.

Every serious student of science knows that this does not imply that the mechanical model of the universe is a complete explanation of anything -- it's not provable, it's simply the assumption that must be made before any useful scientific work can take place.

Here's why: The moment you allow transcendent or metaphysical forces into the equation, by definition they cannot be measured or replicated on demand. So the moment you say, "This event does not have a mechanical cause, but rather a spiritual/intelligent/purposive/magical one," science has stopped cold.

Think how much progress medicine made back when diseases were blamed on gods, and "treated" through sacrifices or prayers alone. Whether invoking gods does any good is a matter of faith; it will never lead you to effective medical treatments.

That is why science simply cannot admit God -- or Intelligent Design -- into the public discussion of science. The moment transcendent forces are invoked, science ends. And that's why I am among those who do not want to see Intelligent Design offered as a scientific alternative to Darwinism in science classes. It is, at best, a distraction; it is not that ID is wrong, it's that it's irrelevant to the project of science.

Why Faith in Darwinism Is No Better

Just because ID cannot be part of the public discussion of science does not mean, however, that people who believe in Intelligent Design cannot be trusted to do good science.

Most scientific discoveries through history have been made by people who believed in God. Period. That's a historical fact.

Why shouldn't a scientist believe that the natural world has a purpose, that it was designed by God, and that life has value for reasons having to do with the purposes of that God? As long as he recognizes that science deals only with mechanical causation, his personal faith will not interfere with his ability to examine the evidence and perform useful and accurate experiments.

In fact, it is an open secret that throughout the sciences, researchers constantly use purposive assumptions to arrive that the hypotheses they test. They may disguise these assumptions by speaking of "elegant" solutions, or "symmetry," but the fact is that scientists commonly expect the universe to make sense. And "making sense" is a very unscientific idea.

Science thus becomes a game -- you are allowed to play only within the rules. But within that sandbox, scientists have made extraordinary discoveries that have transformed our understanding and our lives.

The tragedy is that many scientists forget that the assumption of mechanical causation has not been proven and cannot be. It is a natural human trait to want to believe that what we accomplish in our lives is real, that is has permanent, lasting value. Not all people are able to maintain the humility of a true scientist -- knowing that all his work will inevitably be contradicted, amplified, or otherwise redone by somebody else. And it is profoundly annoying to some of them, at least, to have to admit that they are only playing a game.

No! It's the real world we're dealing with!

But it's not. It's guesses about the real world, and only guesses that pertain to mechanical cause.

Today, though, we have many scientists who think they're saying something intelligent when they proclaim that this or that discovery makes it "no longer necessary to believe in God."

The necessity of believing in God is not a topic that science can even address. No scientist is competent, using the tools of science, to make even the slightest useful remark on the subject. But the Darwinists refuse to admit that they are making an enormous leap of faith when they say, "We can explain everything without reference to God."

Even if this statement were remotely truthful, it would still have this unspoken limitation: Ability to explain things without reference to God does not prove or even indicate the nonexistence of God.

And the statement is not truthful. It is invariably made by scientists working in fields where we are most ignorant. When scientists began to study molecular psychology, for instance, we started getting ludicrous, unscientific statements like, "There is no longer any reason to believe in the existence of the soul."

Such statements are always accompanied by clear indications that what we're seeing is faith and hope (but not charity): "Within ten years, scientists expect that we will know/be able to/understand/learn ..."

Yeah, right. That's a guess, folks. Wishful thinking.

In the case of Darwinism, however, the faith is no longer justified. Darwin, working in an era before we understood the workings of the cell, simply had no way of knowing just how complicated things could get. Clearly "random variation plus natural selection" is not a sufficient explanation.

Ben Stein's movie clearly documents the fact that Darwinists are trying to ban good scientists from the field, not because (or not just because) they believe in God, but because they question the dogmas of Darwinism and publicly point out the flaws in the Darwinian model.

The assumption of Intelligent Design is scientifically useless. But so is the assumption that any idea is so essential to science that it cannot be or must not be questioned, doubted, or even disproved.

Real Science Is in Danger

As long as scientists work within the sandbox of mechanistic causation and publish their results and their methodology fully and honestly, so others can duplicate their experiments and see if they get the same results, then there should be no other standard.

Credentials, national origin, race, gender, and religious faith have often been used as excuses for barring someone from the public conversation of science, but none of these are legitimate reasons.

If a professor of science believes in intelligent design, what does that matter if his science is good?

On the other hand, just because Darwin's theories led to useful results in the past (and they definitely did) does not mean that they are true. Nothing in science is true -- it is only useful and/or not disproven yet.

If ID were the only case in which scientists were silenced -- denied tenure, denied publication, denied grants, not because of the content of their science, but because of their beliefs -- I would not view the situation with so much alarm.

But this insistence on dogma at the expense of science is pervasive. Global warming, for instance, became an instant dogma, long before serious data were collected, and right now good scientists are being denied tenure and other forms of institutional support solely because they make the obvious and truthful statement that we have no idea whether humans are causing global warming or even if global warming is causing or will cause or can cause harm.

Results have been faked in the cause of global warming -- hoaxes as obvious and anti-scientific as Piltdown Man -- and yet the faith persists and the perpetrators are not punished or exposed. The "hockey stick" report was treated as science, even though the perpetrators never published their data or explained their methodology, sure signs that what we're seeing is not science.

Faith in global warming is an orthodox religion, and anyone who questions it is being treated like a heretic, while fakery "in a good cause" is tolerated. The result? Science is over to the degree that the global warming orthodoxy succeed in silencing "dissenters" (i.e., actual science).

Likewise, we have had some very, very bad science -- to the point of dishonesty and fabrication -- in other politically correct areas. Remember the claim that girls were being "kept down" in school because the whole system treated girls worse than boys? Every demonstrable fact about our educational system contradicted this idea. Not only that, but the researcher who supposedly "discovered" this "problem" never published her data. Yet it was treated as if it were real science -- and still is.

So here we are, in a situation where "scientists" are actually voting on matters that can only be decided by the evidence; where effective scientists with excellent records are being expelled from their field and silenced only because of their beliefs about matters outside the realm of science.

And that's what Ben Stein's Expelled: No Intelligence Allowed is about.

Slander?

Some will complain about the fact that Ben Stein links Darwinism with, of all things, the Holocaust.

But that is one of the most important -- and valid -- points in the movie. First, Hitler was a Darwinist. We have forgotten, in our post-racist philosophy, that one of the prime results of Darwinism was the "science" of eugenics. Planned Parenthood began, just like Nazi death camps, with the prime goal of improving the human race by eliminating any chance for "inferior" groups to reproduce. It may be rude to say so, but it's still a fact.

Darwin's theory did not contain these atrocities, but he himself reached those conclusions, wondering why we coddled the feeble-minded and other inferiors, and allowed them to reproduce.

When I hear zealots of atheism like Richard Dawkins cite religion as the cause of most of the evils in the world, I would laugh if it were not such a profoundly ignorant statement. (It is proof, if you want it, that historical causation is not a scientific study.)

The historical fact is that the normative religions -- religions that offer codes of conduct that promote altruism and tolerance, like Buddhism and Christianity -- have acted as a brake on the natural tendency of human beings to be bestial to each other when fear or power-lust makes it seem necessary or desirable.

It is not an accident that the worst atrocities in all of history -- the Holocaust, the deliberate destruction of the Kulaks in the USSR, the Killing Fields of Cambodia -- all were perpetrated by people who had "left religion behind."

When there is no moral restraint, no sense of transcendent responsibility, then why shouldn't powerful people do whatever they think is right? On what basis would a committed atheist like Richard Dawkins prove to us that Hitler was wrong? Science is simply mute on issues of values. Dawkins has no scientific basis for opposing or even criticizing Hitler or Stalin in any way. I'm sure that he would condemn them -- but he could not tell us why in terms that were even slightly more rational than any religion.

The concept of "good" recedes infinitely, resisting noncircular definition. Even when you find a good definition of "good," you can't say why it is a better definition than any other. But people of faith in a normative religion have decided and committed themselves to a code of decent conduct, not because it has been scientifically proven to be "better," but because they believe it to be better on an admittedly unscientific basis.

What Dawkins and other true believers in Darwinism cannot explain is how their faith will lead to a better world in any way. Their philosophy is an ugly negation of other people's faith, not because they themselves are beyond faith, but because they are so sure their faith is true they believe it justifies any action they take in order to assure the triumph of their beliefs over all others.

That's religious fanaticism, whether or not you posit the existence of a god.

The Danger Is Real
It has happened before -- valuable knowledge is lost, along with the knowledge of how to get knowledge. Ancient Egyptian medicine was known to be the best in the world -- specifically because a generation of physicians actually tested their remedies to make sure they worked. But within a few generations, their successors had made the insane (but common) choice to treat the conclusions of these great physicians, rather than their methods, as sacred.

So Egyptian medicine, the best in the world at that time, ossified and, in effect, died. They stopped progressing because they valued the conclusion over the method of learning.

That is what is happening right now with Darwinism, with global warming, and with other politically dominated areas of scientific inquiry. The desirable conclusion is now regarded as being more important than the methodology of science; thus we have serious efforts to shut down any questioning of Darwinism or global warming or other subjects, when every real scientist knows that nothing can ever be beyond question or science is dead.

See This Movie
People flocked to see Al Gore's pack-o'-lies movie because it put forth the orthodoxy of the elite. People flocked to see Michael Moore's deceptive, smug, sneering documentaries because they only attacked people that ignorant elitists have declared to be valid targets. These films have made millions of dollars and have advanced the amount of ignorance in the world.

Ben Stein's Expelled is well made, funny at times, and also disturbing. It's far more honest and accurate than the works of either of the above-mentioned Oscar-winning documentarians. And the issues he discusses are vital.

Meanwhile, though, you will still find me among those demanding that only science be taught in science classes. Intelligent Design is an unprovable hypothesis that has no place in science education.

Unfortunately, classical Darwinism is also an unproven -- and in many ways disproven -- hypothesis that needs serious reexamination. Too bad that in the effort to preserve Darwinian orthodoxy, its proponents are doing more damage to science education than the Intelligent Design folks could ever do.

2009
Robin Collins, Christian Philosopher
Chapter 4 - The Teleological Argument: An Exploration of the Fine-Tuning of the Universe
Chapter in book “The Blackwell Companion to Natural Theology” Edited by William Lane Craig and J. P. Moreland

1. Introduction: Setting Up the Argument

1.1. Nature of project and summary of sections
Historically, the argument from design probably has been the most widely cited argument for the existence of God, both in the West and the East (such as in theistic schools of Hinduism). Modern scientific discoveries, particularly the discovery beginning around the 1950s that the fundamental structure of the universe is “balanced on a razor’s edge” for the existence of life, have given this argument significant new force in the last 30 years, with several books and many essays written on it.1 This precise setting of the structure of the universe for life is called the “fine-tuning of the

cosmos." This fine-tuning falls into three major categories: that of the laws of nature, that of the constants of physics, and that of the initial conditions of the universe, each of which we shall explore in Section 2. As will become clear in Section 5.2, the sort of life that is most significant for the argument is that of embodied moral agents, of which humans are one example.

This chapter is a highly abridged version of an in-process book-length project in which I argue for the existence of God based on this fine-tuning of the cosmos for life along with the beauty and intelligibility of the laws of nature. The main purpose of the book is to put this argument on as rigorous as possible scientific and philosophical foundation. Although this chapter has the same purpose, it will focus solely on the argument based on the fi ne-tuning for life, although in my judgment the argument based on beauty and intelligibility is as strong.

The sections of this chapter are arranged as follows. In Section 1.2, I present some key terms and definitions for easy reference. In Section 1.3, I present the basic form of what I call the core fine-tuning argument for the existence of God. This argument is explicated in terms of what I call the restricted version of the Likelihood Principle. In Section 1.4, I present an alternative way of formulating the argument using what I call the method of probabilistic

Since I shall formulate the argument in Sections 1.3 and 1.4 in terms of certain conditional epistemic probabilities, I need to develop an account of conditional epistemic probability and a general method for determining the degree of conditional epistemic probability that one proposition has on another. I do this in Sections 3.1–3.3. In Sections 4.1–4.5, I address some further critical issues for my formulation of the fi ne-tuning argument, namely, the appropriate background information to use in the argument and the appropriate comparison range of values for the constants of physics. In Sections 5.1 and 5.2, I complete the core fine-tuning argument by using the results of the previous sections to derive the premises of the main argument presented in Sections 1.3 and 1.4.

In Sections 6.1–6.3, I address the so-called multiverse hypothesis as an alternative explanation of the fine-tuning, or at least as a way of undermining the fi ne-tuning argument for theism. The multiverse hypothesis is widely considered the leading alternative to a theistic explanation. In Sections 7.1–7.5, I reply to various miscellaneous objections to the fine-tuning argument, such as the so-called "who designed God?" objection. Finally, in Section 8, I conclude the entire argument.

My overall approach will be to present a version of the fine-tuning argument that is more rigorous than its predecessors by presenting the argument in a step-by-step fashion and then justifying each step using widely used principles of reasoning. This way of developing the argument will not only show that the argument can be developed in a philosophically principled way, but it automatically will answer many of the criticisms that have been raised against it; it also will help us go beyond a mere "battle of intuitions" between advocates and critics of the argument. Further, as much as possible, I shall avoid using theories of confirmation that attempt to account for everyday and scientific forms of reasoning but whose claims go significantly beyond what these forms of reasoning demand. Thus, for instance, I will avoid appealing to prior probabilities and to notions of purely logical probability that claim that relations of probability exist completely independently of human cognizers (see e.g. Sections 1.3 and 3.2).

1.2. Some key definitions, terminologies, and abbreviations

In this section, I shall define some key terminologies and abbreviations that are used in more than one section. This will help the reader keep track of my terms and symbolisms.

1 Embodied moral agents. An "embodied moral agent" will be defined as an embodied conscious being that can make morally significant choices, without prejudging the status of moral

truths. Our main concern, however, will be with embodied beings that are relevantly similar to humans – that is, who exist in a world with fixed laws and who can significantly affect each other for good or ill. Thus, whenever I talk about embodied moral agents, this is the type of agent I shall have in mind.

2 The existence of a life-permitting universe (LPU). This will always mean the existence of a material spatiotemporal reality that can support embodied moral agents, not merely life of some sort. Indeed, in every case where I use the word "life," I shall have in mind embodied moral agents as the relevant kind of life. The reason that embodied moral agents are the relevant kind of life will become clear in Section 5.2, where I argue that LPU is not improbable under theism. Throughout, it will be assumed that the existence of such beings requires a high degree of organized material complexity, such as we find in the brains of higher-order animals.

3 Fine-tuning of the universe; existence of a fi ne-tuned universe; fi ne-tuning evidence; fi ne-tuning data. To stay in conformity with the literature, I shall mean by the "fine-tuning of the universe" or the "existence of a fine-tuned universe" the conjunction of the following two claims: (i) the claim that the laws and values of the constants of physics, and the initial conditions of any universe with the same laws as our universe, must be set in a seemingly very precise way for the universe to support life; and (ii) the claim that such a universe exists, or when the background information includes the information that there is only one universe, the claim that this universe is life permitting, where this is an indexical that picks out the one universe that actually exists. When I speak of the "fi ne-tuning evidence (data)," or "the evidence (data) of fi ne-tuning," or variations of these, I shall be referring only to claim (i). The reason for this is that "evidence" and "data" implicitly refer to what physicists have discovered. Clearly, physicists have not discovered that the laws, constants, and initial conditions are life-permitting since we always knew that based on our existence. Rather, they have discovered claim (i). When I attempt rigorously to formulate the argument, the distinction between claim (i) and claim (ii), and the distinction between the "fine-tuning of the universe" and the "fi ne-tuning evidence (or data)" should be kept in mind.

4 Fine-tuning of a constant C of physics. When discussing a constant C of physics (see Sections 2.3 and 4.2), I shall use the term "fi ne-tuning" specifically to refer to the claim that the life-permitting range of C – that is, the range of values that allows for life – is very small compared with the some properly chosen "comparison range" for that constant. (For how to choose this comparison range, see Sections 4.3 and 4.4.) In connection with a constant C, the term "fine-tuning" will never be used to include the claim that it has a life-permitting value.

5 Constant C has a life-permitting value (Lpc). This denotes the claim that the value of a constant C is such that, given the laws of nature, the initial conditions of the universe, and the values of the other constants, the universe would allow for the existence of the relevant type of life – namely, embodied moral agents.

6 The Theistic hypothesis (T). According to this hypothesis, there exists an omnipotent, omniscient, everlasting or eternal, perfectly free creator of the universe whose existence does not depend on anything outside itself.

7 The naturalistic single-universe hypothesis (NSU). This is the hypothesis that there is only one universe, the existence of which is an unexplained, brute given, and that within that universe the laws and constants of physics do not significantly vary from one space-time region to another. NSU does not build in any hypothesis about the structure of the universe that does exist, other than that it is some sort of material, spatiotemporal reality that obeys physical laws; it also excludes any transcendent explanation of the universe, be that explanation theistic or nontheistic.

8 Multiverse hypothesis. This is the hypothesis that there are many universes or regions of space-time in which the constants and initial conditions of the universe, and in some versions the laws themselves, vary from universe to universe. The naturalistic multiverse hypothesis is the hypothesis that there is no transcendent explanation for such a multiverse.

9 P(A|B) and conditional epistemic probability. P(A|B) represents the conditional epistemic probability of a Proposition A on another Proposition B. See Sections 3.1 and 3.2 for details.

10 Background information k and k¢. k refers to our total background information, whereas k′ refers to some appropriately chosen background information – for example, for the case of the fine-tuning of the constants, k′ is the total background information minus the fact that a particular constant C has a life-permitting value. (See Sections 4.1–4.4 for how to determine k′ for the fi ne-tuning argument.)

11 Other symbols. << will always mean "much, much less than" – for example, P(A|B) << 1 will mean that P(A|B) is very close to zero since P(A|B) cannot have a negative value. ~P(A|B) << 1 will mean that it is not the case that P(A|B) << 1. Wr will usually refer to the width of the life-permitting range of a particular constant C of physics, and WR will usually refer to the width of the "comparison range" for that constant, which we argue is typically the EI region (see Section 4.4). The EI region for a constant will refer to the "epistemically illuminated" region – that is, the region of values for C for which we can determine whether they are life-permitting. A constant is fi ne-tuned if Wr/WR << 1; "BB" stands for "Boltzmann brain" (see Sections 6.3.3 and 6.3.4).

1.3. The basic argument presented: likelihood approach

My basic argument first claims that, given the fine-tuning evidence, LPU strongly supports T over the NSU. I call this the core fine-tuning argument. After developing this argument in Sections 2 through 5, I then present arguments for preferring T over the multiverse hypothesis (Section 6). Finally, in Section 8, I shall briefly consider other possible alternative explanations of the fi ne-tuning.

The core fine-tuning argument relies on a standard Principle of Confi rmation theory, the so-called Likelihood Principle. This principle can be stated as follows. Let h1 and h2 be two competing hypotheses. According to the Likelihood Principle, an observation e counts as evidence in favor of hypothesis h1 over h2 if the observation is more probable under h1 than h2. Put symbolically, e counts in favor of h1 over h2 if P(e|h1) > P(e|h2), where P(e|h1) and P(e|h2) represent the conditional probability of e on h1 and h2, respectively. Moreover, the degree to which the evidence counts in favor of one hypothesis over another is proportional to the degree to which e is more probable under h1 than h2: specifically, it is proportional to P(e|h1)/P(e|h2).2

The Likelihood Principle appears to be sound under all interpretations of probability. The type of probability that we shall be concerned with is what is called conditional epistemic probability. The conditional epistemic probability of a Proposition A on a Proposition B can be defined roughly as the degree to which Proposition B, in and of itself, supports or leads us to expect A to be true. In Section 3.2, I shall explicate this notion of probability in much more detail. Put in terms of epistemic probability, the Likelihood Principle can be reworded in terms of degrees of expectation instead of probability, in which case it becomes what I call the Expectation Principle. According to the Expectation Principle, if an event or state of affairs e is more to be expected under one hypothesis, h1, than another, h2, it counts as evidence in favor of h1 over h2 – that is, in favor of the hypothesis under which it has the highest expectation. The strength of the evidence is proportional to the relative degree to which it is more to be expected under h1 than h2. Rewording the Likelihood Principle in terms of expectation is particularly helpful for those trained in the

sciences, who are not familiar with epistemic probability and therefore tend to confuse it with other kinds of probability even when they are aware of the distinction.

Because of certain potential counterexamples, I shall use what I call the restricted version of the Likelihood Principle, although I shall often refer to it simply as the Likelihood Principle. The restricted version limits the applicability of the Likelihood Principle to cases in which the hypothesis being confirmed is non-ad hoc. A sufficient condition for a hypothesis being non-ad hoc (in the sense used here) is that there are independent motivations for believing the hypothesis apart from the confirming data e, or for the hypothesis to have been widely advocated prior to the confirming evidence. To illustrate the need for the restricted version, suppose that I roll a die 20 times and it comes up some apparently random sequence of numbers – say 2, 6, 4, 3, 1, 5, 6, 4, 3, 2, 1, 6, 2, 4, 4, 1, 3, 6, 6, 1. The probability of its coming up in this sequence is one in 3.6 × 1015, or about one in a million billion. To explain this occurrence, suppose I invented the hypothesis that there is a demon whose favorite number is just the aforementioned sequence of numbers (i.e. 26431564321624413661), and that this demon had a strong desire for that sequence to turn up when I rolled the die. Now, if this demon hypothesis were true, then the fact that the die came up in this sequence would be expected – that is, the sequence would not be epistemically improbable. Consequently, by the standard Likelihood Principle, the occurrence of this sequence would strongly confi rm the demon hypothesis over the chance hypothesis. But this seems counterintuitive: given a sort of commonsense notion of confirmation, it does not seem that the demon hypothesis is confirmed.

Now consider a modification of the demon case in which, prior to my rolling the die, a group of occultists claimed to have a religious experience of a demon they called "Groodal," who they claimed revealed that her favorite number was 2643156432162441366, and that she strongly desired that number be realized in some continuous sequence of die rolls in the near future. Suppose they wrote this all down in front of many reliable witnesses days before I rolled the die. Certainly, it seems that the sequence of die rolls would count as evidence in favor of the Groodal hypothesis over the chance hypothesis. The relevant difference between this and the previous case is that in this case the Groodal hypothesis was already advocated prior to the rolling of the die, and thus the restricted Likelihood Principle implies that the sequence of die rolls confi rms the Groodal hypothesis.3

Using the restricted version of the Likelihood Principle, the core fine-tuning argument can be stated as follows:

(1) Given the fine-tuning evidence, LPU is very, very epistemically unlikely under NSU: that is, $P(LPU|NSU \,\&\, k') << 1$, where k' represents some appropriately chosen background information, and << represents much, much less than (thus making $P(LPU|NSU \,\&\, k')$ close to zero).

(2) Given the fine-tuning evidence, LPU is not unlikely under T: that is, $\sim P(LPU|T \,\&\, k') << 1$.

(3) T was advocated prior to the fine-tuning evidence (and has independent motivation).

(4) Therefore, by the restricted version of the Likelihood Principle, LPU strongly supports T over NSU.

This argument is a valid argument since the conclusion (4) follows from the premises. Accordingly, the key issues for the argument will be justifying the premises and assessing the significance of the conclusion. Premise (3) seems obviously true since T was advocated long before the fine-tuning evidence came to light.4 Supporting Premises (1) and (2) in as rigorous a way as possible will require delving into and resolving several further issues. First, we shall need to be more precise on

what we mean by "epistemic" probability (Section 3.2) and to develop a preliminary theory of what it is that will be usable for our main argument. Second, we shall need to consider how epistemic probability is justifi ed (Section 3.3). In particular, in Section 3.3.2, I argue for what I call the restricted Principle of Indifference. Third, we shall need to carefully determine what the appropriate background information k′ is (Sections 4.1–4.6). If, for example, we were to include in k′ everything we know about the world, including our existence, then both probabilities in Premises (1) and (2) will turn out to be 1.0 since our existence entails LPU. Determining k′ will also provide a comparison region of law structures (or values for the constants) to which we are comparing the life-permitting region (Section 4.4). Having done this, we shall be ready to complete the argument for Premises (1) and (2) in Sections 5.1 and 5.2 – for example, we shall justify Premise (1) for the case of the fine-tuning of the constants by appealing to the restricted version of the Principle of Indifference defended in Sections 3.3.1 and 3.3.2.

Finally, given that we can establish the conclusion, what is its significance? Even if LPU counts as strong evidence in favor of T over NSU, that does not itself establish that T is likely to be true, or even more likely to be true than NSU. In this way, LPU is much like fingerprints found on a murder weapon. Via the Likelihood Principle, a defendant's fingerprints' matching those on the weapon typically provide strong evidence for guilt because the jury correctly judges that it is very unlikely for this matching to occur if the defendant is not guilty (and claims to have never seen the murder weapon), whereas it is not unexpected if the defendant actually used the murder weapon. Although such a match can provide strong evidence that the defendant is guilty, one could not conclude merely from this alone that the defendant is guilty; one would also have to look at all the other evidence offered. Perhaps, for instance, ten reliable witnesses claimed to see the defendant at a party at the time of the shooting. In that case, by the restricted version of the Likelihood Principle, the matching would still count as significant evidence of guilt, but this evidence would be counterbalanced by the testimony of the witnesses. Similarly, we shall claim that the evidence of fi ne-tuning significantly supports T over NSU; this, however, neither shows that, everything considered, T is probably true, nor that it is the most plausible explanation of existence of the universe, nor even that it is more probable than NSU. In order to show that any hypothesis is likely to be true using a likelihood approach, we would have to assess the prior epistemic probability of the hypothesis, something I shall not attempt to do for T.

Our more limited conclusion is nonetheless highly relevant to the rationality of and justification for belief in God, even though it does not itself establish that, all things considered, T is more probable than NSU. One could argue, for example, that in everyday life and science we speak of evidence for and against various views, but seldom of prior probabilities. For example, if one were to ask most physicists why they (tentatively) believe in General Relativity's approximate truth (or at least its future empirical fruitfulness), they probably would cite the evidence in favor of it, along with some of Einstein's motivations. They probably would not cast these considerations – such as Einstein's motivations – into talk of prior probability, either epistemic or otherwise. Of course, at the end of the day, some might say things such as "Einstein's theory is likely to be true," which is a notion of epistemic probability. But I can imagine them saying, "I have no idea what the prior probability of Einstein's theory is; all I will say is that Einstein had motivations for considering it and there are at least three strong pieces of empirical evidence in its favor." Indeed, I think it would be very difficult to estimate the prior probability of General Relativity's approximate truth (or future empirical fruitfulness) in any objective manner, since we should have to weigh incommensurable factors against each other – the simplicity of the mathematical framework of General Relativity against such things as the philosophically puzzling character of the idea of a four-dimensional space-time's being curved. Arguably, this is analogous to the case of T.

One way of putting my approach in perspective is to note that one of the most common philosophical objections to T is an updated version of one offered by Kant, in which the methods of

theoretical reason are restricted to justifying only the existence of natural causes. Unlike Kant, however, modern atheistic philosophers often reject God as a necessary hypothesis of practical reasoning. Typically, these philosophers claim that by analyzing the notion of explanation, particularly as exemplified in natural science, we find that to explain something involves citing overarching laws, mechanical causes, and the like; thus, they assert, the very notion of explanation involves a restriction to purely naturalistic explanations. The idea of God as providing a complete explanation of all contingent reality is therefore rejected as being empty, an improper extension of the notion of "explain" to places where it cannot apply. Another attack is to argue that even if God could be said to explain contingent reality, God's own existence would be as much in need of explanation.

Richard Swinburne (2004, chaps. 2–4) has responded to these critics by offering an alternative analysis of ordinary explanation. He claims that these critics have neglected the notion of personal explanation and then goes on to claim that God provides the best personal explanation of everything we know about the universe. His argument rests on the

dual claim that the simplicity of an explanation is the ultimate criterion of its adequacy and that God provides the simplest explanation of the universe. There are many places one might object to Swinburne's project, particularly these two claims about simplicity. Further, by basing his project on the notion of explanation used in everyday life, Swinburne leaves God's own existence entirely unexplained. Indeed, Swinburne claims that God is the ultimate contingent brute fact and could be said to necessarily exist only in the limited sense that God is without beginning and that, in principle, nothing could explain God's existence.

The approach I am taking avoids this question of how best to analyze the notion of explanation or whether God ultimately provides the best explanation of the universe. Rather, it simply attempts to establish the more limited claim that various features of the universe offer strong evidence in favor of T over its major naturalistic alternatives. I believe that establishing this more limited claim in a careful, principled way would alone be a great accomplishment. In Section 7.1, however, I address how this more limited claim fi ts into an overall argument for the existence of God. In that section, I also briefly address the issue of God's providing an ultimate explanation and respond to the claim that God is as much in need of a designer as the universe itself. A fuller discussion of this issue, however, is beyond the scope of this chapter.

1.4. Alternative version of argument: method of probabilistic tension

One problem with using simply the Likelihood Principle is that whether or not a hypothesis is confirmed or disconfirmed depends on what one builds into the hypothesis. For example, single-universe naturalists could prevent disconfirmation of their hypotheses by advocating the elaborated naturalistic single-universe hypothesis (NSUe), defined as NSU conjoined with the claim that the universe that exists is life-permitting: that is, NSUe = NSU & LPU. Similarly, theists could avoid any question about whether LPU is probable on T by constructing an elaborated theistic hypothesis (Te) which builds in the claim that God desired to create such a universe: Te = T & God desires to create a life-permitting universe.

One could attempt to deal with these sorts of moves by finding some principled way of restricting what can be built into the theistic and naturalistic hypotheses – for example, by requiring that the theistic and naturalistic hypotheses be some sort of "bare" theism and "bare" single-universe naturalism, respectively. This, however, is likely to run into difficulties not only in justifying the principle, but in defining what "bare" theism and "bare" single-universe naturalism are supposed to be. A simpler way of addressing the issue is by means of a concept I call probabilistic tension. A hypothesis h suffers from probabilistic tension if and only if h is logically equivalent to some conjunctive hypothesis, h1 & h2, such that $P(h1|h2) << 1$: that is, one conjunct of the hypothesis is

very unlikely, conditioned on the other conjunct. Among other things, a hypothesis h that suffers from probabilistic tension will be very unlikely: since P(h) = P(h1 & h2) = P(h1|h2) × P(h2) = P(h2|h1) × P(h1), it follows that if P(h1|h2) << 1 or P(h2|h1) << 1, then P(h) << 1.

I claim that significant probabilistic tension is an epistemic black mark against a hypothesis, and thus offers us a reason to reject it. To see this, consider the fi ngerprint example discussed earlier. We noted that based on the Likelihood Principle, the matching of a defendant's fingerprints with those on a murder weapon often strongly confirms the guilt hypothesis over the innocence hypothesis. Such matching, however, does not confi rm the guilt hypothesis over what could be called an "elaborated innocence hypothesis" – that is, an innocence hypothesis constructed in such a way that the matching of the fi ngerprints is implied by the hypothesis. An example of such a hypothesis is the claim that the defendant did not touch the murder weapon conjoined with the claim that someone else with almost identical fingerprints touched the weapon. This hypothesis entails that the fi ngerprints will appear to match, and hence by the Likelihood Principle the apparent matching could not confi rm the guilt hypothesis over this hypothesis.

Nonetheless, this elaborated innocence hypothesis suffers from severe probabilistic tension: one conjunct of the hypothesis (that some other person with almost identical fingerprints touched the weapon) is very improbable on the other conjunct (that the defendant is innocent) since it is extremely rare for two people to happen to have almost identical fingerprints. Given that the guilt hypothesis does not suffer from a corresponding probabilistic tension, the high degree of probabilistic tension of the elaborated innocence hypothesis gives us strong reason to reject it over the guilt hypothesis, even though this elaborated hypothesis is not itself disconfi rmed by the matching of the fi ngerprints.

This idea of probabilistic tension allows us to eliminate any arbitrariness with regard to how we choose the theistic and naturalistic hypotheses that we are confirming or disconfi rming.5 For example, both the theist and the naturalist can build into their respective hypotheses whatever is necessary for them to entail the relevant data. Then one can apply the method of probabilistic tension to these elaborated hypotheses. Consider, for instance, the NSUe and the Te defined earlier: that is, NSUe = NSU & LPU and Te = T & God desires to create a life-permitting universe. Both of these hypotheses entail LPU, and hence neither is confi rmed (via the Likelihood Principle) with respect to the other by LPU.

Now given the truth of Premise (1) of our main argument in Section 1.3, NSUe clearly exhibits a high degree of probabilistic tension relative to background information k′, since one conjunction of the hypothesis, LPU, is very improbable conditioned on the other conjunct, NSU: that is, P(LPU|NSU & k′) << 1.6 Given the truth of Premise (2), elaborated theism will not suffer any corresponding probabilistic tension. The reason is that according to Premise (2), it is not the case that P(LPU|T & k′) << 1, and hence it follows that it is not unlikely that the God of "bare theism" would desire to create a life-permitting universe. This means there will be no probabilistic tension between "bare" theism and the claim that God desires to create such a universe. This will be true even if the probability of P(LPU|T & k′) is merely indeterminate, since such a probabilistic tension would exist only if P(LPU|T & k′) << 1. Thus, the fi ne-tuning evidence causes NSUe to suffer from a severe probabilistic tension without causing a corresponding probabilistic tension in Te. Thus, because it creates this probabilistic tension, we could say that the fine-tuning evidence (but not LPU itself) gives us strong reason to reject NSUe over Te.

In practice, any sufficiently elaborated hypothesis will suffer from severe probabilistic tension somewhere. For instance, the elaborated guilt hypothesis mentioned earlier could include that the knife used in the murder was green, had a certain shaped scratch mark on its handle, had a weight of 0.15679876675876 kg, and the like. The corresponding elaborated innocence hypothesis would

include the same data. Both would suffer from severe probabilistic tension with respect to each piece of data – for example, the murder knife having a weight of 0.15679876675876 kg is very improbable under both the “bare” guilt and “bare” innocence hypothesis. The lesson here is that only the probabilistic tension that one hypothesis has and that another lacks relative to some specifi ed domain can be used as evidence in favor of one hypothesis over another. In our case, the relevant specified domain causing probabilistic tension is that of the fi ne-tuning data. Elaborated naturalism might do better in other areas with regard to probabilistic tension, but to say that the fine-tuning data counts against elaborated naturalism with respect to elaborated theism, all we have to show is that the fine-tuning evidence creates a probabilistic tension within elaborated naturalism without creating a corresponding tension within elaborated theism.

2. The Evidence for Fine-Tuning

2.1. Introduction

The evidence for fine-tuning of the universe for life falls into three categories:

We shall present examples of each type of fine-tuning further in the discussion. Before we begin, we should note that each of the aforementioned types of fi ne-tuning presupposes that a necessary requirement for the evolution of embodied moral agents is that there exist material systems that can sustain a high level of self-reproducing complexity – something comparable to that of a human brain. Given what we know of life on Earth, this seems a reasonable assumption.

2.2. Laws of nature

The first major type of fine-tuning is that of the laws of nature. The laws and principles of nature themselves have just the right form to allow for the existence embodied moral agents. To illustrate this, we shall consider the following five laws or principles (or causal powers) and show that if any one of them did not exist, self-reproducing, highly complex material systems could not exist: (1) a universal attractive force, such as gravity;

(2) a force relevantly similar to that of the strong nuclear force, which binds protons and neutrons together in the nucleus; (3) a force relevantly similar to that of the electromagnetic force; (4) Bohr’s Quantization Rule or something similar; (5) the Pauli Exclusion Principle.

If any one of these laws or principles did not exist (and were not replaced by a law or principle that served the same or similar role), complex self-reproducing material systems could not evolve. First, consider gravity. Gravity is a long-range attractive force between all

material objects, whose strength increases in proportion to the masses of the objects and falls off with the inverse square of the distance between them. In classical physics, the amount of force is given by Newton’s law, F = Gm1m2/r2, where F is the force of attraction between two masses, m1 and m2, separated by a distance r, and G is the gravitational constant (which is simply a number with a value of 6.672 × 10−11 N·m2/kg2). Now consider what would happen if there were no universal, long-range attractive force between material objects, but all the other fundamental laws remained (as much as possible) the same. If no such force existed, then there would be no stars, since the force of gravity is what holds the matter in stars together against the outward forces caused by the high internal temperatures inside the stars. This means that there would be no long-term energy sources to sustain the evolution (or even existence) of highly complex life. Moreover, there probably would be no planets, since there would be nothing to bring material particles together, and even if there were planets (say because planet-sized objects always existed in the universe and were held together by cohesion), any beings of significant size could not move around without floating off the planet with no way of returning. This means that embodied moral agents could not evolve, since the development of the brain of such beings would require significant

mobility. For all these reasons, a universal attractive force such as gravity is required for embodied moral agents.

Second, consider the strong nuclear force. The strong nuclear force is the force that binds nucleons (i.e. protons and neutrons) together in the nucleus of an atom. Without it, the nucleons would not stay together. It is actually a result of a deeper force, the "gluonic force," between the quark constituents of the neutrons and protons, a force described by the theory of quantum chromodynamics. It must be strong enough to overcome the repulsive electromagnetic force between the protons and the quantum zero-point energy of the nucleons. Because of this, it must be considerably stronger than the electromagnetic force; otherwise the nucleus would come apart. Further, to keep atoms of limited size, it must be very short range – which means its strength must fall off much, much more rapidly than the inverse square law characteristic of the electromagnetic force and gravity. Since it is a purely attractive force (except at extraordinarily small distances), if it fell off by an inverse square law like gravity or electromagnetism, it would act just like gravity and pull all the protons and neutrons in the entire universe together. In fact, given its current strength, around 1040 stronger than the force of gravity between the nucleons in a nucleus, the universe would most likely consist of a giant black hole.

Thus, to have atoms with an atomic number greater than that of hydrogen, there must be a force that plays the same role as the strong nuclear force – that is, one that is much stronger than the electromagnetic force but only acts over a very short range. It should be clear that embodied moral agents could not be formed from mere hydrogen, contrary to what one might see on science fiction shows such as Star Trek. One cannot obtain enough self-reproducing, stable complexity. Furthermore, in a universe in which no other atoms but hydrogen could exist, stars could not be powered by nuclear fusion, but only by gravitational collapse, thereby drastically decreasing the time for, and hence probability of, the evolution of embodied moral agents.

Third, consider electromagnetism. Without electromagnetism, there would be no atoms, since there would be nothing to hold the electrons in orbit. Further, there would be no means of transmission of energy from stars for the existence of life on planets. It is doubtful whether enough stable complexity could arise in such a universe for even the simplest forms of life to exist.

Fourth, consider Bohr's rule of quantization, first proposed in 1913, which requires that electrons occupy only fixed orbitals (energy levels) in atoms. It was only with the development of quantum mechanics in the 1920s and 1930s that Bohr's proposal was given an adequate theoretical foundation. If we view the atom from the perspective of classical Newtonian mechanics, an electron should be able to go in any orbit around the nucleus. The reason is the same as why planets in the solar system can be any distance from the Sun

for example, the Earth could have been 150 million miles from the Sun instead of its present 93 million miles. Now the laws of electromagnetism – that is, Maxwell's equations require that any charged particle that is accelerating emit radiation. Consequently, because electrons orbiting the nucleus are accelerating – since their direction of motion is changing they would emit radiation. This emission would in turn cause the electrons to lose energy, causing their orbits to decay so rapidly that atoms could not exist for more than a few moments. This was a major problem confronting Rutherford's model of the atom – in which the atom had a nucleus with electrons around the nucleus – until Niels Bohr proposed his ad hoc rule of quantization in 1913, which required that electrons occupy fi xed orbitals. Thus, without the existence of this rule of quantization – or something relevantly similar – atoms could not exist, and hence there would be no life.

Finally, consider the Pauli Exclusion Principle, which dictates that no two fermions (spin-½ particles) can occupy the same quantum state. This arises from a deep principle in quantum mechanics which requires that the joint wave function of a system of fermions be antisymmetric. This implies that not more than two electrons can occupy the same orbital in an atom, since a single orbital consists of two possible quantum states (or more precisely, eigenstates) corresponding to the spin pointing in one direction and the spin pointing in the opposite direction. This allows for complex chemistry, since without this principle, all electrons would occupy the lowest atomic orbital. Thus, without this principle, no complex life would be possible.7

2.3. Constants of physics

2.3.1. Introduction

The constants of physics are fundamental numbers that, when plugged into the laws of physics, determine the basic structure of the universe. An example of a fundamental constant is Newton's gravitational constant G, which determines the strength of gravity via Newton's law F = Gm1m2/r2. We will say that a constant is fine-tuned if the width of its life-permitting range, Wr, is very small in comparison to the width, WR, of some properly chosen comparison range: that is, Wr/WR << 1. A more philosophically rigorous way of determining this comparison range will be presented in Section 4.4. Here we shall simply use certain standard comparison ranges that naturally arise in physics and hence are used by physicists when they speak of cases of anthropic fi ne-tuning.8

There are many examples of the anthropic fine-tuning of the fundamental constants of physics. Elsewhere, I have more thoroughly examined six of what I considered the most well-established cases, carefully articulating the physical lines of evidence offered in support of these cases along with correcting some incorrect and often-repeated claims regarding fi ne-tuning (Collins 2003). For purposes of illustration, here I shall explicate in some detail only two constants of physics – the strength of gravity and the cosmological constant.9

2.3.2. Fine-tuning of gravity

Using a standard measure of force strengths – which turns out to be roughly the relative strength of the various forces between two protons in a nucleus – gravity is the weakest of the forces, and the strong nuclear force is the strongest, being a factor of 1040 – or 10 thousand billion, billion, billion, billion times stronger than gravity (Barrow & Tipler 1986, pp. 293–5). Now if we increased the strength of gravity a billionfold, for instance, the force of gravity on a planet with the mass and size of the Earth would be so great that organisms anywhere near the size of human beings, whether land-based or aquatic, would be crushed. (The strength of materials depends on the electromagnetic force via the fi ne-structure constant, which would not be affected by a change in gravity.) Even a much smaller planet of only 40 ft in diameter – which is not large enough to sustain organisms of our size – would have a gravitational pull of 1,000 times that of Earth, still too strong for organisms with brains of our size to exist. As astrophysicist Martin Rees notes, "In an imaginary strong gravity world, even insects would need thick legs to support them, and no animals could get much larger" (2000, p. 30). Based on the evidence from Earth, only organisms with brains of a size comparable to our own have significant moral agency. Consequently, such an increase in the strength of gravity would render the existence of embodied moral agents virtually impossible and thus would not be life-permitting in the sense that we defi ned.

Of course, a billionfold increase in the strength of gravity is a lot, but compared with the total range of the strengths of the forces in nature (which span a range of 1040), it is very small, being one part in 10 thousand, billion, billion, billion. Indeed, other calculations show that stars with lifetimes of more than a billion years, as compared with our Sun's lifetime of 10 billion years, could not exist if gravity were increased by more than a factor of 3,000 (Collins 2003). This would significantly inhibit the occurrence of embodied moral agents.

would have to be fine-tuned to be almost exactly opposite of the quantum correction to yield such a relatively small value for the constant (see Donoghue 2007, pp. 234–6). It is important, therefore, not to naively equate discussions of fine-tuning in the physics literature with anthropic fine-tuning, although, as John Donoghue (2007) shows, they are often closely related.

Some other examples of fine-tuning of the constants are the following: if the mass of the neutron were slightly increased by about one part in 700, stable hydrogen burning stars would cease to exist (Leslie 1989, pp. 39–40; Collins 2003); if the weak force were slightly weaker by one part in 109 of the range of force strengths, then the existence of complex life would be severely inhibited (Collins 2003); finally, if the "vacuum expectation value" of the Higgs field were not within a few times its present strength, complex atoms (with atomic numbers greater than hydrogen) could not exist (see Donoghue 2007, pp. 237–8). All these cases, however, need more explication and analysis than can be given here.

The case of fine-tuning of gravity described is relative to the strength of the electromagnetic force, since it is this force that determines the strength of materials – for example, how much weight an insect leg can hold; it is also indirectly relative to other constants – such as the speed of light, the electron and proton mass, and the like – which help determine the properties of matter. There is, however, a fi ne-tuning of gravity relative to other parameters. One of these is the fine-tuning of gravity relative to the density of mass-energy in the early universe and other factors determining the expansion rate of the Big Bang – such as the value of the Hubble constant and the value of the cosmological constant. Holding these other parameters constant, if the strength of gravity were smaller or larger by an estimated one part in 1060 of its current value, the universe would have either exploded too quickly for galaxies and stars to form, or collapsed back on itself too quickly for life to evolve.10 The lesson here is that a single parameter, such as gravity, participates in several different fine-tunings relative to other parameters.

2.3.3. The cosmological constant

Probably the most widely discussed case of fi ne-tuning for life is that of the cosmological constant. The cosmological constant, Λ, is a term in Einstein's equation of General Relativity that, when positive, acts as a repulsive force, causing space to expand and, when negative, acts as an attractive force, causing space to contract. Einstein's equation implies that if the vacuum – that is, space-time devoid of normal matter – has an energy density, then that energy density must act in a mathematically, and hence physically, equivalent way to a cosmological constant. The seeming need for fine-tuning of the cosmological constant arises from the fact that almost every field within modern physics – the electromagnetic field, the Higgs fields associated with the weak force, the infl aton field hypothesized by inflationary cosmology, the dilaton field hypothesized by superstring theory, and the fi elds associated with elementary particles – each contributes to the vacuum energy far in excess of the maximum life-permitting amount. These contributions to the vacuum energy can be either negative or positive. If the total effective cosmological constant is positive and larger than some positive value Λ+max, or negative and smaller than some negative value Λ−max, then the universe would have expanded (if positive), or collapsed (if negative), too quickly for stars or galaxies to form. Thus, for life to occur, the cosmological constant must be between Λ−max and Λ+max. I shall let Λmax designate the larger of the two absolute values of Λ−max and Λ+max. Since the absolute values of Λ−max and Λ+max are within one or two orders of magnitude of each other, I shall explain the cosmological constant problem for the case in which Λ is assumed to be positive, but the same analysis will apply for the case in which Λ is negative.

This latter fine-tuning of the strength of gravity is typically expressed as the claim that the density of matter at the Plank time (the time at which we have any confidence in the theory of Big Bang dynamics) must have been tuned to one part in 1060 of the so-called critical density (e.g. Davies

1982, p. 89). Since the critical density is inversely proportional to the strength of gravity (Davies 1982, p. 88, eqn. 4.15), the fine-tuning of the matter density can easily be shown to be equivalent to the aforementioned claim about the tuning of the strength of gravity. Of course, if one cites this fine-tuning of gravity, one cannot then treat the fine-tuning of the force of the Big Bang or matter density of the Big Bang as an independent fine-tuning. (See Section 5.1.1 for how to combine cases of fi ne-tuning.)

Einstein originally hypothesized the existence of the cosmological constant so that his theory would imply a static universe. Thus, the original cosmological constant that Einstein postulated was not associated with contributions to the vacuum energy of the various fi elds of physics. If we let Λvac represent the contribution to the cosmological constant from the vacuum energy of all the fields combined, and Λbare represent the intrinsic value of the cosmological constant apart from any contribution from these fi elds, then the total value, Λtot, of the cosmological constant is Λtot = Λvac + Λbare. The contributions to Λvac can be further divided into those contributions arising from various forms of potential energy, V, as the universe passes through different phases along with those arising from the zero-point energies of the vacuum fluctuations of the quantum fields of the fundamental forces and elementary particles.

Finally, there have been various proposals for a new and highly speculative type of energy, called quintessence, whose defining feature is that it acts like a cosmological constant in the way it causes space to expand or contract, but unlike the cosmological constant it can change with time as the universe evolves from the Big Bang onward. Consequently, we can define the total effective cosmological constant as the sum of all these contributions that function in the same way as the cosmological constant with regard to causing space to expand or contract: that is, Λeff = Λvac + Λbare + Λq, where Λq designates the contribution resulting from quintessence. The fi ne-tuning problem can now be stated as follows: without fi ne-tuning or some new principle of physics, Leff is expected to be at least 1053 to 10120 times larger than the maximum life-permitting value Lmax. The smallness of the cosmological constant compared to its non-fine-tuned, theoretically expected value is widely regarded as the single greatest problem confronting current physics and cosmology.

To understand this fine-tuning problem more fully, it will be helpful to consider the three major types of contribution to the vacuum energy term, Λvac, of the cosmological constant in modern cosmology. Following standard terminology, we will let ρvac designate the vacuum energy density, and ρmax the maximum vacuum energy density compatible with the existence of life, given that the vacuum energy is the only contribution to the cosmological constant.11 The first contribution we shall consider arises from the Higgs fi eld postulated as part of the widely accepted Weinberg–Salem–Glashow electroweak theory. According to this theory, the electromagnetic force and the weak force acted as one force prior to symmetry breaking of the Higgs field in the very early universe when temperatures were still extremely high. Before symmetry breaking, the vacuum energy of the Higgs fi eld had its maximum value V0. This value was approximately 1053 ρmax. After symmetry breaking, the Higgs field fell into some local minimum of its possible energy density, a minimum which theoretically could be anywhere from zero to 1053 ρmax, being solely determined by V0 and other free parameters of the electroweak theory.12

Now either this local minimum is less than ρmax, or it is greater than ρmax and the other contributions to the cosmological constant offset its contribution to Λeff so that Λeff < Λmax. In either case, the fine-tuning would have to be in one part in 1053. In the former case, for instance, the local minimum of energy would have to be between zero and ρmax, which would be one part in 1053 of its possible range of values.

The second contribution to the vacuum energy is the postulated infl aton field of infl ationary cosmology. Inflationary universe models hypothesize that the infl aton field had an enormously high

energy density in the fi rst 10−35 to 10−37 seconds of our universe, resulting in an effective cosmological constant that caused space to expand by a factor of around 1060 (Guth 1997, p. 185). By around 10−35 seconds or so, however, the value of the infl aton field fell to a relatively small value corresponding to a local minimum of its energy.13 Now, in order to start inflation, the initial energy density of the infl aton fi eld, ρi, must have been enormously larger than ρmax: ρi >> ρmax. Theoretically, however, the local minimum of the infl aton field could be anything from zero to ρi (see Sahni & Starobinsky 1999, sec. 7.0; Rees 2000, p. 154). The fact that the effective cosmological constant after inflation is less than ρmax requires an enormous degree of fine-tuning, for the same reason as the Higgs field mentioned – for example, neglecting other contributions to the cosmological constant, the local minimum of energy into which the infl aton field fell must be between zero and ρmax, a tiny portion of the its possible range, zero to ρi.

The final contribution results from the so-called zero-point energies of the fi elds associated with forces and elementary particles, such as the electromagnetic force and electrons and protons. If we calculate this contribution using quantum field theory and assume that space is a continuum, the contribution turns out to be infinite. Physicists, however, typically assume that quantum field theory is valid only up to a certain very large cutoff energy (see Section 4.5), in which case the contribution turns out to be extraordinarily large, but fi nite, with the actual value depending on the cutoff energy below which quantum fi eld theory is taken as valid. The so-called Plank energy is often assumed to be the energy scale that quantum field theory breaks down, in which case the energy contribution of the zero-point energy for the various fields would be expected to be 10120 ρmax (see Sahni & Starobinsky 1999, p. 44). To reduce this contribution to within an order of magnitude of the life-permitting range (thus eliminating any signifi cant fine-tuning) would require an extremely low cutoff energy, which most physicists consider very unlikely (Donoghue 2007, p. 236).

One solution to the cosmological constant problem is to claim that God, or some other intelligence, fine-tuned the various contributions to the cosmological constant, Λvac + Λbare + Λq, in such a way that Λeff < Λmax. Another much discussed solution is an appeal to multiple universes and some anthropic selection effect, which we shall discuss in Section 6. Is there a nondivine, nonanthropic solution to the fine-tuning of the cosmological constant? Physicist Victor Stenger, the leading critic of the data appealed to by advocates of the fi ne-tuning argument, claims that there is. According to Stenger:

> . . . recent theoretical work has offered a plausible non-divine solution to the cosmological constant problem. Theoretical physicists have proposed models in which the dark energy is not identified with the energy of curved space-time but rather with a dynamical, material energy fi eld called quintessence. In these models, the cosmological constant is exactly 0, as suggested by a symmetry principle called supersymmetry. Since 0 multiplied by 10120 is still 0, we have no cosmological constant problem in this case. The energy density of quintessence is not constant but evolves along with the other matter/energy fields of the universe. Unlike the cosmological constant, quintessence energy density need not be fi ne-tuned. (2004, p. 182)

Although the Higgs fields and the other fields of physics could contribute to inflation, for various technical reasons inflationary cosmology requires a distinct energy field that helps create a very large effective cosmological constant in the very early universe. There is currently no candidate for this field that is “deeply rooted in well-established theories of fundamental physics” (Albrecht 2004, p. 381).

Although in a later publication, Stenger (2007, pp. 151–3) does not mention supersymmetry, he still claims that a hypothesized new form of energy, quintessence, could solve the cosmological constant problem and that it "requires no fine-tuning" (Stenger 2007, p. 152).

Stenger's proposal can be summarized in three steps: (1) postulate some natural symmetry or principle that requires that the cosmological constant, Λtot = Λvac + Λbare, be zero;

(2) postulate some additional quintessential field to account for what appears to be a small positive value of the effective cosmological constant today;14 and (3) postulate that there is some natural equation that implies that Λq < Λmax in the early universe, an equation which itself does not require fi ne-tuning. Since Λeff = Λvac + Λbare + Λq, those three steps would guarantee in a natural way that Λeff < Λmax.

A well-known proposal that would go part way to making Λtot = 0 is the appeal to the speculative hypothesis of supersymmetry. Supersymmetry requires that for each bosonic fi eld there exist a corresponding fermionic fi eld, where bosonic fi elds are those associated with spin-1 particles, such as the photon, and fermionic fields are those associated with spin-½ particles, such as electrons and protons. It further requires that the positive zero-point energy contribution associated with each bosonic field is exactly canceled by the negative zero-point energy contribution associated with the corresponding fermionic fi eld. Consequently, it requires that the total zero-point energies associated with the various fi elds of physics sum to zero, resulting in a net contribution of zero to the total cosmological constant. This solution faces a major difficulty: even if supersymmetry exists, it is presently a broken symmetry and thus cannot solve the cosmological constant problem. As astrophysicist John Peacock notes,"supersymmetry, if it exists at all, is clearly a broken symmetry at present day energies; there is no natural way of achieving this breaking while retaining the attractive consequence of a zero cosmological constant, and so the Λ problem remains as puzzling as ever" (1999, p. 268).

Further, even if some other symmetry could be discovered that would force the contributions of the bosonic or fermionic fields to cancel each other out, the first two contributions to the cosmological constant mentioned earlier would remain – that is, those arising from the Higgs field and the infl aton field. In order to get a zero cosmological constant, one would have to postulate some law, symmetry, or other mechanism that forced the sum of all contributions to the cosmological constant to be zero. In order to get this suggestion to work, physicists would have to either (a) abandon inflationary cosmology, which requires that the effective cosmological constant be initially very large and then fall off to near zero, or (b) invoke some special law, symmetry, or "mechanism" that selectively requires that the cosmological constant be zero at the end of the inflationary period. If options (a) and

The assumption that Λeff > 0 is regarded by most physicists as the best way of accounting for the evidence, based on redshifted light from distant supernovae, that the universe is accelerating. An effective cosmological constant is not the only way of explaining the cosmic acceleration, however. Olga Mena and José Santiago (2006) have recently developed a modification of Einstein's theory of gravity that explains the acceleration of the universe without appealing to an effective cosmological constant. Their model, however, still must assume some nonmaterial substance in addition to normal matter. As stated in their abstract, "the inverse-curvature gravity models considered cannot explain the dynamics of the Universe just with a baryonic matter component." If a successful non-ad hoc and non-fi ne-tuned modification of General Relativity could be developed that would account for the acceleration of the universe, it could serve as an alternative to steps (2) and (3) in an attempt to avoid the fi ne-tuning of the cosmological constant.

(b) are both rejected, one will be left with the fine-tuning problem generated by a large effective cosmological constant required for inflation that must drop off to near zero after infl ation in order for life to exist.

Further, supposing that option (a) or (b) are chosen, steps (2) and (3) are still required to account for the small, nonzero effective cosmological constant today. In typical models of quintessence, Λq "tracks" the matter and radiation density of the universe – that is, Λq is some function of these densities. One problem here is that unless the function is both natural and simple, without any adjustable parameters needed to make Λq < Λmax, the problem of fine-tuning will simply re-arise: if that function is not simple or natural, or such a parameter is needed, then the question will arise as to why that function or parameter is such that the value of the effective cosmological constant is within the life-permitting range instead of falling outside the life-permitting range. So far, no such natural function has been found, and it is widely argued that current models of quintessence require fi ne-tuning, especially when combined with infl ationary cosmology.15 Further, quintessential energy must have special characteristics to act as an effective cosmological constant. As noted by physicists Robert R. Caldwell and Paul J. Steinhardt (2000), "The simplest model proposes that the quintessence is a quantum field with a very long wavelength, approximately the size of the observable universe." The long wavelength of the field means that its energy is dominated by potential energy, which in turn allows for it to act as an effective cosmological constant.

In sum, it is conceivable that by postulating the right set of laws–symmetries– mechanisms, physicists will be able to explain the fine-tuning of the effective cosmological constant in a non-ad hoc way. Nonetheless, two points should be made. First, any such explanation will require the hypothesis of just the right set of laws. At best, this will merely transfer the fi ne-tuning of the cosmological constant to that of the laws of nature; even if those laws of nature are deemed "natural," one would still have to have the right set of laws to eliminate the fine-tuning of the cosmological constant. Consequently, other than eliminating the ability to quantify the degree of fine-tuning, it is unclear how much such a move undercuts the need for some anthropic explanation. Second, it is unclear at what point we should continue searching for such an explanation in terms of physical laws when no plausible candidates have been forthcoming in the last 20 years. Atheists such as Stenger claim that we should continue searching until we can be absolutely sure that no scientifi c explanation can be found. In Section 2.5.2, where I consider the "God of the gaps" objection, I argue that such a requirement begs the question against T.

Finally, one way of avoiding the fine-tuning of the cosmological constant is to claim that one day the current framework of modern physics will be superseded in such a way as to avoid the fine-tuning problem. For example, one could claim that Einstein's theory of General Relativity will be superseded by a future theory that retains the verifi ed predictions of General Relativity but does not predict that vacuum energy will cause space to expand.16 Or one could claim that this prediction is an artifact of General Relativity that is not to be taken realistically, in analogy to how most physicists reject waves that travel backward in time, even though such waves are one mathematically legitimate solution to the equations of electromagnetism. Such moves, however, will involve giving up infl ationary cosmology or radically reformulating it (since it depends on this prediction of General Relativity), and they would present difficulties for explaining the compelling evidence that the expansion of the universe is accelerating. Further, such moves clearly will not work for the fi ne-tuning of other constants, since many of them depend on facts so basic that they certainly will not be superseded. For example, the fine-tuning of the strength of gravity, as discussed in Section 2.3.2, only depends on the fact that bodies with masses typical of planets and stars attract each other with a force approximately given by Newton's law, and that if the gravitational pull of a planet is too large, most organisms would be crushed. Thus, as a general strategy, this way circumventing the fine-tuning of the cosmological constant is of limited value.

2.4. Initial conditions of the universe

One other fundamental type of fine-tuning should be mentioned, that of the initial conditions of the universe. This refers to the fact that the initial distribution of mass-energy – as measured by entropy – must fall within an exceedingly narrow range for life to occur. Some aspects of these initial conditions are expressed by various cosmic parameters, such as the mass density of the early universe, the strength of the explosion of the Big Bang, the strength of the density perturbations that led to star formation, the ratio of radiation density to the density of normal matter, and the like. Various arguments have been made that each of these must be fine-tuned for life to occur (see e.g. Rees 2000; Davies 1982, chap. 4). Instead of focusing on these individual cases of fine-tuning, I shall focus on what is arguably the most outstanding special initial condition of our universe: its low entropy. According to Roger Penrose, one of Britain's leading theoretical physicists, "In order to produce a universe resembling the one in which we live, the Creator would have to aim for an absurdly tiny volume of the phase space of possible universes" (Penrose 1989, p. 343). How tiny is this volume? According to Penrose, if we let x = 10123, the volume of phase space would be about 1/10x of the entire volume (1989, p. 343). This is vastly smaller than the ratio of the volume of a proton – which is about 10−45 m3 – to the entire volume of the visible universe, which is approximately 1084 m3. Thus, this precision is much, much greater than the precision that would be required to hit an individual proton if the entire visible universe were a dartboard! Others have calculated the volume to be zero (Kiessling 2001).

Now phase space is the space that physicists use to measure the various possible configurations of mass-energy of a system. For a system of particles in classical mechanics, this phase space consists of a space whose coordinates are the positions and momenta (i.e. mass × velocity) of the particles, or any other so-called "conjugate" pair of position and momenta variables within the Hamiltonian formulation of mechanics. Consistency requires that any probability measure over this phase space remain invariant regardless of which conjugate positions and momenta are chosen; further, consistency requires that the measure of a volume V(t0) of phase space at time t0 be the same as the measure that this volume evolves into at time t, V(t), given that the laws of physics are time-reversal invariant – that is, that they hold in the reverse time direction.17 One measure that meets this condition is the standard "equiprobability measure" in which the regions of phase space are assigned a probability corresponding to their volume given by their position and momenta (or conjugate position and momenta) coordinates. Moreover, if an additional assumption is made – that the system is ergodic – it is the only measure that meets this condition.18 This measure is called the standard measure of statistical mechanics, and forms the foundation for all the predictions of classical statistical mechanics. A related probability measure – an equiprobability distribution over the eigenstates of any quantum mechanical observable – forms the basis of quantum statistical mechanics.

Statistical mechanics could be thought of as the third main branch of physics, besides the theory of relativity and quantum theory, and has been enormously successful. Under the orthodox view presented in physics texts and widely accepted among philosophers of physics, it is claimed to explain the laws of thermodynamics, such as the second law, which holds that the entropy of a system will increase towards its maximum with overwhelming probability.

Applying this measure to the initial state of the universe, we could then say that under the standard measure, it is enormously improbable, having a probability equal to the minute portion of phase space compatible with it. Indeed, in discussions of the issue, it is typically assumed that this state is enormously improbable. The probability here is not the probability of the particles' (or fields') being in the exact microstate that they were in; that is always zero. Rather, it is the state specified by the requirement that the entropy be low enough for the occurrence of stars and ultimately life. An infinite number of microstates meet this requirement, but they all must be in

that tiny region of phase space that Penrose mentions. Finally, it is important to note that the standard measure of statistical mechanics must imply a corresponding epistemic probability measure. The reason is that statistical mechanics is supposed to tell us what to expect a system's behavior to be. For instance, the calculation that an increase in entropy for a physical system in the next 5 minutes is enormously improbable leads us to be almost certain that it will not occur – that is, it generates a very low epistemic probability for its occurrence. Thus, applying the standard measure to the initial condition of our universe implies that it has an enormously low unconditional epistemic probability of occurring.

The reason that the statistical mechanics measures are assumed to be time-invariant is easy to see, given that the laws of physics are deterministic and time-reversal invariant. Let C(t0) be some class of possible initial states of a system. Each member m(t0) of C(t0) will evolve into some particular state m(t) at time t. Call C(t) the class of all such states m(t). If the laws of physics are time reversal invariant, any state m*(t) $\in$ C(t) could have come from only one state m*(t0) $\in$ C(t0) at time t0. Thus, there is a one-to-one correspondence between microstates in C(t0) and microstates in C(t). Consequently, if the probability of some system having a microstate in a class C(t0) is x%, then it must be the case that the probability of the system having a microstate in the corresponding class C(t) of states at time t is x%.

An ergodic system is one in which in the limit as time goes to infinity, the average proportion of time a system spends in a given region of phase space with finite volume is the same as the standard equiprobability measure for that region.

Many points could be disputed in the aforementioned argument and I cannot adequately enter into the debate here. Rather, I shall just summarize three of the major ways to avoid assigning an extremely low epistemic probability to the initial state of the universe. First, as suggested by David Albert (2000, pp. 150–62), one could attempt to ground the standard probability measure of statistical mechanics in postulated indeterministic quantum processes that have just the right probability distribution to yield this measure. As Albert (2000, p. 160–1) recognizes, such a procedure would still require the postulation of an enormously special, low-entropy macroscopic state at the beginning of the universe but would not require that one postulate a probability measure over the states of its phase space. Second, one could simply restrict all statements of probability in statistical mechanics to statements of conditional probability, where the statement being conditioned on is that that the universe started out in this special macro-state of exceedingly low entropy. Then one could treat the measure over phase space as applying only to those scattered points in phase space consistent with this initial assumption. Doing this would recover all the predictions of statistical mechanics, although it might seem an arbitrary restriction imposed to avoid treating the initial state as improbable. Third, one could point out, as John Earman (2006) has, that no one has been able to develop an even near-adequate mathematical measure for the degrees of freedom of the gravitational field, which is thought to play an essential role in the low entropy of the initial state of the universe.

In light of these responses, how should we view the purported improbability of the initial state? First, we can point out that the improbability assigned by the standard measure is the same as the one that we should assign using the method outlined in Sections 3.3.2 and 3.3.3, in which we argue that scientifi c confirmation requires that we place an epistemic equiprobability measure over the natural variables in a theory. In statistical mechanics these natural variables turn out to be the position and momenta, or other conjugate variables, used to construct phase space. Thus, it demonstrates a certain consistency in the method we proposed for arriving at epistemic probabilities. Second, all these responses admit that the initial state is in some sense enormously special in some way, while denying the degree of "specialness" can be quantified or physically explained. This leaves us with a strong qualitative, although nonquantifi able, form of fi ne-tuning.

2.5. Stenger's objections

As mentioned when we discussed the fine-tuning of the cosmological constant, in the last 15 years Victor Stenger has emerged as one of the leading critics of the evidence for fi ne-tuning. In the next two subsections, we shall look at two of his objections.

2.5.1. Stenger's "Monkey God" objection

One major way in which Stenger has attempted to cast skepticism on fi ne-tuning arguments is by constructing a computer program that shows that random selections of the constants of physics generally produce viable, life-permitting stars. He calls his computer program "Monkey God." Based on his program, Stenger concludes that:

No basis exists for assuming that a random universe would not have some kind of life. Calculations of the properties of universes having different physical constants than ours indicate that long-lived stars are not unusual, and thus most universes should have time for complex systems of some type to evolve. (2000, p. 50)

Stenger calculates the lifetime of stars using the equation ts = (α2/αG) (mp/me)2 hc,¯ /(mpwhere α is the dimensionless electromagnetic interaction strength, αG is the dimensionless gravitational binding energy, mp is the mass of the proton, me is the mass of the electron, ¯his Plank's constant divided by 2π, and c is the speed of light.

Using this equation and a program that randomly selects values for the relevant parameters in the aforementioned equation, Stenger concludes that long-lived stars are not unusual among these randomly selected universes and takes this to count as evidence against claims of fine-tuning. The first criticism of his approach is that he does not address the question of whether these universes would have other life-inhibiting features relative to ours. For example, if one decreases the strength of the strong nuclear force by more than 50 percent (while keeping the electromagnetic force constant), carbon becomes unstable, and with a slightly greater decrease, no atoms with atomic number greater than hydrogen can exist (Barrow & Tipler 1986, pp. 326–7). This would make it virtually impossible for complex life forms to evolve. That Stenger ignores these other life-inhibiting features is clear from his equation for the lifetime of a star (which is unaffected by changes in the strong nuclear force, since none of the parameters he uses depends on this strength), and is also obvious from what he says elsewhere regarding his "Monkey God" calculations:

> I find that long-lived stars, which could make life more likely, will occur over a wide range of these parameters. . . . For example, if we take the electron and proton masses to be equal to their values in our universe, an electromagnetic force any stronger than its value in our universe will give a stellar lifetime of more than 680 million years. The strength of the strong interaction does not enter into this calculation. (Stenger 2004, pp. 179–80)

Obviously, if we increased the electromagnetic force by very much while keeping the strong interaction the same, the nuclei of atoms other than hydrogen would break apart due to the increased electromagnetic repulsion of the protons in the nuclei. In this case, there could be no nuclear fusion in stars, and hence no stars.

Second, the equation he uses is based on a simple star model of stellar evolution. The equation does not take into account the complexities of a stellar evolution, such as whether the energy transport from the center of the star to the surface is by convection or radiative diffusion. More importantly, it assumes that the star is made mostly of hydrogen, which would not be the case if the strong force were increased beyond a small amount (see Collins 2003, p. 192 and references

therein); further, it does not take into account the effects on star stability of quantum degeneracy, which require much more sophisticated codes to take into account. No simple equation could incorporate these sorts of complexities. As I have shown elsewhere (Collins 2003, pp. 192–3), using a simple star model, one can increase the strength of gravity a million- or a billionfold, and still obtain stable, long-lived stars with around the same surface temperature as our Sun. When one takes into account quantum degeneracy effects, however, one can only increase the strength of gravity by around a thousandfold before significantly decreasing the lifetime of stars (Collins 2003, pp. 193–4). Presumably, if one also changed one of the other constants, one could increase the strength of gravity by more than 3,000-fold and still obtain a stable, long-lived star, since it would change when electron degeneracy kicks in. In sum, life-prohibiting effects related to stellar lifetimes and stability only come to light when one begins to consider the complexity of the physics involved in stellar evolution, something Stenger has not done.

2.5.2. Stenger's "God of the gaps" objection

Another common objection to the fine-tuning argument is that it is a variation of the "God of the gaps" argument, and so it should be rejected. Victor Stenger raises this objection with regard to the fi ne-tuning of the cosmological constant. According to Stenger:

> While quintessence may not turn out to provide the correct explanation for the cosmological constant problem, it demonstrates, if nothing else, that science is always hard at work trying to solve its puzzles within a materialistic framework. The assertion that God can be seen by virtue of his acts of cosmological fine-tuning, like intelligent design and earlier versions of the argument from design, is nothing more than another variation on the disreputable God-of-the gaps argument. These rely on the faint hope that scientists will never be able to find a natural explanation for one or more of the puzzles that currently have them scratching their heads and therefore will have to insert God as the explanation. As long as science can provide plausible scenarios for a fully material universe, even if those scenarios cannot be currently tested they are suffi cient to refute the God of the gaps. (2004, p. 182)

Elsewhere, Stenger claims that one would be justified in invoking God only if "the phenomenon in question is not only currently scientifi cally inexplicable but can be shown to forever defy natural description" (2007, pp. 13–4). As he recognizes, this requirement of proof is exceptionally strong. Although he qualifies his assertion regarding God as a scientific hypothesis, the question that arises is the level of proof that we need regarding the nonexistence of a plausible scientific explanation before we are justified in invoking God as an explanation of the fine-tuning, regardless of whether it is considered a scientifi c or a metaphysical explanation.

To answer this latter question, we must consider the reasons for thinking that a "God of the gaps" sort of explanation is in principle something to be avoided. The reasons partly depend on whether one is a theist or an atheist; and if one is a theist, it will depend on how one understands the nature of divine action. Many theists will claim that ultimately we should avoid a God of the gaps explanation because it is bad theology. According to these theists, God would be greater if God created a material order that could function on its own without God's needing to intervene and fill various gaps. If these theists are correct, then for theological reasons one should strenuously avoid appealing to divine intervention in the natural order to explain phenomena that science has not yet explained and instead trust that God has created a material world with its own integrity. Such theological reasons, however, will not apply to the structure of the cosmos itself – its basic laws, its initial conditions, and the values of its constants – since these do not require any intervention in the natural order. Other theists, such as intelligent design theorists, will be even more lenient concerning those cases in which it is appropriate to invoke God as an explanation.

Of course, atheists who are fully committed to a naturalistic account of the cosmos will always claim that it is illegitimate to appeal to God, since God does not exist. In order for the God of the gaps objection to avoid begging the question against the theist, however, it has to be framed in such a way as to carry force even on theistic assumptions. Such an argument does carry force, at least on the assumption of many theists, when God or some other transcendent designer is invoked to explain, for instance, seemingly irreducibly complex biological systems, since in such cases it implies that nature lacks suffi cient integrity to produce the systems on its own. Stenger and others have not shown that it carries any non-question-begging force for the case of the structure of the universe as a whole.

One might object to this response by claiming that the history of science provides independent grounds for rejecting any appeal to God to fill in the apparent gaps left by science. The failure of such appeals, however, can be explained as well by the theist as the naturalist: for example, many theists would claim that Newton's famous invocation of God to keep the planetary orbits stable implies a less than satisfactory picture of a constantly intervening God. The key question is how one inductively extrapolates from these historical incidences, and that all depends on one's background assumptions – that is, whether one is an atheist or a theist, and what kind of theist one is. In themselves, these incidences can tell us nothing about whether we can be justified in appealing to God for explaining the fi ne-tuning.

But what about the scientifi c strictures of methodological naturalism? These would be relevant only if the appeal to God were considered as a scientifi c explanation, something that I am not assuming. Rather, God should be considered a philosophical or metaphysical explanation of LPU. So where does this leave us with regard to the burden of proof? The advocate of the fine-tuning argument will only need to argue that it is unlikely that all the cases can be given a natural explanation that removes their epistemic improbability without transferring that improbability up one level. And as argued in Sections 6.3.1 and 7.2, even if the fine-tuning of the constants of physics can be explained in terms of some set of deeper physical laws, as hypothesized by the so-called "theory of everything" or by an inflationary multiverse, this would simply transfer the improbability up one level to the existence of these deeper laws.

2.6. Conclusion

There are many other cases of fine-tuning that I have not discussed, such as those extensively discussed by biochemist Michael Denton (1998). These latter consist of various higher-level features of the natural world, such as the many unique properties of carbon, oxygen, water, and the electromagnetic spectrum, that appear optimally adjusted for the existence of complex biochemical systems (Denton 1988, chaps 3–6, pp. 19–140). Presumably, these higher-level features of the universe are ultimately grounded in the laws, constants, and initial conditions of the universe. Nonetheless, they provide additional evidence that the fundamental structure of the universe is fi ne-tuned for life.

As illustrated by the case of Victor Stenger discussed earlier (Section 2.5), it should be pointed out that some physicists and scientists have been skeptical of some of the prominent cases of fine-tuning in the literature. As I have shown in detail elsewhere, in some cases this skepticism is warranted, but in other cases the physical arguments offered for fi ne-tuning are solid (see Collins 2003). Nonetheless, even if there are no cases of fi ne-tuning that are suffi ciently established to be beyond doubt, the argument would still have signifi cant force. As philosopher John Leslie has pointed out, "clues heaped upon clues can constitute weighty evidence despite doubts about each element in the pile" (1988, p. 300). This is especially true given that the clues in this case fall into a variety of distinct types – there are not only three distinct fundamental types of fine-tuning, but there are many distinct cases under each type. The only plausible response that a skeptic could give to the multitude of different cases of fine-tuning is to find one or two overarching reasons that

would undercut almost all the cases of fine-tuning in a single stroke. Given the diversity of the cases of fine-tuning, it is very unlikely that this will happen. In any case, in Section 7.2, I will address one such attempt, an attempt I call the "more fundamental law" objection, according to which there might be some fundamental law (or principle) that entails all the cases of fi ne-tuning.

3. Epistemic Probability

3.1. The need for epistemic probability

According to atheist Keith Parsons:

> If atheism is correct, if the universe and its laws are all that is or ever has been, how can it be said that the universe, with all of its 'finely tuned' features, is in any relevant sense probable or improbable? Ex Hypothesi there are no antecedent conditions that could determine such a probability. Hence, if the universe is the ultimate brute fact, it is neither likely nor unlikely, probable nor improbable; it simply is.
>
> Further, even if the universe were somehow improbable, it is hard to see on the hypothesis of atheism how we could ever know this. If we were in the position to witness the birth of many worlds – some designed, some undesigned – then we might be in a position to say of any particular world that it had such-and-such a probability of existing undesigned. But we simply are not in such a position. We have absolutely no empirical basis for assigning probabilities to ultimate facts. (1990, p. 182)

Although commonly raised, Parson's objection is deeply mistaken. It fails to recognize a common, nonstatistical kind of probability that some philosophers have called epistemic probability and others have called inductive probability (e.g. Swinburne 2001, p. 62).19 As Ian Hacking notes in his excellent study of the history of probability theory, the idea of probability was Janus-faced from its emergence in seventeenth-century Europe, with one side being the notion of statistical probability and the other side being the notion of epistemic probability:

On the one side it [the conception of probability] is statistical, concerning itself with stochastic laws or chance processes. On the other side it is epistemological, dedicated to assessing reasonable degrees of belief in propositions quite devoid of statistical background. (Hacking 1975, p. 12)

So, for instance, when people say that the Thesis of Common Ancestry is probably true given the fossil and genetic evidence we currently have, they are clearly not talking about statistical probability, since this thesis is about a unique event in Earth's history. The same holds for any claim about the probable truth (or "empirical adequacy") of a scientifi c theory. In his treatise, A Treatise on Probability (1921), John Maynard Keynes further developed this conception, and there have been several recent attempts to provide a more precise account of this sort of probability (e.g. Swinburne 2001, chaps. 3 and 4; Plantinga 1993, chap. 9).

In conjunction with the Likelihood Principle, this sort of probability is extensively used in scientifi c confi rmation. Consider, for example, the arguments typically offered in favor of the Thesis of Common Ancestry, continental drift theory, and the atomic hypothesis. The Thesis of Common Ancestry is commonly supported by claiming that a variety of features of the world – such as the structure of the tree of life – would not be improbable if this thesis is true, but would be very improbable under other contending, nonevolutionary hypotheses, such as special creation. Consider, for instance, the following quotation from evolutionary biologist and geneticist Edward Dodson, in which he summarizes the case for evolution, understood as the Thesis of Common Ancestry:

> All [pieces of evidence] concur in suggesting evolution with varying degrees of cogency, but most can be explained on other bases, albeit with some damage to the law of parsimony. The strongest evidence for evolution is the concurrence of so many independent probabilities. That such different disciplines as biochemistry and comparative anatomy, genetics and biogeography should all point toward the same conclusion is very difficult to attribute to coincidence. (1984, p. 68; italics added)

Similar lines of reasoning are given for accepting continental drift theory. For example, the similarity between the animal and plant life on Africa and South America millions of years ago was considered to provide significant support for continental drift theory. Why? Because it was judged very unlikely that this similarity would exist if continental drift theory were false, but not if it were true.

Finally, consider the use of epistemic probability in the confirmation of atomic theory. According to Wesley Salmon (1984, pp. 219–20), what finally convinced virtually all physical scientists by 1912 of the atomic hypothesis was the agreement of at least 13 independent determinations of Avogadro's number based on the assumption that atomic theory was correct.20 For example, one method of determining Avogadro's number is through observations of Brownian motion, that is, the random motion of very small particles suspended in a liquid, a motion that was postulated to be caused by the unequal, random impact of the molecules in the liquid. From this motion and the kinetic theory of heat, one can calculate what the mass of each molecule must be in order to account for the observed motion, and then using that value one can obtain Avogadro's number. Avogadro's number = 6.02252 × 1023. Avogadro's number is defined as the number of atoms in 12 grams of carbon 12 and by definition is equal to the number of elementary entities in one mole of any substance.

The scientists reasoned that if atomic theory were false, then such an agreement between thirteen different determinations of Avogadro's number would be exceedingly epistemically improbable – in Salmon's words, an "utterly astonishing coincidence" (1984, p. 220). Indeed, if scientists had not judged the agreement to be exceedingly improbable if atomic theory were false, it is difficult to see why they would take it to count as strong evidence in its favor. On the other hand, the scientists reasoned, if atomic theory were true, such an agreement would be expected. Thus, by implicitly using the Likelihood Principle, they reasoned that these independent determinations of Avogadro's number strongly confi rmed atomic theory.

It should be noted that one could not avoid this sort of reasoning simply by rejecting scientific realism, since even though antirealists reject the truth or approximate truth of certain types of well-confirmed hypotheses, they still accept them as being reliable bases for future explanations and predictions – that is, in Bas van Fraassen's (1980) terminology, they accept them as being "empirically adequate." Consequently, instead of interpreting the confirming evidence as evidence for a hypothesis' truth, they accept it as evidence for the hypothesis' empirical adequacy. This means that insofar as realists need to appeal to epistemic probabilities to support the approximate truth of a theory, antirealists will need to appeal to those same probabilities in support of a theory's empirical adequacy – for example, antirealists would need to claim that it is highly improbable for the determinations of Avogadro's number to agree if atomic theory were not empirically adequate.

Since some of the probabilities in the aforementioned examples involve singular, non-repeatable states of affairs, they are not based on statistical pro babilities, nor arguably other non-epistemic probabilities. This is especially evident for the probabilities involved in the confirmation of atomic theory since some of them involve claims about probabilities conditioned on the underlying structure and laws of the universe being different – e.g. atoms not existing. Hence, they are not based on actual physical propensities, relative frequencies, or theoretical models of the universe's

operation. They therefore cannot be grounded in theoretical, statistical, or physical probabilities. Similar things can be said about many other related types of confirmation in science, such as the confirmation of quantum electrodynamics (QED) by its extraordinarily precise prediction of the gyromagnetic moment of the electron, which we shall discuss later in this chapter. Such cases, I contend, establish the widespread use of purely epistemic probabilities in scientifi c confirmation that are neither grounded in other types of probability nor in experience – e.g. the probabilities invoked in atomic theory clearly are not grounded in experience, since nothing like such an agreement had ever occurred before. We shall return to this in Sections 3.3.2 and 3.3.3 when I discuss the Principle of Indifference.

3.2. An account of epistemic probability

Having established the need for epistemic probability, we now turn to developing an account of it. Accounts of epistemic probability range from the so-called subjective theory to the logical theory. According to the subjective theory, epistemic probability amounts to nothing more than our purely subjective degree of belief in a claim with the only restriction on the rationality of our degrees of belief is that they obey the probability calculus and conform to our own personal inductive standards. In contrast, according to the logical theory, epistemic probability refers to some human-mind independent relation analogous to that of logical entailment. Despite its popularity, I shall say nothing more here about subjective theory, other than that it seems to lead to an extreme form of epistemic relativism. The reason is that it does not distinguish between rational and irrational inductive criteria. Given the right inductive criteria almost any set of beliefs can be made to cohere with the probability calculus – for example, the belief that the Sun and stars revolve around the Earth can be made to cohere with all the current evidence we have to the contrary. (For a further critique, see Swinburne (2001, pp. 73f) and Plantinga (1993, pp. 143f)).

On the other hand, at least two major problems confront the purely logical theory of epistemic probability. First, it is doubtful that we need to hypothesize a metaphysics of human-mind independent relations of logical probability between propositions to ground the rationality of all of our statements involving epistemic probability. As Keynes (1921, pp. 4, 32) pointed out, all we need is the existence of relations of rational support or expectation that are independent of merely personal or cultural beliefs and standards. Consequently, allowing for the relations of epistemic probability to be dependent on the contingent construction of human cognitive faculties fits much better with my overall approach of trying to stay as close as possible to the principles of reasoning that are part of everyday and scientifi c practice (see Section 1.1).

Second, purely logical probability would guide the expectations only of logically omniscient agents – that is, agents that could see all logical relations between propositions, including the relations of logical probability. Humans, however, are limited to a partial grasp of such relations, which is reflected in the relevant usage of epistemic probability in science. For example, as Swinburne acknowledges, based on the current mathematical evidence, Goldbach's conjecture (that every even number greater than two is the sum of two prime numbers) is probably true, but not certainly true. That is, the current evidence – such as that Goldbach's conjecture has been shown to be true for the fi rst trillion numbers and was claimed to be proven by some otherwise truthful mathematician – supports this conjecture, but not enough to justify our being certain that it is true. Since it is a mathematical claim, however, Goldbach's conjecture is either necessarily true, or it is necessarily false, and thus its logical probability is either one or zero. The epistemic probability being invoked here, therefore, is not purely logical probability. Even if one does not agree that this sort of epistemic probability arises in mathematics, nonetheless it is clear that when judging the evidential support for a scientific theory, we are not aware of all the relevant logical relations between the evidence and the theory. Keynes, who made the degree of logical/epistemological probability of one proposition on another relative to human powers, recognized this issue. According to him:

> If we do not take this view of probability, if we do not limit it in this way and make it, to this extent, relative to human powers, we are altogether adrift in the unknown; for we cannot ever know what degree of probability would be justified by the perception of logical relations which we are, and must always be, incapable of comprehending. (1921, p. 33)

Following Swinburne, one could still attempt to take logical probability as the primary kind of epistemic (or what he calls inductive) probability, and then attempt to accommodate human limitations. The problem with this approach is that in order to use logical probability to make statements about the rational degree of credence one ought to place in a theory, or the amount by which we should take a body of evidence to increase our confidence in a theory, one would need some account of how to translate degrees of logical probability to rational degrees of credence for beings subject to our limitations. Consequently, one would still need an account of another more human-centered type of epistemic probability that is relative to human cognitive powers to grasp these human perceptions of logical probability; in itself, logical probability only stipulates what the rational degrees of belief of a logically omniscient agent ought to be, not that of a mere human being. As far as I know, Swinburne does not provide any account that links the two together.

I call the conception of epistemic probability that is grounded in our perceptions of logical relations between propositions, episto-logical probability. In contrast to the epistological account of epistemic probability, Alvin Plantinga (1993, chap. 9, pp. 159–75) has developed an account in which the relations of probability are grounded in the contingent construction of our cognitive faculties, which in many cases need not involve perceptions of logical relations. In his account, for instance, we think that the future will resemble the past, since those aspects of properly functioning human cognitive faculties that are aimed at truth normally incline us to believe that the future will resemble the past. Similarly, we accept simpler theories over complex ones for the same reason. Because of their stress on the contingent construction of our cognitive faculties, I call views such as Plantinga's noetic conceptions of epistemic probability.

The account of epistemic probability that I favor is one in which epistemic probabilities are grounded in some combination of both the contingent construction of our cognitive faculties and the perceived logical relations among propositions. For the purposes of this chapter, I will leave it as an open question which of these conceptions of epistemic probability – the logical, the epistological, the noetic, or some combination thereof – is ultimately correct. A word, however, needs to be said about a problem with Plantinga's account of epistemic probability that is relevant for our purposes. Plantinga defines the conditional epistemic probability of a Proposition A on a Proposition B as follows:

> Plantinga's Definition of Conditional Epistemic Probability: P(A|B) = <x,y> iff <x,y> is the smallest interval which contains all the intervals which represent the degree to which a rational human being S (for whom the conditions necessary for warrant hold) could believe A if she believed B, had no undercutting defeater for A, had no other source of warrant either for A or for -A, was aware that she believed B, and considered the evidential bearing of B on A. (1993, p. 169; italics added)

Plantinga's account of conditional epistemic probability is a counterfactual account that defines epistemic probability in terms of the degree of warrant a rational human being would have in A if she believed B and had no other sources of warrant for A or –A. The italicized portion, which we shall call Plantinga's condition of epistemic probability (CEP), primarily does the job of excluding contributions to our warrant which arise from our epistemic circumstances and other information besides B that is part of our background information k.

We cannot go into a detailed analysis of this account of conditional epistemic probability here. However, we shall consider one major objection that is relevant to the way in which we shall be using epistemic probability. As Bas van Fraassen has pointed out, Plantinga's account does not account for those cases in which B could not be the sole source of warrant for A, an objection that Plantinga attempts to address (1993, p. 168–9). This problem arises in the case of the fine-tuning argument, since we claim that the epistemic probability of LPU is very small under NSU. Our own existence in a body, however, provides a source of warrant for LPU, and it is a source that we cannot eliminate without severely altering our cognitive faculties (or epistemic conditions) in a way that would undermine our rationality.

More recently, Richard Otte has given new teeth to the objection to Plantinga's account raised by van Fraassen. Among other examples, Otte asks us to consider the following variation of one of Plantinga's examples:

P (people are sometimes appeared to redly | I am appeared to redly)

According to Otte:

> Intuitively this probability is 1; if I am appeared to redly, it must be the case that people are sometimes appeared to redly. But Plantinga claims that it is not possible for a rational person's sole source of warrant for people are sometimes appeared to redly to be I am appeared to redly.

Thus this probability is undefined according to CEP, even though it obviously has a value of Otte locates the problem with Plantinga's account in his use of counterfactuals, claiming that spelling out conditional epistemic probability in terms of counterfactuals is the wrong approach. Some sort of counterfactual element, however, is essential to any account of conditional epistemic probability if we are to connect degrees of conditional epistemic probability with actual rational degrees of belief, which we need to do if judgments of conditional probability are to serve as guides to life. This requirement, however, does not imply that we must provide a purely counterfactual analysis of conditional epistemic probability; all it demands is that counterfactuals will play some role in connecting conditional epistemic probability with rational degrees of belief.

Although I cannot develop this idea in detail here, I propose that conditional epistemic probability should be conceived as a relation between propositions that is in part determined by the contingent nature of our cognitive faculties. Through introspection, we have partial access to this relation. We typically determine the epistemic probability, P(A|B), of Proposition A on Proposition B – that is, the degree of rational inclination B should give us for A – by artificially creating in our own minds Plantinga's conditions for CEP – that is, by "bracketing out" all other sources of warrant for A or –A, and any undercutting defeaters for A. Thus, for instance, suppose I see it raining outside but want to access the conditional epistemic probability of "it will rain today" (Proposition A) on Proposition B, where B is the conjunction of the claim that "www.weather.com has predicted a 25 percent chance of rain" and other background information, such as that www.weather.com is reliable weather predictor. In assessing this conditional probability, I block out all other sources of warrant for its raining today (such as seeing dark clouds on the horizon), except for Proposition B, and arrive at the correct conditional probability, P(A|B) = 0.25. The fact that, for the cases when CEP applies, I come to know these counterfactual degrees of warrant by means of this "bracketing procedure" strongly suggests that epistemic probability should not be identified with counterfactual degrees of belief. Rather, it should be considered a non-reducible relation of support or warrant existing between propositions that comes in degrees, is partially dependent on our cognitive faculties, and which we can know by introspection via the "bracketing procedure." This relation in turn gives rise to the corresponding counterfactual degrees of warrant when CEP is met.

The fact that conditional epistemic probability should be considered such a relation existing between propositions that we determine by the "bracketing procedure" is supported by other examples. Consider, for instance, the conditional epistemic probability, P(A|B & k′), of the claim that "human beings exist today" (claim A) based on the claim that the asteroid that supposedly killed the dinosaurs missed planet Earth (claim B) and certain relevant scientific theories (k′) regarding the conditions necessary for the evolution of hominids. Given B and k′, I might judge it would be very unlikely that the dinosaurs would have become extinct, and hence very unlikely that humans would exist: that is, I would judge P(A|B & k′) << 1. The procedure I would go through is that of bracketing out all other sources of warrant for A except the relevant scientific theories, k′, and claim B, and then access the degree to which the remaining information warranted or supported A. For instance, I would bracket out all those everyday pieces of information that imply the existence of human beings. Since CEP cannot be met in this case, the existence of a conditional epistemic probability in this case shows that identifying epistemic probability with counterfactual degrees of warrant (or belief or credence) cannot be right.

Part of the purpose of this section is to provide a theoretical underpinning for both the existence of conditional epistemic probability and the claim that P(A|B & k′) can exist for those cases in which the Proposition B & k′ cannot be the sole source of warrant for A. Such a claim is crucial to the likelihood (and probabilistic tension) formulation of the fine-tuning argument, since LPU will be improbable only on background information k′ in which the information that embodied, conscious observers exist is subtracted out of our background information k (see Sections 4.3 and 4.4). Since all rational people believe that they are embodied, it is impossible for k′ & NSU to be the sole source of warrant for LPU. Hence, Plantinga's CEP cannot be met for P(LPU|k′ & NSU). Despite these theoretical underpinnings, some still might question whether there can exist relations of epistemic probability in those cases in which the antecedent (B & k′) cannot be the sole source of warrant for the consequent (A).

To further support the existence of epistemic probabilities in these cases, consider the sorts of cases, such as those mentioned earlier, in which scientifi c confi rmation appears to depend on claims that some state of affairs S – such as the agreement of the various methods of determining Avogadro's number – is expected under a certain hypothesis h, but very epistemically improbable under the negation of that hypothesis, ~h. Suppose we discovered for one of these cases that S was also necessary for our own existence. It seems clear that such a discovery would not itself undermine the confirmation argument in favor of the approximate truth (or empirical adequacy) of the theory. If it did, then we could undermine the support based on the Likelihood Principle for many theories of physics simply by discovering that the state of affairs S predicted by the theory – for example, the degree of bending of light around the Sun predicted by General Relativity – was necessary for embodied conscious life. This seems clearly wrong. Thus, there must be a probability for P(S|~h & k′) in these cases, where k′ is some appropriately chosen background information that does not implicitly or explicitly include the fact that humans exist. (If k′ included that humans exist, then P(S|~h & k′) = 1, destroying any likelihood confi rmation; see Section 4.3 for more discussion on choosing k′ in cases like this.)

As a specific example, consider QED's precise prediction of the deviation from 2 of the gyromagnetic moment of the electron to nine significant digits, as discussed in Section 3.3.3. In terms of the Likelihood Principle, the reason this prediction has been thought to signifi cantly confirm QED is that such a precise, correct prediction seems very epistemically unlikely if QED is not approximately true (or at least empirically adequate), but it is epistemically likely if QED is true.21 Suppose we discovered that this precise magnitude of deviation was necessary for the evolution of life in our universe. It seems clear that this would not undermine the confirmation that this precise prediction gives to QED.

Finally, since no rational person could doubt LPU, it will often be useful to use the following conceptual device to intuitively grasp the relations of conditional epistemic probability for LPU conditioned on NSU & k′ and conditioned on T & k′. The device is to imagine an unembodied alien observer with cognitive faculties structurally similar to our own in the relevant ways, and then ask the degrees of credence that such a being would have in LPU given that he or she believes in NSU & k′ or in T & k′. This device of the unembodied alien observer should remove any lingering doubts about the existence of a conditional epistemic probability on background information k′ that we could not have – for example, when k′ does not implicitly or explicitly include the existence of embodied conscious beings. Given that such an alien is possible, it could have k′ as its background information and thus would not have the aforementioned problem regarding the existence of an epistemic probability for LPU on k′; hence, the existence of LPU could signifi cantly confi rm T over NSU for that being. It seems clear that if we met such a being and if we discovered that LPU confi rmed T over NSU for that being, then it should do so for us too.22

I believe the various arguments I have offered establish both the crucial role of epistemic probabilities in scientifi c confirmation and their existence between some Propositions A and B & k′ in those cases in which B & k′ could never be the sole source of warrant (or justifi cation) for A. Our next question is how to determine P(A|B & k′).

3.3. Determining epistemic probability

3.3.1. Introduction

Now that we know what we mean by epistemic probability, it is time to consider how it is justified. In science, many times epistemic probability is determined by an appeal to intuition, such as many of the epistemic probabilities considered in the last section – for example, those arising in conjunction with the Thesis of Common Ancestry, continental drift theory, and atomic theory. These probabilities clearly were not justified by an appeal to statistical improbability – for example, we have no statistics regarding the relative frequency of life on a planet having those features cited in favor of evolution either under the evolutionary hypothesis or under some nonevolutionary hypothesis. Indeed, these judgments of epistemic probability were never rigorously justified in any way. Rather, after (we hope) doing their best job of looking at the evidence, scientists and laypersons made judgments of what kind of world we should expect under each hypothesis, and then they simply trusted these judgments. This sort of trust in our judgments of epistemic probability is a pervasive and indispensable feature of our intellectual life. It is these sorts of intuitive judgments, I contend, that ultimately ground the claim that, given the evidence for the first type of fine-tuning we discussed in Section 2.2 – that of the laws of nature – it is very epistemically unlikely that such a universe would exist under NSU & k′.

Of course, the more widely shared these judgments are by those who are relevantly informed, the more seriously we take them. In this regard, it should be noted that, given the fine-tuning data, the judgment that LPU is surprising under naturalism is widely shared by intelligent, informed individuals, as evidenced by the various attempts to account for

For a denial of the kind of claim that I make here – namely, that the confi rmation must be the same for the unembodied being and us – see Sober (2005, pp. 137–40). For a critique of Sober, see footnote in Section 7.5. Even if Sober is correct, my other arguments still hold for thinking there could exist an epistemic probability of LPU on k′ & NSU and k′ & T. Further, these arguments show that confi rmation can still occur even when there is an observer selection effect, such as the aforementioned thought experiments in which we discovered that the data in support of atomic theory or QED had anthropic significance.

it, such as the multiverse hypothesis. Of course, the skeptic might object that scientifi c theories are testable, whereas the theistic explanation is not. But why should testability matter with regard to the acceptability of our judgments of epistemic probability? After all, testability is about being able to find evidence for or against a theory in the future, not about the present likelihood of the theory or the likelihood of some body of data's being the case if the theory is false or not empirically adequate. Thus, I contend, the merely intuitive judgments of epistemic probability in the case of fine-tuning are on as solid ground as many of those accepted in science that cannot be rigorously justified. It is dishonest, therefore, to accept one sort of inference without rigorous justification but reject the other merely because it purportedly lacks such justification. At any rate, we shall present such justification for judgments of epistemic probability in the case of the fi ne-tuning of the constants of physics, regarding which I shall argue that we can go beyond a mere appeal to intuition. Instead, we can provide a solid, principled justification based on what I shall call the restricted Principle of Indifference, which we shall discuss in the next two subsections.23

3.3.2. Restricted Principle of Indifference

According to the restricted Principle of Indifference, when we have no reason to prefer any one value of a variable p over another in some range R, we should assign equal epistemic probabilities to equal ranges of p that are in R, given that p constitutes a "natural variable." A variable is defined as "natural" if it occurs within the simplest formulation of the relevant area of physics. When there is a range of viable natural variables, then one can only legitimately speak of the range of possible probabilities, with the range being determined by probabilities spanned by the lower and upper bound of the probabilities determined by the various choices of natural variables.

Since the constants of physics used in the fi ne-tuning argument typically occur within the simplest formulation of the relevant physics, the constants themselves are natural variables. Thus, the restricted Principle of Indifference entails that we should assign epistemic probability in proportion to the width of the range of the constant we are considering. We shall use this fact in Section 5.1 to derive the claim that $P(Lpc|NSU \& k') << 1$, where Lpc is the claim that the value for some fi ne-tuned constant C falls within the life-permitting range.

To see why the restriction to a natural variable is needed, consider the case in which we are told that a factory produces cubes between 0 and 10 meters in length, but in which we are given no information about what lengths it produces. Using our aforementioned principle, we shall now calculate the epistemic probability of the cube being between 9 and 10 meters in length. Such a cube could be characterized either by its length, L, or its volume, V. If we characterize it by its length, then since the range [9,10] is one-tenth of the possible range of lengths of the cube, the probability would be 1/10. If, however, we characterize it by its volume, the ratio of the range of volumes is: [1,000 − 93]/1,000 = [1,000 − 729]/1,000 = 0.271, which yields almost three times the probability as for the case of using length. Thus, the probability we obtain depends on what mathematically equivalent variable we use to characterize the situation.

In the case of the constants of physics, one can always find some mathematically equivalen t way of writing the laws of physics in which Wr/WR is any arbitrarily selected value between zero and one. For example, one could write Newton's law of gravity as F = U100m1m2/r2, where U is the corresponding gravitational constant such that U100 = G. If the comparison range for the standard gravitational constant G were from 0 to 10100G0, and the life-permitting range were from 0 to 109 G0, that would translate to a comparison range for U of 0 to 10U0 and a life-permitting range of 0 to 1.2U0, since 10U0 = 10100G0 and 1.2U0 = 109G0. (Here G0 is the present value of G and U0 would be the corresponding present value of U.) Thus, using G as the gravitational constant, the ratio, Wr/WR, would be 109G0/10100G0 = 1/1091, and using U as the "gravitational constant," it would be 1.2U0/10U0, or 0.12, a dramatic difference! Of course, F = U100m1m2/r2 is not nearly as

simple as F = Gm1m2/r2, and thus the restricted Principle of Indifference would only apply when using G as one's variable, not U.

Examples such as that of the cube mentioned have come to be known as the Bertrand Paradoxes (see e.g. Weatherford 1982, p. 56). Historically, this has been thought of as the fatal blow to the general applicability of the Principle of Indifference, except in those cases in which a natural variable can be determined by, for instance, symmetry considerations such as in statistical mechanics. In the next section, however, we shall see that for purposes of theory confirmation, scientists often take those variables that occur in the simplest formulation of a theory as the natural variables. Thus, when there is a simplest formulation, or nontrivial class of such formulations, of the laws of physics, the restricted Principle of Indifference circumvents the Bertrand Paradoxes.

Several powerful general reasons can be offered in defense of the Principle of Indifference if it is restricted in the ways explained earlier. First, it has an extraordinarily wide range of applicability. As Roy Weatherford notes in his book, Philosophical Foundations of Probability Theory, "an astonishing number of extremely complex problems in probability theory have been solved, and usefully so, by calculations based entirely on the assumption of equiprobable alternatives [that is, the Principle of Indifference]" (1982, p. 35). Second, in certain everyday cases, the Principle of Indifference seems the only justification we have for assigning probability. To illustrate, suppose that in the last 10 minutes a factory produced the first 20-sided die ever produced (which would be a regular icosahedron). Further suppose that every side of the die is (macroscopically) perfectly symmetrical with every other side, except for each side having different numbers printed on it. (The die we are imagining is like a fair six-sided die except that it has 20 sides instead of six.) Now, we all immediately know that upon being rolled the probability of the die coming up on any given side is one in 20. Yet we do not know this directly from experience with 20-sided dice, since by hypothesis no one has yet rolled such dice to determine the relative frequency with which they come up on each side. Rather, it seems our only justification for assigning this probability is the Principle of Indifference: that is, given that every side of the die is macroscopically symmetrical with every other side, we have no reason to believe that it will land on one side versus any other. Accordingly, we assign all outcomes an equal probability of one in 20.24

A full-scale defense of the restricted Principle of Indifference is beyond the scope of this chapter. See Schlesinger (1985, chap. 5) for a lengthy defense of the standard Principle of Indifference.

In the next section, I shall first offer a powerful reason for epistemically privileging those variables that occur in the simplest overall formulation of the relevant domain of physics. I shall then show how this reason offers a further, strong support for the restricted Principle of Indifference based on scientifi c practice.

3.3.3. Natural variable assumption

Typically, in scientific practice, precise and correct novel predictions are taken to signifi cantly confirm a theory, with the degree of confirmation increasing with the precision of the prediction. We shall argue, however, that the notion of the "precision" of a prediction makes sense only if one privileges certain variables – the ones that I shall call the natural variables. These are the variables that occur in the simplest overall expression of the laws of physics. Thus, epistemically privileging the natural variables as required by the restricted Principle of Indifference corresponds to the epistemic practice in certain areas of scientifi c confirmation; if scientists did not privilege certain variables, they could not claim that highly precise predictions confirm a theory significantly more than imprecise predictions.

We begin our argument by considering only cases in which the predictions of a theory are accurate to within experimental error. In such cases, the known predictive precision will be equal to the experimental precision of the measured quantity. Our fundamental premise will then be that everything else being equal, the confirmation that a prediction offers a theory increases with the known precision of a prediction.

The experimental precision of a measurement of a quantity is dependent on the experimental error. In standard scientifi c notation, the experimental value of a quantity is often expressed as V ± e, where e indicates that one's measuring apparatus cannot distinguish between values that differ by more than e. More precisely, to say that the experimentally determined value is V ± e indicates that we have a certain set degree of confidence – usually chosen to be 95 percent – that the actual value is within the interval [V + e, V − e]. So, for example, one might measure the weight of a person as 145.3 lb ± 0.1: that is, the experiment gives us a 95 percent confidence that the person's weight is within the interval [145.4 lb, 145.2 lb].

Scientists often speak of experimental accuracy/precision in terms of signifi cant digits. Thus, in the above example, the precision is three significant digits since one's measuring apparatus cannot determine whether the person weighs 145.4 lb or 145.2 lb, and thus only three digits (i.e. 145) can be relied on to give one the value of the weight. Because sometimes zeroes can be "placeholder" digits that determine the order of magnitude of a quantity, these digits are not considered significant. For example, the zeroes in 0.000841 are placeholder digits. To eliminate counting placeholder digits as significant, one can simply express the measured value in terms of scientifi c notation, and then count the number of digits that are within the margin of error. Thus, a measurement of 0.000841 ± 0.000002 meters for the length of a piece of steel expressed in scientific notation becomes 8.41 ± 0.02 × 10−4 meters, which yields an accuracy of two significant digits. This measure of precision will not work for those cases in which the measured value is zero, nor should it even be applied to those cases in which the measured value is less than the error.

A more precise way of thinking about this kind of precision is in terms of the ratio of the width, Wr, of the confidence interval [V + e, V − e] to the value of V, with the restriction that V > e. Under this notion of precision, to say that the experimental value has a precision of δ means that Abs[Wr/V] < δ, where Abs denotes the absolute value of the quantity in brackets, and Wr denotes the width of the range [V + e, V − e] – that is, 2e. There is a rough correspondence between precision expressed in terms of this ratio and in terms of signifi cant digits: a precision of n significant digits roughly corresponds to a ratio of one in 10n. Thus, in our weight example, Wr = 2e = 0.2, and hence Wr/V = 0.2/145 ~ 1/1,000.

A more careful analysis would reveal that scientists only consider significant digit (SD) precision as a guide to what I call WR precision, which is the ratio of the width, Wr, of the experimentally determined/predicted range for a variable to what is estimated to be the width of the expected range, WR, for the variable given the background information. The actual value, V, is then taken as a guide to the width of the theoretically possible range, and hence Wr/WR ~ Abs[e/V], where ~ means approximately. We shall return to this issue when we discuss QED, but for the purposes of this chapter, we are concerned only with showing that determining the degree of precision of a prediction – whether SD or WR precision – depends on privileging the natural variable(s) as defi ned.

Finally, one might wonder why we cannot define precision simply as the amount that, with a set degree of probability, the actual value could differ from the experimental value. We could, but it would be a useless notion when it came to the question of experimental confirmation. For example, how could we compare the confirmatory value of a predictive precision of 1 kg with that of 1 μm? Or, is it really plausible to say that, for instance, a predictive precision of 20 significant digits of the mass of the universe has less confi rmatory significance than a prediction of one significant digit

of the mass of a hydrogen atom because the former is less accurate in terms of number of kilograms by which the actual value could differ from the predicted value?

We shall now argue that if either the degree of SD precision or the degree of WR precision is epistemically relevant, it follows that one must privilege variables that are closely tied with the natural variables. We shall start by showing that SD experimental precision depends on the variable one uses to represent the quantity being measured; consequently, in order to speak of precision in a nonrelative sense, one must specify the variable one is using to express the physical situation. To illustrate, consider the case of a cube discussed in the last section. The volume of a cube is equal to the third power of the length of its side: V = L3. Suppose we determine the length of the cube is 10 μm, to within a precision of 1 μm. Thus, expressed as a ratio, the SD precision is Abs[e/V] < 1/10, or one part in 10. Roughly, this means that the length of the cube could be anywhere from 9 to 11 μm. In terms of volume, however, the cube can vary between 93 = 729 μm3 and 113 = 1,331 μm3. This means that the experimental precision is (1,331–1,000)/1,000 ~ 1/3, or one part in three, if we take volume as our variable.

Now consider a theory that predicts that the length of the side of the cube is 10 μm. This is equivalent to the theory predicting the volume of the cube to be 1,000 μm. In this case, the predicted value agrees with the experimental value to within experimental precision. If we ask what the known precision of the prediction is, however, we do not get a defi nite answer. If we consider the theory as predicting the length of the cube, we get one value for the known precision, whereas if we consider the theory as predicting the volume, we get another value for the precision. (Remember, since we are assuming that the theory predicts the correct value to within experimental error, the known predictive precision is equal to the experimental precision.) The moral here is that the known precision of a prediction depends on the mathematical variable – for example, L3 or L in the said example – under which one is considering the prediction. Put differently, one can speak of precision of an experimentally correct prediction only relative to the variable one uses to represent the predicted result. In analogy to Bertrand's Cube Paradox for the Principle of Indifference, in the case of the aforementioned cube it seems that we have no a priori way of choosing between expressing the precision in terms of volume or in terms of length, since both seem equally natural. At best, all we can say is that the predicted precision is somewhere between that determined by using length to represent the experimental data and that determined by using volume to represent the experimental data.

For an illustration from actual physics, consider the case of QED's astoundingly accurate prediction of the correction of the gyromagnetic ratio – called the g-factor – of the electron due to its self-interaction. QED predicted that, because of the self-interaction of the electron, the g-factor (gyromagnetic moment) of the electron differs from 2 by a small amount: g/2 = 1.001 159 652 38 ± 0.000 000 000 26.Very accurate experimental measurements yielded: g/2 = 1.001 159 652 ± 0.000 000 000 20. The precision of the said prediction of g/2 is one part in a billion.

Now determining the experimental value for g/2 is equivalent to determining the experimental value of some arbitrarily defi ned function U(g/2) of g/2, say U(g/2) = (g/2)100. Moreover, if QED predicted the value of g/2 to within experimental error, then it follows that it also predicted the correct value of U to within experimental error. The precision by which U is known, however, is one in 10 million instead of one in a billion, as in the case of g/2. Thus, in analogy to the case of probability, even to speak of the precision of QED's prediction, we must already assume a certain natural variable. It seems that the only non-arbitrary choices are the natural variables defi ned earlier, which is what scientists actually use.

From examples like the one cited earlier, it is also clear that WR precision also depends on the choice of the natural variable, as we explained for the case of fine-tuning. So it seems that in order

to speak of the predictive SD or WR precision for those cases in which a theory predicts the correct experimental value for some quantity, one must assume a natural variable for determining the known predictive precision. One could, of course, deny that there exists any nonrelative predictive precision, and instead claim that all we can say is that a prediction has a certain precision relative to the variable we use to express the prediction. Such a claim, however, would amount to a denial that highly accurate predictions, such as those of QED, have any special epistemic merit over predictions of much less precision. This, however, is contrary to the practice of most scientists. In the case of QED, for instance, scientists did take the astounding, known precision of QED's prediction of the g-factor of the electron, along with its astoundingly accurate predictions of other quantities, such as the Lamb shift, as strong evidence in favor of the theory. Further, denying the special merit of very accurate predictions seems highly implausible in and of itself. Such a denial would amount to saying, for example, that the fact that a theory correctly predicts a quantity to an SD precision of, say, 20 signifi cant digits does not, in general, count signifi cantly more in favor of the theory than if it had correctly predicted another quantity with a precision of two signifi cant digits. This seems highly implausible.

Of course, strictly speaking, to make these sorts of comparisons of relative degrees of confirmation, one need not privilege one particular variable for expressing the experimental result and calculating its precision, since one need not be committed to a specifi c degree of precision. Nonetheless, one must put some significant restrictions on the functions of a given variable on which one bases one's calculation of precision, for otherwise one cannot make any significant comparisons. For example, in some cases, there might be several different equally simple ways of writing the laws of physics, giving rise to several different candidates for natural variables. In that case, one would simply say that the degree of precision fell into a certain range covering the different choices of natural variables.

Finally, consider a Likelihood Principle reconstruction of the confi rmation that QED received from its correct, precise prediction of the correction to the g-factor of the electron. Let QED represent the claim that QED is approximately true or at least empirically adequate; let ~QED represent the negation of this claim; finally, let e represent the fact that the correction to the g-factor of the electron falls within the experimentally determined range. Now, $P(e|QED \& k') = 1$, since QED entails that it will fall into the experimentally determined range. (Since e was old evidence at the time of QED's prediction, k′ is our background minus this old evidence). The value of $P(e|\sim QED \& k')$ will depend on the comparison range one chooses – that is, the range of plausible values for the correction to the g-factor given ~QED & k′. There is no precise way of determining this range, but given that without any correction, the g-factor is 2, it is reasonable to suppose that most physicists would have expected it to be no larger than 2. Suppose that it were reasonable to expect the correction to be no greater than ± 0.01, with no preference for any value between 0 and ± 0.01. This would yield a width, WR, for the comparison range of 0.02. If we let Wr be the range of the experimentally determined value of correction, and we used the restricted Principle of Indifference, we would arrive at $P(e|\sim QED \& k') = Wr/WR \sim 10{-}7$, yielding a large likelihood confi rmation of QED over ~QED.

The lesson here is that any support that correct, precise predictions provide for QED over ~QED via the Likelihood Principle will involve using something similar to the restricted Principle of Indifference, with the epistemically privileged natural variables being those in the simplest formulation of the area of physics in question. The same can be said for the likelihood reconstruction of other cases of confirmation based on precise predictions. Such likelihood reconstructions, if plausible, strongly support the epistemic role of the restricted version of the Principle of Indifference in scientifi c practice.

4. Determining k¢ and the Comparison Range

4.1. Introduction

To complete the philosophical groundwork for our argument, we shall need to provide some way of determining k′. Determining k′ will automatically determine the "possible universes" to which we are comparing the life-permitting ones – that is, what we called the "comparison range." We shall focus on the constants of physics, but everything we say applies to the laws and initial conditions of the universe with minor modifi cations. First, however, we need to get clear on what it means to vary a constant of physics.

4.2. What it means to vary a constant of physics

Intuitively, there is a distinction between laws and constants, and physicists usually suppose such a distinction. In current physics, most laws can be thought of as mathematical descriptions of the relations between certain physical quantities. Each of these descriptions has a mathematical form, along with a set of numbers that are determined by experiment. So, for example, Newton's law of gravity (F = Gm1m2/r2) has a mathematical form, along with a number (G) determined by experiment. We can then think of a world in which the relation of force to mass and distance has the same mathematical form (the form of being proportional to the product of the masses divided by the distance between them squared), but in which G is different. We could then say that such worlds have the same law of gravity, but a different value for G. So when we conceive of worlds in which a constant of physics is different but in which the laws are the same, we are conceiving of worlds in which the mathematical form of the laws remains the same, but in which the experimentally determined numbers are different. It should be noted that the distinction between laws and constants need not be a metaphysical distinction, but only a conceptual distinction.

Now these constants of physics are relative to our current physical models, since these constants only occur within a model. Thus, any probabilities we calculate will only be relative to a certain model. Ian Hacking (1987, pp. 119–227) and Bas van Fraassen (1980, pp. 178–95), among others, have emphasized this model-relativism with regard to the relative frequency interpretation of probabilities. Under this interpretation, probabilities are understood as the limit of the ratio of the favorable outcomes to the total number of outcomes as the number of trials goes to infi nity. Since for most, if not all, cases these infi nite long-run frequencies do not exist in the real world, they ultimately must make reference to frequencies in idealized models, as van Fraassen has worked out in detail (1980, pp. 190–3). Similarly, I shall assume, epistemic probabilities exist only relative to our models of the world and our other background information.

At least in the case of epistemic probabilities, this should come as no surprise, since it has to do with rational degrees of belief, which, of course, are relative to human cognition. If one denies the model dependence of epistemic probabilities, then it is hard to see how any statements of epistemic probabilities will ever be justified. One reason is that they are almost always grounded in conceptualizing alternative possibilities under some measure, as illustrated in Section 3.1 by the sort of epistemic probabilities used to justify the Thesis of Common Ancestry, continental drift theory, or the atomic hypothesis. But such conceptualizations typically involve implicit reference to some (often vague) model of how those possibilities are spread out. In fact, this was illustrated by use of natural variables in science discussed in Section 3.3.3.

The relevant models for the fine-tuning hypothesis are just the models given to us by our best theories in physics, just as if we calculated relative frequencies we should do so using the best models that we had in the relevant domain. At present, the best model we have is the Standard Model of particle physics. Sometimes, however, we can calculate the life-permitting range only for a constant that is less than fundamental, either because we do not have a fundamental theory or because of limitations on our ability to calculate. In that case, the most sensible thing to do is to go with the best model for which we can do calculations, as long as we consider only variations in the

constant that fall within the limits of applicability of the model established by the deeper theory – for example, we could sensibly consider the consequences of varying mass using the model of Newton's theory of gravity as long as the variation were within the range of validity of Newtonian mechanics dictated by Einstein's theory of General Relativity.

Because we are considering only one reference class of possible law structures (that given by variations of the constants within our best theories and/or the ones we can perform calculations for), it is unclear how much weight to attach to the values of epistemic probabilities one obtains using this reference class. Hence, one cannot simply map the epistemic probabilities obtained in this way onto the degrees of belief we should have at the end of the day. What we can do, however, is say that given that we choose our reference class in the way suggested, and assuming our other principles (such as the restricted Principle of Indifference in Section 3.3.2), we obtain a certain epistemic probability, or range of probabilities. Then, as a second-order concern, we must assess the confidence we have in this probability based on the various components that went into the calculation, such as the representative nature of the reference class. Given that there is no completely objective procedure for addressing this secondary concern, I suggest that the probability calculations should be thought of as providing supporting confirmation, based on a plausible, nonarbitrary procedure, of the common intuitive sense that given the fi ne-tuning evidence, LPU is very epistemically improbable under NSU. This evidence will be strengthened by the fact that there are many different fine-tuned constants of physics, and many different kinds of fine-tuning, so that the fine-tuning argument does not depend on one highly specifi c reference class. In light of this, we must keep in mind that our goal is not to provide some exact degree by which the fine-tuning evidence supports T over NSU. Rather, it is to show that the intuitive sense that LPU supports T over NSU is not based on some mistake in thinking or perception, or on some merely subjective interpretation of the data, but rather can be grounded in a justifi ed, nonarbitrary procedure.25

4.3. Determining k′: old evidence problem

In Premises (1) and (2) of our main argument in Section 1.3, the probability of LPU is conditioned on background information k′. As we mentioned in Section 1.3, we cannot simply take k′ to be our entire background information k, since k includes the fact that we exist, and hence entails LPU. To determine what to include in k′, therefore, we must confront what is called the "problem of old evidence." The much-discussed problem is that if we include known evidence e in our background information k, then even if an hypothesis h entails e, it cannot confirm h under the Likelihood Principle, or any Bayesian or quasi-Bayesian methodology, since P(e|k & h) = P(e|k & ~h). But this seems incorrect: General Relativity's prediction of the correct degree of the precession of the perihelion of Mercury (which was a major anomaly under Newton's theory of gravity) has been taken to confi rm General Relativity even though it was known for over 50 years prior to the development of General Relativity and thus entailed by k.

An attractive solution to this problem is to subtract our knowledge of old evidence e from the background information k and then relativize confi rmation to this new body of information k′ = k − {e}. As Colin Howson explains, "when you ask yourself how much support e gives [hypothesis] h, you are plausibly asking how much knowledge of e would increase the credibility of h," but this is "the same thing as asking how much e boosts h relative to what else we know" (1991, p. 548). This "what else" is just our background knowledge k minus e. As appealing as this method seems, it faces a major problem: there is no unambiguous way of subtracting e from k. Consider the case of the fi ne-tuning of the strength of gravity. The fact, Lpg, that the strength of gravity falls into the life-permitting range entails the existence of stable, long-lived stars. On the other hand, given our knowledge of the laws of physics, the initial conditions of the universe, and the value of the other constants, the existence of stable, long-lived stars entails Lpg. Thus, if we were to obtain k′ by

subtracting Lpg from our total background information k without also subtracting our knowledge of the existence of long-lived stable stars from k, then P(Lpg|k′) = 1.

To solve such problems, Howson says that we should regard k as "in effect, an independent axiomatization of background information and k − {e} as the simple set-theoretic subtraction of e from k" (1991, p. 549). That is, Howson proposes that we axiomatize our background information k by a set of sentences {A} in such a way that e is logically independent of the other sentences in {A}. Then k′ would simply consist of the set of sentences {A} − e. One serious problem with this method is that there are different ways of axiomatizing our background information. Thus, as Howson recognizes, the degree to which e confirms h becomes relative to our axiomatization scheme (1991, p. 550). Howson argues that in practice this is not as serious a problem as one might expect, since in many cases our background information k is already represented to us in a partially axiomatized way in which e is logically isolated from other components of k. As he notes, "the sorts of cases which are brought up in the literature tend to be those in which the evidence, like the statements describing the magnitude of the observed annual advance of Mercury's perihelion, is a logically isolated component of the background information." (1991, p. 549). In such cases, when we ask ourselves how much e boosts the credibility of h with respect to what else we know, this "what else we know" is well defined by how we represent our background knowledge. Of course, in those cases in which there are alternative ways of axiomatizing k that are consistent with the way our background knowledge is represented to us, there will be corresponding ambiguities in the degree to which e confirms h. I agree with Howson that this is not necessarily a problem unless one thinks that the degree of confirmation e provides h must be independent of the way we represent our background knowledge. Like Howson, I see no reason to make this assumption: confirmation is an epistemic notion and thus is relative to our epistemic situation, which will include the way we represent our background information.

In the case of fine-tuning, our knowledge of the universe is already presented to us in a partially axiomatized way. Assuming a deterministic universe, the laws and constants of physics, along with the initial conditions of the universe, supposedly determine everything else about the universe. Thus, the set of propositions expressing these laws, constants, and initial conditions constitutes an axiomatization of our knowledge. Further, in scientifi c contexts, this represents the natural axiomatization. Indeed, I would argue, the fact that this is the natural axiomatization of our knowledge is part of our background knowledge, at least for scientific realists who want scientific theories to "cut reality at its seams."26 One might object that this procedure is only justified under the assumption that we live in a deterministic universe, since, otherwise, the k we have chosen is not a true axiomatization of our knowledge. This is true, but it is difficult to see how the thesis that the world is indeterministic could be relevant to the legitimacy of the fi ne-tuning argument.

Furthermore, we have a particularly powerful reason for adopting this axiomatization when considering a constant of physics. The very meaning of a constant of physics is only defined in terms of a particular framework of physics. Saying that the strong force constant has a certain value, for instance, would be meaningless in Aristotelian physics. Accordingly, the very idea of subtracting out the value of such a constant only has meaning relative to our knowledge of the current set of laws and constants, and hence this constitutes the appropriate axiomatization of our relevant background information k with respect to which we should perform our subtraction.

Using Howson's method, therefore, we have a straightforward way of determining k − {e} for the case of the constants of physics: we let k be axiomatized by the set of propositions expressing the initial conditions of the universe and the laws and fundamental constants of physics within our currently most fundamental theory which we can do calculations. Since the constants of physics can be considered as given by a list of numbers in a table, we simply subtract the proposition expressing the value of C from that table to obtain k′. Thus, k′ can be thought of as including the

initial conditions of the universe, the laws of physics, and the values of all the other constants except C.

It should be noted that although Howson's method was developed in the context of subjective Bayesian conception of probability, his argument for this method does not depend on this conception. All it depends on is the claim that "when you ask yourself how much support e gives [hypothesis] h, you are plausibly asking how much knowledge of e would increase the credibility of h," and that this is "the same thing as asking how much e boosts h relative to what else we know" (1991, p. 548). Anyone who subscribes to a probabilistic confirmation account of evidence, according to which e counts as evidence for h if and only if knowledge of e increases our degree of confidence in h, should at least be sympathetic to the underlying premises of his argument.

Finally, it is worth considering how the old evidence problem plays out in the method of probabilistic tension. As mentioned earlier, the major problem with Howson's method is that the background information k′ depends on the subtraction procedure one uses. If we cast the fine-tuning argument in terms of probabilistic tension, as elaborated in Section 1.4, this problem can be avoided; we do not need to privilege any particular subtraction procedure. According to that method, both NSU and T should be elaborated in such a way that each of them entails LPU. (We called these elaborated hypotheses NSUe and Te, respectively.) Thus, LPU does not directly confirm one of these elaborated hypotheses over the other. Nonetheless, the fine-tuning evidence creates severe probabilistic tension for NSUe but not for Te. Thus, it gives us a significant reason to prefer Te over NSUe: if with respect to some domain, one hypothesis h1 has much more probabilistic tension than another, h2, then the probabilistic tension gives us strong reason to prefer h2 over h1, everything else being equal.

To determine the degree of probabilistic tension generated for NSUe by the fi ne-tuning evidence, we need to probe NSUe & k for hidden probabilistic tension related to the fi ne-tuning evidence. Now, when considering only a single constant C, the fi ne-tuning evidence only generates probabilistic tension because of the data Lpc. To bring this probabilistic tension out, we first note that NSUe & k = NSU & k = NSU & k′ & Lpc, since k′ = k – {Lpc} and hence k = Lpc & k′, where no particular subtraction procedure is specifi ed for –{Lpc}. Then, we must consider all k′ such that k = k′ & Lpc, and take the true probabilistic tension of NSUe & k to be given by the lower bound of P(Lpc|NSU & k′), for all possible k′. We then follow a similar procedure for the probabilistic tension of Te & k. Using the lower bound guarantees that the information that a constant fell into the life-permitting range is not implicitly left in the k′ one uses to assess probabilistic tension, as we saw in our given example for the fine-tuning of gravity where the existence of long lived, stable stars was left in k′. This is a determinate procedure that does not depend on any choice of subtraction procedure and demonstrates the power of the idea of probabilistic tension. (As an alternative to Howson's method, one might also use this approach to determine k′ for the Likelihood Principle method mentioned, although we will not pursue this further here.)

4.4. Determining k′: the EI region

Next, for any given fine-tuned constant C, we must determine the comparison range of values for C. My proposal is that the primary comparison range is the set of values for which we can make determinations of whether the values are life-permitting or not. I will call this range the epistemically illuminated (EI) range.27 Thus, given that the EI range is taken as our comparison range, we will say that a constant C is fine-tuned if the width, Wr, of the range of life- permitting values for the constant is very small compared with the width, WR, of the EI range.

To motivate the claim that the comparison range, WR, should be taken as the EI range, we shall consider a more mundane case of a very large dartboard with only some small, finite region around the bull's eye that is illuminated, with the bulk of the dartboard in darkness. In this case, we know

neither how far the dartboard extends nor whether there are other bull's eyes on it. If we saw a dart hit the bull's eye in the illuminated (IL) region, and the bull's eye was very, very small compared with the IL region, we would take that as evidence that the dart was aimed, even though we cannot say anything about the density of bull's eyes on other regions of the board.

One way of providing a likelihood reconstruction of the confirmation of the aiming hypothesis is to include the fact that the dart fell into the IL region as part of the information being conditioned on: that is, include it in the background information k′. We could then use the Likelihood Principle to argue as follows: given that we know that the dart has fallen into the IL region, it is very unlikely for it to have hit the bull's eye by chance but not unlikely if it was aimed; hence, its falling in the bull's eye confirms the aiming hypothesis over the chance hypothesis. Similarly, for the case of fine-tuning, we should include the fact that the value of a constant is within the EI region as part of our background information k′.

Is including in k′ the fact that C falls into the EI range an adequate procedure? The case of the dartboard, I believe, shows that it is not only a natural procedure to adopt, but also arguably the only way of providing a Likelihood Principle reconstruction of the inference in this sort of mundane case. First, it is clearly the ratio of the area taken up by the bull's eye to the IL region around the bull's eye that leads us to conclude that it was aimed. Second, one must restrict the comparison range to the IL range (i.e. include IL in k′) since one does not know how many bull's eyes are in the unilluminated portion of the dartboard. Thus, if one expanded the comparison range outside the IL range, one could make no estimate as to the ratio of the area of the bull's eye regions to the non-bull's eye regions, and thus could not provide a likelihood reconstruction. Yet it seems intuitively clear that the dart's hitting the bull's eye in this case does confirm the aimed hypothesis over the chance hypothesis.

Another way of seeing why the comparison range should be equal to the EI range is in terms of the rational degrees of credence in Lpc of the fictional unembodied alien observer introduced at the end of Section 3.2. In accordance with the method of dealing with old evidence, we imagine our alien observer holding background information k′, in which the knowledge of the value of C is subtracted out. Then we imagine that our alien observer learns that C falls into the EI range. Call this new information Q. Even assuming that it makes sense to speak of C as possibly having any value between minus infinity and infi nity, the alien observer would not know whether the sum of the widths of all the life-permitting regions outside of the EI region are fi nite or infinite. Hence, it would not know the value of P(Q|T & k′), since to say anything about the chance of God's creating C in the EI region, it would have to know if there are other life-permitting regions besides the ones in EI. Hence, P(Q|NSU & k′)/P(Q|T & k′) would be indeterminate. This means that knowledge of Q neither confi rms nor disconfi rms T relative to NSU.

Suppose our alien observer learns the additional information, Lpc, that C falls into the life-permitting region of EI. Since our observer knows Q, assessing whether this additional information confirms T with respect to NSU will depend on the ratio P(Lpc|k′ & Q & T)/P(Lpc|k′ & Q & NSU). Now, since k′ & Q & NSU implies nothing about where C falls in the EI region, it would leave our alien observer indifferent as to where it fell in this region. Hence, assuming the validity of the restricted Principle of Indifference (see Section 3.3.2), P(Lpc|k′ & Q & NSU) = Wr/WR, where WR is equal to width of the EI region. Thus, including the information Q that C falls into the EI region in our background information k′ is equivalent to choosing our comparison range as the EI range.

At this point, one might question the legitimacy of including Q in our background information k′: that is, choosing k′ such that k′⟞k′ & Q. Besides appealing to examples such as the previously discussed dartboard case, in general when comparing hypotheses, we can place into the background information any evidence that we have good reason to believe neither confirms nor disconfirms the

hypothesis in question. In some cases this is obvious: for example, when assessing the ratio of the probabilities of the defendant's fi ngerprints' matching those on the gun under the guilt and innocence hypothesis, respectively, the fact that Jupiter has over 62 moons would be irrelevant information. Thus, jurors would be free to include it as part of their background information.

Another way of thinking about this issue is to note that k′ determines the reference class of possible law structures to be used for purposes of estimating the epistemic probability of Lpc under NSU: the probability of Lpc given k′ & NSU is the relative proportion of law structures that are life-permitting in the class of all law structures that are consistent with k′ & NSU. (The measure over this reference class is then given by the restricted Principle of Indifference.) Thinking in terms of reference classes, the justification for restricting our reference class to the EI region is similar to that used in science: when testing a hypothesis, we always restrict our reference classes to those for which we can make the observations and calculations of the frequencies or proportions of interest – what in statistics is called the sample class. This is legitimate as long as we have no reason to think that such a restriction produces a relevantly biased reference class. Tests of the long-term effi cacy of certain vitamins, for instance, are often restricted to a reference class of randomly selected doctors and nurses in certain participating hospitals, since these are the only individuals that one can reliably trace for extended periods of time. The assumption of such tests is that we have no reason to think that the doctors and nurses are relevantly different than people who are neither doctors nor nurses, and thus that the reference class is not biased. As discussed in Section 4.2, the justification for varying a constant instead of varying the mathematical form of a law in the fine-tuning argument is that, in the reference class of law structures picked out by varying a constant, we can make some estimate of the proportion of life-permitting law structures. This is something we probably could not do if our reference class involved variations of mathematical form. The same sort of justifi cation underlies restricting the class to the EI range.

It is also important to keep things in perspective by noting that there are really two separate issues here. First is the issue of the existence of a meaningful probability for P(Lpc|Q & k′ & NSU). That question reduces to whether there is an epistemic probability measure over the EI region; this will uncontroversially be the case if the EI region is fi nite and the restricted Principle of Indifference is true and applies. The second question is whether Q & k′ is the appropriate background information. If one allowed for prior probabilities and the full use of Bayes's Theorem, then any choice is appropriate as long as one also has meaningful prior probabilities for P(NSU|Q & k′), P(T|Q & k′), and P(Lpc|Q & k′ & T).28 Since I have attempted to avoid the use of prior probabilities, it became important to have some procedure of determining the appropriate background information k′. So this issue arises only for the likelihood version of the argument that avoids prior probabilities. It does not arise for other versions, including the secondary method of probabilistic tension, since, as we saw earlier, that does not depend on the particular choice of appropriate background information.

Including Q in k′ provides a Likelihood Principle reconstruction of John Leslie's "fl y on the wall" analogy, which he offers in response to the claim that there could be other unknown values for the constants of physics, or unknown laws, that allow for life:

> If a tiny group of flies is surrounded by a largish fly-free wall area then whether a bullet hits a fly in the group will be very sensitive to the direction in which the fi rer's rifle points, even if other very different areas of the wall are thick with flies. So it is suffi cient to consider a local area of possible universes, e.g., those produced by slight changes in gravity's strength. . . . It certainly needn't be claimed that Life and Intelligence could exist only if certain force strengths, particle masses, etc. fell within certain narrow ranges. . . . All that need be claimed is that a lifeless universe would have resulted from fairly minor changes in the forces etc. with which we are familiar. (1989, pp. 138–9).

Finally, notice how our methodology deals with a common major misunderstanding of the fine-tuning argument based on the constants of physics. On this misunderstanding, advocates of the fine-tuning argument are accused of implicitly assuming the laws somehow existed temporally or logically prior to the constants, and then afterwards the values of the constants were determined. Then one imagines that if NSU is true, the values occur by "chance," and hence it is very, very unlikely for them to fall into the life-permitting range. Thus, critics of the fine-tuning argument, such as Ian Hacking (1987, pp. 129–30) and John Earman (2006), have claimed that it begs the question, since it already presupposes the existence of a creator. According to Earman, talk of the existence of a fi ne-tuned universe's being improbable "seems to presuppose a creation account of actuality: in the beginning there is an ensemble of physically possible universes – all satisfying the laws of our universe but with different values of the constants – awaiting to be anointed with the property of actuality by the great Actualizer . . ." (2006). It should be clear that the way in which I spell out the argument makes no such metaphysical assumption. We simply consider the ratio of epistemic probabilities P(Lpc|T & k′)/P(Lpc|NSU & k′), where Lpc denotes the claim that a constant fell into the life-permitting range; this does not presuppose a creation account of the laws any more than does a likelihood reconstruction of the confi rmation that old evidence e provides a scientific theory, in which a similar procedure of subtracting old evidence is involved.29

4.5. Examples of the EI region

In this section, we shall consider how to estimate the EI region for the force strengths and some other constants. In doing this, we first note that, as argued in Section 4.2, we must make our estimates of epistemic probability relative to the best calculation-permitting models we have, as long as those models are reasonable approximations of the best current overall models. Consider, for instance, the strong nuclear force, which is only defined in a specific model. We know that this model has only limited applicability since the strong nuclear force is ultimately the byproduct (or residue) of the "color force" between the quarks of which neutrons and protons are composed. Further, the physical model, quantum chromodynamics, describing the color force is thought to have only limited range of applicability to relatively low energies. Thus, the EI region will be finite, since we can only do valid calculations for those values of the strong nuclear force or color force that stay within a relatively low-energy regime.

This limitation of energy regime does not apply just to the theory of strong interactions, but to all of the fundamental quantum theories of nature. In the past, we have found that physical theories are limited in their range of applicability – for example, Newtonian mechanics was limited to medium-sized objects moving at slow speeds relative to the speed of light. For fast-moving objects, we require special relativity; for massive objects, General Relativity; for very small objects, quantum theory. When the Newtonian limits are violated, these theories predict completely unexpected and seemingly bizarre effects, such as time dilation in special relativity or tunneling in quantum mechanics.

There are good reasons to believe that current physics is limited in its domain of applicability. The most discussed of these limits is energy scale. The current orthodoxy in high energy physics and cosmology is that our current physics is either only a low-energy approximation to the true physics that applies at all energies or only the low-energy end of a hierarchy of physics, with each member of the hierarchy operating at its own range of energies.30 The energy at which any particular current theory can no longer to be considered approximately accurate is called the cutoff energy, although (despite its name) we should typically expect a continuous decrease in applicability, not simply a sudden change from applicability to nonapplicability. In contemporary terminology, our current physical theories are to be considered effective fi eld theories. The limitation of our current physics directly affects thought experiments involving changing the force strengths. Although in everyday life we conceive of forces anthropomorphically as pushes or pulls, in current

physics forces are conceived of as interactions involving exchanges of quanta of energy and momentum.31 The strength of a particular force, therefore, can be thought of as proportional to the rate of exchange of energy-momentum, expressed quantum mechanically in terms of probability cross sections. Drastically increasing the force strengths, therefore, would drastically increase the energy-momentum being exchanged in any given interaction. Put another way, increasing the strength of a force will involve increasing the energy at which the relevant physics takes place. So, for instance, if one were to increase the strength of electromagnetism, the binding energy of electrons in the atom would increase; similarly, an increase in the strength of the strong nuclear force would correspond to an increase in the binding energy in the nucleus.32

The limits of the applicability our current physical theories to below a certain energy scales, therefore, translates to a limit on our ability to determine the effects of drastically increasing a value of a given force strength – for example, our physics does not tell us what would happen if we increased the strong nuclear force by a factor of 101,000. If we naively applied current physics to that situation, we should conclude that no complex life would be possible because atomic nuclei would be crushed. If a new physics applies, however, entirely new and almost inconceivable effects could occur that make complex life possible, much as quantum effects make the existence of stable atomic orbits possible, whereas such orbits were inconceivable under classical mechanics. Further, we have no guarantee that the concept of a force strength itself remains applicable from within the perspective of the new physics at such energy scales, just as the concept of a particle's having a defi nite position and momentum, lost applicability in quantum mechanics; or the notion of absolute time lost validity in special relativity; or gravitational "force" (versus curvature of space-time) in General Relativity.33 Thus, by inductive reasoning from the past, we should expect not only entirely unforeseen phenomena at energies far exceeding the cutoff, but we even should expect the loss of the applicability of many of our ordinary concepts, such as that of force strength.

The so-called Plank scale is often assumed to be the cutoff for the applicability of the strong, weak, and electromagnetic forces. This is the scale at which unknown quantum gravity effects are suspected to take place thus invalidating certain foundational assumptions on which current quantum field theories are based, such a continuous space-time (see e.g. Peacock 1999, p. 275; Sahni & Starobinsky 1999, p. 44). The Plank scale occurs at the energy of 1019 GeV (billion electron volts), which is roughly 1021 higher than the binding energies of protons and neutrons in a nucleus. This means that we could expect a new physics to begin to come into play if the strength of the strong force were increased by more than a factor of ~1021. Another commonly considered cutoff is the grand unifi ed theory (GUT) scale, which occurs around 1015 GeV (Peacock 1999, pp. 249, 267). The GUT scale is the scale at which physicists expect the strong, weak, and electromagnetic forces to be united. From the perspective of the currently proposed GUT, these forces are seen as a result of symmetry-breaking of the united force that is unbroken above 1015 GeV, where a new physics would then come into play. Effective field theory approaches to gravity also involve General Relativity's being a low-energy approximation to the true theory. One common proposed cutoff is the Plank scale, although this is not the only one (see e.g. Burgess 2004, p. 6).

Where these cutoffs lie and what is the fundamental justification for them are controversial issues. The point of the previous discussion is that the limits of our current theories are most likely finite but very large, since we know that our physics does work for an enormously wide range of energies. Accordingly, if the life-permitting range for a constant is very small in comparison, then Wr/WR << 1, which means that there will be fi ne-tuning. Rigorously determining Wr/WR is beyond the scope of this chapter. Almost all other purportedly fine-tuned constants also involve energy considerations: for example, because of Einstein's E = mc2, the rest masses of the fundamental particles (which are fundamental constants) are typically given in terms of their rest energies – for example, the mass of the proton is 938 MeV (million electron volts). Further, the cosmological constant is now thought of as corresponding to the energy density of empty space. Thus, the

considerations of energy cutoff mentioned will play a fundamental role in defining the EI region, and hence WR, for many constants of physics.

4.6. Purported problem of infi nite ranges

Finally, let us suppose that the comparison range is infinite, either because of some new theory that applies at all energy scales or because the reasoning in the last two subsections is incorrect. Timothy McGrew, Lydia McGrew, and Eric Vestrup (2001) and, independently, Mark Colyvan, Jay Garfield, and Graham Priest (2005) have argued that if the comparison range is infinite, no meaningful probability can be assigned to a constant's landing in the life-permitting region. (They also mistakenly assume that the only nonarbitrary comparison range for the constants of nature consists of all possible values ($-\infty$ to ∞).) These authors first assert that (i) the total probability of a constant's being somewhere in the infinite range of possible values has to be 1 (since it must have some value), and (ii) if we assume an equiprobability distribution over the possible values – which they claim is the only nonarbitrary choice – the probability of its being in any fi nite region must be zero or undefined. Finally, (iii) they consider any arbitrary way of dividing up the entire range into a countably infinite set of finite, nonoverlapping regions, and assert that the total probability of its being in the entire region must the sum of the probabilities of its being in each member of the set. For example, the probability of its being in the entire region is the sum of the probabilities of its being between 0 and 1, of its being between 1 and 2, of its being between 2 and 3, ad infi nitum, plus the sum of the probabilities of its being between 0 and −1, between −1 and −2, ad infi nitum. But since no matter how many times one adds zero together, one gets zero, this sum turns out to be zero. Hence, if we assume that each probability is zero, we get a contradiction since the probability of the constant having a value somewhere in the entire region is 1. Therefore, it must be undefi ned.

The problem with this argument is the assumption that the epistemic probability for the entire region is the sum of the individual probabilities of each finite disjoint region. In cases where the number of alternatives is finite, this is true: the sum of the probabilities of a die landing on each of its sides is equal to the probability of the die landing on some side. This is a fundamental principle of the probability calculus called fi nite additivity. When finite additivity is extended to a countably infinite number of alternatives, it is called countable additivity, which is the principle that McGrew and Vestrup implicitly invoke.

This latter principle, however, has been very controversial for almost every type of probability, with many purported counterexamples to it. Consider, for example, the following situation. Suppose that what you firmly believe to be an angel of God tells you that the universe is infinite in extent and that there are a countably infinite number of other planets with civilizations on each planet. Finally, the "angel" tells you that within a billion miles of one and only one of those planets is a golden ball 1 mile in diameter and that it has delivered the identical message to one person on each of those planets. Finally, you decide on the following arbitrary numbering system to identify the planets: you label Earth 1, the planet that is closest to Earth 2, the planet that is next farther out 3, and so forth. Since within current Big Bang cosmology an infinite universe would have no center, there is nothing special about Earth's location that could figure into one's probability calculation. Accordingly, it seems obvious that, given that you fully believe the "angel", for every planet k your confidence that the golden ball is within a billion miles of k should be zero. Yet this probability distribution violates countable additivity. One cannot argue that the scenario I proposed is in any way self-contradictory, unless one wants to argue that an infinite universe is self-contradictory. This, however, ends up involving substantive metaphysical claims and is arguably irrelevant, since the issue is the degree to which the propositions delivered by the "angel" justifies, or warrants, the belief that the ball is within a billion miles of our planet, not whether these propositions ultimately could be true.

McGrew and McGrew (2005) have responded to these sorts of arguments by claiming that when the only nonarbitrary distribution of degrees of belief violates the axiom of countable additivity, the most rational alternative is to remain agnostic. They point out that one need not assign epistemic probabilities to all propositions. I do not believe this is an adequate response, since I think in some cases it would be irrational to remain agnostic. For example, it would be irrational for a billionaire who received the aforementioned message to spend millions, or even hundreds, of dollars in search of the golden planet, even if it were entirely rational for him to believe what the "angel" told him; it would even be irrational for him to hope to discover the planet. This is radically different than cases where people are legitimately agnostic, such as perhaps about the existence of extraterrestrials or the existence of God; for example, it seems rationally permitted at least to hope for and seek evidence for the existence of extraterrestrials or God.

The implausibility of being agnostic in the "golden planet case" is further brought out when one considers that if the billionaire were told that the universe was finite with exactly 1010,000 planets with civilizations, clearly he should be near certain that the golden planet is not near Earth. But, clearly, if the billionaire is told that there are even more planets – infi nitely many – the billionaire should be at least as confident that the planet is not near Earth; and, certainly, it should not become more rational for him to search for it than in the 1010,000 planets case, as it would if he should switch to being agnostic.

So the McGrews and others are wrong in claiming that there would be no epistemic probability if the range is infinite. However, they are correct in claiming that this would turn the fine-tuning argument into what McGrew, McGrew, and Vestrup (2001) have called the course-tuning argument (CTA). As they correctly point out, if the comparison range is infinite, then no matter how large the life-permitting range is, as long as it is finite the ratio Wr/WR will be zero. This means that the narrowness of the range becomes irrelevant to our assessment of degree of fine-tuning. The McGrews and Vestrup, reiterating a point made by Paul Davies (1992, pp. 204–5), claim that it is obvious that CTA is not a good argument since CTA would have the same force no matter how "un-fi ne-tuned" a constant is, as long as the life-permitting range is finite. Thus, they argue, this would render the appeal to physics, and the narrowness of the life-permitting range, completely superfluous.

In response, an appeal to physics would still be necessary: we still should have to have good physical reasons to think the life-permitting range to be finite, which itself would involve having a model that we had good reasons to believe was accurate for all values of the parameter in question. This would involve a substantial appeal to physics. Of course, if it turned out that the comparison range were infinite, the restrictiveness of the life-permitting range would no longer play a role, and thus the popular presentation of the argument would have to be modified. Nonetheless, the formal presentation of the argument, based on the claim that $Wr/WR << 1$ and the restricted Principle of Indifference, would remain. As is, I suggest that the reason we are impressed with the smallness is that we actually do have some vague fi nite comparison range to which we are comparing the life-permitting range, namely the EI range.

Finally, rejecting CTA for the reasons the McGrews and Vestrup give is counterintuitive. Assume that the fine-tuning argument would have probative force if the comparison range were finite. Although they might not agree with this assumption, making it will allow us to consider whether having an infinite instead of finite comparison range is relevant to the cogency of the fi ne-tuning argument. Now imagine increasing the width of this comparison range while keeping it finite. Clearly, the more WR increases, the stronger the fi ne-tuning argument gets. Indeed, if we accept the restricted Principle of Indifference (Section 3.32), as WR approaches infi nity, $P(Lpc|NSU \,\&\, k')$ will converge to zero, and thus $P(Lpc|NSU \,\&\, k') = 0$ in the limit as WR approaches infinity. Accordingly, if we deny that CTA has probative force because WR is purportedly infinite, we must

draw the counterintuitive consequence that although the fine-tuning argument gets stronger and stronger as W R grows, magically when WR becomes actually infinite, the fine-tuning argument loses all probative force.34

5. Justifying Premises (1) and (2)

5.1. Justifying premise (1)

The justification of Premise (1) of our main argument in Section 1.3 will depend on which fine-tuned feature of the universe is being considered. For the fine-tuning of the laws of nature, Premise (1) would be justified by an appeal to widely shared intuitions, as explained in Section 3.3.1. For the fi ne-tuning of the initial conditions of the universe, we have two choices. First, we could appeal to the standard measure of statistical mechanics (as is typically done). Second, if we have qualms about the applicability of the standard measure discussed in Section 2.4, we could appeal to the compelling reasons given in that section for thinking that the universe started in an extraordinarily special state; hence, in some real sense it is still epistemically enormously improbable, even if we cannot provide a rigorous mathematical grounding for that probability.

Finally, for the fi ne-tuning of the constants of physics, we shall appeal to the restricted Principle of Indifference (Section 3.3.2). This is the case we shall elaborate in detail. We shall begin by justifying Premise (1) for the case of individual constants that are fi ne-tuned and then consider the case in which the constants are combined. The argument has two steps:

(i) Let C be a constant that is fine-tuned, with C occurring in the simplest current formulation of the laws of physics. Then, by the definition of fi ne-tuning, $Wr/WR << 1$, where Wr is the width of the life-permitting range of C, and WR is the width of the comparison range, which we argued was equal to the width of the EI range.

(ii) Since NSU and k′ give us no reason to think that the constant will be in one part of the EI range instead of any other of equal width, and k′ contains the information that it is somewhere in the EI range, it follows from the restricted Principle of Indifference that $P(Lpc|NSU \& k') = Wr/WR$, which implies that $P(Lpc|NSU \& k') << 1$.

5.1.1. Combining constants

Some have faulted the fine-tuning arguments for only varying one constant at a time, while keeping the values of the rest fixed. For example, Victor Stenger claims that, “One of the many major flaws with most studies of the anthropic coincidences is that the investigators vary a single parameter while assuming all the others remain fi xed!” (2007, p. 148).

This issue can be easily addressed for a case in which the life-permitting range of one constant, C1, does not significantly depend on the value that another constant, C2, takes within its comparison range, R2. In that case, the joint probability of both C1 and C2 falling into their life-permitting ranges is simply the product of the two probabilities. To see why, note that by the method explicated in Sections 4.3 and 4.4, the appropriate background information, k′ 12, for the joint conditional probability of Lpc1 & Lpc2 on NSU is k′ 12 = k − Lpc1 & Q1 − Lpc2 & Q2 = k′ 1 & k′ 2. Here, −Lpc1 and the −Lpc2 represent the subtraction of the information that C1 and C2 have life-permitting values, respectively; Q1 and Q2 represent, respectively, the knowledge that they each fell into their respective EI regions (which is added back in, as explained in Section 4.4); and k′ 1 = k − Lpc1 & Q1 and k′ 2 = k − Lpc2 & Q2 represent the appropriate background information for C1 and C2, respectively, when they are considered separately.

By the definition of conditional probability, $P(Lpc1 \& Lpc2|NSU \& k' 12) = P(Lpc1|NSU \& k' 12 \& Lpc2) \times P(Lpc2|NSU \& k' 12)$. Now, Q2 & Lpc2 = Lpc2 since the claim that C2 fell into its (known)

life-permitting region entails that it fell into its EI region: that is, Lpc2 → Q2. Hence, k′ 12 & Lpc2 = k − Lpc1 & Q1 − Lpc2 & Q2 & Lpc2 = k − Lpc1 & Q1 − Lpc2 & (Q2 & Lpc2) = k − Lpc1 & Q1 − Lpc2 & Lpc2 = k − Lpc1 & Q1 = k′ 1. It follows, therefore, that P(Lpc1|NSU & k′ 12 & Lpc2) = P(Lpc1|NSU & k′ 1), which was merely the probability we calculated for Lpc1 on the background information in which we held all the other constants fixed. So, our next question is, what is the value of P(Lpc2|NSU & k′ 12)? Now, k′ 12 includes the values of all the other constants besides C1 and C2. For C1 and C2 it only includes the information that they are in their respective EI regions. Thus, if the width, Wr2, of the life-permitting range of C2 is not signifi cantly dependent on the value of C1 in C1's EI region, then by the restricted Principle of Indifference, P(Lpc2|NSU & k′ 12) ~ Wr2/WR2 = P(Lpc2|NSU & k′ 2), where WR2 is the width of EI region for C2 when all other constants are held fi xed.35 This means that P(Lpc1 & Lpc2|NSU & k′ 12) ~ P(Lpc1|NSU & k′ 1) × P(Lpc2|NSU & k′ 2). Thus, we can treat the two probabilities as effectively independent.

When will two constants be independent in this way? Those will be cases in which the factors responsible for C1's being life-permitting are effectively independent of the factors responsible for C2's being life-permitting. For example, consider the case of the fine-tuning of the cosmological constant (C1) and the fine-tuning of the strength of gravity (C2) relative to the strength of materials – that is, the first case of the fi ne-tuning of gravity discussed in Section 2.3.2. The life-permitting range of gravity as it relates to the strength of materials does not depend on the value of the cosmological constant, and hence P(Lpc2|k′ 12 & NSU) = P(Lpc2|k′ 2 & NSU). This means that the joint probability of both gravity and the cosmological constant's falling into their life-permitting ranges is the product of these two probabilities: Wr/WR for gravity times Wr/WR for the cosmological constant. This same analysis will hold for any set of fine-tuned constants in which the life-permitting range for each constant is independent of the values the other constants take in their respective EI ranges: e.g., the set consisting of the fi ne-tuning of the strong nuclear force needed for stable nuclei and the previously discussed example of the fi ne-tuning of gravity.

5.2. Justifying premise (2)

In order to justify Premise (2) of our main argument in Section 1.3, we shall need to argue that God has some reason to bring about LPU.36 For definiteness, we shall fi rst consider the case of the fine-tuning of the constants under the assumption that T is true and that there is only one universe. That is, we shall attempt to justify the claim that for any constant C that is fi ne-tuned, ~P(Lpc|TSU & k′) << 1, where TSU is the theistic single-universe hypothesis and k′ is the background information defined in Sections 4.3 and 4.4. It should then be clear how this case generalizes to cases in which the constants are combined, and for the two other fundamental types of fine-tuning discussed in Section 2. Finally, we shall indicate how this argument generalizes for the theistic multiverse hypothesis (TMU).

To determine P(Lpc|TSU & k′), let us invoke our imaginative device (Section 3.2) of an unembodied, alien observer with cognitive faculties relevantly similar to our own and who believes TSU and k′. This observer would designate our universe as "the universe that is actual" – which we shall abbreviate as U – and would know that U has the laws that our universe has and the values of all the other constants, except that it only would know that constant C had a value in the EI region. Now if this unembodied being could perceive no reason for God to create the universe with C in the life-permitting region instead of any other part of the EI region, then P(Lpc|TSU & k′) = Wr/WR << 1. So the claim that ~P(Lpc|TSU & k′) << 1 hinges on this unembodied being's (and hence our) perceiving some reason why God would create a life-permitting universe over other possibilities.

As Richard Swinburne has argued (2004, pp. 99–106), since God is perfectly good, omniscient, omnipotent, and perfectly free, the only motivation God has for bringing about one state of affairs instead of another is its relative (probable) contribution to the overall moral and aesthetic value of reality.37 Simple forms of life, such as bacteria, do not seem in and of themselves to contribute to

the overall moral value of reality, although it is possible that they might contribute to its overall aesthetic value. On the other hand, embodied moral agents seem to allow for the realization of unique types of value. Hence, it is this form of life that is most relevant for arguing that ~P(Lpc|k′ & T) << 1, and thus the most relevant for the fi ne-tuning argument.

Now let EMA represent the claim that the universe contains embodied moral agents, and let Wh represent whatever else God must do over and above creating the universe with the right laws, constants, and initial conditions to ensure that it contains such agents, such as God's intervening in the unfolding of the universe. Now P(EMA|TSU & k′) = P(Lpc & Wh|TSU & k′) = P(Wh|Lpc & k′ & TSU) × P (Lpc|TSU & k′), given that these probabilities have well-defined values or ranges of value. Since P(Wh|Lpc & k′ & TSU) ≤ 1, it follows that P(Lpc|TSU & k′) ≥ P(EMA|TSU & k′), once again assuming that these probabilities have well-defined values or ranges of value. Thus, if we can establish that ~P(EMA|TSU & k′) << 1, we shall have established that ~P(Lpc|TSU & k′) << 1 (which will automatically be true if the probabilities are not well defined). In order for ~P(EMA|TSU & k′) << 1, it must be plausible to suppose that on balance, God has more reason to make U in such a way that EMA is true than to make it in such a way that EMA is false. We must be very careful about what is required here. Since we are dealing with epistemic probabilities, which are relative to human cognitive faculties and limitations, to establish that ~P(EMA|TSU & k′) << 1 does not require that we show that God actually has more reason, only that it is plausible to suppose that God does.

This will require first that we perceive, however dimly, that it is plausible to think that the existence of embodied creatures like us – that is, finite, vulnerable, embodied moral agents –has a (probable) overall positive value, thus giving God a reason to create a world in which such beings could come about. One cannot merely argue for the value of personal agents in general. The reason is that God's fine-tuning universe U to make EMA true will result in various forms of moral and natural evil, unless God constantly intervenes to prevent it, which clearly does not happen in our world.38 Thus, in order for God to have a reason to adjust C so that U contains our type of embodied moral agents, there must be certain compensatory goods that could not be realized, or at least optimally realized, without our type of embodiment. This brings us directly to the problem of evil.

If we have an adequate theodicy, then we could plausibly argue that our unembodied alien observer would have positive grounds for thinking that God had more reason to create the universe so that EMA is true, since it would have good reason to think that the existence of such beings would add to the overall value of reality. In that case, we could argue that P(Lpc|TSU & k′) > 0.5.39 On the other hand, if we have no adequate theodicy, but only a good defense – that is, a good argument showing that we lack suffi cient reasons to think that a world such as ours would result in more evil than good – then our unembodied being would both lack sufficient reason to expect that God would make U so that EMA would be true and lack sufficient reason to expect God to create U so that EMA would be false. Hence, there would be no conditional epistemic probability of EMA on TSU & k′ and therefore no conditional epistemic probability for P(Lpc|TSU & k′). It would still follow, however, that Lpc is not epistemically improbable under TSU: that is, ~P(Lpc|TSU & k′) << 1. Hence, Lpc would still give us good reason to believe TSU over NSU.40

One might challenge this conclusion by claiming that both the restricted Likelihood Principle and the method of probabilistic tension require that a positive, known probability exist for Lpc on T & k′. This seems incorrect, as can be seen by considering cases of disconfirmation in science. For example, suppose some hypothesis h conjoined with suitable auxiliary hypotheses, A, predict e, but e is found not to obtain. Let ~E be the claim that the experimental results were ~e. Now, P(~E|h & A & k) << 1, yet P(~E|h & A & k) ≠ 0 because of the small likelihood of experimental error. Further, often P(~E|~(h & A) & k) will be unknown or indeterminate, since we do not know all the

alternatives to h nor what they predict about e. Yet, typically we would take ~E to disconfi rm h & A in this case because P(~E|h & A & k) << 1 and ~P(~E|~(h & A) & k) <<1.

Thus, unless the atheist can show that it is highly improbable that God would create a world which contained as much evil as ours, it will still be the case that, given the evidence of the fine-tuning of the constants, the conjunction of the existence of evil and the fact that the constants have life-permitting values strongly confirms TSU over NSU. This means that theism is still confi rmed when the strongest evidence that atheists typically offer for their position (i.e. the existence of evil) is combined with the evidence of the fi ne-tuning of the constants. Specifically, if we let Ev denote the existence of the kinds and degrees of evil we find in the world, then, for all fine-tuned constants C, Lpc & Ev gives us good reason to believe in TSU over NSU.41

What about the case of TMU – that is, the hypothesis that God exists and created many universes. One possibility is to consider the evidence, Lpc*, where Lpc* = "the value of the constant C of this universe falls into the life-permitting range," where "this universe" refers to our universe by some means other than "the one and only actual universe": for example, by means of some sort of indexical, such as "the universe that contains this electron," where the unembodied being has some way of referring to "this electron" other than by a definite description that uses only purely qualitative properties. Now, some might worry here that given the existence of multiple universes, God would have no reason to make this universe life-permitting, and thus that P(Lpc*|TMU & k′) << 1. For example, Roger White claims that, "It is only the assumption that there are no other options that we should expect the designer to fi ne-tune this universe for life" (2000, p. 243). I disagree. Given that the existence of our type of embodied moral agents is a (probable) overall good, it would contribute to the overall value of reality even if there were such beings in other universes. Thus, God would still have a reason for fine-tuning this universe, and hence ~P(Lpc*|TMU & k′) << 1. Yet, P(Lpc*/NSU & k′) = P(Lpc/NSU & k′) << 1, and hence Lpc* would confi rm TMU over NSU.

Even if White is correct, however, our unembodied alien would still have the same reason as offered earlier for thinking that God would create some life-permitting universe. Thus, ~P(LPU*|TMU & k′) << 1, where LPU* is the claim that "some life-permitting universe exists." Nonetheless, since for every constant C, NSU & k′ & LPU* entails Lpc & NSU & k′, P(LPU*|NSU & k′) ≤ P(Lpc|NSU & k′) << 1. Thus, by the restricted version of the Likelihood Principle, LPU* confirms TMU over NSU. If White is right, therefore, the relevant confirmatory evidence for TMU versus NSU would become "some life-permitting universe exists" instead of "this universe has life-permitting values for its constants."

6. The Multiverse Hypothesis

6.1. Introduction

The multiverse hypothesis is the hypothesis that there exist many regions of space-time – that is, "universes" – with different initial conditions, constants of physics, and even laws of nature. It is commonly considered the major alternative to the competing hypotheses of T and NSU. Just as in a lottery in which all the tickets are sold, one is bound to be the winning number, so given a varied enough set of universes with regard to some life-permitting feature F, it is no longer surprising that there exists a universe somewhere that has F. Multiverse hypotheses differ both in the features that vary from universe to universe – for example, the initial conditions, the constants of physics, and so on – and what physical process, if any, produced them.

The multiverse objection can be interpreted as either claiming that the multiverse provides an alternative explanation of the fine-tuning of the cosmos, or that it simply eliminates the epistemic improbability of the fine-tuning. We shall focus primarily on the latter objection, since such an objection would undermine any argument based on the Likelihood Principle that the fine-tuning

provides evidence for T over a naturalistic version of the multiverse hypothesis. Put precisely, this version of the multiverse objection is that ~P(LPU|NMU & k′) << 1, where k′ is some appropriately chosen background information and NMU is the relevant naturalistic multiverse hypothesis. Thus, it is claimed, LPU does not provide evidence via the Likelihood Principle for T over an appropriately chosen multiverse hypothesis.

To address this objection, we first need to get clear on exactly how multiverse hypotheses are supposed to explain, or take away the seeming improbability of, the fi ne-tuning. To begin, we need to distinguish between three facts with regard to the fi ne-tuning that are candidates for explanation: (1) what I call the observer-relative life-permitting (LP) fact that we, or I, observe a life-permitting universe instead of a non-life-permitting universe;

(2) what I call the indexical LP fact that this universe is life-permitting – or has some life-permitting feature F, where "this" is an indexical that picks out the universe we inhabit; and (3) what I call the existential LP fact that a life-permitting universe exists, a fact that is equivalent to what we have been referring to by "LPU". The so-called Weak Anthropic Principle, which states that the universe we inhabit must have a life-permitting structure, appears to be enough to make the observer-relative LP fact unsurprising. With regard to the indexical LP fact, some philosophers claim that we cannot make a purely indexical reference to our universe but can only refer to our universe via an implicit description. Thus, for instance, one could claim that "this universe" is reducible to "the universe we inhabit," where the "we" is in turn reducible to some other description such as "conscious observers with characteristics X," where X refers to some set of purely qualitative properties. If this analysis is correct, then the claim that "this universe is life-permitting" would be a tautology, and hence have an epistemic probability of one. Even if one rejected this analysis, one could still claim that the life-permitting character of our universe is a defining, or at least an essential, feature of it, so the indexical LP fact is a necessary truth and thus not surprising. Consequently, it is questionable whether this indexical fact is in any way improbable. In any case, it is clear that the multiverse hypothesis does not itself explain or render probable this indexical LP fact, since whether or not other universes exist is irrelevant to the features our universe might have.

So the only place where the multiverse hypothesis could help in explaining the fi ne-tuning or undercutting its improbability is by explaining or undercutting the apparent improbability of LPU – that is, of the existential LP fact expressed by (3). A hypothesis postulating a sufficiently varied multiverse will entail LPU; hence, purportedly it will not only explain why some such universe exists but will also undercut any claim that the existence of such a universe is improbable. It is here, and only here, that the multiverse could do any work in undercutting the fine-tuning argument for T. The so-called observer-selection effect, often considered an essential part of the multiverse explanation, does not itself contribute at all; this effect only explains the observer-relative LP fact given by (1) and is already taken into account by the Weak Anthropic Principle.

Now it is important to distinguish between two categories of multiverse hypotheses: the unrestricted version (which I shall label UMU) and various types of restricted versions. The unrestricted version is the hypothesis that all possible worlds exist, a version famously advocated by philosopher David Lewis as an account of modal claims. According to Lewis, every possible world actually exists (as a region of space-time) parallel to our own. Thus, for instance, there exists a reality parallel to our own in which objects can travel faster than the speed of light. Dream up a possible scenario, and it exists in some parallel reality, according to Lewis. These worlds, however, are completely isolated from ours, and there are no spatiotemporal or causal relations between the worlds – for example, things in one world do not happen before, at the same time, or after things in our world. Further, they do not overlap in any way, except for the possibility of sharing immanent universals. (1986, p. 2).

Lewis advocates his hypothesis as an account of modal statements – that is, statements that make claims about possibility and impossibility, such as "it is possible that Al Gore won the US presidential election in 2004," and "it is impossible for an object to be a perfect cube and a perfect sphere at the same time." Thus, Lewis calls his view modal realism, with the term "realism" indicating that every possible world exists in as real a way as our own. This term, however, is a misnomer, since it implies that other accounts of modal claims are antirealist, which they are not. The other major advocate of a similar view is Massachusetts Institute of Technology astrophysicist Max Tegmark (1998, 2003). According to Tegmark, "everything that exists mathematically exists physically" (1998, p. 1), by which he means that every self-consistent mathematical structure is in one-to-one correspondence with some physical reality (1998, pp. 1–3). Unlike Lewis, Tegmark's primary argument for his view is to explain LPU. Further, it is unclear whether Tegmark is claiming that every possible universe exists, or only that every possible universe that can be described purely mathematically; in the latter case it would not be a completely unrestricted multiverse hypothesis.

In contrast to Lewis's and perhaps Tegmark's hypothesis, restricted multiverse hypotheses postulate some restriction on the possible universes (or worlds) that actually exist. The most widely discussed versions are those that claim that a multitude of varied universes are generated by some physical process (what I will call a "multiverse generator"). We shall discuss these in Section 6.3. The important point here is that such a restriction will run the danger of reinstantiating the problem of fine-tuning at the level of the restrictions placed on the set of existing universes. In Section 6.3, I shall argue in detail that this is what happens in the case of the most widely discussed multiverse-generator hypothesis, the infl ationary-superstring multiverse hypothesis.

Unlike the restricted versions of the multiverse hypothesis, the unrestricted version does not run any danger of reinstantiating the problem of fine-tuning. As I shall argue in the next subsection, however, it faces the following devastating dilemma as an alternative to a theistic explanation of the fi ne-tuning: it either undercuts almost all scientifi c reasoning and ordinary claims of improbability, or it completely fails to undercut the fi ne-tuning argument for T.42

6.2. Critique of the unrestricted multiverse

To begin our argument, consider a particular event for which we would normally demand an explanation, say, that of Jane's rolling a six-sided die 100 times in a row and its coming up on six each time. Call the type of sequence "coming up 100 times on six" type Tx. Further, let "D" denote the particular die that Jane rolled and DTx the state of affairs of D's falling under type Tx for the particular sequence of die rolls: that is, DTx is the state of affairs of D's coming up 100 times in a row on six for that particular sequence of die rolls. Normally, we should not accept that DTx simply happened by chance; we should look for an explanation. The reason is that DTx is both very improbable, having a one in 6100 chance of occurring, and in some way "special." The quality of being "special" is necessary for our seeking an explanation since all 100 sequences of rolls are equally improbable, but they are not all in need of an explanation. In general, what makes an improbable occurrence special, and thus a coincidence in need of explanation, is difficult to explicate precisely. John Leslie, for example, has proposed that this specialness consists of our being able to glimpse a simple, unified explanation of the occurrence (Leslie, 1988, p. 302). In whatever way one explicates being "special," however, certainly, a six-sided die coming up 100 times in a row on six qualifies.

Now, for any possible state of affairs S – such as DTx – UMU entails that this state of affairs S is actual. Thus, with regard to explanation, for all possible states of affairs S, advocates of UMU must claim that the fact that UMU entails S either (i.a) undercuts all need for explanation, or (i.b) it does not. Further, with regard to some state of affairs S (such as DTx) that we normally and

uncontroversially regard as improbable, they must claim that the fact that UMU entails S either (ii.a) undercuts the improbability of S (since it entails S), or (ii.b) it does not. Both (i.a) and (ii.a) would constitute a reductio of UMU, since it would undercut both all justifications in science based on explanatory merits of an hypothesis and ordinary claims of probability, such as in our die example. If advocates of UMU adopt (i.b) and (ii.b), however, then the mere fact that UMU entails LPU undercuts neither the need to explain LPU nor its apparent improbability.43

Part of what gives rise to the temptation to think that UMU can explain, or render unsurprising, LPU (without doing the same for every other occurrence) is the existence of other "many-trials" scenarios that appear to be analogous but which are really crucially disanalogous. The way in which they are disanalogous is that they only entail the occurrence of a very limited number of states of affairs that we find highly surprising, without entailing the existence of all such states of affairs. What drives inferences of epistemic probability in these cases is what I call the Entailment Principle. This principle states that if h & k′ is known to entail S, or known to render the statistical probability of S near 1, then the conditional epistemic probability of S on h & k′ is near 1: that is, P(S|h & k′) ~ 1.44 For limited multiple-trial hypotheses the Entailment Principle can render epistemically probable the actuality of some state of affairs whose actuality would otherwise be considered highly improbable, without at the same time rendering the actuality of other states of affairs probable that we normally consider improbable. Consider, for example, what could be called the multiple-die-roll hypothesis (MDR), according to which an enormous number of dice are being rolled at every moment throughout the galaxy, in fact so many that the statistical probability that some sequence of 100 die rolls will come up all sixes is almost one. By the Entailment Principle, it follows that it is highly epistemically probable under MDR that some 100-member sequence of die rolls will come up all sixes. The conjunction of MDR and the Entailment Principle, however, does not change the probability of other states of affairs whose improbability is critical for everyday inferences, such as that of some particular sequence of die rolls coming up all sixes.

Now, advocates of UMU could affirm the Entailment Principle and still retain the claim that for some states of affairs S, the actuality of S is epistemically improbable under UMU. As we saw earlier, if S is a possible state of affairs, then UMU entails that S is actual. If we can know that S is possible without knowing that S is actual, then the claim that S is possible would be part of our background information k′, and hence P(S|UMU & k′) = 1. Suppose that for some cases, however, we cannot know whether S is possible apart from S's actually occurring. In those cases, the Entailment Principle could be true and yet for some S, P(S|UMU & k′) < 1, even though UMU entails S. In the case of the die D in our earlier example, the particular die D exists only as part of the world W it occupies, and thus the only possible sequence of rolls of D are those that it has in W.45 Consequently, unless we know the sequences of rolls of D that have actually occurred in W, we cannot know whether it is possible for D to fall in sequence type Tx without knowing whether D has actually fallen in type Tx. This means that even though UMU might entail that D lands in type Tx, we could not deduce this from UMU, and, hence, the conditional epistemic probability of D's falling in Tx could be less than 1. The epistemic probability of P(DTx|k′ & UMU) would then be given by the degree to which k′ & UMU of itself rationally justifies the proposition, DTx, that die D came up in sequence type Tx. Call this the nondeducibility loophole, since it arises from the fact that even though UMU entails the actuality of all actual states of affairs S, we cannot always derive S's actuality from UMU.

Now the nondeducibility loophole will work only if we can refer to D in W in a way that is not equivalent or reducible to providing some qualitative description that uniquely picks it out from among all dice that exist across worlds, since such a qualitative description would have to include everything about D that distinguishes it from its counterparts in other worlds, including DTx, or ~DTx. Put differently, it will work only if we can make statements about the die that essentially involve the use of indexicals – that is, involve the use of indexicals, such as "this die," in a way that

cannot be translated in terms of statements that only use qualitative descriptions such as “the die with properties P,” where the properties P are purely qualitative properties.46

If we allow such essentially indexical propositions about particular objects in the universe, such as the die, then it seems we can also make such essentially indexical statements about the universe we inhabit: we could simply specify that universe U (or “this universe”) refers to the universe that contains some particular object – for example, some particular electron – that we are referring to in an essentially indexical manner. This will allow us to adopt the same loophole to the Entailment Principle as adopted by advocates of UMU. Put differently, what I called the indexical LP fact – that is, the fact that universe U is life-permitting – could no longer be simply dismissed as needing no explanation (or lacking improbability) because it is purportedly a defining or essential feature of this universe that it is life-permitting. The reason is that even though it would be an essential feature of this universe, we could not deduce it from UMU without already knowing that it is possible for universe U to be life-permitting, just as we could not deduce DTx from UMU without knowing that DTx is possible.

Finally, to exploit the nondeducibility loophole for the indexical LP fact, we simply apply our standard procedure for subtracting out old evidence – such as that the universe has life-permitting values for its constants – to obtain background information k′. Now, although k′ and UMU entail that universe U is life-permitting, a being with cognitive faculties relevantly similar to our own could not deduce that simply by knowing k′ and UMU: for example, if our unembodied being introduced at the end of Section 3.2 were given the information k′ and UMU, it would not know whether U was life-permitting or not. Consequently, by the same argument used for the case of the NSU, P(Universe U is lifepermitting|UMU & k′) << 1 and P(Lpc|UMU & k′) << 1.47 Of course, one might argue against this subtraction procedure, but this sort of argument is a direct challenge to my version of the fine-tuning argument itself, not a challenge arising from UMU. (See Section 4.3 for a defense of the subtraction procedure.)

A general lesson to be gained from this analysis is that any multiverse hypothesis that purportedly undercuts the fine-tuning argument by entailing LPU will have to be restricted in the right way: specifi cally, it will have to be such that it does not entail states of affairs S that we normally take to be improbable. Consider, for example, a multiverse hypotheses M that attempts to explain the special initial conditions of our universe by hypothesizing that it is part of a vast array of universes all of which have the same laws L but in which every possible initial condition is realized. The standard inflationarysuperstring scenario discussed in the next section contains such a multiverse as a subset. So do standard multiverse theories based on the existence of an infinite universe with widely varying initial conditions. Assuming that universes lack haecceities – which in this case implies that they are distinguished only by their initial conditions – and assuming the laws are deterministic, then M will entail the existence of our universe along with all of its properties. For example, M will entail DTx. Hence, the mere fact that M entails the existence of our universe and its life-permitting structure cannot be taken as undercutting the claim that it is improbable without at the same time undercutting claims such as that DTx is improbable. Of course, an advocate of M could always use the nondeducibility loophole discussed earlier to save the improbability of the actuality of these states of affairs, but that will open the door to the advocate of the fine-tuning argument’s using the same loophole.49 If this analysis is correct, it will spell trouble for those who claim that the multiverses discussed in contemporary cosmology – such as the inflationary multiverse – can undercut the improbability of the extraordinarily special initial conditions of our universe by claiming that every possible initial condition is realized in some universe or another.

6.3. The inflationary-superstring multiverse explained and criticized

As mentioned in Section 6.1, by far the most commonly advocated version of the restricted multiverse hypothesis is the “multiverse-generator” version that claims that our universe was

generated by some physical process that produces an enormous number of universes with different initial conditions, values for the constants of nature, and even lower-level laws. Many scenarios have been proposed – such as the oscillating Big Bang model and Lee Smolin's claim that many universes are generated via black holes (Smolin 1997). Among these, the one based on inflationary cosmology conjoined with superstring theory is by far the most widely discussed and advocated, since this is the only one that goes beyond mere speculation. According to inflationary cosmology, our universe started from an exceedingly small region of space that underwent enormous expansion due to a hypothesized infl aton field that both caused the expansion and imparted a constant, very large energy density to space as it expanded. The expansion caused the temperature of space to decrease, causing one or more so-called "bubble universes" to form. As each bubble universe is formed, the energy of the infl aton field is converted into a burst of "normal" mass-energy, thereby giving rise to a standard Big Bang expansion of the kind we see in our universe.

In chaotic infl ation models – widely considered the most plausible – space expands so rapidly that it becomes a never-ending source of bubble universes. Thus, an enormous number of universes naturally arise from this scenario. In order to get the parameters of physics to vary from universe to universe, however, there must be a further physical mechanism/law to cause the variation. Currently, many argue that this mechanism/law is given by superstring theory or its proposed successor, M-Theory, which are widely considered the only currently feasible candidates for a truly fundamental physical theory. It should be stressed, however, that both infl ationary cosmology and superstring/M-Theory are highly speculative. For example, Michio Kaku states in his recent textbook on superstring theory, "Not a shred of experimental evidence has been found to confirm . . . superstrings" (1999, p. 17). The same remains true today. The major attraction of superstring/M-Theory is its mathematical elegance and the fact that many physicists think that it is the only game in town that offers significant hope of providing a truly unified physical theory of gravitation with quantum mechanics (Greene 1999, p. 214).

6.3.1. Inflationary-superstring multiverse requires right laws

One major possible theistic response to the multiverse generator scenario, whether of the inflationary variety or some other type, is that the laws of the multiverse generator must be just right – fine-tuned – in order to produce life-sustaining universes. To give an analogy, even a mundane item such as a bread machine, which only produces loaves of bread instead of universes, must have the right structure, programs, and ingredients (fl our, water, yeast, and gluten) to produce decent loaves of bread. Thus, it seems, invoking some sort of multiverse generator as an explanation of the fine-tuning reinstates the fi ne-tuning up one level, to the laws governing the multiverse generator. So, at most, it could explain the fi ne-tuning of the constants and initial conditions. (Even the latter will be problematic, however, as we shall see in the next two sections.)

As a test case, consider the inflationary type multiverse generator. In order for it to explain the fine-tuning of the constants, it must hypothesize one or more "mechanisms" or laws that will do the following five things: (i) cause the expansion of a small region of space into a very large region; (ii) generate the very large amount of mass-energy needed for that region to contain matter instead of merely empty space; (iii) convert the mass-energy of inflated space to the sort of mass-energy we find in our universe; and (iv) cause suffi cient variations among the constants of physics to explain their fi ne-tuning.

Glossing over the details, in inflationary models, the first two conditions are met via two factors. The first factor is the postulated infl aton field that gives the vacuum (that is, empty space), a positive energy density. The second factor is the peculiar nature of Einstein's equation of General Relativity, which dictates that space expand at an enormous rate in the presence of a large near-homogenous positive energy density (see Section 2.3.3). Finally, because the infl aton field gives a constant positive energy density to empty space, as space expands the total vacuum energy within

the space in question will increase enormously. This, in turn, generates the needed energy for the formation of matter in the universe. As one text in cosmology explains, “the vacuum acts as a reservoir of unlimited energy, which can supply as much as is required to inflate a given region to any required size at constant energy density” (Peacock 1999, p. 26).

So, to achieve (i)–(ii), we effectively have a sort of “conspiracy” between at least two different factors: the infl aton field that gives empty space a positive energy density, and Einstein’s equation. Without either factor, there would neither be regions of space that inflate nor would those regions have the mass-energy necessary for a universe to exist. If, for example, the universe obeyed Newton’s theory of gravity instead of Einstein’s, the vacuum energy of the infl aton field would at best simply create a gravitational attraction causing space to contract, not to expand.

The conversion of the energy of the infl aton field to the normal mass-energy of our universe (condition (iii)) is achieved by Einstein’s equivalence of mass and energy, E = mc2, along with the assumption that there is a coupling between the infl aton field and the matter fields. Finally, the variation in the constants (and to some extent the laws) of nature is typically claimed to be achieved by combining inflationary cosmology with superstring/ M-Theory, which purportedly allows for an enormous number (greater than 10500) possible combinations of values for the constants of physics. The important point here is that the laws underlying the inflationary scenario must be just right in order to cause these variations in the constants of physics from one universe to another. If the underlying laws are those given by superstring/M-Theory, arguably there is enough variation; this is not the case, however, for the typical grand unified theories that have been recently studied, which allow for only a very limited number of variations of the parameters of physics, about a dozen or so in the case of the simplest model (Linde 1990, p. 33). As Joseph Polchinski notes in his textbook on superstring theory (1998, vol. II, pp. 372–3), there is no reason to expect a generic field to have an enormous number of stable local minima of energy, which would be required if there is to be a large number of variations in the constants of physics among universes in infl ationary cosmology.

In addition to the four factors listed, the fundamental physical laws underlying a multiverse generator – whether of the inflationary type or some other – must be just right in order for it to produce life-permitting universes, instead of merely dead universes. Specifi cally, these fundamental laws must be such as to allow the conversion of the mass-energy into material forms that allow for the sort of stable complexity needed for complex intelligent life. For example, as elaborated in Section 2.2, without the Principle of Quantization, all electrons would be sucked into the atomic nuclei, and, hence atoms would be impossible; without the Pauli Exclusion Principle, electrons would occupy the lowest atomic orbit, and hence complex and varied atoms would be impossible; without a universally attractive force between all masses, such as gravity, matter would not be able to form sufficiently large material bodies (such as planets) for life to develop or for long-lived stable energy sources such as stars to exist.

Although some of the laws of physics can vary from universe to universe in superstring/ M-Theory, these fundamental laws and principles underlie superstring/M-Theory and therefore cannot be explained as a multiverse selection effect. Further, since the variation among universes would consist of variation of the masses and types of particles, and the form of the forces between them, complex structures would almost certainly be atomlike and stable energy sources would almost certainly require aggregates of matter. Thus, the said fundamental laws seem necessary for there to be life in any of the many universes generated in this scenario, not merely in a universe with our specific types of particles and forces.

In sum, even if an inflationary-superstring multiverse generator exists, it must have just the right combination of laws and fields for the production of life-permitting universes: if one of the

components were missing or different, such as Einstein's equation or the Pauli Exclusion Principle, it is unlikely that any life-permitting universes could be produced. Consequently, at most, this highly speculative scenario would explain the fi ne-tuning of the constants of physics, but at the cost of postulating additional fi ne-tuning of the laws of nature.

6.3.2. Low-entropy problems for inflationary cosmology

Inflationary cosmology runs into a major problem in explaining the low entropy of the universe. This is a critical problem, since unless it can do this, arguably much, if not all, of the motivation for infl ationary cosmology vanishes. Further, this problem will cast severe doubt on the ability of an inflationary multiverse to explain the fine-tuning. The problem is that, applied to the universe as a whole, the second law of thermodynamics demands that the entropy of the universe always increase. Indeed, even if one has doubts about the applicability of the second law to the universe as a whole, inflation invokes a thermalization process, and thermalization is known to be a paradigmatic entropy-increasing process. As Oxford University physicist Roger Penrose states:

> Indeed, it is fundamentally misconceived to explain why the universe is special in any particular respect by appealing to a thermalization process. For, if the thermalization is actually doing anything (such as making temperatures in different regions more equal than they were before), then it represents a definite increasing of entropy. Thus, the universe would have had to be more special before the thermalization than after. This only serves to increase whatever diffi culty we might have had previously in trying to come to terms with the initial extraordinarily special nature of the universe. . . . invoking arguments from thermalization, to address this particular problem [of the specialness of the universe], is worse than useless! (2004, p. 756)

Based on this sort of argument, it is now widely accepted that the preinfl ationary patch of space-time that inflated to form our universe must have had lower entropy than the universe right after inflation. For example, Andreas Albrecht, a defender of infl ationary cosmology, admits that inflationary cosmology must hypothesize a special initial low entropy state: "For infl ation, the infl aton fi eld is the out-of-equilibrium degree of freedom that drives other subsystems. The inflaton starts in a fairly homogeneous potential- dominated state which is certainly not a high-entropy state for that field . . ." (2004, p. 382). Elsewhere, he says the preinfl ation patch must have been in a "very special state" (2004, p. 380).

6.3.3. Albrecht's "dominant channel" response

So, how does inflation explain the special initial conditions of the Big Bang, which is the primary aim of the theory? According to Albrecht, it explains the initial conditions by a two-stage process, via the "chaotic inflation" models mentioned in Section 6.3. First, as Albrecht explains, "One typically imagines some sort of chaotic primordial state, where the infl aton field is more or less randomly tossed about, until by sheer chance it winds up in a very rare fluctuation that produces a potential-dominated state . . ." (Albrecht 2004, p. 384). Potential-dominated states are those in which the potential energy of the infl aton field is enormous compared to the rate of change of the infl aton field with respect to time and space. That is, in order for inflation to occur, the infl aton field must be almost uniform both spatially and temporally relative to the total energy density of the field (Peacock 1999, p. 329). Although macroscopic uniformity of matter is typically a state of very high entropy (such as perfume spread throughout a room), it is generally accepted that in the case of the gravitational field and the infl aton field, greater uniformity entails lower entropy. This is said to explain why the universe becomes more and more inhomogeneous as it expands (with matter clustering into galaxies and stars forming), and yet at the same time its entropy increases. Entropy increases because the gravitational field becomes less uniform. Since the gravitational field

would play a significant role in the space-time of the early universe, a near uniform infl aton fi eld would correspond to extremely low entropy.

Now a general requirement for infl ation is that the infl aton fi eld be nearly uniform, in the potential-dominated sense defined earlier, over some very small patch. Although these states will be extremely rare, given a large enough initial infl aton field, or enough time, they are likely eventually to occur in some small patch of space simply as a result of thermal fluctuations. Once they occur, inflation sets in, enormously expanding the patch. Eventually, because of the postulated nature of the infl aton field, in one or more regions of this expanded space, the field decays, resulting in reheating that produces a bubble universe with ordinary matter. So, in effect, because inflation can only occur in highly uniform states of the infl aton fi eld, any universe produced from an infl ated region will have initially low entropy.

Accordingly, Albrecht proposes that inflation explains the low entropy of our universe by a two-stage process: (i) a low-entropy patch occurs as a result of a statistical fl uctuation, and then (ii) that patch inflates into our universe. As John Barrow and Frank Tipler pointed out over 20 years ago (1986, p. 437), however, if the right special initial conditions must be stumbled upon by a statistical fl uctuation, why not simply hypothesize a very large, or infinite, material field that undergoes a random fluctuation that produces a universe relevantly like ours? Why invoke the additional mechanism of infl ation?

The answer requires looking at the standard objection to "random fl uctuation models." The objection is that universes being produced by such a fluctuation (without infl ation) would almost certainly lead to small islands of observers surrounded by chaos, not one with a low degree of entropy throughout. Even more ominously, a random observer most likely would be a so-called Boltzmann brain (BB). A BB is a small region of mass-energy with the same structure as our brains (including the same sort of apparent memory and sensory experiences), but with the surrounding regions of space and time in a chaotic, high-entropy state. Although the experiences of such brains would be highly ordered for a brief time, they would not in any way correspond to reality, and any sort of inductive reasoning would fail.

The BB concept was originally articulated as part of an objection raised against the proposed anthropic-selection-effect explanation of the low initial entropy offered by Ludwig Boltzmann, one of the principal founders of statistical mechanics. Boltzmann attempted to explain the relatively low entropy of the universe by claiming that it was the result a fluctuation from the normal "chaotic," equilibrium state, and that a fl uctuation with a high degree of order was necessary for the existence of observers. As theoretical physicist Paul Davies and many others have pointed out in response to Boltzmann's anthropic explanation, a fluctuation "the size of the solar system would be suffi cient to ensure the existence of life on Earth, and such a fl uctuation is far more probable than one of cosmic proportions" (Davies 1974, p. 103). Indeed, fluctuations of even smaller dimensions – ones in which matter has the same organization as the brain with all its apparent memories and sense experiences but in which the surrounding space-time was chaos – would be even more likely. Consequently, insofar as a random fluctuation world contained observers, any randomly selected observer would almost certainly be a BB.

To intuitively see why Davies's statement is correct, consider an analogy of a very large scrabble board. If we were to shake the scrabble board at random, we would be much more likely to get an ordered, meaningful arrangement of letters in one small region, with the arrangement on the rest of the board essentially chaotic, than for all the letters on the entire board to form meaningful patterns. Or, as another analogy, consider a hundred coins lined up in a row, which are then shaken at random. Define a local island of order to be any consecutive sequence of five coins which all are on the same side – that is, either all heads or all tails. It is much more likely for the sequence of a

hundred coin tosses to contain one or more subsequences of five consecutive heads or tails than for it to be all heads or all tails. Indeed, it is likely that such a sequence of coins will have at least one such island of five consecutive heads or tails; the probability of the coins coming up all heads or all tails, however, is around one in 1030, or one in a thousand, billion, billion, billion.

The same argument applies to the mass-energy configurations of our visible universe, with the argument being grounded in probability calculations based on the standard probability measure of statistical mechanics over phase space. Roger Penrose's calculations show that among all possible configurations, it is enormously more likely (by a factor of around 1 in 10x, where x = 10123) for local islands of low entropy to form than the whole visible universe to be in a low-entropy state (see e.g. Penrose 2004, pp. 762–5). Indeed, if we consider the set of all configurations of mass-energy that would result in an observer – for example, an organized structure with the same relevant order as our brain – the subset of such configurations that are dominated by BB observers would be far, far larger than those confi gurations that are dominated by non-BB observers.

Some people attempt to draw from these calculations the conclusion that if the random fluctuation model is correct, we should then expect ourselves to be BBs. This assumption, however, is difficult to justify. We can, however, derive the more limited conclusion that under the random fluctuation model it is epistemically very likely that we are BBs conditioned on only our purely subjective experiences: that is, P(BB|k′ & RF) ~ 1, where BB represents the hypothesis that "I am a BB," RF the claim that the random fl uctuation model is correct, and k′ includes all of one's own "purely subjective" experiences but no claim that these experiences correspond to reality.

Many have argued, however, that we have noninferential knowledge of the existence of the external world – that is, knowledge of the external world that cannot be deduced from k′. If this is right, then P(BB|k & RF) = 0, where k* = there is an external world that generally corresponds to our subjective experiences, and k = k′ & k* is our relevantly complete background information. This is the reason we cannot derive the skeptical conclusion that if the random fluctuation model is true, we should expect ourselves to be BBs. However, since P(~BB & k*|RF & k′) << 1, the elaborated RF hypothesis, k & RF = ~BB & k′ & k* & RF, suffers from a severe probabilistic tension that the elaborated ~RF hypothesis, k & ~RF = ~BB & k′ & k* & ~RF, does not. (Here, ~BB is the claim that we are not BBs, and ~RF is the denial of the RF model.) This probabilistic tension gives us strong reasons to accept ~RF over RF, given that that we are not BBs. Or, given that ~RF is not ad hoc in the sense defined in section 1.3, the restricted version of the Likelihood Principle implies that ~BB & k* strongly confirms ~RF over RF, since P(~BB & k*|RF & k′) << 1 and ~P(~BB & k*|~RF & k′) << 1.50

A major question for a chaotic inflationary multiverse model is whether it can circumvent the BB problem that plagues the random fluctuation model. If not, such a model will encounter the same disconfirmation as RF, thus giving us strong reasons to reject it. According to Albrecht, the inflationary model can avoid the BB problem, and this is its key advantage. Says Albrecht:

> Inflation is best thought of as the "dominant channel" from random chaos into a big bang-like state. The exponentially large volume of the Big Bang-like regions produced via infl ation appear to completely swamp any other regions that might have fl uctuated into a Big Bang-like state via some other route. So, if you went looking around in the universe looking for a region like the one we see, it would be exponentially more likely to have arrived at that state via infl ation, than some other way, and is thus strongly predicted to have the whole package of infl ationary predictions. (Albrecht 2004, p. 385; italics added)51

The idea here is that inflation takes small, low-entropy regions and expands them into enormously large regions with enough order so that they will be dominated by non-BB observers (if they have

observers). The assumption is that the regions that undergo inflation are so small that they are much more likely to occur than regions that generate observers by random fluctuations; further, because of infl ation, these initially small regions become so large that they dominate over those regions that produce observers by means of random fluctuations. Albrecht admits, however, that his argument that inflation would be the dominant channel "rests on very heuristic arguments" and that "the program of putting this sort of argument on firmer foundations is in its infancy" (2004, p. 396).

Several articles have been written in recent years arguing that infl ation will generate universes in which BBs enormously dominate among observers in the far future (Bousso & Freivogel 2006; Banks 2007).52 These arguments, however, might only present a problem if one adopts a block universe view, according to which future events have the same ontological status as present and past events. Although advocates of inflation typically assume such a view, they need not. If one adopts a metaphysical view in which the future is not yet real, these arguments will not themselves show that inflation leads to a present dominance of BB universes. Further, as cosmologist Don Page (2006) has pointed out, the same dominance of BBs occurs for long-lived single universes; further, the evidence at present strongly suggests that our universe will continue existing for an enormously long time, if not forever, if there is no supernatural intervention. In any case, I shall next present a powerful reason for thinking that Albrecht's argument is flawed and that without assuming highly special initial conditions, inflationary cosmology leads to a dominance of BBs for any period of time in which observers exist. Since there are many versions of inflationary cosmology, my argument will be very general.

6.3.4. A BB objection to the inflationary multiverse

There is a simple argument that if the BB problem exists for the random fl uctuation multiverse, then the same problem exists for the infl ationary multiverse. Defi ne a megaverse as some very large finite, or even infinite, region of space-time of a universe or multiverse that has some configuration of mass-energy in it.53 The BB problem arises for a random fluctuation multiverse because, when the standard measure M of statistical mechanics is applied to the phase space of an arbitrary megaverse, the measure of confi gurations dominated by non-BB observers is much, much smaller than that of those confi gurations dominated by BB observers. Further, if this is true for the entire megaverse, then it will have to be true for any arbitrarily chosen spacelike hypersurface, hp, of constant time t of the megaverse. Thus, if we let Mt(BB) designate the measure of volume, Vt(BB), of the phase space of hp corresponding to those configurations dominated by BB observers, and Mt(~BB) designate the measure of volume, Vt(~BB), of hp corresponding to confi gurations dominated by non-BB observers, then Mt(~BB)/Mt(BB) << 1.54 That is, the measure for the possible mass-energy-momentum configurations of hp that are non-BB dominated will be much, much smaller than the measure for those configurations that are BB dominated. Assuming that the laws of physics are deterministic and time-reversal invariant, then the measure is time-invariant, as explained in Section 2.4. If we consider the mass-energymomentum configurations of hp as evolving with time, this means that for any volume of phase space V(t0) of measure MV(t0) at time t0, V(t0) will evolve into a volume V(t) of the same measure at time t: that is, MV(t) = MV(t0).

Now, consider the initial conditions of the megaverse defined on some spacelike hypersurface of constant time t0. Let Vt0(BB) and Vt0(~BB) represent the volume of phase space of that hypersurface that evolves into configurations dominated by BB observers and by non-BB observers, respectively, for some later hypersurface at time t. Since the statistical mechanics measure m is time-invariant, the ratio of the measure of Vt0(~BB) to Vt0(BB), that is, Mt0(~BB)/ Mt0(BB), will remain the same. Consequently, Mt0(~BB)/Mt0(BB) = Mt(~BB)/Mt(BB) << 1. This means that the measure of initial states that give rise to a universe dominated by non-BB observers at some arbitrarily chosen later time t is much, much smaller than the measure of initial states that give

rise to a universe dominated by BB observers at t. Consequently, unless the initial state of the megaverse is in a very special low-probability state – that corresponding to volume Vt0(~BB) – it will not give rise to a universe dominated by ~BBs. This is true for any megaverse in which the laws of physics are deterministic and time-reversal invariant. Inflationary cosmology denies neither of these assumptions. Further, even though the laws of physics are not strictly speaking time-reversal invariant – since time-reversal symmetry is broken in weak interactions, notably the decay of neutral kaons – the argument offered by Albrecht and others that was explicated in Section 6.3.3 does not, in any way, exploit this lack of invariance, nor does it exploit any sort of quantum indeterminacy. Thus, without assuming highly special initial conditions, infl ationary cosmology cannot do better with regard to the BB problem than the random fl uctuation multiverse.

To illustrate this argument, consider the following analogy. Let a highly ordered, low-entropy non-BB-dominated megaverse of finite volume containing observers be represented as a black-and-white TV screen with rows and rows of O's throughout, and let a megaverse dominated by BBs be represented by occasional O's with large patches of "snow"

– that is, "random" configurations of black-and-white pixels. We shall call the former arrangement the ordered, non-BB-pixel arrangement, and the latter the BB-pixel arrangement. For simplicity, suppose there are only a finite number of pixels on the TV screen. In that case, the number of ordered non-BB-pixel arrangements would be very small compared with BB-pixel arrangements. Further, suppose the image on the TV screen is being generated by some small magnetic patch on a videocassette recorder (VCR) tape that the VCR head is reading. Finally, suppose that there is a one-to-one correspondence between arrangements of magnetic particles on the patch and the possible confi gurations of blackand-white pixels on the screen.

Because of the one-to-one correspondence, the ratio of possible configurations of magnetic particles on the patch of tape that give rise to non-BB-pixel arrangements to those that give rise to BB arrangements will be the same as the ratio of non-BB-pixel arrangements to BB-pixel arrangements on the TV screen. Thus, if the latter ratio is enormously small, so will the former ratio. This is analogous to what happens in the infl ationary mega-verse: because the laws of physics are deterministic and time-reversal invariant, every microstate m(t0) at time t0 evolves into one and only one microstate, m(t), at time t, and, hence, they can be put into a one-to-one correspondence. Consequently, just as the ratios of the number of non-BB-pixel configurations to the BB-pixel configurations is preserved from VCR patch to TV screen, the ratio of the measure of initial configurations that lead to non-BB-dominant universes to the measure of those that lead to BB-dominant universes is the same as the corresponding ratio at a later time t.55

The fundamental error in Albrecht's reasoning can be illustrated by another analogy. Consider a balloon that is being unevenly inflated. Suppose some patches of its two-dimensional surface are massively blown up – say by a trillionfold in each of its two dimensions (e.g. one-trillionth of a meter becomes a meter). This corresponds to the space out of which bubble universes form, some parts of which are inflated and other parts of which are not. Now, suppose one of the blown-up patches is one square meter in volume and is completely covered by adjacent black Os that are one centimeter in diameter, with the space in between simply consisting of random mix of black-and-white dots. The scale of the order on this patch is one centimeter; at a level of less than one centimeter, there is a random mix of black-and-white dots. The crucial thing to note, however, is that scale of order of the pre-blown-up patch will be much, much smaller: one-trillionth of a centimeter.

Now it is true that for any two patches, larger patches of the same order and scale of order will be much less likely to occur at random than small patches with the same order and scale – for example, a patch covered with adjacent Os of 1 cm in diameter that has an area of one square

meter is much more likely to occur at random than a patch covered with the same pattern of Os that has an area of a thousand square meters. This kind of consideration misleads Albrecht into thinking that very small patches of space-time that inflate into large observer filled, non-BB dominated universes are vastly more likely to occur than large patches of space-time that form.

Some might try to dispute one or more of the assumptions of this argument. The most vulnerable assumptions are the problems of nonarbitrarily dealing with the possible infi nities that might arise when one attempts to define a measure for the entire megaverse, along with the additional problem of making rigorous the claim that in the entire phase space, the measure of non-BB-dominated hypersurfaces is much, much less than that of BB-dominated hypersurfaces. These problems, however, are as much a problem for making Albrecht's argument rigorous. The whole point of Albrecht's argument is that infl ation does better with regard to BBs than the random fluctuation multiverse. In order for this claim to be true, there must be some "correct" measure M for the possible mass-energy states of the multiverse (or at least for arbitrarily chosen very large finite subsets of it) such that non-BB-observer-dominated states have a much, much smaller measure than those of BBobserver-dominated states for the random fluctuation model.

In response, perhaps Albrecht could appeal to some notion of a "generic" initial state that is not dependent on the existence of a measure over phase space. Such an appeal, however, will immediately run afoul an objection Penrose has raised. Consider an enormously large universe that eventually collapses back on itself and assume that all the special laws that are required by inflation hold in that universe. (We could even have an infi nite universe with a negative cosmological constant to ensure collapse.) Suppose that this universe had many domains, some of which are highly irregular. In fact, we can suppose that it is chock full of BBs. As Penrose points out, the collapse of such a universe will result in "a generic space-time singularity, as we can reasonably infer from precise mathematical theorems" (2004, p. 756). Assuming that the laws of physics (including those of infl ation) are time-symmetric (as is typically assumed in these contexts), if we now reverse the direction of time in our model, we shall "obtain an evolution which starts from a general-looking singularity and then becomes whatever irregular type of universe we may care to choose" (2004, p. 757). Since the laws governing inflation will hold in this time-reversed situation, it follows that one cannot guarantee that a uniform or non-BB-dominant universe will arise from generic initial conditions. Thus, inflationary cosmology can explain such a universe only by effectively presupposing those subsets of generic initial conditions that will lead this type of universe. As Penrose notes, "The point is that whether or not we actually have inflation, the physical possibility of an inflationary period is of no use whatever in attempts to ensure that evolution from a generic singularity will lead to a uniform (or spatially fl at) universe" (2004, p. 757).

A non-BB-observer-filled universe via a thermal fluctuation. Consequently, Albrecht is misled into thinking that inflation can help overcome the BB problem confronting the RF model by increasing the relative proportion of non-BB observers. The problem for Albrecht's reasoning is that in order to produce a non-BB observer-dominant universe, the order of the patch that inflates would have to be at a vastly smaller scale – for example, inversely proportional to the factor by which the patch inflated– and hence contain a vastly higher degree of order per unit of volume than a corresponding non-BB-observer patch of the size of our universe that did not inflate. The decrease in likelihood resulting from the higher degree of order compensates for the increase in probability resulting from the size of the patch, as can be seen by our more rigorous argument offered earlier based on the time-invariance of the standard measure. In terms of our balloon analogy, a square patch with sides one-trillionth of a meter in length filled with adjacent Os one-trillionth of a centimeter in diameter is no more likely to occur at random than a square patch with sides of 1 m in length filled with Os that are 1 cm in diameter.

6.3.5. Conclusion

The aforementioned arguments do not show that inflationary cosmology is wrong or even that scientists are unjustified in accepting it. What they do show is that the infl ationary multiverse offers no help in eliminating either the fine-tuning of the laws of nature or the special low-entropic initial conditions of the Big Bang. With regard to the special low-entropic initial conditions, it can explain the special conditions of the Big Bang only by hypothesizing some other, even more special, set of initial conditions. Although a chaotic inflationary model might lead one to expect a universe like ours, unless highly special initial conditions are assumed across the entire multiverse, it will not lead to a multiverse dominated by ~BBs for later times and thus does no better than a random fl uctuation model. It also runs into the generic problems faced by multiverse hypotheses discussed at the end of Section 6.2. If we find the existence of a BB-dominated multiverse unacceptable, it follows that an inflationary-superstring multiverse at best eliminates only the need to explain the life-permitting values of the constants of physics (and perhaps other nonentropic types of special initial conditions). Because of the highly speculative extra laws and conditions required to make an inflationary multiverse work, one could not be blamed if one judged that such purported explanatory ability were far too costly.

7. Miscellaneous Objections

7.1. The "who designed God?" objection

Perhaps the most common objection that atheists raise to the argument from design is that postulating the existence of God does not solve the problem of design but merely transfers it up one level to the question, "Who or what designed God?" The eighteenth-century philosopher David Hume hinted at this objection:

> For aught we can know a priori, matter may contain the source or spring of order originally within itself, as well as mind does; and there is no more difficulty conceiving that the several elements, from an internal unknown cause, may fall into the most exquisite arrangement, than to conceive that their ideas, in the great universal mind, from a like unknown cause, fall into that arrangement. (Hume 1980, pp. 17–8)

A host of atheist philosophers and thinkers, such as J. L. Mackie (1982, p. 144), Graham Oppy (2006, pp. 183–4), J. J. C. Smart (1985, pp. 275–6), Richard Dawkins (1986, p. 316), and Colin McGinn (1999, p. 86) have also repeated this objection. For example, J. J. C. Smart claims that:

If we postulate God in addition to the created universe we increase the complexity of our hypothesis. We have all the complexity of the universe itself, and we have in addition the at least equal complexity of God. (The designer of an artifact must be at least as complex as the designed artifact). (1985, pp. 275–6)

As an objection to our version of fine-tuning argument, it is flawed on several grounds. I have addressed this objection in detail elsewhere (Collins 2005a). Here I shall present a brief response. To begin, this objection would arise only if either T were constructed solely to explain the fine-tuning, without any independent motivation for believing it, or one considered these other motivations as data and then justified T by claiming that it is the best explanation of all the data. Our main argument, however, is not that T is the best explanation of all the data, but only that given the fine-tuning evidence, LPU strongly confi rms T over NSU.

Further, we have substantial reasons for not treating the other motivations for T like data, which we then combine with the fine-tuning evidence to infer to the best explanation. To illustrate, let me focus on one such motivation. Many theists have claimed that for most people at least, belief in God is grounded in a fundamental intuition regarding the existence of God, an intuition relevantly

similar to moral intuitions or the intuitions regarding epistemic norms. If this is right, then, as Keith Ward and others have noted, treating the existence of God like a scientific hypothesis that needs to be justified by some form of inference to the best explanation is "like trying to justify moral belief by reference to the findings of the natural sciences" (1987, p. 178). On this view, faith can be seen as itself "a response to one who claims my loyalty by showing the true nature of my present mode of being and the way of salvation" (Ward 1987, p. 178). It is "a basic and distinctive mode of human thought and activity" (Ward 1987, p. 180). Thus, in analogy to our ethical intuitions, faith should be considered a mode of knowing, not just a mere leap of belief under insufficient evidence. Plantinga (2000) has provided one way of carefully developing this view and shows it has been commonplace in the Christian tradition – for example, Thomas Aquinas and John Calvin (Plantinga 2000, chap. 6). From this point of view, the religious mode of knowing or justification involved in faith, therefore, should not be treated as providing data for an inference to the best explanation but rather as analogous to our ethical intuitions, or even our intuitions regarding epistemic virtues – for example, that, everything else being equal, simpler theories are more likely to be true or empirically adequate than complex theories. Clearly, one cannot ground our belief in these epistemic virtues in an inference to the best explanation, since all such inferences presuppose the virtues. Finally, William Alston (1993) and others have made similar claims with regard to our knowledge of God based on religious experience, claiming it is relevantly analogous to our knowledge of the material world, which they claim is not justified by appeal to an inference to the best explanation.

If we do not treat these other motivations for T as part of a body of data for which we employ the strategy of inference to the best explanation, then the "who designed God?" objection largely evaporates. The existence of God is not a hypothesis that is being offered as the best explanation of the structure of the universe, and hence it is not relevant whether or not God is an explanatorily better (e.g. simpler) terminus for ultimate explanation than the universe itself. Nonetheless, via the restricted version of the Likelihood Principle (Section 1.3), the various features of the universe can be seen as providing confi rming evidence for the existence of God. One advantage of this way of viewing the situation is that it largely reconciles the views of those who stress a need for faith in coming to believe in God and those who stress reason. They each play a complementary role.

To illustrate this point, consider the following analogy. Suppose that in the year 2050 extraterrestrials visit Earth, and we find that they share the same fundamental ethical beliefs as we do – for example, that it is wrong to torture others for no compelling ethical reason. Further, suppose that we were able to show that it is very epistemically unlikely that such an agreement would occur under ethical antirealism – for example, because we have good reason to believe both that unguided naturalistic evolution would not produce these beliefs and that ethical antirealism is not compatible with viable, alternative explanations of human beings based on design (such as T). Finally, suppose we could show that it is not unlikely for this agreement to occur under ethical realism.56 The discovery that these aliens shared the same ethical beliefs as we do would therefore confi rm ethical realism, even though we would not believe ethical realism because it provided the best explanation of some set of phenomena. In fact, I believe it would decisively tip the balance in favor of ethical realism. I suggest that the evidence of fine-tuning does the same for T.

Apart from rejecting the claim that the justification for the existence of God is based on some sort of inference to the best explanation, however, one can also object to the atheist's key assumption, articulated by J. J. C. Smart in the aforementioned quotation, that the "designer of an artifact must be at least as complex as the artifact itself." This assumption is not even clearly true in the human case, since it is at least conceivable that one could produce a computer that is more complicated than oneself, which is a common theme of science fiction. In the case of God, however, we have even less reason to believe it. If the theist were hypothesizing an anthropomorphic God, with a brain and a body, then this objection would be much stronger: one would then be tempted to ask, is that not God's brain and body as much in need of an explanation

as the universe itself? Thus, this objection might seem to have significant bite against such a conception of God. Within traditional theism, however, God has always been claimed to lack any sort of signifi cant internal complexity. In fact, most of the Western medieval tradition claimed that God was absolutely simple in every way – God did not even have complexity with regard to God's properties.Aquinas, for instance, claimed that all of God's properties (such as God's omnipotence and perfect goodness) were absolutely identical; these were, in turn, identical with God's essence and existence. Although I do not think that this view of God as being absolutely simple is coherent, the point here is that the "who designed God?" objection begs the question against traditional theism, by assuming a type of God which traditional theists would all disavow. Even the heirs to traditional Western theism who deny absolute divine simplicity, such as Richard Swinburne (2004), claim that God's overall being is extraordinarily simple. Thus, what these atheists really need to show is that the God of all varieties of traditional theism is logically incoherent insofar as those versions of theism hold on to some form of divine simplicity. This, however, is a very different objection – and a much harder task – than simply raising the "who designed God?" objection and then claiming that one has eliminated the theistic explanation in a single stroke.

7.2. The more fundamental law objection

One criticism of the fine-tuning argument is that, as far as we know, there could be a more fundamental law that entails both the current laws of physics and the values of the constants of physics. Thus, given such a law, it is not improbable that the laws and constants of physics fall within the life-permitting range. Besides being entirely speculative, three problems confront such an objection. First, although many physicists had hoped that superstring theory would entail all the current laws and constants of physics, that hope has almost completely faded as string theorists have come to recognize that superstring theory (and its proposed successor, M-Theory) has many, many solutions, estimated at 10500 or more. Consequently, the prospects of discovering such a fundamental law are much dimmer than they once were. Second, such a fundamental law would not explain the fi ne-tuning of the initial conditions of the universe. Finally, hypothesizing such a law merely moves the epistemic improbability of the fine-tuning of the laws and constants up one level, to that of the postulated fundamental law itself. Even if such a law existed, it would still be a huge coincidence that the fundamental law implied just those lower-level laws and values of the constants of physics that are life-permitting, instead of some other laws or values. As astrophysicists Bernard Carr and Martin Rees note "even if all apparently anthropic coincidences could be explained [in terms of some fundamental law], it would still be remarkable that the relationships dictated by physical theory happened also to be those propitious for life" (1979, p. 612). It is very unlikely, therefore, that the fi ne-tuning of the universe would lose its signifi cance even if such a law were verified.

To illustrate the last response, consider the following analogy. Suppose that superdeterminism is true: that is, everything about the universe, including its initial conditions, is determined by some set of laws, although we do not know the details of those laws. Now consider a flip of a coin and let Lh and Lt denote the claims that the laws are such as to determine the coin to come up heads and tails, respectively. We would have equal reason to believe that Lh as that Lt. Hence, since Lh entails that the coin will come up heads, and Lt that the coin will come up tails, the epistemic probability of heads remains 50 percent, and likewise for tails. This would be true even though each of their physical probabilities would be one or zero. The fact that the laws of nature determine the initial conditions, instead of the initial conditions' not being determined by any law, has no influence on the epistemic probability. This can be seen also by the fact that when Laplacian determinism was thought to be true, everyone nonetheless gave a fair coin a 50 percent chance of coming up heads.

A similar sort of response can be given to the claim that fine-tuning is not improbable because it might be logically necessary for the constants of physics to have life-permitting values. That is,

according to this claim, the constants of physics must have life-permitting values in the same way 2 + 2 must equal 4, or the interior angles of a triangle must add up to 180 degrees in Euclidian geometry. Like the "more fundamental law" proposal mentioned, however, this postulate simply transfers the epistemic improbability up one level: of all the laws and constants of physics that conceivably could have been logically necessary, it seems highly epistemically improbable that it would be those that are life-permitting, at least apart from some sort of Axiarchic Principle discussed in Section 8.57

7.3. Other life-permitting laws objection

According to what I call the "other life-permitting laws objection," there could be other life-permitting sets of laws that we know nothing about. This objection is directly answered by the way in which I have formulated the fine-tuning argument. As I formulated it, the fine-tuning argument does not assume that ours is the only possible set of life-permitting laws. Rather, it only assumes that the region of life-permitting laws (or constants or initial conditions) is very small compared with the region for which we can determine whether the laws, constants, or initial conditions are life-permitting – that is, what I called the EI region (see Section 4.5). In the case of the constants of physics, it assumed only that given our current laws of nature, the life-permitting range for the values of the constants (such as gravity) is small compared to the surrounding EI range for which we can determine whether or not a value is life-permitting.

7.4. Other forms of life objection

As raised against the fine-tuning argument based on the constants of physics, the "other forms of life objection" claims that as far as we know, other forms of non-carbon-based life could exist even if the constants of physics fell outside the purported life-permitting region. So, it is claimed, the fi ne-tuning argument ends up presupposing that all forms of embodied, conscious life must be based on carbon (e.g. Stenger 2004, pp. 177–8). Besides the extreme difficulty of conceiving of how non-carbon-based material systems could achieve the sort of self-reproducing material complexity needed to support embodied moral agents, another problem with this objection is that many cases of fi ne-tuning do not presuppose that all life must be carbon based. Consider, for instance, the cosmological constant. If the cosmological constant were much larger than it is, matter would disperse so rapidly that no stars could exist. Without stars, however, there would be no stable energy sources for complex material systems of any sort to evolve. So, all the fi ne-tuning argument presupposes in this case is that the evolution of embodied moral agents in our universe require some stable energy source. This is certainly a very reasonable assumption.

7.5. Weak Anthropic Principle objection

According to the weak version of so-called Anthropic Principle, if the laws of nature were not fine-tuned, we should not be here to comment on the fact. Some have argued, therefore, that LPU is not really improbable or surprising at all under NSU, but simply follows from the fact that we exist. In response, we simply restate the argument in terms of our existence: our existence as embodied moral agents is extremely unlikely under NSU, but not improbable under T, and therefore our existence confirms T over NSU. As explained in Section 4.3, this requires that we treat LPU and our existence as "old evidence," which we subtract from our background information. This allows us to obtain an appropriate background information k′ that does not entail LPU. The other approach was to use the method of probabilistic tension, which avoided the issue entirely (see Sections 1.4, 4.3, and 4.4).

The methods used in Section 4 deal with this problem of old evidence, and our arguments in Section 3.2 for the existence of conditional epistemic probabilities for $P(A|B \,\&\, k')$ for some cases in which our own existence entails A, provide the formal underpinnings in support of the intuitions underlying the "firing-squad" analogy offered by John Leslie (1988, p. 304) and others in response to this objection. As Leslie points out, if 50 sharpshooters all miss me, the response "if they had not

missed me I would not be here to consider the fact" is inadequate. Instead, I would naturally conclude that there was some reason why they all missed, such as that they never really intended to kill me. Why would I conclude this? Because, conditioned on background information k′ that does not include my continued existence – such as the background information of a third-party observer watching the execution – my continued existence would be very improbable under the hypothesis that they intended to kill me, but not improbable under the hypothesis that they did not intend to kill me.58

8. Conclusion: Putting the Argument in Perspective

As I developed in Sections 1.3 and 1.4, the fine-tuning argument concludes that, given the evidence of the fine-tuning of the cosmos, LPU signifi cantly confirms T over NSU. In fact, as shown in Section 5.2, a good case can be made that LPU conjoined with the existence of evil signifi cantly confirms T over NSU. This does not itself show that T is true, or even likely to be true; or even that one is justifi ed in believing in T. Despite this, I claimed that such confirmation is highly significant – as significant as the confirmation that would be received for moral realism if we discovered that extraterrestrials held the same fundamental moral beliefs that we do and that such an occurrence was very improbable under moral antirealism (see Section 7.1). This confirmation would not itself show that moral realism is true, or even justified. Nonetheless, when combined with other reasons we have for endorsing moral realism (e.g. those based on moral intuitions), arguably it tips the balance in its favor. Analogous things, I believe, could be said for T.

I also considered the challenge raised by the two most widely advocated versions of the multiverse hypothesis – what I called the unrestricted multiverse hypothesis, advocated by Lewis and Tegmark, according to which all possible universes exist, and the restricted multiverse hypothesis arising out of inflationary cosmology. I argued that neither of these is able adequately to explain away the fi ne-tuning or undercut the fi ne-tuning argument.

Finally, one might wonder whether there are other viable alternative explanations of LPU to that offered by T, NSU, or the multiverse hypothesis. One such possibility is various nontheistic design hypotheses – either nontheistic supernatural beings or aliens in some meta-universe who can create bubble universes. The postulated designer, D, could not be a merely "generic" designer but must be hypothesized to have some motivation to create a life-permitting universe; otherwise P(LPU|D & k′) = P(LPU|NSU & k′), as explained in Section 5.2. Unless these non-generic hypotheses were advocated prior to the fi ne-tuning evidence, or we had independent motivations for them, they would not pass the non-ad hocness test of the restricted version of the Likelihood Principle (Section 1.3). Furthermore, from the perspective of probabilistic tension, these alternative design hypotheses typically would generate a corresponding probabilistic tension between the claim that the postulated being had a motive to create a life-permitting world instead of some other type of world and the beings' other attributes, something that does not arise for classical theism (see Section 5.2). Finally, for some of these postulated beings, one could claim that even if LPU confirms their existence, we lack sufficient independent reasons to believe in their existence, whereas for T we have such reasons; or one could claim that they simply transfer the problem of design up one level (see Section 7.1).

The only one of these alternatives that I consider a serious contender is the axiarchic hypothesis, versions of which have been advanced in the last 30 years by John Leslie (1989, chap. 8) and recently by Hugh Rice (2000) and others, wherein goodness or ethical "required-ness" has a direct power to bring about concrete reality. Whatever the merits of this hypothesis, it is likely to entail T. Since God is the greatest possible being, it is supremely good that God exists (Leslie 1989, pp. 168–9). Therefore, it is unclear that the axiarchic hypothesis actually conflicts with T.59 In any case, this chapter has shown that we have solid philosophical grounds for claiming that given the fine-tuning evidence, LPU provides significant support for T over its nonaxiarchic contenders.

2009
We can look up at the sky at night and have an idea of what Alma meant. There are millions of stars and planets all in perfect order. They did not get there by chance. We can see the work of God in the heavens and on the earth. The many beautiful plants, the many kinds of animals, the mountains, the rivers, the clouds that bring us rain and snow—all these testify to us that there is a God.
Gospel Principles Manual

Alma, a Book of Mormon prophet, wrote, "All things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator" (Alma 30:44). We can look up at the sky at night and have an idea of what Alma meant. There are millions of stars and planets all in perfect order. They did not get there by chance. We can see the work of God in the heavens and on the earth. The many beautiful plants, the many kinds of animals, the mountains, the rivers, the clouds that bring us rain and snow—all these testify to us that there is a God.

The prophets have taught us that God is the almighty ruler of the universe. God dwells in heaven (see D&C 20:17). Through his Son, Jesus Christ, he created heaven and earth and all things that are in them (see Moses 2:1). He made the moon, the stars, and the sun. He organized this world and gave it form, motion, and life. He filled the air and the water with living things. He covered the hills and plains with all kinds of animal life. He gave us day and night, summer and winter, seedtime and harvest. He made man in his own image to be a ruler over his other creations (see Genesis 1:26-27).

God is the one supreme and absolute being in whom we believe and whom we worship. He is the Creator, Ruler, and Preserver of all things (see Discourses of Brigham Young, pp. 18-23).

April 2009
Justin Hart
Intelligent Design, Part I
Meridian Magazine

"If it could be demonstrated that any complex organ existed which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down." (Origin of Species, 6th ed. (1988), p. 154) - Darwin

It's understandable that there exists a theological debate among differing religious views. After all, religious understanding and belief derives its momentum from faith-driven exercises rather than hard empirical evidence. But one would expect scientific debate to avoid such quibbles and disagreements in light of their own scientific method, which does derive its momentum from hard empirical evidence. Unfortunately, science is overseen by humans, and the same biases, institutionalized thinking, and raw power involved with any human venture are also present in science.

One debate, looming large on the horizon, pits the "high priests" of evolution against the proponents of "intelligent design." In this article I examine Intelligent Design and its claims against evolution.

Intelligent Design
In 1802, William Paley penned his famous pocketwatch analogy. To wit, if we find a pocketwatch in the desert we assume that some human hand was involved and that the watch did not materialize through some blind natural process. The analogy here is that the complexity of nature points to an intelligent designing force.

This was the prevailing scientific view until Darwin published his Origin of Species in 1859. The evidence that Darwin asserted took the scientific community by storm and evolution has been the prevailing modus operandi since that day.

Evolutionary biology teaches that all biological complexity is "the result of material mechanisms." In short, evolution claims that all things came into existence by means of natural selection and mutation, in minute "baby steps" of progression over millions of years. Organisms adapt for conditions adding to their functionality piece by piece until we are what we are today.

We should note here that no one doubts natural selection as a robust scientific theory. For example, a desert fox has developed longer ears over time to help expel heat from his body. If this were all that evolution purports, everyone would go home happy. Instead the debate turns on Darwin's theory that all species evolved from a handful of previous species. Intelligent Design is a growing scientific movement that challenges Darwin and his naturalistic legacy.

Intelligent Design derives its impetus from systems that are "irreducibly complex." Here's a common analogy that's used to explain the theory.

An everyday example of an irreducibly complex system is the humble mousetrap. It consists of (1) a flat wooden platform or base; (2) a metal hammer, which crushes the mouse; (3) a spring with extended ends to power the hammer; (4) a catch that releases the spring; and (5) a metal bar that connects to the catch and holds the hammer back. You can't catch a mouse with just a platform, then add a spring and catch a few more mice, then add a holding bar and catch a few more. All the pieces have to be in place before you catch any mice. [1]

According to evolution, you should be able to reduce every biological system, piece by piece, down to its beginning. Evolution then could not be the scientific origin of the mouse trap, there must have been some intelligent hand involved. As Darwin admits in our opening quote, if you can demonstrate a complex biological system along the same line of reasoning, then his theory would break down.

Bacterium Flagellum
The question then is this: Are there biological systems that exhibit such complexity? One prominent example is that of bacterium flagellum. Bacterium flagellum are whip-like appendages that move bacteria throughout our body. These flagellum work very much like a motor; each has a rotor, a stator, O-rings, bushings, and a drive shaft. They are powered by the combination of 50 different proteins. These proteins exist independently within the human body and come together to power the flagellum. Take one of these proteins away, and the flagellum fails to operate. The mathematical probability of these 50 proteins coming together under the theory of evolution is so outrageous as to almost insist that there was some higher power involved.

Plasmids
Plasmids are circular pieces of DNA that can easily be exchanged among bacteria. Plasmids can also confer antibiotic resistance. When one bacterium releases a plasmid, another can absorb it, information from the Plasmid is infused from one into the other. The problem begins when we ask

"where did the bacterium that released the plasmid information in turn derive it?" Any evolutionary explanation will be circular reasoning and insufficient to explain the matter.

Eukaryotic Cells
Michael Behe, one of the major proponents of intelligent design explains another example:

Another example of irreducible complexity is the system that allows proteins to reach the appropriate subcellular compartments. In the eukaryotic cell there are a number of places where specialized tasks, such as digestion of nutrients and excretion of wastes, take place. Proteins are synthesized outside these compartments and can reach their proper destinations only with the help of "signal" chemicals that turn other reactions on and off at the appropriate times. This constant, regulated traffic flow in the cell comprises another remarkably complex, irreducible system. All parts must function in synchrony or the system breaks down. [2]

Blood Clotting
The system that prevents our blood from clotting is yet another example. Blood clotting consists of a complex cascade of enzymes and cofactors which must be in place to work. The evolutionist's rebuttal to this is that blood clotting experiments on mice have removed certain enzymes successfully. The Intelligent Design (ID) response is that the mice in the experiment were detrimentally affected by the reduced enzymes; which flies in the face of another evolutionary postulate: the mutated change in an organism must benefit the organism (survival of the fittest after all).

People, Places and Theories
There are a number of prominent players currently working on ID. Here are a few bios and links that you can peruse:

Philip E. Johnson, is a graduate of Harward and the University of Chicago. He was a law clerk for Chief Justice Earl Warren and has taught law for over twenty years at the University of California at Berkeley.

Johnson's most prominent contribution has been Darwin on Trial which examines Evolution from a standpoint of sound reasoning and scientific support.

Michael Behe received his Ph.D. in biochemistry from the University of Pennsylvania in 1978, is a professor of biological sciences at Pennsylvania's Lehigh University. His current research involves the roles of design and natural selection in building protein structure. His book Darwin's Black Box: The Biochemical Challenge to Evolution is available in paperback (Touchstone Books, 1998).

Behe is one of primary proponents of ID. His book has been the focus of many of the evolutionist's rebuttal. Behe has been lambasted and harangued for his viewpoints and his responses are mostly ignored by peer publications. Hmm. sounds like a familiar brick wall.

William A. Dembski, holds Ph.D.'s in mathematics and philosophy, is an associate research professor at Baylor University and a senior fellow with the Discovery Institute in Seattle. His books include The Design Inference: Eliminating Chance Through Small Probabilities (Cambridge University Press, 1998) and No Free Lunch: Why Specified Complexity Cannot Be Purchased Without Intelligence (Rowman and Littlefield, 2001). links

Dembski is known as the Isaac Newton of ID. He has taken informational mathematics to calculate the probability of irreducibly complex biological systems. He has also brought an historical

perspective to the movement demonstrating how evolution failed to adequately dismiss British natural theology.

Jonathan Wells received two Ph.D.'s, one in molecular and cell biology from the University of California, Berkeley, and one in religious studies from Yale University. He has worked as a postdoctoral research biologist at the University of California, Berkeley, and has taught biology at California State University, Hayward. Wells is also the author of Icons of Evolution: Science or Myth? Why Much of What We Teach About Evolution Is Wrong (Regnery Publishing, 2000).

Wells' book has approached ID from an attack vantage point. He details 10 major flaws within evolution and shows how many supposed supports of evolution are nearly fraudulent but are still taught in our schools. Wells has been at the front of a debate in Ohio which is considering whether or not to allow ID to be taught as an alternative to evolution.

Conclusion
We should note that Intelligent Design is a theory just like Evolution is a theory. The debate between the parties is raging on and may eventaully reach a fervent pitch. Currently, several school boards across the country are examing its validity to determine if they should allow it to be taught in schools. Intelligent Design is an exciting venture for us to examine. In the coming months I will report on several books, theories and debates on the issue.

Notes
1. Intelligent Design a special report reprinted from Natural History magazine http://www.actionbioscience.org/evolution/nhmag.html#behe/miller
2. Ibid.

April 2009
God, Science, and Intelligent Design
By Daniel C. Peterson
Meridian Magazine

One of the great scientific achievements of recent decades has been the mapping and sequencing of human DNA completed by the Human Genome Project (HGP). During roughly the same period that that vast effort began to bear fruit (a working draft of the human genome sequence was announced in June 2000), resurgent and very militant voices of atheism also began to be heard more loudly than they had been for many years - claiming, among other things, that belief in God is a relic of the primitive past that should be discarded in our scientific age.

Somewhat awkwardly, though, it turns out that the leader of the Human Genome Project, an extraordinarily complex, cutting-edge, multidisciplinary scientific enterprise, is a devout and very serious Christian. Yet Francis Collins's scientific credentials are impeccable. He holds a Ph.D. in physical chemistry from Yale University and a doctorate in medicine from the University of North Carolina. He is a member of the elite Institute of Medicine and the elite National Academy of Sciences, and his research, first at the University of Michigan and then at the National Institutes of Health, has led to the identification of the genes responsible for such illnesses as cystic fibrosis, neurofibromatosis, Huntington's disease, and Hutchison-Gilford progeria syndrome.

How, despite a life obviously devoted to reason and empirical evidence, can Francis Collins be a believer? He was not reared in a religious home, and he reports that he became an agnostic soon after enrolling in college and then progressed to full-blown atheism during graduate school. But he

still came to religious faith, as an adult. And now he has written a book (Francis S. Collins, The Language of God: A Scientist Presents Evidence for Belief [New York and London: Free Press, 2006]) in which he explains why.

Essentially, obviously influenced by C. S. Lewis's famous book Mere Christianity, Dr. Collins argues from the presence among humans around the world of a "moral law," of fundamentally similar values. Notwithstanding cultural variations and differing applications of those values, they can quite properly be said to be universal. Where did they come from? To Collins, they point to the existence of something or Someone beyond simple matter in motion, mere agglomerations of purposeless molecules.

He is also impressed by arguments for the apparent fine-tuning of the cosmos for life, so far beyond what randomness would lead us to expect. Not surprisingly, therefore, he cites the eminent eighteenth-century German philosopher Immanuel Kant: "Two things fill me with constantly increasing admiration and awe, the longer and more earnestly I reflect on them: the starry heavens without and the Moral Law within."

As regards biology, Dr. Collins is a theistic evolutionist, and he is plainly unimpressed with the currently controversial "Intelligent Design" movement. Whether he has given that movement a fair hearing, however, is debatable.

Utah State University philosophy professor Richard Sherlock argues in a newly published article, "Mormonism and Intelligent Design" (in The FARMS Review 18/2 [2006]: 45-81) that Latter-day Saints should not close the door on the claims of Intelligent Design without having given them serious consideration. Fortunately, at least one solidly-credentialed Mormon biologist has already been reflecting on that topic for many years.

Frank Salisbury is a retired professor of plant physiology at Utah State University who earned his Ph.D. from the California Institute of Technology. Among his numerous publications are such volumes as Truth by Reason and by Revelation (Deseret Book, 1965); Vascular Plants: Form and Function, with Robert V. Parke (Palgrave Macmillan, 1973); The Creation (Deseret Book, 1976); Plant Physiology, 3d ed. (Wadsworth, 1985); and Units, Symbols, and Terminology for Plant Physiology: A Reference for Presentation of Research Results in the Plant Sciences (Oxford, 1996).

In fact, an article that he wrote for the prestigious journal Nature back in 1969 can be regarded as an early harbinger of the contemporary Intelligent Design movement. He had become excited about the complexity of DNA and of proteins, and his Nature essay argued that the probability of any enzyme appearing through mere randomness is vanishingly small.

Most recently, Dr. Salisbury has published The Case for Divine Design: Cells, Complexity, and Creation (Springville, UT: Horizon, 2006). In his book, this superbly qualified biologist presents a persuasive case that, while the scientific evidence doesn't compel belief in an intelligent creator, a reasonable reading of the evidence is entirely consistent with such belief, and, for those inclined toward faith, can powerfully support it. In other words, though certain loud voices claim otherwise, believers in God have rational grounds for their belief.

October 2009
Michael De Groote
Intelligent design and the new atheism: Evolution has limits
Mormon Times

PROVO, Utah — According to Michael Behe, there are limits to what evolution can explain.

Behe spoke on Friday, Oct. 16, at BYU during the Wheatley Institution's "Symposium on Responding to the New Atheism." He quoted a statement signed by 39 Nobel award recipients that says Darwinian evolution was the "unguided, unplanned process of random variation and natural selection."

For Behe, however, evolution via random and gradual mutations can't explain some very complex biological systems or "machines." Biology shows signs of an intelligent designer.

"You deduce design from the physical structure of a system," said Behe, a Catholic and a Lehigh University professor of biochemistry.

A simple example of deducing design, Behe said, would be the difference between looking at an ordinary mountain and looking at Mount Rushmore. One appears to be random; the other shows unmistakable signs of design. "It's not mystical. It's an everyday deduction."

"Everyone agrees that aspects of biology strongly appear to be designed," Behe said. Even one of the leading voices of the new atheism, author Richard Dawkins, wrote in "The Blind Watchmaker," that, "Biology is the study of complicated things that give the appearance of having been designed for a purpose."

Of course, Dawkins doesn't believe biological structures were a product of intelligent design, but he admits they "overwhelmingly impress us with the appearance of design."

"There are structural obstacles to Darwinian evolution," Behe said. "There are physical reasons to think that it can not do what its proponents claim for it."

Behe calls those structural reasons "irreducible complexity." He said it contradicts the premise that evolution could operate slowly and gradually one mutation at a time. An irreducibly complex structure couldn't evolve that way: "You have some system and it has a number of parts and they act on each other and they are all necessary for the function to exist. You take away one or more of the parts and the function is no longer present."

By analogy, Behe offers the mousetrap. A mousetrap has various parts: a spring, a wire "hammer," a catch, a board that holds it all together. Take away any part and you have a meaningless and purposeless collection of parts. There is no way, according to Behe, that it could slowly evolve into that complexity.

IMAGE: A bacterial flagellum is a real example of just such a system. The flagellum is a whiplike propeller that a bacterium spins to move. Any part of the flagellum apparatus, without all the rest, is purposeless. "Like a mousetrap without one of its necessary parts, this one would be broken as well," Behe said.

Behe said critics have responded to his argument about irreducible complexity with "wishful thinking" that someday they will be able to explain them by random events instead of intelligent design. Behe said many continue to make "grand Darwinian claims" as if this evidence already had been discovered. "They are urban legends."

Evolution can explain many things, according to Behe. But not everything. He believes there is an edge to Darwinian evolution. At that edge is intelligent design — the intervention of a designer.

November 2009
Robert D. Hales, Quorum of the Twelve Apostles
Seeking to Know God, Our Heavenly Father, and His Son, Jesus Christ
Ensign Magazine

My brothers and sisters, I express gratitude for the witnesses of God, our Heavenly Father, and His Son, Jesus Christ, given by living prophets during this conference and for the teachings of the Holy Ghost.

As prophesied, we live in a time when the darkness of secularism is deepening around us. Belief in God is widely questioned and even attacked in the name of political, social, and even religious causes. Atheism, or the doctrine that there is no God, is fast spreading across the world.

Even so, as members of the restored Church of Jesus Christ, we declare that "we believe in God, the Eternal Father, and in His Son, Jesus Christ, and in the Holy Ghost."1

Some wonder, why is belief in God so important? Why did the Savior say, "And this is life eternal, that they might know thee the only true God, and Jesus Christ, whom thou hast sent"?2

Without God, life would end at the grave and our mortal experiences would have no purpose. Growth and progress would be temporary, accomplishment without value, challenges without meaning. There would be no ultimate right and wrong and no moral responsibility to care for one another as fellow children of God. Indeed, without God, there would be no mortal or eternal life.

If you or someone you love is seeking purpose in life or a deeper conviction of God's presence in our lives, I offer, as a friend and as an Apostle, my witness. He lives!

Some may ask, how can I know this for myself? We know He lives because we believe the testimonies of His ancient and living prophets, and we have felt God's Spirit confirm that the testimonies of these prophets are true.

From their testimonies, recorded in holy scripture, we know that "[God] created man, male and female, after his own image and in his own likeness."3 Some people may be surprised to learn that we look like God. One prominent religious scholar has even taught that imagining God in the form of man is creating a graven image and is idolatrous and blasphemous.4 But God Himself said, "Let us make man in our image, after our likeness."5

The use of the words us and our in this scripture also teaches us about the relationship between the Father and the Son. God further taught, "By mine Only Begotten [Son] I created these things."6 The Father and the Son are separate and distinct individuals—as any father and son always are. This may be one reason the name of God in Hebrew, Elohim, is not singular but plural.

From the New Testament we know that Heavenly Father and His Son, Jesus Christ, have a physical presence. They stand in one place at one time, as the New Testament disciple Stephen testified: "Behold, I see the heavens opened, and the Son of man standing on the right hand of God."7

We also know that the Father and the Son have voices. As recorded in Genesis and the book of Moses, Adam and Eve "heard the voice of the Lord God, as they were walking in the garden, in the cool of the day."8

We know that the Father and the Son have faces, that They stand, and that They converse. The prophet Enoch declared, “I saw the Lord; and he stood before my face, and he talked with me, even as a man talketh one with another.”9

We know that God and His Son have bodies, in form and parts like ours. From the book of Ether in the Book of Mormon, we read, “And the veil was taken from off the eyes of the brother of Jared, and he saw the finger of the Lord; and it was as the finger of a man, like unto flesh and blood.”10 Later the Lord revealed Himself, saying, “Behold, this body, which ye now behold, is the body of my spirit; and … I [will] appear unto my people in the flesh.”11

We know that the Father and the Son have feelings for us. The book of Moses records, “And it came to pass that the God of heaven looked upon the residue of the people, and he wept.”12

And we know that God and His Son, Jesus Christ, are immortal, glorified, and perfected beings. Of the Savior Jesus Christ, the Prophet Joseph Smith recounts, “His eyes were as a flame of fire; the hair of his head was white like the pure snow; his countenance shone above the brightness of the sun; and his voice was as the sound of the rushing of great waters.”13

No testimony is more significant to us in our time than the witness of Joseph Smith. He was the prophet chosen to restore the ancient Church of Christ in this, the last time when the gospel will be on the earth before the return of Jesus Christ. Like all the prophets who opened the work of God in their dispensations, Joseph was given especially clear and powerful prophetic experiences to prepare the world for the Savior’s Second Coming.

As a 14-year-old boy, he sought to know which church he should join. Then, after pondering on the matter, he turned to the Bible, where he read:

“If any of you lack wisdom, let him [or her] ask of God, that giveth to all men liberally …; and it shall be given him.

“But let him ask in faith, nothing wavering.”14

Believing those prophetic words and with unwavering, childlike faith, Joseph went to a grove of trees near his home and there knelt and prayed. Later he recorded:

“I saw a pillar of light exactly over my head. …

“… When the light rested upon me I saw two Personages, whose brightness and glory defy all description, standing above me in the air.”15

Looking up at these two beings, even Joseph could not have known who They were—for he had not yet witnessed and learned the true nature of God and Christ. But then, he records, “one of them spake unto me, calling me by name and said, pointing to the other—This is My Beloved Son. Hear Him!”16

From that singular experience and others, the Prophet Joseph bore witness, “The Father has a body of flesh and bones as tangible as man’s; the Son also.”17

Prophets throughout the ages have shared witnesses like this one and continue to do so in this very conference. But each of us has agency to choose. As the eleventh article of faith states, “We claim

the privilege of worshiping Almighty God according to the dictates of our own conscience, and allow all men the same privilege, let them worship how, where, or what they may."18

In matters of personal belief, how do we know what really is true?

I testify that the way to know the truth about God is through the Holy Ghost. The Holy Ghost, the third member of the Godhead, is a personage of spirit. His work is to "testify of [God]"19 and to "teach [us] all things."20

However, we must be careful not to constrain His influence. When we do not do what is right or when our outlook is dominated by skepticism, cynicism, criticism, and irreverence toward others and their beliefs, the Spirit cannot be with us. We then act in a way that the prophets describe as the natural man.

"The natural man receiveth not the things of the Spirit of God: for they are foolishness unto him: neither can he know them, because they are spiritually discerned."21 This "natural man is an enemy to God, … and will be, forever and ever, unless he yields to the enticings of the Holy Spirit, … and becometh as a child, submissive, meek, humble, patient, [and] full of love."22

If we do not yield to the gentle influence of the Holy Ghost, we stand in jeopardy of becoming like Korihor, an anti-Christ in the Book of Mormon. Not only did Korihor disbelieve in God, but he also ridiculed the Savior, the Atonement, and the spirit of prophecy, falsely teaching that there is no God and no Christ.23

Korihor was not content merely to reject God and quietly go his own way. He mocked the believers and demanded that the prophet Alma convince him with a sign of God's existence and power. Alma's response is as meaningful today as it was then: "Thou hast had signs enough; will ye tempt your God? Will ye say, Show unto me a sign, when ye have the testimony of all these thy brethren, and also all the holy prophets? The scriptures are laid before thee, yea, and all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator."24

Eventually Korihor was given a sign. He was struck dumb. "And Korihor put forth his hand and wrote, saying: … I know that nothing save it were the power of God could bring this upon me; yea, and I always knew that there was a God."25

Brothers and sisters, you may already know, deep in your soul, that God lives. You may not know all about Him yet and do not understand all His ways, but the light of belief is within you, waiting to be awakened and intensified by the Spirit of God and the Light of Christ, which you are born with.

So come. Believe the testimonies of the prophets. Learn of God and Christ. The pattern to do so is clearly taught by prophets of old and prophets today.

Cultivate a diligent desire to know that God lives.

This desire leads us to ponder on the things of heaven—to let the evidence of God all around us touch our hearts.

With softened hearts we are prepared to heed the Savior's call to "search the scriptures"26 and to humbly learn from them.

We are then ready to ask our Heavenly Father sincerely, in the name of our Savior, Jesus Christ, if the things we have learned are true. Most of us will not see God, as the prophets have, but the still, small promptings of the Spirit—the thoughts and feelings that the Holy Ghost brings into our minds and hearts—will give us an undeniable knowledge that He lives and that He loves us.

Gaining this knowledge is ultimately the quest of all God's children on the earth. If you cannot remember believing in God or if you have ceased to believe or if you believe but without real conviction, I invite you to seek a testimony of God now. Do not be afraid of ridicule. The strength and peace that come from knowing God and having the comforting companionship of His Spirit will make your efforts eternally worthwhile.

Even more, with your own testimony of God, you will be able to bless your family, your posterity, your friends, your own life—all those you love. Your personal knowledge of God is not only the greatest gift you will ever give, but it will bring you the greatest joy you will ever have.

As a special witness of the Only Begotten Son of our loving Heavenly Father, even Jesus Christ, I testify that God lives. I know He lives. I promise that if you and those you love will seek Him in all humility, sincerity, and diligence, you will know with a surety too. Your witness will come. And the blessings of knowing God will be yours and your family's forever. In the name of Jesus Christ, amen.

Notes

1. Articles of Faith 1:1.
2. John 17:3; emphasis added.
3. D&C 20:18; see also Genesis 1:27; Moses 2:27.
4. See Krister Stendahl, "To Speak About God," Harvard Divinity Bulletin, vol. 36, no. 2 (spring 2008): 8–9.
5. Genesis 1:26; Moses 2:26; emphasis added.
6. Moses 2:1.
7. Acts 7:56.
8. Moses 4:14; see also Genesis 3:8.
9. Moses 7:4.
10. Ether 3:6.
11. Ether 3:16.
12. Moses 7:28.
13. D&C 110:3.
14. James 1:5–6.
15. Joseph Smith—History 1:16–17.
16. Joseph Smith—History 1:17.
17. D&C 130:22.
18. Articles of Faith 1:11; emphasis added.
19. John 15:26.
20. John 14:26.
21. 1 Corinthians 2:14.
22. Mosiah 3:19.
23. See Alma 30.
24. Alma 30:44.
25. Alma 30:52.
26. John 5:39.

Steve P
Origin, ID and the God of the Gaps
By Common Consent Blog

Exactly 150 years ago a book that changed the world was published. Blasting onto the world stage it was destined to become one of the most influential books in human history. On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life is still relevant today and remains one of the best introductions to evolution by natural selection around.

Oddly, Mormon's seem to be embracing things like the Creationist movement of "Intelligent Design." ID as it is informally known. What? I mean really, What? Sure it has a name that sounds like it it ought to be something we believe, but is anyone actually looking at it? This is not something Mormon's should be tempted by. Really.

As I've argued before, there is a far more nefarious subtly here, that might actually explain why there are so many atheists hanging around the evolution water cooler (an observation I don't dispute). It started with Reverend Paley. A harmless enough chap who found God everywhere he looked. He asks us to consider a pocket watch found in the sand along the beach. He says you can't look at it and imagine that the whole thing just fell together by itself and so you can infer a designer. Only he said it much more eloquently as only 18th century writers can.

> But suppose I had found a watch upon the ground, and it should be inquired how the watch appened to be in that place; I should hardly think of the answer which I had before given, that, for any thing I knew, the watch might have always been there. Yet why should not this answer serve for the watch as well as for the stone? why is it not as admissible in the second case, as in the first? For this reason, and for no other, viz. that, when we come to inspect the watch, we perceive (what we could not discover in the stone) that its several parts are framed and put together for a purpose, e.g. that they are so formed and adjusted as to produce motion, and that motion so regulated as to point out the hour of the day; that, if the different parts had been differently shaped from what they are, of a different size from what they are, or placed after any other manner, or in any other order, than that in which they are placed, either no motion at all would have been earned on in the machine, or none which would have answered the use that is now served by it.

Natural Theology was the name that got associated with this. Sounds like a good idea. Just like ID. In fact some people interpret this, from the Alma 30:44 in the Book of Mormon, as something right out of Natural Theology:

> Show unto me a sign, when ye have the testimony of all these thy brethren, and also all the holy prophets? The scriptures are laid before thee, yea, and all things denote there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator.

I see this scripture as being about the relationship of creation to its creator rather than a statement about the kind of inferences we can make about God's existence from the facts and laws of the universe.

In general, these kinds of arguments don't work well and aren't convening. Many people see the same things and don't have a testimony of God. The facts of astronomy testify of a universe with law-like qualities, but the source of those laws can't just be read from the existence of those laws. It takes some work–you have to get to Moroni 10 to get to the heart of what is actually convincing.

Darwin read Paley. In the mean time he also discovered how to explain complexity without intervention. And many of the religious who hung their hat on Natural Theology left the fold. That's because they are trying to make inferences about God from missing data. There's a hole here. God must fill it! But then an explanation comes along, and God has less role to play then He did before and their Faith in Him shrinks proportionally. This is formally called the "God of the Gaps."

The problem with the kind of inferences can be illustrated with this thought experiment. Suppose science figures out how life started on the Earth? There has been some very interesting progress in this direction. All it needs is a chemical system that has the necessary ingredients for evolution (variation, inheritance and selection) and it's off to the races. But for the sake of argument I'll agree we don't have an answer yet. But what if we get it? What if we can show exactly, repeatedly, and with very clear explanation how it got started? Suppose we can start it anytime we want in a test-tube? Further, in our thought experiment, suppose we find this story not only laid out in the geological history on Earth, but we find it on Mars. Maybe even Europa or Titan. Suppose science cracks this problem spectacularly? Do you quit believing in God? Is this current lack of explanation for the 'hows' of life starting on Earth somehow the basis of your faith? Why offer it as evidence then? This is the classic case of the God of the Gaps. That's why these arguments are so harmful. They pit faith and science as enemies and ultimately they turn out to be as bad of theology as they are science. If evolution is true, then it's a part of our faith, as chemist Henry Eyring said.

This is why the Intelligent Design movement fails so badly. It seeks to put God into explanatory gaps. We can't explain it yet! Proof that God must be involved! It's too complex! Too hard to explain! What's that you say? Science just explained it? No matter here is something else that science can't explain! Proof God must be involved! Wait, What's that? . . . You can see where this leads. A God that inhabits a smaller and smaller place as the explanatory gap shrinks. This is why it seems we have so many atheists today, the believer's world is badly conceived and articulated with these kinds of arguments. And Atheists have taken this as their representation of what Faith is. It's a sickly kind of faith that can't be maintained in the presence of a fully conceived scientific understanding of the physical universe.

God is too magnificent. Too important to let these kind of silly arguments be used in His defence. It diminishes Him. God is there whether evolution is true or not. To me it magnifies him to understand the universe and life more completely and more fully. Evolution is a wonderful thing. It explains so much. Underscores the beauty and rarity of the world and all the evidence points in that direction. Your God may be hiding under a rock in the gaps left by science. Mine stands in majesty in and through all things. Including the wondrous evolutionary history of our planet.

Bookmark Origin, ID and the God of the Gaps
Posted in Mormon. 119 Comments »
119 Responses to "Origin, ID and the God of the Gaps"

1.
gomez Says:
November 24, 2009 at 7:08 am

"This is why it seems we have so many atheists today, the believer's world is badly conceived and articulated with these kinds of arguments. And Atheists have taken this as their representation of what Faith is."

Or maybe it's because atheism is cool right now. In my experience, most atheists rely on soundbites and are as ignorant of the science behind them every bit as much as the fundamentalists

and IDers you/they deride. It is not hard to find a reasonable defense for faith if you are genuinely interested in looking. But most are content to base their whole view of religion and people of faith on the polemics of Dawkins et al.

2.

Ben Says:
November 24, 2009 at 7:13 am

Beautifully put, Steve; a wonderful tribute for today. I especially enjoyed your reading of Alma. And I echo your entire final paragraph.

3.

gomez Says:
November 24, 2009 at 7:23 am

Sorry Steve, my comment in #1 may sound a little snarky. I agree with most everything you said and like Ben particularly liked you concluding paragraph. I just felt that the line I quoted in #1 went too far in absolving atheists of their responsibility to discover the best that faith has to offer in a post where you are encouraging religionists to discover the best that science has to offer.

4.

john f. Says:
November 24, 2009 at 7:23 am

The whole "your God/my God" thing, especially when you're talking to other Mormons, seems like an odd posture when you're trying to win over fellow Mormons to accept human evolution as a fact.

Great essay though. Rosalynde's dad confronted the God of the Gap theory by quoting Bonhoeffer — it was a great comment. I'll see if I can dig it up.

5.

John Mansfield Says:
November 24, 2009 at 7:33 am

So, when Spencer Kimball repeated the watchmaker story in a First Presidency message, he was demonstrating a kind faith as worthy of derision as that of the priests of Baal, and it is the fault of people like him that atheists have no faith? But what is holding back the atheists from latching onto SteveP's magnificent God? It must be that the dumb stocks promoted by those like Kimball are confusing matters, blinding men from receiving a true witness.

6.

john f. Says:
November 24, 2009 at 7:48 am

Russ Frandsen's reference to Dietrich Bonhoeffer on the god of the gaps was at Times and Seasons:

http://timesandseasons.org/index.php/2009/10/holland-and-the-gap-again/#comment-300693

Bonhoeffer's quote is persuasive in support of finding a different theory of how God fits in with science:

> [H]ow wrong it is to use God as a stop-gap for the incompleteness of our knowledge. If in fact the frontiers of knowledge are being pushed further and further back (and that is bound to be the case), then God is being pushed back with them, and is therefore continually in retreat. We are to find God in what we know, not in what we don't know.

It is preferable to conceive of God not being in retreat based on fewer gaps that need filling. Still, there are and will always be gaps because our knowledge and potential for obtaining and maintaining knowledge are faulty due to human fallibility and, of course, the Heisenberg Principle.

7.
john f. Says:
November 24, 2009 at 7:49 am

(the blockquote was only supposed to be one paragraph in #6 and not two — my tag appears to have been broken.)

8.
Mark D. Says:
November 24, 2009 at 8:01 am

Natural Theology was the name that got associated with this

Ironically, the term “Natural Theology” pre-dates Paley by at least six hundred years, and is conventionally used in nearly the opposite sense. The basic idea is that God’s creation is reflected in the timeless laws of nature, and divine intervention is a rare exception, if any.

Thomas Aquinas was really big on this, and the tradition goes back at least to Aristotle. In any case, Thomism tends to make for a scientifically respectable form of “Intelligent Design” – no divine intervention in evolution after the fact, i.e. separate from the initial creation of the universe ex nihilo.

9.
SteveP Says:
November 24, 2009 at 8:33 am

Mark D. There earliest argument from natural theology I could find was Xenophon on which I blogged a couple of weeks ago on the Mormon Organon.

10.
Dan Weston Says:
November 24, 2009 at 8:52 am

The problem, Steve, is that God is becoming too magnificent. A god that meddles incessently in your life must be dealt with, but as the role (or even possibility of detection) recedes, the pedestal becomes too high.

Independent of whether God actually exists, psychologists are building an ever more increasing role for a “God gene”, naturally selected to favor ever more complex forms of human groupings. If God floats too high above this human need, something else will fill it (Scientology, anyone?)

The landlord cannot be too long absent from his field, or the servants will sell it off to another. It is not enough for God to say “Bang” 14ish billion years ago, then stepped back to let nature take its course.

It’s high time for another burning bush.

11.
john f. Says:
November 24, 2009 at 9:04 am

Dan, another burning bush.

12.

Stephanie Says:
November 24, 2009 at 9:11 am

I really don't understand the divide between creationism and evolution. God didn't just create – he organized matter. To me, that explains a whole lot of things.

13.

Arthur H. Says:
November 24, 2009 at 9:15 am

#10. An Eternal God who is timeless can simultaneously adjust the initial conditions of His creation and obtain the results He wants. The idea that God "created" the World, then stepped back might be a primitive view of what He did/is doing right now.

And for me, the fact that my consciousness exists right now, with qualia, is a constant, moment-by-moment reminder that our existence is miraculous. A constant burning bush all the time, every day.

14.

Arthur H. Says:
November 24, 2009 at 9:16 am

Not to mention the fact that I can choose between equally good options every day.

15.

Stephanie Says:
November 24, 2009 at 9:18 am

Re 13 – that is a really intriguing thought.

16.

john f. Says:
November 24, 2009 at 9:21 am

Stephanie, you would be correct except for two things: (1) early twentieth century statements by Church leaders seem to be informed and persuaded by contemporary creedal Christian Fundamentalist views on young earth theory and incorrect nature of the theory of human evolution; and (2) an apparent increased willingness of lay Mormons to be persuaded by the creedal Christian Fundamentalist beliefs in creation ex nihilo, which seems to weigh against an earth billions of years old and an organic approach to physical creation.

I'm with you though on wondering why in the world Mormons would see a contradiction or divide between God and evolution. Any field of faith or knowledge is game for further revelation, i.e. further light and knowledge.

To me it boils down to politics: the left has identified itself as the "side" that accepts evolution and more broadly a scientific approach, which has meant that Mormons, wanting to be accepted by the creedal Christian Fundamentalist right, have gravitated toward the views on evolution of the Fundamentalist right (a group of people that otherwise despises Mormons) instead of just adopting their politics.

17.

SteveP Says:
November 24, 2009 at 9:25 am

john (16) I fear it is true. Scientific findings have been politicized.

18.

john f. Says:
November 24, 2009 at 9:36 am

To continue on 16, many Mormons seek identification with the political right because of certain single-issue-voting social issues (granted, sometimes two or three of them bundled together) and by association, instead of just joining into the political camp of the Fundamentalist right, based on these social issues, Mormons are being influenced by these key themes that are hot topics for Fundamentalist creedal Christians.

Let's be Mormons, gracefully harmonizing and unifying science and faith — seeing faith enhanced and enlarged through science, and seeing advances in science (to the extent not further politicized by the left, as has been in the past) as evidence of the Spirit of God moving upon all of humanity to the benefit of all of us and bringing us all closer to ultimate truth.

19.

Arthur H. Says:
November 24, 2009 at 9:38 am

#16. Exactly. I have a story about the Evangelical Right… once upon a time, a man picked up a snake at the top of a cold, cold mountain…

20.

britt Says:
November 24, 2009 at 9:48 am

I think it's the fall that does it for me. How does the fall fit in with evolution.

21.

john f. Says:
November 24, 2009 at 9:49 am

Why does it have to conflict? (And I assume you're talking about human evolution and not organic evolution generally.)

22.

Andrew Says:
November 24, 2009 at 9:59 am

I guess I have to echo comment 5. The "sickly" faith of the gaps is pretty debilitating, but rejecting it doesn't alone make the case for the "magnificent God."

For example, as we start including more of the natural world, I have to dim my view of god and divinity…until I don't feel like either "god" or "divinity" are good terms to describe what is available.

23.

SteveP Says:
November 24, 2009 at 10:06 am

britt (20) Part of the problem is that the LDS have become very used to having all the answers in our theology. We are not used to open questions. I don't know how the Fall fits in. I know it does. I know evolution is the mode and method of creation. I know the Fall happened. How they fit? I don't know. But I am comfortable with open questions. They are everywhere in science. I revise what I know when new data present themselves, sometimes I have to put claims of seeing how it all fits aside with hope I will one day see the whole picture. We need to get more comfortable with

just not knowing certain things. That doesn't mean we shouldn't try to find them, and use our best thought to explore them, but if during that process they remain open, I am comfortable with that.

24.

britt Says:
November 24, 2009 at 10:07 am

yes human evolution.

My understanding of the fall (which is where the problem could be) is that Adam and Eve were people and their choice brought death into the world. That's a rather simplistic, partial statement.

My understanding of human evolution definitely involves death.

How did we get to adam and eve without death?

At what point were spirits involved?

25.

Gerrit Says:
November 24, 2009 at 10:12 am

This is a really interesting post. I think the issue with Mormons and evolution is the definition of evolution. The ID textbook, Pandas and People reminds us that there are really three different evolutions:

1. Change over time (the idea that species look different today than even a few hundred years ago)
2. Common ancestry (life forms have all stemmed from a common ancestor)
3. Random variation and natural selection (only the strong survive which makes species change relative to strengths–i.e., change is random)

The last two, and particularly the second, are the evolutions which cause Mormons and Fundamentalist Christians the most alarm.

The first, change over time, really is an idea that is not necessarily at odds with Mormon theology. As has been stated, we believe the earth was organized from matter already existent.

As for the caution over the Mormon acceptance of ID, again this comes down to definition. Intelligent Design is not limited to just the deist "Watchmaker." ID is simply defined, at least by the authors of P&P, as a belief that "life had an intelligent source" (161). Mormons believe this very thing. At least by this definition it seems that ID and Mormonism are not at odds.

Finally, I am not sure about the argument that because man can duplicate what God has done must mean that God is "receding." Science is constantly catching up with what God already knows and has applied in the creation of the universe. Just because science could someday duplicate life does not mean that God is somehow enervated. Intelligent design would in this regard actually be strengthened because science, duplicating the creation of life, would show that it can only be done with human intervention (i.e., intelligent design).

26.

gomez Says:
November 24, 2009 at 10:14 am

Britt (#23) – there are a lot of them, but some of the comments in the following post may interest you:

http://bycommonconsent.com/2009/11/10/when-do-you-change-your-beliefs/#more-13203

27.

gomez Says:
November 24, 2009 at 10:18 am

Sorry Britt, ignore the last post. I was thinking of a post (another of SteveP's, I think) where the comments were filled with ideas of how to reconcile evolution with the doctrine of the Fall. Anyone any idea what I'm talking about?

28.

Ben Says:
November 24, 2009 at 10:31 am

#24: I never thought I would see Pandas and People quoted on BCC.

I guess there is a first time for everything.

29.

Gerrit Says:
November 24, 2009 at 10:32 am

Haha. Yup.

30.

john f. Says:
November 24, 2009 at 10:33 am

Making fun of britt and Gerrit isn't going to engender an environment of understanding.

31.

britt Says:
November 24, 2009 at 10:34 am

Gerrit, I'm fine with the last one there…I don't see how you could NOT notice that. Obviously the strong survive to reproduce. That doesn't change a gnat to a frog, but it does give you a better gnat for that environment-at least that is my understanding of natural selection-please correct me here.

What I dislike is the implication that a creature could chose to evolve as happens in dinosaur books I read to my son. the book will say something to the effect of due the the dry conditions and worms being deeper in the earth the beak lengthened…um no. The creatures with the longer beaks survived to reproduce…BIG difference.

32.

britt Says:
November 24, 2009 at 10:37 am

Have I been made fun of and I didn't even notice. I'm shocked and offended (or is that appalled and horrified-come on who else here reads ericdsnider, help) that it was so poorly done that I didn't even notice.

33.

john f. Says:
November 24, 2009 at 10:37 am

I would think natural selection is the most clearly demonstrated and obvious of the three in Gerrit's list. Now, it is easy to understand why it would be troubling as a concept to Calvinist-

leaning American creedal Christian Fundamentalists — but we Mormons don't and should not fall into that category.

34.
john f. Says:
November 24, 2009 at 10:39 am

re # 31, I guess it was just Gerrit referred to in # 27. Gerrit just laughed so it was no big deal.

35.
Gerrit Says:
November 24, 2009 at 10:39 am

britt
Exactly. The strong are the ones who survive. Fundamentalists dislike this not because it is not noticeable in nature so much as that it is used by atheists to 'prove' that life evolved randomly, and therefore must have started randomly, instead of by design.

I agree, I didn't think anyone was being made fun of.:)

36.
Tim Says:
November 24, 2009 at 10:39 am

The problem with "intelligent design" is that it seeks to find parts of evolution that the "intelligent designer" must have done, through some sort of miracle or incredibly-advanced technology, because evolution has a hard time describing how it was done.

Unfortunately for proponents of Intelligent Design, our knowledge about evolution is continually increasing, and those gaps in knowledge are being filled in, one by one.

Those who ascribe to Theistic Evolution not only believe in God, but they actually call him God (and not "Intelligent Designer.") They also have no problem accepting good science (including evolution).

To the members of the church who are attracted to Intelligent Design, I would suggest Theistic Evolution would be a better option.

37.
britt Says:
November 24, 2009 at 10:50 am

Well I've never liked intelligent design anyway, so that's not really an issue for me. I just see on one END of the spectrum science politicized and on the other science religiousized.

I have just never been able to get the fall and evolution to fit so I've accepted the fall and said i don't know where evolution fits or what to do with it. similar to steve P but different. I'm more likely to doubt my concept of evolution than I am to doubt my concept of the fall.

clear as mud, but it covered the ground

38.
Arthur H. Says:
November 24, 2009 at 11:02 am

I'm not sure about the Fall. However, I'm completely willing to put it in a post-modern light, viewing Adam and Eve as symbols… or even metaphors for our own descent into mortality. It seems like the Temple and the Pearl of Great Price have already used Adam and Eve for these same purposes.

It's a lot like gravity really. Up until Einstein, the concept of "gravity" worked pretty darn well, and we used it to figure out how the Solar System moves and what holds the galaxies together. Einstein discovered that gravity isn't really a force per se, it's just that mass distorts and bends space and time. Earth doesn't go around the Sun because of the force of gravity, it goes around because that's the shortest path through space and time it can take. Adam and Eve might just be like gravity: not necessarily "true" but a good enough metaphor that works for all intents and purposes. Metaphors are Christ's primary MO. The people couldn't really grasp complex topics so Christ gave them metaphors to illustrate ideas.

The only problem is when we get so caught up in the metaphors that we miss the purpose of the metaphors. It's human nature- the Pharisees built their careers on this. But Christ's followers weren't all ticked off when they spent all night searching fields and never found any pearls. The key to truth is whether the symbology is useful or not.

I'm not saying we should look at everything in life and deconstruct it and not believe anything really happened, but I do know that whether Adam was the son of a lesser being doesn't change whether I have to go to work tomorrow or not.

39.
britt Says:
November 24, 2009 at 11:12 am

Then do we only need a metaphorical Christ? And a symbolic atonement?

40.
john f. Says:
November 24, 2009 at 11:17 am

britt, I think there's ways to accommodate both a literal Adam/Eve and organic evolution/human evolution. One way is simply to take the approach SteveP. has described of acknowledging that we just don't know how they fit together at this point but that we look forward to further light and knowledge, whether that comes to us through further scientific discoveries/developments or through further revealed/scriptural truth.

The short answer is that there's no reason to deny the science or the method behind organic evolution or human evolution since the full picture is not yet in view. One can accept the full palet of truth available through the scientific method on the topic of evolution and through scripture on the topic of the Fall and Redemption of Man. They just don't have to conflict unless someone wants them to — and usually that happens as a result of a desire to stick a finger in someone's eye.

41.
Arthur H. Says:
November 24, 2009 at 11:18 am

I believe that Christ was "real" and the Atonement was "real." That having been said, the way humans USE things like this is identical whether it's real or not. To us, everything is symbolic. The simple fact that two people can't agree on whether a movie is good or what it "means" shows us that humans just take what they see and create a complex myth system to live by based on their own presuppositions.

Even taking a look at the Atonement. How many people say "we still don't understand all aspects of the Atonement and humans can't comprehend the length and breadth of it." This shows us that even the Atonement is an abstraction based on something much, much bigger and more complex.

42.
Gerrit Says:
November 24, 2009 at 11:21 am

I am not sure about how far we can go with the metaphor. Prophets have spoken of Adam and Eve as real people, having real trials and difficulties, with real life experiences even recorded in modern scripture.

I respect your idea of a 'post-modern' view of the Fall is but I still believe Adam and Eve were real. Joseph F. Smith wrote that he saw them both in the great procession of the dead, along with his father and Joseph Smith (D7C 138: 38-39,53). If I believe Hyrum actually lived, it is hard to then say that Adam and Eve didn't, in this context.

#39 Totally agree…and laughed out loud over the last line (true and sad at the same time).
43.
Arthur H. Says:
November 24, 2009 at 11:30 am

#42. I also think Adam and Eve were real. Like I said, I don't think we can pretend nothing in life is real, it leads to ridiculous solipsism. But it's easy in my mind to say "Adam and Eve were the first people who made covenants with the Lord. They were blissfully ignorant of God's Laws, but once God made the Law known to them, they transgressed the Law, bringing misery onto themselves worse than before. However, Enoch teaches us that this Fall was forgiven through Adam's baptism, and Adam went abroad teaching his children the true Gospel of the Christ that would come." None of this really contradicts scripture.
44.
Jeff G. Says:
November 24, 2009 at 11:31 am

What gets me is that most Mormons are motivated in their rejection of evolution because they have no idea what to do with Adam and the Fall. I agree that it is the most difficult question.

The thing is that ID helps absolutely nothing in this area. ID does NOT deny common ancestry. Issue regarding irreducible complexity and information theory speak nothing, absolutely nothing again common ancestry. And let's face it, the common ancestry of human is one of the stronger, not weaker point of Darwin's theory.

It's for this reason that I appreciate NDBF Gary's position more than any ID mumbo-jumbo.
45.
britt Says:
November 24, 2009 at 11:31 am

Arthur I similarly believe the fall is bigger than I can comprehend, but that Adam and Eve were real people. Just as we physically need to do things in ordinances, I believe the fall and the atonement required someone very real to physical DO them.

oh my that's simplistic.
46.
Jeff G. Says:
November 24, 2009 at 11:38 am

BTW, here is my basic attempt at harmonizing an evolution fully endorsed by science with a fall which goes slightly, but not too far beyond official teachings of the church:

http://www.newcoolthang.com/index.php/2005/10/monkey-man/151/#comment-6140

47.
britt Says:
November 24, 2009 at 11:39 am

Jeff, so doesn't it makes sense if Mormons cling to the fall and just kind of back burner evolution-keeping it somewhere in the back and vague?

If I cant figure out how the go together I figure evolution must be wrong-or the more likely of the two to need tweaking.

48.
Jeff G. Says:
November 24, 2009 at 11:48 am

Britt,

Sure, that's all well and good, but again, the fall is denied by ID just as much as by real science. So, sure, deny real science in favor of the fall, but don't do yourself the disservice of buying into any of that ID garbage.

49.
john f. Says:
November 24, 2009 at 11:51 am

so doesn't it makes sense if Mormons cling to the fall and just kind of back burner evolution-keeping it somewhere in the back and vague

britt, that's different than joining creedal Christian Fundamentalists in the ID or young earth crusades.

As you noted above, it is not fundamentally different than the approach SteveP takes except that as a professor of biology with years of research and exposure to actual data and facts about evolution and what it actually is, he embraces it as an explanatory theory and puts the literal Fall somewhat on the back burner in the sense of claiming to know how it fits with the evidence for evolution that he finds so compelling.

Both of those are completely reasonable and thoroughly Mormon approaches. Unfortunately, SteveP looks down so much on his fellow Mormons who in a pinch back-burner evolution that it seems he's had a lot of frustrating conversations on the topic!

50.
britt Says:
November 24, 2009 at 11:54 am

Oh I don't care about ID-

So I can be perfectly rational, still "believe and understand science" (to some extent-but not to SteveP's satisfaction). and just back burner evolution…. great.

51.
john f. Says:
November 24, 2009 at 11:58 am

britt, you have to do what's right for you — this isn't about approval from me or SteveP or JeffG or NDBTF Gary. To me the approach you are taking sounds perfectly fine and is I think what many or most Mormons do. You are probably right that this is not sufficient for SteveP as he seems to want more Mormons to explicitly and formally embrace the theory of human evolution as a fact to the same extent that he does. Unfortunately, very few Mormons have PhDs in organic evolution or biology so we aren't confronted with ultra-persuasive facts about missing links and human evolution on a daily basis the way he is.

But I believe the two broad groups within Mormonism can be reconciled with each other. One way is to mutually acknowledge that the back burner does not equal off the stove.

52.

J. Nelson-Seawright Says:
November 24, 2009 at 12:47 pm

It's nice to have biologist friends. If you know the right ones, they will invite you into their labs and show you evolution happening live, in front of you. When you've had that experience, belief flows naturally because, as they say, faith is dead…

53.

J. Nelson-Seawright Says:
November 24, 2009 at 12:52 pm

Britt, I don't think you can believe and understand science and simultaneously "back burner" evolution. Evolution is extraordinarily central to gigantic swaths of science; even my work in political science is sometimes indirectly informed by evolutionary work on neurology. Somehow bracketing evolution is similar to bracketing the information conveyed by the periodic table or disregarding quantum mechanics; you can rationally do this if you don't care about the scientific project of understanding, but you can't do it and claim to be involved with science.

Many Mormons have been sold a fraudulent load of goods by outsiders, originally Seventh-Day Adventist pseudo-scientists, but now primarily evangelicals, who claim (a) that evolution is reasonably vulnerable to intellectual rebuttal given current evidence and knowledge, and (b) that evolution necessarily implies atheism. Seeing that postulate (a) is definitely incorrect requires some work, but there are mass-market books that will do the job. Seeing that postulate (b) is false is easy: find a biologist who believes in God; I suggest Steve as a good example. It's unfortunate that so many of our co-religionists have been sold these falsehoods in the name of God.

54.

john f. Says:
November 24, 2009 at 1:04 pm

JNS, I think your first paragraph in 53 comes on a little strong. If a Mormon like britt can't see how to satisfactorily reconcile the Fall and human evolution within their own minds and choose therefore to put the role of human evolution in the whole picture on the back burner as a result, I don't think that is rejecting all of science or even a significant portion thereof. It's not even actually "rejecting" human evolution to put it on the back burner; rather, it's just doing the same thing that SteveP does in acknowledging that britt doesn't know where or how it fits in. SteveP said this is already what he does, even though as far as he is concerned, human evolution is undeniable by any rational person.

55.

J. Nelson-Seawright Says:
November 24, 2009 at 1:19 pm

John, let's distinguish between (a) putting the theological puzzle of evolution and the Fall on the back burner, and (b) putting evolution per se on the back burner. Doing (a) is obviously rational, reasonable, compatible with science, etc. But position (b) is not, as it disregards a central pillar of science supported by more evidence than a person can master in ten lifetimes on a whim. You can do that if you want, no problem, but if you do, you aren't engaged with science — that's just how it works.

56.

J. Nelson-Seawright Says:
November 24, 2009 at 1:21 pm

In other words, I think a rational position might be as follows: "Evolution is as strongly supported as basically any human knowledge. So it's very probably how life came about on Earth. I don't understand how that conclusion fits with my theology, but I believe both my theology and that scientific proposition about the origins of life (although for different reasons and in different ways). I'm not sure this isn't a paradox, but it's one I'll live with for now."

57.

john f. Says:
November 24, 2009 at 1:22 pm

JNS, you're being obtusely obstructive to dialogue on this issue. So be it.

58.

john f. Says:
November 24, 2009 at 1:24 pm

(with reference to 55; your 56, of course, says something similar to what I've been saying, minus the sort of superior air about knowledge about evolution, so it's not obtuse.)

59.

J. Nelson-Seawright Says:
November 24, 2009 at 1:27 pm

John, good grief — obstructing dialogue is your job in this thread, it seems…:)

60.

J. Nelson-Seawright Says:
November 24, 2009 at 1:27 pm

Since #55 and 56 say the same thing, your distinction is odd to me, John. Why isn't it useful to distinguish between the irrational move of "back burnering" evolution and the reasonable move of "back burnering" theological puzzles?

61.

john f. Says:
November 24, 2009 at 1:32 pm

How about this:

"Organic evolution is strongly supported by many different kinds of testable and provable (i.e. scientific) evidence. So it is probable that organic life developed over eons through this process. The same evidence strongly supports the theory that homosapiens developed through an evolutionary process, even though certain key links have not yet been found. So it is also very possible that homosapiens developed through such processes. I don't understand how that conclusion fits with my beliefs about human beings in the family of Adam and Eve, but I believe both my religious beliefs and such scientific propositions about the origins of life (although for different reasons and in different ways). Sometimes this seems like a paradox to me; other times it

seems to fit together better. Either way, I am comfortable acknowledging that I don't necessarily know how everything fits together but there's no reason to think that both are correct and I believe that there is much more to learn on both fronts than is currently known."

62.
john f. Says:
November 24, 2009 at 1:33 pm

"no reason to think that both are not correct"

63.
john f. Says:
November 24, 2009 at 1:41 pm

re # 59, why? What's been obstructive?

64.
J. Nelson-Seawright Says:
November 24, 2009 at 1:43 pm

John, that's maybe a bit too weak on the evidence regarding human origins. It seems that you're perhaps interjecting doubt that isn't supported by the evidence, which would be a non-scientific move. (Again, fine if you don't care about science; not if you do.) I'm confused by this: "there's no reason to think that both are correct." Here's my proposed revision:

"Organic evolution is strongly supported by many different kinds of testable and provable (i.e. scientific) evidence, and has successfully made more testable predictions than almost any other theory. So it essentially meets the current limits of human certainty that organic life developed over eons through this process. The same evidence equally strongly supports the theory that homosapiens developed through an evolutionary process. So it also essentially meets the current limits of human certainty that homosapiens developed through such processes. I don't understand how that conclusion fits with my beliefs about human beings in the family of Adam and Eve, but I believe both my religious beliefs and such scientific propositions about the origins of life (although for different reasons and in different ways). Sometimes this seems like a paradox to me; other times it seems to fit together better. Either way, I am comfortable acknowledging that I don't necessarily know how everything fits together. I'm not ready to throw out either proposition, or to disregard the best available information (either scientific or theological) because of the resulting tensions."

For what it's worth, I think the fireworks over the Fall are a superficial distraction from the real, difficult issues of evolution and Mormon theology. For example, if humanity originates through evolution, then at least important aspects of the "end point," i.e., us (although we aren't really any kind of end point in evolutionary thought), are a priori unpredictable. This means that God can't have known in any great detail what kinds of bodies he was creating for us. Which in turn raises serious questions about propositions that God and us have the same kinds of bodies, that spirits in some sense correspond to bodies, etc.

Or another one. It seems to be possible to account for an increasing number of features of consciousness via evolutionary arguments in conjunction with comparative anatomy. This puts us in a position of being unable to answer the question: what is a spirit, and what role does it play in human life? It may well be the case that cognition, affect, etc., are all evolved biological capacities, which may leave little role for the spirit as a component of a person's behavior or inner life.

I think these are tougher issues than the Adam and Eve story, because that's a singular story that comes from a textual tradition which we know to be filled with symbolism, complexity, invention, etc. All it takes is a different understanding of what the Fall entails and you're through the maze, and different understandings of the Fall are sort of a dime a dozen in Mormonism through its history. These other issues are harder, because they don't involve simple issues of interpreting a single event, but rather speak to basic conceptions of the theology of humanity…

65.

J. Nelson-Seawright Says:
November 24, 2009 at 1:45 pm

John #63, how about your comment #57: instead of engaging my distinction between bracketing the science of evolution and bracketing theological puzzles, you simply call it obstruction! Oh, well. Good times. Reminds me of the days when you and your German House roommates put the anti-environmentalist poster on your door for irony…:)

66.

RJH Says:
November 24, 2009 at 2:01 pm

john,
Did an evolutionist do something mean to you when you were a kid?

67.

Mark D. Says:
November 24, 2009 at 2:07 pm

Steve P.: There earliest argument from natural theology I could find was Xenophon on which I blogged a couple of weeks ago on the Mormon Organon.

My complaint here is that the dominant tradition in natural theology is precisely the opposite of a typical argument from design. "Intelligent Design" traditionally refers to temporal intervention in the evolutionary process, if not special creation. The dominant tradition in natural theology going back thousands of years (and reaching its greatest expression Aquinas) is the opposite – all about God's timeless creation of the laws of nature.

It is like the difference between saying God designed the laws of electromagnetism to accomplish these purposes vs he intervened in history to tweak this cell or that organism. Scientists don't and can't care about the former from a scientific perspective – creatio ex nihilo is the ultimate violation of the laws of nature, but after that they stay the same. But intervention in evolutionary history is the sort of quasi-miraculous thing that science cannot possibly explain, because it tends to involve suspending the laws of nature here and there and everywhere. And if it really was a miracle, how or why it happened isn't a scientific question either.

Natural theology traditionally is all about trying to understand God and his purposes through the analysis of the laws of nature, not an analysis of some possible intervention here or there. And that is why it (the traditional, timeless perspective) is much more compatible with scientific inquiry than the latter.

68.

john f. Says:
November 24, 2009 at 2:10 pm

JNS, as noted in my # 62, that phrase that you said you didn't understand was missing the "not".

Why did you delete this in your revision:

"I believe that there is much more to learn on both fronts than is currently known."

This makes it seem like you are making the most absolute claim about human evolution that is possible — that nothing more can be learned about it through further discovery.

I think the following is unnecessarily strong in its claims:

"The same evidence equally strongly supports the theory that homosapiens developed through an evolutionary process. So it also essentially meets the current limits of human certainty that homosapiens developed through such processes."

To my knowledge it is not established to the point of "meeting the current limits of human certainty" — and what does it bring your definition to make such a strident claim?

As to the problems that accepting human evolution as a probable method of the development of homosapiens, I don't agree that those necessarily follow on the religious side of things. How could such issues possibly cast doubt on the origin and function of the human spirit that Mormons believe inhabit these physical bodies? That is entirely a matter of faith.

69.

john f. Says:
November 24, 2009 at 2:12 pm

Um, Ronan, I don't get your question given that pretty much everything I've said on this thread and the other thread is supportive of evolution and is in the posture of reaching out to Mormons who are skeptical and reassuring them that, in my view, theories of human evolution and LDS religious belief neither are nor should be mutually exclusive, contradictory or even particularly troubling.

70.

RJH Says:
November 24, 2009 at 2:21 pm

You know I love you JF, so fret not. Note that I mused whether it was evolutionists (rather than evolution) that stole your lunch money.

71.

Mark D. Says:
November 24, 2009 at 2:24 pm

"Evolution is as strongly supported as basically any human knowledge"

Strongly supported in some sense or another, absolutely. As strongly supported as a large number of other fields of human inquiry, hardly. Physics, mathematics, computer science, and engineering (to name a few) are all light years ahead of evolutionary biology in terms of precision, predictive power, and depth of understanding.

That is not particularly surprising, however, because the latter is a much more complex problem. At the moment the computational power to accurately simulate a single cell in quantum mechanical terms is far beyond the capacity of present computer technology, even with football fields full of computers.

72.

J. Nelson-Seawright Says:

November 24, 2009 at 2:26 pm

John, what are the current limits of human certainty? If spectacular scientific success crossing dozens of fields of inquiry doesn't count, what does?

Regarding the "much more to learn" clause, of course that's true. I deleted it because it's often misunderstood with respect to evolution. Of course there is much more — possibly infinitely more — to learn about how evolution works. But people often think that this lack of knowledge makes it plausible to imagine that evolution tout court will turn out to be wrong in light of future discoveries. This is of course possible, but not plausible.

Regarding the theological puzzles that I think result from understanding evolution, I agree that the proposition that there's a spirit in our bodies is a pure issue of faith. The proposition that the spirit acts in some sense to co-produce our thoughts and actions may not be — it might be an empirical question. That is to say, it's now possible to account for an awful lot of human consciousness without invoking the existence of the spirit, and that may have implications. If it turns out to be demonstrable that the spirit isn't necessary at all to account for our thoughts and feelings, that's an oddity worth working through. These puzzles don't disprove Mormonism, obviously. But they're tricky for thinking about how we believe our beliefs; that's the total substance of my claim.

73.

Dan Weston Says:
November 24, 2009 at 2:28 pm

#61,

I don't understand how that conclusion fits with my beliefs about human beings in the family of Adam and Eve

I think it would be more interesting to worry about where Adam and Eve went, not what car they drove in to get there.

As I mentioned in another post comment, the easiest resolution of ID/creationism and evolution is to punt: Descartes mind-body dualism (Ghost in the Machine). Poof, problem solved. Various species evolved, and when one of them at random (a primate, as it happens) evolved a brain complex enough, God infused it with the Spirit of Adam and Eve, and off you go.

This has the added benefit that when we die, the corpse rots (as even children notice) and we don't have to worry about the spirit getting stuck in it.

The angst in the comments above seems to me to arise where body and soul are put into a one-to-one correspondence. Instead of Adam materializing into any random suitable body, you require a specific creation. Why must such importance be placed on the vessel? When people go on vacation, they don't take pictures of the rental car. Why should premortal/mortal/postmortal souls have not just a corresponding premortal/mortal/postmortal body but the same body. The soul goes where the body cannot follow.

For me, the flaw even in this minimalist theory is the mentally retarded. Whereas perfect intelligence can be trapped in a frail body (after all, we're just along for the ride), what to think about frail intelligence? How do premortal souls lose intelligence? How do they get it back? (answer here).

This is the more interesting question for me, not the mechanics of how this temporary flesh shell I inhabit came to be complex enough to house me during my stay here on Earth.

74.

J. Nelson-Seawright Says:
November 24, 2009 at 2:31 pm

Mark D., mathematics and computer science are actually sort of a different animal. Those are the study of human-made systems…

Regarding comparisons in terms of predictive power, precision, and depth of understanding, these seem to me to be ill-defined to the point of meaninglessness. Certainly evolution doesn't allow plots of simple orbits (although physics still runs into trouble when there are too many objects exerting gravity on each other), but this seems like the wrong sort of metric. How can "precision," for example, be measured in a way that is relevant to the kinds of hypotheses advanced by both physics and evolution and that is comparable between them? I'm not sure you can solve this problem.

My point is simply that evolution accounts for vastly more evidence, solves inordinately more problems, than any competing theory in biology. Physics does the same. How much better does it get than that?

75.

J. Nelson-Seawright Says:
November 24, 2009 at 2:33 pm

Dan, please don't equate the spirit with the mind in a Cartesian sense! There's increasingly good evidence that the mind as usually understood, i.e. consciousness, is a biological function of the body. The spirit would have to be something else.

76.

J. Nelson-Seawright Says:
November 24, 2009 at 2:42 pm

For that last comment, I'm obviously not an expert, but I've read some neat books by people who are. Here are three.

77.

Dan Weston Says:
November 24, 2009 at 2:45 pm

J. Nelson-Seawright,

Please don't escape the topological problem with word games.:)

If mind and spirit are connected in any way, they must connect somewhere. So, where? Whatever that somewhere is, it must be either in intimate contact with the mind, or else be action at a distance. The latter does essential damage to the concept of agency.

78.

Ugly Mahana Says:
November 24, 2009 at 2:48 pm

I am really enjoying the conversation here and elsewhere on the topic of evolution.

One question: Is it ok to not be engaged with science, or do all those not so engaged have the right (responsibility?) to look down their noses at their co-religionists for whom science is not their primary means of interpreting their lives?

79.

J. Nelson-Seawright Says:
November 24, 2009 at 2:54 pm

Dan, that's the problem! If mind is an evolved biological capacity, as scientists are increasingly arguing, then the role of the spirit in a human being is a puzzle! The spirit can't reasonably be believed to be equal to the Cartesian mind, because we know that the Cartesian mind can be easily damaged or fundamentally changed through manipulation or lesion to the brain (or through amputation of limbs, spinal cord injuries, etc.). Our theology would seem to demand some relation between the apparently biological process that Descartes mysticized as mind and the spirit, but what that relation can be is hard to spell out. The spirit can't reasonably be offered as the cause of synapses, hormone flows, etc., since those are biological, evolvable, and evolved. So the story has to be trickier than we usually think.

80.

J. Nelson-Seawright Says:
November 24, 2009 at 2:55 pm

Mahana, if people want to ignore science altogether, that's their choice in my view. It's a hard choice for me to understand — but as long as it doesn't turn into hostility or rejection, it's all good with me.

81.

Rob Osborn Says:
November 24, 2009 at 2:56 pm

Steve P,

I do not agree that ID theory is a god of the gaps. Look at your own theory concerning the origins of life through mere natural processes. You state all of these "what-ifs" concerning if scientists were to find out how life could originate from random natural processes in nature. Scientists have been studying the phenomenon of biogenesis for hundreds of years investigating why life only comes from life sources. They have put up so much documented proof of the fact of the law of biogenesis that in it's wake it destroys any fantastical approach to some non-scientific, law based theory of abiogenesis.

What ID has found, or has perpetueated is just that- that life only comes from life and that because of this science- "natural" science has a lot of explaining to do- namely that either life has always existed in some form in the universe, or that known laws of biochemistry are really not known at all. Rather than throw out hundreds of years of research and study, ID scientists are left with the all to obvious- that intelligent life only comes from intelligent life. In fact, this is the very doctrine of the church- that the only reason we exist on this planet is because of the intervention of a previous life-form- yes, an "intelligent designer" interacted with matter and created us with both purpose, intellect, design capabilities, etc. The truth is that naturalistic science explanations and the revealed word of God do not coincide with each other. ID is thus not a god-of-the-gaps, but in reality the end result of noting the physical laws of biogenesis. Abiogenesis and biogenesis contradict each other. Its amusing to me that evolutionists will recognize the law of abiogenesis on one hand and then on the other admit that it is or can be wrong- at least at one point in the past, otherwise they have no way to explain how life origunated because they surely won't point in the direction of where the truth is leading- that direction of life only coming from life, and- it is what our church firmly teaches.

You posit that it must be possible for life to spontaneously arise on other planets as if there be no God, no creator involved. As of yet, we have shown over and over again that the enigma we call life is at a complete losss of words in a purely random naturalistsic setting.

The signs are very clear that we have an intelligent designer who created all life and the galaxie we live in. It is not har to extrapolate after viewing the last ten years in genomic and DNA research that this phenomenon of "directions, designs, coded language" as found in cellular processes is not the act of anything short of genius! It says there is a God, there must be a God. Someday, it will be proven, will be shown as fact, that Jesus Christ orchestrated the creation- that he is the "enigma" that science has been so perplexed by. There will come a day when all known biological processes will be known to be the direct act of an intelligent agent acting upon matter. God is real, the creator is real, and ID is real. Why do LDS subscribe to ID theory? Because our very scriptures tell us so.

82.

Cynthia L. Says:
November 24, 2009 at 2:56 pm

Regarding #53 and follows, what Ugly Mahana said. JNS, your proposed statements are fine for scientists. But not everyone is a scientist. Why do we have to hate on britt and others who are trying to be on our side–to the extent they even think about the issue–but are just saying that this isn't something they think about all that much. Jeesh.

83.

J. Nelson-Seawright Says:
November 24, 2009 at 3:05 pm

Hey, Cynthia, see my #80! I agree with you in advance; I've pointed out several times in this thread that for people who don't care about science, none of this need apply. My argument is simply for people who want to be engaged with science.

No hating on britt from my corner, either. Britt's got good questions, I think.

84.

Cynthia L. Says:
November 24, 2009 at 3:10 pm

Yeah I didn't see your #80, sorry. Consider my #82 retracted.

85.

SteveP Says:
November 24, 2009 at 3:11 pm

Wow, you guys do so well without me (I was at a dissertation defense)! Carry on! You know how I feel about this.

86.

Jeff G. Says:
November 24, 2009 at 3:22 pm

Haha! You're funny, Rob!

"What ID has found…."
"…ID scientists…"

Ah, those are good ones.

87.
Dan Weston Says:
November 24, 2009 at 4:17 pm

One example of how already Free Agency cannot stand up to scientific inquiry:

fMRI Evidence Used in Murder Sentencing
http://blogs.sciencemag.org/scienceinsider/2009/11/fmri-evidence-u.html

The intersection of theology and science is politics. It should be quite a ride.
88.
Tracy M Says:
November 24, 2009 at 4:20 pm

Skipping all the comments, I just wanted to say SteveP, I really love your POV, and admire you as a man of faith AND science.
89.
Mark D. Says:
November 24, 2009 at 6:32 pm

mathematics and computer science are actually sort of a different animal. Those are the study of human-made systems

Virtually everything about physics for at least four centuries running would be hand waving if it weren't for the the precise and exquisitely empirically verified expression of the laws of physics in mathematical terms. So you can't really go around claiming that mathematics is just something that people make up. It is instantiated in the real world to a greater degree than anything except matter itself – completely inescapable.

Now with computer science and engineering are indeed synthetic fields – what other field supports the mass production of systems with hundreds of millions of custom designed components down to the level of handfuls of molecules. Molecular biology is (as yet) incapable of comparably constructing even a single cell.

The multi-body problem is real for physics of loosely coupled systems, a problem largely avoided in the engineering of solid state devices, but biology is much closer to the latter than the former – too many things floating around.

Calculating something like the way a protein will fold is a major computational challenge. So sure, biology is far more complex than the mechanics of microprocessors, but we understand far less about it. It is like studying an alien technology from thousands of years in the future. We can tweak it and morph it here and there, but we are (as yet) unable to duplicate it ourselves. And if we can't duplicate it, we certainly do not really understand it.
90.
Mark D. Says:
November 24, 2009 at 6:53 pm

R. Osborn, I think there are two challenges here. The first is the challenge of hard reductionism of life as it exists, which claims that everything about human life is reducible in a hard, deterministic sense to pure mechanism and clockwork. Or in other words, that intelligence is epiphenomenal, not a fundamental property of existence at all. Clearly, if it is impossible to tell

whether a third party is conscious, it isn't really necessary to include consciousness in your model of the way the mind works. That is Daniel Dennett's example.

Of course a lot of people, including a number of well respected philosophers of biology, believe that degree of reduction is impossible for a variety of reasons. The two of the longest standing are the mind body problem and the question of (libertarian) free will, two fundamental questions that biology and cognitive science aren't even close to resolving. And that is assuming that you have a fully formed human brain to start with.

The other challenge is establishing the hard reductionism of the process that led to the development of the human brain. That is the proposition that the ID people are trying to attack, albeit with little in the way of mathematical rigor so far. Maybe that will change someday.

The alternative, to prove (for example) that the origin of life occurred and can re-occur from neutral initial conditions without the free will of anyone or anything (including at some primitive level, the molecules themselves) would be tantamount to demonstrating that hard reductionism of the evolutionary process is correct. No one has done that yet, and no one is close.

91.

J. Nelson-Seawright Says:
November 24, 2009 at 8:37 pm

Virtually everything about physics for at least four centuries running would be hand waving if it weren't for the the precise and exquisitely empirically verified expression of the laws of physics in mathematical terms. So you can't really go around claiming that mathematics is just something that people make up. It is instantiated in the real world to a greater degree than anything except matter itself – completely inescapable.

Mark, this doesn't really work for me as yet. I agree that humans have developed mathematics into a set of languages that do a great job of capturing ideas and demonstrating relationships among them. It's also true that a tiny proportion of mathematically possible ideas correspond well with physical data. But it doesn't follow that math wasn't humanly made — just that it was made well. Math isn't instantiated in the world; it's a model of the world. Similar relation, but the causal flow is reversed.

I might be wrong, though: persuade me.

92.

Jon Ogden Says:
November 24, 2009 at 9:04 pm

"Oddly, Mormon's seem to be embracing things like the Creationist movement of 'Intelligent Design.'"

Where do you see this happening? I personally haven't heard anyone say something like this; all the Mormons I know have no problem with evolution.

93.

SteveP Says:
November 24, 2009 at 9:13 pm

Jon Ogden you are a doubly blessed man. May your perspective spread and grow to fill the world.

94.

SteveP Says:

November 24, 2009 at 9:18 pm

Mark D., I am a mathematical modeler so tend to see mathematical models as holding less shine than you do, even for physics.

95.

Jeff G. Says:
November 24, 2009 at 9:41 pm

Mark,

You have misunderstood Dennett, reductionism and the relationship which exists between the two. I only bring this up as an illustration of a misunderstanding which I suspect you have of naturalism in general.

Dennett is NOT a reductionist; a hard core naturalist, yes, but not a reductionist.

Accordingly, he does NOT claim that "everything about human life is reducible in a hard, deterministic sense to pure mechanism and clockwork." Nor does he believe "that intelligence is epiphenomenal." He does, however, believe that intelligence exists in every non-extravagant sense of the word.

Now, as for these respectable philosophers of biology who believe the reduction of biology to physics to be impossible, count Dennett as one of these philosophers. Similarly, he does NOT believe the mind to be reducible to the body.

Now for the main point I am trying to make. Evolution, and naturalism in general, do not entail hardcore reductionism or epiphenomenalism. (At the very least, one can believe in naturalism AND freewill/intelligence without being transparently self-contradictory.) And secondly, the fact the reduction of biology to physics seems impossible to many of the well informed should give theist very, VERY little comfort. You can believe in evolution without believing in reductionism and you can disbelieve reductionism without believing in theism. Dennett is a shining example of both of these.

96.

Mark D. Says:
November 24, 2009 at 11:46 pm

JNS: Math isn't instantiated in the world; it's a model of the world

If you said "Science isn't instantiated in the world, it's a model of the world", I would fully agree. Math, on the other hand, is an entirely different animal. Science is a model of the world as it is. Mathematics, on the other hand, is more like logic – it necessarily applies to all logically possible worlds.

Science can trivially go wrong due to epistemological limitations. Mathematics cannot – it can only go wrong due to errors in logic. Mathematics in the abstract cannot go wrong at all, any more than logic in the abstract can go wrong. Not in any logically possible world, at any rate.

Any mathematics that can be dreamt of can be instantiated in some logically possible world. Most logically possible worlds can instantiate multiple forms of mathematics by composition or simulation. In some cases we may not know precisely which form of mathematics is instantiated in some physical system – that is a scientific question. But with regard to the proposition that some form of mathematics is instantiated in every logically possible system we can be absolutely certain.

Either our world is logically possible, real, self-consistent, and governed by (or comprehensible in terms of) mathematics or it is logically impossible, unreal, inconsistent, subjective and incomprehensible. The latter is mysticism, subjectivism, and solipsism of the highest order.

97.

Mark D. Says:
November 25, 2009 at 12:02 am

Jeff G, I don't know where you get the idea that Dennett isn't a reductionist. I believe he is rather well known for his defenses of reductionism, not what he calls "greedy reductionism" (explaining away higher level properties) to be sure, but a rather hard reductionism nonetheless.

Take a look at this summary for example. Now if you have any references in support of the idea that Dennett is not a hard reductionist, I would very much like to see them.

98.

J. Nelson-Seawright Says:
November 25, 2009 at 4:27 am

Mark, heard of Godel lately? It's impossible to mathematically prove that the basic axioms of a mathematical system are coherent — so a given system of math could in fact be at its root illogical and we wouldn't necessarily be able to tell.

But with regard to the proposition that some form of mathematics is instantiated in every logically possible system we can be absolutely certain.

What does this even mean? I think it's probably true that humans can invent a flavor of math to represent any observable regularity. But it isn't necessarily true that all "logically possible systems" are in any sense regular.

Your last paragraph begins to sound a bit Pythagorean — you've got a mysticism of your own here. Humans invent math, we just do, so math is not the essence of reality. Your worldview is backwards, I suspect, like someone trying to chase away a shadow.

99.

SteveP Says:
November 25, 2009 at 1:28 pm

Jeff is right. Dennett is a determinist but not a reductionist (I've read three of his books). Few are these days. To see the destination think of traffic jams. They are not reducible to individual cars and drivers. You could study a particular car and driver until the world's end and not learn anything about traffic jams. Traffic jams supervene on cars and can be explained by them, but they don't reduce to them. They are an emergent property of car and drivers.

100.

Jeff G. Says:
November 25, 2009 at 1:32 pm

Well, it's difficult to think of a single Dennett book that DOESN'T mention in some way the distinction between the intentional and physical stances as well as the irreducibility of one to the other. As for your link, on the other hand, it isn't a very good representation of Dennett or reductionism, but then Dennett is pretty tough to really get your head around at times.

"In Consciousness Explained, Dennett argued that, without denying that human consciousness exists, we can understand it as coming about from the coordinated activity of many components in the brain that are themselves unconscious."

Dennett fully endorses this as a naturalist, BUT THIS ISN'T REDUCTIONISM. Well, maybe it's ontological reductionism. The thing is, they have another name for ontological reductionism; it's "naturalism".

The reductionism which Dennett, Sober and all those other reputable philosophers you mention are talking about is something else entirely. It's better understood and being able to translate all mental talk into physical talk by way of equating mental (or biological) entities with physical entities. It's quite common and uncontroversial for naturalists to reject this other, more important kind of reductionism.

If you want to understand Dennett's position on this, I suggest pages 65-68 of his The Intentional Stance, a section titled "The Prospects of Reduction" where he rejects both the reductions posited by both identity and functionalist theories. Ultimately he argues that mental talk is legitimizing by, not reduced to physical talk; if anything physical entities are defined in terms of the mental rather than the other way around.

I might also recommend "Daniel Dennett: Reconciling Science and Our Self-Conception" by Matthew Elton, pg. 63-67 titled: "Dennett's Argument Against Reduction".

Indeed, doesn't the common charge, which isn't very far off the mark I might add, that Dennett is an Instrumentalist about the mental suggest that he isn't too keen on reductionism?

101.

Mark D. Says:

November 25, 2009 at 10:23 pm

JNS: heard of Godel lately? It's impossible to mathematically prove that the basic axioms of a mathematical system are coherent

So what? The fact that the world is real is all the evidence needed to establish that the mathematical axioms that are instantiated in the real world are in fact mathematically consistent. Do we really need a mathematician to prove that there is an objective reality out there?

To look at it another way, has a mathematician ever established that a basic empirical fact was not actually the case? Should we worry that a mathematician is going to prove that President Obama doesn't exist? Or that there are really 17 rather than 435 members of the House of Representatives?

If indeed the mathematics instantiated in the real world was inconsistent, it is a well established fact that every binary proposition and is opposite would both be "true". I.e. every proposition about the real world would be meaningless, or in other words, the world wouldn't be real at all.

102.

Mark D. Says:

November 25, 2009 at 10:58 pm

Jeff G: BUT THIS ISN'T REDUCTIONISM. Well, maybe it's ontological reductionism. The thing is, they have another name for ontological reductionism; it's "naturalism".

Ontological reductionism is part and parcel of the reductionist position, and ontological reductionism one of the propositions that Mr. Sober has spent some considerable effort attempting to disprove. I quote:

Reductionism is not just a claim about the explanatory capabilities of higher and lower level sciences, it is a claim that the higher level properties of a system are fully reducible to lower level properties of a system (Sober, MRAAR paper, second page)

Sober claims that multiple realizability means that this proposition (ontological reductionism) is not true. I don't think he means to imply that he is not a naturalist.

Jeff G: Indeed, doesn't the common charge, which isn't very far off the mark I might add, that Dennett is an Instrumentalist about the mental suggest that he isn't too keen on reductionism?

Not quite – instrumentalism about any field implies that the advocate may be in some considerable doubt about whether the subject of his inquiry is real at all. Technically, you are right, that is not reductionism per se, it is worse. It this context it is the position that consciousness is imaginary.

However, the position that X is imaginary does not imply the position that every real higher level property Y is not reducible to some set of real, lower level properties Z. One can maintain that consciousness is imaginary without denying reductionism with regard to everything one considers to be real.

103.

Jeff G. Says:

November 26, 2009 at 1:22 am

Mark,

You still aren't getting it. Sober is a naturalist. He believes that all there is in the world is matter in motion. And yet still, he rejects reductionism in exactly the same way that Dennett does and for roughly the same reasons that he does. Let me spell it out as clearly as I can:

Reductionism, as it pertains to the mind, is the thesis that all mental entities can be fully defined in terms of physical entities and as such, we can just talk of physical entities without leaving anything out. The same goes for mental laws, such as the law of effect; they can, under reductionism, be translated into laws of physics.

Sober and Dennett both reject these theses WITHOUT appealing to anything non-natural. Sure, they appeal to the non-physical, but not the non-natural. The multiple realizability argument that Sober describes is based in premises which a naturalist can fully accept and these premises lead to a conclusion which a naturalist can fully accept as well.

There is no talk in that article of naturalism or "ontological reductionism". The article is about explanatory reductionism. Put a little more technically, Dennett, Sober and the like at accept token physicalism, or the supervenience thesis if you will, but they reject any kind of type physicalism. Yes, all mental objects and mental phenomena can also be seen as mere matter in motion, but the former will never be EXPLAINED in terms of the latter.

If you don't believe it, then please summarize Sober's argument in your own words. Show us why ontological reductionism is false rather than simply restating what you take to be someone else's conclusion on the subject.

104.
Mark D. Says:
November 26, 2009 at 3:20 am

Jeff G: The article is about explanatory reductionism.

But not only about explanatory reductionism, or even primarily about explanatory reductionism. Do I really have to repeat what Sober said? It is clear as a bell to me. No need to make an argument. This is elementary English grammar.

Reductionism is not just a claim about the explanatory capabilities of higher and lower level sciences, it is a claim that the higher level properties of a system are fully reducible to lower level properties of a system

Not “just” a claim about “explanatory capabilities”. A claim that “higher level properties” are “fully” reducible to “lower level properties”. In a paper where he presents the multiple realizability argument against reductionism.

By the way, have I said anything recently to indicate that I was not a reductionist? In fact, I find it rather amusing to find myself rather more reductionist than Sober is, in precisely the sense that he claims is false, namely the full reducibility of higher level properties to lower level properties.
105.
Dan Weston Says:
November 26, 2009 at 12:02 pm

Here is a math analogy, since Mark seems to favor math.

The emergent behavior is an algebra, the material building blocks are (merely) the carrier. All intelligence needs is enough stuff to form basic spatially and temporally recursive control structures. Then natural selection takes over, literally inventing (through massive pruning) a highly evolved attribute grammar. The carrier is unimportant.

Without feedback, you need a very precise transistor. With feedback, any old junk will do, the real signal will be controlled by the interaction of junk. The circuit (constantly rewired by evolution) matters, not the circuit board.

Reductionism is like taking a beautiful painting and scraping off the paint for analysis under a microscope, forgetting that any old paint would have done: it is the information that provides the function, information that feels selective pressure, information that sometimes hops from one carrier to another (as when faxing a letter, or when mitochondria went from independent organism to part of our cell).

And NONE of this requires that you believe in anything more than the Equipartition Theorem and some source of imperfect self-replication.
106.
J. Nelson-Seawright Says:
November 26, 2009 at 1:58 pm

Mark, you say, “The fact that the world is real is all the evidence needed to establish that the mathematical axioms that are instantiated in the real world are in fact mathematically consistent.” This is nonsense, isn’t it? As I’ve pointed out above, mathematics is not instantiated in the real world.

107.
Jeff G. Says:
November 26, 2009 at 2:38 pm

Mark,

I know what Sober said. My point is that I don't think you know what he meant when he said. "Reductionism" as Sober uses the word, does not mean what you think it means. This is why I ask you to do a little more than quote mine his paper for what you what. If you could just explain what his argument is, it should be clear to all, yourself included, that his reductionism says nothing about evolution, naturalism or anything of the sorts.

Sober is a naturalist, an evolutionist and an anti-reductionist. So is Dennett. Doesn't this make you think you might be missing something?
108.
Kathryn Lynard Soper Says:
November 26, 2009 at 3:11 pm

Dudes. Go eat some turkey.
109.
Jeff G. Says:
November 26, 2009 at 3:47 pm

Hahaha! An hour and counting!
110.
Mark D. Says:
November 26, 2009 at 6:35 pm

Jeff G, I completely agree that Sober is a "naturalist, an evolutionist and an anti-reductionist". Not only that, but that he is an anti-reductionist in the sense that he doesn't believe that higher level properties are fully reducible to lower level properties. He says as much in his own words.

As far as I can tell the only meaningful dispute here is that you claim that Sober's anti-reductionism doesn't include opposition to one of the very things Sober claims reductionism does include. Well, that is a rather peculiar perspective, and there is nothing I can say to make you change you mind, if Sober's own statement on the subject isn't sufficient to convince you. I have no desire to belabor the point any further.

JNS: This is nonsense, isn't it? As I've pointed out above, mathematics is not instantiated in the real world.

So you say. I seriously doubt you could find more than a tiny minority of scientists who would agree with you on that point. I have three apples in one basket and two apples in the other basket. Together, I have five apples. Sounds like mathematics is instantiated in the real world to me. Is there any risk that a mathematician is going to come along and prove that I actually have seven?

Here again I do not have anything new to add to the subject, and if elementary arithmetic with regard to concrete objects doesn't reliably obtain in the world as you see it, I can hardly say more.
111.
J. Nelson-Seawright Says:
November 26, 2009 at 7:03 pm

Mark, really no — scientists tend to understand their mathematical models as models, not reality. For one thing, scientists know that all our models are incomplete. Your arithmetic thing is irrelevant — counting was developed as an incredibly accurate model of exactly your example, but your view is a kind of mysticism which places the math in reality and therefore gets causation backwards. Apples existed before the natural numbers.

In any case, the mathematics of integers has proven, in the hands of Godel, that it is impossible to know that arithmetic is logically coherent. So you claim to know that which cannot be known.

112.

Mark D. Says:
November 26, 2009 at 7:03 pm

Dan W. Reductionism is like taking a beautiful painting and scraping off the paint for analysis under a microscope, forgetting that any old paint would have done

There is absolutely nothing about reductionism that implies that the structure (or information content) of the relationship between higher and lower level properties is somehow irrelevant, to say nothing of the structure or information content of the relationship between the lower level properties themselves.

A molecular level model of a microprocessor has a rather high information content, does it not? And reducing an engineering level model of a microprocessor to a much more detailed molecular level model of the same is a classic example of the reductionist approach. Information isn't going away, if anything it is being introduced – due to real world physical considerations. No one suggests that we can derive the properties of a modern computer by studying the properties of a single atom. That is absurd.

The emergent behavior is an algebra, the material building blocks are (merely) the carrier. All intelligence needs is enough stuff to form basic spatially and temporally recursive control structures. Then natural selection takes over, literally inventing (through massive pruning) a highly evolved attribute grammar. The carrier is unimportant.

This is an excellent analogy. The first problem is, no one has *ever* done it from neutral initial conditions and neutral transition rules, not even in computer simulation. Take the game of LIFE for example. If we turned a thousand supercomputers to simulating the structures that evolved from random initial configurations, do you think we would ever see something even plausibly described as intelligent, within a thousand lifetimes?

113.

J. Nelson-Seawright Says:
November 26, 2009 at 7:10 pm

Regarding the Sober argument, I can't really understand Mark's position. Sober argues, roughly, against the proposition that higher-level phenomena are not emergent in the sense that the system of physical entities and interactions that produce the phenomena has properties that do not belong to any of the individual elements of that system. OK. As far as I can tell, this is identically Dennett's point of view regarding mental phenomena. Which makes Dennett a non-reductionist.

Explaining consciousness, for example, in terms of evolution is not reductionism unless one assumes that consciousness is a higher-level phenomenon than evolution. That assumption, among others, seems uncertain. Mark, are you prepared to defend it? If not, your position is hard to decipher.

114.

J. Nelson-Seawright Says:
November 26, 2009 at 7:13 pm

If we turned a thousand supercomputers to simulating the structures that evolved from random initial configurations, do you think we would ever see something even plausibly described as intelligent, within a thousand lifetimes?

Some problems. First, why require random initial configurations? That doesn't seem to be part of evolutionary theory. Second, if the supercomputers are capable of accurately simulating the analogue of whole DNA strings and organisms, then there should be no problem. Just allow the simulated equivalent of a couple billion years to pass and all should be well.

But you seem not to believe that — which is because you don't believe consciousness evolved. So your comment doesn't really get you anywhere; your skepticism is grounded in begging the question.

I hereby declare Mark D. a troll and request that he not be fed.

115.

Mark D. Says:
November 26, 2009 at 7:29 pm

JNS: In any case, the mathematics of integers has proven, in the hands of Godel, that it is impossible to know that arithmetic is logically coherent. So you claim to know that which cannot be known.

On the contrary, what Godel demonstrated was that it was impossible for a logical system to be used to construct a proof of its own self consistency. I am making a higher level argument, that the uncontroversial proposition that the world is real implies (by definition) that it is not inconsistent with itself, therefore any mathematical relationship that is consistent with the real world is consistent. The only way out is to claim that the world isn't real, i.e. that there is no such thing as objectivity.

Mark, really no — scientists tend to understand their mathematical models as models, not reality.

I could hardly agree more (I majored in physics, by the way). However, there is a difference between a mathematical model of the natural world, fully limited by imprecision and epistemological considerations and the mathematics (and natural laws) that actually obtain. In other words, you are confusing epistemology and metaphysics.

The existence of a single, time-independent natural law is adequate to establish the instantiation of some form of mathematics in the real world. It doesn't matter if we know what that law is, or in what form it takes. All that matters is that there is at least one natural law. The reality of the number of apples in my basket is a trivial example, one that directly corresponds to the law of non-contradiction.

You imply that the law of non-contradiction with regard to the properties and number of real world entities is a figment of the imagination, as if a tree fell in a forest and didn't make a sound. If the tree inevitably makes some kind of sound, some kind of natural law applies, completely independent of whether we know about it, what we believe about it, or anything else.

Either trees that fall in a forest reliably make some sort of sound, or there are no natural laws. Real natural laws, ones completely independent of what anyone thinks or knows about them. That is what "real" means. You claim that mathematics isn't real in any and all conceivable forms. I beg to differ, and my position is hardly an uncommon one, even among those so commonly divorced from natural reality as mathematicians themselves.

Kurt Godel was a mathematical realist, by the way, i.e. one who holds that mathematical entities (like numbers) exist independently of what we think or know about them. Paul Erdos is another.

116.

Mark D. Says:
November 26, 2009 at 7:44 pm

JNS (#113), Reductionism has a precise mathematical and logical definition, and it is not as you (roughly) describe it.

Explaining consciousness, for example, in terms of evolution is not reductionism unless one assumes that consciousness is a higher-level phenomenon than evolution

This whole thing about "explaining" is a bit of a distraction, in fact it is one of the weaker claims that reductionism entails. Reductionism from consciousness to evolution entails that knowing everything about the evolution of a system entails knowing everything about the consciousness of a system. A difference of level is not required. If consciousness and evolution are at the same level, it merely implies that the converse is also true, that knowing everything about the consciousness of a system entails knowing everything about the evolution of a system.

Most people find the latter proposition dubious, hence the assertion that reductionism generally only works in the direction of consciousness to evolution, to the extent that they maintain that consciousness reduces to evolution at all.

117.

Mark D. Says:
November 26, 2009 at 7:58 pm

JNS, I am at least going to answer your direct questions.

First, why require random initial configurations?

Because it is conventional in science not to assume the Platonic existence of that which you are trying to prove. That means starting with anything other than a ball of gas is an unjustifiable assumption. After all, we could just assume the existence of human civilization and be done with it, right?

Second, if the supercomputers are capable of accurately simulating the analogue of whole DNA strings and organisms

They are not. In fact at present they are incapable of accurately simulating the operation of a single cell, even with football fields full of computers. How many years will have to pass before a computer can simulate the advent and propagation of the first cell from some proteanaceous ooze? Personally, I would be impressed with any physical theory of abiogenesis that did not rely on a cosmic accident.

118.

Jeff G. Says:

November 26, 2009 at 10:56 pm

Mark,

I guess I'm just really confused about what relevance the whole reductionism thing has to the conversation. I've traced it back to your comment in #90 directed at Rob, but I can't for the life of me figure out where you are coming from and where you are going with it.

I took you to be using Dennett as a kind of poster boy for bad evolution: Evolution entails reductionism, and reductionism entails a meaningless existence.

Not let's get a few questions in the open:

1. How do you feel about evolution?
2. How do you feel about reductionism?
3. Do you think evolution entails reductionism?
4. Do you think reductionism entails nihilism?

119.
Mark D. Says:
November 26, 2009 at 11:51 pm

Jeff G, To answer your questions:

1. I believe in common descent, incrementalism, natural selection, and all that. However, I am a property dualist at the microscopic level, which (among other things) does not rule out anything vaguely teleological.

2. I am a reductionist, albeit an unconventional one. I deny radical emergence. I deny that composite systems of arbitrary complexity have any properties whatsoever that cannot be fully reduced to an explanation in terms of the properties of the components and the manner in which they are arranged. I differ from the views of garden variety reductionists in the sense that I am a property dualist and they are not.

3. No, I don't think evolution entails reductionism, although it strongly implies it. I maintain that the idea that evolution is a baseline natural law, underivable from lower level laws (as they are in actual fact) is absurd.

4. No, I don't think reductionism entails nihilism, although the views of many garden variety reductionists (the non-property dualist type) tends to suggest it.

I might add that I: (i) am not a determinist (ii) believe in libertarian free will (iii) deny the existence of intrinsic (non-statistical) randomness (iv) deny that evolution or abiogenesis can be adequately simulated on a machine designed to be deterministic. (v) claim that property dualism of some sort (including what might vaguely be described as micro-teleological or pan-experientialist) is necessary to make an adequate account of evolution (vi) think that the idea that human civilization can arise in a strictly deterministic or stochasto-deterministic fashion from a random ball of gas is absurd, notwithstanding that to an outside observer that may superficially appear to be precisely what happened.

January 2010
The Teleological Argument and the Anthropic Principle
William Lane Craig, Biola University / Talbott School of Theology

The discovery during our generation of the so-called anthropic coincidences in the initial conditions of the universe has breathed new life into the teleological argument. Use of the Anthropic Principle to nullify our wonder at these coincidences is logically fallacious unless conjoined with the metaphysical hypothesis of a World Ensemble. There are no reasons to believe that such an Ensemble exists nor that, if it does, it has the properties necessary for the Anthropic Principle to function. Typical objections to the alternative hypothesis of divine design are not probative.

"The Teleological Argument and the Anthropic Principle." In The Logic of Rational Theism: Exploratory Essays, pp. 127-153. Edited by Wm. L. Craig and M. McLeod. Problems in Contemporary Philosophy 24. Lewiston, N.Y.: Edwin Mellen, 1990.

Introduction

Widely thought to have been demolished by Hume and Darwin, the teleological argument for God's existence has nonetheless continued during this century to find able defenders in F.R. Tennant, Peter Bertocci, and Stuart C. Hackett.

All of these have appealed to what Tennant called "wider teleology," which emphasizes the necessary conditions for the existence and evolution of intelligent life, rather than specific instances of purposive design. Unfortunately, they could speak of this wider teleology for the most part only in generalities, for example, "the fitness of the inorganic to minister to life," but could furnish few specific examples of experimental fact to illustrate this cosmic teleology.

In recent years, however, the scientific community has been stunned by its discovery of how complex and sensitive a nexus of conditions must be given in order for the universe to permit the origin and evolution of intelligent life on Earth. The universe appears, in fact, to have been incredibly fine-tuned from the moment of its inception for the production of intelligent life on Earth at this point in cosmic history. In the various fields of physics and astrophysics, classical cosmology, quantum mechanics, and biochemistry, various discoveries have repeatedly disclosed that the existence of intelligent carbon-based life on Earth at this time depends upon a delicate balance of physical and cosmological quantities, such that were any one of these quantities to be slightly altered, the balance would be destroyed and life would not exist.

Let us briefly review some of the cosmological and physical quantities that have been found to exhibit this delicate balance necessary for the existence of intelligent life on Earth at this epoch in cosmic history.1

Examples of Wider Teleology

Physics and Astrophysics

To begin with the most general of conditions, it was shown by G. J. Whitrow in 1955 that intelligent life would be impossible except in a universe of three basic dimensions. When formulated in three dimensions, mathematical physics possesses many unique properties which are necessary prerequisites for the existence of rational information-processing observers like ourselves. Moreover, dimensionality plays a key role in determining the form of the laws of physics and in fashioning the roles played by the constants of nature. For example, it is due to its basic three-dimensionality that the world possesses the chemistry that it does, which furnishes some key conditions necessary for the existence of life. Whitrow could not answer the question why the actual universe happens to possess three dimensions, but noted that if it did not, then we should not be here to ask the question.

More specifically, the values of the various forces of nature appear to be fine-tuned for the existence of intelligent life. The world is conditioned principally by the values of the fundamental

constants a (the fine structure constant, or electromagnetic interaction), mn/me (proton to electron mass ratio, aG (gravitation), aw (the weak force), and as (the strong force). When one mentally assigns different values to these constants or forces, one discovers that in fact the number of observable universes, that is to say, universes capable of supporting intelligent life, is very small. Just a slight variation in any one of these values would render life impossible.

For example, if as were increased as much as 1%, nuclear resonance levels would be so altered that almost all carbon would be burned into oxygen; an increase of 2% would preclude formation of protons out of quarks, preventing the existence of atoms. Furthermore, weakening as by as much as 5% would unbind deuteron, which is essential to stellar nucleosynthesis, leading to a universe composed only of hydrogen. It has been estimated that as must be within 0.8 and 1.2 its actual strength or all elements of atomic weight greater than four would not have formed. Or again, if aw had been appreciably stronger, then the Big Bang's nuclear burning would have proceeded past helium to iron, making fusion-powered stars impossible. But if it had been much weaker, then we should have had a universe entirely of helium. Or again, if aG had been a little greater, all stars would have been red dwarfs, which are too cold to support life-bearing planets. If it had been a little smaller, the universe would have been composed exclusively of blue giants which burn too briefly for life to develop. According to Davies, changes in either aG or electromagnetism by only one part in 1040 would have spelled disaster for stars like the sun. Moreover, the fact that life can develop on a planet orbiting a star at the right distance depends on the close proximity of the spectral temperature of starlight to the molecular binding energy. Were it greatly to exceed this value, living organisms would be sterilized or destroyed; but were it far below this value, then the photochemical reactions necessary to life would proceed too slowly for life to exist. Or again, atmospheric composition, upon which life depends, is constrained by planetary mass. But planetary mass is the inevitable consequence of electromagnetic and gravitational interactions. And there simply is no physical theory which can explain the numerical values of a and mn/me that determine electromagnetic interaction.

Moreover, life depends upon the operation of certain principles in the quantum realm. For example, the Pauli Exclusion Principle, which states that no more than one particle of a particular kind and spin is permitted in a single quantum state, plays a key role in nature. It guarantees the stability of matter and the size of atomic and molecular structures and creates the shell structure of atomic electrons. In a world not governed by this principle, only compact, superdense bodies could exist, providing little scope for complex structures or living organisms. Or again, quantization is also essential for the existence and stability of atomic systems. In quantum physics, the atom is not conceived on the model of a tiny solar system with each electron in its orbit around the nucleus. Such a model would be unstable because any orbit could be an arbitrary distance from the nucleus. But in quantum physics, there is only one orbital radius available to an electron, so that, for example, all hydrogen atoms are alike. As a consequence, atomic systems and matter are stable and therefore life-permitting.

Classical Cosmology

Several of the constants mentioned in the foregoing section also play a crucial role in determining the temporal phases of the development of the universe and thus control features of the universe essential to life. For example, aG, and mn/me constrain (i) the main sequence stellar lifetime, (ii) the time before which the expansion dynamics of the expanding universe are determined by radiation rather than matter, (iii) the time after which the universe is cool enough for atoms and molecules to form, (iv) the time necessary for protons to decay, and (v) the Planck time.

Furthermore, a fine balance must exist between the gravitational and weak interactions. If the balance were upset in one direction, the universe would have been constituted by 100% helium in its early phase, which would have made it impossible for life to exist now. If the balance were

tipped in the other direction, then it would not have been possible for neutrinos to blast the envelopes of supernovae into space and so distribute the heavy elements essential to life.

Furthermore, the difference between the masses of the neutron and the proton is also part of a very delicate coincidence which is crucial to a life-supporting environment. This difference prevents protons from decaying into neutrons, which, if it happened, would make life impossible. This ratio is also balanced with the electron mass, for if the neutron mass failed to exceed the proton mass by a little more than the electron mass, then atoms would simply collapse.

Considerations of classical cosmology allow us to introduce a new parameter, S, the entropy per baryon in the universe, which is about 109. Unless S were < 1011, galaxies would not have been able to form, making planetary life impossible. S is itself a consequence of the baryon asymmetry in the universe, which arises from the inexplicably built-in asymmetry of quarks ever anti-quarks prior to 10 to the minus 6th seconds after the Big Bang.

In investigating the initial conditions of the Big Bang, one is also confronted with two arbitrary parameters governing the expansion of the universe: Wo, related to the density of the universe, and Ho, related to the speed of the expansion. Observations indicate that at 10-43 seconds after the Big Bang the universe was expanding at a fantastically special rate of speed with a total density close to the critical value on the borderline between recollapse and everlasting expansion. Hawking estimated that even a decrease of one part in a million million when the temperature of the universe was 1010 degrees would have resulted in the universe's recollapse long ago; a similar increase would have precluded the galaxies from condensing out of the expanding matter. At the Planck time, 10-43 seconds after the Big Bang, the density of the universe must have apparently been within about one part in 1060 of the critical density at which space is flat. This results in the so-called "flatness problem": why is the universe expanding at just such a rate that space is Euclidean rather than curved? A second problem that arises is the "homogeneity problem." There is a very narrow range of initial conditions which must obtain if galaxies are to form later. If the initial inhomogeneity ratio were > 10 to the minus 2nd, then non-uniformities would condense prematurely into black holes before the stars form. But if the ratio were < 10 to the minus 5th, inhomogeneities would be insufficient to condense into galaxies. Because matter in the universe is clumped into galaxies, which is a necessary condition of life, the initial inhomogeneity ratio appears to be incredibly fine-tuned. Thirdly, there is the "isotropy problem." The temperature of the universe is amazing in its isotropy: it varies by less than one part in a thousand over the whole of the sky. But at very early stages of the universe, the different regions of the universe were causally disjointed, since light beams could not travel fast enough to connect the rapidly receding regions. How then did these unconnected regions all happen to possess the same temperature and radiation density? Penrose has calculated that in the absence of new physical principles to explain this, "the accuracy of the Creator's aim" when he selected this world from the set of physically possible ones would need to have been at least of the order of one part in 10 to the 10^{th} (123)!

Contemporary cosmologists have found an answer to these three problems--or at least seem certain that they are on its track--in inflationary models of the early universe. According to this adjustment to the standard Big Bang cosmology, between 10 to the minus 43rd and 10 to the minus 35th seconds after the Big Bang, the universe underwent an exponentially rapid inflation of space faster than the speed of light. This inflationary epoch resulted in the nearly flat curvature of space, pushed inhomogeneities beyond our horizon, and served to bury us far within a single region of space-time whose parts were causally connected at pre-inflationary times.

Inflationary scenarios have problems of their own --such as getting inflation started, getting it to end without excess turbulence, and having it produce irregularities just right for galaxy formation. Indeed, it is interesting to note that Hawking has recently declared both the so-called "old

inflationary model" and the "new inflationary model" to be "now dead as a scientific theory"--though he still holds out hope for Linde's more recent "chaotic inflationary model."2 Whether this model proves to be any more successful than its predecessors remains yet to be seen; the whole inflationary scenario seems rather ad hoc, and one cannot help but suspect that much of the attraction to such models is due to the desire to escape the sort of inferences as Penrose's conclusion above. More importantly, however, inflationary scenarios seem to require the same sort of fine-tuning which some theorists thought these models had eliminated. For example, in order to proceed appropriately, inflation requires that the two theoretical components of Einstein's cosmological constant, "bare lambda" and "quantum lambda," cancel each other out with an enormously precise though inexplicable accuracy. A change in the strengths of either aG or aw by as little as one part in 10100 would destroy this cancellation on which our lives depend. So although inflationary models may succeed in providing a unifying explanation of some of the forces which play a role in classical cosmology, it does not thereby dispense with the appearance of fine-tuning or teleology.

Biochemistry
Life which is descended from a simpler form of life and which ultimately came into existence spontaneously must be based on water, carbon dioxide, and the basic compounds of the elements C, H, O, and N. Each of these possesses unique properties which, while not sufficient for the existence of life, are necessary conditions of it.

Water, for example, is one of the strangest substances known to science. Its specific heat, surface tension, and most of its other physical properties have anomalous values higher or lower than any other known material. The fact that its solid phase is less dense than its liquid phase, so that ice floats, is virtually a unique property in nature. Its melting point, boiling point, and vaporization point are all anomalously higher than those of other substances. For example, when calculated by atomic weight and number, the boiling point of water would be expected to be -100oC rather than +100oC. The disparity is due to its strong hydrogen bonds, which are difficult to break. Furthermore, because the H-O-H angle in water is so close to the ideal tetrahedral structure, water can form such a structure with very little strain on the bonds. As a result, it tends to polymerize into an open structure, so that ice is less dense than water. This property of water is essential to life, for were ice more dense than water, it would sink to the bottom of bodies of water, where it would remain in the deepest parts until eventually all lakes and oceans would be solidly frozen. Instead, ice forms a protective skin on the surface of reservoirs of water. Water also has a higher specific heat than almost any organic compound. This property allows water to be a store of heat and so stabilize the environment. The thermal conductivity of water is also higher than that of most liquids, which again permits water to act as a temperature stabilizer on the environment. Water has, moreover, a higher heat of vaporization than any known substance. This makes water the best possible coolant by evaporation, and living creatures make extensive use of it in temperature control. Water's high surface tension, exceeded by very few substances, serves to make biochemical reactions more rapid; and the way water bonds shapes organic molecules such as enzymes and nucleic acids into their biologically active forms and permits the formation of cell walls and membranes.

The elements H, O, and C are the most abundant elements in living organisms. They possess many unique properties and are vital to chemical reactions necessary to sustain life. For example, CO2 has the property, unique among gases, of having at ordinary temperatures about the same concentration of molecules per unit volume in water as in air. This enables CO2 to undergo perpetual exchange between living organisms and their environment, so that it is everywhere available for photosynthesis and thereby for molecular synthesis. The element N, on the other hand, is a rare element on Earth, but it does make up 80% of the earth's atmosphere, which is a unique stroke of fortune for Earth's living organisms.

This selective sampling of physical and cosmological quantities which are necessary conditions of the existence of intelligent life on Earth at this point in cosmic history illustrates the sort of wider teleology which Tennant emphasized, but could only dimly envision. The discoveries of contemporary science in this regard are particularly impressive for two reasons: (1) The delicate balance of conditions upon which life depends is characterized by the interweaving of conditions, such that life depends for its existence, not merely upon each individual condition's possessing a value within very narrow limits, but also upon ratios or interactions between values and forces which must likewise lie within narrow parameters. The situation is thus not comparable to a roulette wheel in Monte Carlo's yielding a certain winning number; nor even yet to all the roulette wheels (each representing a physical quantity or constant) in Monte Carlo's turning up simultaneously certain numbers within narrowly circumscribed limits (say, wheel 1 must show 72 or 73 while wheel 2 must show 27-29, etc.); rather it is like all the roulette wheels in Monte Carlo's yielding simultaneously numbers within narrowly prescribed limits and those numbers bearing certain precise relations among themselves (say, the number of wheel 3 must be one-half the square of the number of wheel 17 and twice the number of wheel 6). It seems clear that worlds not permitting intelligent life are vastly more to be expected than life-permitting worlds. (2) The constants and quantities which go to make up this complex nexus of conditions are apparently independent of one another. The development of inflationary models ought to cause us to be cautious in making such a claim; nevertheless, it is the case that there seems to be no nomological necessity requiring the quantities and constants of nature to be related as they are. The value of S, for example, seems to be utterly unrelated to the parameters W, Ho, or inflationary scenarios. But even if it were possible to reduce all the physical and cosmological quantities to a single equation governing the whole of nature, such a complex equation could itself be seen as the supreme instance of teleology and design. Hence, some of those whose hopes seem to lie in the discovery of such an equation are forced to assert that such an equation must be necessarily true; that is to say, there is really only one logically possible set of physical constants and forces. But such a hypothesis seems clearly outlandish. As Nagel observes, none of the statements of natural laws in the various sciences are logically necessary, since their denials are not formally contradictory; moreover, the appropriate procedure in science should then cease to be experimentation, but be deductive proofs in the manner of mathematics.3 Hence, the notion that the nomological necessity of such an equation should reduce to logical necessity seems obviously false.

The Anthropic Principle

This pattern of discoveries has compelled many scientists to conclude that such a delicate balance cannot be simply dismissed as coincidence, but requires some sort of account. Traditionally, such considerations would have been taken as evidence of divine design--one thinks of Paley's teleological argument in his Natural Theology, for example. Loath to admit the God-hypothesis, however, many scientists are seeking an alternative in the Anthropic Principle, and a tremendous debate involving both scientists and philosophers has broken out concerning this principle, a debate which has spilled over into the popular press and captured the attention of science-minded laymen. The attempt to come to grips with the appearance of cosmic teleology has forced many scientists beyond physics into meta-physics, so that the boundaries between science and philosophy have become ineradicably blurred, well-illustrating George Gale's remark that "we are now entering a phase of scientific activity during which the physicist has out-run his philosophical base-camp, and, finding himself cut off from conceptual supplies, he is ready and waiting for some relief from his philosophical comrades-in-arms."4 The theistic philosopher can therefore without apology or embarrassment introduce his metaphysical commitment to theism as an at least equally plausible, if not superior, alternative explanation to metaphysical, naturalistic accounts of the complex order of the universe.

Exposition

First proposed by Brandon Carter in 1974,5 the Anthropic Principle has assumed a number of different forms, generating a great deal of confusion concerning what it is precisely that the principle means to assert. In their recent monumental book, The Anthropic Cosmological Principle, physicists John Barrow and Frank Tipler state various versions of the principle, the most fundamental being the Weak Anthropic Principle (WAP):

> WAP: The observed values of all physical and cosmological quantities are not equally probable, but they take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by the requirement that the Universe be old enough for it to have already done so.6

Barrow and Tipler regard WAP as "in no way speculative or controversial,"7 since it is "just a restatement . . . of one of the most important and well-established principles of science: that it is essential to take into account the limitations of one's measuring apparatus when interpreting one's observations."8 For example, if we were calculating the fraction of galaxies that lie within certain ranges of brightness, our observations would be biased toward the brighter ones, since we cannot see the dim ones so easily. Or again, a ratcatcher may say that all rats are bigger than six inches because that is the size of his traps. Similarly, any observed properties of the universe which may initially appear astonishingly improbable can only be seen in their true perspective after we have accounted for the fact that certain properties could not be observed by us, were they to obtain, because we can only observe those compatible with our own existence. "The basic features of the Universe, including such properties as its shape, size, age, and laws of change must be observed to be of a type that allows the evolution of the observers, for if intelligent life did not evolve in an otherwise possible universe, it is obvious that no one would be asking the reason for the observed shape, size, age, and so forth of the universe."9 Thus, our own existence acts as a selection effect in assessing the various properties of the universe. For example, a life form which evolved on an earthlike planet "must necessarily see the universe to be at least several billion years old and . . . several billion light years across," for this is the time necessary for the production of the elements essential to life and so forth.10

Now, we might ask, why is the "observed" in the quotation in the above paragraph italicized? Why not omit the word altogether? The answer is that the resulting statement

1. The basic features of the universe must be of a type that allows the evolution of observers

is undoubtedly false; for it is not logically or nomologically necessary that the universe embrace intelligent life. Rather what seems to be necessarily true is

2. If the universe is observed by observers which have evolved within it, then its basic features must be of a type that allows the evolution of observers within it.

But (2) seems quite trivial; it does nothing to explain why the universe in fact has the basic features it does.

But Barrow and Tipler contend that while WAP appears to be true, but trivial, it has "far-reaching implications."11 For the implication of WAP, which they seem to interpret along the lines of (2), is that no explanation of the basic features of the universe need be sought. This contention seems to be intimately connected with what is appropriate to be surprised at. The implication of WAP is that we ought not to be surprised at observing the universe to be as it is, for if it were not as it is, we could not observe it. For example, "No one should be surprised to find the universe to be as large as it is."12 Or again, ". . . on Anthropic grounds, we should expect to observe a world possessing precisely three spatial dimensions."13 Or again,

We should emphasize once again that the enormous improbability of the evolution of intelligent life in general and Homo sapiens in particular does not mean we should be amazed we exist at all. This would make as much sense as Elizabeth II being amazed she is Queen of England. Even though the probability of a given Briton being monarch is about 10-8, someone must be. Only if there is a monarch is it possible for the monarch to calculate the improbability of her particular existence. Similarly, only if an intelligent species does evolve is it possible for its members to ask how probable it is for an intelligent species to evolve. Both are examples of WAP self-selection in action.110

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110 F. B. Salisbury, Nature 224, 342 (1969), argued that the enormous improbability of a given gene, which we computed in the text, means that a gene is too unique to come into being by natural selection acting on chance mutations. WAP self-selection refutes this argument, as R. F. Doolittle in Scientists confront creationism, L. R. Godfrey (Norton, NY, 1983) has also pointed out.14

Here we have a far-reaching implication that goes considerably beyond the apparently trivial WAP. Accordingly, although Barrow and Tipler conflate WAP and the implications thought to follow from it, I want to distinguish these sharply and shall refer to these broader implications as the Anthropic Philosophy. It is this philosophical viewpoint, rather than WAP itself, that I believe, despite initial impressions, stands opposed to the teleological argument and constitutes scientific naturalism's most recent answer to that argument. According to the Anthropic Philosophy, an attitude to surprise at the delicately balanced features of the universe essential to life is inappropriate; we should expect the universe to look this way. While this does not explain the origin of those features, it shows that no explanation is necessary. Hence, to posit a divine Designer is gratuitous.
Critique

WAP and Self-Selection
Now it needs to be emphasized that what the Anthropic Philosophy does not hold, despite the sloppy statements on this head often made by scientists, is that our existence as observers explains the basic features of the universe. The answer to the question "Why is the universe isotropic?" given by Collins and Hawking, ". . . the isotropy of the Universe is a consequence of our existence,"15 is simply irresponsible and brings the Anthropic Philosophy into undeserved disrepute, for literally taken, such an answer would require some form of backward causation whereby the conditions of the early universe were brought about by us acting as efficient causes merely by our observing the heavens. But WAP neither asserts nor implies this; rather WAP holds that we must observe the universe to possess certain features (not that the universe must possess certain features) and the Anthropic Philosophy says that therefore these features ought not to surprise us or cry out for explanation. The self-selection effect affects our observations, not the basic features of the universe itself. If the Anthropic Philosophy held that the basic features of the universe were themselves brought about by our observations, then it could be rightly dismissed as fanciful. But the Anthropic Philosophy is much more subtle: it does not try to explain why the universe has the basic features it does, but contends that no explanation is needed, since we should not be surprised at observing what we do, our observations of those basic features being restricted by our own existence as observers.

But does the Anthropic Philosophy follow from the Anthropic Principle, as Barrow and Tipler claim? Let us concede that it follows from WAP that

3. We should not be surprised that we do not observe features of the universe which are incompatible with our own existence.

For if the features of the universe were incompatible with our existence, we should not be here to notice it. Hence, it is not surprising that we do not observe such features. But it follows neither from WAP nor (3) that

4. We should not be surprised that we do observe features of the universe which are compatible with our existence.

For although the object of surprise in (4) might at first blush appear to be simply the contrapositive of the object of surprise in (3), this is mistaken. This can be clearly seen by means of an illustration (borrowed from John Leslie16): suppose you are dragged before a firing squad of 100 trained marksmen, all of them with rifles aimed at your heart, to be executed. The command is given; you hear the deafening sound of the guns. And you observe that you are still alive, that all of the 100 marksmen missed! Now while it is true that

5. You should not be surprised that you do not observe that you are dead,

nonetheless it is equally true that

6. You should be surprised that you do observe that you are alive.

Since the firing squad's missing you altogether is extremely improbable, the surprise expressed in (6) is wholly appropriate, though you are not surprised that you do not observe that you are dead, since if you were dead you could not observe it. Similarly, while we should not be surprised that we do not observe features of the universe which are incompatible with our existence, it is nevertheless true that

7. We should be surprised that we do observe features of the universe which are compatible with our existence,

in view of the enormous improbability that the universe should possess such features.

The reason the falsity of (7) does not follow from (3) is that subimplication fails for first order predicate calculus. For (3) may be schematized as

3'. ~S: (x) ([Fx × ~Cx] É ~Ox)

where "S:" is an operator expressing "we should be surprised that" and "F" is "is a feature of the universe," "C" is "is compatible with our existence," and "O" is "is observed by us." And (7) may be schematized as

7'. S: ($x) (Fx × Cx × Ox)

It is clear that the object of surprise in (7') is not equivalent to the object of surprise in (3'); therefore the truth of (3') does not entail the negation of (7').17

Therefore, the attempt of the Anthropic Philosophy to stave off our surprise at the basic features of the universe fails. It does not after all follow from WAP that our surprise at the basic features of the universe is unwarranted or inappropriate and that they do not therefore cry out for explanation. But which features of the universe should thus surprise us? --those which are necessary

conditions of our existence and which seem extremely improbable or whose coincidence seems extremely improbable. Thus, we should amend (7) to read

7*. We should be surprised that we do observe basic features of the universe which individually or collectively are excessively improbable and are necessary conditions of our own existence.

Against (7*), the WAP is impotent.18

WAP and a World Ensemble

Now proponents of the Anthropic Philosophy will no doubt contend that I have missed the whole point of the WAP. For (7*) is true only if the basic features of our observable universe are co-extensive with the basic features of the Universe as a whole. But proponents of the Anthropic Philosophy avoid (7*) by conjoining to WAP the hypothesis of a World Ensemble, that is to say, the hypothesis that our observable universe is but one member of a collection of diverse universes that go to make up a wider Universe-as-a-Whole. Given the existence of this wider Universe, it is argued that all possible universes are actualized and that the WAP reveals why surprise at our being in a universe with basic features essential to life is inappropriate.

Various theories, some of them quite fantastic, have been offered for generating a World Ensemble. For example, Wheeler proposes a model of the oscillating universe in which each cycle emerges with a new set of physical laws and constants.19 Linde suggests an inflationary model according to which our observable universe is but one of many different mini-universes which inflated from the original larger Universe.20 One of the most widely discussed World Ensemble scenarios is Everett's Many Worlds Interpretation of quantum physics, according to which all possible states of a quantum interaction are actualized, the observer himself splitting off into each of these different worlds.21

Now it needs to be emphasized that there is no evidence for any of these theories apart from the fact of intelligent life itself. But as John Leslie, the philosopher of science who has occupied himself most thoroughly with the Anthropic Principle, points out, any such evidence for a World Ensemble is equally evidence for a divine Designer.22 Moreover, each of the above scenarios faces formidable scientific and philosophical objections.23 Wheeler's theory, for example, not only succumbs to the problems generic to oscillating models,24 but insofar as it posits singularities at the termini of each cycle, it is not even a model of an oscillating universe at all, but of just a series of unrelated worlds. Inflationary models not only face the problems of how to get the inflation started, how to get it to end without excess turbulence, and how to get it to allow galaxy formation, but more importantly they themselves require an extraordinary amount of fine-tuning prior to inflation, so that the appearance of design is not eluded. The Many Worlds Interpretation of quantum physics is so fantastic that philosopher of science John Earman characterizes its postulated splitting of space-time as a "miracle." "Not only is there no hint as to what causal mechanism would produce such a splitting," he complains, "there is not even a characterization of where and when it takes place."25 In fact, Quentin Smith indicts the theory as incoherent, since the many worlds are supposed to exist in a timeless superspace, which is incompatible with the stipulation that they branch off serially as quantum interactions occur.26

Objections can be raised against each of the theories proposed for generating many worlds; but even if we conceded that a multiple universe scenario is unobjectionable, would such a move succeed in rescuing us from teleology and a cosmic Designer? This is not at all obvious. The fundamental assumption behind the Anthropic philosopher's reasoning in this regard seems to be something along the lines of

8. If the Universe contains an exhaustively random and infinite number of universes, then anything that can occur with non-vanishing probability will occur somewhere.

But why should we think that the number of universes is actually infinite? This is by no means inevitable, not to mention the paradoxical nature of the existence of an actually infinite number of things.27 And why should we think that the multiple universes are exhaustively random? Again, this is not a necessary condition of many-worlds hypotheses. In order to elude the teleological argument, we are being asked to assume much more than the mere existence of multiple universes.

In any case, the move on the part of Anthropic philosophers to posit many worlds, even if viable, represents a significant concession because it implies that the popular use of the WAP to refute teleology in a Universe who properties are coextensive with the basic features of our universe is fallacious. In order to stave off the conclusion of a Designer, the Anthropic philosopher must take the metaphysically speculative step of embracing a special kind of multiple universe scenario. That will hardly commend itself to some as any less objectionable than theism.

The point is that the Anthropic Principle is impotent unless it is conjoined with a profoundly metaphysical vision of reality. According to Earman, "Some anthropic theorizers seem all too eager to embrace any form of world making that gives purchase to their modus operandi."28 Why this desperation? John Leslie explains that although the idea of a World Ensemble is sketchy and faces powerful objections, still people think that it must be correct, for how else could life originate?29 But Leslie argues that the God hypothesis is no more obscure than the World Ensemble nor less scientific, since natural laws and initial conditions are not generally taken to be scientifically explicable.30 A scientist should consider the interpretation of a divine Designer, or else admit that he simply has no personal interest in the problem, for the only alternative to the World Ensemble is the God hypothesis, so that if we reject the latter we are stuck with the former.31

Martin Gardner, quoting physicist Heinz Pagels, says that the Anthropic Principle raises a new mystery:

> "How can such a sterile idea," Pagels asks, "reproduce itself so prolifically?" He suspects it may be because scientists are reluctant to make a leap of faith and say: "The reason the universe seems tailor-made for our existence is that it was tailor-made . . . . Faced with questions that do not neatly fit into the framework of science, they are loath to resort to religious explanations; yet their curiosity will not let them leave matters unaddressed. Hence, the anthropic principle. It is the closest that some atheists can get to God."32

Similarly physicist Tony Rothman writes,

> It's not a big step from the [Anthropic Principle] to the Argument from Design . . . . When confronted with the order and beauty of the universe and the strange coincidences of nature, it's very tempting to take the leap of faith from science into religion. I am sure many physicists want to. I only wish they would admit it.33

But if for atheist and timorous theist alike the World Ensemble and Anthropic Principle are functioning as a sort of God surrogate, what is so sad about this situation is that it is so unnecessary. For with the World Ensemble we have already launched our bark out onto the metaphysical deep; if the God hypothesis provides us a surer passage, why not avail ourselves of it? As Leslie reminds us, those who think that "science proper" has boundaries which are easy to fix are becoming increasingly rare.34

The Hypothesis of Divine Design

In any case, the philosopher who is a theist is certainly at liberty qua philosopher, if not qua scientist, to introduce God as his explanatory ultimate. What objections then might be raised against the theistic hypothesis? No friend of the Anthropic Principle, Earman seems sympathetic to the hypothesis of divine design, but in the end does not find it compelling because there is no need to adopt a creation theory of actuality, which this hypothesis presupposes:

> If one adopts a creation story of actuality and if one calculates that the probability of creation of a big bang model having the features in question is nil, then no anthropic principle, construed as a selection principle, is going to resolve the problem. The resolution calls rather for something akin to the traditional argument from Design.
>
> Alternatively, the need for a creation story of actuality and the need to wrestle with improbabilities of actualization can be obviated by treating actuality as a token-reflexive property of possible worlds not unlike the 'nowness' property of instants of time (see Lewis 1986). On this view all possible worlds, including the merely logically possible as well as the physically possible, are all equally 'actual'. No Creator is needed to anoint one of these worlds with the magical property of 'actuality' and the question of why this property was conferred upon a world having the features in question is mooted.35

Here we see the metaphysically extravagant lengths to which philosophers seem compelled to go in order to avoid a divine Designer. Earman, while excoriating Anthropic philosophers for their unwarranted postulate of a World Ensemble, shows himself quite willing to go even further, postulating the actual existence of all logically possible worlds. This involves a metaphysical commitment which is so enormous ontologically and so superfluous for explaining modal locutions that most philosophers have dismissed it as science fiction. Indeed, Plantinga has shown that such a theory of actuality entails the outrageous view that I have all my properties essentially, since it is not I, but a counterpart of me, who exists and possesses different properties in other logically possible worlds.36 In comparison with Earman's commitment, the hypothesis of theism seems modest indeed.

Barrow and Tipler also object to the hypothesis of divine design, maintaining that "careful thinkers" would not today "jump so readily" to a Designer, for (i) the modern viewpoint stresses time's role in nature; but since an unfinished watch does not work, arguments based on omnipresent harmony have been abandoned for arguments based on co-present coincidences; and (ii) scientific models aim to be realistic, but are in fact only approximations of reality; so we hesitate to draw far-reaching conclusions about the nature of ultimate reality from models that are at some level inaccurate.37 But Barrow and Tipler seem unduly diffident here. A careful thinker will not readily jump to any conclusion, but why may he not infer a divine Designer after a careful consideration of the evidence? Point (i) is misleading, since the operations of nature always work; at an earlier time nature is not like an unfinished watch, rather it is just a less complex watch.38 In any case, the most powerful design argument will appeal to both present adaptedness and co-present coincidences. Point (ii) loses much of its force in light of two considerations: (a) this is a condition that affects virtually all our knowledge, which is to say that it affects none of it in particular, so that our only recourse is simply to draw conclusions based on what we determine most accurately to reflect reality; fortunately, the evidence at issue here is rather concrete and so possesses a high degree of objectivity; (b) Barrow and Tipler do not feel compelled to exercise such restraint when proposing metaphysically speculative but naturalistic accounts of the universe's basic features, for example, their defense of the Many Worlds Interpretation of quantum physics or scenarios for the origin of the universe ex nihilo, which leads one to suspect that a double standard is being employed here. Their objections, therefore, seem to have little force.

John Leslie's reservations with the theistic hypothesis are somewhat different: while concurring with the necessity of positing a divine Designer of the cosmos, he nonetheless argues that the ultimate explanation of the order in the universe cannot be God as traditionally conceived. Leslie plumps for what he characterizes as a Neo-platonic concept of God as the creativity of ethical requiredness. That is to say, if I understand Leslie correctly, the universe exists as it does because it should; it is morally necessary that a universe of free agents exist. This ethical requiredness of the universe has a sort of creative power to it that makes the world exist. If there is a personal deity, he, too, is the result of this more fundamental principle. Presumably, Leslie calls this conception Neo-platonic because according to that metaphysic the One, which takes the place of Plato's Good, produces being, the first emanation being the Nous, or Mind, which in turn produces the world. The God of traditional theism would be like Plotinus's Nous and Leslie's God like the ultimate form of the Good.

But why is the traditional concept of God so unpalatable? Leslie's critique on this score is disappointing and surprisingly weak.39 Proceeding from the Leibnizian question, "Why is there something rather than nothing?" Leslie rejects the answer of God conceived as either a factually or a logically necessary being. For if God is only factually necessary, then He exists logically contingently, albeit eternally, and no reason is supplied for His contingent existence. On the other hand, God cannot be shown to exist necessarily in the logical sense, for when the ontological argument asserts, "It is possible that God exist," this possibility is epistemic only and, hence, does not show that God's existence is logically possible.

But this objection seems confused. If God is merely a factually necessary being, then there are possible worlds in which He does not exist. But then it is logically impossible for Him to exist in all possible worlds, that is to say, it is logically necessary that He exist contingently. But then, assuming that God is the explanatory ultimate in any world in which He exists, it makes no sense to seek a reason for His existence. To demand a reason for His existence is to ask for a logically necessary being which accounts for the fact that God exists. But on this hypothesis, it is logically impossible that there be such a being, for if it were possible such a being would exist in every possible world, including this one, and so God would not be the explanatory ultimate. Hence, if God is a mere factually necessary being, it is logically impossible for there to be a reason for His existence. One need only add that it is wrong-headed to indict a position for not supplying what is logically impossible.

On the other hand, why hold that God is merely factually necessary? The Leibnizian Principle of Sufficient Reason might lead us to reject the concept of God as a merely factually necessary being and hold instead that He is logically necessary. The failure of the ontological argument as a piece of natural theology is irrelevant to the coherence of this conception of God. Leslie correctly points out that when the ontological argument asserts that the proposition "A maximally great being exists" (where maximal greatness entails being omnipotent, omniscient, and morally perfect in every possible world) is possible, there is an ambiguity between "epistemically possible" and "logically possible." To say that such a proposition is epistemically possible is only to say that for all we know it is true. So understood, it makes sense to say, "Possibly a maximally great being exists, and possibly He doesn't." This sense is insufficient for the purposes of the ontological argument. But if we are talking about logical possibility, then to say that the proposition "A maximally great being exists" is possible is to say that He does exist. For if He exists in any possible world, then by definition He exists in all. Thus, if this proposition is possibly true in the logical sense, it is necessarily true. Now I agree with Leslie that the ontological argument seems to fail because all we intuit is that a maximally great being is epistemically possible, but we cannot say if His existence is logically possible. But how is this even relevant to the issue at hand? The coherence of the logical necessity of God's existence does not depend on the success of the ontological argument or our intuitions. It is possible that the ontological argument fails to prove God's existence, and yet for all

we know God's existence is logically necessary. Philosophers such as Plantinga, Robert Adams, and William Rowe have defended the coherence of God as a logically necessary being,40 and Leslie says nothing to impugn this notion. Using the Leibnizian query as his starting point, Leslie ought to conclude to the existence of a being which is by nature such that if it exists in any possible world, it exists in all; such a being must exist in this world in order to explain why something exists rather than nothing, and, therefore, in all worlds, thereby obviating the need for an explanation of its existence.41 In this way Leslie's quite legitimate demand for a reason for the existence of something rather than nothing would yield an answer for the universe's existence without requiring one for God's existence, and this without endorsing the ontological argument.

As for Leslie's own alternative conception of God, I think that its lack of explanatory power seems painfully clear. How can there be design without the previsioning of an intelligent mind? Personal agents, not impersonal principles, design things. If one says that the traditional God is a sort of personal demiurge who designed the world, then how can he be produced in being by an abstract principle? Abstract objects such as numbers, propositions, and properties have no spatio-temporal locations and sustain no causal relations with concrete objects. So how does the abstract object posited by Leslie cause a concrete object like God to exist? It thus seems clear that traditional theism is the preferable explanation of the world's design.

Concluding Remarks

Teleologists and Anthropic philosophers enjoy a peculiar "love/hate" relationship: they agree that the delicate balance of cosmological and physical conditions necessary for intelligent life does cry out for some sort of interpretation which will render it intelligible; but they differ radically as to what that interpretation should be. Theistic philosophers view this sensitive nexus of conditions as evidence of wider teleology and therefore indicative of a cosmic Designer. Anthropic philosophers contend that due to the self-selection effect imposed by our own existence we can only observe a limited number of worlds; therefore, we should not be surprised at observing this one. Moreover, if a Word Ensemble exists in which all possible values of cosmological and physical quantities are somewhere instantiated, it follows necessarily that our world with its delicate balance of conditions will also obtain. We have seen, however, that in the absence of the hypothesis of the World Ensemble the reasoning of the Anthropic philosopher, based on the trivial WAP is simply logically fallacious. As for the World Ensemble, there is not only no evidence that such an ensemble of worlds exists, but there are substantive objections against each of the proposed means of generating such an ensemble. In any case, the postulation of a world ensemble is metaphysically extravagant, for it must involve the existence of an infinite number of exhaustively random worlds if one is to guarantee that our world will by chance alone obtain in the ensemble. Theism is certainly no more objectionable than this.

Finally, I should like to say a word concerning the religious value of the hypothesis of divine design as an explanation for the wider teleology we have discovered in nature. As the debate over the Anthropic Principle has spread, it has even taken on literary dimensions, finding its way into the contemporary novel Roger's Version by John Updike. When Dale Kohler explains that physicists are proving the existence of God, Roger Lambert, a professor of theology, replies:

> For myself I must confess that I find your whole idea aesthetically and ethically repulsive. Aesthetically because it describes a God Who lets Himself be intellectually trapped, and ethically because it eliminates faith from religion, it takes away our freedom to believe or doubt. A God you could prove makes the whole thing immensely, oh, uninteresting. Pat. Whatever else God may be, He shouldn't be pat.42

Roger's objections, so typical of contemporary theology, reveal fundamental misunderstandings about the revelation of God and the nature of faith. God's handiwork in nature is not a matter of

His being intellectually trapped, but of His revelation of Himself to His creation, a self-disclosure which is aesthetically beautiful; as the Psalmist says, "The heavens are telling the glory of God and the firmament proclaims his handiwork" (Ps. 19.1). And the decision to believe in God or not is not so much a matter of assensus, but of fiducia. The demonstration of His existence on the basis of His created order in no way removes our freedom to trust in ourselves rather than in Him; as Paul wrote, "although they knew God, they did not honor him as God . . ." (Rom. 1.21). The teleological argument, then, if successful, hardly makes belief in God pat.43 Rather it helps to bring us more quickly to the true crisis of faith.

Endnotes

1 I depend for this section on the impressive compilations by John D. Barrow and Frank J. Tipler, The Anthropic Cosmological Principle (Oxford: Clarendon Press, 1986) and John Leslie, "The Prerequisites of Life in Our Universe," in Newton and the New Direction in Science, ed. G.V. Coyne, M. Heller, J. Zycinski (Vatican: Citta del Vaticano, 1988). Detailed discussion and documentation may be found there.

2 Stephen Hawking, A Brief History of Time: from the Big Bang to Black Holes (N.Y.: Bantam Books, 1988), p.132.

3 Ernst Nagel, The Structure of Science, 2d ed. (Indianapolis: Hackett, 1979), pp. 53-54.

4 George Gale, "Some Metaphysical Perplexities in Contemporary Physics," paper presented at the 1985 meeting of the Society of Metaphysics.

5 Brandon Carter, "Large Number Coincidences and the Anthropic Principle," in Confrontation of Cosmological Theories with Observational Data, ed. M.S. Longair (Boston: D. Reidel, 1974), pp. 291-98.

6 Barrow and Tipler, Anthropic Principle, p. 15.

7 Ibid., p. 16.

8 IBid., p. 23.

9 Ibid., pp. 1-2.

10 Ibid., p. 3.

11 Ibid., p. 2.

12 Ibid., p. 18.

13 Ibid., p. 247.

14 Ibid., pp. 566, 575.

15 C.B. Collins and S.W. Hawking, "Why Is the Universe Isotropic?" Astrophysical Journal 180 (1973):317.

16 John Leslie, "Anthropic Principle, World Ensemble, Design," American Philosophical Quarterly 19 (1982):150.

17 Similarly, the falsity of (6) does not follow from the truth of (5), for (5) may be schematized as ~S: ~ ($x) ([Mx × ~Ax] × Ox), where M is 'is me', Ox is 'is observed by me', and A is 'is alive'. From this it does not follow that ~S: ($x) ([Mx × Ax] × Ox), which is the negation of (6).

18 Once the central fallacy is thus removed, Barrow and Tipler's argument in the lengthy quotation in the text seems to amount to little more than the old objection that any state of affairs is highly improbable and therefore the obtaining of the actual state of affairs requires no special explanation. But this objection is surely misconceived. What unprejudiced and right-minded person could possibly regard a chimpanzee's haphazardly typing out the complete plays and sonnets of Shakespeare as equally probable with any chaotic series of letters? The objection fails to reckon with the difference between randomness, order, and complexity. On the first level of randomness, there is a non-denumerably infinite number of chaotic sequences, e.g., "adfzwj," each of which is equally improbable and which collectively could serve to exhaust all sequences typed by the ape. But the meta-level of ordered letters, e.g., "crystalcrystalcrystal," need never be produced by his random efforts, were he to type for eternity. Even more improbable is the meta-meta-level of complexity, in which information is supplied, e.g., "To be or not to be, that is the question." Hence,

it is fallacious to assert that since some set of conditions must obtain in the universe, the actual set is in no way improbable or in need of explanation.
19 John A. Wheeler, "From Relativity to Mutability," in The Physicist's Conception of Nature, ed. J. Mehra (Dordrecht: D. Reidel, 1973).
20 A.D. Linde, "The Inflationary Universe," Reports on Progress in Physics 47 (1984):925-986.
21 Hugh Everett, "'Relative State' Formulation of Quantum Mechanics," Reviews of Modern Physics 29 (1957):454-462.
22 John Leslie, "Modern Cosmology and the Creation of Life," in Evolution and Creation, ed. Ernan McMullin, University of Notre Dame Studies in the Philosophy of Religion (Notre Dame, Ind.: University of Notre Dame Press, 1985), pp. 97-77.
23 See, for example, the critiques in Quentin Smith, "World Ensemble Explanations," Pacific Philosophical Quarterly 67 (1986):73-81; Leslie, "Prerequisites of Life."
24 Viz., (i) there is no known physics which could cause the universe to oscillate, (ii) the density of the universe appears to be far below the critical level needed to bring about re-contraction, and (iii) the thermodynamic properties of oscillating models reveal that while they have an infinite future, they possess only a finite past. For discussion, see my The Kalam Cosmological Argument, Library of Philosophy and Religion (London: Macmillan, 1979), pp. 122-30, 135-36.
25 John Earman, "The SAP Also Rises: A Critical Examination of the Anthropic Principle," American Philosophical Quarterly 24 (1987):312.
26 Smith, "World Ensemble Explanations," pp. 77-78. It is not clear to me why Smith does not think that his own view of the universe as a quantum fluctuation does not succumb to this same objection, since the superspace of quantum geometrodynamics is atemporal. Perhaps he thinks of the superspace as also temporal, but then one is caught in positing time beyond time, which seems incoherent. And even if a temporal superspacetime is coherent, in infinite time some random fluctuation would have spawned an open universe, which would by this time have so expanded as to coalesce with any other universe produced in the superspacetime by a quantum fluctuation, since it has had eternity to do so, thereby eliminating any ensemble of distinct worlds.
27 The paradoxical nature of the infinite was emphasized by Hackett, Theism, pp. 194-95, 294, whose exposition was the seed of my own Kalam Cosmological Argument, pp. 69-102.
28 Earman, "SAP Also Rises," p. 312. He adds,"That anthropic theorists stand ready to make use of any such speculation which proves handy tells us something about their methodology" (Ibid, p. 311).
29 John Leslie, "Observership in Cosmology: the Anthropic Principle," Mind 92 (1983):575.
30 Leslie, "Cosmology and the Creation of Life," pp. 98, 112.
31 John Leslie, "God and Scientific Verifiability," Philosophy 53 (1978):79.
32 Martin Gardner, "WAP, SAP, PAP, & FAP," New York Review of Books, (May 8, 1986), p. 23. The quotation from Pagels is from Heinz Pagels, "A Cozy Cosmology," The Sciences (March/April, 1985).
33 Tony Rothman, "A 'What You See Is What You Beget' Theory," Discover, (May 1987), p. 99.
34 Leslie, "God and Scientific Verifiability," p. 79.
35 Earman, "SAP also Rises," p. 310. Earman's reference is to D. Lewis, On the Plurality of Worlds (London: Basil Blackwell, 1986).
36 Alvin Plantinga, The Nature of Necessity (Oxford: Clarendon Press, 1974), pp. 102-20.
37 Barrow and Tipler, Anthropic Principle, p. 30.
38 The response to this objection would also seem appropriate with regard to Earman's proposed satirical antidote to our surprise at the fine-tuning of the universe: "Imagine . . . the wonderment of a species of mud worms who discover that if the constant of the thermometric conductivity of mud were different by a small percentage they would not be able to survive" (Earman, "SAP also Rises,"p. 314). For if our argument has been correct, then, if mud worms possessed self-conscious intelligence, they should indeed be stunned at the fine-tuning requisite for their existence. For even if mud worms were the highest form of life, the delicate balance of conditions necessary for life itself, not to mention the unbelievable complexity involved in an organism so highly developed as a mud worm, remains unaffected by such an attenuation. Indeed, many teleologists argue for the hypothesis of design simply on the basis of a single cell, a gene, or even a DNA molecule, not to

speak of organisms so fantastically intricate as a lowly mud worm. (See, e.g., Charles B. Thaxton, Walter L. Bradley, and Roger L. Olsen, The Mystery of Life's Origin [New York: Philosophical Library, 1984]; Hubert Yockey, "A Calculation of the Probability of Spontaneous Biogenesis by Information Theory," Journal of Theoretical Biology 67 [1977]:377.) The argument based on the existence of intelligent human life simply heaps on the complexity to be explained.
The truth in Earman's argument is the same point made by Deist satires of the teleological argument: the mud worms could not infer that their existence was the target at which the Creator aimed nor that the Creator was some Great Mud Worm. (Cf. McMullin's similar complaint that one cannot infer from the evidence that man is the goal of creation or that it was necessary for God to create this sort of universe in order to produce man [Ernan McMullin, "How Should Cosmology Relate to Theology?" in The Sciences and Theology in the Twentieth Century, ed. A.R. Peacocke (Notre Dame, Ind.: University of Notre Dame Press, 1981), pp. 44-45].) But the teleological argument need not be so anthropocentrically construed. It contends merely that the complex order of the universe requires as its most plausible explanation a Cosmic Intelligence which designed the universe. To show that man (or mud worms) is the goal of creation would require additional arguments, say, the moral argument, or revelation.
39 See John Leslie, "The World's Necessary Existence," International Journal for Philosophy of Religion 11 (1980):207-24.
40 Plantinga, Nature of Necessity, pp. 197-221; Robert Adams, "Has It Been Proved that All Real Existence is Contingent?" American Philosophical Quarterly 8 (1971):284-91; William L. Rowe, The Cosmological Argument (Princeton: Princeton University Press, 1975), chap. 4.
41 See the helpful comments by Thomas V. Morris, review of The Quest for Eternity by J.C.A. Gaskin, Faith and Philosophy 3 (1986):334.
42 John Updike, Roger's Version (London: Deutsch, 1986).
43 One thinks in this connection of Aristotle's God, who served in his physics and metaphysics as an explanatory principle, but was not an object of religious devotion or worship. Aristotle's conception of deity ought to make quite clear that the postulate of a divine Designer does not settle for us the religious question.

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Jerry Fodor and Massimo Piattelli-Palmarini (Non-LDS Atheistic Philosophers of Science)
What Darwin Got Wrong
Book (Farrar, Straus and Giroux)

Preface

> It is perfectly safe to attribute this development to `natural selection' so long as we realize that there is no substance to this assertion; that it amounts to no more than a belief that there is some naturalistic explanation for these phenomena.
> Noam Chomsky, Language and Mind, 1972
>
> I am well aware that scarcely a single point is discussed in this volume on which facts cannot be adduced, often apparently leading to conclusions directly opposite to those at which I have arrived. A fair result can be obtained only by fully stating and balancing the facts and arguments on both sides of each question.
> Charles Darwin, On the Origin of Species, 1859
>
> If it could be demonstrated that any complex organ existed which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down.

Charles Darwin, On the Origin of Species, 1859

Terms Of Engagement

This is not a book about God; nor about intelligent design; nor about creationism. Neither of us is into any of those. We thought we'd best make that clear from the outset, because our main contention in what follows will be that there is something wrong — quite possibly fatally wrong — with the theory of natural selection; and we are aware that, even among those who are not quite sure what it is, allegiance to Darwinism has become a litmus for deciding who does, and who does not, hold a `properly scientific' world view. `You must choose between faith in God and faith in Darwin; and if you want to be a secular humanist, you'd better choose the latter'. So we're told.

We doubt that those options are exhaustive. But we do want, ever so much, to be secular humanists. In fact, we both claim to be outright, card-carrying, signed-up, dyed-in-the-wool, no-holds-barred atheists. We therefore seek thoroughly naturalistic explanations of the facts of evolution, although we expect that they will turn out to be quite complex, as scientific explanations often are. It is our assumption that evolution is a mechanical process through and through. We take that to rule out not just divine causes but final causes, elan vital, entelechies, the intervention of extraterrestrial aliens and so forth. This is generally in the spirit of Darwin's approach to the problem of evolution. We are glad to be — to that extent at least — on Darwin's side.

Still, this book is mostly a work of criticism; it is mostly about what we think is wrong with Darwinism. Near the end, we'll make some gestures towards where we believe a viable alternative might lie; but they will be pretty vague. In fact, we don't know very well how evolution works. Nor did Darwin, and nor (as far as we can tell) does anybody else. `Further research is required', as the saying goes. It may well be that centuries of further research are required.

You might reasonably wonder whether writing a critique of the classical Darwinist programme is worth the effort at this late date. Good friends in `wet' biology tell us that none of them is `that kind' of Darwinist any more; no one in structural biology is a bona fide adaptationist. (Some of the reasons why they aren't will be reviewed in Part one.) We are pleased to hear of these realignments, but we doubt that they are typical of biology at large (consider, for example, ongoing research on mathematical models of optimal natural selection). They certainly are not typical of informed opinion in fields that either of us has worked in, including the philosophy of mind, natural language semantics, the theory of syntax, judgement and decision-making, pragmatics and psycholinguistics. In all of these, neo-Darwinism is taken as axiomatic; it goes literally unquestioned (see Appendix). A view that looks to contradict it, either directly or by implication, is ipso facto rejected, however plausible it may otherwise seem. Entire departments, journals and research centres now work on this principle. In consequence, social Darwinism thrives, as do epistemological Darwinism, psychological Darwinism, evolutionary ethics — and even, heaven help us, evolutionary aesthetics. If you seek their monuments, look in the science section of your daily paper. We have both spent effort and ink rebutting some of the most egregious of these neo-Darwinist spin-offs, but we think that what is needed is to cut the tree at its roots: to show that Darwin's theory of natural selection is fatally flawed. That's what this book is about.

In the course of it, we propose to indulge a penchant for digressions. The critique of Darwinism that we will offer raises side issues that we just can't bear not to discuss. So, we've allowed ourselves various asides we think are interesting. Our excuse is that a lot of issues that at first appear to be orthogonal to our concerns turn out, on closer consideration, not to be. We are occasionally asked whether we can really believe that we have found `fatal flaws' in a body of theory that has been, for such a long time, at the centre of scientific consensus. We are reminded that hubris is a sin and are cautioned against it. Our reply is that, if the kinds of complaints that we will raise against

Darwinism have not previously been noticed, that's partly because they have fallen between stools. It seems to us past time to rearrange the furniture. For example, we will run a line of argument that goes like this: there is at the heart of adaptationist theories of evolution, a confusion between (1) the claim that evolution is a process in which creatures with adaptive traits are selected and (2) the claim that evolution is a process in which creatures are selected for their adaptive traits. We will argue that: Darwinism is committed to inferring (2) from (1); that this inference is invalid (in fact it's what philosophers call an `intensional fallacy'); and that there is no way to repair the damage consonant with commitment to naturalism, which we take to be common ground. Getting clear on all this will be a main goal of the book.

Why, you may reasonably ask, hasn't this tangle of connections been remarked upon before? We think the answer is pretty clear: although there has been a long and rich discussion of issues to which intensional explanations give rise, it is found almost entirely in the philosophical literature, which is not one that plays a large part in the education of biologists. Likewise the other way around: very few philosophers are sufficiently conversant with the tradition of evolutionary theorizing in biology to understand how much it relies on an unexplicated notion of 'selection-for'. When philosophers have thought about intensional explanation, it has almost invariably been intensional psychological explanation that they have had in mind. It seems, in retrospect, that an extensive interdisciplinary discussion of evolutionary theory between philosophers and biologists might have proved profitable. But, of course, everybody is busy and you can't read everything.

Nor can we.

There are other examples of issues about which useful interdisciplinary discussions of adaptationism might have occurred but did not. A recurrent theme in what follows is the important analogy between the account of the fixation of phenotypes that Darwin offered and the `learning theoretic' account of the acquisition of `behavioural repertoires' promoted by the once very influential Harvard psychologist Burrhus Frederic Skinner, a father of behaviourism. In fact, we claim that Skinner's account of learning and Darwin's account of evolution are identical in all but name. (Probably Skinner would have agreed with us; he made frequent attempts to shelter under Darwin's wing.) B. F. Skinner was perhaps the most notable academic psychologist in America in the mid-twentieth century. Certainly he was the most widely discussed. His explicit goal was to construct a rigorous and scientific account of how learned behaviours are acquired. The theory he endorsed blended the associationism of the British empiricists with the methodological positivism of psychologists such as Watson and philosophers such as Dewey. From the empiricists he inherited the thesis that learning is habit formation; from the positivists he inherited the thesis that scientific explanation must eschew the postulation of unobservables (including, notably, mental states and processes). Putting the two together produced a kind of psychology in which the organism is treated as a black box and learning is treated as the formation of associations between environmental stimuli and the behavioural responses that they elicit. The formation of such stimulus response associations was supposed to be governed by the law of effect — namely that reinforcement increases habit strength. These theses are, of course, a long way from any that Darwin held. But we'll see presently that what is wrong with Darwin's account of the evolution of phenotypes is very closely analogous to what is wrong with Skinner's account of the acquisition of learned behaviour.

Since the 1950s, it has been widely acknowledged that Skinner's project can't be carried out, and that the reasons that it can't are principled (for a classic review, see Chomsky, 1959; for later relevant arguments, see Chomsky's contributions in Piattelli-Palmarini, 1980). That being so, it is natural to wonder whether analogues of the objections that proved decisive against Skinner's learning theory might not apply, mutatis mutandis, against the theory of natural selection. In the event, however, evolutionary biologists do not read a lot about the history of behaviouristic learning theories, psychologists do not read a lot about evolutionary biology (although here the tide

may be turning) and philosophers, by and large, do not read any of either. So, although the analogy between the theory of natural selection and the theory of operant conditioning has occasionally been remarked upon, the question of how the logic of the one might illuminate the logic of the other has rarely been seriously pursued. We hope to convince you that, once you've seen why Skinner can't have been right about the mechanisms of learning, it becomes pretty clear, for much the same reasons, that Darwin can't have been right about the mechanisms of evolution. Skinner was, of course, a behaviourist, and Darwin, of course, was not. But we will argue that the deepest problems that their theories face — versions of intensional fallacies in both cases — transcend this difference.

Chapter 2 - Internal Constraints: What The New Biology Tells Us

> One can spend an entire lifetime correcting a flawed paper published in a reputable journal and still lose the battle if people like the basic idea.
> V. Hamburger, developmental neurobiologist, cited in Rakic, 2008

As we mentioned earlier, some of our good friends, patented experimental biologists (usually known as `wet' biologists) who have read previous versions of this manuscript, slapped us on the wrist because they think what we are saying is overkill. They told us, `no one is that kind of Darwinian any more'. We'd be happy if that were so, but there is good reason to doubt that it is. And, if it is true, the news has not been widely disseminated even among wet biologists (see, for example, Coyne, 2009).1 This chapter and the next two are essentially a summary of why those biologists say what they (rightly) say. Chapter 5 wades into relatively new territory, even for biologists. News of what we summarize there has, alas, remained even more elusive so far.

Strict neo-Darwinists are, of course, environmentalists by definition: the genotype generates candidate phenotypes more or less at random; the environment filters for traits that are fitness enhancing.2 But there are signs of a deep revisionism emerging in current evolutionary theory: modern biology urges us to conclude (what Darwin himself had acknowledged) that the effect of ecological variables on phenotypes is not the whole story about evolution. Indeed it goes further, urging us to conclude that ecological variables aren't even the most important part of the story about evolution. We will now see, in summary, how and why contemporary biology has changed classical neo-Darwinian adaptationism beyond recognition. Many important discoveries and many explicit quotes by their discoverers bear witness to this momentous change. Our book as a whole, however, parts company with many of these distinguished biologists. Paraphrasing a famous slogan by Karl Marx (an author whose views we do not consider to be otherwise germane), we can say: biologists have changed neo-Darwinism in many ways; the point now is to subvert it.

Natural selection is real, of course (when properly construed)

There can be little doubt that shifting equilibria 3 (that is, variations in the relative frequencies of phenotypic types within and across populations) happen all the time, on land, in the seas, in lakes, in rivers and in streams all over this planet. They also happen within our bodies. Alterations in epithelial (skin) cells, pancreatic cells, lymphocytes (white blood cells), neurons and synapses occurred in us even as we wrote these lines and in you even as you read them. Such shifts are relentless and have been happening on Earth for hundreds of millions of years. And webs of relations of predation, commensalism (food-sharing), competition and migration are intermingled with these shifts and modify, in the long run, our structure and that of our ecosystems. The distributions of biological and behavioural traits in populations that we see today are results of these processes, although certainly not exclusively so, and probably not even chiefly so (assuming that a reliable measure [a reasonable metric] could be established for such probabilistic evaluations, a topic to which we will return). It's common ground that distributions of phenotypic traits in populations change slightly and relentlessly over time. Having said this much, however, it

must be emphasized that such shifting equilibria do not explain the distribution of phenotypes; rather, they are among the phenomena that theories of evolution are supposed to explain. These days biologists have good reasons to believe that selection among randomly generated minor variants of phenotypic traits falls radically short of explaining the appearance of new forms of life. Assuming that evolution occurs over very, very long periods does not help if, as we believe, endogenous factors and multilevel genetic regulations play an essential role in determining the phenotypic options among which environmental variables can choose. Contrary to traditional opinion, it needs to be emphasized that natural selection among traits generated at random cannot by itself be the basic principle of evolution. Rather there must be strong, often decisive, endogenous constraints and hosts of regulations on the phenotypic options that exogenous selection operates on. We think of natural selection as tuning the piano, not as composing the melodies. That's our story, and we think it's the story that modern biology tells when it's properly construed. We will stick to it throughout what follows.

We think (and will argue in later chapters) that there are convincing a priori arguments that show this. For the moment, however, concede that it's often very hard to anticipate the effects of applying a process of selection to a randomly generated population of traits. Even slight variations in the initial frequencies, in the rates of random mutation and in the selection coefficients can lead to drastically different new equilibria. 4 This chapter summarizes a panorama of specific mechanisms the discovery of which makes the gradualist/ adaptationist theory of natural selection plainly wrong in at least some cases, because new phenotypic traits aren't generated at random (as they would be if the mutations that they express are independent) or because adaptation to the ecology plays only a secondary role in the fixation of the phenotypes, or for both of these reasons.

Unidimensionality

The traditional doctrine of natural selection (NS) is unidimensional. Ecological structure is taken to be the explanation par excellence of phenotypic structure; the contribution of internal (endogenous) sources of variance and of internal constraints is, at most, deemed to be marginal. This suggests that for purposes of evolutionary explanation, one could abstract from the character of connections among genes and their phenotypic expressions, and also from the character of the genome itself. All of that internal structure is construed as largely irrelevant to explaining the course of evolution: NS will find its solutions regardless of genetic details. The clearest and most authoritative example of this sort of claim is to be found in Ernst Mayr, one of the main architects of the `modern synthesis' (that is, the fusion of classical Darwinism with genetics, beginning in the first decades of the twentieth century). We quote what seems, in hindsight, and against the background of the `evo-devo' revolution (see later in this chapter), a rather stunning statement:

> Much that has been learned about gene physiology makes it evident that the search for homologous genes is quite futile except in very close relatives. If there is only one efficient solution for a certain functional demand, very different gene complexes will come up with the same solution, no matter how different the pathway by which it is achieved. The saying `many roads lead to Rome' is as true in evolution as in daily affairs.
> Mayr, 1963, p. 609

As we will see shortly, both the frequent cases of conservation of the same master genes across hundreds of million of years and the entire field of evo-devo tell a quite different story. The evo-devo revolution tells us that nothing in evolution makes sense except in the light of developmental biology — Mayr's statement is symptomatic of the unbounded power attributed to NS. A paradigmatic case was the formation of the eye across distant species, supposed to have taken place convergently and independently many times in evolution (at least five, maybe many more). But then, with the discovery of the same master genes for eye development (notably Pax3, Pax2, Pax6 and Dach) across very distant classes and species (from the sea urchin, in which the genes

remain unexpressed, to medusae, to fruit flies, to vertebrates) the evolutionary scene changed quite considerably (for stunning data and considerations, see Sherman, 2007).

As we will see in subsequent chapters, the picture that we get from the modern synthesis is like the one that behaviourist theory of learning proposes in psychology: a random generator of diversity, mapping onto phenotypes that, in turn, meet the demands imposed by environmental filters. The schema is something like that shown here.

Although they were no doubt always considered to be important in the world of real biological systems, considerations concerning the arrow in the diagram were taken to be largely irrelevant to evolutionary theory. As the quote from Mayr testifies, the assumption was that the theory of NS could abstract away from the details of genetic organization and from the details of developmental processes; the latter were deemed to be the concern of embryologists. Basically, in the new synthesis, convergent evolution was considered ubiquitous, rather than occasional, and endogenous variables were treated as random;5 the exogenous variables were supposed do all the work. That is what gives the theory its unidimensional character. One `big' arrow only.

Clear, indeed graphic, evidence of this way of thinking comes from some 8o years of picturing the course of evolution in terms of `fitness landscapes' and `adaptive landscapes'. The very first such graphs looked a lot like orographic contour maps, with valleys of low fitness and peaks of high fitness corresponding to different combinations of variants of genes (Wright, 1932). The effect of NS over time was supposed to be a progressive `hill climbing' [sic] of biological populations, one generation after the other, up towards the peaks. Nice as they undoubtedly look graphically, there are many conceptual and practical problems with such maps. Frequently accompanied by mathematical equations, suggesting great scientific rigour, they remain nonetheless mere visual metaphors, as Pigliucci and Kaplan (2006) rightly emphasize.6 The literature on this topic is huge, and we will not enter any details here .7

It must be noticed, at least in passing, that to assume the existence of a single, continuous, uni-valued mapping between gene configurations and the overall fitness of the organism neglects important factors, such as: the complexity of developmental pathways that are variable in systematic ways and constitute one of the many sources of internal constraints; the role of genomic imprinting (Peters and Robson, 2008) and of epigenetic factors (see below); and the impact of developmental noise (in the sense of Lewontin, 2000, Chapter i) (developmental noise is a term that covers random microscopic events occurring at all levels, from individual cells to tissues, thus making even identical twins not completely identical, even at birth) (Fraga et al., 2.005; Stromswold, 2006; Kaminsky et al., 2009). These internal fluctuations affect the course of phenotypic evolution prior to, and independent of, the effects of ecological variables.

Beanbag genetics

The range of new phenotypic options that are open at a given stage of evolution is, as we are going to see, drastically limited by internal constraints. Moreover, exogenous selection hardly ever operates on mutually independent traits. The idea that phenotypic traits can be independently selected was colourfully labelled `beanbag genetics' by Ernst Mayr, who (to his credit) didn't believe it.

> The Mendelian was apt to compare the genetic contents of a population to a bag full of colored beans. Mutation was the exchange of one kind of bean for another. This conceptualization has been referred to as `beanbag genetics'. Work in population and developmental genetics has shown, however, that the thinking of beanbag genetics is in many ways quite misleading. To consider genes as independent units is meaningless from the physiological as well as the evolutionary viewpoint.

Mayr, 1963, P. 263

One of the founders of population genetics, J. B. S. Haldane, replied to Mayr, defending this approach in a classic 1964 paper.8 Another British geneticist, Gabriel Dover, aptly tells us:

> It is naïve to assume that there are independent genes for each and every characteristic that have accumulated through past episodes of natural selection. The nature of biology is such that the basis of individuality is largely uncapturable, making all talk of the evolutionary origins of the unknown premature at best and vacuous at worst ... Selection is not a process as such with predictable outcomes based on fixed, selective `powers' of individual genes controlling aspects of phenotype. Selection involves whole phenotypes, which are in part influenced by their unique combination of genetic interactions; hence, evolution involves descent with modification of genetic interactions. Genetic interactions are phenotypic, not genotypic. Advocacy of the gene as the unit of selection is operationally incoherent and genetically misconceived.
> Dover, 2006

A further crucial factor that militates against the idea of 'beanbag genetics' — that is, against the idea that inheritable variations in one trait' are independent from inheritable variations in any other trait — lies in the convoluted `packing' of genes in the chromosomes. The long `strings' of DNA that form the genetic material are tightly coiled in the chromosomes in such a way that genes that are 'distant' in a purely sequential (linear) DNA ordering are brought spatially close and become, thus, susceptible to being jointly regulated. These intricate topological configurations of DNA make the joint regulation of gene expression within the same chromosome a rule, and even joint regulation of genes across different chromosomes (called `kissing chromosomes') has been discovered (Kioussis, 2005). Moreover, in the cells of higher organisms, many proteins implicated in DNA repair cluster to form nuclear structures referred to as `DNA repair factories', or `foci'. The composition of these foci following different types of DNA lesions, the regulatory hierarchy of their assembly and the molecular details of events occurring inside these structures are under intense scrutiny (Meister et al., 2003). As we will see, there are several units of regulation, spanning several genes, and these units are conserved not only across the successive cell divisions within a single organism, but often also across different species.

We will come back to this issue, but it's worth emphasizing right away that the assumption of atomistic (one trait at a time) mechanisms of natural selection is still at the core of many popular or semi-popular neo-Darwinian explanations. The structural 'solidarity' of several different traits, which have to be selected wholesale or not at all, makes 'free-riders' and accessory phenotypes not a rare exception, but rather the rule.9 Surely, as a consequence of genetic, developmental and evolutionary modularity (see pages 48-9), in no living organism is everything effectively connected to everything else. If we imagine all the bits of structure and function in an organism as a very large pairwise interaction table, most of the cells in this table would be empty. Otherwise, evolution would have been impossible. The interesting question concerns the non-empty cells in that table: where they are and why. And the ensuing interesting question about evolution, in a genuinely modern perspective, is how it has taken place, given these local inter-dependencies, each one representing an evolutionary constraint.

Internal constraints and filters: `evo-devo'

One common American phrase, sometimes said in a New England accent, is `You can't get there from here'.10 The `there' in our case, is new theoretically possible species; the `here' is an actual species, with all the constraints imposed by its internal structure. We saw above that the classical model of neo-Darwinism represented the manifest (phenotypic) consequences of internal changes in the genes (genotypic variants) as a unidimensional arrow from genotypes to phenotypes. In essence,

it abstracted from all effects of development on visible traits, aside from the effects of genetic mutations, which were themselves considered to be largely independent of one another. But the internal developmental filters that neo-Darwinism tried so hard to abstract from now increasingly seem to be at the very core of evolution. Genes and phenotypes still count, of course; 11 but the evo-devo revolution 12 has stressed that evolution is essentially the evolution of the arrow that connects them. The slogan is: evolution is the evolution of ontogenies. In other words, the whole process of development, from the fertilized egg to the adult, modulates the phenotypic effects of genotypic changes, and thus `filters' the phenotypic options that ecological variables ever have a chance to select from. The evo-devo revolution changes the classical picture quite considerably.13 Clear statements to this effect are ubiquitous in the evo-devo literature:

> By viewing evolution as a branching tree of adults or genes, theorists have omitted what selection really acts upon: ontogeny. Ontogenies evolve, not genes or adults. Mutated genes are passed on only to the extent that they promote survival of ontogenies; adulthood is only a fraction of ontogeny.
> McKinney and Gittelman, 1995

> In an evo-devo perspective, there is no reason for treating the first phase of a life cycle as if it was just a preparatory phase for the production of a living organism that will be sieved by the environment later on. From a formal standpoint, once production has occurred (i.e., when there are new individuals and new developmental processes have started, for instance from fertilized eggs), a downstream process that biases the composition of the `bundle of ontogenetic trajectories' that constitutes a population is functionally a process of sorting, random as the lottery of life, nonrandom as natural selection, or a combination of the two.
> Fusco, 2005

> One foreseeable task of Evo-Devo is to set the limits between homology and bricolage, consisting of independent recruitment of a gene network and, in the end, to ascertain at what levels evolutionary constraints favour the recurrent invention of certain features, while preventing others from emerging.
> Baguna and Garcia-Fernandez, 2003

The main discovery of evo-devo has been the remarkable invariance of the genetic building blocks of evolution. Because highly conserved master genes (see below, page 44 and passim) can persist through hundreds of millions of years of evolution, it is possible to perform experiments that exhibit aspects of genetic `rescue'. This means that a `healthy' variant of a given gene, if suitably inserted into the embryo at a very early stage and then activated, can successfully compensate for a `defective' variant of that same gene (rescuing the function of the gene). This is an impressive biotechnological feat, but it stands to reason that it works. What's truly extraordinary is that such genetic rescue can also occur in organisms across distant species, illustrating both the extreme complexity of genotype to phenotype relations and the reality of the conservation of genes over evolutionary time. For instance, the standard, naturally occurring, version of a specific gene — the 'wild-type allele' in the technical vocabulary — from the fruit fly is able to `rescue' a defective gene in the mouse, and vice versa. Further examples of the strict functional correspondence between genes across distant species are too numerous to mention.14 New discoveries15 of the deep similarity between genes in distant species, families, orders and even phyla continue to be published almost every month.16

Conservation of genes and gene complexes is not only compatible with variation in overall body plans typical of speciation, it is itself the principal source of such variation, by means of gene duplications, quadruplications and alternative switches in the regulation of these genes. Mirror images — binary polarity inversions — of very old gene complexes explain the difference, for

instance, between the ventral organization of the nervous system in insects and its dorsal position in vertebrates."

There are thus invariants in the developmental dynamics across evolutionarily distant animal forms, and there are also many genetic specificities that are preserved from phylum to phylum and from species to species. Moreover, comparisons of adults with adults, or of genomes with genomes, can be unrevealing when the units of trait transmission are whole pathways of development. Pace Ernst Mayr (see above), the identity of genes and gene complexes matters enormously in determining the process by which phenotypic properties can converge across different types of organisms: the conservation of genes and their roles in development over quite distant phyla and hundreds of millions of years of evolution is crucial to understanding such convergences. In the words of Nobel laureate Christiane Nusslein-Volhard: `this remarkable conservation [of genes and gene complexes] came as a great surprise. It had been neither predicted nor expected'. Certainly it's remarkable, given that phenotypic structure is presently modelled as largely the outcome of endogenous variables.

Some (undue) perplexities about the evo-devo revolution

The discovery that the same genes and gene complexes are found across very different forms of life, spanning hundreds of millions of years of evolution, has not failed to raise initial perplexity in the biological profession. In 2002, in a commentary/review of work in evo-devo up to that moment, Elisabeth Pennisi interviewed several (in her own words) `evo-devo enthusiasts' in Science and reported their growing puzzlement, when they `get down to details' (Pennisi, 2002). In the overall economy of this book, and of this chapter in particular, we think that this piece is very revealing and we indulge here in some verbatim quotes. Pennisi rightly states that evo-devo has turned a famous motto by the evolutionist Theodosius Dobzhansky on its ear. Dobzhansky, in a lay sermon to American teachers of biology in 1973, ventured to state that `nothing in biology makes sense except in the light of evolution' (Dobzhansky, 1973). Evo-devo tells us that it's the other way around: nothing in evolution makes sense except in the light of developmental biology. But it has not been easy, and it still isn't, to set out in precise evolutionary terms what is known about genes and development. Researchers have been grappling for some years with the problem of reconstructing the way in which similar genes mastermind the development of wildly different creatures. William Jeffery, an evolutionary developmental biologist at the University of Maryland, College Park, told Pennisi: `You can collect lists of conserved genes, but once you get those lists, it's very hard to get at the mechanisms [of evolution]'. His conclusion is rather drastic: `Macroevolution is really at a dead end.' Jeffery's colleague at Maryland, Eric Haag (significantly, we think) adds that the fundamental question is whether the mutations that result in real novelty are the same mutations that happen day to day or are the ones that occur only rarely, on a geological timescale. Rudolf Raff, an evo-devo researcher at Bloomington, Indiana, told Pennisi that, since variation is the very stuff of evolution, `what developmental biologists consider noise, the [micro] evolutionists consider gold.'

The data on the remarkable conservation of genes are, however, incontrovertible, and constantly growing in quantity and detail. In the last few years, a vast body of research and manipulations of various sorts on model organisms (such as the omnipresent fruit fly, the nematode [a roundworm], the tiny zebrafish, the chick embryo, and so on) has shed light onto a variety of subtle genetic regulations. The initial perplexities we have evoked above are being superseded by new concepts, new avenues of research and new models of the basic evolutionary dynamics. As we will see in a moment, multiple levels of regulation act on the expression of genes at various stages of development.

Summary on the lessons from evo-devo

The very least that can be said, in the light of evo-devo, is that a unidimensional theory of evolution hasn't a prayer of being adequate. The frequent conservation of genes and gene complexes refutes the idea that morphological and functional convergences are, almost always and everywhere, to be construed as adaptive `solutions' to correspondingly ubiquitous survival `problems'.18 But we do not want, either, to be taken as committing the fallacy of suggesting that, if a theory cannot explain everything, then it cannot explain anything. For the sake of the argument, let's concede that there are some prima facie plausible cases of evolutionary convergence not explicable by common descent (see Rueber and Adams [200s] for examples concerning dentition, body shape and the shape of head and mouth of the cichlids [fish species] in Lake Tanganyika). And there are prima facie plausible cases of morphological and behavioural adaptation quite probably caused by environmental changes (as in the changes of blood density and the loss of haemoglobin in several species of icefish in the Antarctica — for a lay description of this case see Carroll [2006]. Yet, recent advances in evo-devo show that phenotypic convergence is, more often than not, the effect of genetic and developmental invariants. Conversely, numerous examples have been found, some replicated in the laboratory,19 of remarkable differences in terminal forms produced by slight variations in the regulation of the same gene complexes and/or in the timing of activation of such complexes. The interesting consequence is that the huge variety of extant and fossil life forms ('endless forms most beautiful', in the words of Sean Carroll [10051, borrowed from Darwin), is not only fully compatible with the high conservation of genes, but also explained by it. They are, in other words, explained by the complex intermingling of genetic conservation and variable gene regulations, at various levels.20 The actual cases of, respectively, evolutionary convergence in the cichlids and adaptation to extreme cold in the icefish do not lend themselves to being generalized as evolutionary standards, as offering a single layer of evolutionary explanations. (We will return in some detail in the following chapters to what we think is the true nature and import of this different kind of evolutionary explanation.)

Much more of much the same

Gene conservation and the conservation of developmental (technically called 'ontogenetic') processes are two of the ways that phenotypes can converge even as the corresponding ecologies vary. Neither of these claims is seriously disputed in current biological discussions; and both imply internal filters on the phenotypes on which exogenous selection acts. They challenge the classical neo-Darwinist view that the course of evolution is exhaustively driven by exogenous factors. The old argument in evolutionary biology was about whether internal constraints are the exceptions or the rule; the present consensus is increasingly that they are the rule. At a minimum, there are plenty of other examples of internal filters on phenotypic variables, and they are to be found at a variety of levels of endogenous structure. Here are some more.

Genetic mutation is basically a quantum phenomenon, chance substitutions of one of the four `letter "(nucleotides) in a DNA sequence for another. Therefore, at their very source, mutations may occur at random; but their effects are not uniform either across the different positions inside the affected gene, or the position that gene occupies in the whole genome, or across species. For example, there are several known instances of regions in genomes that are called 'hypermutable' and there are 'hotspots'. What this means, as these labels clearly indicate, is that mutations are more likely to affect these genetic regions than others (Shen and Storb, 2004). Some of these regions are likely to produce tumours in humans and other species (Laken et al., 1997). Slippage during the gene replication process, resulting in gains or losses of repeat DNA units, is a cause, but not the only one. The so-called minisatellites are especially affected (Yauk, 1998). These form a class of highly variable (polymorphic) `tandem repeats' in the DNA sequence. They include some of the most variable spots in the human genome, with mutation rates ranging from 0.5 to over 20 per cent per generation (Bois, 2003). At the opposite extreme, various processes of repair (DNA repair) (Feuerhahn and Egly, 2008) act as a buffer against mutations (for recent findings in the human

genome, see Berglund et al., 200; Hurst, 10o9). Mutations in the proteins that execute this task are usually lethal.

In essence, thus, the traditional assumption that mutations have a fixed probability of occurring anywhere at random in the genome of any species (something like one chance in a million, per locus per generation) does not stand up to a more refined scrutiny. It surely is not the case that there are random corresponding effects downstream. In other words, even if they were actually random, mutations would not always produce random novel phenotypes.

In fact, the next stages of the processes that connect genomes with phenotypes reveal still other mechanisms that uncouple random mutations of the DNA from their phenotypic consequences. For example, the transcription of DNA into messenger RNA (mRNA), the very first process towards gene expression, has multiple internal regulators. RNA editing (the term suggests intuitively what it's all about) effectively alters the transcript of a gene into an mRNA, so that the chemical (amino acid) sequence of the actually encoded protein differs from the one that would be predicted by the original genomic DNA sequence. This central process, the transcription of whole genes, the step through which the DNA of the genes is transferred (technically, `transcribed') into the daughter molecule called RNA, is subject to a manifold of regulatory processes. These contribute in crucial ways (True et al., 2004).

This means that some potentially deleterious mutations (they would be so, if they were expressed there and then) can be kept at bay for generations, passed on from one generation to the next but remaining inert, until some other mutation, or major changes in the environment (shocks, see page 58), can expose them, that is, can make of that genotype a corresponding phenotype. 26 A direct molecular interaction between HSP90 and a protein of the chromatin (called Trithorax, or for short TRX) has been reported recently. Since the chromatin proteins control the developmental fate of cells by modulating epigenetic signals (see below), these data explain in detail the central role of HSP90 in cooperating with these proteins in maintaining the active expression state of target genes, notably including master genes such as the Hox genes. When HSP90 is damaged, either by genetic mutations or by external pharmacological inhibition, the function of these master genes is downregulated, with the ubiquitous and dramatic consequences we have indicated above.

Alternative splicing

Finally (for the purposes of the present summary exposition) the segments of a gene that actually encode segments of proteins (these are called exons, while the segments that do not code for proteins are called introns) can be spliced in different alternative ways.27 As a result, a single gene can code for many different proteins, and a single mutation in one of the exons can affect many of these proteins in a single stroke. When the human genome was decoded there was a lower than expected number of genes (of the order of only 24,000), prompting renewed interest in alternative splicing, as a way for a single gene to encode many proteins. Genes were supposed to be `multitasking'. And they are.28

A recent study by Christopher B. Burge of MIT and colleagues analysed the entire sequence of the messenger RNA (mRNA) of fifteen different human tissue types or cancer cell lines to produce a comprehensive catalogue of gene and alternative mRNA expression (Wang et al., 2008). Over 90 per cent of human genes are now estimated to undergo alternative splicing, exploiting this form of mRNA processing that yields multiple proteins from a single gene. Almost all mammalian genes have interruptions in their coding regions and are alternatively spliced. This mechanism permits greater phenotypic complexity than indicated by gene number alone.29

Last but not least: molecular drive and biased gene conversion

Deploring the traditional monopoly attributed to natural selection and random genetic drift as the sole causes of the formation of new species, Gabriel Dover proposed a new mechanism, called `molecular drive' (Dover, 1982a,b). In essence, Dover's proposal consisted of a molecular process of turnover internal to the genome, independent of natural selection. A concerted pattern of fixation that permits the formation of novel biological forms `in a manner not predicted by the classical genetics of natural selection and genetic drift'. In explaining, with the tools available in the early i98os, the possible details of such completely mechanistic molecular processes, totally internal to the genetic apparatus, Dover used three words that have become quite prominent, more than 25 years later: `directional', `biased' and `conversion'.

In essence, Dover stresses that all genomes of all examined species from bugs to worms to humans are riddled with the ubiquitous genomic mechanisms of turnover (replicative transposition, inversion, duplication) that power what he calls molecular drive. The recurrent instability of genomes leads to reorganizations and to new temporary stabilizations. Dover stresses that the spreading consequences of molecular drive also work in exactly the same way (sampling error) that stochastic genetic drift works at the phenotype level. Besides gene conversion (biased and unbiased), to which we will return in a moment, there are transpositions, slippages, unequal crossing over of chromosomes and other processes, which together ensure, in Dover's picture, that what starts off as a single mutation in a single gene in a single chromosome in a single individual can, with the passing of the generations, spread throughout a sexually reproducing population. This internally driven spreading process can open up, for a population, in the course of time, paths of development and reproduction and behaviour that were previously inaccessible to it. In Dover's schema (see also his 200s book, Dear Mr Darwin), the establishment of novel, environmentally friendly functions can be envisaged as dependent on an interaction between many processes: molecular drive, random drift and (yes, also) natural selection. In his schema, summarizing it drastically, there are forces at work that are basically due to the instability of genomes (ubiquitous non-Mendelian mechanisms of turnover). These provide a radically wider comprehension of the evolved nature of biological functions.

One aspect of Dover's earlier intuitions (and data, and calculations) is now being emphasized: the process called biased gene conversion (BGC).30 This mechanism, related to gene recombination with ensuing segregation and distortion, is presently observed to drive the fixation of new gene variants (new alleles) independently of any selective process. A class of numerous and evolutionarily recent differences in DNA sequences between corresponding genes in humans and in non-human primates that were previously attributed to intense natural selection now appear to be due to BGC (Berglund et al., 2009). The decisive impact of BGC on traditional conceptions (and statistical calculations) of alleged selective `sweeps' in human evolution is also stressed in Duret, 2009; Galtier et al., 2009; Hodgkinson et al., 2.009. How distinct these genetic conversion processes are from any semblance of natural selection is shown by the fact that they can even promote the fixation of deleterious mutations in primates.

The English biochemist Laurence Hurst, in a commentary in Nature on 29 January 2.009, writes of the data produced by Berglund et al.:

> The[se] results ... accord with the view of BGC as a driver of sequence evolution, potentially explaining the occurrence of large spans of approximately homogeneous nucleotide content ... in our genome. More disturbingly, the results bring into question the usefulness of the standard tool kit for identifying hotspots of changes that are beneficial to organisms. Convincing demonstration of positive selection now requires both evidence that the changes were not caused by BGC and scrutiny of the impact of the amino-acid changes.
> Hurst, 2009, P.544

Perhaps we don't need to go into greater details, in the present chapter, to conclude, as many distinguished biologists do these days, that even if mutations were really random at their source, the corresponding phenotypes are not. In other words, before any phenotype can be, so to speak, `offered' to selection by the environment, a host of internal constraints have to be satisfied and, as we are going to see, interactions at many levels have to be stabilized. A variety of filters, some acting in series, some cooperating or interfering, stand between mutations and their expression.

There is, in short, no single `arrow' connecting a random generator of genetic diversity to the phenotypes on which exogenous selection acts. There are different effects of different kinds of filters and regulatory processes, at different levels, presently under intense scrutiny (Mattick, 2005; Amaral and Mattick, 2008; Mattick and Mehler, 2008). There usually are differential rates of efficiency for the different variants, at each level, and different kinds of local (that is, endogenous) selections. There are also exogenous selections, but here too the story is quite different from the one offered by standard neoDarwinism, as we will see in a moment. Some evolutionary biologists have, in fact, generalized and expanded the mechanisms of Darwinian selection to include internal selection.31 Part two will explain the conceptual shortcomings of Darwinism that also apply to these Darwinian expansions, but before we go into that, several other facts and new developments in biology proper have to be taken into account. The picture of the relation between genes and phenotypes becomes even more complicated when we look at the next family of levels up: that is, the relations between the genome as a whole and pathways of development. We turn to these in the next chapter.

Chapter 3 - Whole Genomes, Networks, Modules And Other Complexities

Gene regulatory networks

Extremely complex gene regulatory networks are at work in the developing organism and they offer important new keys to the origins of animal body plans and evolution (Davidson, 2006; Davidson and Erwin, 2006; de Leon and Davidson, 2009).' Davidson and Erwin (2006) argued that known microevolutionary processes cannot explain the evolution of large differences in development that characterize entire classes of animals.2 Instead, they proposed that the large distinct categories called phyla arise from novel evolutionary processes involving large-effect mutations acting on conserved core pathways of development. Gene regulatory networks are also modular in organization (Oliveri and Davidson, 2007). This means, in essence, that they form compact units of interaction relatively separate from other similar, but distinct, units.

The consequence is that these processes make the connection between specific biological traits, specific evolutionary dynamics and natural selection very complicated at best, impossible at worst. In the words of a leading expert of gene regulatory networks:

> Developmental gene regulatory networks are inhomogeneous in structure and discontinuous and modular in organization, and so changes in them will have inhomogeneous and discontinuous effects in evolutionary terms ... These kinds of changes imperfectly reflect the Class, Order and Family level of diversification of animals. The basic stability of phylum-level morphological characters since the advent of bilaterian assemblages may be due to the extreme conservation of network kernels. The most important consequence is that contrary to classical evolution theory, the processes that drive the small changes observed as species diverge cannot be taken as models for the evolution of the body plans of animals. These are as apples and oranges, so to speak, and that is why it is necessary to apply new principles that derive from the structure/function relations of gene regulatory networks to approach the mechanisms of body plan evolution.
> Davidson, 2006, p. 195, emphasis added

Additional phenomena, such as developmental modules, entrenchment and robustness, further separate random mutations at the DNA level from expressed phenotypes at the level of organisms. We will develop the idea of developmental and evolutionary modularity in a moment. Let's first briefly characterize entrenchment and robustness.

Entrenchment

The different components of a genome and/or of a developmental structure usually have different effects `downstream', that is, on the characteristics of the fully developed adult, through the entire lifetime. The magnitude of these effects is measured by the 'entrenchment' of that structure. The entrenchment of a gene or a gene complex changes by degrees — it's not an all-or-none property. From an evolutionary point of view, the entrenchment of a unit has multiple and deep consequences for its role in different groups of organisms and different species, notably affecting other units that depend on its functioning. Generative entrenchment (Wimsatt, 1987; Schank and Wimsatt, 200s; Wimsatt, 2.003) is seen both as an `engine' of development and evolutionary change, and as a constraint. This amounts to saying that crucial developmental factors ('pivots' in Wimsatt's terms) may be highly conserved and be buffered against change, or may undergo minor heritable changes with major evolutionary consequences. Generative entrenchment, as the expression aptly suggests, is very probably linked to spontaneous and quite general collective form-generating processes that we will review in the next chapter, but it is (of course) also under the control of genes, gene complexes and developmental pathways. How these different sources of order and change (some generically physicochemical and some specifically genetic) interact is still largely unknown (Kauffman, 1987, 1993).

Robustness

A trait is said to be robust with respect to a genetic or environmental variable if variation of the one is only weakly correlated with variations in the other. In other words, robustness is the persistence of a trait of an organism under perturbations, be they random developmental noise, environmental change or genetic change. Many different features of an organism, both microscopic and macroscopic, could qualify as traits in this definition of robustness. A trait could be the proper fold or activity of a protein, a gene expression pattern produced by a regulatory gene network, the regular progression of a cell division cycle, the communication of a molecular signal from cell surface to nucleus or a cell interaction necessary for embryogenesis or the proper formation of a viable organism or organ, for example (Felix and Wagner, 2008). Robustness is important in ensuring the stability of phenotypic traits that are constantly exposed to genetic and non-genetic variation. In recent years, robustness has been shown to be of paramount importance in understanding evolution, because robustness permits hidden genetic variation to accumulate. Such hidden variation may serve as a source of new adaptations and evolutionary innovations (Kitano, 2.004).

The source of robustness lies in the fact that the developmental processes that give rise to complex traits are nonlinear (Nijhout, 1002). In a recent paper, two leading experts say:

> A consequence of this nonlinearity is that not all genes are equally correlated with the trait whose ontogeny they control. Because robustness is not controlled independently from the core components of a system, it is not straightforward to disentangle buffering mechanisms that have been subject to natural selection from those that have not. This is a major challenge for future work.
> Felix and Wagner, 2008, emphasis added

In 2005, reviewing a book on robustness and evolvability by Andreas Wagner (Wagner, 200s) in Science, Gregory C. Gibson, the William Neal Reynolds Distinguished Professor of Genetics at North Carolina State University, says:

> Robustness must involve non-additive genetic interactions, but quantitative geneticists have for the better part of a century generally accepted that it is only the additive component of genetic variation that responds to selection. Consequently, we are faced with the observation that biological systems are pervasively robust but find it hard to explain exactly how they evolve to be that way.
> Gibson, 2005, p. z37, emphasis added

In what is music to our ears, in this review Gibson adds, `[this book] contributes significantly to the emerging view that natural selection is just one, and maybe not even the most fundamental, source of biological order.'

Darwin himself had explicitly acknowledged that natural selection is not the only mechanism in evolution, but it's worth stressing that these days, as Gibson prudently (with `maybe') says, it's `not even the most fundamental one'. We want to go further along this path and conclude that these multiple levels of internal constraints on possible phenotypes make the notion of evolution as the product of external selection operating on phenotypic variations generated at random radically untenable.' Darwin argued that (to borrow Dennett's phrase) phenotypes `carry information about' the ecologies in which they evolved. The brown colour of the butterfly tells us that it evolved in a smoky atmosphere.' But it now seems undeniable that evolved phenotypes also carry information about the internal organization of the creatures that have them (about their genotypic and ontogenetic structures, for example.) It is an open, empirical and highly substantive question how narrowly such endogenous effects constrain the phenotypic variations on which external selection operates. It will take a while to find out. But, until that question gets answered, it is unadvisable to take a neo-Darwinist account of evolution for granted.

Master genes are 'masters'

Many different traits are indissociably genetically controlled by the same `master gene' (this is technically called pleiotropism — from the ancient Greek, meaning `motion in many directions'). Any mutation affecting one master gene, if viable, has an impact on many traits at once. Moreover, new variants of a trait may interact differently with variants of other traits. The timing and intensity of expression of genes are, as we saw, controlled through complex gene regulatory networks (Coyne, 2006; Davidson and Erwin, 2006; Erwin and Davidson, 2006). An important consequence of genetic pleiotropism is that, when a gene affects several traits at once, any change in that gene that is not catastrophic (any viable mutation) will affect all or most of these traits. Supposing that one such change in one such trait is adaptive, then natural selection will eventually fixate that mutation. But then all the other changes in all the other traits will also be stabilized, possibly opening up wholly different selective processes, eventually dwarfing the effects of the initial selection driven by the initially adaptive trait.6

There is an interesting example that we choose here, tentative as it may be, because it concerns the evolution of brain and therefore of cognition. It has been suggested that there are regulatory genes that affect many different organs, including the development of the cerebral cortex (Simeone, 1998; Simeone et al., 1992, 1993). A well-studied gene family, called Otx, masterminds the development of kidneys, cranio-facial structures (Suda et al., 200g), guts, gonads and the cerebral cortex (segmentation and cortical organization). Several mutants are known, including severe pathological cases in humans (at one extreme lissencephaly — an abnormally smooth brain surface — at the other schizoencephaly — an exaggeratedly deep inter-hemispheric cleft). Mutants are usually short lived and leave no progeny.

Italian geneticist Edoardo Boncinelli (Boncinelli, 1998, 2000) has offered an interesting and relatively tentative hypothesis which, if even roughly correct, implies that there are significant

aspects of our brain structure that are not consequences of selection for their fitness but rather side effects of selection for quite other phenotypic traits (spandrels in Gould and Lewontin's sense; see Chapter 6); in particular, since the Otxi `master' gene controls the development of the larynx, inner ear, kidneys and external genitalia and the thickness of the cerebral cortex, selective pressures sensitive to changes in the functions of the kidneys (due to the bipedal station, or different liquid intake and excretion resulting from floods or droughts), or the fixation of different sexual patterns, may have had in turn secondary effects on the expansion of the cerebral cortex and the structure and function of the larynx. The peculiarity of the overall picture of the evolution of language and cognition in humans, should this reconstruction prove to be correct, has been stressed to us by Boncinelli (personal communication, June 2009). Neither we nor Boncinelli are claiming that this actually is the right evolutionary story about the emergence of the enlarged cortex in the human brain, only that some such story might be correct and that it is, as far as we know, consonant with the facts currently available. A dogmatic adherence to adaptationism blinds one to such interesting possibilities.

Moreover, it's known today that, just as the same phenotype may be the result of quite different genes or gene complexes (convergence), different phenotypes may be the result of the same genes or gene complexes (differential gene regulation). The epigenetic effects that we mentioned earlier, and to which we will return shortly, may mimic genetic ones, with drastically different consequences for the degree of plasticity of that trait, and/or different possibility of its fixation and susceptibility to further variation and evolution. The effect of the genetic context as a whole upon a new variant may be one of suppression (negative epistasis), of enhancement (positive epistasis) or compensation (compensatory epistasis), with quite different effects on its contribution to overall fitness (Pigliucci, 2009b). Moreover, a general non-lethal decrease of average fitness in a population may `turn' a disadvantageous mutation into an advantageous one (Silander et al., 2007).'

Developmental modules

Let's start with a definition.8 A module is a unit that is highly integrated internally and relatively insensitive to context externally. Developmental modules exist at different levels of organization, from gene regulation to networks of interacting genes to organ primordia. They are relatively insensitive to the surrounding context and can thus behave invariantly, even when they are multiply realized in different tissues and in different developmental phases. Different combinations of developmental modules in each context, however, produce a difference in their functions in development. There is evidence of the integration of several interacting elements into a module when perturbation of one element results in perturbations of the other elements in that module, or in gene—gene interaction (epistasis) within the module, in such a way that the overall developmental input—output relation is altered. This is another signal case in which the conservation of genetic and developmental building blocks, together with their multiple recombinations in different tissues and organisms, explains the diversity of life forms as well as the invariance of basic body plans.9 The double-edged (so to speak) character of developmental modules consists in their relative context insensitivity to external factors and their relative context sensitivity to some internal substitutions of subcomponents.'0 This is presently a very active and very complex domain of inquiry (for a vast survey see the volume edited by Schlosser and Wagner, 2004). In evolution, developmental modules may preserve their integrity in spite of being embedded into different heritable variations of their context and also, in several cases, in spite of the replacement of some of their sub-modules by others. Gerhard Schlosser writes: `[Developmental modules] may form coherent and quasi-autonomous units in evolution (modules of evolution) that are repeatedly recombinable with other such units' (Schlosser, 2004, p. 520).

In essence, the `logical' role of a module is one of presenting cascades of interacting elements, where the output of one provides some of the input to the others. Developmental modules are triggered in a switch-like fashion by a variety of inputs, to which they are only weakly linked. This

weak linkage admits variations and allows relatively novel inputs. These inputs are `triggers' (sic, in this literature) not templates of shapes. The way in which modules affect different downstream processes depends on the overall genetic context. It's worth stressing that the internal machinery is predisposed to react in complex ways to a class of switches. All this makes the development of organisms an intricate network of context-independent processes (the modules) and of internally context-dependent ones (interactions between modules and interactions of the modules with other structures). The reverberation of the effects of gene mutations is usually multiple and only the viable overall result is then accessible to selection.

There are different classes of modules. The most basic and earliest operating class affects the regulation of gene transcription at distinct but interacting levels. As a consequence, DNA sequences that act as promoters and enhancers can be swapped between genes. It is also the case that multiple enhancers exist for a single gene, each controlling a particular expression domain of the gene. These can be multiply recombined. The basic transcriptional apparatus (BTA) is itself modular, and its specificity can be changed by swapping different transcription factors.

An especially interesting class of modules are the signalling pathways, families (or classes) of proteins acting in concert in cascades that constitute whole cycles or networks, and representing biochemical `signals' that have specific types of cells as their targets in different issues, such target cells often lying side by side with unresponsive (non-target) cells. Only five major families appear to be important during early embryonic development (because of their [separate] initial discoveries, they bear names that sound bizarre to the uninitiated: hedgehog, TGF, Wnt, receptor tyrosine kinases [RTKs] and Notch). Each family is relatively autonomous with respect to the others; each class has its own primary role, but many can also play multiple roles in the development of very different tissues. For example, the Notch system also acts as a positive feedback loop between neighbouring cells, amplifying initial differences (determining different fates of neighbouring cells). This complex system of master signals regulates tissues as different as the central nervous system, pharynx, hair cells, odontoblasts, kidney, feathers, gut, lung, pancreas, hair and ciliated epidermal cells across many different vertebrate and invertebrate species. Every mutation in any one of the genes involved will alter many organs and their functions — a far cry from `beanbag genetics'.

Organ primordia such as limb buds and mandible and teeth primordia act like modules (Zelditch et al., 2008) and can be transplanted to develop ectopically — that is, in different, non-canonical parts of the embryo." This can happen partially, to a certain extent, or even completely, in diverse parts of the embryo, with different results in different species. As a rule of thumb, the transplantation and activation of genes across species, or out of place (ectopically) in the same species, is more successful for genes that are normally expressed sooner in the life of the embryo than for genes that are expressed later. This, as Stephen Jay Gould and Brian Goodwin have argued, gives some, only some, substance to the old idea (originally due to K. E. von Baer and Ernst Haeckel) that ontogenesis recapitulates phylogenesis (the successive forms of the developing embryo are reminiscent of the ascent of forms in evolutionary time).

Some modules are systemic modules, distributed throughout the organism. The best examples are hormonally mediated processes, in which only a subset of cells in various tissues is responsive to a particular hormone, intermingled with unresponsive cells. Nonetheless, the response is substantially the same everywhere, with many orchestrated changes: new metabolic enzyme expressions are switched on; likewise extensive programmed cell death (or its inhibition), and the differentiation of new cell types (gut, epidermis); likewise the remodelling of muscles, and of parts of the nervous system. The thyroidhormone-dependent metamorphosis in amphibians is modulable at will by mere administration of various doses of the hormone.

The lesson here is that modularity gives a new complex picture of evolution, one in which internal constraints and internal dynamics filter what selection can act upon, and to what extent it can do so. Precisely because so much cannot change, other things can change at the (so to speak) genetic periphery of organisms. It is often (although not always) the case that when we witness gene duplications, a ubiquitous kind of genetic modification, the `original' gene continues acting as it did in earlier forms of life, while the `copy' can `explore' new functions over evolutionary time (these metaphors are commonplace in the professional literature).

Coordination

We saw earlier how badly misguided the additive, `beanbag' conception of genes is. There is more to be said about this. The Russian zoologist and evolutionist Ivan Ivanovich Schmalhausen (1884-1963) had rightly stressed that living organisms are not the mere atomic 'adposition' of separate parts, but rather highly `coordinated' systems (for a historical and critical review, see Levit et al., 2006). Today justice is done to Schmalhausen by experimental evidence that some mutations in genes specifically affecting one part of the body carry with them suitable modifications in other related parts. When limbs are induced ectopically (that is, where they don't belong), often sensory neurons, receptor organs, cartilage and blood vessels also develop as a consequence around them (see Kirschner and Gerhart, 2005 for stunning examples). A laboratory-induced and quantitatively controllable modification in two key proteins12 in chick and finch embryos early in development produces as the main result variable elongation and thinning of the upper part of the beak (Abzhanov et al., 2006). However, the lower beak and the neck muscles also `follow'.

The lesson here is, once again, that natural selection cannot select isolated traits, but rather coordinated complexes of traits, coming all together in virtue of pleiotropism, developmental solidarity (Schmalhausen's coordination) and epigenetic modifications (see below).

Morphogenetic explosions

After what we have seen in this rapid and summary exposition, it stands to reason that, in consequence of the many internal constraints on possible new life forms, when one or more of these constraints are internally, genetically, relaxed or withheld, new possibilities open up, sometimes in an explosive way (Gould, 1989, vindicated in Erwin, 2008 and Theissen, 2.009). Over periods that are relatively short in geological terms, a great variety of new life forms appears suddenly and (as palaeontologists say) `explosively'. This seems to have happened at least twice in the remote past, and at least once more recently.

The Ediacara fossils (from 575 to 542. million years ago) represent Earth's oldest known complex macroscopic life forms. A comprehensive quantitative analysis of these fossils indicates that the oldest Ediacara assemblage, the Avalon assemblage, already encompassed the full range of the possible forms of the Ediacara (what is technically called their `morphospace', the repertoire of accessible forms) (Erwin, 2008; Shen et al., 2008). A comparable morphospace range was occupied by the subsequent White Sea assemblage (56o to S50 million years ago) and Nama assemblage (550 to 542. million years ago), although it was populated differently (taxonomic richness increased in the White Sea assemblage but declined in the Nama assemblage). These changes in diversity, occurring while the range of forms (the morphospace) remained relatively constant, led to inverse shifts in morphological variance. The Avalon morphospace expansion may well mirror the Cambrian explosion (about 545 million years ago) when in the relatively short period of 5 to 10 million years most of the complex life forms we see today appeared on Earth, and both events may reflect similar underlying mechanisms. The palaeontologist Douglas H. Erwin (2008) summarizes these findings, saying that they amount to the recognition that these ancestral forms of life apparently contained already a suite of developmental tools for differentiating their body plans, although not yet the sophisticated developmental tools capable of building the regional body patterning of higher animals. For that, we will have to wait until the momentous Cambrian explosion.

Another example of morphological explosion and of its importance in the unravelling of poorly understood macroevolutionary processes is analysed in Moyle et al. (2009). The relatively recent (between two million and a million and a half years ago) explosive Pleistocene diversification and hemispheric expansion of 'white-eye' passerine birds (Zosteropidae, a family containing among the most species-rich bird genera) represents a per-lineage diversification rate among the highest reported for vertebrates (estimated to be between I.9 and 2.6 species per million years). However, these authors stress that, unlike the much earlier explosions seen above, this rapid rich diversification was not limited in geographic scope, but instead spanned the entire Old World tropics, parts of temperate Asia and numerous Atlantic, Pacific and Indian Ocean archipelagos.

Interestingly, this paper reports that the tempo and geographic breadth of this rapid radiation `defy any single diversification paradigm, but implicate a prominent role for lineage-specific life-history traits (such as rapid evolutionary shifts in dispersal ability) that enabled white-eyes to respond rapidly and persistently to the geographic drivers of diversification' (Moyle et al., 2009).

By means of a comparative analysis of sequences of nuclear and mitochondria) DNA, a small group of ancestors characterized as `great speciators' (Diamond et al., 1976) has been extrapolated. This 'hyperdiversification' can only be explained via a complex interaction between intrinsic and extrinsic drivers of rapid speciation, combining with processes of reproductive isolation and migration. These authors conclude that `the pattern and tempo of diversification recovered for the white-eyes do not fit comfortably within any single diversification paradigm (e.g., dispersal, vicariance, equilibrium island biogeography, etc.) and underscore the importance of casting a broad net, in terms of taxonomy, geography, and theory, in modern diversification studies' (Diamond et al., 1976).

We can summarize by saying that morphological explosions may well reflect major changes in internal constraints as crucial components in speciation. If so, then the effects of natural selection may well consist largely of post-hoc fine-tuning in the distribution of subspecies and variants (Newman and Bhat, 2008): quite a different kind of account13 from the one of gradual selection of randomly differing small variations.14

Plasticity and the (non)transitivity of fitness

This survey of stumbling blocks for gradualism (that is, for the thesis that many intermediate variants must have existed between any two significantly different evolutionarily related forms) is by no means complete.15 We now propose to add a few more. The first is that Darwinian fitness is heavily dependent on the context in which it is assessed. The second is that, as a consequence, relative fitness does not transfer from one comparison to another, even within the same species. The third is that not only phenotypes but also genomes can be plastic. The fourth and, for the moment, final is that the textbook cases of Mendelian inheritance, in spite of their great historical and didactic importance, are more the exception than the rule.

A crucial, though usually tacit, assumption of gradualism is that adaptive modification is transitive. If variant A has greater fitness than variant B, and B has greater fitness than C, then A must have greater fitness than C. There is no gradualist adaptive story to be told unless the process is assumed to be transitive.16 This leads to a perennial puzzle about how evolution avoids being trapped in local maxima of fitness." In fact, gradualist-selectivist adaptationism characteristically depicts the evolutionary process as one of hill climbing, not infrequently deploying, as we said earlier, pleasant graphic artistry to convey the intuitions behind the model of fitness landscapes and adaptive landscapes. Although the possibility that an organism (or a population) has been `trapped' on top of a local maximum, in the proximity of a nearby, but inaccessible, higher peak has long been acknowledged in classical neo-Darwinism, with few exceptions the climbing process itself has

always been assumed to be smooth, and each path locally transitive. However, where there have been morphogenetic explosions, fitness relations become surely non-transitive and plausibly irrelevant. There is no hill climbing, not even a smooth path from each level of fitness to the next; only a jumpy traverse of a maze" or a 'glass-like' surface with a huge number of neighbouring peaks.

In fact, numerous instances of non-transitive differentials of fitness have been observed. For instance, when one variant A only competes with another variant B, then A leaves more descendants and `outsmarts' variant B. The same occurs when variant B only competes with variant C. But if all three compete, then it may well be that C wins over A.

The relation between genotypic variation and phenotypic plasticity suggests that we could consider genes as `norms of reaction' to different environments (Lewontin et al., 200,). Plotting the measure of a trait against environmental parameters usually gives complex curves, complex `norms of reaction' that do not reveal transitive relations of fitness. For instance, out of about a dozen variants of the plant Achillea, one is the tallest at low altitudes and at high altitudes, but the shortest at intermediate ones (Suzuki et al., 1981). Mapping the size of such variants of Achillea over heights ranging from sea level to 3,000 meters, we obtain quite `bumpy' curves that criss-cross one another. The same intricate zigzagging geometry also applies to the curves plotting total leaf area, total leaf number and mean leaf size as a function of soil moisture in the plant Polygonum persicaria (spotted ladysthumb) (Sultan and Bazzaz, 1993). In the animal kingdom, similar criss-crossing curves for different genotypes are to be found, for instance in the number of abdominal bristles in the fruit fly, as a function of the ambient temperature during development, and in the rate of production of specific membrane proteins in the immune system for different human genotypes as a function of early exposure to domestic animals (Eder et al., 2000; Martinez, 2000; von Mutius, 2007).

our sleeves. We'll argue presently that, quite aside from the problems it has accommodating the empirical findings, the theory of natural selection is internally flawed; it's not just that the data are equivocal, it's that there's a crack in the foundations.

Chapter 4 - Many Constraints, Many Environments

In recent years, several pleas have been made for considering selection at many levels, and for revising the traditional neo-Darwinian thinking that either the individual, or the population as a whole, are the sole units of selection. There are selective processes and competitions and synergies also at the level of genes, chromosomes, whole genomes, whole epigenomes, cells, developing tissues, kin groups, societies and communities; and, of course, organisms and populations. Each one of these levels shows specific dynamics and interface phenomena with the levels immediately below and above (Michod, 1999).

This chapter summarizes some of them.

Selection without adaptation

Along with the recent discoveries and developments that we have just reviewed, we also wish to mention a conundrum (for the canonical neo-Darwinians) that has been on the scene for decades, although mostly neglected until very recently. The interesting saga leading to the discovery of the chaperone HSP90 mentioned earlier has equally interesting antecedents that deserve to be told, at least in essence.

The aforementioned British geneticist and embryologist Conrad Hal Waddington showed in the 1950s that, under unusual environmental conditions, by repeated artificial selection, new phenotypes can emerge that have no evident adaptive relation to these environments. For instance, a

small fraction of wild-type strains of fruit flies repeatedly grown in the egg stage in the presence of fumes of ether develop (an initially quite small) second pair of wings. By repeatedly selectively cross-breeding these variants, one generation after the other, and repeatedly submitting the progeny to fumes of ether in the egg stage, a progressively greater number of individuals can be produced that develop this additional pair of wings (resulting in two pairs of wings, instead of one). The second pair consists of small winglets, rather than the tiny wing buds of the wild type, called halteres.1 Eventually, after many generations so treated and cross-bred, Waddington noticed that individuals with the aberrant additional pair of wings could produce offspring that no longer needed ether egg shock to produce the wings. This new phenotype had become stabilized.

Let's notice that it would have been quite impossible for natural selection to create this second pair of wings, because there is no spontaneous variation in this character. Similar procedures were applied, and similar results were obtained, by Waddington and others on a variety of different traits. For instance, another interesting variant appears when wild-type fruit flies are raised at high temperature and are again cross-bred for generations. This other variant is characterized by unusually large eyes (Waddington, 1956, 1957). After selective crossbreeding over several generations, these phenotypes are stabilized too and are observed even when the offspring of the selected fruit flies are raised in a normal environment. Waddington called this phenomenon `genetic assimilation'.

A general characterization of this story is the following2: a character has no variation normally, but if you shock the developmental system in suitable ways, then a few individuals with an abnormal trait appear. If you breed from those individuals, and again shock their offspring early in development, the effect becomes more pronounced and more and more of them are affected, one generation after the other. You eventually get enough modified individuals and can breed for the abnormal character without further shocking.' There is no adaptive process in sight, and the relation between these environments and these phenotypes is, to put it mildly, elusive.4

These data have only recently turned out to be most revealing from a genetic, epigenetic and developmental point of view (Rutherford and Lindquist, 1998; Queltsch et al., 2002; True et al., 200; Sangster et al., 2008). Waddington had unearthed the presence of silent mutations accumulating in what are now called `evolutionary capacitors'. In spite of some differences in the experimental procedures, the outcomes are very similar. In fact, Waddington applied an unusual growth milieu (ether or high temperature) and then selective breeding for many generations, while Lindquist and colleagues mutated the gene for HSP90 pharmacologically. In both cases, the expression of the related phenotypes is today of central importance to genetics, and to epigenetics. What we wish to stress is the lack of any transparent adaptive correlation between such phenotypes and the selecting environment. Terms such as `canalization' (due to Waddington) and `capacitor' (due to Lindquist, Sanger and Rutherford) reveal a considerable change with respect to the canonical neo-Darwinian picture.

The achievement of neo-Darwinian explanations is supposed to consist precisely in starting with a story of blind trials and errors, and deriving, at the end of the day, a `brilliant', `exquisite' match between the evolved phenotype and the requirements of the external environment.5 By contrast, the sorts of cases reported here do not suggest an adaptationist treatment; in consequence, they were largely forgotten until the emergence of epigenetics revived an interest in Waddington's experiments. The lesson from such cases is that unusual environments and selective processes in them (artificial in this case, natural in others) do produce various phenotypes, of which some are not lethal, but not adaptive either. It bears emphasis that the `information' that such phenotypes give about the evolutionary environment in which they emerged is very, very indirect, or nil.

Constraints on selectability and the rise of contingency

There are, as we have seen, all sorts of internal constraints on adaptation. There are also external constraints that do not operate by natural selection. This has long been acknowledged in population genetics, wherein standard textbooks emphasize the fixation of phenotypic traits in small populations by random genetic drift, frequency-dependent selection, density-dependent selection and so forth.6 There are, for example, well-examined, clear cases of when fitness is a function of (among many other variables) overall population size, and when there is `the ascent of the abundant' — that is, when abundant phenotypes may acquire an evolutionary advantage regardless of their fitness (Cowperthwaite et al., 2008). The very complex interplay of all these factors, of internal constraints, internal selection and external selection, is arguably the very core of evolution which is a different and vastly more complex story than the one told by classical neo-Darwinism.

Bacteria, Sugars And Dead Ends

It is worth the effort to consider a paradigmatically simple case, discovered serendipitously, in the most famous of all experimental biological models: the intestinal bacterium Escherichia coli. It is paradigmatic because a bacterium is the simplest self-reproducing organism there is (viruses need bacteria or cells to reproduce), because the processes at work are so elementary, and because the function on which selection converged is the most straightforward one can imagine: the enzymatic digestion (fermentation) of sugars (Hall, 1978, 1981).'

The story is as follows: in the naturally occurring variant (wild type) of E. coli we find an enzyme (called ebgA) that `digests' (ferments) the naturally occurring sugar lactose (let's call it sugar i) but cannot digest similar, but distinct, sugars (lactulose — let's call it sugar 2 — and lactobionate — let's call it sugar 3). There is also a gene (ebgR) that regulates the synthesis of this enzyme. The initial aim of a direct (let's notice, direct) laboratory selection was to obtain a variant of the bacterium that could also ferment sugar 3. But this failed. A backtracking procedure was then followed. The attempt was made to select, one step at a time, bacterial strains that would ferment sugar 2. Various quite ingenious methods of serial selection were tried out, and the desired result was eventually obtained, but many `dead ends' [sic] were also produced. In particular, after having selected strains that carry the desired (unregulated) variant of the regulatory gene (obtaining strains that could digest both sugar 1 and sugar 2), attempts were made to directly select strains that could digest sugar 3 as well. But no luck; the glitch is that the strains capable of fermenting both sugar i and sugar 2 never give mutants that can also digest sugar 3. In fact, if one selects from a sugar-1 strain, one must screen away and dump all mutants that can also utilize sugar 2, otherwise one will never obtain any mutants that can utilize sugar 3. Notice that these bacteria have never encountered sugar 2.8

In effect the sugar-1 and -2 strains are dead ends towards the utilization of sugar 3. The order of the selective steps cannot be altered. Moreover, it turns out that some optimally effective mutants for the old function are dead ends for further adaptation to the new function. That is, selection for a new function (by a planned change of the growth medium) sometimes reduces the efficiency of the old function. It is not the case that the best adapted to the old function is also the best adapted to the new one, nor is it the case that the converse applies — that is, that the best adapted to the new function is also the best adapted to the old one.

Some Lessons From This Paradigmatic Ultra-Simple Case

In the story above, we know exactly what was being selected, how, when and `for' what, because it was an artificial selection made by smart experimentalists and published in detail. Yet, other (undesired, in this case) traits were also being selected, with no possibility of doing otherwise. Selection with just sugar i gives as a result some strains of bacteria that also carry the capacity to digest sugar 2. In a well-established terminology, to which we will return in what follows, this second capacity is a 'free-rider' on the first. Had it not been for the unanticipated block that it represents towards the additional utilization of sugar 3, it would have been a welcome new trait.

On paper, this additional capacity is advantageous; being able to use two types of sugar instead of only one looks like an evolutionary plus. Too bad, though, that it precludes all possibility of also using sugar 3. In the laboratory, these 'free-riders' were detected and discarded; in a laboratory environment, coextensive phenotypic traits can be experimentally dissociated to determine which of them is actually adaptive and which merely free-rides. But, of course, natural selection doesn't perform experiments; if phenotypic traits are coextensive in the environment of selection, then, if either is selected, both are.

Let's repeat, for the sake of clarity, that those bacteria had never been exposed to sugar 2, and free-riding would have been undetectable in the initial selective medium (sugar i). We will return to this point (see Chapter 6). Suffice for now that there is an interesting and transparent analogy with free-riding phenotypes in the case of domestication. Many traits that were never directly selected for by breeders appear in domesticated species. These traits 'free-ride' on domestication but, unlike the `dead ends' in the case of E. soli, had no reason to be discarded. Domesticated species as different as sheep, poodles, donkeys, horses, pigs, goats, mice and guinea pigs, each one of them artificially selected for some specific trait (quality of wool, friendliness to humans, loadability in transportation, and so on), also present dwarf and giant varieties, piebald coat colour, wavy or curly hair, floppy ears and more (Trut, 1999).

Out in nature things are never as simple as they are in a laboratory, or on a farm; natural selection is whatever it happens to be, and it's hard, often impossible, to reconstruct what trait (if any) has been naturally selected, and `for' what, as distinct from traits that merely free-ride (see Chapter 6). Past natural situations capable of `splitting' coextensive phenotypes may have never happened, or may have happened leaving no trace. Dead ends are prone to be just that: dead. And we will never know whether they existed, what they looked like if they did exist, or why they were doomed. Counterfactual reasoning (what would have been the case if ...) is unavailable in cases in which controlled experiments cannot be run. Moreover, the order of the selection steps may well be as crucial in nature as it was in this experiment, and the final result may well be strictly dependent on past contingencies.9 In this case, we are told which steps were taken in which order. Lucky us! But again, out in nature, there is usually no way for us to reconstruct the steps and their order. The moral here is that the application of adaptationism even to specific elementary cases such as a bacterium and the digestion of three sugars presents formidable problems. So far, these cases are not telling us that natural selection did not happen, but they tell us that the parallel between artificial selection and natural selection, so central to Darwin's theory, is flawed (a point to which we will return in Part two). They also tell us that our capacity to reconstruct the vagaries of natural selection is extremely limited, to say the least. The vastly more complex case of the evolution of higher multicellular species, with all the intricate internal constraints and gene interactions, often makes reconstruction impossible unless model systems (actual species) can be genetically manipulated in a laboratory and strong analogies to plausible evolutionary events can be drawn (for one of the earliest and most persuasive such reconstructions, see Ronshaugen et al., 2002).

New Kinds Of Environments

In a centenary symposium in honour of Ernst Mayr (but with a quite different perspective from Mayr's), Mary-Jane West-Eberhard, a prominent representative of 'evo-devo', focuses on developmental plasticity and invites us to consider a quite different kind of 'environmentalism'; not the traditional one in which an all-powerful selective filter winnows pre-existing genetic variability, but an environment that initiates genetic changes by amplifying developmental plasticity (a topic to which we will return):

> Change in trait frequency involves genetic accommodation of the threshold or liability for expression of a novel trait, a process that follows rather than directs phenotypic change.

> Contrary to common belief, environmentally initiated novelties may have greater evolutionary potential than mutationally induced ones. Thus, genes are probably more often followers than leaders in evolutionary change. Species differences can originate before reproductive isolation and contribute to the process of speciation itself. Therefore, the genetics of speciation can profit from studies of changes in gene expression as well as changes in gene frequency and genetic isolation ... A very large body of evidence shows that phenotypic novelty is largely reorganizational rather than a product of innovative genes. Even if reorganization was initiated by a mutation, a gene of major effect on regulation, selection would lead to genetic accommodation, that is, genetic change that follows, and is directed by, the reorganized condition of the phenotype.
> West-Eberhard, 2005, pp. 6543, 6547

The message here is that the very idea of what constitutes an 'environment' and of the relations between internal and external factors in evolution needs to be drastically revised. The constellation of phenomena we are going to see next confirms that.

Epigenetics And Imprinting

Various processes of strictly local chemical alteration (technically called methylation, phosphorylation, acetylation, etc.) normally target the proteins that compose the histones, that is, the multiply repeated reels around which DNA is coiled in the chromosomes, forming what is called `chromatin'. The similarity of wording with `chromosome' is totally non-accidental, since chromosomes are formed by long uninterrupted strings of DNA annealed around the chromatin reels. The net effect of these ubiquitous and vital chemical modifications of the proteins forming the chromatin is one of physically exposing genes to the processing machinery of the cell, activating them, or burying them into the grooves of the chromatin, blocking their expression. Specific locations along the very long helix of the DNA itself can be the target of such micro-chemical modifications,'10especially methylation, resulting in an additional and all-important mechanism of genetic regulation."

Genes and possibly entire genomes are susceptible to many such minute, pervasive and crucial chemical modifications during development and then throughout adult life. The effect of such modifications of genes and genomes that are transmitted by the mother or by the father (especially in mammals) constitutes what is technically called parental `imprinting' of the genes.

About 8o imprinted genes are presently known in the mouse and most tend to occur in clusters. Their activity is suppressed or silenced in a parent-specific pattern. Both maternal and paternal imprinting have been reported. Short sequences of RNA that do not code for proteins, in particular the gene regulatory factors we mentioned earlier, called micro-RNAs, are especially affected (Peters and Robson, 2008). Recent studies in humans of identical (monozygotic) and fraternal (dizygotic) twins have shown that the effect of sharing the same placental milieu adds to that of sharing the same genes (Kaminsky et al., 2009). The effects of these chemical modifications of genes, giving different phenotypes in spite of an identical underlying genetic DNA, are actually intensely studied and have created a whole field of inquiry called 'epigenetics' (This already constitutes a vast scientific literature.

For a comprehensive treatment see Allis et al. [2006], for accessible early summaries see Pray [2004], and for more specific treatments see Rutherford and Henicoff [2003] and Vercelli [2004].)

The heritability of some such epigenetic modifications has been suggested in rodents, certainly down to the second generation, possibly as far as the fourth (Anway and Skinner, 2006; Jirtle and Skinner, 2007). In humans, probable cases of epigenetic inheritance of male infertility and susceptibility to other diseases have been reported. The clearest and most studied case of the

heritability of epigenetic modifications in humans is offered by the tragic, Nazi-inflicted, Dutch famine in the winter of 1944-1945. The women who managed to give birth in those months had babies of height and weight considerably less than the norm. The surprising datum is that now, their granddaughters, in spite of their history of perfectly normal nutrition, still give birth to babies measuring below the norm. Another case showing that imprinted genes are good candidates to mediate nutrition-linked transgenerational effects on growth comes from Sweden. In this case there is also a paternal, probably sperm-mediated, imprinting (Pembrey, 2002). Analysing a long record of early nutritional influences on cardiovascular and diabetes-related mortality, Kaati, Bigren and Edvinsson of the University of Umea exploited records of annual harvests from an isolated community in northern Sweden that go back as far as 1799 to explore the effects of food availability across three generations (Kaati et al., 2002). In essence, scarcity of food in grandfather's periods of slow growth was associated with a significantly extended survival of the grandchildren for many years, while food abundance was associated with a greatly shortened lifespan of the grandchildren. Opposite effects have been attributed to the epigenetic role of nutrition for the grandmothers. The crucial steps in the process seem to have been the nutritional situation during the formation of sperm in the grandfathers, and the formation of the ovules in the grandmothers (Kaati et al., 2002).12

A metaphor adopted by one of the pioneers in the field of epigenetics (Randy Jirtle of Duke University) suggests that the genome is the `hardware', while epigenetic modifications are the `software'.

Indeed, these modifications of the phenotype happen without any change in the corresponding DNA, much as the same hardware can be programmed to run different software.

Very recent data, from January 2009 (Tariq et al., 2009) explain in detail the effects originally discovered by Waddington and confirm the earlier data and insights of John M. Rendel (see above). Chaperones such as HSP90 connect an epigenetic network, controlling major developmental and cellular pathways, with a system sensing external cues (heat shocks, for instance). Damages to this connecting process explain the manifestation of abnormal traits and the relatively rapid fixation of these under shock followed by selective breeding. Some 50 years later, the perplexity (not to say scepticism) with which Waddington's original experiments were received has no reason to persist. What he had aptly called `genetic assimilation' and `canalization' is now explained through complex, but perfectly mechanistic, molecular mechanisms.

The jury is still out on the heritability of epigenetic modifications, and we do not know yet how generalized and frequent epigenetic inheritance will turn out to be, and whether it will be ascertained to have hereditary effects even after the second generation down the line. As a result, especially in some popularization reports, this domain has raised perplexities (excessive, in our opinion), caused by the fear that Lamarckism may be making a comeback.13

Jumping Genes And `Horizontal' Gene Transfer

We wish to insert into this summary sketch of non-Darwinian and non-selectionist interactions between organisms and different kinds of environments (including internal environments), a pervasive, evolutionarily crucial, phenomenon that has been unravelled in recent years: `horizontal' gene transfer. This is an exchange of genes that takes place not in the canonical way, not by descent from one generation to the next (the transmission is then called `vertical'), but rather between organisms that exist, so to speak, side by side (that's why it's called `horizontal' transmission). Horizontal transmission takes place through a process that is not too dissimilar from the way viruses infect living cells. However, the case that is relevant to evolution is the frequent one in which these genetic `outsiders' end up inserting themselves permanently into the genome of a species and then being transmitted `vertically' in the canonical way through successive gener-

ations. First discovered in maize by Barbara McClintock (1902-1992) in the 1940s and 1950S (her work was much belatedly rewarded with a Nobel Prize in 1983), this phenomenon is ubiquitous. It has been estimated that at least 45 per cent of our genes derive from such horizontal gene transfers. These genetic elements are called in technical terms `transposons' or transposable elements (TEs). TEs are present in virtually all species and often contribute a substantial fraction of their genome size, as they do in our own species. They can also 'transpose' or move around to different positions within the genome. A type of transposon called a retrotransposon is transcribed into RNA and then reintegrated into the genomic DNA, after its RNA is 'transcribed back' into DNA (a process that is the inverse of that we saw earlier). The most common form of retrotransposons in the human genome are the so-called Alu elements, which occur in more than one million copies in each of our genomes and occupy approximately 10 per cent of the whole human genetic sequence. They appear to be characteristic of primates and their possible role in hominization has
been explored."

A signal case is the full-blown immune system of mammals, called `adaptive' because it is added on top of the so-called `innate' immunity system already present in insects and because, as we all know, it `adapts' to infections throughout our life. This extremely complex apparatus, comprising specific antigen receptors, immunoglobulins, B lymphocytes and T lymphocytes, seems to owe its evolutionary origins to the chance insertion of two transposons, called RAGi and RAG2 (the latter possibly an ancient duplication of RAGr), into an ancestor of modern sharks, followed by a sort of multiplication explosion of those inserted genes, which were originally connected to the specific replication and multiplication of segments of DNA (Agrawal et al., 1998; Hiom et al., 1998; Malecek et al., 2008). There is agreement that understanding the functional roles, evolution and population dynamics of TEs is essential to understanding genome evolution and function. These chance insertions represent, at the level of the genomic apparatus, rather massive injections of new genetic material, variably followed by further transpositions internal to the genome, internal stabilization, multiplication, partial loss and further mutations. These transposable elements represent a kind of genomic and evolutionary wild card, presently under intense scrutiny. How the different TEs in different species are subsequently subjected to internal and external selection remains to be defined.15

In the present context, we wish to point out that horizontal genetic transfer is the rule, rather than the exception, in microorganisms, to the point that the very notion of a `tree of descent' is being questioned. The preferred metaphor today in microbiology is that of a bush or a network (Doolittle, 1999). The very idea of the tree has been questioned, perhaps too radically, also for the evolution and descent of higher animals. Be it as it may, the relatively massive, sudden and repeated `horizontal' introduction of genetic material is a new factor in the present picture of evolution. It was worth being reported here, because we are ascertaining one more evolutionary process that was not contemplated in the standard neo-Darwinian model.

Interchangeability Between Reactions To External And Internal Perturbations

As we have learned from Mary-Jane West-Eberhard (see above), change in trait frequency and genetic accommodation of the threshold of expression of a novel trait frequently occur as consequences, rather than causes, of phenotypic change. The plasticity of adaptations to new external inputs may well be deployed also when heritable internal changes occur. In particular, developmental plasticity may be what allows new adaptive evolutionary changes to be stabilized, once they have occurred by mutation. Interestingly, it has been suggested that this effect may have been particularly strong in the evolution of the brain. For instance, Kirschner and Gerhart (200s) explain how shaving off whiskers in the mouse predictably affects `backwards' the developmental pattern of organization of the nerve fibres and the brain centres to which they are connected.16 This is the consequence of an external perturbation (the shaving of the whiskers). But the blind mole presents a perfectly analogous, although in this case congenital (i.e. internal) reorganization

of its nervous system: the sensory tactile appendages of the nose `project' to the barrels of the brain cortex in the same geometric pattern as do the mouse whiskers in an ordinary non-blind mouse whose whiskers have been shaved.

Another signal case of interchangeability of the effects of exogenous and endogenous causes is sex determination in reptiles. There are, generally speaking, two avenues to sex determination: genotypic sex determination (GSD), which is always the case in mammals, and temperature-dependent sex determination (TSD), frequent in other vertebrates (such as reptiles). Population density, food scarcity and differential sex-related mortality may also be factors (see Mary-Jane West-Eberhard's 2003 book for cases of alternating GSD and TSD in very close species of reptiles). The distribution of TSD and GSD across reptiles suggests several independent evolutionary transitions in sex-determining mechanisms, but transitional forms had yet to be demonstrated until one such case was recently observed in Central Australia.

The bearded dragon lizard (Pogona vitticeps) offers an instance of smooth transition between temperature-induced and gene-induced sex determination (Quinn et al., 2007). Unlike mammals, in which the chromosomal structure of females is XX and that of males is XY, in this species ZZ individuals are males, while ZW individuals are females. There is a temperature- sensitive gene product present in two copies in males but in only one copy in females. The gene is fully active at intermediate temperatures but becomes progressively inactivated at higher temperatures. Reversal of the ZZ genotype to the female phenotype at extreme temperatures will bias the phenotypic sex ratio towards females and drive down the frequency of the W chromosome under frequency-dependent selection. This could account for the pattern observed in many TSD reptiles, in which both low and high temperatures produce 100% females, }yet intermediate temperatures produce predominantly (occasionally 100%) males. (For still another clear case of interchangeability, see note i and figure 2).

We wish to stress, as Kirschner and Gerhart do, that the interchangeability of external factors and genetic fixation can well redraw the whole picture of evolution. The basic mechanisms are the same, and biologists are only beginning to understand the evolutionary impact of this fact.

Conclusions for this chapter

The internal constraints we reviewed in Chapter 2 were limitations to what can, in the first place, become the target of natural selection. The multiple levels of regulation and the genetic, developmental and evolutionary compartmentalization of organisms we reviewed in Chapter 3 constituted conditions on how natural selection can operate, if and when it does. Neo-Darwinists have tried to adjust to most of these processes by expanding its scope and invoking other kinds of natural selection, essentially multilevel adaptations and internal selections to internal milieus. Possibly, they may now want to try even harder and incorporate into their adaptive explanations processes such as those reviewed in this chapter: selection without adaptation, genetic assimilation, genotypic and phenotypic plasticity, contingency, sudden explosions of new forms, transposable elements, epigenetic regulations and the interchangeability of reactions to internal and external factors. These ought to increase, we think, the discomfort of classical neo-Darwinians. If they really want to go this far, then their theory will have to be subverted, not just reformed or expanded — a consummation devoutly to be wished. These are some of the tiles of a completely new and rapidly expanding mosaic, not additions to the old one. The following chapter will, we hope, accentuate the discomfort.

Chapter 5 - The Return Of The Laws Of Form

In the previous chapters we saw several constraints `from below', from molecular interactions all the way up to phenotypes, and canalized interactions `across' different kinds of internal

organization and the milieus with which they interact. What we are going to see now is an entire spectrum of other factors that must have played a major role in evolution and that are equally, if not even more, alien to adaptation and natural selection. For historical reasons, and for want of a better term, we will call these `the laws of form'. These are, in a sense, constraints `from above',' because the mathematical and physico-chemical laws that explain spontaneous self-organization and the `discovery' of optimal solutions exceed the boundaries of biology and are necessarily quite abstract. Lest we might be accused of wanting to `reduce' biology to physics and chemistry, we wish to make it clear that these factors are intimately enmeshed with hosts of contingent evolutionary happenings and mis-happenings (from meteorites to glaciations, from volcanic eruptions to floods and much more) and with the manifold genetic and epigenetic contingent mechanisms we have just reviewed. The important emerging consideration is that these physicochemical invariants also play a role in evolution, not that they are all there is to evolution. Of course not.

In the Fibonacci series, each term is equal to the sum of the two preceding ones (1, 1, 2, 3, 5, 8, 13, 21, 34, 55, and so on). By connecting, with a continuous curve, the outer vertices of an ordered pattern of juxtaposed squares that have areas given by the Fibonacci series we obtain the Fibonacci spiral (© Ian Stewart). The presence of Fibonacci patterns is ubiquitous in nature, from galaxies to seashells, from magnetized droplets in a viscous medium to the organization of florets in plants (as shown in the figure for sunflowers). Moreover, the numbers of such spirals (clockwise versus counterclockwise) are typically Fibonacci numbers (21 and 34 respectively).

When very similar specific morphologies (Fibonacci series and Fibonacci spirals 20 are observed in spiral nebulae, in the geometrical arrangement of magnetically charged droplets in a liquid surface, in seashells,' in the alternation of leaves on the stalks of plant stems and in the disposition of seeds in a sunflower, it can hardly be that natural selection is responsible.',' The relative rates of growth and the initial stages in a plant's production of lateral buds (florets) is controlled by many hormones and networks of metabolites, proteins and so on that are under the control of genes and their regulatory networks. Yet, there is seemingly a simple `rule', which is to place the new bud as far away as possible from the inhibitory hormone effects of the apex and of the last placed buds. Every species does this according to the genes and their regulatory networks that control the types, magnitudes of effects and amounts of inhibitory and stimulating hormones. The simple `rule' is not, as such, dictated by the genes — it is something to which biological growth has to submit. It is the result of the laws of physics and chemistry creating constraints on possible biological forms, more particularly on stable and reproducible biological forms. This is what, basically, the expression `laws of form' tries to capture.

As we are going to see in some paradigmatic instances, the relevant search space would be so huge that the hypothesis of such `rules' and such constraints on stability having been found by blind trial and error followed by natural selection becomes exceedingly improbable. It is even harder to suppose that some genetic machinery is specifically (one has to insist on this: specifically) responsible for coding these forms as such. It's vastly more plausible to suppose that the causes of these forms are to be found in the elaborate self-organizing interactions between several components that are, indeed, coded for by genes (protein complexes, morphogenetic gradients, hormones, cell—cell interactions, and so on) and the strictures dictated by chemical and physical forces. The latter are vastly more ubiquitous and vastly less modular than biological processes. They transcend the biological subdivisions into species, genera, families, orders, classes and phyla. The vagaries of genetic and developmental factors operating over hundreds of millions of years, together with various internal and external levels of selection, must have been exploring the narrow channels allowed by maximization principles that are applicable to biology but exceed its boundaries.

In the apt words of mathematician Peter Timothy Saunders, someone who has been criticizing standard neo-Darwinism for many years and has insisted on the importance of the laws of form (Saunders, 198o), biologists have to delimit the realm of possible creatures first, and only then ask about natural selection: `The primary task of the biologist is to discover the set of forms that are likely to appear ... [for] only then is it worth asking which of them will be selected' (Saunders, 1992, p. xii).

Another main advocate of the importance of the laws of form in biology, Stuart Kauffman, rightly (and somewhat sadly) says, in the preface to his important book on the origins of biological order: `No body of thought incorporates self-organization into the weave of evolutionary theory' (Kauffman, 1993).

As we are going to see, there are good reasons for this divorce, although a recent and still somewhat sporadic return of the laws of form into biology may be conducive to some integration in the decades to come.

A little bit of history

The monumental pioneering work of D'Arcy Wentworth Thompson launched the very expression `laws of form' in the early twentieth century (Thompson, 1917; reprinted and edited by Tyler Bonner in 1992).6 He made the prescient suggestion that biologists had overemphasized the role of evolution and underemphasized the roles of physical and mathematical laws in shaping the form and structure of living organisms.' In many ways his vast and ambitious work was premature, because the discovery of the biochemical and genetic bases of growth and form were still in the future, and because the mathematics mobilized to explain the phenomena was inadequate.

A few years later, in 1924, the Italian mathematician Vito Volterra (later summarized in a monograph in French [Volterra, 1931] and the American mathematician Alfred J. Lotka [Lotka, 1925,1956]) independently and convergently discovered differential equations regulating the oscillatory equilibria of predators and prey in ecosystems, and applicable also to sustainable rates of growth, birth and mortality rates, biochemical cycles and rates of energy transformations, and even the evolution of human means of transportation and fluctuations in financial markets. These equations soon became staple food for mathematical ecologists and theoretical chemists the world over, and still are. Only very recently have some timid links with genetic networks been tried out.

The importation of the laws of form into biology proper had to wait several decades. In 1952, Alan Turing tried to explain biological patterns on the sole bases of canonical equations of chemical diffusion (Turing, 1952; Saunders, 1992). This long-forgotten paper had, in hindsight, major flaws,' and the development of molecular genetics ever since the late 1950s paid no attention to it (with the exception of the British geneticist and embryologist Conrad Hal Waddington, cited by Turing in his paper, whose work we have briefly reviewed in the previous chapter [Waddington, 19571, and to which we will return shortly).

In the meantime, the Russian chemists Boris P. Belousov and Anatol M. Zhabotinsky discovered the spontaneous formation of complex shapes and permanently oscillating reactions (spontaneously arising from perfectly homogeneous solutions).9 The Russian-Belgian physical chemist Ilya Prigogine (19,7-1003) later developed this whole domain of inquiry (labelled `dissipative structures') into a high art, writing down the complete physical and chemical theory of these phenomena, down to quantum physics (his 1977 Nobel lecture remains illuminating; see Prigogine, 1993) • Interestingly for us, a debate between Prigogine and Jacques Monod flared up, in which the role of natural selection versus the role of spontaneous morphogenesis was the cornerstone of the disagreement. Neglected or marginalized by Monod (just as it was by all his colleagues in molecular genetics) but

touted by Prigogine, the importance of complex spontaneous morphogenesis in evolution had still to emerge into full view.

A prestigious ally of Prigogine's was the French mathematician Rene Thom (see Prigogine, 1993), who had been awarded the coveted (by mathematicians the world over) Fields Medal in 1958 for the theory of structural stability and morphogenesis. His universal classification of discontinuous morphogenetic forms into seven elementary `catastrophes' under even slight critical variations of the control parameters10 prompted Thom to venture into possible (and quite unfortunate) applications well beyond biology (sociology, psychoanalysis, semantics, etc.). The English translation of Thom's main synthetic treatise Structural Stability and Morphogenesis (French original 1972., English edition 1975; see Thom, 1975) has, significantly, a foreword by Conrad Hal Waddington, who was in those years looked upon with some suspicion — or simply ignored — by mainstream geneticists and embryologists, although in recent years his early discoveries of the role of epigenetics have vindicated the importance of a lot of his data (see the previous chapter). Waddington coined terms such as `canalization', `canalized selection', 'chreod' and 'homeorhesis' to capture the subtle interaction of morphogenetic processes under the influence of genes in getting around or exploiting the constraints imposed by physical and geometric factors acting on embryology and evolution. Waddington was held in great suspicion by mainstream molecular geneticists in those years (approximately the 1960s and 1970s)

This brief history can be wrapped up by mentioning later contributions12 by Stuart Kauffman, Brian Goodwin, Lewis Wolpert, Antonio Lima-de-Faria, Antonio Garcia-Bellido, Stuart Newman and Gerd Mueller, among others.13 Special mention needs to be made of the recurrent insistence on the significance of laws of form in biological evolution by the late Stephen Jay Gould and his colleague and co-author Richard C. Lewontin.14 This whole field has been widely ignored by entire generations of militant geneticists, `wet' molecular biologists and molecular embryologists.15 The age of specificity, starting with the discovery of the structure of DNA by Crick and Watson in 1953, steered molecular biology away from these relatively generic approaches (Watson and Crick, 1953). Perhaps for that reason, no concrete problem in molecular genetics or microbiology has yet been solved by appeal to laws of form, although connections between these fields are proliferating. As we are going to see, in diverse quarters, somewhat episodically, there is a return of the laws of form into biology. It's reasonable to expect more and more in the years to come. The phenomena that have been uncovered represent serious and diversified challenges to gradualistic adaptationism and neo-Darwinism.

The 'fourth dimension' of living systems

The body masses of living organisms vary from 10 to the minus 13th grams (bacteria) to 10 to the eighth grams (whales), that is, by 21 orders of magnitude. It's interesting to see how other physico-chemical and biological properties and processes, and their ratios, scale with mass. How, for instance, surfaces and internal rates of transport, rates of cellular metabolism, whole organism metabolic rate, heartbeat, blood circulation time and overall lifespan scale with mass. These are, of course, all three-dimensional systems, so it seems astounding that all the scaling factors, encompassing microorganisms, plants and animals, are multiples of a quarter, not of a third.16

The puzzle has been solved in collaborative work by physicists and biologists at Los Alamos, Santa Fe and Albuquerque. In essence, they have discovered a `fourth dimension' of biological systems. The explanation of the one-quarter scaling laws was found `in the fractallike architecture of the hierarchical branching vascular networks that distribute resources within organisms' (West et al., 1999, P. 1677). Their papers reveal a remarkable convergence between the experimental values and the predicted ones (sometimes down to the third decimal), under this hypothesis of fractal-like architecture, for properties such as radius, pressure and blood velocity in the aorta; cardiac frequency; number and density of capillaries; overall metabolic rate; and many more. Their

mathematically detailed model (refined over the years) (West et al., 2002) takes into account biological data such as the 60,000 miles of the entire circulatory system of a human body (capillaries notably included) and the fact that the diameter of capillaries is an invariant in the realm of vertebrates.

Guiding criteria have been the maximization of the inner and outer exchange surfaces, while minimizing distances of internal transport (thus maximizing the rates of transport). A passage in the 1999 paper deserves to be quoted in full:

> Unlike the genetic code, which has evolved only once in the history of life, fractal-like distribution networks that confer an additional effective fourth dimension have originated many times. Examples include extensive surface areas of leaves, gills, lungs, guts, kidneys, chloroplasts, and mitochondria, the whole-organism branching architecture of trees, sponges, hydrozoans, and crinoids, and the treelike networks of diverse respiratory and circulatory systems ... Although living things occupy a three-dimensional space, their internal physiology and anatomy operate as if they were four-dimensional. Quarter-power scaling laws are perhaps as universal and as uniquely biological as the biochemical pathways of metabolism, the structure and function of the genetic code and the process of natural selection.
> West et al., 1999, p• 1679

In the words of these authors, natural selection has `exploited variations on this fractal theme to produce the incredible variety of biological form and function', but there were `severe geometric and physical constraints on metabolic processes'.

The conclusion here is inescapable, that the driving force for these invariant scaling laws cannot have been natural selection. It's inconceivable that so many different organisms, spanning different kingdoms and phyla, may have blindly `tried' all sorts of power laws and that only those that have by chance `discovered' the one-quarter power law reproduced and thrived. The maximization principles that have constrained such a bewildering variety of biological forms are of a physico-chemical and topological nature. Biochemical pathways, the genetic code, developmental pathways and (yes) natural selection cannot possibly have shaped these geometries. They had no `choice' (so to speak) but to exploit these constraints and be channelled by them.

The same kind of lesson comes from calculations, and data, in the domain of brain connectivity.

Non-genomic nativism

The expression 'non-genomic nativism' was coined by Christopher Cherniak and collaborators at the University of Maryland in 1999 and has been used by them ever since (Cherniak et al., 1999; Cherniak et al., 2.004; Cherniak, 2009). Combining a detailed anatomo-physiological analysis of the nervous system of the nematode, all the way up to the cortex of cats and monkeys, with a long series of computational simulations, it emerged that the minimization of connection costs among interconnected components appears either perfect, or as good as can be detected with current methods. Such wiring minimization can be observed at various levels of nervous systems — invertebrate and vertebrate — from placement of the entire brain in the body down to the subcellular level of neuron arbor geometry. These instances of optimized neuroanatomy include candidates for some of the most complex biological structures known to be derivable `for free, directly from physics' [sic]. Such a `physics suffices' picture for some biological self-organization directs attention to innate structure via non-genomic mechanisms.

Since general network optimization problems are easy to state, but enormously computationally costly to solve exactly (they are in general what computer scientists call 'NP-hard': that is,

exponentially exploding in complexity), some simplifications had to be introduced. A `formalism of scarcity' of interconnections (the so-called `Steiner trees') was borrowed from engineering and used as the computational engine of network optimization theory, which characterizes efficient use of limited connection resources." Cherniak et al. conclude that the cortex is better designed than the best industrial microchip. For the macaque, fewer than one in a million of all alternative layouts conform to the adjacency rule better than the actual layout of the complete macaque set. In the relatively simpler case of the nematode Caenorhabditis elegans, its nervous system having been the first ever to be fully mapped, the actual layout of eleven ganglia is the wirelength-minimizing one, out of 40 million alternative possibilities.

In a 2009 paper, Cherniak specifies that:

> The neural optimization paradigm is a structuralist position, postulating innate abstract internal structure — as opposed to an empty-organism blank-slate account, without structure built into the hardware (structure is instead vacuumed up from input). The optimization account is thereby related to Continental rationalism; but for brain structure, rather than the more familiar mental structure.
> Cherniak, 2009

His message is that there is a 'pre-formatting' issue for evolutionary theory. Seeing neuroanatomy so intimately meshed with the computational order of the Universe brings one back, as he suggests, to the explanatory project of D'Arcy Wentworth Thompson and Turing (Cherniak, 2009). There is, indeed, in our terminology, a return of the laws of form.'$

Further examples
These further examples all share the property that we have emphasized: evolution seems to have achieved near optimal answers to questions which, if pursued by the application of exogenous filters to solutions generated at random, as the neo-Darwinist model requires, would have imposed searching implausibly large of spaces of candidate solutions.19 This seems an intractable enigma, unless prior filtering by endogenous constraints is assumed.20

The brain's grey and white matter
The segregation of the brain into grey and white matter has been shown by biophysicists to be a natural consequence of minimizing conduction delay in a highly interconnected neuronal network. A model relating the optimal brain design to the basic parameters of the network, such as the numbers of neurons and connections between them, as well as wire diameters, makes testable predictions all of which are confirmed by anatomical data on the mammalian neocortex and neostriatum, the avian telencephalon and the spinal cord in a variety of species (of mammals and birds) (Wen and Chklovskii,
200s).

Invariants of animal locomotion
Scaling laws and invariants in animal locomotion have been uncovered by engineer Adrian Bejan (Duke University) and biologist James H. Marden (University of Pennsylvania) by considering that `animal locomotion is no different than other flows, animate and inanimate: they all develop (morph, evolve) architecture in space and time (self-organization, self-optimization), so that they optimize the flow of material' (Bejan and Marden, 2006, p. 246).21

Pulling together, in their model, 'constructal' (sic) principles, equally applicable to the morphing of river basins, atmospheric circulation, the design of ships and submarines, and animal locomotion, regardless of whether it consists in crawling, running, swimming or flying, they can explain the nature of the constraints and derive principles for optimized locomotion. The parameters that

characterize, for each species, the locomotion that accomplishes the most for unit of energy consumed, that is, the points at the bottom of the U-shaped curve of cost versus speed, align neatly along a straight line in a logarithmic scale. Plotting optimal force against body mass, from the smallest marine creature to elephants, this straight line scales the very narrow range of speeds that maximize, for each species, the ratio of distance travelled to energy expended.
Simple equations that correlate body mass, body density, body length, the gravitational acceleration and the coefficient of friction reveal that even the distinction between flying, swimming and walking (crawling, running) is immaterial. Physical principles of optimization and simple scaling laws govern the phenomena of animal locomotion.

The physics of birdsong
Two physicists and a biologist, publishing in a physics journal, show that

> The respiratory patterns of the highly complex and variable temporal organization of song in the canary (Serinus canaria) can be generated as solutions of a simple model describing the integration between song control and respiratory centres. This example suggests that sub-harmonic behaviour can play an important role in providing a complex variety of responses with minimal neural substrate.
> Trevisan et al., 2006

A straightforward generalization to other kinds of birdsong in other species of singing birds is plausibly anticipated.

We want to raise the issue: have all sorts of suboptimal neuronal setups and of the ensuing suboptimal singing patterns been tried out at random over the aeons and natural selection made it so that only the optimal singers left descendants? Did the sub-harmonic equations become slowly encoded in the canary genes by chance trials and selection? Or are we witnessing an instance of physical optimization constraints channelling genetic, developmental and behavioural traits? Nobody at present has an idea of how these physical optimization factors interact, over evolutionary times and over ontogenetic times, with the genetic and epigenetic machinery of organisms. This is why the younger generation of biologists and biophysicists will enjoy unexpected discoveries in the decades to come. Lucky them!

The perfect leaves
Regarding the plant kingdom, a team of American and French biologists and physicists has recently determined by means of mathematical equations and artificial simulations that the spontaneous biological `design' of leaves is perfect. They generated parallel networks of channels in layers of artificial polymeric material (large molecules formed by multiply repeated smaller molecules chained together), and showed through such simple networks that the scaling relations for the liquid flow driven by evaporation reveal basic design principles that satisfy the most stringent engineering requirements for devices that are driven by evaporation—permeation factors. These authors highlight the role of physical constraints on the biological design of leaves (Noblin et al., 2008).22 They show that the flow rate through their biomimetic and real leaves increases linearly with channel density until the distance between channels is comparable with the thickness of the polymer layer, above which the flow rate saturates. A comparison with plant vascular networks shows that the same optimization criterion can be used to describe the placement of veins in leaves.

Optimal foraging strategies:23 the honeybees
As von Frisch had taught us, at the start of a foraging period some individual honeybees go out foraging on their own ('proactive' searchers) and some ('reactive' searchers) stay in the hive awaiting information from returning foragers that is conveyed by the famous `bee dance' (von

Frisch, 1967). The issue to be solved was: which optimal percentage of individuals should go out and forage on their own and which correspondingly optimal percentage should wait for information? Clearly, it can't be the case that all searchers are reactive; so the question arises whether there is an optimal percentage of proactive to reactive searchers (as a function of colony size and the availability of perishable food). Researchers (Dechaume-Moncharmont et al., 200s) combined measurements of actual foraging behaviours with a mathematical model of the energy gain by a colony as a function both of the probability of finding food sources and of the duration of their availability. The key factor is the ratio of proactive foragers to reactive foragers. Under specifiable conditions, the optimum strategy is a totally independent (proactive) foraging for all the bees, because potentially valuable information that reactive foragers may gain from successful foragers is not worth waiting for. This counter- intuitive outcome is remarkably robust over a wide range of parameters. It occurs because food sources are only available for a limited period. But their study emphasizes the importance of time constraints and the analysis of dynamics, not just steady states, to understand social insect foraging. The predictions of their model for optimal foraging, often quite counter-intuitive, have been confirmed both in the wild and in laboratory conditions (Dechaume-Moncharmont et al., 200s). The bees appear to be `sitting' (so to speak) at the optimum of the curve of the possible ratios of proactive versus reactive foragers in a variety of situations.
Once again, we want to raise some key issues for the theory of evolution: it's not possible that all sorts of foraging strategies have been tried out at random over the aeons, and that natural selection determined that only the optimal foraging bees left descendants. Maybe no neo-Darwinian wishes today to suggest this kind of crude hypothesis. A somewhat more plausible picture is that, once some change in foraging strategies has occurred, the range of further changes beyond that will have changed completely. The subset of possible further small changes around the present behavioural phenotype is constrained, and so is the subset around the underlying genotype and the developmental pathway. As suggested by Richard Lewontin, the metaphor is rather one of finding one's way through a maze, with no possibility of wandering back to the starting point. The population, or the species as a whole, is committed to certain downstream passages. Every evolutionary change constrains to some subset, and new sub-subsets of possible further mutational effects at the next step. It's hard, at present, to go beyond such metaphors.24 However, the picture of a blind search winnowed by selection is utterly implausible. Multiple stepwise canalization of variants, under the kinds of physical-computational constraints suggested by Cherniak et al. must have eventually led to an inbuilt computation of the optimal ratio of proactive and reactive foragers, somehow encoded in the interaction between genes, development and the action of some laws of form. The question here involves multiple individuals and their behaviour, and the solution will in due time turn out to be more complex than that of the individual canaries. Once again, nobody today really has a clue to a solution of these problems. These issues need to be raised nonetheless.

We have seen examples where it seems that only physicochemical and geometric constraints can explain the narrow canalizations that natural selection must have explored. The case of the bees, and two more that we are going to see (just a sample among many more in the recent literature) are such that, once more, the space of possible solutions to be explored seems too gigantic to have been explored by blind trial and error. The inference appears to be that a highly constrained search must have taken place. Accordingly, the role of natural selection may have been mostly just fine-tuning. Or less.

The perfect wing stroke

The utility of a sixth or a fifth of a wing has been questioned for quite some time (including by one of us in past writing) as a challenge for gradualist adaptationism. With a sixth of a wing an animal does not fly a sixth of the time or a sixth of the distance. It does not fly at all. Therefore, the challenge for gradualist adaptationism is to explain how mutations capable of producing full wings can have accumulated silently over a long evolutionary time in the absence of any adaptive advantage. This issue was raised for the evolution of insect wings by Kingsolver and Koehl (1985).

Insect wings are an evolutionarily significant novelty whose origin is not recorded in the fossil record. Insects with fully developed wings capable of flight appear in the fossil record in the upper Carboniferous (ca. 320 million years ago), by which time they had already diversified into more than ten orders, at least three of which are still extant. On the contrary, wingless insects are observed in the fossil record as early as the Silurian (ca. 400 million years ago) (Engel and Grimaldi, 2004). The intervening fossil record is poor, and no fossils showing intermediate stages in the evolution of wings have been identified (Yang, 2001). Several evolutionary scenarios have been proposed (Jockush and Ober, 2004). The interesting suggestion by Kingsolver and Koehl was that the initial selective factor had been thermal exchange, not mobility. A sixthof a wing in an insect cannot generate any lift, so no airborne mobility. That comes only after the wing reaches about 85 per cent of its full final size. But it does generate, by means of the tiny wing veins, a non-negligible capacity for raising the insect's temperature when exposed to sunlight. Their study was based on the comparative anatomy and physiology of several species of insects very similar to one another, except for having or not having wings, on calculations and on experiments with scale models in wind tunnels. Kingsolver and Koehl concluded that wings must have initially developed in insects as thermal organs, and later on, after gradual increase driven by this function, once a size capable of providing lift had been developed, further selection of a quite different kind ensued: selection for flight. If true, this would be another signal case of the role of free-riding traits (spandrels) in evolution, a topic to which we will return in a later chapter. In the meantime, however, the picture has somewhat changed. A complex interplay between master genes (homeotic genes) and tandem duplications of dorsal thoracic genes seems to be involved in the appearance of wings in insects (Carroll, 1995)• It is still being debated whether insect wings are an evolutionarily sudden novelty, or have evolved by modification of limb branches that were present in ancestral arthropods (Jockush and Ober, 2004). Possibly, the 'exaptationist' process suggested by Kingsolver and Koehl and internal genetic changes may have acted in concert. We saw in the previous chapter that such interchanges between internal genetic reorganizations and external factors do actually take place.

A different tack, this time for the evolution of wings in birds, was taken in a paper published in Nature in January 2008 by Kenneth P. Dial, Brandon E. Jackson and Paolo Segre (Dial et al., 2008). They present the first comparison of wing-stroke kinematics of the primary locomotor modes (descending flight and incline flap-running) that lead to level-flapping flight in juvenile ground birds throughout development. They offer results `that are contrary both to popular perception and inferences from other studies'. Prior to this study, no empirical data existed on wing-stroke dynamics in an experimental evolutionary context. In a nutshell, starting shortly after hatching and continuing through adulthood, ground birds use a wing stroke confined to a narrow range of less than 20 degrees, when referenced to gravity, that directs aerodynamic forces about 4o degrees above horizontal, permitting a 180-degree range in the direction of travel. Estimated force orientations from the birds' conserved wing stroke are limited to a narrow wedge. A main result of their extremely detailed comparative analysis of the wing-stroke plane angle, estimated force orientation and angle of attack among locomotor styles is that, when wing-stroke plane angles are viewed side by side in both the vertebral and gravitational frames of reference, the wing stroke is nearly invariant relative to gravity, whereas the body axis reorients among different modes of locomotion.

> Their experimental observations reveal that birds move their `proto-wings', and their fully developed wings, through a stereotypic or fundamental kinematic pathway so that they may flap-run over obstacles, control descending flight and ultimately perform level flapping flight. Interestingly, these authors offer the hypothesis that the transitional stages leading to the evolution of avian flight correspond both behaviourally and morphologically to the transitional stages observed in ontogenetic forms. Specifically, from flightless hatchlings to flight-capable juveniles, many ground birds express a `transitional wing' during development that is representative of evolutionary transitional forms.

Dial et al., 2008

They say that locomotor abilities of extinct taxa, such as the recently discovered fossil forms possessing what is assumed to be `half a wing', and long cursorial legs, might be better understood if we evaluate how proto-wings and hindlimbs function during ontogeny in extant taxa. Their experimental observations show that protowings moving through a stereotypic and conserved wing stroke have immediate aerodynamic function, and that transitioning to powered flapping flight is limited by the relative size of the wing and muscle
power, rather than development of a complex repertoire of wingbeat kinematics.

Fine, but then, in our view, another problem arises for gradualistic adaptationism, because another kind of discontinuity is appealed to.

In their own words: '... the gravity based wing-stroke did not come
about through a long series of migrational stages of the forelimb (from ventro-lateral to lateral to dorso-lateral): rather, the primitive wing-stroke started in a similar orientation as we see it today in hatchlings using their proto-wings' (Dial et al., 2008).

The angles of effective wing stroke are extremely narrow, as these authors have determined, and one wants to question the process through which this narrow wedge of angles became fixated even before there was any real flight. The amplitude of the search space for the optimal angle seems to be even more daunting than that of the search space for the series of migrational stages (ventro-lateral to lateral to dorso-ventral). One cannot help wondering, in this case too, whether physical (gravitational, aerodynamic) constraints have not narrowed down the morphological search space drastically. Evodevo mechanisms seem once more to have been severely constrained by non-biological, and surely non-selectional, factors.

The zombifying wasp

Finally, a case (again, among many) in which the genetic programming of a complex behaviour leaves no doubt. Such behaviours can be shown to be completely automatic through the whole sequence, and unlearned. To cut a long story short, a particular species of wasp (Ampulex compressa) uses a venom cocktail to manipulate the behaviour of its cockroach prey. As in some other species of solitary wasp, the female wasp paralyzes the cockroach without killing it, and then transports it into her nest and deposits her eggs into the belly of the cockroach, so that the hatchlings can feed on the cockroach's live body. What is peculiar to this species of wasp is that, by means of two consecutive stings, separated by a rather precise time interval, in two different and precisely chosen parts of the cockroach nervoussystem, the wasp becomes capable of literally `driving' the zombified cockroach into her prepared nest. The wasp does not have to physically drag the cockroach into the pit, because it can manipulate the cockroach's antennae, or literally ride on top of it, steering it as if it were a dog by a leash, or a horse by a bridle (Libersat, 2003). The first sting in the thorax causes a transient front leg paralysis lasting a few minutes. Some behaviours are blocked but not others. The second sting, several minutes after, is directly in the head.

As a result the wasp can grab one of the cockroach's antennae and walk to a suitable oviposition location. The cockroach follows the wasp in a docile manner like a dog on a leash (Williams, 1942; Fouad et al., 1994). A few days later, the cockroach serves as an immobilized and fresh food source for the wasp's offspring.

Some evolutionary questions

This rather horrendous entomological saga suggests some key evolutionary questions. Such complex, sequential, rigidly pre-programmed behaviour could have gone wrong in many ways, at any one of its steps. The biochemical nature of the cocktail of venoms could have been different in many

ways, being, as a result, either totally ineffective, or overdoing it, by killing the prey. The timing and location of the stings could have gone wrong in many ways, letting the cockroach recover, for instance, and kill the much smaller wasp. The wasp could have failed to `understand' that the prey can be led by the leash, after these two master strokes, and could have painfully dragged the rather big body to the nest. And so on and so on. The ways in which this behavioural sequence could have gone awry are indeed innumerable. Not even the most committed adaptationist neo-Darwinians suppose that all kinds of alternatives have been blindly tried out by the ancestors of the wasp and that better and better solutions were progressively selected, and that this optimal solution was finally retained and encoded for in the genes. True: wasps have been around for a very long time (some 400 million years, maybe more) but even this is not a long enough time to try out innumerable alternative behavioural solutions, with alternative possibilities conceivable at each step of the behavioural sequence. What, then? No one knows at present. Such cases of elaborate innate behavioural programs (spider webs, bee foraging as we saw above, and many more) cannot be accounted for by means of optimizing physicochemical or geometric factors. But they can hardly be accounted for by gradualistic adaptation either. It's fair to acknowledge that, although we bet that some naturalistic explanation will one day be found, we have no such explanation at present. And if we insist that natural selection is the only way to try, we will never have one.

A lot of tunnel at the end of the light

There is only so much that the 24,000 or so genes in the human genome can do to assemble a human being. To be sure, there are multiple gene regulations and networks of interactions, and morphogenetic attractors, and epigenetic modifications, and alternative gene splicing and complex interactions with many environments. The latter, in the case of humans, comprise `culture'. The task of those relatively few genes looks awesome, even considering the remarkable `multiplier' represented by alternative splicing (see Chapter 3). Among other complex structures, tens of millions of kinds of antibodies have to be produced, and 10 to the 11th neurons and 10 to the 13th situated synapses to be developed and fixated, and about 60,000 miles of veins, arteries and capillaries to be exactly placed in each of our bodies. Many processes of spontaneous self-organization surely take place, at many levels. That's where the physics of collective phenomena leaves a signature, in ways that still elude us. Both the genetic-epigenetic processes and these other processes are internally caused. Cherniak's notion of 'non-genomic nativism' (Cherniak et al., 1999, 2004; Cherniak, 2009) is appropriate and, it appears, inescapable.

Wrap-up of this chapter

Neo-Darwinists are keen to say that natural selection never optimizes, it only finds locally satisfactory solutions. 's From Francois Jacob's evolutionary `tinkering' to Maynard Smith's and Dennett's `satisficing',26 emphasis is always put on this consideration. It is important to our critique of neo-Darwinism that the problem of finding optimal solutions to evolutionary problems by filtering candidates generated at random would often be intractable. But, as we have just seen, there are some instances of optimal (or near-optimal) solutions to problems in biology; so, if natural selection cannot optimize, then something else must be involved. Very plausibly, the `something else' includes: physics, chemistry, autocatalytic processes, dissipative structures and principles of self-organization, and surely other factors that the progress of science will in due time reveal.

The moral here is a sort of dilemma for neo-Darwinists: even if we suppose, for the sake of argument, that natural selection does operate in the way that canonical neo-Darwinism claims it does, its degrees of freedom must be severely restricted. The minute proportion of the theoretical morpho-spaces of life that are actually occupied (McKinney and McGhee, 2003; McGhee, 2007; Raup, 1966) is something for which the theory of natural selection cannot account.27 We are understandably awed by the variety and the diversity of the forms of life, but it is important to underline

that, at an abstract level, when plotting the continuous possible variation of parameters of form, extant and extinct forms of life are a very tiny subset of what is possible in the abstract.28

NOTES

Chapter 2

1. Experimental data on, and computer simulations of, rather straightforward natural selection acting on random genetic mutations are being published in the most accredited biologicaljournals as of this writing (March 2009). See, for instance, Teo'tonio et al. (9), just one instance among many.
2. In the words of an expert on the history of evolutionary theories: `Darwin's theory of natural selection ... concentrates on the steady pressure of the environment when changes are very slow ... There can be no direction imposed on evolution by factors internal to the organisms, because the variation upon which selection acts is random in the sense that it is composed of many different and apparently purposeless modifications of structure. The environment determines which shall live and reproduce, and which shall die, thus defining the direction in which the population evolves ... In such a theory, the course of evolution is open-ended and unpredictable, because each population is subject to changes in its local environment or may encounter entirely new environments through migration' (Bowler, 2003, pp. 10-11). (We are grateful to Professor Thomas Lindell of the University of Arizona for this quote.)
3. The expression `shifting balance' was introduced into evolutionary theories by Sewell Wright in 1932. (Wright, 193z)• This is the component of `invisible hand' that Darwin himself had probably imported from Adam Smith and the evolution of free markets. The expression appears in Smith's The Wealth of Nations and in The Theory of Moral Sentiments with slightly different characterizations.
4. A smart, simple software, called NetLogo, allows one to visualize, step by step, the evolution of model situations. A priori intuition cannot anticipate the outcomes.
5. Some caveats are needed here. No neo-Darwinian would propose that hill climbing would be just as likely to generate a new trait requiring one base change as to a generate a new trait requiring ten base changes. Traits do not emerge with equal probability from some uniform flat `trait space'. Several probabilistic nuances and calculations were part of the canonical picture (Rice, 2004). But we think we can be excused from attending to these nuances here. The `blind' character of internal variation by mutation is indeed a prominent component of the neo-Darwinian picture (see especially Dawkins, 1986). Getting a lot (many highly complex life forms) from very little (a blind source of diversity) is supposed to be the glory of neo-Darwinism, the core (in Dennett's terms) of `Darwin's dangerous idea' (Dennett, 1995) (the reader be cautioned: Dennett thinks it's a marvellous idea — perhaps the best anyone has ever had; see also Dennett, 2007). In short, internal variation by mutation is supposed to be strictly random with respect to the selectional environment; there is no `look ahead' in deciding which mutations to produce. That much we are ready to grant, although epigenetics (see below) sometimes seems to suggest a rather different story.
6. An important technical problem worth mentioning here is that these representations assimilate the combination of gene frequencies to the frequency of their combination, and the rate of reproduction by a genotype to the rate of reproduction of that genotype (for a detailed critique of these confusions in formal models of Darwinian fitness, see Ariew and Lewontin, 2004).
7. For an application of fitness landscapes to (heaven help us) industrial supply networks, see Li et al. ().
8. For a recent balanced evaluation of Haldane's defence, see Ewens ().
9. In a remarkable early (1985) review of developmental constraints in evolution, we read: `[In adaptive evolution] it must often be the case that small changes in genotype often cause small changes in phenotype and that genetic changes altering one trait do not always result in excessively maladaptive changes in others. If complex adaptations involving many genes are to evolve by natural selection, it must be possible to change single traits without disturbing the others in a way

that reduces overall fitness ... However, there is more to evolution than an increase in adaptation, and various types of developmental constraints, linking diverse traits, do exist' (Maynard Smith etal., 1985, p. z66, emphasis added). We will return to this paper later on.
10. The origin of this story is detailed in the Wikipedia article `Bert & I' (see http://en.wikipedia.org/wiki/Bert_and_I [accessed September 9]).
11. We have been reminded recently (October) of the unabated importance of DNA sequences in an editorial in Science, aptly entitled `It's the sequence, stupid!' (Colley and Kruglyak,). In a nutshell, the transplantation of an entire human chromosome (chromosome 21) into a mouse cell that also contains the whole complement of the mouse genome shows that it is the regulatory DNA sequence, rather than any other species-specific factor, that constitutes the single most important determinant of gene expression (Wilson et al.,).
12 This term 2008 was coined in the mid-1990s from the words `evolution' and `development', rightly seen as two faces of the same coin. It became almost at once successful. It's presently common currency both in biology proper and in scientific popularizations.
13. Excellent accessible expositions have been available now for some years: West-Eberhard, 2003; Kirschner and Gerhart, 2005; Carroll, 2005, 2006. An earlier important recognition came with the 1995 Nobel Prize for Physiology or Medicine to Lewis, Nusslein-Volhard and Wieschaus (see Lewis et al., 1997).
14. There are at least 282 genes in humans that are somehow associated with mental retardation, of which i6% have orthologues (genes precisely corresponding, by position, sequence and function) in the fruit fly (Restifo, 2005). Detailed studies of the neural causes of specific forms of mental retardation in children (Noonan syndrome) are carried out by `knocking out' corresponding genes in the mouse, and by studying the developmental role of analogous genes in the fruit fly (Gauthier et al., 2007).
15. As early as 1991, a transferred human master gene (HOX4B) was shown to produce a head-specific expression in Drosophila (fruit fly) embryos (Malicki et al., 199z)
16. A recent daring hypothesis, of a universal genome, has been advanced by Michael Sherman of Boston University. He says: `I propose [the hypothesis of a] Universal Genome that encodes all major developmental programs essential for various phyla of Metazoa emerged in a unicellular or a primitive multicellular organism shortly before the Cambrian period ... The Metazoan phyla, all having similar genomes, are nonetheless so distinct because they utilize specific combinations of developmental programs. This model has two major predictions, first that a significant fraction of genetic information in lower taxons must be functionally useless but becomes useful in higher taxons, and second that one should be able to turn on in lower taxons some of the complex latent developmental programs, e.g., a program of eye development or antibody synthesis in sea urchin' (Sherman, 2007).
17. For the opposite polarity in the origins of the nervous systems in insects and vertebrates see Sprecher and Reichert (2003).
18. Much more in Chapter 8 against this ill-conceived notion that there are evolutionary `problems' that species are supposed to have to `solve'. (Germane considerations are to be found in Pigliucci 2009a, page 2z3.)
19. The first such laboratory reproduction of a plausible evolutionary event was Ronshaugen et al. (2002).
20. We want to mention here, but not develop, the close parallel between the notion that a variety of life forms have been generated by differences in regulatory processes acting on the same (or very similar) genes and the idea that the manifest differences in the languages of the world may have been generated by changes in a small set of `parameters' acting on the same (or very similar) basic linguistic principles. (For a recent treatment see Chomsky, 2009; for a classic treatment, see Chomsky, 1981; for one of the earliest detailed cases, see Rizzi, 1989). Chomsky's initial suggestion (in lectures at MIT in 1978 and 1979) was explicitly motivated by ideas due to the French geneticist (and Nobelist) Francois Jacob about how slight rearrangements of timing and organization of regulatory circuits might yield the difference between an elephant and a fly (see also Chomsky, 9).

21. A uniquely human developmental factor (a gene enhancer called HACNSi) accounting for the particular formation of human limbs has been recently identified by comparison with the corresponding factor in transgenic mice, rhesus monkeys and chimpanzees (Prabhakar et al.,).
22. For recent comprehensive reviews, see Mattick, 2005; Amaral and Mattick, 2008; Mattick and Mehler,; Stefani and Slack, .
23. The messenger RNA undergoes several modifications and processing (notably splicing, see below) and is then `translated' in the ribosomes into a sequence of amino acids, called a polypeptide. Finally the folding of this sequence into a specific three-dimensional configuration is the protein that is said to be `coded' by the gene. The complex relation between the linear sequence of the amino acids and the three-dimensional protein configuration has been actively studied for decades but remains to this day elusive (for recent advances on the `knotting' of the polypeptide chain, see Mallam et al.,).
24. It has been suggested recently, on solid evidence and sound theory, that the internal structure of living cells (bacteria excluded) is relevantly similar to the structure of glass (Trepat et al., 2007) (we are grateful to Professor Fernando Martinez of the University of Arizona for bringing this interesting idea to our attention). Further suggestions of a 'glass-like' structure of the fitness landscape in a mathematical model of speciation in general have been made by Heo et al. (20o9).
25. See the next chapter on the pioneering experiments by Waddington.
26. A recent analysis of the buffering of mutations by HSP90 in the plant Arabidopsis thaliana has led the authors to state: `This result strengthens the plausibility of previous suggestions that HSP90 might play an important role in enhancing the rate of evolutionary change. Moreover, we propose that far more genetic variation may be available to alter phenotype than quantitative genetic studies generally suggest' (Sangster et al.,, p. 1973). To the simple question of how many traits can be affected, their answer is `nearly every one'. `We demonstrate that HSP9o-responsive natural genetic variation can be observed in A. thaliana at such a frequency that nearly every trait could be expected to be affected.'
27. Quite intuitively, supposing that a gene contains ten exons, in one case (typically, in one kind of tissue) all of them are transcribed and expressed in that order. In another case (in another kind of tissue) we can have, say, the sequence 1,2,5,6,7,8,9,10, in yet another 1,2,3,4,7,8,9,10 and so on. A mutation affecting one exon will affect all the proteins in which it is expressed, hence affecting many tissues at once.
28. A felicitous formula suggested by Schmucker and Chen (2009) when reviewing data on alternative splicing of a number of genes connected with the immune system, neural wiring and the adhesion between cells in various species is: `complex genes in simple animals, complex animals yet simple genes'.
29. Alternative splicing also seems to be linked to a process (technically called 'polyadenylation') whereby a repeat of chemical groups (the adenines) are added to the ends of mRNA to help stabilize it. Both processes (alternative splicing and stabilization) appear to be regulated by a common mechanism.
30. BGC is not the only mechanism in Dover's original picture. There is also unbiased gene conversion, a process that has basically the same effects as BGC, but over much longer evolutionary times.
31. Notably Gerald Edelman, in several popularization books (e.g. Edelman, 1987) and technical articles, has promoted his `theory of neuronal group selection' (TNGS). Similar `internal' Darwinian mechanisms for the development of the brain have been proposed by French neurobiologist Jean-Pierre Changeux (Dehaene et al., 1987).

Chapter 3
1. An excellent short summary of gene regulation in higher organisms (eukaryotes) is to be found in http://users.rcn.com/ jkimball.ma.ultranet/BiologyPages/P/Promoter.html [accessed September 2009].

2. Let's be reminded of the biological classifications, top to bottom, with some simple canonical examples for each group. Historically, it goes all the way back to Carl Linnaeus (1707-1778): Domain (eubacteria, archaea, eukaryotes) Kingdom (protista, chromista, fungi, plants, animals, metazoa) Phylum (chordates, arthropods, molluscs, annelids, echinoderms) Sub-phylum (urochordates, cephalochordates, vertebrates, crustaceans) Class (mammals) Order (primates) Family (lemuridae) Genus (lemur) Species (ring-tailed lemur)
3. Interestingly, a debate ensued in Science pitting Davidson andErwin against a defender of more traditional Darwinism, Jerry A. Coyne, who questioned these assumptions and claimed to be able to show that natural selection adequately explains the origin of new phyla. Coyne characteristically (and perplexingly) states that `it is unlikely that macromutations played an important role in major evolutionary change' (Coyne, 20o6). See the reply by Erwin and Davidson (2006). See also Coyne (2009).
4. Of course, nobody ever claimed that variations arise completely at random. As we said earlier, even in the canonical neoDarwinian picture, a variation that is the result of, say, ten mutations, is less likely to arise than one that is the result of one mutation only. Such differential probabilistic patterns have been assumed as a standard. However, the `blind' character of mutations and some kind of random `engine' at the roots of genetic variability are at the very core of the picture.
5. It doesn't, however, tell us that the mechanism by which it evolved was natural selection. Darwinism implies environmentalism, but not conversely. This is important because, as we'll see in later chapters, there remains something deeply wrong with selectionism even if environmentalism is assumed.
6. This is strictly connected with the notion of evolutionary spandrels, to which we will amply return in Chapter 6.
7. Interesting considerations are developed by these authors, based on experimental data and accurate mathematical models. `The most consistent result in more than two decades of experimental evolution is that the fitness of populations adapting to a constant environment does not increase indefinitely, but reaches a plateau. Using experimental evolution with bacteriophage, we show here that the converse is also true. In populations small enough such that drift overwhelms selection and causes fitness to decrease, fitness declines down to a plateau. Both of these phenomena must be due either to changes in the ratio of beneficial to deleterious mutations, the size of mutational effects, or both. The most significant change in mutational effects is a drastic increase in the rate of beneficial mutation as fitness decreases. In contrast, the size of mutational effects changes little even as organismal fitness changes over several orders of magnitude (a factor 300 in this case)' (Silander et al., 2007). The overall size of the population is shown to be crucial in determining the possibility of fixation or disappearance both of advantageous and of disadvantageous mutations.
8. See Schlosser (2.004).
9. A cogent defence of the idea that dynamic developmental modules may have been the key to the explosion of new life forms in the Cambrian is to be found in Newman and Bhat
10.. We see that the notion of developmental and evolutionary modules isn't really so simple to define, but it's easy to get it intuitively. Let's say that components belong to a module when it is easier for them to communicate with one another than with anything else. Think of a jury that has a spokesperson: the members of the jury can talk to one another, but only the spokesperson can talk to the judge.
11. In the fruit fly, an antenna may be made to grow where normally a leg develops, or the rudiments of an eye can be made to develop almost anywhere, by activating the Pax6 gene complex.
12. The BMP4 protein (a ubiquitous bone morphogenetic protein) and the factor CaMKII (calmodulin kinase II).
13. As usual, we aren't saying that we've got right what environmentalists get wrong. Our point is just that, contrary to frequently heard claims that neo-Darwinism is the only game in town, there

are, in fact, prima facie plausible alternatives. Nobody knows exactly how evolution works, so internalists sometimes tell `just so' stories too.
14. `Although evolutionary change, biogeographic provinciality, and paleo-environments might have played a role in Ediacara taxonomic evolution, they do not seem to have controlled the overall range of the realized morpho-space, which appears to be invariant to notable taxonomic differences. Thus, changes in taxonomic diversity that occurred through time while morphospace range remained relatively constant should affect the internal structure of morphospace' (Shen et al.,).
15. A recent vindication of discontinuous evolutionary processes (an explicitly and intentionally dissonant note in the vast concert of celebrations of the Darwinian bicentenary) is found in Theissen (2.00g). Let's be reminded of the oft-quoted
and rather sad (in hindsight) passage in Darwin that we have transcribed at the very opening of this book: `If it could be demonstrated that any complex organ existed which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down' (Darwin, 18.59, p. 194)•
16. We are, once more, indebted to Richard Lewontin for having rightly insisted, over many years, on the crucial importance of the transitivity assumption in adaptationist explanations.
17. 'Epistasis means that the phenotypic consequences of a mutation depend on the genetic background (genetic sequence) in which it occurs ... These distinctions are crucial in the context of selection. Mutations exhibiting magnitude epistasis or no epistasis are always favoured (or disfavoured), regardless of the genetic background in which they appear. In contrast, mutations exhibiting sign epistasis may be rejected by natural selection, even if they are eventually required to increase fitness. In other words, some paths to the optimum contain fitness decreases, while other paths are monotonically increasing. When all paths between two sequences contain fitness decreases, there are two or more distinct peaks. The presence of multiple peaks indicates reciprocal sign epistasis, and may cause severe frustration
of evolution. Indeed, reciprocal sign epistasis is a necessary condition for multiple peaks, although it does not guarantee it: ... two may be connected by a fitness-increasing path involving mutations in a third site' (Poelwijk et al., 2007, p. 383).
18. Richard Lewontin aptly insists on the greater value of this different metaphor.
19. A genetic analysis of the many-tentacled polyp Hydra (also rich in mythological overtones), carried out with sixteen different types of Hydra from fifteen widely separated and ecologically distinct localities in India, has revealed that local adaptation
is simply the result of switching specific genes, depending on the ecological requirements (Rastogy and Pandey, 199z; Hoenigsberg, 100z).. The special implications of such systems for the action of natural selection had long been recognized by Sewall Wright (Wright, 1931).. In their reply to Coyne, Erwin and Davidson emphatically declare: `Nowhere in our paper did we reject natural selection, because we support it'.. There is at present only one rather well-supported adaptationist reconstruction of human phenotypes: protection from malaria conferred by the heterozygotes for haemoglobin S. A much less plausible case is the one of vitamin D, and fair skin related to poor exposure to sunlight. Contrary to many claims made by evolutionary psychologists, no clear case exists at all in the domain of human behaviours and cognition (for germane considerations, see Lewontin, 1998).

Chapter 4
1.These variants are aptly called ultrabithorax, and the master gene controlling this developmental pathway is called Ubx. Interestingly, as a further instance of the interchangeability of reactions to external shocks and to genetic changes, the phenotypes resulting from well-characterized (homeotic) mild mutations in the Ubx gene closely resemble the phenotypes resulting from early exposure to the ether fumes.
2. We wish to express our debt to Richard Lewontin for suggestions on this whole section.

3. Later work by Rendel (Rendel, 1968, 1969) — especially focused on the 'scute' mutant in the fruit fly — has shown that there are genes that buffer development, in the sense that small internal variations and small variations in an ordinary environment have no effect downstream in development. The shock, being a major variation in the environment, uncovers the effects of otherwise hidden variation, driving a few individuals outside the zone of buffering. Some buffering genes, somewhere in the genome of those individuals, are not doing such a good job. With repeated selective breeding, the frequency of those gene variants increases. More and more individuals are completely outside the buffering zone and they can produce abnormal offspring without need of any shock. Rendel and Lewontin point out that this is the explanation of what Waddington had aptly called `canalization' and `genetic assimilation'.
4. Claims can be made that we have not yet discovered the adaptive role of these phenotypes. Adaptationists are inclined to make such claims. But we wish to suggest that it's likely that these phenotypes have no adaptive role at all. The complex dynamics of repeated selection and cross-breeding in the laboratory, over many generations, unmasks pre-existing silent mutations, and the different developmental pathways induced by these give rise to new phenotypes. No adaptive process is needed. Analogous phenomena have no doubt happened in evolution.
5. We will return to this issue in Chapter 8.
6. For a full mathematical treatment see Rice (2004).
7. We are indebted to Richard Lewontin for drawing our attention to this case and for comments and suggestions on an earlier draft of this section.
8. Only two out of the four initial strains could ferment (digest) sugar z. These were taken and a further selection for sugar 3 was tried. One strain was such that this could never be obtained. In essence, there were several dead ends after the first phase, and one dead end after the second phase.
9. Another remarkable case of the role of contingency in evolution has been published recently (Blount eta!.,). After monitoring 31,500 generations in identical populations of E. coli, a variant capable of utilizing citrate finally appeared. These authors conclude that it is probably an ordinary mutation, but one whose physical occurrence or phenotypic expression is contingent on prior mutations in that population. They say: '... the evolution of this phenotype was contingent on the particular history of that population. More generally, we suggest that historical contingency is especially important when it facilitates the evolution of key innovations that are not easily evolved by gradual, cumulative selection' (p. 7899). The importance of contingency, now increasingly stressed in biology proper, supports our suggestion that evolutionary explanations based on adaptation and natural selection are not in the same league as proper scientific laws, but rather in that of historical explanations (see Chapter 9) (D'Arcy Wentworth Thompson had insightfully suggested exactly this, back in 1917 in his monumental essay `On growth and form' [Thompson, 1917).
10. The size of one of these chemical groups that can become stuck to the histones, or to DNA, is to the size of the histories themselves, or of the DNA composing an entire gene, as the size of a pebble picked up by a groove in a tyre is to the size of a whole bus. But small does not mean unimportant.
11. A detailed genetic and epigenetic analysis of the DNA sequences in various cells of identical (monozygotic) and fraternal (dizygotic) twins, with special attention to the differences in the DNA methylation sites, has been completed (February 2.009) in concert between laboratories in Canada, the USA, Taiwan and Sweden. Cutting a long and fascinating story quite short, the 26 authors of the report conclude `that molecular mechanisms of heritability may not be limited to DNA sequence differences' (Kaminsky et al., 20o9).
12. If you are of Swedish origins, you had best hope that your grandfathers didn't have too much to eat, but that your grandmothers did.
13. Jean Baptiste de Lamarck (1744-182.9) maintained that evolution, and speciation in particular, takes place via inheritance by the offspring of individual modifications caused by the environment in their parents. Although Darwin was a kind of self-confessed Lamarckian, Darwinism sounded the

death knell for any such idea, and it is still the case that the simple mention of Lamarckism leads the majority of biologists to draw their revolvers. Whence the present perplexity caused by some aspects of epigenetics. Let's state clearly that, at present, only quite tentative links have been established between the inheritance of epigenetic traits and speciation (Randy Jirtle, personal communication, February 9). We are bringing epigenetics into our picture because it's an extremely vital new field of inquiry, because it offers a remarkable instance of the multiplicity and subtlety of different `environments' and to stress the many nuances that one has to take into consideration when connecting genes to phenotypes (for early reviews, see Hoenigsberg and Pembrey [2002]).
14. A recent (October) analysis of one human gene, SEPNi, which is known to be involved in a type of muscular dystrophy, along with comparative data from chimpanzee and macaque tissues, suggested that the presence of a muscle-specific Aluderived exon resulted from a human-specific change that occurred after humans and chimpanzees diverged evolutionarily (Lin et al.,).
15. In a recent report (October) a team of Stanford geneticists has explored the population dynamics and evolution of transposable elements in the fruit fly (Drosophila), with special attention to their possible adaptive role. Theirs is the first comprehensive genome-wide screen for recent adaptive TE insertions in Drosophila. Using several independent criteria, they identified a set of 13 `adaptive' TEs. It is estimated that 25-5o TEs have played adaptive roles since the migration of Drosophila out of Africa. These TEs are judged by these authors to have contributed significantly to local adaptation in this species (Gonzalez et al.,).
16. In particular: the development of the brainstem trigeminal nuclei (the so-called barrelettes), of the barreloids in the thalamus and of the barrels in the neocortex.

Chapter 5
1. `From above' doesn't, of course, mean `from God'; it means multi-molecular and multicellular factors and abstract formal principles. Nothing else.
2. Technical note: in the Fibonacci series, each term is equal to the sum of the two preceding ones (, r, z, 3, 5, 8, 13,, and so on). Connecting the outer vertices of an ordered pattern of juxtaposed squares that have areas given by the Fibonacci series with a continuous curve, we obtain the Fibonacci spiral. The ratio between two successive terms of the Fibonacci series tends to the golden mean as a limit (approximately 1.611803399). Fibonacci spirals are usually formed when the elements of a pattern optimize their disposition with respect to two opposing forces. The presence of Fibonacci patterns is ubiquitous in plants (phyllotaxis) (Maynard Smith et al., 1985), and two French statistical physicists, Stephane Douady and Yves Couder, have shown how these arise in nature, in a laboratory experiment (with magnetically charged droplets) and in mathematical simulations, from self-organization in an iterative process. These patterns, realizing optimal packaging solutions, depend only on initial conditions and one parameter that determines the successive appearance of new elements. The ordering is explained by the system's tendency to avoid rational (periodic) organization, thus leading to a convergence towards an angle dictated by the golden mean. For beautiful figures and a formal treatment, see Douady and Couder (1992). For a movie clip showing the formation of Fibonacci spirals by the droplet in real time, see http://maven.smith.edu/-phyllo/Assets/Movies/ DouadyCouderExp5.9MB.mov [accessed September 9].
3. Logarithmic spirals are commonly observed in molluscs, brachiopods and some foraminifera, as remarked already by D'Arcy Wentworth Thompson (Thompson, 1917, 199z) and later analysed mathematically and empirically by David M. Raup, Steven Jay Gould and A. Michelson (for an analysis and a rich bibliography, see the already cited review by Maynard Smith et al. [1985]; see also Raup [1966, 1967]).
4. Zexian Cao and colleagues at the Chinese Academy of Sciences recently used stress engineering to create differently shaped microstructures just 12 micro-m across with a silver core and a Si02 shell. They discovered that if the shells were encouraged into spherical shapes during cooling, `golden' triangular stress patterns formed on the shells. On the other hand, if they were encouraged into conical shapes, spiral stress patterns were formed. These spiral patterns were

Fibonacci spirals. Their comment is that biologists have long suspected that the branching of trees and other occurrences of the Fibonacci sequence in nature are simply a reaction to minimize stress; they say that their experiment `using pure inorganic materials may provide proof to this principle' (Cartwright, 2007; see also Li et al., 2007).
5. For (what some may consider rather daring) applications of the Fibonacci numbers to linguistic structures at various levels, see Medeiros,; Piattelli-Palmarini and Uriagereka, 2008; Soschen, .
6. It is of some historical interest that the great German poet and naturalist Johann Wolfgang von Goethe, inspired by Plato's theory of eternal and changeless forms, and by Spinoza's doctrine of an infinite combination of `modes', had the idea of Urpflanze, the archetypal forms after which all other plants are patterned. However, the modern scene actually starts with D'Arcy Wentworth Thompson.
7. He suggested, as we also do in Chapter 7, that evolutionary explanations are historical and narrative in character, employing the same intentional and teleological vocabulary we use in presenting human history, and hence, while perhaps on occasion of heuristic value, they are not part of biology as a natural science (see also Leiber, 2001).
8. Some of Turing's statements in that paper sound rather preposterous today: '... it is only by courtesy that genes can be regarded as separate molecules. It would be more accurate (at any rate at mitosis) to regard them as radicals of the giant molecules known as chromosomes ... The function of genes is presumed to be purely catalytic. They catalyze the production of other morphogens, which in turn may only be catalysts.'
9. An interesting anecdote: in 1951 Belousov (Director of the Institute of Biophysics in Moscow) submitted a paper to a scientific journal reporting to have discovered an oscillating chemical reaction. It was roundly rejected with a critical note from the editor that it was clearly impossible. The editor's confidence in its impossibility was such that even though the paper was accompanied by the relatively simple procedure for performing the reaction, he could not be troubled. If citric acid, acidified bromate and a ceric salt were mixed together, the resulting solution oscillated periodically between yellow and clear. He had discovered a chemical oscillator. (See the website of Rubin R. Aliev, Institute of Theoretical & Experimental Biophysics, Puschino, Moscow Region, Russia, and movie clips of such reactions at http://online.redwoods.cc.ca.us/instruct/darnold/DEProj/Sp98/Gabe/intro.htm [accessed September 2009].
10. Catastrophes in systems with only one state variable: the fold (one control parameter); the cusp (two control parameters); the swallowtail (three control parameters); the butterfly (four control parameters). Catastrophes in systems with two state variables: the hyperbolic umbilic (three control parameters); the elliptic umbilic (three control parameters); the parabolic umbilic (four control parameters). Thom proved that no classification can be made at all for systems with more than four control parameters.
11. An exception is the attention to, and endorsement of, Waddington's work expressed in the 1985 review by Maynard Smith, Burian, Kauffman, Wolpert and colleagues (Maynard Smith et al., 2005). The work of Rendel and his Australian school, as mentioned in the previous chapter, offered an explanation of the phenomena discovered by Waddington, and his model of genetically modulated developmental buffering is a bridge to the modern field of epigenetics.
12. Mostly, it has to be said, by stressing the importance of the laws of form for evolution and development rather than offering workable concrete models.
13. Maynard Smith and Savage (1956) stressed how the law of the lever requires that any uncompensated changes in the speed with which a limb can be moved will reduce the force that it can
exert.
14. Lewontin has recently expressed perplexity towards the terminology of `laws of form', being doubtful that there are any genuine `laws' in biology (personal communication, October 2008).
15. Eva Jablonka and Marion Lamb, in a 2005 book that explains very clearly most of the recent developments in evolutionary biology and rightly pleads for a radical reconsideration of evolutionary theory, completely ignore the issue about the laws of form (see Piattelli-Palmarini,).

Curiously, they stress the need for a `fourth dimension' in evolution, ignoring that West, Brown and Enquist in 1999 had introduced this very expression for a totally different aspect of evolution (the fractal law) (West et al., 1997, 1999,).
16. The natural general equation is of the form Y = Yo(M) to the b power, where b is the scaling exponent, M the body mass and Yo a normalization constant. It turns out that b is a simple multiple of 1/4 instance:
— diameter of tree trunks and aortas, b = % (therefore, for their cross-sectional area, b = 3)
— rates of cellular metabolism and heartbeat, b = —'/4 — blood circulation time and lifespan, b = 1/4
— whole organism metabolic rate, b = 3/
17. The field matured in the 1970s for microcircuit design, typically to minimize the total length of wire needed to make a given set of connections among components.
18. The nearly optimal character of the genetic code is another instance. Among thousands of possible alternatives, the genetic code as we know it is optimal for minimizing the effect of frame-shift mutations and minimizing the energy wasted in synthesizing the start of anomalous protein sequences. In the words of the authors: `the universal genetic code can efficiently carry arbitrary parallel codes much better than the vast majority of other possible genetic codes' (Itzkovitz and Alon, z.007).
19. In the case of brain connectivity optimization a la Cherniak and colleagues we have a rather precise calculation of the hypothetical search space. The distribution of wirecosts (total wirelength) of all possible layouts of ganglia of the `simple' nematode Caenorhabditis elegans (a 10,000-bin histogram) represents almost 40 million possibilities (39,916,800 alternative orderings). The numbers for the possible layouts of the nervous systems of more complex and more recent species spiral upwards steeply. The possibility of a blind search, followed by natural selection, in such gigantic spaces is extremely implausible.
20. As stated elsewhere (in Part two), we use here for mere expediency this (alas) standard notion of `problems' posed to the evolution of organisms, and of `solutions' to these problems, with scare quotes..
21. We are indebted to Professor Marc Hauser of Harvard University for presenting these data by Bejan and Marden at a symposium in 2005, before they were published.
22. They say: `The long evolution of vascular plants has resulted in a tremendous variety of natural networks responsible for the evaporatively driven transport of water. Nevertheless [until now], little [wa]s known about the physical principles that constrain vascular architecture' (Noblin et al., p. 9140).
23. The specialized literature on optimal foraging is huge, spanning the individual and collective behaviours of a variety species of fish, ants, bees, birds, deer, monkeys and apes.
24. Both Anna Dornhaus and Richard Lewontin pointed this out to us in personal exchanges.
25. Let's stress here and now that the quite popular metaphor of `problems' that require `solutions' in the domain of evolution is badly misguided (see Part two for a detailed discussion, see also Lewontin [2000] and Pigliucci [2009a]). We have used it previously and we use it again here only for the sake of simplicity, but our present considerations do not depend on taking this metaphor seriously. Its use can only worsen the case of adaptationist neo-Darwinism.
26. The term 'satisficing', initially coined in the domain of decision-making by the economist and psychologist Herbert Simon (1916-2001), winner of the Nobel Prize for Economics in 1978, characterizes a strategy which, somewhat more modestly and more rapidly, attempts to meet criteria for adequacy, rather than to identify an optimal solution. Under this or similar labels, the concept has been widely adopted by evolutionary biologists such as John Maynard Smith, by neo-Darwinian cognitive scientists such as Daniel Dennett and Gerd Gigerenzer (fast and frugal heuristics) and by researchers in artificial intelligence and computer science.
27. Evolutionary biology has traditionally been concerned with explaining why there are the life forms that there are. By contrast, the present issue is why there aren't the life forms that there aren't (see the previous chapter). We will return to such issues in Chapter 7.

28. For example, in the helical morphology of colonies of moss animals called bryozoans, a very common fossil the world over, actual forms cluster into a handful of shapes, showing a space that is otherwise massively empty (McKinney and McGhee, 2003).

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Creationism and Intelligent Design: Scientific and Theological Difficulties
David H. Bailey

Introduction

Many religious believers today are comfortable with the notion of an evolutionary process over many millions of years as God's means for achieving the creation. In other words, they believe that while God governed the creation in some sense, it proceeded largely by natural laws and processes that can be uncovered by diligent research. An open-ended philosophy of this sort is entirely consistent with modern scientific knowledge, and for many (the present author included), the "war" between science and religion ends here.

A recent report by the National Academy of Science observed, "Science and religion are based on different aspects of human experience … Attempts to pit science and religion against each other create controversy where none needs to exist." The report adds, "Scientists and theologians have written eloquently about their awe and wonder at the history of the universe and of life on this planet, explaining that they see no conflict between their faith in God and the evidence for evolution."1 Among the notable and openly religious scientists cited in this report are Francis Collins (Director of the U.S. National Institutes of Health and former Director of the Human Genome Project), Kenneth Miller (a well-known biologist and co-author of a widely used biology textbook), and George Coyne (former Director of the Vatican Observatory).

Others in modern society (often but not always associated with conservative religious movements) insist on a more traditional view of the creation. Many of these persons further believe that there is scientific evidence to support such a view. In a 2004 poll, 45 percent of Americans agreed that "God created human beings pretty much in their present form at one time within the last 10,000 years or so."2 In a 2005 poll, 42 percent of Americans agreed that "humans and other living things have existed in their present form since the beginning of time."3 Such persons have been drawn to the "creationist" movement and still are, although today the "intelligent design" (ID) movement has been growing in popularity.

Typical of recent creationist literature is the declaration that "millions of years of evolution not only contradicts the clear teaching of Genesis and the rest of Scripture but also impugns the character of God."4 ID literature is more accepting of modern science, but still holds that Darwinian evolution is scientifically faulty, and cannot be reconciled with Judeo-Christian theism.5

This paper will examine the "creationist" and "intelligent design" movements from both a scientific and a theological perspective. This discussion is framed for adherents of the Church of Jesus Christ of Latter-day Saints (LDS), although much of this analysis is independent of any particular religious denomination.

I wish to emphasize that the terms "Creationism" and "Intelligent Design" are used here only to designate the two specific movements described above. As noted above, a suitably open-ended notion of "creation" and "design" is entirely consistent with both scientific knowledge and theology, and is recommended as a basis for those seeking harmony between science and religion.

Traditional Creationism and Intelligent Design

The traditional creationist movement, which has been termed "scientific creationism" or "creation science" by its practitioners, originated with the publication of George McCready Price's book The New Geology in 1923, and gained momentum in the 1960s, 1970s and 1980s with works by John Whitcomb, Henry Morris and Duane Gish.6 These writers have attempted, by means of both scientific and theological arguments, to defend a highly literal (albeit somewhat selective) reading of Genesis – the earth was created a few thousand years ago, and its fossil layers were deposited during a great flood at the time of Noah. Efforts to promote this form of creationism in public schools foundered in 1982, when an Arkansas court ruled that creationism is religious dogma, and lost more ground in 1987, when the U.S. Supreme Court ruled that a Louisiana law requiring "equal time" for creationism and evolution was unconstitutional.7

However, the creationist movement continues to exert considerable influence in the U.S. and elsewhere. One indication of this is the popularity of the new Creation Museum in Petersburg, Kentucky (near Cincinnati, Ohio). This facility features a series of exhibits depicting, among other things, the creation in 4000 BC, a global flood in 2350 BC that deposited all fossil layers, and humans and dinosaurs living together. Murals contrast "human reason" with "God's Word."

In the two years since it opened in 2007, the museum has attracted over 700,000 visitors.8 In the early 1990s, a group of scholars formed the "intelligent design" (ID) movement. Unlike creationists, these scholars, including Michael Behe, William Dembski, Phillip Johnson and Jonathan Wells, have respectable academic credentials and generally accept the overall scientific account and timeline of the creation. However, they still insist that many features of life on earth are too complex to be explained by natural evolution. They generally acknowledge limited variations within basic "kinds," but insist that the individual kinds were separately formed or designed by an intelligent entity, utilizing means that may not be subject to human investigation.9

ID writers and their proponents take pains to distinguish themselves from traditional creationists, but it is clear that both the creationist and ID movements are connected to the evangelical world. Each of the four prominent ID scholars mentioned above (except for Michael Behe, who is Catholic) is affiliated with an evangelical denomination, and all have acknowledged that religious beliefs are a principal motivation for their work. The ID-authored textbook Of Pandas and People is a lightly edited version of an earlier creationist textbook, where, among other things, the word "creation" has been replaced with "intelligent design."10 The Discovery Institute's Center for Science and Culture, which is the umbrella organization and funding source for much of the ID work, is devoted "to defeat scientific materialism and its destructive moral, cultural, and political legacies" and "to replace materialistic explanations with the theistic understanding that nature and human beings are created by God." To this end, they have outlined a "wedge" strategy, which recommends that they proceed in degrees, first by "teaching the controversy" of evolution, then promoting ID as an alternative theory to evolution, then edging out evolution in favor of biblical theism.11

Capitalizing on widespread popular support, various groups have attempted to require teaching of creationism or ID in public schools, or at least to require some form of disclaimer of evolution. A Georgia suburban school district recently required stickers to be placed in textbooks emphasizing that evolution is "a theory, not a fact."12 The Kansas Board of Education approved a new science curriculum that requires challenges to evolution.13 Both of these measures were later overturned by court rulings.

In one prominent case, the Dover Area School Board in Pennsylvania voted that "Students will be made aware of gaps/problems in Darwin's theory and of other theories of evolution including, but not limited to, intelligent design." The school district then required that students be read a statement emphasizing that "The Theory [of evolution] is not a fact" and recommending the

IDauthored text Of Pandas and People for student use. Several parents sued, and a widely publicized trial was held in October-November 2005.14 In December, U.S. District Judge John E. Jones ruled that the school board's policy is unconstitutional. He further found that ID is "a religious view, a mere re-labeling of creationism, and not a scientific theory," and "ID cannot uncouple itself from its creationist, and thus religious, antecedents."15

An initial attempt to influence the Utah School Board in September 2005 was not fruitful, but in January 2006 State Senator Chris Buttars introduced a bill to require that "instruction to students on any theory regarding the origins of life, or the origins or present state of the human race, shall stress that not all scientists agree on which theory is correct."16 This measure was modified several times, then defeated. However, attempts continue in other U.S. states and internationally.

Creationism, Intelligent Design and the LDS Faith

Like the Catholic Church and most large Protestant denominations, the Church of Jesus Christ of Latter-day Saints (LDS) in recent years has officially distanced itself from largely scientific issues such as evolution. Conventional scientific theories, including biology, evolution and geology, are openly taught at Brigham Young University and BYU-Idaho, and a notable number of the scientific faculty members are well-published in these fields. Students who inquire as to the Church's views on evolution are referred to "Origin of Man and Evolution,"a packet of information approved by the LDS First Presidency. The packet contains a 1909 First Presidency statement on the origin of man that speaks negatively of the notion that human beings developed from lower orders of the animals, but this is balanced by inclusion of the article on evolution from the 1992 Encyclopedia of Mormonism. This short article quotes a 1931 First Presidency letter saying, "Leave geology, biology, archaeology and anthropology, no one of which has to do with the salvation of the souls of mankind, to scientific research, while we magnify our calling in the realm of the Church."17

Several books with a positive view of evolution have recently been published by LDS scientists. 18 Also of interest is Mormonism and Evolution: The Authoritative LDS Statements, a collection of articles and statements published by the LDS Church on evolution.19

Nonetheless, a creationist worldview prevails in the hearts and minds of many LDS people. For example, a 2009 poll found that only 22% of American Latter-day Saints believe that evolution is the best explanation for human life – a figure that is lower than all other major religious denominations except for Jehovah's Witnesses.20

Creationist material has even appeared occasionally in LDS Church publications, although it is not clear that any of this material has official endorsement. In 1998 the Ensign published an article asserting that Noah's flood covered the entire earth and destroyed all living things not aboard Noah's ark.21 In 2002 the Ensign reprinted the 1909 First Presidency statement, which has skeptical comments on humans developing from lower orders, but failed to mention more recent updates that omit such language.22 The Old Testament manual for BYU and LDS Institutes of Religion presents a very negative view of evolution, quoting from Joseph Fielding Smith's 1952 statement: "You cannot believe in this theory of the origin of man, and at the same time accept the plan of salvation." The manual quotes at length from the writings of Harold Coffin, a Seventh- day Adventist creationist, and mentions speculations by Immanuel Velikovsky that worldwide catastrophes have occurred in recent times.23 I have heard that many instructors ignore this material, which was written many years ago, although others continue to take it quite seriously.

Several recent books and articles by LDS writers have criticized evolution and science in general. For example, Joseph Fielding McConkie, a retired BYU religion professor, recently wrote "we cannot overcome the irreconcilable differences between the theory of organic evolution and the doctrine of the Fall."24 Other examples include the book Using the Book of Mormon to Combat

Falsehoods in Organic Evolution25 and Prophets or Evolution.26 The latter work argues that evolution coincides with the teachings of Korihor, a Book of Mormon anti-Christ figure, and further asserts that the scientific community is intentionally ignoring contrary evidence that nullifies the theory of evolution. While much more accepting of evolution, Utah State University Philosophy Professor Richard Sherlock nonetheless criticizes the 2005 Dover court decision. He finds merit in some of the scientific arguments advanced by ID scholars, such as Behe's "irreducible complexity," and concludes that "Latter-day Saints and serious Christians generally should be sympathetic and supportive of intelligent design."27

Modern Scientific Evidence

The notions that the universe is at least 13 billion years old, that the earth is at least four billion years old, and that life has developed on earth through a branching evolutionary process over many millions of years, are all very firmly established in the scientific literature by extensive empirical data. The geological ages of various fossil layers are particularly well established, since these ages are based on multiple dating schemes, firmly grounded in fundamental laws of physics, which schemes have survived careful scrutiny for over 50 years.28

In the past few years, modern genome sequencing and computer technology have placed enormous volumes of DNA data at the fingertips of researchers worldwide. These data strongly confirm the evolutionary paradigm, including the hierarchical organization and common ancestry of all organisms, and the evolution of these organisms via incremental mutations and natural selection.29 Data of this sort have already confirmed the "family tree" of species that was previously constructed based only on comparisons of anatomy and biological function. As LDS biologist Daniel Fairbanks observes, "The results of hundreds of large-scale experiments based on DNA analysis overwhelmingly confirm the reality of evolution."30

One example of these data is the table below, which compares the 146-unit amino acid sequences of beta globin (a component of hemoglobin) among various species of animals. Note that human beta globin is identical to that of chimpanzees, differs in only one location from that of gorillas, yet is increasingly distinct from that in red foxes, polar bears, horses, rats, chicken and salmon.31

The picture is the same if we examine any of thousands of other genes and proteins. For example, the gene that, when mutated, results in cystic fibrosis in humans is nearly identical to the corresponding gene in chimpanzees, but is progressively less similar to the corresponding gene in orangutans, baboons, marmosets, lemurs, mice, chicken and puffer fish.32

Percent Agreement between Beta Globin of Various Species

	Hu- Chimp	Gor- illa	Red Fox	Dog	Polar Bear	Horse	Rat	Chickman en	Salmon
Human	100.	100.	99.3	91.1	89.7	89.7	83.6	81.5	69.2	49.7
Chimp	100.	100.	99.3	91.1	89.7	89.7	83.6	81.5	69.2	49.7
Gorilla	99.3	99.3	100.	91.8	90.4	90.4	82.9	80.8	68.5	49.0
Red Fox	91.1	91.1	91.8	100.	98.6	95.2	80.8	80.1	72.6	49.7
Dog	89.7	89.7	90.4	98.6	100.	94.5	80.1	79.5	71.2	49.0
Polar Bear	89.7	89.7	90.4	95.2	94.5	100.	80.8	82.9	71.9	48.3
Horse	83.6	83.6	82.9	80.8	80.1	80.8	100.	76.0	67.8	46.3
Rat	81.5	81.5	80.8	80.1	79.5	82.9	76.0	100.	65.8	49.7
Chicken	69.2	69.2	68.5	72.6	71.2	71.9	67.8	65.8	100.	54.4
Salmon	49.7	49.7	49.0	49.7	49.0	48.3	46.3	49.7	54.4	100

DNA evidence has also dramatically confirmed some earlier conjectures. For example, scientists noted long ago that humans have only 23 pairs of chromosomes, whereas other great apes –

chimpanzees, bonobos, gorillas and orangutans – have 24. Thus they were led to conjecture that two of the human chromosomes have fused since the split between ancestral human and ape lineages. This hypothesis gained credence in 1982, when scientists found that chromosomes from humans, chimpanzees, gorillas and orangutans are highly similar and can be aligned with one another, with human chromosome #2 corresponding to the slightly overlapped union of ape chromosomes 2A and 2B. The final confirmation came in 1991 from a detailed analysis of human DNA, which found two complementary telomeres (repeated sequences of a certain DNA string that appear at the end of a chromosome) spanning the exact spot of union.33

Technical Issues

As mentioned above, ID writers generally have respectable academic credentials (although hardly any of their peer-reviewed articles deals directly with ID34) and, as mentioned earlier, they have approached the issue by acknowledging much of the standard scientific framework, including the "old earth" timeline. But like creationists, ID scholars have not yet produced a solid body of quantitative, falsifiable scientific hypotheses of their own; instead they have focused their efforts on identifying weaknesses in the established evolutionary theory. One difficulty with this approach was noted by Judge John E. Jones in the Dover case: "ID is at bottom premised upon a false dichotomy, namely, that to the extent evolutionary theory is discredited, ID is confirmed. … We do not find this false dichotomy any more availing to justify ID today than it was to justify creation science two decades ago."35

Nonetheless, many are convinced that the creationist and ID writers have identified substantive technical issues that draw into question certain aspects of evolutionary theory. Since these issues are invariably raised whenever this topic is discussed, a few of these claims will be briefly mentioned here, together with the consensus response of the scientific community. For more details, readers are referred to several recently published references.36

Gaps in the fossil record. Both creationist and ID writers have argued that there are significant gaps in the fossil record, and these gaps are evidence that the evolutionary model is wrong.37 Scientists readily acknowledge that gaps exist in the fossil record, but point out that large numbers of these gaps (including several gaps specifically highlighted by creationist and ID writers) have been filled by transitional fossils found in the past few decades.38 Examples include fossils spanning the transition between land and marine mammals (having exactly the expected combination of terrestrial and aquatic features that had been predicted)39 and a long-sought intermediate fossil linking fish and early tetrapods (four-legged animals) that was found in 2004 on an island in the Canadian Arctic.40

One recent fossil discovery potentially relevant to human evolution is the "Ardi" skeleton, which lived 4.4 million years ago, not long after the split between the humans and chimpanzees.41 Creationists have typically dealt with hominid fossils by assigning them to either "human" or "ape" categories, but they have failed to agree among themselves as to which hominids should be assigned to which category. Biologist Kenneth Miller observes, "ironically, validation of our common ancestry with primates comes directly from those who are most critical of the idea."42

Irreducibly complex systems. ID scholar Michael Behe has argued that certain biological systems, such as bacterial flagella, blood clotting processes and the immune system, are "irreducibly complex": they consist of multiple subsystems, the removal of any one of which would render the system nonfunctional. He argues that such systems must have been designed by an intelligent entity, because none of the components could have evolved in the absence of the others.43 Scientists counter that systems labeled as "irreducibly complex" by Behe can arise by natural evolution – individual parts may arise separately, each useful in different context, and then later be combined into a larger system. For example, researchers recently found that the DNA sequence of

bacterial flagella is almost identical to that of a “needle” that certain bacteria use to insert toxins.44 Similarly, most of the proteins involved in the blood clotting system are genetically similar and most likely are the result of gene duplication.45 With regards to the immune system, during the Dover trial 58 peer-reviewed publications, nine books, and several textbook chapters were presented to the court summarizing research on immune system evolution. Facts such as this ultimately convinced Judge Jones to write in his decision, “We therefore find that Professor Behe’s claim for irreducible complexity has been refuted in peer-reviewed research papers and has been rejected by the scientific community at large.”46

Probability. Both traditional creationists and ID scholars have invoked probability arguments in criticisms of evolution. One typical argument goes like this: the human alpha globin molecule, a component of hemoglobin, is a protein chain based on a sequence of 141 amino acids. There are 20 different amino acids common in living systems, so the number of potential chains of length 141 is 20141, which is roughly 10183 (i.e., a one followed by 183 zeroes). Thus the probability of the specific human alpha globin molecule forming at random is so remote that even after billions of years, it is very unlikely that it would ever appear.47

But scientists point out that this calculation is faulty, because most of the 141 amino acids can be changed without altering the basic biological function. More importantly, this and other probability-based arguments suffer from the fatal fallacy of presuming that a structure such as alpha globin arises by a single all-at-once event (which, after all, is the creationist theory, not the scientific theory, of their origin). Instead, available evidence suggests that alpha globin and other proteins arose as the end product of a long sequence of intermediate steps, each of which was biologically useful in an earlier context. Probability calculations such as the above, which do not take into account the process by which the structure came to be, are not meaningful and can easily mislead.

Along this line, scientists note that if one (erroneously) presumes that a snowflake arises by an all-at-once random assemblage of water molecules, instead of by known natural processes, then by analyzing symmetry one would calculate exceedingly small probabilities for their formation, even more remote than the figures mentioned above for alpha globin. Yet no one insists that supernatural action is required to produce snowflakes.48

Information theory. ID writer William Dembski has invoked probability and information theory (the mathematical theory of information content) in arguments against Darwinism. But knowledgeable researchers who have examined Dembski’s works in detail are sharply critical. Mathematician Jeffrey Shallit and biologist Wesley Elsberry conclude that Dembski’s notion of “complex specified information” is incoherent and unworkable.49 Richard Wein, in a review of Dembski’s book No Free Lunch, characterizes it as “pseudoscientific rhetoric.”50

Biological novelty. Creationists and ID scholars have insisted that whereas minor changes may occur within an established kind, “random” evolution can never produce anything fundamentally bacterium E. coli that is responsible for metabolizing lactose was removed. Within 24 hours the bacteria had re-evolved a capability to utilize lactose, by means of a similar but distinct three-part biochemical pathway.52 Another example is a bacterial species discovered in Japan that has adapted to digest nylon waste (which did not exist until the 20th century) as the result of a “frame shift” mutation.53 As a third example, certain Italians, all descended from a single individual several generations back, possess a genetic mutation that results in measurably improved cardiovascular health.54 Perhaps the best-known examples, however, are the recent evolution of new strains of tuberculosis that are resistant to all known anti-TB drugs, and drug-resistant strains of HIV that in many cases evolve within the body of a single patient.55

Along this line, scientists note that computer programs mimicking the process of evolution have been utilized to construct computer algorithms and engineering designs that in many cases are superior to the best-known human efforts. Applications have been found in aerospace, chemistry, electrical engineering, financial analysis, materials engineering, robotics, and others.56

Speciation. Creationists and ID scholars often assert that the splitting of a species into two species has never been actually observed. Although speciation typically requires many thousands of years, biologists cite examples of present-day species that appear to be in the process of splitting. 57 One example is a certain salamander species in California, which is visibly different from one end of its habitat to the other, enough so that by established standards (such as failure to interbreed), specimens from the two ends would be classified as from two distinct species.58

Origin of life. Scientists readily acknowledge that many questions regarding the evolution of life on earth remain to be resolved. The origin of life, for instance, is still not understood, although intriguing advances have been made recently.59 In any event, it is not clear what is to be gained for the creationist/ID cause by highlighting the remaining unknowns in the origin of life arena, since the evolution of living organisms after biogenesis is very well grounded experimentally, independent of how the first biomolecules formed. In summary, the consensus of the vast majority of scientists who have examined these issues is that the arguments raised so far by the creationist and ID communities are not genuinely substantive. For the most part, these questions were settled long ago in the scientific literature. They certainly do not threaten the foundations of the evolutionary paradigm.

Scriptural Interpretations

Passages in Genesis, as well as similar passages in other books such as the Book of Moses and the Book of Abraham, describe the process of the creation and early earth history. One key issue is how literally one should interpret these passages – for example, what period of time was required for the creation, or whether Noah's flood was a local event or a global immersion. Along this line, it is worth noting that the Book of Abraham account of the creation uses the word time instead of day to denote each creative period [e.g., Abr. 4:8]. As mentioned earlier, both the creationist and ID movements are closely allied with evangelical Christianity. Many (albeit not all) evangelicals subscribe to the Chicago Statement on Biblical Inerrancy, which declares: "Being wholly and verbally God-given, Scripture is without error or fault in all its teaching ... in what it states about God's acts in creation, about the events of world history, and about its own literary origins under God."60 Partly because of such beliefs, many in the evangelical world (including the Discovery Institute that backs the ID movement) agree that Darwinian evolution is fundamentally incompatible with scripture and the Christian faith.61

Ironically, this view is shared by some prominent modern-day atheists on the other end of the intellectual spectrum, who hold that modern science proves religion to be utterly false.62

In any event, most modern Bible scholars agree that an inerrant reading of the Bible is no longer defensible, in light of both textual and archaeological research.63 This should not come as a surprise to LDS readers, since Mormonism was founded on a rejection of biblical inerrancy and completeness. Bible scholars also point out that an approach that fails to acknowledge the human element in the Bible makes it difficult to deal with passages that appear to endorse holy war, slavery and subjugation of women.64 With respect to the creation scriptures, scholars have long concluded that these passages were written to reaffirm God's love for his people, not as a scientific discourse in the modern sense. Karen Armstrong, for instance, writes that the Genesis text "was emphatically not intended as a literal account of the physical origins of life."65 LDS Apostle James E. Talmage made essentially the same point in 1931:

The opening chapters of Genesis, and scriptures related thereto, were never intended as a textbook of geology, archaeology, earth-science, or man-science. Holy Scripture will endure, while the conceptions of men change with new discoveries. We do not show reverence for the scriptures when we misapply them through faulty interpretation.66

In this context, it is reasonable to ask why the creation scriptures should be read very literally, when no one insists that these other passages should be read literally: 1 Sam. 2:8. ... for the pillars of the earth [are] the LORD'S, and he hath set the world upon them. Psa. 93:1. ... the world also is stablished, that it cannot be moved. Psa. 104:5. [Who] laid the foundations of the earth, [that] it should not be removed for ever. Eccl. 1:5. The sun also ariseth, and the sun goeth down, and hasteth to his place where he arose. These passages, among many others that could be listed, affirm the geocentric cosmology of antiquity: the earth is flat with four corners, is set on a foundation of pillars, and is immovable, with the sun and other heavenly bodies moving on transparent spheres above the earth. Such passages are not interpreted literally today, but they were the foundation of the persecution of Galileo and others over Copernican astronomy during the 16th and 17th centuries.67

Theological Difficulties
ID scholar Phillip Johnson criticizes the assumption of "methodological naturalism" underlying the scientific enterprise, namely the notion that the universe is governed by natural and comprehensible laws. Johnson argues that this assumption unfairly rules out the hypothesis of a supernatural designer.68 He also suggests that some questions regarding the creation of our world are "mysteries," beyond the realm of human investigation or understanding.69 ID scholars Dembski and Behe have also criticized the naturalistic worldview. Behe has said that "design," from his point of view, means beyond the laws of nature.70

Scientists acknowledge that methodological naturalism underlies their research, but argue that they have no choice. As scientific philosopher Robert Pennock observes, Once such supernatural explanations are permitted they could be used in chemistry and physics as easily as Creationists have used them in biology and geology. Indeed, all empirical investigation beyond the purely descriptive could cease. ... Methodological Natu- ralism is not a dogmatic ideology that simply is tacked on to the principles of the scientific method; it is essential for the basic standards of empirical evidence.71

Theologians point out that the creationist and ID attempts to identify phenomena that cannot be explained by natural law lead directly to a "God of the gaps" theology – meaning that God's influence is to be found in the gaps of what currently remains unexplained in science. This approach has been characterized as theological suicide, since many of those who have adopted it over the centuries have been disappointed as scientific knowledge has expanded.72 This worldview also contrasts with LDS theology, which has traditionally viewed God as acting within the realm of eternal natural laws, thus effectively eliminating the need for warfare between science and religion. Here are some excerpts from LDS President Brigham Young and LDS Apostles John A. Widtsoe and Parley P. Pratt, respectively, on this topic:

Yet I will say with regard to miracles, there is no such thing save to the ignorant – that is, there never was a result wrought out by God or by any of His creatures without there being a cause for it. There may be results, the causes of which we do not see or understand, and what we call miracles are no more than this – they are the results or effects of causes hidden from our understandings.73

Just what forces were brought into operation, or what process was used, to organize the "elements" into an earth is not known. Latter-day Saints are inclined to hold that forces about us, known in part through common human experience, especially in the field of physical science, were

employed in the formation of the earth. The progress of science may yet shed much light on the origin of the earth.74

Among the popular errors of modern times, an opinion prevails that miracles are events which transpire contrary to the laws of nature, that they are effects without a cause. If such is the fact, then, there never has been a miracle, and there never will be one. The laws of nature are the laws of truth. Truth is unchangeable, and independent in its own sphere. A law of nature never has been broken. And it is an absolute impossibility that
such law ever should be broken.75

Some creationist writers have acknowledged the evidence for an extremely old earth, for instance, but have explained this by saying that God created the world with an "appearance of age," perhaps as a test of our faith.76 ID scholars are more reserved in this regard, but Johnson's notion that certain aspects of the creation are "mysteries," held beyond the reach of human investigation and understanding, is in this same general vein.77

God epitomized by the credo "The Glory of God is intelligence; in other words light and truth." [D&C 93:36]. Writers from other religious traditions have also been sharply critical of the notion of a God who deliberately distorts evidence or withholds truth from humans. Catholic biologist Kenneth Miller writes,

In order to defend God against the challenge [creationists] see from evolution, they have to make him into a schemer, a trickster, even a charlatan. Their version of God is one who intentionally plants misleading clues beneath our feet and in the heavens themselves. … To embrace that God, we must reject science and worship deception itself."78

The ID community's notion that each individual species or "kind" has been meticulously designed presents severe theological problems in light of the many troublesome features of nature, such as pain, disease, violence, as well as the millions of species that have become extinct. For example, scientists have found 22 distinct species of elephants that arose and became extinct during the past six million years. Why did it take so many tries to design modern elephants?79

For that matter, certain features of the human body are highly troublesome from a "design" hypothesis in the above sense. Many persons suffer from back ailments, due to a skeletal design adapted from four-footed ancestors.80 Most mammals generate their own vitamin C, but while we have the same biochemical machinery, it doesn't work because mutations have inactivated a key final step (evidently these mutations occurred after our ancestors adopted a diet rich in fruit, when it was no longer essential to generate our their vitamin C).81 Thirty percent of the roughly 1000 human genes associated with the sense of smell are inoperable due to accumulated mutations. 82 In human eyes, the optic nerves emerge from the front of the retina, and then travel to the back, resulting in a blind spot. By contrast, mollusk eyes are designed more logically with nerve connections on the back of the retina.83 Each of these examples makes perfect sense from evolutionary history, but they are inexplicable as the product of meticulous design by a transcendent Being. Even worse, as noted tongue-in-cheek by Kenneth Miller, one could argue that the ID movement's designer is a plagiarist, because the DNA errors that have inactivated our ability to produce vitamin C have been copied into the genomes of three other primates.84

The "War" Between Science and Religion

Creationist and ID scholars have adopted a combative stance against the findings and theories of modern science, particularly evolution – indeed, they see science and religion pitched in mortal combat. But many other scientists and theologians fail to see the need for this "war." As Kenneth Miller explained recently on PBS,

I think that faith and reason are both gifts from God. And if God is real, then faith and reason should complement each other rather than be in conflict. Science is the child of reason. Reason has given us the ability to establish the scientific method to investigate the world around us, and to show that the world and the universe in which we live are far vaster and far more complex, and I think far more wonderful, than anyone could have imagined 1,000 or 2,000 years ago.

Does that mean that scientific reason, by taking some of the mystery out of nature, has taken away faith? I don't think so. I think by revealing a world that is infinitely more complex and infinitely more varied and creative than we had ever believed before, in a way it deepens our faith and our appreciation for the author of that nature, the author of that physical universe. And to people of faith, that author is God.85

LDS biologist Daniel J. Fairbanks offered this advice:

Those who sincerely seek both scientific and spiritual understanding would do well to abandon the dichotomy [that one must choose between science and religion]. Denying the evidence of evolution, including human evolution, is honest only in ignorance. The incredible diversity on life on Earth, the many fossils unearthed, the varied yet similar anatomical features among species, the obvious hierarchical arrangement of life, and the literally millions of ancestral relics in our DNA – all undeniably attest to our common evolutionary origin with the rest of life. If someone can believe that all living organisms share the same creator, why not consider that all living organisms share a common genetic heritage? Indeed, we can find wonder, even comfort, in embracing our biological relationship with all living things. As Darwin understood, "there is grandeur in this view of life."86

In contrast to the highly negative view of evolution that one reads in the creationist and ID literature, Catholic biologist Francisco Ayala argues that evolution can be seen in a positive light, as the solution to the "last prong" of the problem of suffering and evil:

As floods and drought were a necessary consequence of the fabric of the physical world, predators and parasites, dysfunctions and diseases were a consequence of the evolution of life. They were not a result of deficient or malevolent design.87

This is reminiscent of a comment made by LDS President David O. McKay in 1952, who argued that evolution could be seen as evidence that mankind is destined for eternal life:

For example, evolution's beautiful theory of the creation of the world offers many perplexing problems to the inquiring mind. Inevitably, a teacher who denies divine agency in creation, who insists there is no intelligent purpose in it, will infest the student with the thought that all may be chance. I say, that no youth should be so led without a counterbalancing thought. Even the skeptic teacher should be fair enough to see that even Charles Darwin, when he faced this great question of annihilation, that the creation is dominated only by chance wrote: "It is an intolerable thought that man and all other sentient beings are doomed to complete annihilation after such long, continued slow progress."

And another good authority, Raymond West, said, "Why this vast [expenditure] of time and pain and blood?" Why should man come so far if he's destined to go no farther? A creature that travels such distances and fought such battles and won such victories deserves what we are compelled to say, "To conquer death and rob the grave of its victory." 88

Catholic theologian John Haught adds the following:

If God were a magician or a dictator, then we might expect the universe to be finished all at once and remain eternally unchanged. If God insisted on being in total control of things, we might not expect the weird organisms of the Cambrian explosion, the later dinosaurs and reptiles, or the many other wild creatures that seem so exotic to us. We would want our divine magician to build the world along the lines of a narrowly human sense of clean perfection. But what a pallid and impoverished world that would be. It would lack all the drama, diversity, adventure, and intense beauty that evolution has in fact produced. A world of human design might have a listless harmony to it, and it might be a world devoid of pain and struggle, but it would have none of the novelty, contrast, danger, upheaval and grandeur that evolution has brought about over billions of years. Fortunately, the God of our religion is not a magician but a creator. And we think this God is much more interested in promoting freedom and the adventure of evolution than in preserving the status quo.89

Conclusion
There is nothing in the overall scientific picture of the creation that is fundamentally antireligious. To the contrary, many stand in awe at the grandeur of life on earth and the universe's elegant, lawful construction. Further, as some authors cited above have argued, evolution can be seen as a solution to the problem of why suffering and evil exist in the world, and as evidence that mankind is destined for eternal life (as in the LDS doctrine of "eternal progression").

With regards to the scientific evidence, Carl Sagan observed that "extraordinary claims require extraordinary evidence."90 Most scientists (even those professing religious faith) who have examined the claims of the creationist and ID movements agree that what these communities have produced so far is either negated by available scientific evidence, or, at the very least, falls far short of the level required to challenge existing theories. These movements have also failed to formulate a body of quantitative, falsifiable hypotheses of their own that can withstand empirical testing and peer review.

With regards to theology, the creationist and ID communities seek to identify phenomena that cannot be explained by natural laws, in an attempt to "prove" the hand of God, thus making faith unnecessary. Ironically, this approach implicitly affirms the materialist worldview of prominent atheists, who say that religion is false because of modern science. More importantly, this approach leads directly to a "God of the gaps" theology, which has left a legacy of disappointment through the years as science has filled many of the remaining gaps. Furthermore, as noted above, certain creationist and ID writings have overtones of "God the Great Deceiver" theology – the notion that God has deliberately altered physical evidence to have an "appearance of age," or has withheld truth regarding the creation from humans. Such notions are inimical to the LDS tradition of a rational, comprehensible God who works within the realm of natural law.

Some have suggested that creationist or ID scholarship might be useful to bolster religious conviction of those who waver. But it seems highly unwise to base one's personal faith on precepts that are questioned by many God-believing scientists. As Paul warned the Corinthians, "For if the trumpet give an uncertain sound, who shall prepare himself to the battle?" [1 Cor. 14:8].

In summary, it is not only futile to battle modern science, as the creationist and ID communities have done, but it is also unnecessary. Most major religious denominations, including the LDS Church, have made peace with the scientific world, recognizing that science addresses very different questions and employs very different methods. Many leading scientists affirm a religious faith. And both scientists and nonscientists can stand in awe at the majesty of the universe, which is now known to be much vaster, more intricate and more magnificent than ever before realized in human history.

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James Le Fanu, Historian of Science
Why Us? – How Science Discovered the Mystery of Ourselves
Book

Introduction: A Mystery to Ourselves

> `Know then thyself, presume not God to scan; The proper study of mankind is man...
> Sole judge of Truth, in endless Error hurled: The glory, jest and riddle of the world!'

Alexander Pope, An Essay on Man' (1734)

`Wonders are there many, observed the Greek dramatist Sophocles — 'but none more wonderful than Man: And rightly so for man, as far as we can tell, is the sole witness of the splendours of the universe he inhabits — though consistently less impressed by his existence than would seem warranted.

`Men go abroad to wonder at the height of mountains, at the huge waves of the sea, at the long courses of the rivers, at the vast compass of the ocean, at the circular motion of the stars,' observed St Augustine in the fifth century AD, `and they pass by themselves without wondering.

The reasons for that lack of wonder at ourselves have changed over the centuries, but the most important still stands: the practicalities of our everyday lives are so simple and effortless as to seem unremarkable. We open our eyes on waking to be surrounded immediately by the shapes and colours, sounds, smells and movement of the world around us in the most vivid and exquisite detail. We feel hungry, and by some magical alchemy of which we know nothing, our bodies transform the food and drink before us into our flesh and blood. We open our mouths to speak and the words flow, a ceaseless babbling brook of thoughts and ideas and impressions. We reproduce our kind with ease and play no part in the transformation, in three short months, of the single fertilised egg into an embryo, no larger than a thumbnail, whose four thousand functioning parts include a beating heart the size of the letters on this page, and a couple of eyes the size of the full stop at the end of this sentence. We attend to our children's needs, but effortlessly they grow inch by inch, year by year to adulthood, replacing along the way virtually every cell in their bodies, refashioning the skull, limbs and internal organs, while retaining the proportions of one part to another.

The moment one starts to reflect on any of these practicalities, their effortlessness does begin to seem rather astonishing. They clearly are not in the least bit simple — yet in reality they are almost the simplest thing we know. They appear simple because they have to be so: if our senses did not accurately capture the world around us, if our metabolism did not abstract and utilise every nutrient, if procreation was not almost too easy and the growth of children into adulthood not virtually automatic, if we had to consciously make an effort to speak a sentence — then `we' would never have happened.

This should make us pause for a moment because, from common experience, there is nothing more difficult and arduous than to make the complex appear simple — just as the concert pianist's seemingly effortless keyboard skills are grounded in years of toil and practice. So, it is precisely the effortlessness of our everyday lives that should command our attention — recognising their semblance of simplicity as a mark of their profundity.

But most people nowadays do `pass by themselves without wondering'; though less justifiably so than in St Augustine's time, for we now know prodigiously more about the deep biological complexities that underpin those simplicities of our everyday lives. We should, by rights, be enormously more appreciative of nature's ingenuity, and the deceptive effortlessness of our seeing and talking and reproducing our kind should be part of common knowledge, a central theme of the school biology curriculum, promoting a sense of wonder in the young mind at the fact of its very existence.

Yet one could search a shelf full of biology text books in vain for the slightest hint of the extraordinary in their detailed exposition of these practicalities of our lives. And why? Scientists do not `do' wonder. Rather, for the past 150 years they have interpreted the world through the prism of supposing that there is nothing in principle that cannot be accounted for, where the unknown is merely waiting-to-be-known. And so it has been till very recently, when two of the most ambitious

scientific projects ever conceived have revealed, quite unexpectedly — and without anyone really noticing — that we are after all a mystery to ourselves. This is the story of how it happened, and its (many) consequences.

Chapter 1 - Science Triumphant, Almost

> `The real voyage of discovery consists not in seeking new lands, but in seeing with new eyes.'
> Marcel Proust

We live in the Age of Science, whose lengthy roll-call of discoveries and technical innovations has immeasurably changed our lives for the better. Within living memory children succumbed in their thousands every year from polio and whooping cough, telephones were a rarity, colour television was yet to be invented and the family would gather every evening around the wireless after supper to listen to the news.

Since then, the therapeutic revolution of the post-war years has reduced death in infancy to its irreducible minimum, while ensuring that most now live out their natural lifespan; the electronic revolution has prodigiously extended both the capacity of the human mind, with computers of ever smaller size and greater power, and its horizons, with the Hubble telescope circling in orbit around the earth, relaying back from the far reaches of the cosmos sensational images of its beauty and grandeur.

The landmarks of this post-war scientific achievement are familiar enough: for medicine, there are antibiotics and the pill, heart transplants and test tube babies (and much else besides); for electronics, the mobile phone and the Internet; for space exploration, the Apollo moon landing of 1969 and the epic journey of Voyagers I and II to the far reaches of our solar system. But these last fifty years have witnessed something yet more remarkable still — a series of discoveries that, combined together, constitute the single most impressive intellectual achievement of all time, allowing us to `hold in our mind's eye' the entire sweep of the history of the universe from its beginning till now. That history, we now know, starts fifteen thousand million years ago (or thereabouts) with the Big Bang, `a moment of glory too swift and expansive for any form of words [when] a speck of matter became in a million millionth of a second something at least ten million million million times bigger: Eleven thousand million years pass, and a massive cloud of gas, dust, pebbles and rocks in a minor galaxy of that (by now) vast universe coalesces around a young sun to create the planets of our solar system. Another thousand million years pass, the surface of the earth cools and the first forms of life emerge from some primeval swamp of chemicals. Yet another two and a half thousand million years elapse till that moment a mere(!) five million years ago when the earliest of our ancestors first walked upright across the savannah plains of central Africa.

And again, within living memory we knew none of this, neither how the universe came into being, nor its size and composition; neither how our earth was born, nor how its landscape and oceans were created; neither the timing of the emergence of life, nor the `universal code' by which all living things reproduce their kind; neither the physical characteristics of our earliest ancestors, nor the details of their evolutionary transformation to modern man. Now we do, and holding this historical sweep `in our mind's eye' it is possible to appreciate the intellectual endeavour that underpins it will never, can never, be surpassed. How astonishing to realise that today's astronomers can detect the distant echoes of that `moment of glory' of the Big Bang all those billions of years ago, and capture in those astonishing images transmitted from the Hubble telescope the very processes that brought our solar system into existence. How astonishing that geologists should have discovered that massive plates of rock beneath the earth's surface, moving

at the rate of a centimetre a year, should have formed its continents and oceans, the mountains and valleys of the snow-capped Himalayas thrust upwards by the collision of the Indian subcontinent with the Asian landmass. How astonishing, too, that biologists should now understand the internal workings of the microscopic cell, and how the arrangements of the same four molecules strung out along the elegant spiral of the Double Helix contain the `master plan' of every living thing that has ever existed.

It is impossible to convey the intellectual exhilaration of such momentous discoveries, but the account by Donald Johanson of finding the first near-complete skeleton of our three-and-a-half-million-year-old hominid ancestor `Lucy' conveys something of the emotions felt by so many scientists over the past fifty years.

> Tom [Gray] and I had surveyed for a couple of hours. It was now close to noon, and the temperature was approaching 110. We hadn't found much: a few teeth of a small extinct horse; part of the skull of an extinct pig, some antelope molars, a bit of a monkey jaw...
>
> `I've had it said Tom. `When do we head back to camp?'
>
> But as we turned to leave, I noticed something lying on the ground part way up the slope.
>
> `That's a bit of a hominid arm,' I said.
>
> `Can't be. It's too small. Has to be monkey of some kind.' We knelt to examine it.
>
> `Much too small, said Gray again.
>
> I shook my head. `Hominid:
>
> `What makes you so sure?' he said.
>
> `That piece right next to your hand. That's hominid too.
>
> `Jesus Christ, said Gray. He picked it up. It was the back of a small skull. A few feet away was part of a femur; a thigh bone. `Jesus Christ, he said again. We stood up and began to see other bits of bone on the slope. A couple of vertebrae, part of a pelvis — all of them hominid. An unbelievable, impermissible thought flickered through my mind. For suppose all these fitted together? Could they be parts of a single extremely primitive skeleton? No such skeleton has ever been found — anywhere.
>
> `Look at that,' said Gray. `Ribs.
>
> A single individual.
>
> `I can't believe it I said, `I just can't believe it.
>
> `By God you'd better believe it!' shouted Gray. His voice went up into a howl. I joined him. In that 110 degree heat we began jumping up and down. With nobody to share our feelings, we hugged each other, sweaty and smelly, howling and hugging in the heat-shimmering gravel, the small brown remains of what now seemed almost certain to be parts of a single hominid skeleton lying all around us.

Momentous events have multiple causes, and the source of this so recent and all-encompassing delineation of the history of our universe stretches back across the centuries. It is impossible to hope to convey the intellectual brilliance and industry of those who brought this extraordinary enterprise to fruition, whose major landmarks are summarised here as the Thirty Definitive Moments of the past six decades.

TABLE **1**
Science Triumphant 1945-2001: Thirty Definitive Moments

1945 The atom bomb: Hiroshima and Nagasaki

1946 The electron microscope reveals the internal structure of the cell

1947 The invention of the transistor launches the Electronic Age 1953 Theory of formation of the chemical elements of life by nuclear fusion within stars

1953 The laboratory simulation of the `origin of life'

1953 James Watson and Francis Crick discover the Double Helix 1955 The first polio vaccine

1957 The Soviet Union launches Sputnik and the epoch of planetary exploration

1960 The oral contraceptive

1961 The Genetic Code deciphered

1965 The theory of the Big Bang confirmed by discovery of cosmic microwave background radiation

1967 The first heart transplant

1969 US astronaut Neil Armstrong becomes the first man on the moon

1969 James Lovelock proposes theory of a life-sustaining atmosphere 1973 The advent of genetic engineering

1973 The invention of magnetic resonance imaging of the brain 1974 The discovery of `Lucy, Australopithecus afarensis, dated 4 million years BC

1974 The first Grand Unified Theory of particle physics 1977 The first complete genetic sequence of an organism

1977 The first personal computer designed for the mass market 1979 Voyagers I and II relay data from Jupiter, Saturn, Uranus and

Neptune 1979 The first `test tube baby'

1980 The asteroid impact hypothesis of the mass extinction of dinosaurs

1984 The discovery of `Turkana Boy, the first complete skeleton of Homo erectus, dated 1.5 million years BC

1984 Confirmation of theory of plate tectonics

1987 Formulation of the `out of Africa' hypothesis of human evolution 1989 Launch of world wide web

1990 The Decade of the Brain

1999 The Hubble space telescope observes the birth of stars in the constellation Taurus

2001 Publication of the Human Genome

The triumph of science, one might suppose, is virtually complete. What, during these times, have we learned from the humanities — philosophy, say, theology or history — that begins to touch the breadth and originality of this scientific achievement and the sheer extraordinariness of its insights? What, one might add, have the humanities done that begins to touch the medical therapeutic revolution of the post-war years or the wonders of modern technology?

That history of our universe as revealed in the recent past draws on many disciplines: cosmology and astronomy obviously, the earth and atmospheric sciences, biology, chemistry and genetics, anthropology and archaeology, and many others. But science is also a unified enterprise, and these areas of enquiry all `hang together' to reveal the coherent story outlined above. There remained, however, two great unknowns, two final obstacles to a truly comprehensive theory that would also explain our place in that universe.

The first is how it is that we, like all living things, reproduce our kind with such precision from one generation to the next. The'instructions, as is well recognised, come in the form of genes strung out along the two intertwining strands of the Double Helix in the nucleus of every cell. But the question still remained: How do those genes generate that near-infinite diversity and beauty of form, shape and size, and behaviour that distinguish one form of life from another? How do they fashion from a single fertilised human egg the unique physical features and mind of each one of us?

The second of these `great unknowns' concerned the workings of the brain, and the human brain in particular. To be sure, neurologists have over the past hundred years identified the functions of its several parts — with the frontal lobes as the `centre' of rational thought and emotion, the visual cortex at the back, the speech centre in the left hemisphere and so on. But again the question remained: How does the electrical firing of the brain's billions of nerves `translate' into our perception of the sights and sounds of the world around us, our thoughts and emotions and the rich inner landscape of personal memories?

These two substantial questions had remained unresolved because both the Double Helix and the brain were inaccessible to scientific scrutiny: the Double Helix, with its prodigious amount of genetic information, comes packed within the nucleus of the cell, a mere one five thousandth of a millimetre in diameter; while the blizzard of electrical activity of the billions of neurons of the brain is hidden within the confines of the bony vault of the skull. But then, in the early 1970s, a series of technical innovations would open up first the Double Helix and then the brain to scientific investigation, with the promise that these final obstacles to our scientific understanding of ourselves might soon be overcome. We will briefly consider each in turn.

The Double Helix

The Double Helix, discovered by James Watson and Francis Crick in 1953, is among the most familiar images of twentieth-century science. Its simple and elegant spiral structure of two intertwined strands unzips and replicates itself every time the cell divides — each strand, an immensely long sequence of just four molecules (best conceived, for the moment, as four different-

coloured discs — blue, yellow, red and green). The specific arrangement of a thousand or more of these coloured discs constitutes a `gene, passed down from generation to generation, that determines your size and shape, the colour of your eyes or hair or any other similarly distinguishing traits, along with the thousands of widgets or parts from which we are all made. It would take another fifteen years to work it all out, at least in theory — but the practical details of which particular sequence of coloured discs constituted which gene, and what each gene did, still remained quite unknown. This situation would change dramatically in the 1970s, with

Three technical innovations that would allow biologists first to chop those three billion `coloured discs' into manageable fragments, then generate thousands of copies the better to study them, and finally to figure out' the sequence (red, green, blue, green, yellow, etc., etc.) that constitutes a single gene.

Fig 1-1: James Watson (left) and Francis Crick (right) in the Cavendish laboratory in Cambridge point out the main features of their first full model of the Double Helix.

It lies beyond hyperbole to even try to convey the excitement and exhilaration generated by this trio of technical innovations, whose potential marked `so significant a departure from that which had gone before' they would become known collectively as `the New Genetics'. The prospect of deciphering the genetic instructions of `life' opened up a Pandora's box of possibilities, conferring on biologists the opportunity to change the previously immutable laws of nature by genetically modifying plants and animals. The findings of the New Genetics filled the pages not only of learned journals but of the popular press: `Gene Find Gives Insight into Brittle Bones, `Scientists Find Genes to Combat Cancer, `Scientists Find Secret of Ageing, `Gene Therapy Offers Hope to Victims of Arthritis, `Cell Growth Gene Offers Prospect of Cancer Cure, `Gene Transplants to Fight Anaemia, and so on.

The New Genetics, in short, swept all before it to become synonymous with biology itself. Before long the entire spectrum of research scientists — botanists, zoologists, physiologists, microbiologists — would be applying its techniques to their speciality. The procedures themselves in turn became ever more sophisticated, opening up the prospect that the New Genetics might transcend the possibilities of discovering `the gene for this and the gene for that, to spell out the entire sequence of coloured discs strung along the Double Helix and thus reveal the full complement of genes, known as The Genome. There was every reason to suppose that deciphering the full set of genetic instructions of what makes a bacterium a bacterium, a worm a worm, and a common housefly a common housefly would reveal how they are made and how they come to be so readily distinguishable from each other — why the worm should burrow and the fly should fly. Then, at the close of the 1980s, the co-discoverer of the Double Helix, James Watson, proposed what would become the single most ambitious and costly project ever conceived in the history of biology — to spell out the full complement of human genes. Thus the Human Genome Project (HGP) was born, with its promise to make dear what it is in our genes that makes us, `us. The truism that `the answer lies in the genes' is not merely an abstract idea, rather the set of instructions passed down from generation to generation influences every aspect of our being: our physical characteristics, personality, intelligence, predisposition to alcoholism or heart disease, and much else besides. Spell out the human genome in its entirety, and all these phenomena, and more, should finally be accounted for.

`The search for this "Holy Grail" of who we are, observed Harvard University's Walter Gilbert, `has now reached its culminating phase; the ultimate goal is the acquisition of all the details of our genome ... that will transform our capacity to predict what we will become.' There could be no greater aspiration than to `permit a living creature, as Robert Sinsheimer, Chancellor of the

University of California, put it, `for the first time in all time, to understand its origins and design its future' The Genome Project would, claimed Professor John Savile of Nottingham's University Hospital, `like a mechanical army, systematically destroy ignorance, while `promising unprecedented opportunities for science and medicine.

The Human Genome Project was formally launched in 1991, with a projected cost of $3 billion over the fifteen years it was expected it would run. The task of assembling the vast quantity of data generated by spelling out the human genome was divided across several centres, most of them in the United States, Britain and Japan. The scene within those `genome centres' could have come from a science fiction film — gleaming automated machines as far as the eye could see, labelling each cbemical of the Double Helix with its own fluorescent dye which was then `excited' by a laser and the results fed directly into a computer. The Future Is Now' trumpeted the cover of Time magazine, imposing that iconic image of the Double Helix over the shadowy outline of a human figure in the background.

The Brain

Meanwhile, the human brain too was about to reveal its secrets. Its physical appearance is quite as familiar as the Double Helix. But the specialisation of those separate parts for seeing, hearing, movement and so on is in a sense deceptive, concealing the crucial question of how their electrical firing translates the sights and sounds of the external world, or summons those evocative childhood memories from the distant past. How does this mere three pounds of soft grey matter within the skull contain the experience of a lifetime?

Here again, a series of technical innovations, paralleling those of the New Genetics, would permit scientists for the first time to scrutinise the brain `in action: In 1973 the British physicist Godfrey Hounsfield invented the Computed Tomography (CT) scanner, revealing the brain's internal structure with an almost haunting clarity, revolutionising the diagnosis of strokes and tumours and other forms of mischief. Soon after, the further technical development of Positron Emission Tomography (PET) scanning would transform the CT scanner's static images or `snapshots' of the brain into `moving pictures.

Put simply, this is how it works. All of life requires oxygen to drive the chemical reactions in its cells. This oxygen is extracted from the air, inspired in the lungs and transported by blood cells to the tissues. When, for example, we start talking, the firing of the neurons in the language centre of the brain massively increases their demand for oxygen, which can be met only by increasing the blood-flow to that area. The PET scanner detects that increase in blood-flow, converting it into multi-coloured images that pick out the `hotspots' of activity. Now, for the first time, the internal workings of the brain induced by smelling a rose or listening to a violin sonata could be observed as they happened. Or (as here) picking out rhyming words:

A woman sits quietly waiting for the experiment to begin — her head ensconced in a donut-shaped device, a PET scanning camera. Thirty-one rings of radiation detectors make up the donut, which will scan thirty-one images simultaneously in parallel horizontal lines. She is next injected with a radioactive isotope (of oxygen] and begins to perform the task ... The words are presented one above the other on a television monitor. If they rhyme, she taps a response key. Radiation counters estimate how hard the brain region is working ... and are transformed into images where higher counts are represented by brighter colours [thus] this colour map of her brain reveals all the regions acting while she is judging the paired words.

The details will come later, but the PET scanner would create the discipline of modern neuroscience, attracting thousands of young scientists keen to investigate this previously unexplored territory. Recognising the possibilities of the new techniques, the United States

Congress in 1989 designated the next ten years as `the Decade of the Brain' in anticipation of the many important new discoveries that would deliver `precise and effective means of predicting, modifying and controlling individual behaviour'. `The question is not whether the neural machinery [of the brain] will be understood,' observed Professor of Neurology Antonio Damasio, writing in the journal Scientific American, `but when:

Throughout the 1990s, both the Human Genome Project and the Decade of the Brain would generate an enormous sense of optimism, rounding off the already prodigious scientific achievements of the previous fifty years. And sure enough, the completion of both projects on the cusp of the new millennium would prove momentous events.

The completion of the first draft of the Human Genome Project in June 2000 was considered sufficiently important to warrant a press conference in the presidential office of the White House. `Nearly two centuries ago in this room, on this floor, Thomas Jefferson spread out a magnificent map ... the product of a courageous expedition across the American frontier all the way to the Pacific,' President Bill Clinton declared. `But today the world is joining us here to behold a map of even greater significance. We are here to celebrate the completion of the first survey of the entire human genome. Without a doubt this is the most important, most wondrous map ever produced by mankind.

The following year, in February 2001, the two most prestigious science journals, Nature and Science, each published a complete version of that `most wondrous map ever produced by mankind' as a large, multi-coloured poster displaying the full complement of (as it would turn out) twenty-five thousand human genes. It was, as Science observed, `an awe-inspiring sight: Indeed, it was awesome twice over. Back in the 1950s, when Francis Crick and James Watson were working out the structure of the Double Helix, they had no detailed knowledge of a single gene, what it is or what it does. Now, thanks to the techniques of the New Genetics, those involved in the Genome Project had, in less than a decade, successfully culled from those three billion `coloured discs' strung out along its intertwining strands the hard currency of each of the twenty-six thousand genes that determine who we are.

The Human Genome map, like Thomas Jefferson's map of the United States, portrays the major features of that genetic landscape with astonishing precision. While it had taken the best part of seven years to find the defective gene responsible for the lung disorder cystic fibrosis, now anyone could locate it from that multi-coloured poster in as many seconds. Here too at a glance you can pick out the gene for the hormone insulin, which controls the level of sugar in the blood, or the haemoglobin molecule that transports oxygen to the tissues. To be sure, the functions of many thousands of those genes remained obscure, but now, knowing their precise location and the sequence of which they are composed, it would be only a matter of time before they too would be known. It was a defining moment. `Today will be recorded as one of the most significant dates in history; insisted one of the major architects of the Genome Project, Dr Michael Dexter of the Wellcome Trust in Britain. `Just as Copernicus changed our understanding of the solar system and man's place within it, so knowledge of the human genome will change how we see ourselves and our relationship to others.

The goals of the Decade of the Brain were necessarily more open-ended, but still the PET scanner, and the yet more sophisticated brain imaging techniques that followed in its wake, had more than fulfilled their promise, allowing scientists to draw another exquisitely detailed map locating the full range of mental abilities to specific parts of the brain. There were many surprises along the way, not least how the brain fragmented the simplest of tasks into a myriad of different components. It had long been supposed, for instance, that the visual cortex at the back of the brain acted as a sort of photographic plate, capturing an image of the external world as seen through the eye. But now it

turned out that the brain `created' that image from the interaction of thirty or more separate maps within the visual cortex, each dedicated to one or other aspect of the visual image, the shapes, colour, movement of the world `out there: `As surely as the old system was rooted in the concept of an image of the visual world received and analysed by the cortex,' observes Semir Zeki, Professor of Neurobiology at the University of London, `the present one is rooted in the belief that an image of the visual world is actively constructed by the cerebral cortex.'

Steven Pinker, Professor of Brain and Cognitive Science at the Massachusetts Institute of Technology, could explain to the readers of Time magazine in April 2000 (the close of the Decade of the Brain) how neuroscientists armed with their new techniques had investigated `every facet of mind from mental images to moral sense, from mundane memories to acts of genius, concluding, `I have little reason to doubt that we will crack the mystery of how brain events correlate with experience.

Both the Human Genome Project and the Decade of the Brain have indeed transformed, beyond measure, our understanding of ourselves — but in a way quite contrary to that anticipated.

Nearly ten years have elapsed since those heady days when the `Holy Grail' of the scientific enterprise, the secrets of life and the human mind, seemed almost within reach. Every month the pages of the science journals are still filled with the latest discoveries generated by the techniques of the New Genetics, and yet more colourful scans of the workings of the brain — but there is no longer the expectation that the accumulation of yet more facts will ever provide an adequate scientific explanation of the human experience. Why?

We return first to the Human Genome Project, which, together with those of the worm and fly, mouse and chimpanzee and others that would follow in its wake, was predicated on the assumption that knowledge of the full complement of genes must explain, to a greater or lesser extent, why and how the millions of species with which we share this planet are so readily distinguishable in form and attributes from each other. The genomes must, in short, reflect the complexity and variety of `life' itself. But that is not how it has turned out.

First, there is the `numbers problem: That final tally of twenty-five thousand human genes is, by definition, sufficient for its task, but it seems a trifling number to `instruct, for example, how a single fertilised egg is transformed in a few short months into a fully formed being, or to determine how the billions of neurons in the brain are wired together so as to encompass the experiences of a lifetime. Those twenty-five thousand genes must, in short, 'multi-task', each performing numerous different functions, combining together in a staggeringly large number of different permutations.

That paucity of genes is more puzzling still when the comparison is made with the genomes of other creatures vastly simpler than ourselves — several thousand for a single-cell bacterium, seventeen thousand for a millimetre-sized worm, and a similar number for a fly. This rough equivalence in the number of genes across so vast a range of `organismic complexity' is totally inexplicable. But no more so than the discovery that the human genome is virtually interchangeable with that of our fellow vertebrates such as the mouse and chimpanzee — to the tune of 98 per cent or more. There is, in short, nothing to account for those very special attributes that so readily distinguish us from our primate cousins — our upright stance, our powers of reason and imagination, and the faculty of language.

The director of the Chimpanzee Genome Project, Svante Paabo, had originally anticipated that its comparison with the human genome would reveal the `profoundly interesting genetic prerequisites' that set us apart:

> The realisation that a few genetic accidents made human history possible will provide us with a whole new set of philosophical challenges to think about ... both a source of humility and a blow to the idea of human uniqueness.

But publication of the completed version of the chimpanzee genome in 2005 prompted a more muted interpretation of its significance: `We cannot see in this why we are so different from chimpanzees,' Paabo commented. `Part of the secret is hidden in there, but we don't

understand it yet: So `The obvious differences between humans and chimps cannot be explained by genetics alone' — which would seem fair comment, until one reflects that if those differences `cannot be explained' by genes, then what is the explanation?

These findings were not just unexpected, they undermined the central premise of biology: that the near-infinite diversity of form and attributes that so definitively distinguish living things one from the other must `lie in the genes: The genome projects were predicated on the assumption that the `genes for' the delicate, stooping head and pure white petals of the snowdrop would be different from the `genes for' the colourful, upstanding petals of the tulip, which would be different again from the `genes for' flies and frogs, birds and humans. But the genome projects reveal a very different story, where the genes `code for' the nuts and bolts of the cells from which all living things are made — the hormones, enzymes and proteins of the `chemistry of life' — but the diverse subtlety of form, shape and colour that distinguishes snowdrops from tulips, flies from frogs and humans, is nowhere to be found. Put another way, there is not the slightest hint in the composition of the genes of fly or man to account for why the fly should have six legs, a pair of wings and a brain the size of a full stop, and we should have two arms, two legs and that prodigious brain. The `instructions' must be there, of course, for otherwise flies would not produce flies and humans humans — but we have moved, in the wake of the Genome Project, from assuming that we knew the principle, if not the details, of that greatest of marvels, the genetic basis of the infinite variety of life, to recognising that we not only don't understand the principles, we have no conception of what they might be.

We have here, as the historian of science Evelyn Fox Keller puts it:

> one of those rare and wonderful moments when success teaches us humility ... We lulled ourselves into believing that in discovering the basis for genetic information we had found `the secret of life'; we were confident that if we could only decode the message in the sequence of chemicals, we would understand the `program' that makes an organism what it is. But now there is at least a tacit acknowledgment of how large that gap between genetic `information' and biological meaning really is.

And so, too, the Decade of the Brain. The PET scanner, as anticipated, generated many novel insights into the patterns of electrical activity of the brain as it looks out on the world `out there', interprets the grammar and syntax of language, recalls past events, and much else besides. But at every turn the neuroscientists found themselves completely frustrated in their attempts to get at how the brain actually works.

Right from the beginning it was clear that there was simply `too much going on: There could be no simpler experiment than to scan the brain of a subject when first reading, then speaking, then listening to, a single word such as `chair'. This should, it was anticipated, show the relevant part of the brain `lighting up' — the visual cortex when reading, the speech centre when speaking, and the hearing cortex when listening. But no, the brain scan showed that each separate task `lit up' not

just the relevant part of the brain, but generated a blizzard of electrical activity across vast networks of millions of neurons — while thinking about the meaning of a word and speaking appeared to activate the brain virtually in its entirety. The brain, it seemed, must work in a way previously never really appreciated — not as an aggregate of distinct specialised parts, but as an integrated whole, with the same neuronal circuits performing many different functions.

The initial surprise at discovering how the brain fragmented the sights and sounds of the world `out there' into a myriad of separate components grew greater still as it became clear that there was no compensating mechanism that might reintegrate all those fragments back together again into that personal experience of being at the centre, moment by moment, of a coherent, ever-changing world. Reflecting on this problem of how to `bind' all the fragments back together again, Nobel Prize-winner David Hubel of Harvard University observed:

> This abiding tendency for attributes such as form, color and movement to be handled by separate structures in the brain immediately raises the question how all the information is finally assembled, say for perceiving a bouncing red ball. It obviously must be assembled — but where and how, we have no idea.

But the greatest perplexity of all was the failure to account for how the monotonous electrical activity of those billions of neurons in the brain translate into the limitless range and quality of subjective experiences of our everyday lives — where every transient, fleeting moment has its own distinct, unique, intangible feel: where the cadences of a Bach cantata are so utterly different from the flash of lightning, the taste of Bourbon from the lingering memory of that first kiss.

The implications are clear enough. While theoretically it might be possible for neuroscientists to know everything there is to know about the physical structure and activity of the brain, its `product, the mind, with its thoughts and ideas, impressions and emotions, would still remain unaccounted for. As the philosopher Colin McGinn expresses it:

> Suppose I know everything about your brain: I know its anatomy, its chemical ingredients, the pattern of electrical activity in its various segments, I even know the position of every atom and its subatomic structure. Do I therefore know everything about your mind? It certainly seems not. On the contrary, I know nothing about your mind. So knowledge of your brain does not give me knowledge of your mind.

This distinction between the electrical activity of the material brain and the non-material mind (of thoughts and ideas) as two quite different things might seem so self-evident as to be scarcely worth commenting on. But for neuroscientists the question of how the brain's electrical activity translates into thoughts and sensations was precisely what needed explaining — and their failure to do so has come to haunt them. So, for everything that the Decade of the Brain undoubtedly achieved, nonetheless, as John Maddox, editor of Nature, would acknowledge at its close: `We seem as far from understanding [the brain] as we were a century ago. Nobody understands how decisions are made or how imagination is set free:

This verdict on the disappointing outcomes of the Genome Project and the Decade of the Brain might seem a trifle premature. These are, after all, still very early days, and it is far too soon to predict what might emerge over the next twenty to thirty years. The only certainty about advances in human knowledge is that they open the door to further seemingly unanswerable questions, which in time will be resolved, and so on. The implication that here science may finally have `reached its limits' would seem highly contentious, having been expressed many times in the past, only to be repeatedly disproved. Famously, the physicist Lord Kelvin, at the close of the nineteenth century, insisted that the future of his discipline was to be looked for in `the sixth place of decimals' (that

is, futile refinements of the then present state of knowledge). Within a few years Albert Einstein had put forward his General Theory of Relativity, and the certainties of Lord Kelvin's classical physics were eclipsed.

The situation here, however, is rather different, for while the New Genetics and those novel brain scanning techniques offer almost inexhaustible opportunities for further research, it is possible to anticipate in broad outline what their findings will add up to. Scientists could, if they so wished, spell out the genomes of each of the millions of species with which we share this planet — snails, bats, whales, elephants and so on — but that would confirm only that they are composed of several thousand similar genes that `code' for the nuts and bolts of the cells of which they are made, while the really interesting question, of how those genes determine the unique form and attributes of the snail, bat, elephant, whale or whatever, would remain unresolved. And so too for the scanning techniques of the neurosciences, where a million scans of subjects watching a video of bouncing red balls would not take us an iota further in understanding what needs explaining — how the neuronal circuits experience the ball as being red and round and bouncing.

At any other time these twin setbacks to the scientific enterprise might simply have been relegated to the category of problems for which science does not as yet have the answer. But when cosmologists can reliably infer what happened in the first few minutes of the birth of the universe, and geologists can measure the movements of vast continents to the nearest centimetre, then the inscrutability of those genetic instructions that should distinguish a human from a fly, or the failure to account for something as elementary as how we recall a telephone number, throws into sharp relief the unfathomability of ourselves. It is as if we, and indeed all living things, are in some way different, pro-founder and more complex than the physical world to which we belong.

Nonetheless there must be a reason why those genome projects proved so uninformative about the form and attributes of living things, or why the Decade of the Brain should have fallen so far short of explaining the mind. There is a powerful impression that science has been looking in the wrong place, seeking to resolve questions whose answers lie somehow outside its domain. This is not just a matter of science not yet knowing all the facts; rather there is the sense that something of immense importance is `missing' that might transform the bare bones of genes into the wondrous diversity of the living world, and the monotonous electrical firing of the neurons of the brain into the vast spectrum of sensations and ideas of the human mind. What might that `missing' element be?

Much of the prestige of science lies in its ability to link together disparate observations to reveal the processes that underpin them. But this does not mean that science `captures' the phenomena it describes — far from it. There is, after all, nothing in the chemistry of water (two atoms of hydrogen to one of oxygen) that captures its diverse properties as we know them to be from personal experience: the warmth and wetness of summer rain, the purity and coldness of snow in winter, the babbling brook and the placid lake, water refreshing the dry earth, causing the flowers to bloom and cleansing everything it touches. It is customary to portray this distinction as `two orders of reality: The `first' or `primary reality' of water is that personal knowledge of its diverse states and properties includes not just how we perceive it through our senses but also the memories, emotions and feelings with which we respond to it. By contrast, the `second order reality' is water's materiality, its chemical composition as revealed by the experimental methods of the founder of modern chemistry, the French genius Antoine Lavoisier, {who in 1783 sparked the two gases of hydrogen and oxygen together in a test tube, to find a residue of dew-like drops that `seemed like water.)

These two radically different, yet complementary, `orders of reality' of water are mutually exclusive. There is nothing in our personal experience that hints at water's chemical composition,

nor conversely is there anything in its chemical formula that hints at its many diverse states of rain, snow, babbling brook, as we know them from personal experience. This seemingly unbridgeable gap between these two orders of reality corresponds, if not precisely, to the notion of the `dual nature of reality, composed of a non-material realm, epitomised by the thoughts and perceptions of the mind, and an objective material realm of, for example, chairs and tables. They correspond, again if not precisely, to two categories of knowledge that one might describe respectively as the philosophic and the scientific view. The `first order' philosophic view is the aggregate of human knowledge of the world as known through the senses, interpreted and comprehended by the powers of reason and imagination. The `second order' scientific view is limited to the material world and the laws that underpin it as revealed by science and its methods. They are both equally real — the fact of a snowflake melting in the palm of the hand is every bit as important as the fact of the scientific explanation that its melting involves a loosening of the lattice holding its molecules together. The 'philosophic' view, however, could be said to encompass the scientific, for it not only `knows' the snowflake melting in the hand as a snowflake, but also the atomic theory of matter and hence its chemical composition.

It would thus seem a mistake to prioritise scientific knowledge as being the more `real, or to suppose its findings to be the more reliable. But, to put it simply, that is indeed what happened. Before the rise of science, the philosophic view necessarily prevailed, including the religious intimation from contemplating the wonders of the natural world and the richness of the human mind that there was `something more than can be known.

From the late eighteenth century onwards the burgeoning success of science would progressively challenge that inference through its ability to `reduce' the seemingly inscrutable complexities of the natural world to their more readily explicable parts and mechanisms: the earth's secrets surrendered to the geologist's hammer, the intricacies of the fabric of plants and animals to the microscopist's scrutiny, the mysteries of nutrition and metabolism to the analytical techniques of the chemist. Meanwhile, the discovery of the table of chemical elements, the kinetic theory of heat, magnetism and electricity all vastly extended the explanatory powers of science. And, most significant of all, the theory of biological evolution offered a persuasive scientific explanation for that greatest of wonders — the origins and infinite diversity of form and attributes of living things.

The confidence generated by this remorseless expansion in scientific knowledge fostered the belief in its intrinsic superiority over the philosophic view, with the expectation that the universe and everything within it would ultimately be explicable in terms of its material properties alone. Science would become the `only begetter of truth, its forms of knowledge not only more reliable but more valuable than those of the humanities. This assertion of the priority of the scientific view, known as scientific materialism (or just `materialism'), marked a watershed in Western civilisation, signalling the way to a future of scientific progress and technical advance while relegating to the past that now superseded philosophical inference of the preceding two thousand years of there being `more than we can know. That future, the scientific programme of the twentieth century, would be marked by a progressively ever deeper scientific penetration into the properties of matter, encompassing the two extremes of scale from the vastness of the cosmos to the microscopic cell from which all living things are made. It began to seem as if there might be no limits to its explanatory power.

The genome projects and the Decade of the Brain represent the logical conclusion of that supposition. First, the genome projects were predicated on the assumption that unravelling the Double Helix would reveal `the secret of life, as if a string of chemicals could possibly account for the vast sweep of qualities of the wonders of the living world; and second, the assumption of the Decade of the Brain that those brain scanning techniques would explain the mind, as if there could be any equivalence between the electrical firing of neurons and the limitless richness of the

internal landscape of human memory, thought and action. In retrospect, both were no more likely to have fulfilled the promise held out for them than to suppose the `second order' chemical composition of water might account for its diverse `first order' states of rain, snow, oceans, lakes, rivers and streams as we know them to be.

This necessarily focuses our attention on what that potent `missing force' must be that might bridge the gap between those two `orders of reality, with the capacity to conjure the richness of human experience from the bare bones of our genes and brains. This is an even more formidable question than it might appear to be, for along the way those genome projects have also, inadvertently, undermined the credibility of the fundamental premise of what we do know about ourselves — that the living world and our uniquely human characteristics are the consequence of a known, scientifically proven, process of biological evolution. Certainly, the defining feature of the history of the universe, as outlined earlier, is of the progressive, creative, evolutionary transformation from the simplest elements of matter to ever higher levels of complexity and organisation. Over aeons of time the clouds of gas in intergalactic space evolved into solar systems such as our own. Subsequently the inhospitable landscape of our earth evolved again into its current life-sustaining biosphere, and so on. Thus the whole history of the cosmos is an evolutionary history. That is indisputable, but the biological theory of evolution goes further, with the claim to know the mechanisms by which the near-infinite diversity of forms of life (including ourselves) might have evolved by a process of random genetic changes from a single common ancestor.

It is, of course, possible that the living world and ourselves did so evolve, and indeed it is difficult to conceive of their not having done so. But the most significant consequence of the findings of the genome projects and neuroscience is the transformation of that foundational evolutionary doctrine into a riddle. The dramatic discovery of Lucy's near-complete skeleton, already described, provides compelling evidence for man's progressive evolutionary ascent over the past five million years. Why then, one might reasonably ask, is there not the slightest hint in the Human Genome of those unique attributes of the upright stance and massively expanded brain that so distinguish us from our primate cousins?

The ramifications of the seemingly disappointing outcomes of the New Genetics and the Decade of the Brain are clearly prodigious, suggesting that we are on the brink of some tectonic shift in our understanding of ourselves. These issues are nowhere more sharply delineated than in an examination of the achievements of the first human civilisation which marked the arrival of our species, Homo sapiens, thirty-five thousand years ago.

Chapter 3 - The Limits of Science 1: The Quixotic Universe

> The world will never starve for want of wonders, but only for want of wonder.
> G K Chesterton

The world is so full of wonder, it is a wonder we do not see it to be more so. Every dawn the `undeviating and punctual' sun rises on the horizon to flood our lives with the light and warmth that drive the great cycle of organic life — thirty million times more natural energy in a single second than that generated by manmade power stations in a whole year. And punctually at dusk, its setting brings the day to a close with a triumphant explosion of purple, red and orange streaked across the sky. `Of all the gifts bestowed upon us; wrote the Victorian art critic John Ruskin, `colour is the holiest, the most divine, the most solemn.' Those limitless nuances of colour and light that suffuse our daily lives mark too the procession of the seasons, a constant reminder of the profound mystery of self-renewing life.

And there is nothing so full of wonder as life itself, the more so now we know that the vital actions of even the humblest bacterium, smaller by far than the full stop at the end of this sentence, involve the concerted action of thousands of separate chemical reactions, by which it transforms the nutrients absorbed from soil and water into the energy and raw materials with which it grows and reproduces itself. But life there is, and marching down through the ages in such an abundance of diversity of shape, form, attributes and propensities as to encompass the full range and more of what might be possible. And what variety!

`No one can say just how many species there are in these greenhouse-humid jungles,' writes naturalist and broadcaster David Attenborough of the forests of South America.

There are over forty different species of parrot, over seventy different [species of] monkeys, three hundred [species of] humming birds and tens of thousands of [species of] butterflies. If you are not careful, you can even be bitten by a hundred different kinds of mosquito ... Spend a day in the forest, turning over logs, looking beneath bark, sifting through the moist litter of leaves and you will collect hundreds of different kinds of small creatures: moths, caterpillars, spiders, long-nosed bugs, luminous beetles, harmless butterflies disguised as wasps, wasps shaped like ants, sticks that walk, leaves that open wings and fly ... One of these creatures at least will almost certainly be undescribed by science.

And the millions of species with which we share the planet themselves represent a mere 1 per cent of those that have ever been, each form of life the opportunity for a further myriad of subtly different variations on a theme. Why should the extraordinary faces of the bat family, whose near-blindness should make them indifferent to physical appearances, nonetheless exhaust the possibilities of the design in the detailed geometry of their faces? Why should the many thousands of species of birds yet be so readily distinguishable one from the other by their pattern of flight or the shape of their wing, the colour of their plumage or the notes of their song?

But birds, as the American naturalist Frank Chapman once observed, are 'nature's highest expression of beauty, joy and truth; whose annual migration exemplifies that further recurring mystery of the biological world, those idiosyncrasies of habits and behaviour that defy all reason — like the Arctic tern, that every year traverses the globe, setting out from its nesting grounds in northern Canada and Siberia, winging its way down the coasts of Europe and Africa to the shores of the Antarctic, only to turn round and return northwards again: a round journey of twenty-five thousand miles that takes them eight months, flying twenty-four hours a day. How swiftly they fly, how confidently across the pathless sea at night!

And while we might rightly wonder how the Arctic tern knows how to navigate by the stars, it seems almost more wonderful still that the salmon should find its way from the depths of the ocean back to the same small stream whence it set out, detecting through its highly developed sense of smell the waters of its spawning ground; or that the common 'European eel should cross the Atlantic twice, first from its breeding grounds off the North American coast to the rivers of Europe — and then back again. `The number of [such] admirable, more or less inexplicable traits that one might cite is limited not by the inventiveness of nature; writes biologist Robert Wesson, `but rather by the ability of scientists to describe them. There are, he points out, an estimated twenty thousand species of ant, of which only eight thousand have been described. So far biologists have got round to studying just one hundred of them in depth, each of which has its own unique, bizarre pattern of behaviour – such as `the female of a parasitic ant which on finding a colony of its host, seizes a worker, rubs it with brushes on her legs to transfer its scent making her acceptable to enter the host colony: How did there come to be such sophisticated and purposive patterns of behaviour in such minute creatures?

And yet that near-infinite diversity of life is permeated by an underlying unity, where everything connects in the same web of self-renewing life. The rain falling on the mountains feeds the springs that fill the streams. Those streams become rivers and flow to the sea, the mists rise from the deep and clouds are formed, which break again as rain on the mountainside. The plants on that mountainside capture the rainwater and, warmed by the energy of the sun, transform the nutrients of the soil, by some extraordinary alchemy, into themselves. A grazing animal eats that same plant to set up another complex web of connections, for it in turn is eaten by another, and its remains will return to the earth, where the microbes in the soil cannibalise its bones, turning them back into their constituent chemicals. And so the process of reincarnation continues. Nothing is lost, but nothing stays the same.

Wheels within wheels; and across that vast landscape of living things, from the highest to the lowest, the survival and prosperity of man is yet, as J. Arthur Thomson, Professor of Natural History at Aberdeen University reminds us, completely dependent on the labours of the humble earthworm, without whose exertions in aerating the dense, inhospitable soil there could never have been a single field of corn.

When we pause to think of the part earthworms have played in the history of the earth, they are clearly the most useful of animals. By their burrowing, they loosen the earth, making way for the plant rootlets and the raindrops; by bruising the soil in their gizzards they reduce the mineral particles to more useful forms; they were ploughers before the plough. Five hundred thousand to an acre passing ten tons of soil every year through their bodies.

So, the world `will never starve for want of wonders, the more so for knowing and wondering how the sky above and the earth below and `all that dwell therein' – including the human mind, with its powers of reason and imagination – originated as a mass of formless atoms in that `moment of singularity' of the Big Bang fifteen billion years ago.

The poet William Wordsworth, seeking to catch the enfolding delight of that sky above and earth below, called it `the sublime,

> Whose dwelling is the light of setting suns,
> And the round ocean and the living air,
> And the blue sky,
> A spirit that impels and rolls through all things.

The feelings evoked by nature and `the sublime' were for the American poet Walt Whitman, as for so many poets and writers, the most powerful evidence for a hidden, mystical core to everyday reality.

`There is, apart from mere intellect, he wrote, `a wondrous something that realises without argument an intuition of the absolute balance, in time and space of the whole of this multifariousness we call the world; a sight of that unseen thread which holds all history and time, and all events like a leashed dog in the hand of the hunter.

That sublime nature has always provided the most powerful impetus to the religious view, its celebration a central feature of all the great religions. For the German theologian Rudolph Otto (1869-1937), the `sublime' was a `mysterium tremendum etfascinans': both awesome, in whose presence we feel something much greater than our insignificant selves, and also fascinating, compelling the human mind to investigate its fundamental laws.

This brings us to the second of the dual meanings of `wonder' suggested at the close of the preceding chapter, to `wonder why, which, as the Greek philosopher Plato observed, `is the beginning of all knowledge.

> `The scientist does not study nature because it is useful to do so, wrote the nineteenth-century French mathematician Henri Poincare. `He studies it because he takes pleasure in it; and he takes pleasure in it because it is beautiful. If nature were not beautiful, it would not be worth knowing, and life would not be worth living ... I mean the intimate beauty which comes from the harmonious order of its parts and which a pure intelligence can grasp.'

The greatest (probably) of all scientists, Isaac Newton, seeking to comprehend that `harmonious order of parts', would discover the fundamental laws of gravity and motion, that, being Universal (they hold throughout the universe), Absolute (unchallengeable), Eternal (holding for all time) and Omnipotent (all-powerful), he inferred, offered a glimpse into the mind of the Creator. Newton captured this dual meaning of wonder, to `wonder at' and to `wonder why, in his famous confession that the most he could hope to achieve was to illuminate the workings of some small part of that sublime world: ‘I do not know what I may appear to the world,' he wrote, `but to myself I seem to have been only like a boy playing on the sea shore, diverting myself now and then, finding a smoother pebble than ordinary, whilst the great ocean of truth lay all undiscovered before me.’

The wonders of the world are so pervasive that to the seemingly less sophisticated minds of earlier ages (such as Newton's) they were best understood as `natural miracles' To be sure, the undeviating and punctual sun, the cycle of life, the infinite variety of living things, their interconnectedness to each other, these are all part of nature, and are faithful to its laws. They are `natural: But the totality of it all, its beauty and integrity and completeness, that `great undiscovered ocean of truth, lie so far beyond the power of the human mind to properly comprehend, they might as well be `a miracle: Thus science and religion were cheerfully reconciled, the scientist seeing his task as a holy calling, where Robert Boyle, the founder of modern physics, would perceive his role as `a priest in the temple of nature.

This is scarcely the modern view. Most people, of course, acknowledge the beauty and complexity of the world and find it admirable, even uplifting — but you could search in vain for a textbook of biology or zoology, astronomy or botany, or indeed of any scientific discipline, which even hints that there is something astonishing, extraordinary, let alone `miraculous; about its subject. Science no longer `does' wonder, which is more readily associated nowadays with the incurious mysticism and incense of the New Age. Science prefers to cultivate an aura of intellectual neutrality, the better to convey its disinterested objectivity, its commitment to the `truth: Hence the highly technical, and to the outsider often impenetrable, prose of its texts and learned journals, from which any sense of wonder is rigorously excluded.

There are, as will be seen, several important reasons for this modern-day lack of astonishment, but the most important is undoubtedly the general perception that science, since Newton's time, has revealed those `natural miracles' to have a distinctly non-miraculous, materialist explanation — culminating in that firestorm of scientific discovery of the past fifty years, which has integrated into one coherent narrative the entire history of the universe from its origins to the present day. To be sure, science may not capture the beauty and connectedness of it all, the `sublime spirit that rolls through all things, but this is more than compensated for by the sheer drama and excitement of the events it has so convincingly described.

The scale of that intellectual achievement is so great that there might seem little room any more for the `natural miracles' of an earlier age, or to `wonder' whether there might after all be more

than we can know. It would certainly require a truly Olympian perspective, capable of surveying the vast landscape of science, to recognise where and what the limits to its knowledge might be — and that would seem an impossibility. Yet it is not quite so, for while that landscape is indeed vast, and far beyond the comprehending of any individual, it is nonetheless sustained by three great unifying phenomena that impose order on the world — which on examination can tell us something very profound about science and the limits of its materialist explanations.

It is fruitless — always has been, always will be — to pose that most elementary of all questions: `Why is there something rather than nothing?' The same however does not apply to the second and supplementary question: `Why, given there is something, are both the physical universe (and all that it contains) and all life (in its infinite diversity) so ordered?' They should not be, for anything left to itself will tend towards chaos and disorder, as fires burn out and clocks run down — unless countered by a compensating force imposing order, restituting lost energy.

There are (to put it simply) three `forces for order':

- First, the force of gravity, as discovered by Sir Isaac Newton, the glue that binds the universe together;

- Second, the all-powerful genes strung out along the Double Helix, imposing the order of form, the shape, characteristics and attibutes unique to each of the millions of species of living things; and

- Third, the human mind, that imposes the order of understanding on the natural world and our place within it.

These three forces control or sustain all (or virtually all) phenomena in the universe, and stand proxy for the `vast landscape' of science. Thus, if they are knowable scientifically as belonging to that materialist, second-order reality of the physics and chemistry of matter (where water is a combination of two atoms of hydrogen and one of oxygen), then by definition there is nothing in theory that science cannot know. But if they are not so knowable, one can only infer that they exert their effects through some other force that lies beyond the range of science and its methods to detect. We start with Sir Isaac Newton's theory of gravity.

Isaac Newton, born in 1642 into a semi-literate sheep-farming family in rural Lincolnshire, was one of the tiny handful of supreme geniuses who has shaped the categories of human knowledge. From the time of Aristotle onwards, and for the best part of two thousand years, the regularity and order of the physical world was as it was because it was divinely ordained to be so: the punctual and undeviating sun, the movement of the planets across the heavens, the passage of the seasons and apples falling from trees. Newton's genius was to realise that these and numerous other aspects of the physical world were all linked together by the hidden force of gravity.

Soon after graduating at the age of twenty-three from Cambridge University, Newton was compelled by an epidemic of bubonic plague to return to his home in Lincolnshire. There, over a period of just two years, he made a series of scientific discoveries that would not be equalled till Einstein, almost 250 years later. These included the nature of light and the mathematical method of differential calculus, with which it is possible to calculate the movement of the planets in their orbit. Newton's most famous insight came when, sitting in his garden, he saw an apple fall from a tree. He `wondered' whether the force of the earth's gravity pulling the apple to the ground might reach still further, and hold the moon in its orbit around the earth.

Newton's friend Dr William Stukeley would later record his reminiscences of that great moment.

> After dinner, the weather being warm, we went into the garden and drank tea, under the shade of some apple trees, only he and myself. Amidst other discourse, he told me he was just in the same situation as when, formerly, the notion of gravitation came into his mind. It was occasioned by the fall of an apple, as he sat in a contemplative mood. Why should that apple always descend perpendicularly to the ground, thought he to himself? Why should it not go sideways or upwards, but constantly to the earth's centre? Assuredly, the reason is, that the earth draws it. There must be a drawing power in matter ... and if matter thus draws matter, it ... must extend itself through the universe.

Newton's `notion of gravitation, of `matter drawing on matter, would resolve the greatest conundrum of the movement of those heavenly bodies, why they remained in their stately orbits (the moon around the earth, the earth around the sun) rather than, as they should by rights, being impelled by their centrifugal force into the far depths of outer space. Newton, being a mathematical genius, calculated the strength of that countervailing force of gravity, showing it to be determined by the masses of the moon and earth, earth and sun respectively, multiplied together and divided by the square of the distance between them, and so too throughout the entire universe. By the time Newton published his epic three-volume Principia Mathematica in 1697, describing the theory of gravity and the three laws of motion, he had transformed the divinely ordained physical world into which he was born into one governed by absolute and unchallengeable universal laws known to man, where everything was linked to everything else in a never-ending series of causes — all the way into the past and indefinitely into the future.

From the beginning, the force of gravity at the moment of the Big Bang imposed the necessary order on those billions of elementary particles, concentrating them into massive, heat-generating stars. Several thousand millions of years later, the same force of gravity would impose order on our solar system, concentrating 99 per cent of its matter within the sun to generate the prodigious amounts of energy, heat and light that would allow the emergence of life on earth. And anticipating the future? Newton's friend, the Astronomer Royal Edmond Halley, used Newton's laws to work out the elliptical orbit of the comet that bears his name and so predict its seventy-six-year cycle of return. Three hundred years later, NASA scientists would use those same laws to plot the trajectory of the first manned space flight to the moon. And it is even possible to predict when it will all end — in five thousand million years' time (or thereabouts), when the prodigious energy generated by our sun will be exhausted, and our earth will perish.

As time has passed, so the explanatory power of Newton's laws of gravity has grown ever wider, to touch virtually every aspect of human experience: the movement of the sun and stars (obviously), the waxing and waning of the moon, the ebb and flow of the tides, the contrasting climates of the Arctic Circle and the sand-swept desert, the cycle of the seasons, rain falling on the ground, the shape of mountains sculpted by the movement of glaciers, the flow of rivers towards the sea, the size of living things from whale to flea and indeed ourselves — for we could not be any bigger than we are without encountering the hazard, posed by gravity, of falling over.

Newton's laws epitomise, to the highest degree, the explanatory power of science, through which for the first time we humans could comprehend the workings of that vast universe to which we belong. But, and it is a most extraordinary thing, three hundred years on, the means by which the powerful, invisible glue of gravity imposes order on the universe remains quite unknown. Consider, by analogy, a child whirling a ball attached to a string around its head, just as gravity holds the earth in its perpetual orbit around the sun. Here, the string (like gravity) counteracts the centrifugal force that would hurtle the ball (the earth) into a distant tree. But there is no string. Newton himself was only too well aware that there had to be some physical means by which gravity must exert its influence over hundreds, thousands, of millions of miles of empty space. It was, he

wrote, `an absurdity that no thinking man can ever fall into' to suppose that gravity `could act at a distance through a vacuum without the mediation of anything else, by which that action and force may be conveyed.

Perhaps, he speculated, space was suffused by an invisible `ether' composed of very small particles that repelled one another and by which the sun could hold the earth in its orbit — though this would mean that over a very long period the movement of the planets would gradually slow down through the effects of friction. But in 1887 the American physicists, Albert Michelson and Edward Morley, discovered that there was no `ether: Space is well named — it is empty. Put another way, Newton's theory encompasses the profound contradiction of gravity being both an immensely powerful force imposing order on the matter of the universe, linking its history all the way back to the beginning and anticipating its end, yet itself being non-material. This extraordinary property of gravitation requires some sort of context, by contrasting it with, for example, that equally potent invisible `force' electricity, which at the touch of a switch floods the room with light. But whereas electricity is a `material' force — the vibration of electrons passing along a copper wire — gravity exerts its effects across billions of miles of empty space, through a vacuum of nothingness.

Newton's theory stands (for all time), but has been modified in two directions. First, in 1915, Albert Einstein in his General Theory of Relativity reformulated the concept of gravity to allow for space to be `elastic, so that a star like our sun could curve and stretch the space around it — and the bigger the star, the greater the effect. Matter, Einstein showed, warps space. This takes care of the more bizarre phenomena in the universe, such as `black holes, that capture even the weightless particles of light — but for all that the profound Newtonian mystery of how gravity exerts its force through the vacuum of space remains unresolved.

Next, it has emerged that Newton's gravitational force is not alone, being just one of four (similarly non-material) forces, including those that bind together the atomic particles of protons and neutrons — whose disruption generates the prodigious energy of an atomic explosion. In the twentieth century, the conundrum of the non-materiality of those gravitational forces was compounded when it emerged that their strength is precisely tuned to permit the consequent emergence of life and ourselves. If the force they exert were, for example, ever so slightly stronger, then stars (like our sun) would attract more matter from interstellar space, and being so much bigger would burn much more rapidly and intensely — just as a large bonfire outburns a smaller one. They would then exhaust themselves in as little as ten million years, instead of the several billion necessary for life to `get going. If, contrariwise, the force of gravity were ever so slightly weaker, the reverse would apply, and the sun and stars would not be big enough to generate those prodigious amounts of heat and energy. The sky would be empty at night, and once again we humans would never have been around to appreciate it. It is, of course, very difficult to convey just how precise those forces necessary for the creation of the universe (and the subsequent emergence of life on planet earth) had to be, but physicist John Polkinghorne estimates their fine tuning had to be accurate to within one part in a trillion trillion (and several trillion more), a figure greater by far than all the particles in the universe — a degree of accuracy, it is estimated, equivalent to hitting a target an inch wide on the other side of the universe.

Isaac Newton's theory of gravity is the most elegant idea in the history of science. Nothing touches its combination of pure simplicity, readily understandable by a class of ten-year-olds, and all-encompassing explanatory power. His contemporaries were dazzled that so elementary a mathematical formula could account for so much — prompting the poet Alexander Pope to propose as his epitaph in Westminster Abbey:

> Nature and nature's laws lay hidden in night
> God said Let Newton be! And all was light.

,Newton's gravitational force, imposing `order' on the physical universe, clearly fails the test of scientific `knowability, for while we can readily comprehend all its consequences we are `left with that absurdity at no thinking man can ever fall into' of having to suppose that a non-material force can `act at a distance' across millions of miles of empty space without the mediation of anything by which that action and force may be conveyed. Thus, ironically, this most scientific of theories, grounded in the observation of the movements of the planets expressed in mathematical form, subverts the scientific or materialist Mew which holds that everything must ultimately be explicable in,terms of its material properties alone.

We turn now to the living world of plants, insects, fishes, birds and ourselves, which is billions upon billions upon billions of times more complex than Newton's non-living, physical universe. Hence, the two forces that impose order on that world, the Double Helix imposing the order of form on living things, and the human brain and its mind imposing the order of understanding, will be profounder than the glue of gravity by similar orders of magnitude. We might anticipate that these two further forces of order will, like Newton's theory of gravity, similarly prove to be non-material, and therefore fail the test of scientific knowability. But to `get there' we must first come to grips with how we have come to suppose otherwise, and specifically how in the 'mid-nineteenth century Darwin's grand evolutionary theory, as set out in the twin texts of On the Origin of Species and The Descent of Man, offered an apparently all-encompassing and exclusively materialist explanation for the phenomena of life.

Chapter 5 - The (Evolutionary) `Reason for Everything': Doubt

`The central question was whether the mechanism underlying microevolution can be extrapolated to explain the phenomena of macroevolution. At the risk of doing violence to the positions of some of the people at the meeting, the answer can be given as a clear, no.'

Report in the journal Science on a conference held at Chicago's Field Museum of Natural History, 1980

Science is by definition a progressive enterprise, hence its onward and upward march over the past four hundred years. The main impulse for its thirst for discovery is the inquisitive human mind, drawn like moths to a light to seek out and investigate the anomalies and inconsistencies of prevailing theories, in the anticipation that further investigation will reveal new facts and observations that will open the way to new and better theories. But Darwin's grand theory of evolution would remain virtually unchanged in principle for 150 years, proving impregnable to critical evaluation of its `difficulties: Its critics, from Richard Owen onwards, seen off with the accusation that they were seeking to reassert the theological interpretation of the wonders of the natural world; its faults set aside by its proponents, from Thomas Huxley onwards, insisting that it is better to have a speculative theory than no theory at all. Time and again this combination of resilience and elasticity would allow it to accommodate all serious challenges to its credibility. They would come in two waves. The first, in the early part of the twentieth century, arose from the discovery by the Augustinian monk Gregor Mendel of the genetic basis of inheritance that would, for a while, leave Darwin's story without a mechanism for evolutionary change. And then, from e 1970s onwards, the difficulties posed by explaining away those troublesome twin axioms of the `puzzle of perfection' (such as the eye) and the failure of the fossil record to demonstrate the `continuity of life, would re-emerge, threatening `the crust of conventional (by now, evolutionary) opinion' that had prevailed for so long.

DOUBT: PART 1

Gregor Mendel and a (Temporary) Eclipse

Darwin's imaginative leap in The Origin was more audacious yet than might appear, for in 1859 the practicalities of genetic inheritance, the central issue for any theory of evolution, remained quite unknown: how physical characteristics are passed on from parent to child; how genetic mutation might give rise to those `favourable' variations; and even the details of what happened at the moment of conception. Instead Darwin supposed, as the prevailing view held, that parents passed on their characteristics to their children via `gemules, consisting of cells budding off from the parental heart, lungs, brain and limbs which diffused into the bloodstream to be transported to the reproductive organs. Then, at the moment of conception, these `gemules' in the paternal sperm and the maternal egg bonded together, passing on the properties of the heart, lungs, brain etc. to their offspring. Thus a cat's `gemules' give rise to kittens, dog `gemules' to puppies, and human `gemules' produce babies.

In 1856, three years before the publication of The Origin, a Bavarian monk, Gregor Mendel, initiated a systematic study of the pattern of heredity in peas in his monastery garden that would overthrow this (to modern eyes at least) bizarre theory. Over a period of ten years Mendel laboriously pollinated by hand each of twelve thousand plants selected for their distinct character traits of size (tall or short), colour and shape of seed, dusting the pollen from a single, known individual plant onto the flowers of another. His findings were unequivocal: those traits (tall or short, smooth or wrinkled seeds) are transmitted as fixed particles (or genes, as they would subsequently be called) by parents to offspring, and on to the next generation, and so on. The parental traits do not, as the gemule theory supposed, blend together, becoming mixed and diluted. The offspring of a yellow pea and a green pea was not a mixture of the two, but either yellow or green, just as the child of a blue-eyed mother and a brown-eyed father does not have bluish-brown eyes: they will be either blue or brown.

This `fixity' of genes explains how, for example, the same striking characteristic — such as the protuberant chin of the Spanish branch of the Austrian royal family, the Habsburgs — might be passed down unchanged through several generations. It explains, too, the astonishment so often expressed when comparing family photographs over time at the striking similarity in facial appearance, all the way down to such details as the positioning of moles or the 'gappiness' of teeth. It also explains how characteristics such as height, hair colour or a personality trait can skip a generation to reappear in the next.

Mendel duly presented his findings to the baffled members of the Natural Science Society in Brunn, and soon after was elected Abbot of his monastery. He wrote a couple of learned papers that went unread, and never performed another experiment. When he died in 1884, aged sixty-one, the budding composer Leo§ Janacek was the organist at his funeral. Sixteen years later, three prominent biologists independently rediscovered his findings, which, it was immediately obvious, posed a serious threat to Darwin's theory of evolution. The concept of the `fixity' of the gene passed on as a hard particle (like a piece of shot) through the generations clearly contradicts Darwin's supposition of natural selection acting on numerous small variations, `each profitable to its possessor:

> Further investigation revealed that exposing flies to high doses of radiation, so as to damage their reproductive organs, generated sudden and dramatic physical changes in their offspring. Certainly these major genetic mutations were almost invariably harmful, but it was possible to imagine how a beneficial one might initiate the necessary substantial anatomical changes that could transform a fish into a reptile. Such naturally occurring, sudden and dramatic mutations seemed to offer a much more plausible mechanism for those

major evolutionary transitions than supposing that they were the consequence of the'accumulation of small inherited modifications.

It is difficult to convey the significance of this without going into too much detail, but the crucial point is that the experimental investigation of genetic inheritance, with all its possible ramifications for the understanding of the causes of genetic disease, prospered to the detriment of Darwin's evolutionary theory. For more than twenty years Mendel's genetics cast a dark shadow over Darwin's evolutionary `reason for everything' (or, as it now seemed to many, the `wrong reason for everything'). But in the early 1920s, salvation would arrive from a most unlikely source — the highest level of abstract mathematics.

This is how. It would be most surprising, when out on a walk, to find that everyone was the same height and weight —say, five feet eight inches and ten stone. On the contrary, the most striking feature is people's variety: some are much taller and fatter, others smaller and thinner, and so on. But, gather together two thousand people, weigh and measure them, and an `average' would emerge. The vast majority would fall within a narrow range of the `mean, while the numbers of the progressively taller and shorter, fatter and thinner would fall away in a distribution known as the'bell-shaped curve, which it so closely resembles.

The investigation of this phenomenon of the `mean' or `average' of physical characteristics had a special appeal for biologists with a mathematical bent, who developed statistical techniques that could define this hidden propensity of the traits of large numbers of people to tend `towards the mean. Both height and weight, as well as other physiological features, are determined (at least in part) by the genes, which would imply that they are not quite as `fixed' as they might seem, but are sufficiently elastic to allow fora range of minor mutations that would allow some individuals to be tall, others small, some fat, others thin — the whole range of differences represented by that bell-shaped curve. And thus, argued Professor of Genetics Ronald Fisher (of London and later Cambridge University), it should be possible to reconcile Mendel's genetics with Darwin's theory of evolution, those minor genetic-based differences in physical characteristics being precisely the sort of small `variations' that Darwin had suggested might confer some biological advantage on their possessors, and that, `selected' by nature, would drive the evolutionary process forward. In essence, Fisher switched the locus of evolution from the individual to the species as a whole, where the high frequency of the same minor genetic mutations within a species of reptile (say) or bird or mammal would push it in one direction rather than another.

This account has tried so far to avoid technical terminology, in the hope that all readers might at least follow the gist of the issues involved. The purpose of reproducing here just a small part of Fisher's twenty-five-page statistical proof of his major work, The Genetical Theory of Natural Selection, published in 1930, is not to clarify his argument, but simply to convey its most salient point — its impenetrable obscurity.

Fisher himself compared the explanatory power of his `Fundamental Theorem' to Newton's laws of gravity, but his mathematical computations lay far beyond the comprehension of ordinary working biologists. `If only we could have understood what he meant!' the evolutionary biologist George Price would observe four decades later. But luckily the biologists did not have to understand the maths, they only had to presume that it proved the reformulation of Darwin's theory, which is as follows. The genes are the major determinants of the form and attributes of living things. Every so often they `mutate' (that is, as currently understood, every time the Double Helix divides and replicates itself, one or other of the coloured beads or chemicals that constitute a single gene is mis-spelt). That mutation may give rise to some novelty or other that:provides the raw material to drive the evolutionary process forward. Nature, in turn, selects those advantageous novelties which if widespread in, say, a species of fish, might be sufficient to transform it into a reptile. Or, as a

major biology textbook puts it: `Mutation is ultimately the source of all genetic variation and therefore the foundation for evolution:

Most such random mutations are rare, and the vast majority (over 99 per cent) of those that do have any effect are harmful in some way. 'Most mutations are more or less disadvantageous to their possessor, comments evolutionary biologist Theodosius Dobzhansky, `[causing] deterioration, breakdown and disappearance of some organs. The potentially beneficial mutation is not just rare, but very, very rare, and to have any effect must act in unison with numerous other similarly (very, very rare) beneficial mutations amongst fellow members of a species. The significance of Fisher's theorem is that, ostensibly, it proves this to be a viable mechanism for the evolutionary process. `The thoughtful student; counters biology professor James Mayor, `will ask whether random mutations could have built up organisms as complicated as the higher plants and animals. At present, no satisfactory direct answer can be given. The long eons of time [over which the evolutionary process takes place] is not in itself an entirely satisfactory answer.

Still, there is always safety in numbers, and Fisher's theorem prompted two other mathematically inclined biologists, John Haldane in Britain and Sewall Wright in the United States, to derive their own similarly impenetrable statistical `proofs: Mathematics is a persuasive and exact science, so for three eminent practitioners to come up with such powerful confirmatory evidence would seem to vindicate Darwin's theory of natural selection as the driving force of the evolutionary process. Except that when devising their proofs, Fisher, Wright and Haldane, as it later emerged, had started from different premises, employed different mathematical techniques, and came to different conclusions as to how the new, revised evolutionary theory actually worked.

The unity achieved by the employment of mathematical methods .. . was accompanied by striking disunity in the interpretation of the way in which selection operated ... So although Fisher and Wright were interested in showing how natural selection could operate ... the unification was not accompanied by one consistent explanation about how that process actually took place.

Biologists do not, in general, understand higher mathematics, but these `proofs' conferred a mathematical aura of invincibility on Darwin's theory that would form the basis for the relaunch in the 1930s of a modernised version, commonly known as the New Synthesis or neoDarwinism. So now natural selection was re-established as the `reason for everything; and more. For Julian Huxley, grandson of Darwin's great supporter Thomas Huxley and co-founder of that New Synthesis, speaking at the centennial celebration of the publication of The Origin in Chicago in 1959, it would enable us to discern the lineaments of the new religion that will arise to serve the needs of the coming era. There is no longer either need or room for the supernatural. The earth was not created, it evolved. So did all the animals and plants that inhabit it, including our human selves, mind and soul as well as brain and body.

The same year the Professor of Genetics at Edinburgh University, Conrad Waddington, in his contribution to a collection of essays, A Century of Darwin, struck a less triumphalist note. He drew attention to the intuitive lack of appeal in supposing, as the higher mathematics of Fisher had allegedly proven, that the glorious panoply of nature should be the consequence solely of random genetic mutation: `Possibly it is true that genes are unstable entities which may sometimes alter spontaneously for unascertainable reasons. But this can hardly be the whole story. One would like to have a coherent, logical connection between new variation and something else in the organism's world.' He could only look forward optimistically to that 'eventual understanding' when the practicalities of how random genetic mutation might provide the raw material of the evolutionary process would be `less patently incomprehensible than it is at present.

DOUBT: PART 2 - The Fossil Record, Perfection (and Homology) Revisited

The New Synthesis, buttressed by those obscure mathematical proofs, would prevail for the best part of forty years. But Nature is as it is, and obstinately refuses, despite much badgering, to conform with fallible

human ideas of how it works, so uncomfortable facts have the disconcerting habit of sticking around despite the best efforts of those who might suppose they have been resolved. By 1980 the two most uncomfortable difficulties of Darwin's evolutionary theory had resurfaced more acutely than ever. They were, it will be recalled, the lack of evidence in the fossil record for the `inconceivably great' number of transitional fossils required by a process of gradualist evolutionary transformation; and, second, the `puzzle of perfection, the impossibility of demonstrating how a blind, `trial and error, random process can give rise to `organs of extreme perfection, such as the eye. What had happened?

(i) The fossils' verdict

The startling discovery so soon after the publication of The Origin of several fossilised specimens of archaeopteryx, with features of both reptiles and birds, had, as noted, enormously enhanced Darwin's credibility at the expense of `the most eminent palaeontologists' of his day. Subsequently the search for similar `transitional forms' would become a major focus of research. The most convincing yet to have been discovered is the order of Therapsida, whose bony skeleton has several features intermediate between reptiles and mammals. Most of the characteristics that might distinguish, say, a reptilian lizard from a mammalian rat cannot be preserved in fossilised form, so we can know nothing of the evolutionary transition from cold- to warm-bloodedness, from egg-laying to viviparity (live birth), from scaly skin to hair, and so on. But the fossilised skulls of Therapsida are undoubtedly `transitional; where the bones that make up the reptile's lower jaw progressively shrink in size and move back towards the jaw joint, becoming eventually the small bones of the inner ear of mammals, the `hammer' and `anvil' that convert the resonance of the eardrum into the electrical impulses of the auditory nerve.

This sounds persuasive, so why, by 1980, had palaeontologists become (reluctantly) persuaded that the doubts of their nineteenth-century predecessors were well founded? The scant evidence, epitomised by the fossilised remains of Therapsida, of gradualist transformation between reptiles and mammals is swamped (literally) by the `bigger picture, which reveals its antithesis — that the evolutionary process occurred in `fits and starts.

`For more than a century, biologists have portrayed the evolution of life as a gradual unfolding of new living things from old, the slow moulding of animals and plants into entirely different forms,' observes Steven Stanley of Johns Hopkins University. `Today the fossil record forces us to revise this view as it turns out myriad of species have inhabited the earth for millions of years without noticeably evolving. On the other hand, major evolutionary transformations have been wrought during episodes of rapid change, when new species have quickly budded off from old ones. In short, evolution has moved by fits and starts.'

The main reason for palaeontologists' loss of faith in the orthodox evolutionary doctrine was the realisation that the most notable feature of the fossil record is that most of the time nothing happens. Successive strata of rock up a cliff face, representing tens of millions of years of geological time, yield: `Zigzags, minor oscillations and the very occasional slight accumulation of change at a rate too slow to account for all the prodigious changes that have occurred in evolutionary history,' writes palaeontologist Niles Eldredge. `When we do see the introduction of evolutionary novelty, it usually shows up with a bang, and often with no firm evidence that the organisms did not evolve elsewhere!'

This `stasis' clearly contradicts Darwin's supposition of a continuous process of gradualist transformation, but by itself it might not seem particularly interesting. Its corollary most certainly is — for when species stay unchanged for tens of millions of years, this drastically reduces the time available for the evolutionary transformations that do occur, which must then happen both suddenly and rapidly. But how rapidly?

It is necessary here to recall that grand overview of the fossil record of the preceding chapter, and to focus on that crucial moment around sixty-five million years ago of the extinction of the dinosaurs, currently attributed to a change in atmospheric conditions caused by a meteor colliding with the earth. The small mammals left behind would, over the next several million years, diversify to become that vast repertoire of mammals (elephants, kangaroos, rabbits, etc., etc.), some of which (the bat) would take to the air, while others (the whale) to the sea. Darwin's imaginative (if improbable) supposition of the process of gradualist transformation in The Origin of that black bear swimming for hours and becoming `more and more aquatic', ending up `almost like a whale', could now be recast as follows: starting with a medium-sized mammal, the whale's presumed ancestor pakicetus, what, asked palaeontologist Steven Stanley, would it take for it to become a whale in twelve million years?

Fig 5-2: What does it take to become a whale in twelve million years? In 1978 Professor Philip Gingerich of the University of Michigan discovered a fifty-two- million-year-old skull of the wolf-sized carnivore pakicetus with characteristics in common with the probable ancestor of the whale elomeryx. Over the following; three decades palaeontologists would find the fossilised remains of the near-complete skeleton of rodhocetus, that swims with its legs, and the fully aquatic dorudon, that uses its tail for propulsion while retaining residual elements of pelvis and limbs. Together they represent `the sweetest series of transitional forms an evolutionist could ever hope to find, observes the natural historian Stephen Jay Gould — but to fit with the Darwinian theory of gradualist evolutionary transformation they pre-suppose a further myriad of transitional species in the briefest of periods (relatively speaking) of geological time, of a mere twelve million years.

The conventional evolutionary scenario might perhaps put `end to end' ten to fifteen successive species during this period, each `modified by descent' from its predecessor, which might conceivably have permitted pakicetus to acquire, by numerous small modifications, evolutionary novelties epitomised by the transition of the fox-sized eohippus to the modern horse. It could, however, scarcely have begun to become a whale by the same process — which would require hundreds, or even thousands, of transitional species to effect the necessary modifications for its massive increase in size, modifications of the skull to bring the nostrils to the top of the head to account for the famous `fountain, the streamlining and reduction of hind limbs, the evolution of tail flukes, the replacement of sweat glands by a thick layer of rubbery fat to control the body temperature, the ability to suckle its young underwater without their drowning, and much else besides.

There is, in short, neither the time nor the mechanism that could begin to account for so rapid and dramatic an evolutionary transformation from that small mammal to the extraordinary whale in so (relatively) short a period as twelve million years — or indeed to account for why it should have taken to the air and acquired the equally great number of unique physical characteristics necessary to become a bat.

By 1980 the logical implications of such biological 'insolubilia' seemed inescapable: the central premise of Darwin's evolutionary theory of gradualist transformation was no longer tenable. `The central question; as a report from a major academic conference on evolution in Chicago that year

would put it, `was whether the mechanism underlying microevolution [as in the finches' beaks] can be extrapolated to explain the phenomena of macroevolution [shrew-like mammals into whales]. At the risk of doing violence to the positions of some of the people at the meeting, the answer can be given as a clear, no.

Some other dramatic mechanism, as yet unknown to science, must account for that extraordinary diversity of life as revealed by the fossil record. Steven Stanley comments elliptically: `We would predict that if the ancestral species gave rise to strikingly new species this would not have happened by their own transformation, but by their budding off of distinctive new forms, which would, in turn, have budded off others.'

(ii) The Puzzle of Perfection

Meanwhile, the endeavours of bioengineers during the same period had thrown into sharp relief the impossibilities of Darwin's second axiom, that a succession of random variations could conceivably account for such `puzzles of perfection' as the human eye. The many substantial contributions of bioengineers to medicine's therapeutic evolution in the post-war years include most obviously the life-sustaining technologies of the intensive care unit, such as artificial ventilation, dialysis, cardiac pacing and so on. But their attempts directly o replicate the complex functioning of whole organs such as the heart rave proved far beyond their competence.

The heart is an astonishingly powerful pump, capable of propelling he entire volume of the body's five litres of blood through the `pipeline' of arteries and veins that, stretched end to end, would circle the globe five times —100,000 miles in all. This `pump' may be no bigger than an ▸range, nestling in the palm of the hand and weighing just a quarter of a pound, but it generates enough force to propel a fountain of blood Against gravity six feet into the air, and in doing so utilises as much energy as the legs of a marathon runner pounding the pavement.

The heart is not just powerful, it is also highly `efficient, in the technical sense of performing twice as much `work' in relation to the amount)f `fuel' utilised as any conventional man-made pump. This is due to the unique arrangement of the overlying spirals of its muscle fibres, which Become progressively shorter as they taper down towards the tip (in the dame way that the number of bricks in each row of a cathedral spire gradually diminishes as it tapers upwards), thus squeezing every last drop of blood out of the cavity of the ventricles at each heartbeat. And or good measure, this masterpiece of engineering efficiency should with tick run the two and a half billion cycles of a lifetime without maintenance or lubrication, or the need to replace its four sets of valves, which)pen and close four thousand times every hour.

Starting in the 1960s, the early pioneers of the artificial heart anticipated some difficulty in matching such specifications, but it still took twenty years to come up with the first workable device, which was implanted into a retired American dentist who went on to develop respiratory and kidney failure, pneumonia and blood poisoning before dying four months later. Over the next ten years a similar fate befell a further two hundred patients before the US Food and Drug Administration intervened and called a halt.

By now it was clear the task was hopeless — though perhaps, it was suggested, it might be possible to create an artificial heart that could Mutt as a stopgap in patients with severe heart failure, tiding them over

until a natural version in the form of a heart transplant became available. After forty years and billions of dollars, that, it seems, is as far as we are likely to get. The current model weighs twice as much, and is a fraction as efficient, as nature's version, its energy supply transmitted through a couple of tubes connected to a `console' the size of a chest of drawers which can be moved around

only on rollers and so confines the patient to hospital. This clumsy device can sustain a patient for up to two months — until a transplant of nature's much better efforts becomes available, that can keep its recipient fit and healthy for twenty years or more. In 2003, forty-two-year-old American Kelly Perkins became the first heart transplant recipient to climb the Matterhorn, having already conquered Mount Fuji (from whose summit she scattered the ashes of her donor) and Mount Kilimanjaro. She couldn't have done that with an artificial heart.

The pump-like mechanism of the heart is much the simplest of physiological systems, simpler by far than the complexities of kidney or brain, or the sense organs such as the eye. So when, as here, the purposive efforts of brilliant bioengineers employing the most sophisticated modern technology fall so far short of nature's model, it seems merely perverse to suggest that the undirected process of nature, acting on numerous small, random genetic mutations, could give rise to this or any other of those `masterpieces of design.

This is not to suggest there must be a Creator after all, whose higher intelligence trumped the best efforts of those bioengineers, but to draw attention to the necessity for there to be some prodigious biological phenomenon, unknown to science, that ensures the heart, lungs, sense organs and so on are constructed to the very highest specifications of automated efficiency.

(iii) The `unsolved problem' of homology

The saga of the artificial heart resurrects William Paley's conundrum of why `Nature's contrivances of design' should be `greater and more to a degree that exceeds all computation' than man's much humbler
efforts. Meanwhile, the findings of modern embryology would resurrect the conundrum of Cuvier's law of homology, or similarity, with its supposition of some `formative influence' ensuring that the structures of the limbs of bats, birds, porpoises and humans were all built to the same blueprint (see illustration, page 74).

Darwin had claimed that similarity to be powerful evidence in favour of his proposed mechanism of evolutionary transformation of one species to another.

Who was right?

Darwin's interpretation of those similarly fashioned limbs as evidence of their originating from a common ancestor would, self-evidently, require that they originate from the same basic structures in the developing embryo. But it was clear from the moment nineteenth-century biologists first started scrutinising the embryos of different species down the microscope that the pattern of division of the fertilised egg, even to the untrained eye, was quite different in the major classes of vertebrates: amphibians (frogs), reptiles (lizards) and mammals (such as humans). Then, in the 1960s, the distinguished embryologist Sir Gavin de Beer, subsequently director of the British Museum of Natural History, found that the embryological origins of those homologous limbs arose from quite different `segments' of the trunk in the newt, lizard and man.

It does not seem to matter where in the egg or the embryo the living substance out of which homologous [similar] organs are formed comes from, he observed in his monograph Homology: An Unsolved Problem. `That [similarity of structure] cannot be pressed back to similarity of position of the cells of the embryo out of which these structures are ultimately formed.'

And if `it does not matter, then that `common architectural plan' of the forelimbs of reptiles and mammals, so long held to be powerful evidence for Darwin's theory, can no longer be interpreted in favour of descent from a common ancestor. `The concept of homology is absolutely fundamental to

what we are talking about when we speak of evolution, de Beer's contemporary the biologist Sir Alister Hardy observed, `yet in truth we cannot explain it at all in terms of present-day theory.'

Thus, as of the early 1980s, science no longer had an adequate materialist explanation for the history of life. The surprise perhaps is how readily refutable Darwin's theory turns out to be, as if it must contain some hidden flaw that invalidates its scientific credentials — as indeed it does. Darwin's interpretation of the differences between those finches' beaks conforms to the scientific method of formulating a hypothesis, in the light of his numerous observations, of the subtle `micro-evolutionary' differences between closely related species. But he was obliged, when extrapolating from this form of `micro' to `macro' evolution, to abandon the scientific method. Now all observations had to be tailored to fit the presumed evolutionary mechanism — no matter how contradictory or improbable it might seem. The fossil record certainly appears discontinuous, happening in `fits and starts, but the priority of Darwin's theory required him to present only those observations that might fit the pattern of a gradual continuous merging of one species into another, and put to one side all that might contradict it. Similarly, the eye with its constituent parts certainly seems as if it is designed for the purpose of seeing, but again Darwin's prior commitment to his own theory required him to argue, per impossibile, that it was brought into existence by the accumulation of numerous small, random variations.

Nonetheless, Darwin's theory, thanks to its resilience and tenacity, survived virtually unscathed. Then, as now, sceptics are seen fending off the charge that they are closet creationists, while its many faults accommodated on the grounds of there being no better alternative. at tenacious preference for Darwin's doctrine remains almost universal, the supposition that he solved the mystery of the origins of life light uncritically in schools and universities. But behind the facade scientific unanimity, the crust of conventional opinion has been breaking up, with a dissident minority of evolutionary biologists king to reconcile, in a series of articles in scientific journals (`Is a w Evolutionary Synthesis Necessary?, `Is a New and General Theory Evolution Emerging?'), the claims of this dominant scientific theory our age with the evidence which so clearly contradicted it. Indeed, en one camp accuses another of making `unsubstantiated assertions ting on the surface of a quaking marsh of unsupported claims', only elicit the counterclaim of `ideas so confused as to be hardly worth bothering with, one might reasonably suppose that this was a theory the point of collapse.

Meanwhile, the pioneers of the New Genetics were refining those techniques that would culminate in spelling out the genomes of fly, Worm, mouse and man, whose definitive, if unintentional, implications for the validity of Darwin's evolutionary theory have already been hinted at. We turn now to that concluding episode of this great saga, hose astonishing and totally unexpected insights into the mechanisms of genetic inheritance would put to the test the 'scientific knowability' of the means by which the Double Helix imposes the order of form on the near-infinite diversity of life.

Chapter 6 - The Limits of Science 2: The Impenetrable Helix

> `How is it we have so much information, but know so little?'
> Noam Chomsky

The elegant spiral of the Double Helix, like Newton's law of gravity combines great simplicity with phenomenal power. But the practicalities of what it does, how it imposes the order of `form' and all the cornplexities of life on the fertilised egg, are of a qualitatively different order — and for the obvious reason that `life' is immeasurably more complex than `matter. Compare, for example, a pebble at the bottom of a pond with a humble fly of similar size on its surface. The pebble is compose(of several billion atoms of calcium and phosphorus, all neatly arrange(in a highly

regularised pattern. And the fly? The contrast is so startling that it scarcely needs spelling out: a similar number of atoms are her(arranged in an enormously greater number of different ways — as it: face, with antennae, eyes and mouth parts; its dot-sized brain, which orchestrates its flying skills; its wings, beautifully jointed limbs, and so on. To the seventeenth-century naturalist, this symphony of parts glimpsed for the first time through the newly discovered microscope was a revelation:

> It seems as though God has bejewelled them in compensation for their lack of size. They have crowns, blooms, and other attire upon their heads against which anything invented by the richest of men must pale; and those who have used only their eyes have never seen anything so beautiful, so fitting or so magnificent in the houses of the greatest princes as that which can be seen with magnifying glasses on the head a simple fly ... so much beauty concentrated in so small a space...

But this contrast between the outer physical appearance of fly and?ebble is merely the beginnings of the differences between them. For e fly, or any form of life, is fashioned from successively more fundamental `organisational' levels, or layers, of increasing complexity. First, the organs such as the heart, brain and gut. Those organs in turn are fashioned from the unique arrangement of nerves, muscles and glands at make up the tissues. The tissues themselves are fashioned from the most fundamental unit of life, the cell; at which point if we were to step aside we would find ourselves `in a world of supreme technology:

> `We would see endless corridors branching in every direction [along which] a huge range of products [proteins, enzymes] and raw materials [chemicals] shuffle in a highly ordered fashion to and from all the various assembly plants, writes biologist Michael Denton. `We would wonder at the level of control implicit in the movement of so many objects, all in perfect unison. We would see that nearly every feature of our own advanced machines has its analogue in the cell:... memory banks for information storage and retrieval, elegant control systems regulating the automated assembly of parts, proof reading devices utilised for quality control, assembly processes involving the principle of prefabrication and modular construction ... This automated factory carries out almost as many unique functions as all the manufacturing activities of man on Earth. but with one capacity not equalled in any of our most advanced machines — it is capable of replicating its entire structure within a matter of a few hours.
>
> `[And yet] the cell, this remarkable piece of machinery that possesses the capacity to construct every living thing that has ever existed is several thousand million million million times smaller than the smallest piece of functional machinery ever constructed by man.
>
> 'Tor does it stop there, for the properties of the humble fly on the urface of his pond belong in a dimension that has no parallel with he inanimate pebble: the capacity to transform the nutrients on which t feeds into its own tissues, to repair its parts and reproduce its kind. The humble fly is, in short, billions upo billions upon billions of imes more complex than the pebble.

The history of biology over the last four hundred years is essentially he progressive and purposive unravelling, in successive waves of discovery, of the ever more fundamental layers of the complexity of life - from the descriptive anatomy of the whole organism in the seventeenth century, through the physiology, histology, embryology and biochemistry of the eighteenth and nineteenth centuries, culminating in he penetration over the last sixty years of the mysteries of the cell and he instructions determining the form of all living things strung out long the Double Helix. There is nowhere further for biology to go. ['his is the end of the line, and just as the fly is so vastly

more complex han the pebble, so the directive force of the genetic instructions of the double Helix must, when compared to Newton's physical laws of natter, be billions upon billions upon billions of times more potent. ['he deciphering of those genetic instructions would be biology's last treat task: how do they impose form on living things? How do they replicate themselves to be transmitted from one generation to the next? -low might they change so that one form of life is transformed into mother?

There are no profounder questions. Their elucidation over the past,years has come in three major instalments. It began, as already ed on, with Mendel's famous pea experiments, which revealed the characteristic traits of living things are passed down from one ration to the next in the form of `genes, for the most part fixed unchanging, ensuring that the offspring of cats will always be kittens, except for the occasional — usually harmful — `mutation'.

The second instalment began in 1953, when Francis Crick and James on discovered that those genes were strung out along the two inter-twining strands of the Double Helix, each strand a sequence of just four Gals that, so far, we have portrayed as `coloured discs, but which are commonly designated by the first letters of their names: C(ytosine), canine), A(denine) and T(hymine). Christopher Wills, Professor of Biology at the University of California, draws an appropriate analogy:

> 1 have just with some difficulty hefted Webster's Third New International Dictionary onto my lap. This is the one that you see in libraries, sitting;;.proudly on its own little lectern. I find there are about sixty letters to a line, 150 lines to a column and three columns to a page. This works out at 27,000 different letters to a page. The dictionary has roughly 2,600 pages adding up to seventy million letters in all. Since there are about three billion [letters] in the human genome, it would take forty-three volumes the size of this enormous dictionary, filling a shelf twelve feet long, to list the information that they carry.

In reality, of course, those C G A T chemical molecules are minuscule compared with the letters representing them, so when strung together ng the Double Helix they produce a continuous strand of approximately three inches (or seventy-five millimetres) long. But those seventy-five millimetres must be packed into the nucleus of the cell, which is about 1/500th of a millimetre across. The Double Helix, in achieving this extraordinary feat, `packs over a hundred trillion times as much information by volume as the most sophisticated computerized information system ever devised' This is how it works.

We start by straightening the helix to form a ladder whose outer banisters (as it were) are formed from two continuous strands of sugar molecules (known as deoxyribose). From each is suspended the sequence of C GA T chemicals (the crucial part of a compound known as nucleic acids). that grip together in the middle to form the ladder steps — three billion in all. The initials of the Deoxyribose sugar `banisters' and the Nucleic Acid chemicals of the `steps' give the technical term DNA.

This memorably simple and elegant structure is perfectly suited to the necessity of replicating the `trillion times compressed' information every time the cell divides to form two daughter cells. First the Double Helix splits down the middle, and the stubs of the half-steps on either side each now form a complementary sequence of letters. These stubs then form the template on which the cell builds a further complementary strand — so one Double Helix becomes two, or, as Crick and Watson described it in the `most important scientific paper in the history of biology':

> We imagine that, prior to duplication, the bonds [connecting the two half-steps] are broken and the two chains unwind and separate [the ladder, as it were, splits down the middle), each chain then acts as a template for the Lion onto itself of a new companion chain so that eventually we shall two pairs of chains where we only had one before. However, the presence of the pairs will have been duplicated exactly.

Crick and Watson's economical prose does not begin to do justice to staggering logistics of this process: with up to four million new ing created in the body every second, a thousand enzymes down the Double Helix like a team of readers systematically . g through the volumes of Webster's Dictionary, copying each three billion C G A T chemicals in precisely the right sequence then stringing them all together again.

We turn now to the crucial question of how the Double Helix embodies `information; or specifically, how those C G A T molecules arranged into genes, and how those genes `instruct' for the complexities of life. Here the serial arrangement of those molecules obviously represents some form of `code'. This is best understood by going back to that description of the workings of the `automated
history' of the cell. We will focus on just one of the `products' as it rolls off the assembly line — the haemoglobin molecule, tens of thousands of which in each red blood cell capture the atoms of oxygen in the inspired air of the lungs and transport them to the nerves and muscles, to fuel the chemical reactions that drive the machinery of their cells.

We rightly marvel at the bewilderingly intricate structure of this haemoglobin molecule which performs so simple a task — but it is no more intricate than the tens of thousands of other `products; proteins and enzymes rolling off the cells' assembly lines from which all living things are made. We find, scrutinising that haemoglobin molecule more closely, that it is fashioned from hundreds of small parts, which on closer scrutiny still come in just twenty different forms — comparable to the rectangles, squares, circles and triangles in a box of children's bricks. These different `parts' (known as amino acids) come from the food we eat, digested in the gut and transported to the cells to be reconstituted into ourselves and products such as haemoglobin. Now, reverting to the genetic `code, we find that those CGAT chemicals strung out along the Double Helix, when arranged in threes (or triplets) — say, C G G — each `speaks for' one or other of those twenty different-shaped parts.

This may be the point at which some might fear losing the thread — but with a simple diagram (opposite) all should become clear. How does the red blood cell make those haemoglobin molecules? First, the Double Helix splits at the point where several hundred of those CGAT letters, arranged in triplets, form the haemoglobin `gene, each triplet `speaking for' one or other of those parts. The gene makes a duplicate of itself, known as its `messenger. The `messenger' then passes out of the nucleus into the main part of the cell to find one of the many mini-factories for making the `products' of the cell. The `messenger' feeds itself, like a tickertape, in at one end of the mini-factory, reads the first triplet, and finds and adds the relevant part, one of those different-shaped building blocks, to the assembly line. Then it reads the next triplet (ditto), then the next (ditto) and the next (ditto), until the last triplet is reached and the final part is in place. And then what?

Those different-shaped parts (squares, circles, triangles, etc.), now strung out in a long, thin sequence, slip off the assembly line and, hey presto, all spontaneously `spring together' to form that bafflingly complex haemoglobin molecule. By analogy: suppose you wish to buy a new home-assembly chest of drawers for the bedroom. You purchase its component parts from a furniture store, lay them on the bedroom floor in the correct sequence, stand back, and watch in amazement as it spontaneously constructs itself. It is possible to get a glimpse here of the stunning conundrum of how the `simple, elegant Double Helix might give rise to the infinite complexities of life. The

`encoded' information in the triplets of the haemoglobin gene serves a dual purpose, both determining the parts or building blocks of which the haemoglobin molecule is composed, and also the sequence in which they are arranged, so that when those parts are strung together as they come off the production line they will spontaneously adopt the necessary structure for clutching those atoms of oxygen and transporting them to the tissues.

This simplified and simplistic account cannot convey the ferment of remorseless activity it represents — with the `messages' generated from the genes strung out along the Double Helix streaming out of the nucleus; the parts pouring off the factory assembly line and self-assembling themselves into `products'; these are then loaded onto minuscule `trucks' to be transported along congested `highways' out of the cell to fulfil their many and diverse functions. Periodically this remorseless activity is interrupted by a massive upheaval; the cell, having duplicated all its own constituent parts (the Double Helix, the nucleus, protein factories and so on), tears itself apart to form two `daughter cells', each a direct copy of itself.

The mind reels just contemplating what all this entails. How does the cell ensure that its components are replicated so faithfully every time it divides? How does the cell `know' at any one instant to activate, say, the haemoglobin gene rather than that of any of the other tens of thousands strung along its length? Where does all that `information' come from: the intention of the SOS message in Morse code is understood only because its inventor, Samuel Morse, established the convention that three dots mean an S, three dashes an 0, and so on. How was the convention established that a GAG triplet should code for one `part' or building block, a GTG triplet another?

The Double Helix, to do so much, possesses two sets of extraordinary, and indeed contradictory, properties. First, it is both stable and dynamic: `stable' in that it passes on precisely the same genetic information from generation to generation over millions of years; yet also `dynamic, for the vitality that distinguishes the biological world from the physical (a pebble from a fly) is the dynamic capacity to make a replica of itself every time the cell divides.

Next, the Double Helix is both an architectural blueprint and lied craftsman in one: it both contains the plan for the individual organism, and directs its development down to the last detail.

The dual powers confer on the Double Helix an almost spiritual tension. It is immortal, being passed on from generation to generation, and yet for each individual it determines who they are, their physical and mental attributes, and what they will become.

On the one hand [there is] the simplicity of the principle, on the other the endless complexity of the process; writes biologist Maitland Edey.,`It is that magisterial power that commands our attention. Its four molecules are absurdly simple. They are not alive, but they can do things no [molecules] ever dreamed of. . . They wave their instructional wands ... to make everything that can be called alive, to monitor the development of every fern and feather on earth, to direct their growth, to enable them to function, to replace worn-out parts, to turn things on, to turn them off. Lo, there emerges a bacterium, a flower, a fish, a Frenchman.'

The Double Helix is an extraordinary phenomenon. But, tantalisingly, the elegant simplicity of its intertwined strands held out the promise that those extraordinary properties and the prodigious amount of information they contained might be decipherable — that the fundamental mysteries of `life' might be knowable. And that, of course, was precisely the promise of the third and final instalment of the unravelling of the double helix, those technical innovations of the 1970s, touched on in the opening chapter, which held out the seasonable expectation that spelling out every gene would reveal the true cause of living things, and how chance changes or mutations in:'those genes could bring about their evolutionary transformation one 'into the other.

It is difficult to convey the excitement amongst biologists as they realised how those three technical innovations of the New Genetics might permit them to read and interpret the genetic instructions coded within the Double Helix. The first of those innovations, it may be recalled, permitted researchers to cut up the sequence of the three billion chemical molecules, C G A and T, that made up the Double Helix, into manageable fragments. Next they learned how to produce numerous `photocopies' of those fragments, the better to find out what they did. And finally they developed the methods that would `spell out' the sequence of letters or chemicals of the individual genes, and thus work out which products they coded for and what they did.

This was real science, of the sort that fills the pages of learned journals and earns Nobel Prizes all round; and with the forty-three Webster-sized volumes of information waiting to be explored, there was more than enough for everyone to be getting on with. Surprisingly, the daunting prospect of working it all out soon appeared much easier than expected, and for the most unlikely reason — the realisation that 95 per cent of that Double Helix was `junk, tens of thousands of repetitions of just one letter of the genetic code (an A say, or a G) that, not coming in the form of threes or triplets, could not `speak for' one or other of those parts or building blocks. To clarify. Nature is invariably parsimonious —a fly has all it takes to be a fly, nothing more, nothing less, a worm to be a worm, and so on. It would therefore be reasonable to expect to find the genetic instructions strung out along the Helix to be expressed in some similarly cogent and compressed way. This is the supposition behind Christopher Wills' analogy of there being forty-three volumes of `information' packed within the nucleus. But that is not how it turned out. Instead, the disproportionate amount of `junk' in the Double Helix means that the equivalent of forty-two of the fortyinthree Webster volumes contain no genetic information at all, while the genes themselves come in fragmented pieces, separated out again by further long sequences of `junk' that first have to be `edited out' to form a coherent message. Put another way, the arrangement of those genetic instructions along the Double Helix is almost the reverse of what one might reasonably expect. There is, after all, little difficulty in providing the directions to your house (turn left at the post office, past the petrol station, etc., etc.) — as long as you do not chop the words up into little pieces and intersperse them with page after page of meaningless gibberish.

This was the first intimation of the perplexities to come. There was every reason to suppose that the profound complexities of life would require an equivalent prodigious amount of `information, but the surprise was how little information was required, with just one `volume's worth' of Webster's International Dictionary containing sufficient instructions to transform a single fertilised egg into a human being. It was all very odd.

There was, however, no difficulty in putting such oddities to one for right from the beginning the techniques of the New Genetics proved spectacularly successful not just in tracking down and identifying thousands of genes, but in identifying the changes or `mutations' genetic instructions that result in all types of genetic illnesses — ich the simplest to understand is the mutation in the haemogene that causes the blood disorder sickle-cell anaemia. This, in provided the first opportunity critically to examine that central concept of the evolutionary theory, how such random `mutations' might also give rise to beneficial variations, which cumulatively might those organs of extreme perfection such as the eye, and cause the formation of one species into another.

The red blood cells in those who suffer from sickle-cell anaemia, as name suggests, are `sickle' shaped, causing them to clump together, blocking the blood flow through the capillaries and depriving the tissues oxygen — with painful and potentially lethal consequences. Back in 1956 an English chemist, Vernon Ingram, working at the famous Cavendish laboratory in Cambridge (where Crick and Watson had discovered the Double Helix just three years earlier), found the instability of the red blood cells to be

due to a faulty arrangement of just one of the parts of which the haemoglobin molecules are made. Two decades later, when it became possible, thanks to the New Genetics, to spell out the full sequence of the haemoglobin gene, it emerged that that faulty arrangement was caused by a single mutation which should normally read GAG, but is mis-spelt in those with sickle-cell anaemia to read GTG — so the protein factory inserts the `wrong' part. By analogy with that self-assembling chest of drawers, just a single defective part would cause it to collapse.

This first demonstration of the devastating consequences of just a single 'mis-spelling' or mutation could scarcely be more persuasive, and before long the genetic mutations responsible for many important disorders had been identified: the bleeding disorder haemophilia, famously transmitted by Queen Victoria to the royal households of Europe, caused by a mutation in the gene that codes for one of the proteins involved in the clotting of the blood; cystic fibrosis, the commonest inherited genetic disorder in the Western world, a disease of the lungs that predisposes to chronic infection leading to respiratory failure; muscular dystrophy, which causes a progressive weakness of the muscles; and the dementing illness Huntingdon's chorea, whose many victims include the American folk singer Woody Guthrie.

And yet, that single mutation responsible for sickle-cell anaemia began to appear ever more exceptional. Many genetic illnesses proved to have not one but dozens of possible `mutations': two hundred in the case of cystic fibrosis that could cause the disease, and a further two hundred that made no difference. Further, it emerged, it was possible to have a devastating genetic mutation without its causing any abnormality at all — as illustrated by two sisters, both with the same defective gene for the inherited form of blindness known as retinitis pigmentosa. The younger was indeed blind, but the visual acuity of her older sister, whose gene contained exactly the same mutation, was excellent, and did not prevent her from working as a night-time truck driver. These complexities, inexplicable in the conventional understanding of how genes behave, became ever more perverse, with the same genetic disease caused by different mutations in several genes, while, contrariwise, several different diseases can stem from mutations in a single gene.

The puzzle proliferated further when biologists, seeking to define more precisely the function of those newly discovered genes, devised one ingenious experiments that involved `knocking out' the gene in embryo of an experimental animal (such as a mouse), and observing the effects on its subsequent development.

> `In some cases a "knockout" may have no effect whatsoever, despite the fact that the gene codes for a protein that is thought to be essential,' writes Michel Morange, Professor of Biology at Paris's Ecole Normale Superieure, describing the `discouraging' result of experiments involving more than a thousand separate genes. `Sometimes the knockout can even improve the performance of the mutated animal(!) ... or have effects that are completely different from those that were expected. Then the inactivation of the gene does indeed produce the predicted defect, but to a much lesser extent than expected ... Finally, there are cases where the inactivation of a gene does indeed lead to the predicted effect, but these examples are relatively rare.

These `discouraging' results required a drastic shift from the naive (in retrospect, at least) notion that the individual genes `for this and that' fight explain the complexity of living things. Rather, it began to appear that the genes did not have single, discrete functions, but are multi-tasked, the same gene being involved in the development of any different parts — eyes, nose, brain, pituitary gland, gut and pancreas — and not alone, but in unison with thousands of other genes all working together: six thousand of the fly's total complement of thirteen thousand genes are involved in the formation of its heart, while the sexual organs of a wo rm less than a millimetre in length are guided the interaction of two thousand genes. Further, it is now clear that context is all'; so,

depending on what is required, the gene can have quite contradictory properties, in one context promoting the growthof the cell, but in another its self-destruction. Similarly, the same gene can be both essential for, and yet irrelevant to, its purpose: the much-studied gene involved in the formation of eyes is also found in blind worms, while `knocking it out' in another species seems to have no 'deleterious effect, as the eyes form nonetheless.

The elegant simplicity of the Double Helix began to seem ever more deceptive, as it now appeared that the genes must somehow be acting in unison in staggeringly complex ways when instructing those factories in the cell to turn out their `products' that form the complex tissues of the brain, heart, lungs and so forth.

> `The heart of the problem,' observed Philip Gell, Professor of Genetics at the University of Birmingham, `lies in the fact that we are dealing not with a chain of causation but with a network, that is a system like a spider's web in which a perturbation at any point of the web changes the tension of every fibre right back to its anchorage in the blackberry bush.

And that `spider's web' seemed to pose an ever more daunting challenge for the supposed mechanism of evolutionary transformation. For when it takes six thousand genes to build a heart, what chance was there that a `random mutation' in any one of them might generate a beneficial variation in favour of the heart's further perfection? Perhaps there were some `mastermind' switching genes, turning the others `on and off' according to some preconceived plan. Find those master genes, and the perplexing and contradictory findings would become clear. And sure enough, in the late 1980s, soon after Philip Gell's cautionary analogy with the spider's web, the Swiss biologist Walter Gehring discovered two clusters of those master genes. These Hox genes, as they are known, determine the three-dimensional organisation of the front and back half of the fly respectively, the first cluster being involved in the development of the antennae, legs, wings and so on, while the second does the same for the `tail end: Perhaps those master genes might finally reveal the secret of those evolutionary transformations — where (and why not?) some random mutation might change the form of one species into another; not gradually, as Darwin had surmised, but suddenly and dramatically causing a fish to move to dry land and become an amphibian, or a land-based animal to sprout wings and become a bird, or a shrew-like mammal to take to the sea and transform itself into a whale — just as the pattern of sudden emergence of the fossil record suggests.

But when Gehring and his colleagues pursued this extraordinarily important discovery further, they found something yet more astonishing still (indeed, probably the most astonishing discovery in the history of biology): that precisely the same `master' genes mastermind the three-dimensional structures of all living things: frogs, mice, even humans. The same master genes that cause a fly to have the form of a fly cause a mouse to have the form of a mouse. `The central significence' of such findings, observed the late influential biologist and ter Stephen Jay Gould, `lies not in the discovery of something previously unknown — but in their explicitly unexpected character'; to which we now turn.

From the mid-1990s onwards, the powerful techniques of the New Genetic s would culminate in the genome projects, in anticipation that spelling out the full complement of genes would reveal the Holy Grail of biology, the secrets of genetic inheritance that distinguish one form of so readily from another. But the findings of those genome projects would, as touched on in the opening chapter, prove yet more perplexing than all that had gone before — the surprising paucity of genes for the task of fashioning the diversity and form of living things, and their near-equivalence across so vast a range of complexity, from bacteria to humans. Nonetheless, the genomes, taken together, encompassed the entire evolutionary trajectory, from the simplest, earliest forms of life (bacteria) to the most complex (humans), and so, comparing one with other, might account (at least in part)

for those apparent perplexities. It is possible to get a feel for that trajectory at an elementary (but instructive) level by tracing the progressive increase in the size and complexity of the full complement of genes, or genomes, over time. e start with the earliest, smallest and simplest form of free-living organism, the bacterium, little more than a drop of interacting chemical reactions surrounded by a cell wall whose fossilised remains first pear in strata of rock laid down 3,500 million years ago. Bacteria fight seem simple, but being billions of times more complex than animate matter (such as a pebble), are in reality not simple at all. eir genomes range in size from the 470 genes of the (pneumonia-using) mycoplasma, presumed to be the irreducible minimum necessary for an organism to function and reproduce its kind, all the way to the eight thousand genes of the soil bacterium Mesorhizopium, that promotes the growth of plants.

It would take another 1,500 million years for the next step in that evolutionary trajectory, the emergence of strikingly more sophisticated single-cell organisms such as the yeast Saccharomyces, whose extraordinary properties we glimpsed in `that world of supreme technology' outlined earlier. The genomes of these more complex forms of free-living organism are on average twice as large — coming in with a genome count of just under five thousand.

And the next step after that, after a further interval of 1,500 million years, would be the dramatic `Cambrian explosion' five hundred million years ago of 'multi-cellular' forms of life, with the emergence of their several distinct body plans together with the necessary prerequisites for their survival: the sense organs of sight and hearing to perceive the world around them, digestive and circulatory systems, sex organs for reproduction, and so on. This leap in organismal complexity would, not surprisingly, have required a massive increase in the complexity of the genome, where even the blind, millimetre-long roundworm C. Elegans, with just 959 cells in total, comes in at 19,100 genes. It is thus more than surprising to discover that the prodigiously more talented fly, with its eyes, wings, legs and capacity for memory and courtship, should turn out to have a genome of just 13,600 genes, while we humans, our primate cousins and mice get by with around twenty-five thousand genes, which would seem scarcely sufficient to begin to account for, for example, the human brain with its tens of billions of nerve cells.

This brief history of the evolution of life as revealed in the landscape of these genomes confirms an underlying trend of a progressive increase in gene numbers from bacteria through yeast, flies, worms, mice and ourselves — but that history offers not the slightest hint of the driving force behind the ever-increasing complexity of the information encoded by those genomes, nor how they might account for those characteristic features that so readily distinguish one form of life from another. Their genomes and those of all the organisms with which we share this planet do no more than code for those same `products' or parts of the cells that are common to all, and from which all living things are formed. Thus we share, unchanged over thousands of millions of years, many of the genes found in bacteria, for they, like us, utilise the same enzymes that drive the chemical reactions that generate the energy that keeps them (and us) alive. We share many more of our genes with the fly and the mouse, because their `housekeeping' duties are the same. They too require haemoglobin to transport oxygen from the lungs to the tissues, insulin to ensure a constant supply of sugar in the blood, and reproductive hormones that will ensure the propagation of their kind. So the seeming perplexity of the economy and equivalence of genes across so vast a range of life is, at this level at least, explained. How is it then that living things are so unambiguously distinctive one from the other?

Hence the significance of those `master' or regulatory genes just touched on, which though constituting a fraction of the total (around per 2 cent), nonetheless possess the capacity to conjure from that universal `gene kit' the antennae, legs and wings of a fly. But the relief at their discovery, as noted, was short-lived, when it emerged that the same master genes that cause the fly to be a fly cause a mouse to be a

mouse. The implications of this conundrum are well illustrated by the eyes respectively of flies and mice, which are `constructed' on a very different plan. The mouse eye (like our own) is the familiar camera e that so prompted the admiration of William Paley. By contrast, 'bees have `compound eyes' composed of sheets of lenses at different angles. But the same `master gene' known as Pax 6 brings both forms eye (and indeed all eyes) into existence.

This directive power of the same Pax 6 gene in the formation of the very different types of eye is further illustrated by two of the most astonishing experiments in the history of biology. In the first, scientists ingeniously activated the Pax 6 gene in many tissues of the embryonic fly — causing it to form eyes on its wings, legs and other parts. Next, the experiment was repeated, but this time by introducing the mouse version of the gene, which in the mouse gives rise to the camera-type eye, but which when inserted into the fly embryo gives rise to those extra fly-like compound eyes. And so too the limbs, where the same gene that orchestrates the formation of a fly's leg also instructs for the limbs of crustaceans, spiders, centipedes and chickens. And the heart too: Along the topside of the fly there is a heart that contracts to pump fluid around the inside of the body. It is not much of a heart by human standards but it does the job, writes Professor Sean Carroll of the University of Wisconsin. `Geneticists discovered the gene required for making the fly heart, and named it Tin Man (after the character in The Wizard of Oz who lacked a heart). But Tin Man, it emerged, also played an important role in the formation of the infinitely more complex and differently structured four-chambered human heart.

How then, one might reasonably ask, does the same `master switch' orchestrate the same several thousand genes from the universal toolkit to produce such diverse structures appropriate to the organism to which they belong — bringing into being a compound-type eye here, a camera-type eye there, a spider's leg here, a lobster's pincher there, a fly heart here, a human one there. The prevailing explanation holds that those `master genes' turn the genes of the universal toolkit `on and off' in a different sequence and at different times to produce these different structures.

`Diversity is not so much a matter of the complement of genes in an animal's toolkit but "in the way you use it" observes Professor Carroll. `The development of form depends upon the turning on and off of genes at different times and places in the course of development.

It is certainly difficult to conceive of any other explanation, but the logistics of that switching `on and off' defy all imagining as one tries to conceive how it would be possible to generate from the same universal toolkit such staggeringly complex and distinct types of eye, each so beautifully `designed' for its purpose and appropriate for the creature to which it belongs. Further, the parts of the fly — its eyes, wings and limbs — are all `of a piece, and it is difficult again to conceive how the relevant master gene for each could have chanced upon the correct sequence of switches to generate the appropriate part. It is as if the ‘idea’ of the fly (or any other organism) must somehow permeate the genome that gives rise to it, for it is only through the master genes the embryonic fly's knowing it is a fly that they will activate that sequence of switches that will give rise to those appropriate structures.

There is clearly a problem here. The genomes strung out along the Double Helix must, we know, give rise to the infinite diversity of form d attribute of living things, all the way down to the last detail of every species of tree and plant, fish, bird and animal, and humans —otherwise those details could not be passed down with such fidelity in one generation to the next. Why then does this seductive simplicity of the Double Helix contain not the slightest trace of those tails? Clearly the Double Helix is not simple because it is simple. is simple because it has to be simple if it is to pass on `the code of life' by duplicating itself every time the cell divides. And that obligation to be simple requires the Double Helix to condense within itself those complexities that would distinguish one form of life from other.

The implications are twofold. First, the necessity for the Double Helix to be simple means that it cannot act alone. Rather, the vastly more complex cell within which it is located must somehow `know' its needs, and then determine which of those 26,000 genes at any moment are to be activated to send the appropriate tickertape message to the protein factory to produce one or other of those thousands of parts. And the cell in issuing those instructions will in turn be influenced by the needs of the tissues and organs within which it is located, and so on all the way up the hierarchy to the organism in its entirety. Next, that simplicity also requires that the principle of self-organisation epitomised by the haemoglobin molecule spontaneously assembling itself from the parts of which it is made) must also apply at succesively higher levels of `organisation' from the automated factory of the cell upwards. Further, from an evolutionary perspective, while the near-equivalence of the human genome to that of our primate cousins would certainly confirm our `common ancestral heritage, beyond that every finding — the paucity of genes, their multi-tasking, those shared 'master genes' — is a nail in the coffin of Darwin's proposed mechanism of natural selection acting on numerous small, random genetic mutations.

From all this, it is possible to glimpse how the Double Helix fails the test of scientific knowability not just once, but twice over. The imperative to condense within those double strands of CGAT molecules the diversity, form and attributes that so readily distinguish man from fly and from all other forms of life would seem to pose an impenetrable barrier to scientific understanding.

The Double Helix fails the further test of scientific knowability because, like Newton's gravitational force, it imposes the order of `form' on life without there being any evidence of some scientifically measurable objective means by which it might do so. And it fails the test on a much grander scale. It is one thing to try to imagine how the sun might exert its influence on the earth across ninety-two millions of miles of empty space, quite another to try to imagine how that monotonous string of chemical genes can give rise to the millions of species of insect, fish, bird and mammal with which we share this planet. This compels us to recognise, as Baron Cuvier and his fellow natural historians of the nineteenth century inferred, that there must be some non-material formative influence that, from the moment of conception, imposes the order of form on the developing embryo of, say, octopus, squid or kangaroo and holds it constant while its cells and tissues are continually renewed as it grows into adulthood. We cannot, by definition, know that formative `life force' directly, only infer its reality as the missing factor that might bridge the unbridgeable gap between the `first order' reality of the phenomena of life as we know it to be in all its wondrous beauty and diversity and the `second order' reality of its explanation as revealed by those genome projects.

The radical implications of that formative `life force' will be returned to — but it is appropriate to close this most extraordinary episode in the history of biology, with its `totally unexpected findings', with two final observations. First, it is astonishing the difference it makes to our everyday lives to acknowledge that we no longer know, as until recently we thought we might, the secrets of genetic inheritance. So while, as ever, a snowdrop is as it is because it is made that way by its snowdrop genes, now, when contemplating a dozen or so of them thrusting their way up through the snow, we are forced to recognise that science cannot tell us how those genes fashion those delicate drooping heads with their evocative white and green colouring. Suddenly it begins to seem as if those snowdrops, and indeed the whole glorious panoply of nature, are infused with a deep sense of the tery of `How can these things be?'

And we find too the Human Genome Project ('the most important and significant project that humankind has ever mounted'), for all its scientific sophistication and unexpected findings, paradoxically ends up telling us nothing of real interest about `humanity: It tells us nothing, for example, about the skill and courage of the twenty-four--old lone yachtswoman Ellen MacArthur

who, the same week the wondrous map' of the genome was published in 2001, completed her to circumnavigation of the globe. Her genome, ransacked from top to bottom, would not give the slightest hint of the courage and determination that would have her navigating her boat through the heavy of the Pacific Ocean, or clambering to the top of the mast to repair sails and rigging.

Chapter 9 - The Silence

> `Although many details remain to be worked out, it is already evident that all the objective phenomena of the history of life can be explained by purely materialistic factors.. . Man is the result of a purposeless and natural process that did not have him in mind.'
> George Gaylord Simpson, The Meaning of Evolution (1949)

The world, and our understanding of it, is happily full of surprises — but few quite as surprising as the scientific revelations of the recent past. Who could have anticipated that the cell would turn out to be an `automated factory' capable of `carrying out almost as many unique functions as the manufacturing activities of man on earth'; or the profound implications of the necessity of the Double Helix to be simple, condensing the unfathomable biological complexities of living organisms within its two strands of chemical genes? Who could have predicted that the genetic instructions determining the staggering differences in form and attributes of fly and man should be fashioned from the same `master genes'? And, most astonishingly of all, who could have supposed for an instant that the most significant insight of science's culminating projects of the New Genetics and the Decade of the Brain should be the (re)discovery of that `dual nature of reality' that encompasses both the material world and the unfathomable power and profundity of that non-material animating life force and the human soul? These are `no ordinary' discoveries. They introduce a further dimension into the common interpretation of how things are, where my thoughts and intuitions must be considered as every bit as `real' as the chair on which I sit (indeed more so, for that chair, as I know it to be through my senses, turns out to be in large part a construct of my mind). And yet one might be forgiven for supposing there is nothing in the least untoward or dramatic in these findings. It would be reasonable to expect that the findings of the genome projects would have prompted a critical re-examination of current theories of genetic inheritance. Not a bit of it. The journal Science, commenting on the recently completed genome of the sea urchin in November 2006, felt no need to draw attention to the remarkable finding that this creature, with its rather uneventful life (other than causing grief to unwary swimmers), has virtually the same number of genes as ourselves.

Similarly, it would be reasonable to expect scientists to have revised their exclusively materialist explanation for the human mind; but Britain's most prominent neuroscientist, Professor Colin Blakemore, insists:

> `The human brain is a machine which alone accounts for all our actions, our most private thoughts, our beliefs. It creates ... the sense of self. It makes the mind ... we [may] feel ourselves to be in control of our actions, but that feeling is itself a product of our brain, whose machinery has been designed by means of natural selection.'

Professor Blakemore's allusion to the brain's being `designed by means of natural selection' brings us to the closely related and yet more surprising discovery of the recent past: the shocking inadequacy of biology's foundational evolutionary doctrine to account for anything other than the trivial differences that might distinguish one species of finch from another. That doctrine, we now see, is not merely flawed or incomplete, but its proposed mechanism of natural selection as the `cause' of the diversity of living things is contradicted at every turn by the empirical evidence of science itself. Yet again, there is not the slightest hint that such insights might pose a challenge to Darwin's

proposed evolutionary mechanism — which indeed has never been more loudly asserted as being `as much in doubt as the earth's orbit around the sun: `Nothing in biology makes sense except in the light of evolution,' biologist Theodosius Dobzhansky remarked in 1973, and nothing, it would seem, has happened to challenge that interpretation.

> `Darwin's theses of common descent, the gradualism of evolution and the theory of natural selection have been fully confirmed; pronounced the doyen of evolutionary biologists Ernst Mayr in the journal Scientific American in July 2000. `No educated person any longer questions the validity of the theory of evolution, which we now know to be a simple fact:

Silence can at times be much more eloquent than words. Scientists are no more willing than anyone else to concede that their suppositions may have been mistaken, particularly so when (as here) the devastating challenge to their narrow materialist explanations comes from within the scientific enterprise itself. This might imply some deliberate conspiracy to conceal from public view the significance of the findings of the recent past. It would, however, be more accurate to suggest that scientists simply do not `see' the wider implications — and why?

Science's unique contribution to human knowledge is its capacity to measure, quantify and analyse the material world of objects and physical forces, from the vastness of the cosmos to the minuscule cell. That commitment to materialism, as the biologist Richard Lewontin of Harvard University points out, is `absolute':

It is not that the methods and institutions of science somehow compel us to accept a materialist explanation of the world, but, on the contrary, that we are forced by adherence to materialist causes to create an apparatus of investigation that produces materialist explanations. Moreover, that materialism is absolute.

That absolute commitment to materialism has, as also noted, been immensely successful, culminating in that supreme intellectual achievement of weaving a single coherent account of the history of the universe, as described in the opening chapter. But along the way, that success almost inevitably fostered the belief among scientists that theirs is the only reliable avenue to getting at the truth of how things are.

There are, to be sure, many other forms of knowledge — commonsense knowledge, historical knowledge, knowledge of music and the arts, the tacit knowledge of skilled craftsmen or the clinical judgement of doctors, and much else besides. But scientists cannot acknowledge the possibility of there being a'dual' nature of reality, with both a material and a non-material realm, for that would be to subvert their exclusive claims to understand how the world `works: Hence the silence. Scientists cannot `see' the significance of the findings of the recent past because they cannot stand outside their materialist view and conceive of forms of understanding different from those in which they have been trained.

Science may have got along more than well enough (till recently) with its absolute commitment to materialism, but the same cannot be said of humanity, who uniquely inhabit the parallel, non-material domain. We live our lives engaging non-material minds like our own in conversation through the mutual exchange of non-material thoughts and ideas, entering into relationships with them, attributing the non-material values of good and evil to our experiences, invoking non-material concepts such as beauty and ugliness — none of which have any place in the language of science. We carry on doing these things as we always have, but our understanding of their significance is drastically narrowed. From Cromagnon man onwards the dual nature of reality was part of the commonsense of mankind — but no more. Nowadays, while children must learn in tedious detail the facts of the material world as revealed by science, such as the chemical

composition of saturated fats, they gain not the slightest inkling of an insight into the mind-boggling attributes of the human mind. They must learn by rote the technical terminology of the early stages of foetal development, without the slightest intimation of the profundities of the forces that guide the process of embryonic transformation. The dual nature of reality has, in short, been censored, written out of the script as being of historical interest only, a relic of the superstitious ways of thinking of the distant past.

The eclipse of the non-material realm is an almost inevitable casualty of its close association with religious belief, where the wonders of the natural world and the unique spiritual nature of the human mind were commonly perceived as the most powerful evidence for a supreme intelligence. This disentangling of the precepts of science from religious belief might seem all to the good, for their confusion can only lead to mischief. It is much better, as the writer and biologist Stephen Jay Gould argues, that they should be seen as occupying 'non-overlapping domains', where `science can no more answer the question of how we ought to live than religion can decree the age of the earth.

Nothing at first sight could be more reasonable — except, of course, it is not like that. Science has extended its sphere of interest far beyond questions such as `the age of the earth, and has asserted its own exclusively materialist interpretation of reality. Gould's reasonable view might be better summarised as: `We scientists are very broad-minded people and have no objection to those who might find a purpose or meaning in their existence in one religious belief or another.' That's fine, so long as all acknowledge science is the guardian of the flame of objective and rational knowledge, which just happens to include the scientifically proven certainty that man and everything else is the consequence of a known materialist process. Or, as the evolutionary biologist George Gaylord Simpson puts it:

> Although many details remain to be worked out, it is already evident that all the objective phenomena of the history of life can be explained by purely materialistic factors.. . Man is the result of a purposeless and natural process that did not have him in mind.

Gould's assertion of science and religion as occupying two non-overlapping domains could thus reasonably be interpreted as a deceptive sleight of hand to conceal science's `absolute' commitment to materialism. The point at issue is not that science deals with `facts' and religion with `values, but precisely the reverse — the profound influence of science's materialist `values' on Western thought over the past 150 years is grounded in the dismissal of (or failure to recognise) all those `facts' that might point to the reality of a non-material realm.

Those materialist values are so pervasive, in the Western world at least, that it can be difficult to recognise their partiality, their incompleteness as an account of the human experience. They entail, in brief, the assumption that science has proved the world to be organised `strictly in accordance with materialist principles. Hence the supposition of the reality of the human soul must be a mirage, there can be no moral laws to guide our conduct, the notion of free will must be an illusion, and there can be no `higher' meanings to our existence other than those that we invent for ourselves. Or as the philosopher Bertrand Russell puts it:

`There is darkness without and when I die there will be darkness within. There is no splendour, no vastness anywhere, only triviality for a moment and then nothing'

It would seem necessary to reconsider briefly how and why those materialist `values' should have eclipsed for so long the contrary'philosophic' view, with its intimation of there being `more than we can know: This might seem a formidable task, but it is summarised in just a single concept, albeit the most important in framing the modern world: the concept of `progress; whose significance is

best appreciated by revisiting briefly, and from a slightly different perspective, the immensely influential ideas of the Enlightenment touched on in an earlier chapter.

We are so familiar with, and committed to, the notion of progress — technical progress, industrial progress, medical progress, social progress — that it can be difficult to recognise its higher, more 'metaphysical' connotations in giving meaning and purpose to human existence, the promise of a better world where all might enjoy the fruits of prosperity, freed of the burden of physical suffering and injustice. Progress is objective and measurable, its benefits readily apparent in every new technical innovation, captured in the statistics of social progress of the rise in literacy and the decline in infant mortality.

Progress, too, is virtually synonymous with the scientific enterprise, its arrival on the human stage being marked by the scientific revolution of Galileo and Newton who, inspired by the notion of human reason as `the supreme authority in matters of knowledge, held out for future generations the promise that man might know anything he wanted. And it is that juxtaposition, between disinterested, objective, impartial scientific reason, and faith, the faith of Biblical revelation grounded in the countervailing authority of the Church, that more than anything else would define the future direction of Western thought.

`Science suddenly stood forth as mankind's liberation, empirical, rational, appealing to a concrete reality that every person could touch and weigh for himself,' observes Professor Richard Tarnas of the California Institute of Integral Studies. `Verifiable facts and theories tested and discussed among equals replaced dogmatic revelations hierarchically imposed by the institutional Church.

The findings of the scientific revolution would in turn inspire the Enlightenment, whose most famous son and undisputed leader, the French philosopher Voltaire, articulated the struggle for human freedom under the banner `Ecrassez l'infame' (Crush iniquity) — the iniquity of a corrupt Catholic Church and the absolute power of the monarchs of Catholic Christendom. Forced into exile in Britain in 1726, Voltaire fell under the spell of the ideas of the scientific revolution presided over by the now ageing Sir Isaac Newton, seeing in his `natural laws' of gravity and motion that govern the universe a model for human society. That society would be stable and harmonious, its citizens empowered by `natural rights' — to a fair trial, freedom of expression, and protection from the tyranny of a capricious state. Newton's `natural laws' suggested too a model for a new form of religious belief: `natural religion', grounded not in the dogmatic tenets of Christian faith with its miracles and `tales of demons thrown out' and all the rest, but in reason. Voltaire, despite his antipathy to established religion, held there to be nothing so self-evident as the two halves of human experience, of the material and the non-material, from which he could only infer the necessity for there being an `eternal and supreme' God. The most powerful evidence for the divine hand was (as ever), first, the wonders of the natural world, from `the meanest of insects... the disposition of a fly's wings or the feelers of a snail' — and second, the rational human mind.

We are intelligent beings: intelligent beings cannot have been formed by a crude, blind, insensible being: there is certainly some difference between the ideas of Newton and the dung of a mule. Newton's intelligence, therefore, comes from another intelligence.

The values of the Enlightenment that Voltaire articulated so forcefully would be written into the constitution of the newly independent United States, and would pervade the struggles for democracy and universal suffrage of the nineteenth century. But Voltaire's `natural religion' grounded in reason would founder in the face of the remorseless onward march of science, and of two technical innovations in particular that would drive deep inroads into that bastion of the non-material realm, the seemingly inscrutable mystery of self-renewing life and its wondrous realisation in the near-infinite diversity of the natural world. Those innovations were, first, the microscope,

that would reveal the hitherto hidden and successively more fundamental levels of `organisation' of living organisms; and secondly chemistry, whose analytic methods would reveal the chemical basis of life. Though it might seem late in the day, we must consider them briefly in turn, for their staggering success would define the direction of biology over the subsequent 150 years — which in the process would drive underground the reality of the non-material realm.

The origins of the microscope stretch back to the early part of the seventeenth century, when a Dutch spectacle-maker, Hans Lippershey, holding a spectacle lens in each hand and lining them up in the direction of the steeple of a nearby church, was amazed by the apparent proximity of the weathercock perched so far above the ground. He duly fitted the two lenses into a tube to maintain their relative distance from each other, and thus created the first telescope. This might have remained a mere curiosity were it not for the Florentine genius Galileo, who, hearing of Lippershey's discovery and realising its potential for resolving the astronomical controversies of his day, constructed his own telescope and discovered the millions of stars that 'make up the Milky Way, the rings of Saturn, the moons of Jupiter, and much else besides.

The same principles of magnification that permit the human eye to visualise the distant stars can equally be applied to enlarging the very small, and with a few technical modifications, Galileo's telescope became The microscope — though it would require considerable technical modification before biologists in the early part of the nineteenth century Would begin systematically to investigate the micro-anatomical structure of every tissue and organ — the heart, lungs, kidneys, skin and liver, culminating in Camillo Golgi's astonishing discovery of the delicate tracery of the electrical wiring of the brain, as described in the previous chapter. This previously hidden world, with each intricate organ elegantly `designed' for its relevant purpose, offered, as one of its pioneers, Jan Purkinje, remarked, `an inexhaustibility of new possibilities' where almost every day brings forth new discoveries'.

Along the way, in 1839, Theodore Schwann of Berlin University would formulate what would become biology's grand `unifying' idea, that all living things are composed of the same fundamental unit — the Cell — whose protean forms would subsequently be compared to `a set of magic bricks':

> Some rigid as bone, some fluid as water, some clear as glass, some opaque as stone, some factories of furious chemistry, some as inert as death, some engines of mechanical pull, some scaffoldings of static support.. . each one of all the millions and millions so finely specialised into something helpful to the whole, as if each understood its special power.

The enthusiastic microscopists then turned their attention to the greatest and profoundest mystery of all: the astonishing fidelity with which all forms of life reproduce their kind, observing for the first time the fusion of sperm and egg at the moment of conception and the process of embryonic transformation into a fully formed organism. `Nothing; comments the historian of science William Coleman, `could compare with [observing] the beauty of those rapid transformations working themselves out in front of their eyes.'

Paralleling this remorseless unravelling of life's hidden structures, the German chemist Justus von Liebig would resolve the further outstanding question of how the living organism transforms the inanimate matter of its nutrients into its own living flesh and blood — and the energy and heat that drives its vital functions. It all started with the chemical revolution of the late eighteenth century, initiated by the French genius Antoine Lavoisier, who, like Newton before him, penetrated far beneath the appearance of things to find the unifying scientific explanation of the seemingly inexplicable. `Has anyone ever been able to explain how a log in the hearth changes into glowing embers?' Voltaire had asked in 1738. `From the stars to the earth's centre, in the external world and within ourselves, every substance is unknown to us. But no longer. Lavoisier, in a series of

brilliant experiments, demonstrated that each of the supposedly fundamental elements of matter — air, fire, earth and water — was itself composed of the interaction of the same chemical elements: air composed of atoms of nitrogen, oxygen and carbon dioxide; fire and heat by the interaction of oxygen and carbon; water of atoms of hydrogen and oxygen — and so on.

Lavoisier achieved great things, but the scale of the facts waiting to be uncovered, the puzzles waiting to be solved, was simply too vast to be encompassed by any individual. They required a new type of scientific institution, the laboratory, first established in the universities of Germany at the close of the eighteenth century, where the vast possibilities of chemistry could be unravelled in an organised and systematic way. The first laboratory, and a prototype for all that would follow, was created by the young German Justus von Liebig, who in 1824, aged just twenty-one, was appointed Professor of Chemistry in the German city of Giessen — `a formidable figure in a formidable scientific age. — carbohydrates, fats and proteins — that were chemically strikingly similar, each with a backbone of carbon atoms running down the centre to which are attached atoms of hydrogen and oxygen, thus allowing them to be transformed one into the other.

The fascination of chemistry lies in its ability to find the common causal explanation linking the most seemingly disparate phenomena. And what could be more different than the two `organic kingdoms, as they are known, of plants and animals? To be sure, they are both `living, although one would be hard pushed to think that an apple had much in common with a tiger, or a rose bush with an elephant. But Liebig and his fellow chemists discovered to their astonishment when analysing tissues from the two `kingdoms' that they were composed of exactly the same 'stuff', variations on just three chemical compounds

Suddenly and dramatically, the deep mysteries of the transformation of nutrients of food into flesh and blood were resolved. `How beautifully and admirably simple with the aid of these discoveries appears the process of nutrition,' Liebig exclaimed in his major work Animal Chemistry (1842). But it was one thing to show the essential chemical similarity of the tissues of plants and animals, quite another to account for how they might first be disaggregated into their basic molecules in the gut and then reconstituted and transformed into the tissues and organs of the human body. Then in 1833 a couple of French chemists crushed germinated barley in cold water, added alcohol, and extracted a white precipitant that proved quite staggeringly potent - capable of breaking down two thousand times its own weight of starchy carbohydrate into component simple sugars of dextrine and glucose in just a few minutes. They had found the first enzyme, one of thousands of immensely complex proteins, each with a slightly different shape, designed to facilitate just one or other of the chemical reactions in the body by latching onto a chemical compound, untying its bonds and reducing it to its simpler component parts — or the reverse, linking those simpler parts together to form some new chemical compound. One hundred years on and that first enzyme had become thousands, facilitating every step of the `chemistry of life' while generating the limitless source of energy that sustains it.

This too-brief synopsis can only hint at the excitement generated by the combined assault of the microscope and chemical analysis on the Citadel of Life, collapsing its non-material `vital' force into so many scientifically knowable particulars. `The vital [animating] force does not exist, insisted the nineteenth-century German physiologist and investigator of the electrical activity of nerves Emil du Bois-Reymond. `It is quite clear it makes no sense to consider [it to be] a separate entity that maintains an existence independent of matter.

There were dissenting voices to point out that the onward march of biology's investigations of life in terms of its ever more basic elements was, at least in part, deceptive. It did not so much explain `the mysteries of nature' as displace them to the next level down.

`These attempts at the division [of the organism into its component parts] produce many adverse effects,' the German poet and scientific polymath Johann Goethe observed. `To be sure it is possible to dissect what is alive into its component parts, but from those parts it is impossible to restore it back to life. Each creature is a patterned gradation of one great harmonious whole.

This might seem no more than the self-evident truism that `the whole' is vastly more than the sum of its parts — but it is central to the driving underground of that `vital force: The project of itemising the several thousand chemical reactions that take place within the cell does not begin to account for those extraordinary properties that so clearly distinguish the living from the non-living, the animate from the inanimate world. Further, the more the intellectual juggernaut of the microscopists and chemists advanced, atomising the living organism into its ever more basic constituent parts, the more distant would become the prospect of recognising the reality of that `vital' life force that resides in its totality.

So we return again to the role of scientific progress in obscuring the dual nature of reality. In the mid-nineteenth century, the perception that the microscopists and chemists had demonstrated that `the vital force does not exist' would link up with Darwin's incorporation of man into the evolutionary framework that would drive underground the second and complementary pillar of the non-material realm — the exceptionality of the human mind focused on the nonmaterial soul.

They would prove mutually reinforcing, to the advantage of both. The never-ending stream of new findings generated by the laboratory-based science bolstered, by association, the credibility of Darwin's evolutionary theory. Meanwhile, by way of reciprocation, Darwin's evolutionary 'reason for everything' offered an intellectual framework through which scientists could assert their exclusive claims to knowledge. There could be no compromise. The `absolute' commitment to materialist explanations precluded, by definition, the possibility of there being a non-material realm.

The outcome was scarcely in doubt. Materialist science, allied so closely with the values of the Enlightenment, would become the main agent of progress, rescuing humanity from a dismal past of want and ignorance, leading it to a glorious future. By contrast, the non-material realm, compromised by its close association with the tenets of `superstitious' religious belief, could offer no such practical benefits.

> `The spiritual had sunk the human race in darkness for thousands of years,' writes the philosopher Graham Dunstan Martin. `It offered a spurious knowledge, superstitious belief in nonsense such as the soul, angels, devils, ghosts, gods and God. It offered stasis and immobility, and ignorant credulity. It preached obedience and incuriosity. Through persecutions, torture and burnings it sought to suppress new questions and new understanding. It sided with the rich against the poor, with the ignorant and complacent against the lively and inquisitive. The moral was clear: reject the spiritual. Matter is all.

Together, Darwin's evolutionary theory and the biologists' reductionist programme would extend the influence of science far beyond its legitimate concerns in explaining `the phenomena of life, to drive forward the progressive secularisation of Western society. The seemingly self-evident veracity of Darwin's theory would itself become an article of faith for all who aspired to that better future where man would no longer be, in the words of the free-thinking nineteenth-century German physician Ludwig Buchner, `the humble and submissive slave of a supernatural master, nor the helpless toy in the hands of heavenly powers — but a proud and free son of nature, understanding its laws and knowing how to tutor them to his own use.

Certainly some scientists, at least initially, proved resistant. But the commitment to Darwin's materialist explanation of the living world would, in time, become a qualification requirement for

all who aspired to pursue a career in biology — where to express doubt (at least publicly) was tantamount to confessing to being of unsound (or at least unscientific) mind.

Throughout the nineteenth century and the early part of the twentieth, the remorseless drive of biology's 'reductionist' programme of reducing'the whole' to its constituent parts accelerated, with the discovery of the autonomic nervous system and a dozen different hormones, numerous vitamins and micro nutrients, the gut enzymes involved in digesting and absorbing food, the diverse ways by which the kidneys filter the blood to remove its waste products, the mechanisms of adaptation to heat and cold, and the specialisation of distinct parts of the brain to fulfil the diverse functions of seeing and hearing, language and movement. By the late 1930s the entire jigsaw of human physiology was nearly complete, and just when it seemed there was nowhere further to go, the massive increase in magnifying power of the recently discovered electron microscope would allow biologists to cross the final frontier, penetrating deep into the astonishing structure and function of the cell to unravel those mysteries of genetic inheritance, protein synthesis and much else besides which would preoccupy them for the subsequent sixty years — before reaching the final destination, the `instructions' for the secret of life strung out along the Double Helix.

There has never been anything quite like it, the most protracted and sustained project in the history of science. Amidst all the excitement when `every day brings new discoveries, and inspired by the vision of finding the Holy Grail of the secret of life in the elegant spirals of the Double Helix, it was easy to overlook the profounder questions about the phenomena of life — and particularly how its properties so far surpass those of the most sophisticated of man-made machines, which neither grow from fertilised eggs nor reproduce their kind, neither rebuild their own parts when destroyed, nor maintain their form and structure unchanged while their material composition is in a constant state of flux.

> `I was present at a meeting of one of the most distinguished of biochemistry departments," recalls biologist William Beck of a most revealing incident. `The discussion was interrupted by a message from a local philosophical society asking if the department would provide a speaker to participate in a forthcoming symposium on the nature of life. All assembled understood biochemistry and heredity and genes and enzymes, but no one felt he had anything to say about life. The request was politely declined.'

So too the human mind, and what it might be, is conspicuous only by its absence from the discourse of neuroscientists. `Nobody has the slightest idea how anything material [such as the brain] could be conscious,' observes the cognitive scientist Jerry Fodor. `Nobody even knows what it would be like to have the slightest idea about how anything material could be conscious.'

And that, to put it simply, is how the combination of a progressive evolutionary doctrine and the progressive unravelling of the complexities of biology drove underground the twin pillars of the'non-material, the formative vital force of life and the human soul. Together they successfully extinguished the challenge to their exclusive claims to knowledge by first conflating the non-material realm with religious belief rooted in the past, while simultaneously allying their exclusively materialist explanations with the Enlightenment vision of a better world. That dual nature of reality, the material and non-material, would remain buried so long as science continued to advance towards that better future. But when its remorseless progress reached its final destination, the genome of man and fly spelt out, the brain observed `in action' smelling a rose and constructing a sentence, the reality of the non-material domain would, inevitably, re-emerge from the shadows.

For biology, and science generally, this is now both `the best of times and the worst of times'. The best of times because its prestige has never been greater, the scale of its research institutions

never more impressive, its financial support never more lavish. And yet this is also the worst of times, for by the time it is possible to say `This is how it happened' — this is how the universe and our solar system came into being, this is how the landscape of our earth was formed, this is the universal code of life, and so on — then `the future, what comes after, is likely to be something of an anticlimax.

The perception that science's glory days may be drawing to a close extends to the practical applied disciplines of technology and medicine on which its reputation as the agent of human progress so soundly rests. The future prospects of the space programme, which so epitomised the adventurous scientific spirit, are constrained by the realisation that we will never travel beyond our solar system to discover other worlds like our own. So too the electronics revolution, where the capacity of the worldwide web and satellite television to communicate information and entertainment far exceeds that of the human mind to absorb it. When it is possible to flick through a choice of seventy channels from the comfort of the sitting-room couch, further technical refinements that might give access to yet more channels would seem scarcely necessary. To be sure, there may be considerable scope for improving their content and quality, but that is a different, non-scientific matter.

So too medicine, where the tidal wave of therapeutic innovation of the post-war years, from heart transplants to test tube babies, provided the most dramatic evidence of the magnificent power of science to free people from the fear of illness and untimely death. But when, as now, most in the Western world live out their natural lifespan to succumb from illnesses strongly determined by ageing, then realistically much of what is do-able has been done.

There is more than a glimpse here of the observations of the main character in Thomas Mann's great novel Buddenbrooks (1901):

> I know from life and from history something you have not thought of: often the outward, visible, material signs and symbols of happiness and success only show themselves when the process of decline has already set in. The outer manifestations take time — like the light of that star up there which may in reality already be quenched when it looks to us to be shining at its brightest.

The light of those stars we now see shining brightly in the heavens (or relayed back from the Hubble telescope) has taken millions of years to reach us, by which time the energy from which it flows has long since been exhausted. Similarly, the light of scientific success that now shines so brightly was generated by the endeavours of many, stretching back over the past four hundred years. Where now are those new ideas, the fresh fruits of research and innovation to maintain that momentum?

For the best part of twenty years the prospects of further advance have rested almost exclusively on the shoulders of the New Genetics and neuroscience, whose potent, and now technically routine, methods for generating new knowledge have swept all other forms of investigation aside, to become virtually synonymous with the scientific enterprise itself. To the uncritical eye these generously funded bastions of Big Science could not be more productive, filling the pages of academic journals with new findings on an unprecedented scale — a year's worth of (for example) the Journal of Biological Chemistry now fills an entire library shelf.

But the fundamental premise no longer holds that the New Genetics and neuroscience would make clear all that is currently obscure. They have certainly, as we have seen, revolutionised our understanding of genetic inheritance and the workings of the brain — though not in the way intended. They have revealed, too, much of interest with practical application in both medicine and agriculture, such as the discovery of the genes involved in specific diseases and the genetically

engineered version of human insulin. But in general the fortunes of the biotechnology industry that sought to turn those discoveries to commercial advantage have been disastrous, `one of the biggest money-losing industries in the history of mankind, the Chief Executive of Genentech informed financial analysts in New York in 2006 — to the tune of $100 billion over a period of twenty years. There is a strong impression, too, of sensationalism in the extravagant claims made on behalf of cloning, experiments on human embryos and similarly controversial cutting-edge fields of research whose ability to generate publicity far outstrips any evidence of practical benefit.

The New Genetics and neuroscience have both proved to be, as it were, one step too far in biology's 'reductionist' programme. Biologists now find themselves in the invidious situation of having to suppose that the sheer accumulation of yet more facts about `which genes do what' might somehow, like a bulldozer, drive a causeway through the perplexities posed by, for example, those `master genes' — without the slightest inkling of a theory of what their accumulated facts might all add up to. And so too neuroscientists and the cardinal mysteries of the mind. The overwhelming impression is of labourers excavating a vast hole, where the more energetically they dig, the deeper it becomes. Or, to switch analogies, `Under the Upas tree nothing grows,' and the continuing dominance of the Big Science of the New Genetics and neuroscience, with their capacity to generate an ever vaster accumulation of facts, yet more genome projects and brain-imaging studies, has stifled the `spirit of science, and with it the investigation of the anomalies in current explanations on which genuine scientific progress depends. They have become `degenerate research programs, as described by philosopher Hubert Dreyfus of the University of California, Berkeley. Such a programme starts out with great promise, offering an approach that leads to impressive results in a limited domain. Almost inevitably researchers will want to try to apply the approach more broadly ... As long as it succeeds the research program expands and attracts followers. If, however, researchers start encountering unexpected but important phenomena that consistently resist the new techniques the program will stagnate and researchers will abandon it as an alternative approach becomes available.

The prospects for that `alternative approach, and its fruitful consequences, are perhaps more immediate than might be supposed. Still, for the moment, the merry-go-round of life goes on, and the failure to find the secret of life in the Double Helix or to `crack' the brain makes not a jot of difference to people's lives. The confounding of Darwin's evolutionary theory similarly is of no practical significance. The near-universal belief prevails, at least in the West, that Darwin solved the problem of man's origins, and indeed his evolutionary theory functions well enough as the great cosmogenic myth of the twentieth century, just as did the cosmogenic myths of Genesis that preceded it. It is the nature of our species to pose such questions, and equally in the absence (by definition) of any certain answers, to construct our myths accordingly.

> `Theories of evolution reinforce the value system of their creators by reflecting their image of themselves and of the society in which they live,' observed the Oxford historian John Durant at a meeting of the British Association for the Advancement of Science in the early 1980s. `Time and again ideas of human origins turn out on closer examination to tell us as much about the present as about the past, as much about our own experiences as those of our remote ancestors.'

Many no doubt will prefer to stick to the `scientific version' of our origins, and indeed look favourably on its substantial contribution to the progressive secularisation of Western society. But it cannot be that the current state of science, that has played so powerful a role in framing the modern mind, is of no concern. The general rule holds that the uncritical endorsement of misleading explanations can have grievous consequences. We have glimpsed in an earlier chapter some of those in the propagation of eugenic policies and the absurdities of sociobiology. But there is more, for, paradoxically, despite 150 years of remorseless scientific progress, we are left with a

surprisingly pessimistic view of humanity as the perpetrators of the terrible destructive wars of the past century and the destroyers of the planet that sustains us. `We eat well, we drink well, we live well,' comments the cultural historian Michael Ignatieff, `but we no longer have good dreams.

The many reasons for that pessimism become clearer when we contrast the present age with that most vibrantly optimistic of times, the eighteenth-century Enlightenment whose values pervaded western Europe — `illuminazione' in Italian, `lumiere' in French, `Aufklarung' in German. Its catchphrase, the German philosopher Immanuel Kant suggested in an essay written in 1784, should be `sapere aude' — `dare to know': not just scientific knowledge but self-knowledge, the knowledge that would set man free to create a society based on tolerance and freedom. The citizens of eighteenth-century Europe enjoyed none of the benefits of modern science, their lives compared with ours were plagued by physical suffering, but unlike us they had a vision of a better world, set to music by Bach and Handel, Mozart, Haydn and Beethoven. That optimism was underpinned by the recognition of man's exceptionality, the desire, as the writer Kenan Malik puts it, `to place Man at the centre of philosophical debate, to glorify his abilities and to see human reason as the tool through which to understand nature and himself

Now, as then, people lead purposeful and fulfilled lives — the more so, one would suppose, for being the beneficiaries of all the wonders of modern technology. But the vibrant optimism of that Enlightenment view of man has evaporated. Indeed, we could almost be said to live in an age of `counter' enlightenment — where the prevailing scientific view maintains that man's sense of himself as an autonomous independent being is no more than an illusion generated by his brain, and the joys and agonies of human love no more than a device for the propagation of his genes.

Many factors have contributed to that cultural pessimism, but the most obvious feature that distinguishes modern man from Voltaire and his contemporaries is the ascendancy of scientific materialism, and the loss of an appreciation of there being a non-material reality that transcends our everyday concerns. We have lost that sense of living in an enchanted world. We might now, thanks to science, comprehend the universe of which we are a part, only to discover that its properties, as evolutionary biologist Richard Dawkins puts it, `are precisely those we should expect if there is, at bottom, no design, no purpose, no evil and no good — nothing but blind, pitiless indifference. We have lost, too, sight of the most significant factor of all — the exceptionality of the human mind. We no longer appreciate what at one time seemed self-evident: the extraordinariness of possessing a mind whose powers of reason can distinguish truth from falsehood. There is nothing remotely scientific in denying the most certain thing we know, our sense of self; but `On the maps provided by contemporary science,' writes Bryan Appleyard, `we find everything except ourselves:

> We have experienced, in short, a drastic narrowing of our horizons and our appreciation of what might be possible. `As for the meaning of life, I do not believe it has any — and it is a source of great comfort,' observed the philosopher Isaiah Berlin. `We make of it what we can and that is all there is to it. Those who seek for some cosmic all-encompassing explanation are deeply mistaken:

There is, of course, a bleak heroism in this view of man, who, having shed all the illusions that enriched his life in the past, now recognises he is no more than the fortuitous consequence of impersonal natural laws, an unusual life form on an insignificant planet in a remote corner of the universe. But the findings of the recent past have changed all that. We can no longer be certain, as we might have been till recently, that Professor Berlin is right in supposing `that is all there is to it, because we cannot, by definition, comprehend the nature of that potent non-material realm with its power to conjure the wonders of life from the bare material bones of scientific knowledge.

It is only by recognising the narrow confines of the materialist view that it becomes possible to move on, comments the philosopher Roger Scruton, to replace the sarcasm which knows that we are merely animals, with the irony that sees that we are not

The time has come to break the silence and restore a coherent, balanced view of ourselves and our world by putting aside biology's foundational evolutionary theory and embracing the dual nature of reality. This may perhaps seem highly improbable, but it cannot be long before a proper appreciation of the true significance of the findings of the recent past begins to sow doubts in inquisitive minds.

Chapter 10 - Restoring Man to His Pedestal

`Dare to know!' Immanuel Kant

We turn now to the future, perhaps ten years from now, to imagine how differently our world might appear once the astonishing discoveries of the recent past have become common knowledge. The great drawback of Darwin's simple, all-encompassing evolutionary theory has always been that it robs the living world of its unknowable profundity. There is nothing too wonderful, awe-inspiring or bizarre that it cannot account for as having evolved to be so over millions of years. When the same ready explanation is applied to each and every fact of biology — no matter how extraordinary — the phenomena of life are reduced to mere banalities.

Strip away the comfort blanket of Darwin's Reason for Everything and the `facts' remain the same, but now appear fresh-minted in glorious Technicolor as astounding and amazing, magical and mysterious: the automated factory of the cell, the Arctic tern's twentyfive-thousand-mile migration, the geometrical design of a bat's face, the surprisingly non-sloth-like toilet habits of the giant sloth — every detail, in short, of the billionfold complexities of living organisms. The most obvious of facts appear distinctly non-obvious. How to begin to account for the sheer profligacy of life, whose limitless novelties of form encompass the entire range of what might be possible, from the elephant's trunk and giraffe's neck to the'long-nosed bugs, luminous beetles, harmless butterflies disguised as wasps, wasps shaped like ants, sticks that walk, leaves that open their wings and fly' of the Amazonian forest? And so on, ad infinitum, for any list of such novelties would end up itemising virtually every significant characteristic of every living thing on earth.

The same sense of astonishment applies in equal measure to all those critical innovations that mark the stages of the history of life as we recognise how, in truth, we know virtually nothing about how they came to be: the first single-celled organisms; the genetic code; the photosynthesis by which plants capture the energy of the sun to drive the great cycle of life; the first multi-cellular life forms of the `Cambrian explosion; aware through their senses of sight and touch of the world around them; the mechanism of those transitions from fish to reptile, to mammals, to birds, each stage initiating a further `explosion' of millions of new and unique species.

The setting aside of that evolutionary doctrine would also drag from the shadows all those very important facts passed over or censored in the conventional account lest they raise doubts as to its veracity — none more so than the riddle of the origins of our species, epitomised by the hazards of standing upright and acquiring that prodigiously enlarged brain, complete with its `language acquisition device: That censorship of significant facts extends, most obviously, to the human mind, where the self-evident truism that intellectually we share (as we must) much in common with our primate cousins is a triviality when set against the manifold differences so long concealed. Now, once again, we can begin to appreciate those distinct properties that so unambiguously set us apart. We have access, through the faculty of language, to thoughts and ideas, our own and those

of others. Our primate cousins do not. We possess the power of reason, through which we comprehend causes and their effects and can thus make sense of the world around us. They do not. We can imagine things to be different from how they are, and plan for our futures. They cannot. We know our beginnings and our end, and recognising the fact of our mortality, are impelled to seek explanations for our brief sojourn on earth. They do not. We inhabit the spiritual domain centred on the self, the soul, the `I, with its several distinct interconnected parts which, being nonmaterial, and thus not constrained by the material laws governing the workings of the brain, is free to choose one thought over another or one course of action over another. And that inextricable connection between the non-material self and freedom is the defining feature of man's exceptionality, for we, unlike our primate cousins, are free to forge our own destinies to become that distinct, unique person responsible for our actions of which all human societies are composed, and from which virtually everything we value flows.

Science can know nothing of this, and thus, by necessity, denies man his freedom and the reality of his soul, with all the grievous consequences already touched on. The philosophic view alone recognises the dual nature of reality, and reasserting its priority would prompt one of those rare convulsive upheavals in human understanding that the historian Thomas Kuhn described as a `paradigm shift' from one way of `knowing' to another. It is easy to suppose that we are on a never-ending upward trajectory of knowledge, as we know so much more about the natural world than a century ago, and more still than the century before that. But, as Kuhn pointed out, it is not like that. Science is for the most part a humdrum problem-solving affair, filling in the details of the broad picture of what is already known while the anomalies and inconsistencies that do not fit prevailing theories are readily overlooked. There comes a time, however, when cumulatively those anomalies can no longer be ignored, at which point science enters into `a state of crisis' which can be resolved only by a radical shift in its fundamental theories and its perception of `how things are' These paradigm shifts include most obviously Galileo's liberation of astronomy in the seventeenth century from the certainty of an earth-centred cosmos, relocating it as just one of several planets in orbit around the sun. The subsequent massive expansion in intellectual horizons is the defining characteristic of a `paradigm shift' in revealing how little the prevailing theories explain, while simultaneously opening the door to knowing so much vastly more than was previously thought possible.

We are, it seems, on the brink of a similar paradigm shift, not once but twice over, in our understanding of both the natural world and of ourselves. We are led through the New Genetics to the necessity to set aside Darwin's evolutionary doctrine. It has served its purpose well enough as a tidy, all-encompassing `reason for everything', providing the wider context within which biologists could pursue their investigations without fear that the processes so revealed might defy any simple materialist explanation. But as time has passed its anomalies and inconsistencies have proved ever more pressing, and now, with the crushing verdict of the genome projects, we are left to stare into the abyss of our ignorance of virtually every aspect of the complexities of the living world and its evolutionary history. And yet, conversely, our

knowledge of the natural world becomes vastly greater than could be imagined, as we can now recognise those profundities for what they are, rather than seeing them through that distorting prism which would suppose them to be so much simpler than they really are.

Again we are led through the findings of the Decade of the Brain to recognise the unfathomable depths of the workings of its neuronal circuits and their relationship to the human mind. Yet conversely we open the door to knowing so vastly more than we could imagine by restoring our confidence in the intuition of our extraordinary minds into the reality of the non-material realm. Thus we come to deepen our understanding by recognising how little we know, and through meditating on the profundities touched on in this account: the mysterious creative evolutionary

force which from the beginning has conjured ever more complex forms of organisation from the simplest elements of matter; the inscrutable origins of that cell with its capacity to bring into being every life form that has ever existed; the sudden, dramatic emergence of new forms of life from the `Cambrian explosion' onwards; those seemingly mundane practicalities of our everyday lives of the Introduction: seeing, talking, growing and reproducing our kind; the phenomenal information-processing power of the human brain; the potency of the forces of the non-material realm — and the (rediscovered) human soul.

The major beneficiary of this new understanding will be science itself, liberated from the dead hand of evolutionary certainty and the ever-deepening hole of Big Science's degenerate research programmes to turn its attention to all those substantial questions which have so far eluded its methods of investigation. How do birds navigate their thousand-mile journeys across the featureless ocean? Where, in its depths, are the breeding grounds of whales? What happens to the chemistry of the brain to cause us to sleep and dream, and why should sleep refresh our bodies? What events deep in the earth cause earthquakes to quake and volcanoes to erupt?

Biologists, freed from the obligation to subscribe to the evolutionary doctrine, could turn their attention to those many observations and anomalies that contradict its too ready explanations. `All nature is at war, one organism with another,' claimed Darwin — but it is not so, for the most striking feature of the natural world is not the competitive struggle for existence, but its antithesis — cooperation. So while in the past biologists have interpreted much that is apparently cruel and wasteful in the living world as evidence of a random, purposeless evolutionary process, the greater challenge is to account for the much greater evidence of harmony and purpose.

There is not a single species that does not have a mutually beneficial relationship with another. That cooperation takes many forms, most obviously in providing a hospitable, if sometimes surprising, refuge, such as a species of crab that lives within the rectum of the sea urchin, or another within the shell of the oyster. The sea worm Urechis caupo is nicknamed `the innkeeper' for giving space to thirteen species of fish, arthropod and mollusc in the u-shaped burrow it makes in the Californian mudflats. Mutual cooperation is evident too in the transport that mobile creatures provide for stationary ones, and the manner by which bees, honey birds and bats are all rewarded by plants with nutritious nectar for facilitating their cross-fertilisation. Then there are numerous examples of mutual protection: where, for example, baboons associate with gazelles on the plains of Africa and profit from their keen sense of smell, while the gazelles benefit from the baboons' superior visual acuity in detecting predators. Many species foster the health of others by providing a cleaning service, as in the blowfly's preference for laying its eggs in the festering wounds of animals. `This might appear to be one of nature's great cruelties, observes George Stanciu of the University of Michigan, `but when the larvae hatch they feed on the pus and consume dead tissues, even their excretions disinfect the wound! Far from being cruel, the fly larvae may be the animal's only chance to recover from a possibly lethal infection.

A greater challenge still would be to pursue the many neglected observations and experiments over the past hundred years that hint at the existence of yet unknown forces in biology, such as that remarkable capacity of living organisms to regenerate their parts. This presupposes, as biologist Rupert Sheldrake points out, the existence of some `field' by which an organism knows itself, and its parts, in their entirety. How else to account for the facility with which limbs, once broken, heal and remodel themselves as before, or the capacity of the brain to compensate for blindness by massively increasing the acuity of its other sense organs, such as touch and hearing? How otherwise, too, could the humble flatworm when cut in two reconstruct itself as two separate organisms, the head acquiring a new tail, and the tail a new head? There is more than a hint too of those hidden biological forces in the evocative beauty and harmony of the geometric laws of proportion of the human body, whose several parts — head, limbs and thorax —grow in synchrony with each other and

with the body as a whole. That synchronous growth from embryo to adulthood reflects how, as the biologist D'Arcy Wentworth Thompson puts it, `throughout its fabric one part is related and fitted to another.

The reinvigoration of science with novel (or rediscovered) ideas and better theories might in turn be expected to counter the current disillusion with a subject that for many seems no more than a disconnected (and often poorly taught) collection of tedious facts, divorced of any grand vision of what it might all add up to. It is possible to imagine that the recent and precipitous fall in the numbers of science graduates might be reversed were the subject reinfused with that recognition of the unfathomable profundities of the natural world that for Isaac Newton, likening himself to `a boy playing on the seashore, was so powerful an incentive to `wonder why.

The new paradigm must also lead to a renewed interest in and sympathy for religion in its broadest sense, as a means of expressing wonder at the `mysterium tremendum et fascinans' of the natural world. It is not the least of the ironies of the New Genetics and the Decade of the Brain that they have vindicated the two main impetuses to religious belief — the non-material reality of the human soul and the beauty and diversity of the living world — while confounding the principal tenets of materialism: that Darwin's `reason for everything' explains the natural world and our origins, and that life can be `reduced' to the chemical genes, the mind to the physical brain.

There is, of course, nothing in the new paradigm that can be interpreted as direct evidence for a Creator, or that would resolve the insuperable difficulty for many of conceiving of his existence and purpose. But while it is as hard as ever to imagine him hard at work designing several thousand species of beetle, there is vastly greater evidence of `design' — for those who would wish to interpret it as such — than the supposition that the vast panoply of nature should be the incidental consequence of those numerous random genetic mutations that the genome projects have so unequivocally failed to identify. Indeed, those two critical innovations, the genetic code and language, might almost seem to require a higher intelligence to devise the code and draw up those rules of syntax. There is, after all, nothing intrinsic in the chemical molecules strung out along the Double Helix to explain why they should carry a specific genetic message. Or, put another way, the message is `extraneous' to the chemical and physical properties of the molecules themselves. So, just as it requires human intelligence to produce anything with a high information content, whether books or dictionaries, music scores or compact discs, so by analogy it would be reasonable to infer that it would require a `higher intelligence' to formulate the genetic code.

This puts a rather different gloss on the influential arguments of the main protagonists of the evolutionary doctrine, Richard Dawkins, Daniel Dennett and Ed Wilson, who seek to explain away the near-universality of some form of religious belief as a self-gratifying delusion to make us feel better about the vagaries of our lives. Their remorseless hostility to religion ('a dangerous collective delusion') is best interpreted as a rhetorical device, a sleight of hand to distract attention from the intellectual weaknesses of scientific materialism. Dawkins, in a typical passage, invokes the standard juxtaposition of rational science and irrational religion to buttress his assertion that faith is `one of the world's great evils':

`It is fashionable to wax apocalyptic about the threats to humanity' he writes, `but I think a case can be made that faith, the principal vice of any religion, is one of the world's great evils, comparable to the smallpox virus but harder to eradicate. Faith is a great cop-out, the great excuse to evade the need to think and evaluate evidence.

There is, to be sure, ample evidence for the wickedness carried out in religion's name that is the grist to Professor Dawkins' influential argument. But one could as well, in the light of the findings of the recent past, reverse his juxtaposition as being one rather between rational faith and irrational

science. For many, such as Voltaire, it has seemed reasonable, both intellectually and intuitively, to infer from the wonders of the natural world and the exceptionality of the human mind the existence of some Divine Being. From this perspective, faith is not, as Dawkins claims, `the great excuse to evade the need to think and evaluate evidence, but on the contrary, as the writer C S Lewis describes it, `the art of holding on to things your reason has once accepted.

By contrast, it now seems deeply irrational for materialist science to deny the exceptionality of the human mind and to insist that the sense surprising in retrospect that Marx's and Freud's self-evidently erroneous theories should have proved so persuasive to so many and for so long, Now it is the turn of Darwin, whose reputation can scarcely surer the devastating verdict of the findings of the recent past. Before long he must fill that vacant chair in heaven alongside Marx and Freud, at which point the triumvirate will be complete. As for ourselves, the eighteenth-century poet Alexander Pope could not, it now appears, have pot it more succinctly:

> Sole judge of Truth, in endless Error hurled; the glory, jest and riddle of the world!

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Teleology - A Shopper's Guide
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ABSTRACT: Teleology features prominently in recent discussions in the philosophy of mind, action theory, philosophy of biology, and in the dispute between Intelligent Design theorists and Darwinian naturalists. Unfortunately, discussants often talk past each other and oversimplify the issues, failing to recognize the differences between the several theories of teleology philosophers have historically put forward, and the different natural phenomena that might be claimed to be teleological. This paper identifies five possible theories of teleology, and five distinct levels of nature at which teleology might be said to exist. Special attention is paid to the differences between Aristotelian-Thomistic and ID theoretic approaches to teleology.

The telos of a thing or process is the end or goal toward which it points. Teleological notions feature prominently in current debates in philosophy of biology, philosophy of action, philosophy of mind, and philosophy of religion. Naturalists generally hold that teleological descriptions of natural phenomena are either false or, if true, are reducible to descriptions cast in nonteleological terms. Nonnaturalists generally hold that at least some natural phenomena exhibit irreducible teleology. For example, Intelligent Design (ID) theorists hold that certain biological phenomena cannot properly be understood except as the products of an intelligence which designed them to carry out certain functions.

Teleology's controversial status in modem philosophy stems from the mechanistic conception of the natural world, which early modem thinkers like Bacon, Galileo, Descartes, Hobbes, Boyle, and Locke put in place of the Aristotelian philosophy of nature that featured in medieval Scholasticism. Following Aristotle, the Scholastics took the view that a complete understanding of a material substance required identifying each of its "four causes." Every such substance is, first of all, an irreducible composite of substantial form and prime matter (irreducible because on the Scholastic view, substantial form and prime matter cannot themselves be understood apart from the substances they compose, making the analysis holistic rather than reductionist).

The substantial form of a thing is its nature or essence, the underlying metaphysical basis of its properties and causal powers; it constitutes a thing's formal cause. Prime matter is the otherwise

formless stuff that takes on a substantial form so as to instantiate it in a concrete object, and apart from which the form would be a mere abstraction• it constitutes a thing's material cause. That which brings a thing into existence constitutes its efficient cause. And the end or goal towards which a thing naturally Points is its final cause.'

As the last sentence indicates, the notion of a final cause is closely tied to that of a telos and thus to the notion of teleology. But the adverb "naturally" is meant to indicate how the Aristotelian notion of final cause differs from other conceptions of teleology. For Aristotle and for the Scholastics, the end or goal of a material substance is inherent to it, something it has precisely because of the kind of thing it is by nature. It is therefore not to be understood on the model of a human artifact like a watch, whose parts have no inherent tendency to perform the function of telling time, specifically, and must be forced to do so by an outside designer. For example, that a heart has the function of pumping blood is something true of it simply by virtue of being the kind of material substance it is, and would remain true of it whether or not it has God as its ultimate cause.

The thinkers who founded modern philosophy and modern science rejected this picture of nature. In particular, they rejected the notions of substantial form, of matter as that which takes on such a form, and of a final cause as an inherent end or telos of a thing. Of Aristotle's four causes, only efficient cause was left in anything like a recognizable form (and even then the notion was significantly altered, since, as we shall see, efficient causes were regarded by the Scholastics as correlated with final causes).2 Material objects were reconceived as comprised entirely of microscopic particles (understood along either atomistic, corpuscularian, or plenum-theoretic lines) devoid of any inherent goal-directedness and interacting in terms of "push-pull" contact causation alone. This "mechanical philosophy" underwent various trans- formations as modem philosophy and modem science developed. The philo- ophical inadequacy of the contact model of causal interaction soon became evident in light of the critiques of occasionalists, Humeans, and others; and in any event, the model could not survive the empirical difficulties posed for it by Newtonian gravitation, electromagnetism, and quantum mechanics. But what has clearly survived the anti-Aristotelian "mechanistic" revolution to the present day is the rejection of teleology as an inherent feature of the natural order. As philosopher of science David Hull has written:

Mechanism in its extreme form is clearly false because numerous physical phenomena of the most ordinary sort cannot be explained entirely in terms of masses in motion. Mechanics is only one small part of physics. Historically, explanations were designated as mechanistic to indicate that they included no reference to final causes or vital forces. In this weak sense, all present-day scientific explanations are mechanistic.'

Modem philosophers have almost universally embraced this conception of scientific explanation. They have disagreed about whether an appeal to irreducible teleology conceived of as something extrinsic to the material world ought to supplement the mechanistic explanations of empirical science. Contemporary naturalists deny that any such appeal can be justified. By contrast, early modem thinkers like Boyle and Newton regarded an appeal to extrinsic teleology—in particular, to God's intentions and activity as artificer of the natural world—as an essential capstone to the edifice of science.4 William Paley's design argument gave this line of thought its most fully developed and influential articulation. As we will see in a later section, the arguments of contemporary ID theorists like William Dembski, though differing from the arguments of Boyle, Newton, and Paley in various particulars, carry on their appeal to teleology as something extrinsic to the material world, and allow that at least much of the natural order is in principle nonteleological. Where these thinkers all agree with each other and with their naturalistic opponents is in rejecting the Aristotelian-Scholastic conception of final causes as inherent in material substances.

Among contemporary writers, it is primarily Thomists, and especially those who regard Thomism as essentially building on Aristotelianism, who reject mechanism as defined above and endorse a return to something like the Scholastics' philosophy of nature, its application suitably modified in light of the empirical findings of modem science. Aristotelico-Thomistic (A-T) arguments for irreducible teleology, and for the existence of God as the ultimate explanation of the reality of such teleology (such as Aquinas's Fifth Way), thus differ significantly from Paleyan design arguments and the arguments of contemporary ID theory.

Unfortunately, this history and the conceptual nuances reflected in it (only some of which we have touched on so far) seem to have been forgotten in many contemporary philosophical discussions of teleology. Consequently, partisans on either side of various debates within philosophy of biology, philosophy of mind, philosophy of religion, and other philosophical subdisciplines often talk past one another, or either affirm or reject the existence of irreducible teleology on the basis of arguments that may in fact be relevant only to some conceptions of teleology and not to others.

In the sections that follow, I aim to provide a "shopper's guide" of sorts for philosophers interested in questions about teleology, in the course of which I will expand upon some of the historical and conceptual themes already alluded to. Specifically, I will show in the second section, "Five Approaches to Teleology," that the question of whether teleology exists in nature is not susceptible of a simple "yes or no" answer, but that there are in fact five main positions that can and have been taken on the issue. In the third section, "Levels of Teleology," I will show that there are also at least five levels of nature at which irreducible teleology might be claimed to exist, so that to establish that it exists or does not exist at one of them does not suffice to determine whether it exists at the others. With at least five levels of nature at which teleology might be said to exist, and five possible ways in which to conceive of teleology at any of these levels, the conceptual lay of the land can be seen to be complex indeed. Finally, in the last section I will address the implications of these conceptual distinctions for the debate over teleological arguments for the existence of God. In particular, I will explain how the approach taken by philosophers committed to A-T metaphysics differs radically from that taken by ID theorists and defenders of Paley-style design arguments. In the process I hope to shed light on a phenomenon that many ID theorists seem to find puzzling, namely, that Thomists, who would seem to be their natural allies in the dispute with naturalism, are typically very critical of ID. As we will see, this state of affairs has less to do with disagreements about the merits of Darwinian evolutionary biology (though it does sometimes have something to do with that) than it has to do with disagreements over basic metaphysics—disagreements which, for the A-T metaphysician, show that the ID theorist is (surprising as this might seem) philosophically closer to the Darwinian naturalist than to A-T.

In the interests of full disclosure, I should note that my own sympathies are with the A-T position. But the point of what follows is not to defend that position, but only to provide a road map to the debate over teleology in the various branches of philosophy I have mentioned. There is nothing in the classification that I will propose that could not in principle be accepted by any philosopher, whichever position he happens to take on these issues.

Five Approaches to Teleology

As happens, the five main approaches to teleology parallel the five main approaches that have, historically, been taken to the problem of universals—nominalism, conceptualism, and three varieties of realism. Indeed, as we will see, there are several ways in which the problem of universals and the problem of teleology are intertwined. So it will be useful briefly to summarize the main approaches to the former problem before discussing the latter.

They are as follows: Realism affirms that universals—triangularity, "catness," humanness, and so forth—are irreducible to their particular instances and exist in a way that is in some sense independent of the human mind. Nominalism denies that there are any true universals and insists that only particulars are real—there is this triangle and that one, this cat and that one, but no such thing as "triangularity" or "catness" over and above them. Conceptualism can be thought of as a kind of middle-ground position, and holds that universals exist, but only in the mind—"triangularity," "catness," and the like are the products of abstraction, and correspond to nothing in the world of external objects, all of which are particular.

Realism in turn takes three different forms. Platonic realism (sometimes called "extreme realism") holds that universals exist in a "third realm" distinct from the world of particular things and distinct from the human mind. Aristotelian realism (sometimes called "moderate realism") rejects the "third realm" approach, and regards universals as existing only in the particular things that instantiate them and in the intellect that abstracts them from the particulars. It differs from nominalism in regarding universals as irreducible to their instances, and from conceptualism in regarding the products of abstraction as grounded in the particulars themselves and not a sheer invention of the mind—triangularity corresponds to something really there in actual triangles (waiting to be abstracted, as it were). Finally, Scholastic realism—the position developed by medieval writers like Aquinas as a way of harmonizing Aristotelian realism with Augustine's brand of Platonism—holds that while universals do indeed exist only in either their particular instances or in intellects, they nevertheless do not depend entirely on particulars or on finite intellects for their being insofar as they exist eternally in the infinite divine intellect, as the archetypes according to which God creates the world.'

Now let us turn to the five corresponding approaches to teleology. Teleological realism affirms that teleology is a real and irreducible feature of the natural world, paralleling the realist view that universals are real and irreducible to particulars. Parallel to nominalism is what (following Christopher Shields) we might call teleological eliminativism, the view that there is no genuine teleology at all in the natural world. Shields cites ancient atomists like Democritus and Leucippus as representatives of this view, and it seems to be held by at least many contemporary adherents to the modern antiteleological mechanistic conception of nature described in the first section above.' Many, but not all. For other contemporary writers whose views are broadly mechanistic would seem more appropriately described as committed to teleological reductionism, the view that there is a sense in which teleology exists in nature, but that it is entirely reducible to nonteleological phenomena. For example, philosophers of biology who hold that the function of a biological structure can be analyzed in terms of the reasons why that structure was favored by natural selection would seem to be taking a reductionist rather than eliminativist position.' Since conceptualism can be thought of as a reductionist view—universals are real, but contrary to the realist they are really "nothing but" ideas abstracted by the mind—we can regard teleological reductionism as the approach to teleology that parallels the conceptualist view of universals.'

Kant's approach to teleology in the Critique of Judgment is an interesting case. It might be interpreted as another possible kind of teleological reductionism, and one with even more obvious parallels to conceptualism insofar as Kant regarded teleological analysis as a regulative principle the mind brings to bear on its explanation of biological phenomena. On the other hand, if it is merely a regulative principle, with no objective validity, Kant's position might instead be interpreted as a kind of eliminativism.9 But since what Kant denied was not that the notion of teleology has objective validity but rather that we can know that it does, it might be best to interpret him as taking the agnostic position that some version of teleological realism, reductionism, or eliminativism is true, but we can never know which.of greater interest for our purposes, though, is the fact that teleological realism might be spelled out in ways that correspond to each of

the three varieties of realism about universals. Christopher Shields and Andre Ariew have recently emphasized the distinction between the first two of these ways)°

Platonic teleological realism holds that the irreducible teleology manifest in nature is extrinsic, entirely derivative from an outside source." Natural phenomena as such are not teleological, but they have been ordered to certain ends by (say) a divine mind. Shields cites Anaxagoras as an ancient representative of this view; Ariew cites Plato (given the demiurge of the Timaeus), Newton, and William Paley. Aristotelian teleological realism holds that teleology or final causality is intrinsic to natural substances, and does not derive from any divine source. Aristotle did of course believe in a divine Unmoved Mover. But he thought that the existence of the Unmoved Mover followed from the fact of motion or change, not from the existence of final causes, which he regarded instead as simply a basic fact about the world. The acorn points beyond itself to the oak—not because it was made that way, but because it just is that way by nature, simply by virtue of being an acorn.12 It does not do this consciously, of course, since acorns are totally unconscious. The whole point of the Aristotelian view is to insist that goal-directedness does not require a mind which consciously intends the goal. Hence, pace many adherents of the Platonic approach to teleology, there is on the Aristotelian view no necessary connection between teleology and theism.

What Shields and Ariew overlook is that there is a middle ground position between the Platonic and Aristotelian views, which we might call Scholastic teleological realism; and it corresponds quite neatly to the Scholastic middle ground position between Platonic and Aristotelian approaches to the problem of universals. On this view, represented most prominently by Aquinas's Fifth Way, final causes are indeed immanent within or intrinsic to natural substances, just as the Aristotelian claims they are. The acorn can be known to be "directed at" the oak entirely independently of the question of God's existence, and theism can in practice be "bracketed off' from the study of final causes as such. All the same, for the Scholastic teleological realist, the existence of final causes must ultimately be explained in terms of the divine intellect. The difference from the Platonic approach is that the Scholastic view does not take the existence of a divine ordering intelligence to follow directly from the existence of teleology in nature. An intermediate step in argumentation is required, for the link between teleology and an ordering intelligence is (with a nod to Aristotle) not taken to be obvious. This is one reason why (as we shall see) the Fifth Way differs from the strategy taken by Paley and by contemporary ID theorists.

Note the parallels with the three versions of realism about the problem of universals. For Platonic realism about universals, the universal essence acorn exists entirely apart from particular acorns and from the finite minds that grasp this universal, in a "third realm"; for Platonic teleological realism, the end or goal of an acorn exists entirely apart from it, in (say) a divine mind, which orders it to its end. For Aristotelian realism about universals, the universal essence acorn exists only in particular acorns themselves and in the finite minds that abstract it; for Aristotelian teleological realism, the end or goal of an acorn exists only intrinsic to the acorn itself. For Scholastic realism about universals, the universal essence acorn exists in the particular acorns themselves and in the finite minds that abstract it, but it also preexists in the divine intellect as the archetype according to which God creates acorns; for Scholastic teleological realism, the end or goal of an acorn exists intrinsic to the acorn itself, but only because God created it according to the preexisting essence in question, which includes having the generation of an oak as an end or goal.

To summarize the five main approaches to teleology: Teleological eliminativism denies that there is any teleology at all in the natural world. Teleological reductionism allows that there is, but holds that it can be reduced to nonteleological phenomena. Platonic teleological realism holds that there is irreducible teleology in the natural world but only in the sense that an external ordering intellect orders things to certain ends. Aristotelian teleological realism holds that there is irreducible teleology in the natural world and that it is immanent, existing in things simply by virtue of their

natures and in no way dependent on an ordering intelligence. Scholastic teleological realism holds that there is irreducible teleology in the natural world and that it is immanent to things given their natures, but also that the fact that they exist with natures directing them to those ends cannot itself ultimately be made sense of apart from a divine ordering intelligence.

Levels of Teleology

We will have more to say about what motivates the Scholastic position. But before doing so, it will be useful to identify the five levels of the natural world at which teleology might be held to exist. In philosophical discussions of teleology, biological examples have tended to dominate, certainly in modern philosophy and to some extent even in Aristotle. Indeed, it is often assumed that to attribute teleology to some natural phenomenon is to attribute to it a function of the kind a biological organ serves, or perhaps of the kind a human artifact serves. But this is a mistake. For many teleological realists—in particular, for the Scholastic teleological realist—biological function is merely one kind of teleology among others.

Biological teleology paradigmatically involves a part serving to realize the good of some whole, in the way the stomach functions to digest food so that the organism as a whole can survive, or the way sexual organs function to enable an organism to reproduce so that the species as a whole will carry on beyond its death. For Scholastic writers, a capacity for this sort of "immanent causation" (to use the Scholastic jargon) just is what makes something a living thing. Inanimate phenomena are capable only of "transeunt causation," causation which terminates in an effect outside the cause itself and therefore does not promote the cause's own good. (Living things exhibit transeunt causation as well; the point is that, unlike inanimate things, they are also capable of immanent causation.")

But inanimate phenomena are nevertheless capable of exhibiting a more basic kind of teleology. Indeed, for the Scholastics, even the simplest causal regularity in the order of efficient causes presupposes final causality. If some cause A regularly generates some effect or range of effects B—rather than C, D, or no effect at all—then that can only be because A of its nature is "directed at" or "points to" the generation of B specifically as its inherent end or goal. To oversimplify somewhat, we might say that if A is an efficient cause of B, then B is the final cause of A.'^ If we deny this—in particular, if we deny that a thing by virtue of its nature or essence has causal powers that are directed toward certain specific outcomes as to an end or goal—then (the Scholastic holds) efficient causality becomes unintelligible. Causes and effects become inherently "loose and separate," and there is no reason in principle why any cause might not be followed by any effect whatsoever or none at all. From an A-T point of view, it is precisely the early moderns' rejection of final causes, substantial forms (or inherent essences), and the like that opened the way to Humean puzzles about causation and induction.15 (Interestingly, there has been a trend in recent analytic metaphysics back toward the idea that material substances have inherent causal powers by virtue of which they exhibit what George Molnar calls a kind of unconscious "physical intentionality," and what David Armstrong calls a "proto-intentionality" or "pointing beyond themselves" to certain outcomes.16 What such writers do not seem to realize is that they have essentially returned to a Scholastic position. 17)

More complex inanimate causal patterns might also arguably exhibit teleology. A-T philosopher David Oderberg holds that natural cycles like the water cycle and the rock cycle provide clear examples.18 Consider the water cycle: condensation leads to precipitation, which leads to collection. which leads to evaporation, which leads to condensation, and the cycle begins again. Scientists who study such processes identify each of their stages as playing a certain specific role relative to the others. In particular, each stage has the production of a certain outcome or range of outcomes as the "end" or "goal" toward which it points—the role of condensation is to bring about precipitation, for example. Nor, Oderberg argues, will it do to suggest that the cycle could be

adequately described by speaking of each stage as being the efficient cause of certain others, with no reference to its playing a "role" of generating some effect as an "end" or "goal." For each stage has many other effects that are not part of the cycle. Condensation in some area might for all we know cause someone to have arthritic pain in his big toe. But causing arthritic pain is no part of the water cycle. Some causal chains are relevant to the cycle and some are not. Nor is it correct to say that the student of the water cycle just happens to be interested in how water in one form brings about water in another form, and is not interested in arthritis, so that he pays attention to some elements in the overall causal situation rather than others. For the patterns described by scientists studying such cycles are objective patterns in nature, not mere projections of human interests. But the only way to account for this is to recognize that each stage in the process, while it might have various sorts of effects, has only the generation of certain specific effects among them as its "end" or "goal" in the cycle. In short, it is to recognize such cycles as teleological.

Obviously, many questions might be raised about such arguments, but the point is merely to note that both basic causal regularities and complex inorganic processes provide further examples of arguably teleological natural phenomena, additional to the standard example of biological phenomena. Within biological phenomena too, though, we might distinguish two further possible examples of natural teleology. The "immanent causation" spoken of above is common to all living things, whether plants or animals. But unlike plants, animals are capable of sensation, appetite, and locomotion, namely, movement prompted by appetite in response to what sensation has detected in an animal's environment. All of this entails a kind of goal-seeking—the kind manifest in conscious desires—that goes beyond the mere coordination of parts to the good of the whole that plants also possess. This plausibly indicates a further level of biological teleology, beyond the basic level represented by plants. Furthermore, in human beings, desire is informed by reason; our actions are guided by thought, which has a conceptual structure foreign to other animals. Here we have intentionality, and purpose in the fullest sense—and, it seems, yet another level of teleology. And that human action is irreducibly teleological is a thesis that has had a long history in philosophy. 19

Again, whether there really is teleology at these or any other levels of nature—and if so, whether it ought to be interpreted in a reductionist, Platonic, Aristotelian, or Scholastic fashion—is not something we can settle here. The point is that there are at least these five levels at which irreducible teleology might be said to exist: in basic causal regularities; in complex inorganic processes; in basic biological phenomena20; in distinctively animal life; and in human thought and action?1

Teleological Arguments in Paley, ID Theory, and Thomism

It is generally assumed in contemporary philosophy that if irreducible teleology really does exist in nature, then it necessarily follows that there must be an ordering intelligence (presumably a divine one) responsible for this. Naturalists deny that such irreducible teleology exists and defenders of Paley-style design arguments and/or of ID theory affirm that it does, but they share this assumption about what the existence of irreducible teleology would entail if it were real. But as we have seen, Aristotelian teleological realism denies this assumption, and holds instead that teleology is both immanent to the natural world and in need of no further explanation, divine or otherwise. One of the differences between Paley and ID defenders on the one hand, and A-T defenders of Aquinas's Fifth Way on the other, is that the latter acknowledge the Aristotelian challenge and take it seriously. The reason is that they reject the mechanistic conception of nature held in common by naturalists on the one hand and Paley and ID defenders on the other—a conception which, by definition, rules out from the start the Aristotelian view that teleology is immanent to natural substances.

Now, defenders of ID theory do sometimes deny that their position is mechanistic. For example, William Dembski does so several times in his book The Design Revolution.22 But elsewhere in the

same book, and in other writings, Dembski makes assertions that clearly presuppose the truth of a mechanistic conception of nature, at least as A-T writers understand "mechanism." For example, in discussing Aristotle in The Design Revolution, Dembski identifies "design" with what Aristotle called techne or "art."23 As Dembski correctly says, "the essential idea behind these terms is that information is conferred on an object from outside the object and that the material constituting the object, apart from that outside information, does not have the power to assume the form it does. For instance, raw pieces of wood do not by themselves have the power to form a ship." This contrasts with what Aristotle called "nature," which (to quote Dembski quoting Aristotle) "is a principle in the thing itself." For example (again to quote Dembski's own exposition of Aristotle), "the acorn assumes the shape it does through powers internal to it: the acorn is a seed programmed to produce an oak tree"—in contrast to the way the "ship assumes the shape it does through powers external to it," via a "designing intelligence" which "imposes" this form on it from outside.

Having made this distinction, Dembski goes on explicitly to acknowledge that just as "the art of shipbuilding is not in the wood that constitutes the ship" and "the art of making statues is not in the stone out of which statues are made," "so too, the theory of intelligent design contends that the art of building life is not in the physical stuff that constitutes life but requires a designer" (emphasis added). In other words, living things are for ID theory (at least as Dembski understands it) to be modeled on ships and statues, the products of techne or "art," whose characteristic "information" is not "internal" to them but must be "imposed" from "outside." And that just is what A-T philosophers mean by a "mechanistic" conception of life. As Dembski says elsewhere, in putting forward ID theory, "I don't want to give the impression that I'm advocating a return to Aristotle's theory of causation. There are problems with Aristotle's theory, and it needed to be replaced."24 So, for ID theory as for Paley, it is (contrary to the A-T position) at least possible that natural substances have no end, goal, or purpose; they just think this is improbable. The reason is that their essentially mechanistic conception of nature leads them to model the world on the analogy of a human artifact. The bits of metal that make up a watch have no inherent tendency toward functioning as a timepiece; it is at least theoretically possible, even if improbable, that a watch-like arrangement might come about by chance. And natural objects are like this too; there is nothing inherent in any natural object or system—no essences, natures, substantial forms or anything else corresponding to such Aristotelian-Scholastic categories—by which we might read off final cause or teleology. The world might be like a collection of bits of metal that have by sheer accident come together in the form of something resembling a watch. It is just that this is so highly improbable that the "best explanation" is that some intelligence arranged the bits that make up the world into their present purposive configuration, much as a watchmaker arranges bits of otherwise purposeless bits of metal into a watch. This approach is what led Paley to focus on complex biological phenomena, and it has led ID theorists to do the same. It is only because the eye or the bacterial flagellum exhibits "specified complexity" (as William Dembski holds) or "irreducible complexity" (as Michael Behe claims) that they stand out as candidates for design. The implication is that fingernails or eyelids (say)—not to mention inanimate substances and processes—would not provide nearly as powerful a case, or even any case at all.

The A-T approach could not be more different.25 For the Aristotelico-Thomist, there is simply a fundamental metaphysical difference between natural substances and human artifacts. The parts of a living thing, for example, are oriented inherently and by nature toward functioning together for the good of the whole. The parts of an artifact, by contrast, have no inherent or natural tendency to function together in this way, and must be made to do so by something outside them. Their natural orientation is toward other ends—those inherent in their being whatever natural substances they happen to be--even if an artificer might be able to organize them in such a way that these natural tendencies do not frustrate the artificial end he wants them to serve. To take an example from Aristotle, if a wooden bed could be planted (while the wood was still fresh from the original tree, say) what would grow from it, if anything, would be a tree and not a bed.26 The natural

orientation of the fresh wood is to be "treelike" rather than bedlike, even if a skilled craftsman can arrange it so as to function as a bed all the same. In general, for A-T, artifacts and the ends they are made to serve presuppose natural substances and the tendencies they naturally exhibit, so that it is incoherent to model natural substances on artifacts. That does not mean that natural objects are not created by God. But it does entail that God does not create them in the way a craftsman arranges parts so as to produce an artifact.

Similarly, the reason A-T philosophers affirm the existence of irreducible teleology in nature has nothing at all to do with complexity or the weighing of probabilities, nor with any analogy to human designers, nor with biological phenomena more than any other natural phenomena. As we saw in the third section, A-T affirms the existence of irreducible teleology at all five of the levels of nature there distinguished, including the simplest causal regularities.27 Qua teleological, the functions served by fingernails or eyelids, or the tendency of an ice cube to cause room temperature water to grow colder, are no more or less significant than the eye or the bacterial flagellum. A-T holds that teleology must exist of metaphysical necessity in the natural objects that have it, otherwise they simply would not be the objects they by nature are—it is not a matter of probability, high or low. For that very reason, A-T philosophers follow Aristotle in holding that detecting teleology has nothing whatsoever to do with reasoning on the basis of an analogy between some natural substance or process and the products of human design, or indeed even with supposing that there is a designer in the first place. If a thing is naturally directed toward a certain end, that is (naturally) because it is in its nature to be, and we can know the natures of things without knowing where they came from.

Explaining (as opposed to detecting) the existence of irreducible natural teleology is a different story, at least for Scholastic teleological realism if not for Aristotle himself. But even here the question has nothing to do with drawing analogies with human designers, weighing probabilities, or the like. This brings us to Aquinas's Fifth Way. The argument starts out as follows:

We see that things which lack intelligence, such as natural bodies, act for an end, and this is evident from their acting always, or nearly always, in the same way, so as to obtain the best result. Hence it is plain that not fortuitously, but designedly, do they achieve their end.28

This essentially sums up what has been said already. Aquinas is not saying here that certain exceptional natural objects—those which exhibit "specified complexity" or "irreducible complexity," say—are so difficult to account for in purely naturalistic terms that it is probable that they were made by an intelligent designer. He is saying that any natural body at all--even a very simple one—which regularly behaves in a certain way must have that way of behaving as its natural end. It is not a matter of "high probability," but a matter of the way a thing has to act given its nature.29 It is in this sense that such unintelligent objects act "designedly" rather than "fortuitously." Aquinas is not referring here to an intelligent designer; he does not get to God until the second half of the argument. He is instead simply making the Aristotelian point that regularity points to teleology, that if A is an efficient cause of B then generating B must be the final cause of A. Other translations have "by purpose" or "by intention" rather than "designedly," and all of these expressions must be read in an Aristotelian way, as connoting final causality or immanent end-directedness as opposed to chance or fortuitousness.

At this stage in the argument, then, Aquinas is not saying anything that would not also be said by the Aristotelian teleological realist. Where he goes beyond the latter to a distinctively Scholastic teleological realist position is in the second half of the argument:

Now whatever lacks intelligence cannot move towards an end, unless it be directed by some being endowed with knowledge and intelligence; as the arrow is shot to its mark by the archer. Therefore

some intelligent being exists by whom all natural things are directed to their end; and this being we call God.

Here Aquinas does claim that the teleology or end-directedness in nature affirmed in the first half of the argument must ultimately be explained in terms of a divine ordering intelligence. Notice that here too, though, he makes no a form in the intellect. Is there any other way the end or goal might exist already? There would seem to be only four possibilities: It might exist in the natural object itself; it might exist in a Platonic "third realm"; it might exist in some human intellect, or in another intellect within the natural world; or it might exist in an intellect outside the natural world altogether. But it obviously does not exist in the natural object itself; if the form of an oak were already in the acorn itself, it would be an oak, and it is not. It cannot exist in a Platonic "third realm" either, at least not if one endorses (as the Scholastic teleological realist does) the Aristotelian realist critique of Platonic realism about universals. Nor can it exist in some human or other intellect within the natural order, at least not without a vicious regress. Humans obviously are not the ones directing acorns and other natural objects (including human beings themselves) to their natural ends; and if we supposed that some other nonhuman but still natural intellects were doing so, this would just raise the question of what directs those intellects (since they too would be natural objects with final causes of their own) to their ends. The only possibility remaining, then, is the last one: Final causation in the natural world is intelligible because there is an intelligence altogether outside the natural order that directs natural objects to their ends.

To the "How can something nonexistent be a cause?" objection to final causation, then, the Thomist's reply is to say, "It can't. That's why the final cause of a natural object must exist already as an idea or form in an intellect existing altogether outside the natural order." Notice that, though the exposition of the argument made reference to the example of a house builder, it is not an "argument from analogy" in the sense that design arguments are thought to be. The reasoning is not "Houses are made by intelligent beings, and natural objects are analogous to houses, so they too are probably made by intelligent beings." The point of the builder example is rather to illustrate one of several possible ways the form of a thing might be efficacious even though the thing itself does not yet exist. The argument then goes on to try to show that all the other possibilities can be ruled out, and thus that there is no other way to make sense of the efficacy of final causes. Its structure is that of an attempted metaphysical demonstration, not that of an appeal to analogy, inductive generalization, argument to the best explanation, or any other exercise in empirical hypothesis formation.

In summary, then, the thrust of the Fifth Way is this: (1) Irreducible teleology is immanent to the natural order; (2) but such teleology is unintelligible unless there is an intellect outside the natural order; so (3) there is an intellect outside the natural order. The argument differs from Paley-style design arguments and the arguments of ID theorists in ways other than those already mentioned. For example, since the entities comprising the natural world have the final causes they have as long as they exist, the intellect in question has to exist as long as the natural world itself does, so as continually to direct things to their ends. The deistic notion that God might have "designed" the world and then left it to run independently is ruled out. Here, as in the other main Thomistic arguments for God's existence, the aim is to show that God is a sustaining or conserving cause of the world rather than that He got the world started at some point in the past. But why assume that the ordering intellect in question has all the divine attributes in the first place? Here appeal would have to be made to broader themes of A-T metaphysics. For example, an ordering intelligence which sustains a thing's having the natural ends it has would thereby be that which gives it its nature or essence. From an A-T perspective, this in turn entails conjoining an essence with an "act of existence," and only that in which essence and existence are identical—that which is ipsum esse subsistens or Subsistent Being Itself—can possibly do that. When this notion is itself unpacked, all the divine attributes follow. Hence the suggestion that the ordering intellect might be a very

powerful but still finite designer (often raised against the "design argument") or even an extraterrestrial (as ID theorists sometimes allow) is also ruled out. The Fifth Way, when worked out, is intended to get us all the way to the God of classical theism.

Whether it succeeds in doing so is not something that can be settled here. The point is just to explain how the A-T approach to these questions differs from those that have gotten the bulk of the attention in the contemporary debate over the teleological argument. With at least five main approaches that could be taken to the question of whether teleology exists in the natural world, at least five levels of nature at which it could be said to exist, and at least two main approaches one could take to constructing a teleological argument for God's existence, the issue of teleology is far more complex than many contemporary philosophers may realize.31

Notes

1. For a brief exposition and defense of Aristotelian-Scholastic metaphysics and philosophy of nature, see ch. 2 of my Aquinas (Oxford: One world, 2009). For a more detailed exposition and defense, see my The Last Superstition: A Refutation of the New Atheism (South Bend, IN: St. Augustine's, 2008). The most thorough recent defense of Aristotelian- Scholastic metaphysics is David S. Oderberg, Real Essentialism (London: Routledge, 2007).
2. See Kenneth Clatterbaugh, The Causation Debate in Modern Philosophy 1637-1739 (London: Routledge, 1999) for a useful overview of the history of the early modems' gradual transformation of the notion of efficient cause.
3. The Cambridge Dictionary of Philosophy, s.v. "mechanistic explanation." Cf. William Hasker, The Emergent Self (Ithaca, NY: Cornell University Press, 1999), 59-64.
4. For an account of the transition from an intrinsic to an extrinsic conception of teleology among such early modern thinkers and its effect on natural theology, see Margaret J. Osler, "From Immanent Natures to Nature as Artifice: The Reinterpretation of Final Causes in Seventeenth-Century Natural Philosophy," The Monist 79 (1996): 388-407. Cf. William B. Ashworth, Jr., "Christianity and the Mechanistic Universe," in When Science and Christianity Meet, ed. David C. Lindberg and Ronald L. Numbers (Chicago: University of Chicago Press, 2003).
5. For a useful recent introduction to the problem of universals, see J. P. Moreland, Universals (Montreal: McGill-Queen's University Press, 2001). Unfortunately, contemporary discussions of the issue tend to pay little or no attention to the position I have labeled "Scholastic realism." For a recent exposition and defense, see John Peterson, Introduction to Scholastic Realism (New York: Peter Lang, 1999). Cf. Feser, The Last Superstition, 39-49, 90-1.
6. Christopher Shields, Aristotle (London: Routledge, 2007), 90. Andre Ariew labels this view "materialism," but Shields's label seems more appropriate given that it is (as we will see presently) possible to be a materialist while being a reductionist rather than an eliminativist about teleology. See Ariew's articles "Platonic and Aristotelian Roots of Teleological Arguments," in Functions: New Essays in the Philosophy of Psychology and Biology, ed. Andre Ariew, Robert Cummins, and Mark Perlman (Oxford: Oxford University Press, 2002); and "Teleology," in The Cambridge Companion to the Philosophy of Biology, ed. David L. Hull and Michael Ruse (New York: Cambridge University Press, 2007).
7. For the debate over `naturalistic" analyses of biological functions, see David J. Buller, ed., Function, Selection, and Design (Albany, NY: State University of New York Press, 1999).
8. Strictly speaking, then, conceptualism would be a species of a more general approach to universals we might call reductionism, where other possible varieties of reductionism would include (e.g.) the view that universals are reducible to the totality of their instances. But since the standard classification of approaches to the problem of universals as "realism, nominalism, and conceptualism" is so well established, I have opted to follow tradition rather than introduce a novel (but arguably more precise) "realism, nominalism, and reductionism" classification.

9. Such a reading might also be called "instrumentalist," but since a useful fiction is still a fiction, such an instrumentalism would still seem nothing more than a riff on eliminativism rather than a separate view.
10. See Shields, Aristotle, 68-90, and the two articles by Ariew cited above.
11. Shields labels this view "teleological intentionalism," and Ariew calls it "Platonic teleologism."
12. See Monte Ransome Johnson, Aristotle on Teleology (Oxford: Oxford University Press, 2005) for a recent book-length treatment of Aristotelian teleological realism.
the end or goal of an acorn exists entirely apart from it, in (say) a divine mind, which orders it to its end. For Aristotelian realism about universals, the universal essence acorn exists only in particular acorns themselves and in the finite minds that abstract it; for Aristotelian teleological realism, the end or goal of an acorn exists only intrinsic to the acorn itself. For Scholastic realism about universals, the universal essence acorn exists in the particular acorns themselves and in the finite minds that abstract it, but it also preexists in the divine intellect as the archetype according to which God creates acorns; for Scholastic teleological realism, the end or goal of an acorn exists intrinsic to the acorn itself, but only because God created it according to the preexisting essence in question, which includes having the generation of an oak as an end or goal.
To summarize the five main approaches to teleology: Teleological eliminativism denies that there is any teleology at all in the natural world. Teleological reductionism allows that there is, but holds that it can be reduced to nonteleological phenomena. Platonic teleological realism holds that there is irreducible teleology in the natural world but only in the sense that an external ordering intellect orders things to certain ends. Aristotelian teleological realism holds that there is irreducible teleology in the natural world and that it is immanent, existing in things simply by virtue of their natures and in no way dependent on an ordering intelligence. Scholastic teleological realism holds that there is irreducible teleology in the natural world and that it is immanent to things given their natures, but also that the fact that they exist with natures directing them to those ends cannot itself ultimately be made sense of apart from a divine ordering intelligence.
Levels of Teleology
We will have more to say about what motivates the Scholastic position. But before doing so, it will be useful to identify the five levels of the natural world at which teleology might be held to exist. In philosophical discussions of teleology, biological examples have tended to dominate, certainly in modern philosophy and to some extent even in Aristotle. Indeed, it is often assumed that to attribute teleology to some natural phenomenon is to attribute to it a function of the kind a biological organ serves, or perhaps of the kind a human artifact serves. But this is a mistake. For many teleological realists—in particular, for the Scholastic teleological realist—biological function is merely one kind of teleology among others.
Biological teleology paradigmatically involves a part serving to realize the good of some whole, in the way the stomach functions to digest food so that the organism as a whole can survive, or the way sexual organs function to enable an organism to reproduce so that the species as a whole will carry on beyond its death. For Scholastic writers, a capacity for this sort of "im
13. For discussion, see Feser, Aquinas, 132-7, and Oderberg, Real Essentialism, 177-83.
14. As Aquinas puts it, "every agent acts for an end: otherwise one thing would not follow more than another from the action of the agent, unless it were by chance" (Summa Theologiae I, q.44, a.4). By "agent" he means not just thinking beings like us, but anything that brings about an effect.
15. But not only from an A-T point of view. Alfred North Whitehead makes a similar point in Science and the Modern World (New York: The Free Press, 1967), arguing that the problem of induction is generated by a mechanistic conception of matter on which for any material particular, "there is no inherent reference to any other times, past or future" (51). Hence, "if the cause in itself discloses no information as to the effect, so that the first invention of it must be entirely arbitrary, it follows at once that science is impossible, except in the sense of establishing entirely arbitrary connections which are not warranted by anything intrinsic to the natures either of causes or effects" (ibid., 4).
16. See George Molnar, Powers: A Study in Metaphysics (Oxford: Oxford University Press, 2003), and D. M. Armstrong, The Mind—Body Problem (Boulder, CO: Westview, 1999), 13840.

17. On the other hand, this implicit vindication of Aristotelianism is acknowledged in Nancy Cartwright, "Aristotelian Natures and the Modem Experimental Method," in Inference, Expla
nation, and Other Frustrations: Essays in the Philosophy of Science, ed. John Earman (Berkeley: University of California Press, 1992).
18. David S. Oderberg, "Teleology: Inorganic and Organic," in Contemporary Perspectives on Natural Law, ed. Ana Marta Gonzalez (Aldershot: Ashgate, 2008).
19. The irreducibly teleological character of human action has been defended most recently in G. F. Schueler, Reasons and Purposes (Oxford: Oxford University Press, 2003) and Scott Sehon, Teleological Realism (Cambridge, MA: MIT Press, 2005).
20. There are further distinctions that could be made within this level. E.g., as Ariew has emphasized in the articles cited above, the adaptation of an organism to its environment is only one apparent instance of biological teleology, and one that is commonly claimed to have been explained away by Darwin. Developmental processes, and in particular the fact that some growth patterns are normal and others aberrant, provide another example, and one that Darwinism has not explained away. (Cf. Marjorie Grene, `Biology and Teleology," in The Understanding of Nature: Essays in the Philosophy of Biology (Dordrecht: D. Reidel, 1974), and J. Scott Turner, The Tinkerers Accomplice: How Design Emerges from Life Itself (Cambridge, MA: Harvard University Press, 2007).) Then there is the way in which genetic information seems to "point beyond itself' to a phenotypic expression—a circumstance physicist Paul Davies has noted appears to evince precisely the sort of purpose mechanism rules out, and which biophysicist Max Delbruck characterized as a vindication of Aristotle. (See Paul Davies, The Fifth Miracle (New York: Simon and Schuster, 1999), 121-2; and Max Delbruck, "Aristotle-totle-totle," in Of Microbes and Life, ed. Jacques Monod and Ernest Borek (New York: Columbia University Press, 1971). For a recent debate, see Sahotra Sarkar, "Genes Encode Information for Phenotypic Traits," and Peter Godfrey-Smith, "Genes Do Not Encode Information for Phenotypic Traits," in Contemporary Debates in Philosophy of Science, ed. Christopher Hitchcock (Oxford: Blackwell, 2004).)
21. These last three correspond, of course, to the traditional Aristotelian distinction between vegetative, animal, and rational forms of life. Whether one thinks these really are irreducible, it is (pace the glib assumption to the contrary made by most contemporary philosophers and scientists) at least debatable whether they are. See Oderberg, Real Essentialism, chs. 8-10 for a recent defense of the traditional Aristotelian distinction.
22. William Dembski, The Design Revolution (Downers Grove, IL: InterVarsity, 2004), 25, 151.
23. Ibid., 132-3.
24. William Dembski, Intelligent Design (Downers Grove, IL: InterVarsity 1999), 124 (emphasis added). C£ Dembski's No Free Lunch (New York: Rowman and Littlefield, 2002), 5. The context of the discussion in both cases is the early modem philosophers' rejection of Aristotelian formal and final causes, and Dembski makes it clear that his problem is not with the rejection of Aristotle's position, but only with how "what replaced it" ended up "excluding design" of any sort.
25. For a critique of Paley's design argument from an A-T perspective, see Christopher F. J. Martin, Thomas Aquinas: God and Explanations (Edinburgh: University of Edinburgh Press, 1997), ch. 13. For a critique of ID theory written from a broadly A-T point of view, see Ric Machuga, In Defense of the Soul (Grand Rapids, MI: Brazos, 2002), 161-6, though there are significant inaccuracies in Machuga's exposition of A-T metaphysics. Benjamin Wiker, "Review of Ric Machuga, In Defense of the Soul," ISCID Archive (October 18, 2003) is a response to Machuga that corrects the errors in his exposition and sets out a more detailed account of the differences between A-T and ID. See also Oderberg, Real Essentialism, 287; Francis J. Beckwith, "How to Be an Anti-Intelligent Design Advocate," University of St. Thomas Journal of Law and Public Policy 4:1 (2009-10); Michael Tkacz, "Aquinas vs. Intelligent Design," This Rock (November 2008); and the more-or-less A-T inspired critique of ID presented by Edward T. Oakes in his review of Phillip E. Johnson's The Wedge of Truth in First Things, January 2001, and the debate this generated in "Edward T. Oakes and His Critics: An Exchange," First Things, April 2001.
26. Aristotle Physics bk. 2, ch. 1.

27. Contrast Dembski, The Design Revolution, 140, which allows that such regularities are "as readily deemed brute facts of nature as artifacts of design."
28. Thomas Aquinas, Summa Theologica, trans. Fathers of the English Dominican Province (New York: Benzinger Brothers, 1946), 1, q.2, a.3.
29. Why, then, does Aquinas speak of things acting "always, or nearly always" in a certain way? Because a natural tendency can be frustrated. An acorn will always grow into an oak under the right circumstances—rather than into an elm, or a spider, or a dog—because that is its natural tendency. But of course, the right circumstances do not always obtain. The acorn may be damaged, or put into a desk drawer, or eaten. When A-T philosophers talk about the way things have to behave by nature, they don't mean that they will always succeed in behaving that way, but rather that that is the way they naturally tend to behave, the way they will behave unless prevented from doing so.
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a form in the intellect. Is there any other way the end or goal might exist already? There would seem to be only four possibilities: It might exist in the natural object itself; it might exist in a Platonic "third realm"; it might exist in some human intellect, or in another intellect within the natural world; or it might exist in an intellect outside the natural world altogether. But it obviously does not exist in the natural object itself; if the form of an oak were already in the acorn itself, it would be an oak, and it is not. It cannot exist in a Platonic "third realm" either, at least not if one endorses (as the Scholastic teleological realist does) the Aristotelian realist critique of Platonic realism about universals. Nor can it exist in some human or other intellect within the natural order, at least not without a vicious regress. Humans obviously are not the ones directing acorns and other natural objects (including human beings themselves) to their natural ends; and if we supposed that some other nonhuman but still natural intellects were doing so, this would just raise the question of what directs those intellects (since they too would be natural objects with final causes of their own) to their ends. The only possibility remaining, then, is the last one: Final causation in the natural world is intelligible because there is an intelligence altogether outside the natural order that directs natural objects to their ends.
To the "How can something nonexistent be a cause?" objection to final causation, then, the Thomist's reply is to say, "It can't. That's why the final cause of a natural object must exist already as an idea or form in an intellect existing altogether outside the natural order." Notice that, though the exposition of the argument made reference to the example of a house builder, it is not an "argument from analogy" in the sense that design arguments are thought to be. The reasoning is not "Houses are made by intelligent beings, and natural objects are analogous to houses, so they too are probably made by intelligent beings." The point of the builder example is rather to illustrate one of several possible ways the form of a thing might be efficacious even though the thing itself does not yet exist. The argument then goes on to try to show that all the other possibilities can be ruled out, and thus that there is no other way to make sense of the efficacy of final causes. Its structure is that of an attempted metaphysical demonstration, not that of an appeal to analogy, inductive generalization, argument to the best explanation, or any other exercise in empirical hypothesis formation.
In summary, then, the thrust of the Fifth Way is this: (1) Irreducible teleology is immanent to the natural order; (2) but such teleology is unintelligible unless there is an intellect outside the natural order; so (3) there is an intellect outside the natural order. The argument differs from Paley-style design arguments and the arguments of ID theorists in ways other than those already mentioned. For example, since the entities comprising the natural world have the final causes they have as long as they exist, the intellect in question has to exist as long as the natural world itself does, so as continu
31. The blogosphere has recently seen some fairly intense debate between ID theorists and A-T philosophers. Some readers might find of interest an exchange on the subject between me, Vincent Torley, and William Dembski that occurred in early 2010 at my personal blog and at the blog Uncommon Descent. In the course of the exchange I address several issues that are beyond the

scope of the present paper but relevant to understanding the larger dispute between ID and A-T. Here are the relevant Web addresses: Feser, "Intelligent Design' Theory and Mechanism," http://edwardfeser.blogspot.com/2010/04/intelligent-design-theory-and-mechanism.html; Tor-ley, "A Response to Professor Feser," http://www.uncommondescent.com/intelligent-design/aresponse-to-professor-feser/; Feser, "ID Theory, Aquinas, and the Origin of Life: A Reply to Torley," http://edwardfeser.blogspot.com/2010/04/id-theory-aquinas-and-origin-of-life.html; Dembski, "Does ID Presuppose a Mechanistic View of Nature?" http://www.uncommondescent.com/intelligent-design/does-id-presuppose-a-mechanistic-View-of-nature/; Feser, "Dembski Rolls Snake Eyes," http://edwardfeser.blogspot.com/2010/04/dembski-rolls-snake-eyes.html; Torley, "In Praise of Subtlety," http://www.uncommondescent.com/intelligent-design/in-praiseof-subtlety/; and Feser, "ID, A-T, and Duns Scotus: A further reply to Torley," http://edwardfeser.blogspot.com/2010/04/id-t-and-duns-scotus-f irther-reply-to.html.